CHAPTER 10

Anatomy of the Muscular System

CHAPTER OUTLINE

LANGUAGE OF SCIENCE

agonist (AG-ah-nist) [*agon* struggle]

anal triangle [*anal* pertaining to the anus]

antagonist (an-TAG-oh-nist) [*ant-* against, *-agon-* struggle]

aponeurosis (ap-oh-nyoo-ROH-sis) [*apo-* from, *-neur-* sinew, *-osis* condition of]

belly

buccinator muscle (BYOOK-si-NAY-tor) [*bucci* cheek]

bulbospongiosus muscle (bul-boh-spun-jee-OH-ses MUSS-el)

calcaneal tendon (kal-KAH-nee-al) [*calcane-* heel, *-al* pertaining to]

circular muscles

coccygeus muscle (kohk-SIJ-ee-us MUSS-el) [*coccyg* coccyx]

convergent muscles (kon-VER-jent)

corrugator supercilii muscle (COR-eh-gay-tor soo-per-SIL-ee-eye) [*corrugare* to wrinkle, *super-* above, *-cillium* eyelash]

deltoid (DEL-toyd) [*delta-* triangle, *-oid* resembling]

diaphragm (DYE-ah-fram) [*dia-* two, *-phragm* septum]

endomysium (en-doh-MEE-see-um) [*endo-* within, *-mys* muscle]

epimysium (ep-i-MIS-ee-um) [*epi-* upon, *-mys* muscle]

erector spinae muscle (eh-REK-tor SPINE-ee) [*erigere* to erect, *spina* spine]

extensor digitorum longus muscle (ek-STEN-ser dij-i-TOH-rum) [*extendere* to stretch, *digit* finger or toe, *longus* long]

external anal sphincter muscle (eks-TER-nal AY-nal SFINGK-ter MUSS-el) [*externa* outward, *anal* pertaining to the anus, *sphingein* to bind]

external intercostal muscle (eks-TER-nal in-ter-KOS-tal) [*externa* outward, *costa* rib]

external oblique muscle (eks-TER-nal oh-BLEEK) [*externa* outward, *obliquus* slanted]

extrinsic foot muscles (eks-TRIN-sik foot) [*extrinsecus* on the outside]

extrinsic muscles (eks-TRIN-sik) [*extrinsecus* on the outside]

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Survival depends on the ability to maintain a relatively constant internal environment. Such stability often requires movement of the body. Whereas many different systems of the body have *some* role in accomplishing movement, it is the skeletal and muscular systems acting together that actually produce most body movements. We have investigated the architectural plan of the skeleton and have seen how its firm supports and joint structures make movement possible. However, bones and joints cannot move themselves. They must be moved by something. Our subject for now, then, is the large mass of skeletal muscle that moves the framework of the body: the **muscular system.**

Movement is one of the most distinctive and easily observed "characteristics of life." When we walk, talk, run, breathe, or engage in a multitude of other physical activities that are under the "willed" control of the individual, we do so by contraction of skeletal muscle.

There are more than 600 skeletal muscles in the body. Collectively, they constitute 40% to 50% of our body weight. And, together with the scaffolding provided by the skeleton, muscles also determine the form and contours of our body.

Contraction of individual muscle cells is ultimately responsible for purposeful movement. In Chapter 11 the physiology of muscular contraction is discussed. In this preliminary chapter, however, we will learn how contractile units are grouped into unique functioning organs—or muscles. The manner in which muscles are grouped, the relationship of muscles to joints, and how muscles attach to the skeleton determine purposeful body movement. A discussion of muscle shape and how muscles attach to and move bones is followed by information on specific muscles and muscle groups. The chapter ends with a review of the concept of posture.

SKELETAL MUSCLE STRUCTURE

Connective Tissue Components

The highly specialized skeletal muscle cells, or *muscle fibers*, are covered by a delicate connective tissue membrane called the **endomysium** (Figure 10-1). Groups of skeletal muscle fibers, called *fascicles*, are then bound together by a tougher connective tissue envelope called the **perimysium.** The muscle as a whole is covered by a coarse sheath called the **epimysium.** Because all three of these structures are continuous with the fibrous structures that attach muscles to bones or other structures, muscles are firmly harnessed to the structures they pull on during contraction. The epimysium, perimysium, and endomysium of a muscle, for example, may be continuous with fibrous tissue that extends from the muscle as a **tendon,** a strong tough cord continuous at its other end with the fibrous periosteum covering a bone. Alternatively, the fibrous wrapping of a muscle may extend as a broad, flat sheet of connective tissue called an **aponeurosis,** which usually merges with the fibrous wrappings of another muscle. So tough and strong are tendons and aponeuroses that they are not often torn, even by injuries forceful enough to break bones or tear muscles. They are, however, occasionally pulled away from bones. Fibrous connective tissue surrounding the muscle organ and outside the epimysium and tendon is called **fascia.** *Fascia* is a general term for the fibrous connective tissue found under the skin and surrounding many deeper organs, including skeletal muscles and bones. Fascia just under the skin (the hypodermis) is sometimes called *superficial fascia*, and the fascia around muscles and bones is sometimes called *deep fascia*.

Tube-shaped structures of fibrous connective tissue called **tendon sheaths** enclose certain tendons, notably those of the wrist and ankle. Like bursae, tendon sheaths have a lining of synovial membrane. Its moist, smooth surface enables the tendon to move easily, almost without friction, in the tendon sheath.

Size, Shape, and Fiber Arrangement

The structures called *skeletal muscles* are organs. They consist mainly of skeletal muscle tissue plus important connective and nervous tissue components. Skeletal muscles vary considerably in size, shape, and arrangement of fibers. They range from extremely small strands, such as the stapedius muscle of the middle ear, to large masses, such as the muscles of the thigh. Some skeletal muscles are broad in shape and some are narrow. Some are long and tapering and some are short and blunt. Some are triangular, some quadrilateral, and some irregular. Some form flat sheets and others form bulky masses.

The strength and type of movement produced by the shortening of a muscle is related to the orientation of its fibers and overall shape, as well as its attachments to bone and involvement in joints. This is yet another example of the relationship between structure and function. Six muscle shapes are often used to describe and categorize skeletal muscles (Figure 10-2).

1. **Parallel muscles** can vary in length, but long straplike muscles with parallel fascicles are perhaps most typical. The sartorius muscle of the leg is a good example. The rectus abdominis muscles, which run the length of the anterior abdominal wall, have parallel muscle fascicles that are "interrupted" by transverse intersections.
2. **Convergent muscles** have fascicles that radiate out from a small to a wider point of attachment, much like the blades in a fan. The pectoralis major muscle is a good example.
3. **Pennate muscles** are said to be "feather-like" in appearance. Three categories of these muscles have uniquely different types of fascicle attachments that in some ways resemble the feathers in an old-fashioned plume pen. *Unipenate muscles*, such as the soleus, have fascicles that anchor to only one side of the connective tissue shaft. *Bipennate muscles*, such as the rectus femoris in the thigh, have a type of double-feathered attachment of fascicles. In *multipennate muscles*, such as the deltoid, the numerous interconnecting quill-like fascicles converge on a common point of attachment.
4. **Fusiform muscles** have fascicles that may be close to parallel in the center, or "belly," of the muscle but converge to a tendon at one or both ends. The brachioradialis is a good example.
5. **Spiral muscles,** such as the latissimus dorsi, have fibers that twist between their points of attachment.
6. **Circular muscles,** sometimes called *sphincters*, often circle body tubes or openings. The orbicularis oris around the mouth is a good example.

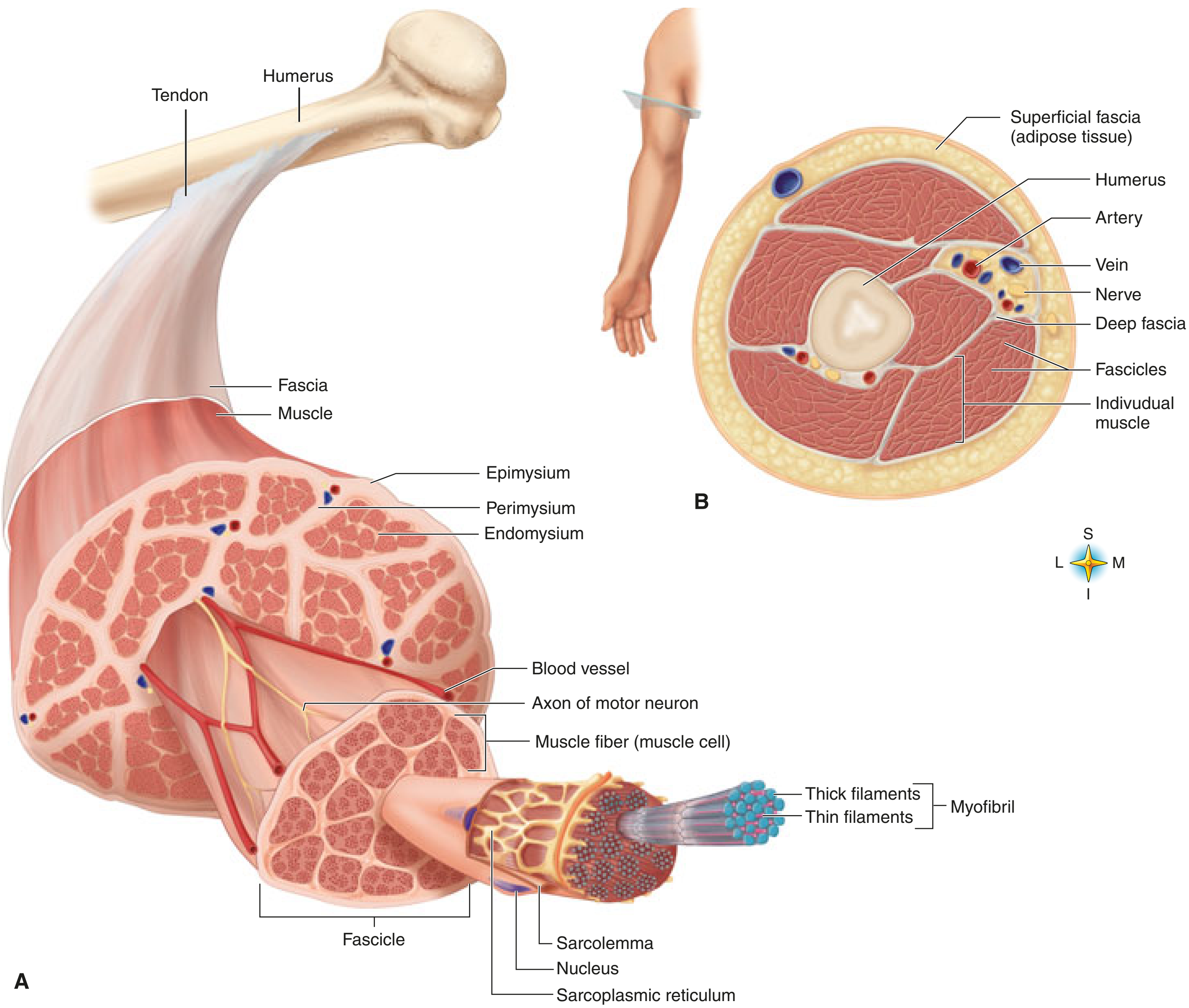

Figure 10-1 ***Structure of a muscle organ.*** **A,** Note that the connective tissue coverings, the epimysium, perimysium, and endomysium, are continuous with each other and with the tendon. Note also that muscle fibers are held together by the perimysium in groups called fascicles. **B,** Diagram showing the arm in cross section. Note the relationships of superficial and deep fascia to individual muscles and other structures in the plane of section.

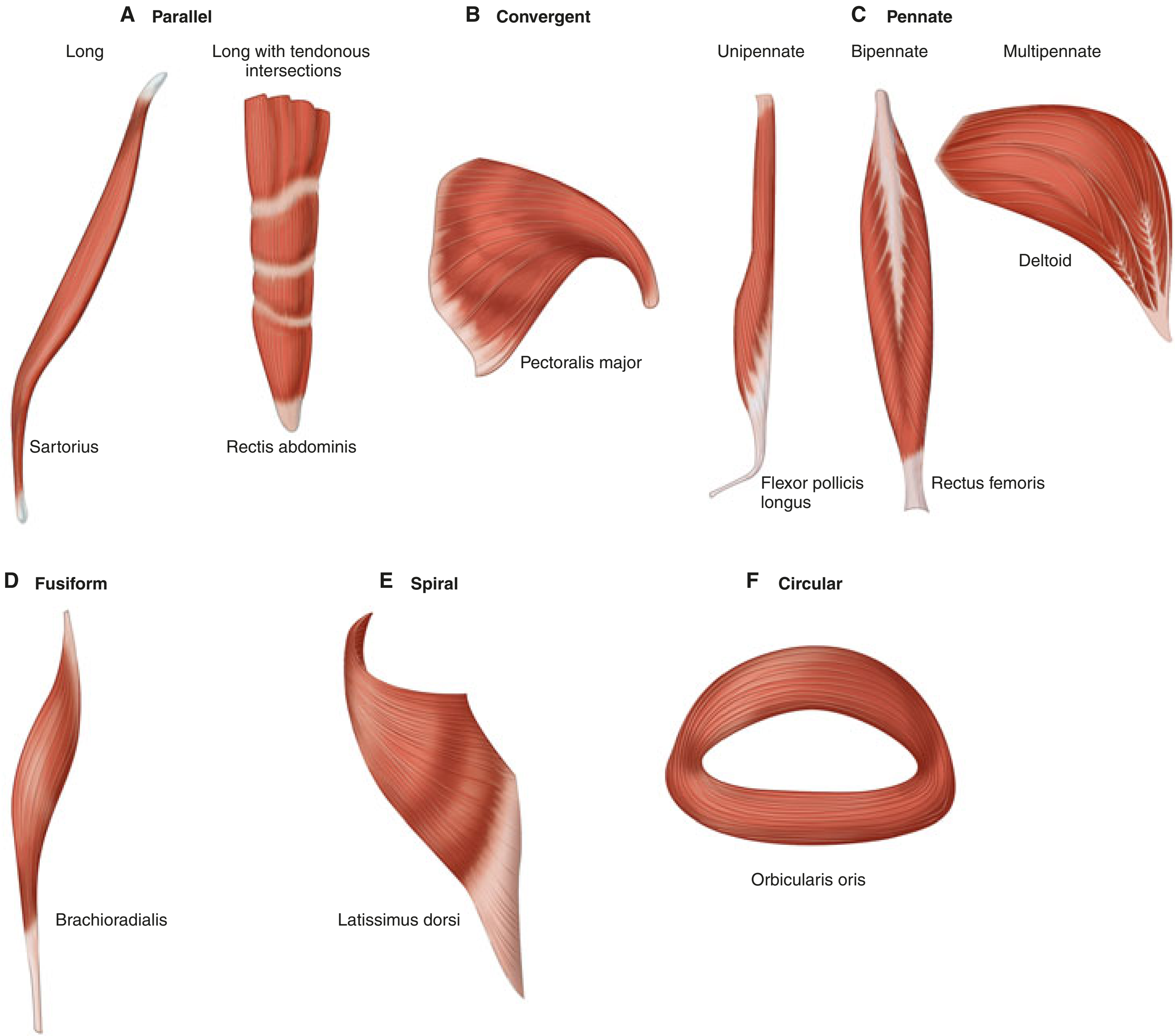

Figure 10-2 ***Muscle shape and fiber arrangement.*** **A,** Parallel. **B,** Convergent. **C,** Pennate: unipennate, bipennate, multipennate. **D,** Fusiform. **E,** Spiral. **F,** Circular.

QUICK CHECK

1. Identify the connective tissue membrane that (a) covers individual muscle fibers, (b) surrounds groups of skeletal muscle fibers (fascicles), and (c) covers the muscle as a whole.
2. Name the tough connective tissue cord that serves to attach a muscle to a bone.
3. Name three types of fiber arrangements seen in skeletal muscle.

Attachment of Muscles

Most of our muscles span at least one joint and attach to both articulating bones. When contraction occurs, one bone usually remains fixed and the other moves. The points of attachment are called the *origin* and *insertion*. The **origin** is the point of attachment that does not move when the muscle contracts. Therefore, the origin bone is the more stationary of the two bones at a joint when contraction occurs. The **insertion** is the point of attachment that moves when the muscle contracts (Figure 10-3). The insertion bone therefore moves toward the origin bone when the

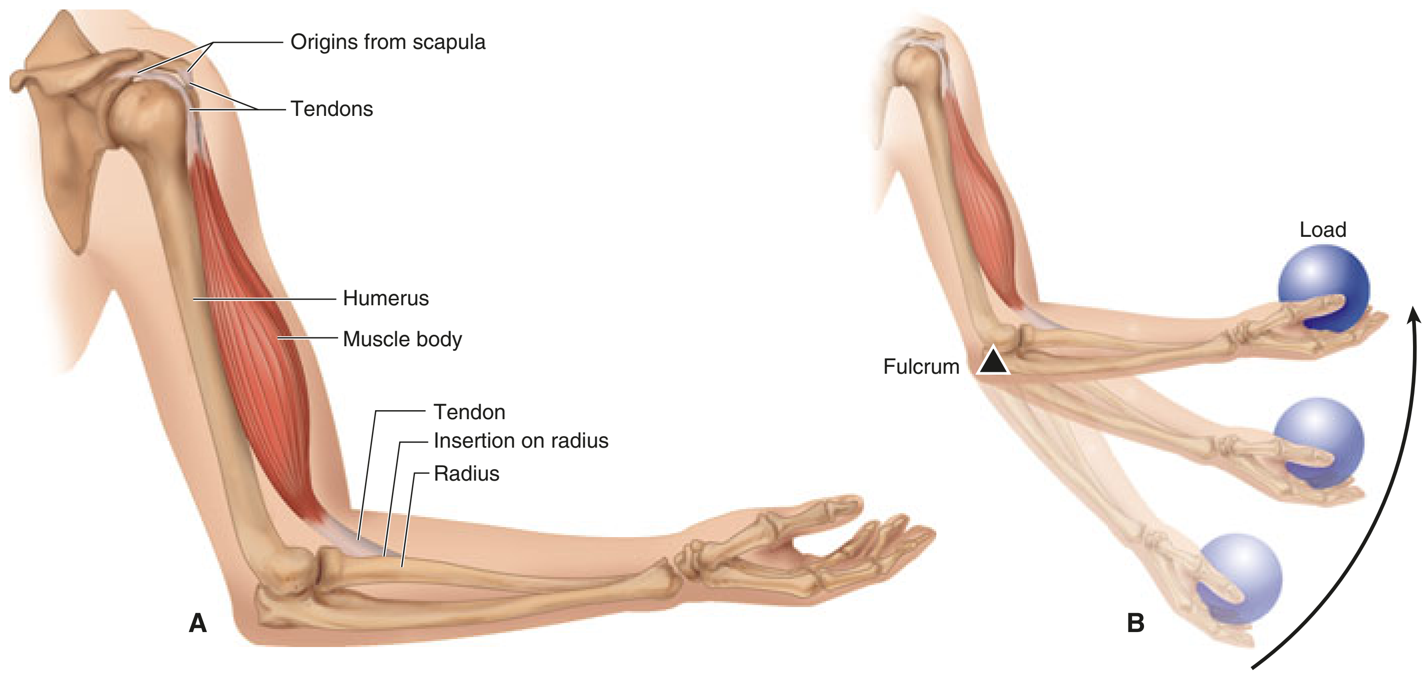

Figure 10-3 ***Attachments of a skeletal muscle.*** **A**, Origin and insertion of a skeletal muscle. A muscle originates at a relatively stable part of the skeleton (origin) and inserts at the skeletal part that is moved when the muscle contracts (insertion). **B**, Movement of the forearm during weightlifting. Muscle contraction moves bones, which serve as levers, and by acting on joints, which serve as fulcrums for those levers. See the text for discussion and review Figure 10-4, which illustrates types of levers.

muscle shortens. In case you are wondering why both bones do not move because both are pulled on by the contracting muscle, one of them is normally stabilized by isometric contractions of other muscles or by certain features of its own that make it less mobile.

The terms *origin* and *insertion* provide us with useful points of reference. Many muscles have multiple points of origin or insertion. Understanding the functional relationship of these attachment points during muscle contraction helps in deducing muscle actions. The attachment points of the biceps brachii shown in Figure 10-3 help provide functional information. Distal insertion on the radius in the lower part of the arm causes flexion to occur at the elbow when contraction occurs. It should be realized, however, that origin and insertion are points that may change under certain circumstances. For example, not only can you grasp an object above your head and pull it down, but you can also pull yourself up to the object. Although *origin* and *insertion* are convenient terms, they do not always provide the necessary information to understand the full functional potential of muscle action.

Muscle Actions

Skeletal muscles almost always act in groups rather than singly. As a result, most movements are produced by the coordinated action of several muscles. Some of the muscles in the group contract while others relax. The result is a movement pattern that allows for the functional classification of muscles or muscle groups. Several terms are used to describe muscle action during any specialized movement pattern. The terms *prime mover (agonist)*, *antagonist*, *synergist*, and *fixator* are especially important and are discussed in the following paragraphs. Each term suggests an important concept that is essential to understanding such functional muscle patterns as flexion, extension, abduction, adduction, and other movements discussed in Chapter 9. The term **prime mover** or **agonist** is used to describe a muscle or group of muscles that directly performs a specific movement. The movement produced by a muscle acting as a prime mover is described as the "action" or "function" of that muscle. For example, the biceps brachii shown in Figure 10-3 is acting as a prime mover during flexion of the forearm.

Antagonists are muscles that when contracting, directly oppose prime movers (agonists). They are relaxed while the prime mover is contracting to produce movement. Simultaneous contraction of a prime mover and its antagonist muscle results in rigidity and lack of motion. The term *antagonist* is perhaps unfortunate because muscles cooperate, rather than oppose, in normal movement patterns. Antagonists are important in providing precision and control during contraction of prime movers.

Synergists are muscles that contract at the same time as the prime mover. They facilitate or complement prime mover actions so that the prime mover produces a more effective movement.

Fixator muscles generally function as joint stabilizers. They frequently serve to maintain posture or balance during contraction of prime movers acting on joints in the arms and legs.

Movement patterns are complex, and most muscles function not only as prime movers but also at times as antagonists, synergists, or fixators. A prime mover in a particular movement pattern, such as flexion, may be an antagonist during extension or a synergist or fixator in other types of movement.

QUICK CHECK

4. Identify the point of attachment of a muscle to a bone that (a) does not move when the muscle contracts and (b) moves when the muscle contracts.
5. What name is used to describe a muscle that directly performs a specific movement?
6. What type of muscles helps maintain posture or balance during contraction of muscles acting on joints in the arms and legs?
7. Name the type of muscles that generally function as joint stabilizers.

Lever Systems

When a muscle shortens, the central body portion, called the **belly**, contracts. The type and extent of movement are determined by the load or resistance that is moved, the attachment of the tendinous extremities of the muscle to bone (origin and insertion), and the particular type of joint involved. In almost every instance, muscles that move a part do not lie over that part. Instead, the muscle belly lies proximal to the part moved. Thus, muscles that move the lower part of the arm lie proximal to it, that is, in the upper part of the arm.

Knowledge of **lever systems** is important in understanding muscle action. By definition, a **lever** is any rigid bar free to turn about a fixed point called its *fulcrum*. Bones serve as levers, and joints serve as fulcrums of these levers. A contracting muscle applies a pulling force on a bone lever at the point of the muscle's attachment to the bone. This force causes the insertion bone to move about its joint fulcrum.

A lever system is a simple mechanical device that makes the work of moving a weight or other load easier. Levers are composed of four component parts: (1) a rigid rod or bar (bone); (2) a fixed pivot, or fulcrum (F), around which the rod moves (joint); (3) a load (L), or resistance, that is moved; and (4) a force, or pull (P), which produces movement (muscle contraction). Figure 10-4 shows the three different types of lever arrangements. All three types are found in the human body.

First-Class Levers

As you can see in Figure 10-4, *A*, the fulcrum in a first-class lever lies between the effort, or pull *(P)*, and the resistance, or load *(W)*, as in a set of scales, a pair of scissors, or a child's seesaw. In the body the head being raised or tipped backward on the atlas is an example of a first-class lever in action. The facial portion of the skull is the load, the joint between the skull and atlas is the fulcrum, and the muscles of the back produce the pull. In the human body first-class levers are not abundant. They generally serve as levers of stability.

Second-Class Levers

In second-class levers the load lies between the fulcrum and the joint at which the pull is exerted. The wheelbarrow is often used as an example. The presence of second-class levers in the human body is a controversial issue. Some authorities interpret the raising of the body on the toes as an example of this type of lever (Figure 10-4, *B*). In this example the point of contact between the toes and the ground is the fulcrum, the load is located at the ankle, and pull is exerted by the gastrocnemius muscle through the Achilles tendon. Opening the mouth against resistance (depression of the mandible) is also considered to be an example of a second-class lever.

Third-Class Levers

In a third-class lever the pull is exerted between the fulcrum and the resistance or load to be moved. Flexing of the forearm at the elbow joint is a frequently used example of this type of lever (Figure 10-4, *C*). Third-class levers permit rapid and extensive movement and are the most common type found in the body. They allow insertion of a muscle very close to the joint that it moves.

BOX 10-1: SPORTS AND FITNESS

Assessing Muscle Strength

Physical therapists, certified athletic trainers, and other health care providers are often required to assess muscle strength. A basic principle of muscle action in a lever system is called the optimum angle of pull. An understanding of this principle is required for correct assessment of muscle strength.

Generally, the optimum angle of pull for any muscle is a right angle to the long axis of the bone to which it is attached. When the angle of pull departs from a right angle and becomes more parallel to the long axis, the strength of contraction decreases dramatically. Contraction of the brachialis muscle demonstrates this principle very well. The brachialis crosses the elbow from the humerus to the ulna. In the anatomical position the elbow is extended and the angle of pull of the brachialis is parallel to the long axis of the ulna (see Figure 10-21, *D*). Contraction of the brachialis at this angle is very inefficient. As the elbow is flexed and the angle of pull approaches a right angle, the contraction strength of the muscle is greatly increased. Therefore, to test brachialis muscle strength correctly, the forearm should be flexed at the elbow. Understanding the optimum angle of pull for any given muscle makes a rational approach to correct assessment of functional strength in that muscle possible.

HOW MUSCLES ARE NAMED

The first thing you may notice as you start studying the muscles of the body is that many of the names seem difficult and foreign. The terms are less difficult if you keep in mind that many have Latin roots. Latin-based muscle names are easier to learn if you gain an appreciation for the Latin roots even if a particular name is given in Latin-based English. Although we have strived to use only English names in this edition, some Latin terms still remain in common use. This is especially true in the health-related disciplines. For example, in some texts the deltoid muscle is called the *deltoideus* (Latin) and in others the *deltoid* (Latin-based English). To minimize confusion, if both Latin and English terms are

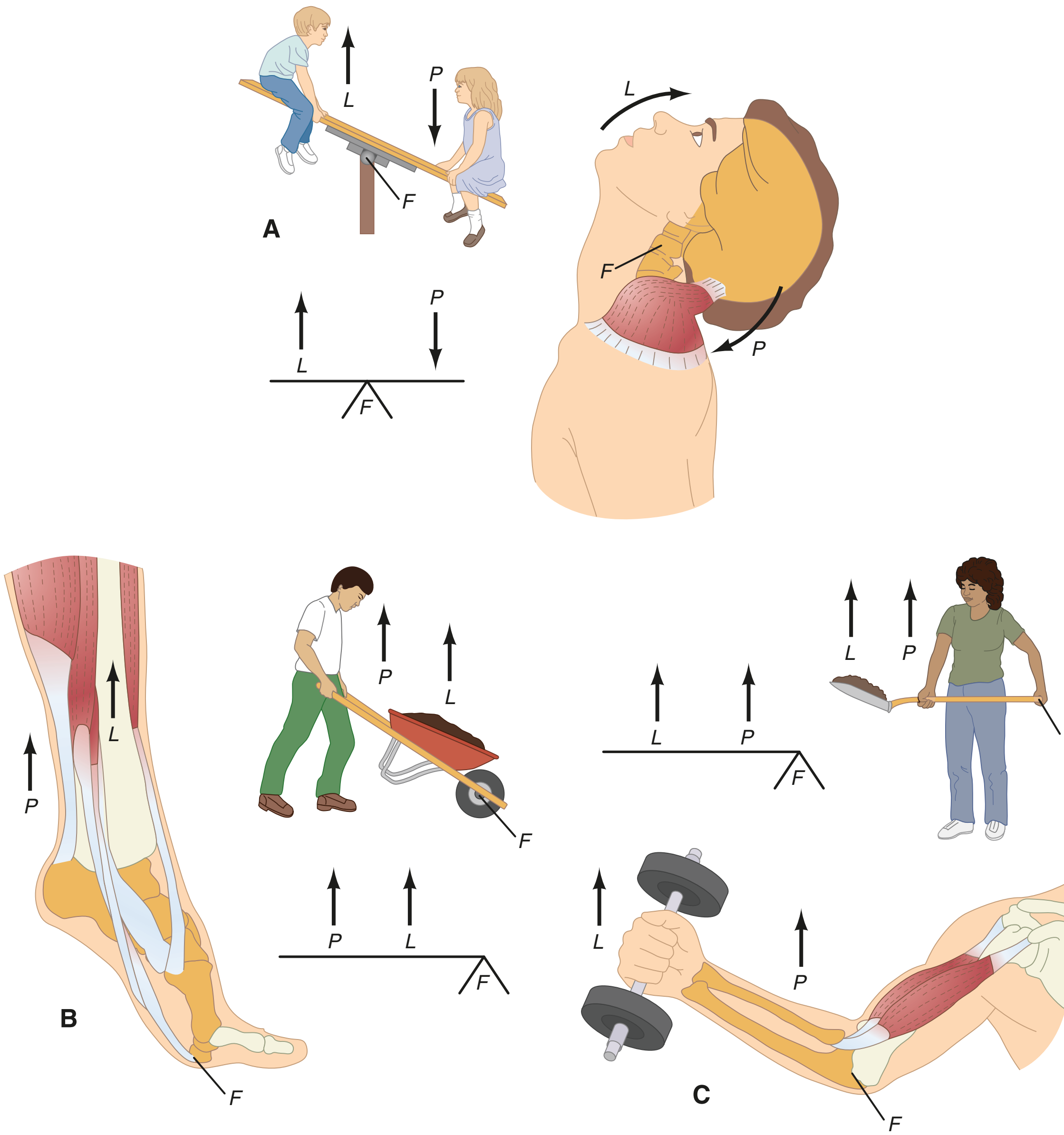

Figure 10-4 ***Lever classes.*** **A,** Class I: fulcrum *(F)* between the load *(L)* and force or pull *(P);* **B,** Class II: load *(L)* between the fulcrum *(F)* and force or pull *(P);* **C,** Class III: force or pull *(P)* between the fulcrum *(F)* and the load *(L)*. The lever rod is yellow in each.

used to identify a particular muscle in the chapter, the terms used will be from the *Terminologia Anatomica* (see Chapter 1).

Regardless of the muscle name used, when one understands the reasons for the term used, it will seem more logical and easier to learn and understand. Many of the muscles of the body shown in Figures 10-5 and 10-6 or listed in Tables 10-1 through 10-5 are named in accordance with one or more of the following features:

- **Location.** Many muscles are named as a result of location. The *brachialis* (arm) muscle and *gluteus* (buttock) muscles are examples. Table 10-1 is a listing of some major muscles grouped by location.
- **Function.** The function of a muscle is frequently a part of its name. The *adductor* muscles of the thigh adduct, or move, the leg toward the midline of the body. Table 10-2 lists selected muscles grouped according to function.
- **Shape.** Shape is a descriptive feature used for naming many muscles. The *deltoid* (triangular) muscle covering the shoulder is deltoid, or triangular, in shape (see Table 10-3).
- **Direction of fibers.** Muscles may be named according to the orientation of their fibers. The term *rectus* means straight. The fibers of the *rectus abdominis* muscle run straight up and down and are parallel to each other (see Table 10-4).
- **Number of heads or divisions.** The number of divisions or heads (points of origin) may be used to name a muscle. The

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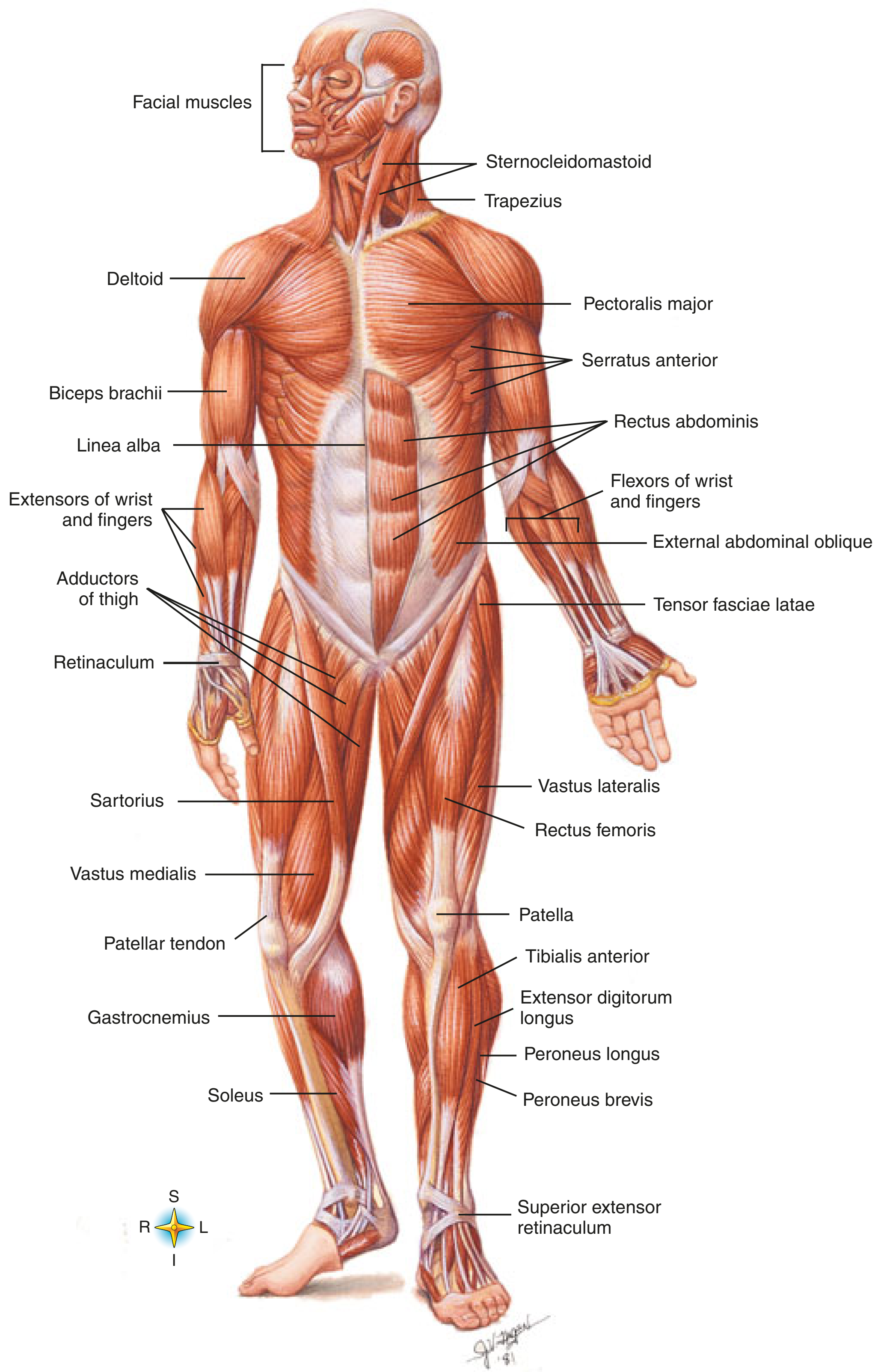

Figure 10-5 ***General overview of the body's musculature.*** Anterior view.

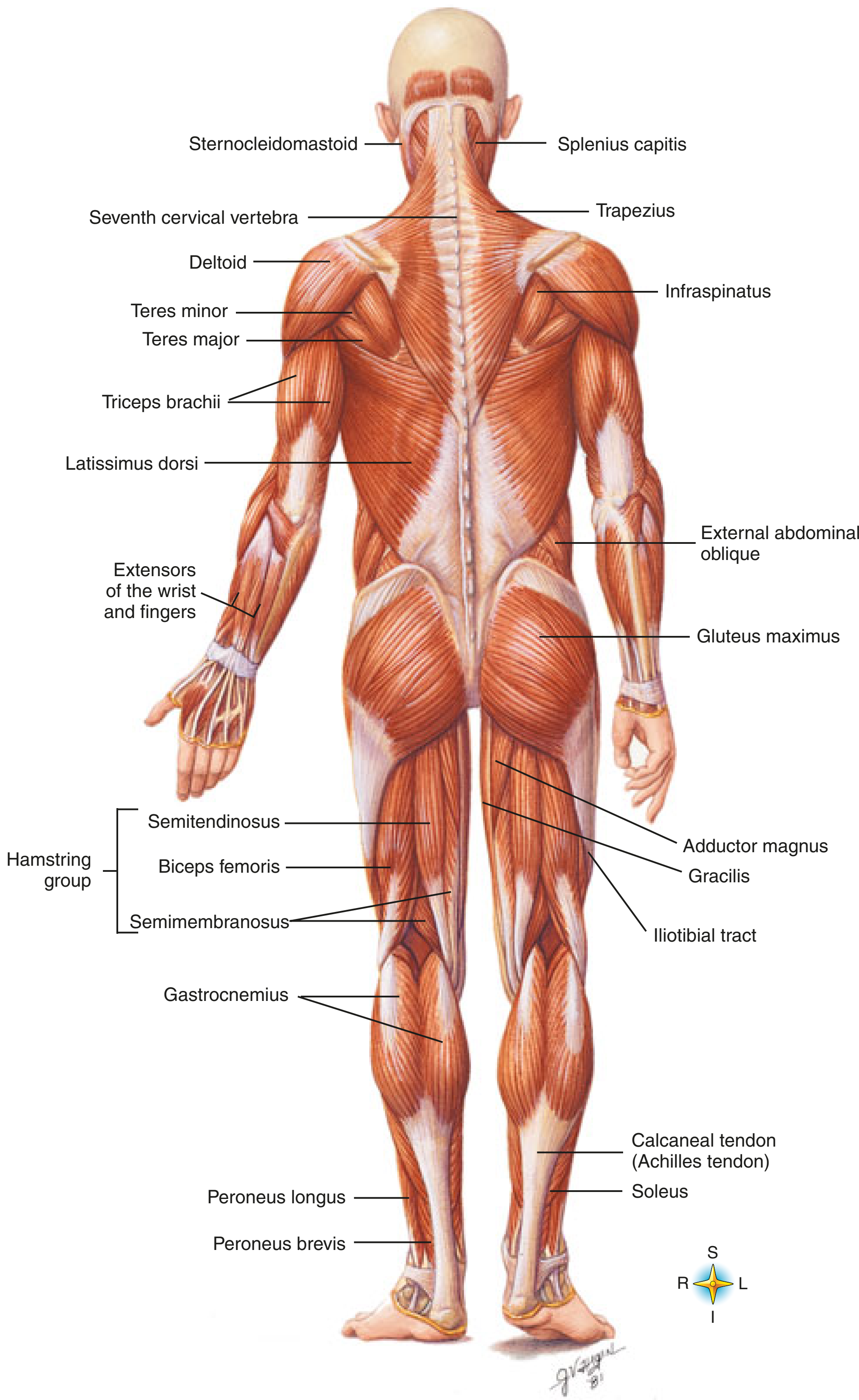

Figure 10-6 ***General overview of the body's musculature.*** Posterior view.

Table 10-1 Selected Muscles Grouped According to Location

LOCATION	MUSCLES
Neck	Sternocleidomastoid
Back	Trapezius
Chest	Latissimus dorsi Pectoralis major Serratus anterior
Abdominal wall	External oblique
Shoulder	Deltoid
Upper part of arm	Biceps brachii Triceps brachii Brachialis
Forearm	Brachioradialis Pronator teres
Buttocks	Gluteus maximus Gluteus minimus Gluteus medius Tensor fascia latae
Thigh	
Anterior surface	Quadriceps femoris group Rectus femoris Vastus lateralis Vastus medialis Vastus intermedius
Medial surface	Gracilis Adductor group (brevis, longus, magnus)
Posterior surface	Hamstring group Biceps femoris Semitendinosus Semimembranosus
Leg	
Anterior surface	Tibialis anterior
Posterior surface	Gastrocnemius Soleus
Pelvic floor	Levator ani Coccygeus

Table 10-2 Selected Muscles Grouped According to Function

PART MOVED	EXAMPLE OF FLEXOR	EXAMPLE OF EXTENSOR	EXAMPLE OF ABDUCTOR	EXAMPLE OF ADDUCTOR
Head	Sternocleidomastoid	Semispinalis capitis		
Upper part of arm	Pectoralis major	Trapezius Latissimus dorsi	Deltoid	Pectoralis major with latissimus dorsi
Forearm	With forearm supinated: biceps brachii With forearm pronated: brachialis With semisupination or semipronation: brachioradialis	Triceps brachii		
Hand	Flexor carpi radialis and ulnaris Palmaris longus	Extensor carpi radialis, longus, and brevis Extensor carpi ulnaris	Flexor carpi radialis	Flexor carpi ulnaris
Thigh	Iliopsoas Rectus femoris (of quadriceps femoris group)	Gluteus maximus	Gluteus medius and minimus	Adductor group
Leg	Hamstrings	Quadriceps femoris group		
Foot	Tibialis anterior	Gastrocnemius Soleus	Evertors Peroneus longus Peroneus brevis	Invertor Tibialis anterior
Trunk	Iliopsoas Rectus abdominis	Erector spinae		

Table 10-3 Selected Muscles Grouped According to Shape

NAME	MEANING	EXAMPLE
Deltoid	Triangular	Deltoid
Gracilis	Slender	Gracilis
Trapezius	Trapezoid	Trapezius
Serratus	Notched	Serratus anterior
Teres	Round	Pronator teres
Rhomboid	Rhomboidal	Rhomboideus major
Orbicularis	Round or circular	Orbicularis oris
Pectinate	Comblike	Pectineus
Piriformis	Wedge-shaped	Piriformis
Platys	Flat	Platysma
Quadratus	Square	Quadratus femoris
Lumbrical	Wormlike	Lumbricals

Table 10-4 Selected Muscles Grouped According to Number of Heads and Direction of Fiber

NAME	MEANING	EXAMPLE
A. Number of Heads		
Biceps	Two heads	Biceps brachii
Triceps	Three heads	Triceps brachii
Quadriceps	Four heads	Quadriceps
Digastric	Two bellies	Digastric
B. Direction of Fibers		
Oblique	Diagonal	External oblique rectus
Rectus	Straight	Rectus abdominis
Transverse	Transverse	Transversus abdominis
Circular	Around	Orbicularis oris
Spiral	Oblique	Supinator

word part *-cep* means *head*. *Biceps* (two), *triceps* (three), and *quadriceps* (four) refer to multiple heads, or points of origin. The *biceps brachii* is a muscle having two heads located in the arm (see Table 10-4).

- **Points of attachment.** Origin and insertion points may be used to name a muscle. For example, the *sternocleidomastoid* has its origin on the sternum and clavicle and inserts on the mastoid process of the temporal bone.
- **Size of muscle.** The relative size of a muscle can be used to name a muscle, especially if it is compared to the size of nearby muscles (see Table 10-5). For example, the *gluteus maximus* is the largest muscle of the gluteal (Greek *glautos*, meaning "buttock") region. Nearby, there is a small gluteal muscle, the *gluteus minimus*, and a midsize gluteal muscle, the *gluteus medius*.

Table 10-5 Selected Muscles Grouped According to Size

NAME	MEANING	EXAMPLE
Major	Large	Pectoralis major
Maximus	Largest	Gluteus maximus
Minor	Small	Pectoralis minor
Minimus	Smallest	Gluteus minimus
Longus	Long	Adductor longus
Brevis	Short	Extensor pollicis brevis
Latissimus	Very wide	Latissimus dorsi
Longissimus	Very long	Longissimus
Magnus	Very large	Adductor magnus
Vastus	Vast or huge	Vastus medialis

QUICK CHECK

8. Name the four major components of any lever system.
9. Identify the three types of lever systems found in the human body and give one example of each.
10. What type of lever system permits rapid and extensive movement and is the most common type found in the body?
11. List six criteria that may determine a muscle's name, and give an example of a specific muscle named according to each criterion.

Hints on How to Deduce Muscle Actions

To understand muscle actions, you first need to know certain anatomical facts, such as which bones muscles attach to and which joints they pull across. Then, if you relate these structural features to functional principles, you may find your study of muscles more interesting and less difficult than you anticipate. Some specific suggestions for deducing muscle actions follow.

1. Start by making yourself familiar with the names, shapes, and general locations of the larger muscles by using Table 10-1 as a guide.
2. Try to deduce which bones the two ends of a muscle attach to from your knowledge of the shape and general location of the muscle. For example, look carefully at the deltoid muscle as illustrated in Figures 10-5 and 10-17. To which bones does it seem to attach? Check your answer with Table 10-13, p. 372.
3. Next, determine which bone moves when the muscle shortens. (The bone moved by a muscle's contraction is its insertion bone; the bone that remains relatively stationary is its origin bone.) In many cases you can tell which is the insertion bone by trying to move one bone and then another. In some cases either bone may function as the insertion bone. Although not all muscle attachments can be deduced as readily as those of the deltoid, they can all be learned more easily by using this deduction method than by relying on rote memory alone.

4. Deduce a muscle's actions by applying the principle that its insertion moves toward its origin. Check your conclusions with the text. Here, as in steps 2 and 3, the method of deduction is intended merely as a guide and is not adequate by itself for determining muscle actions.
5. To deduce which muscle produces a given action (instead of which action a given muscle produces, as in step 4), start by inferring the insertion bone (bone that moves during the action). The body and origin of the muscle will lie on one or more of the bones toward which the insertion moves—often a bone, or bones, proximal to the insertion bone. Couple these conclusions about origin and insertion with your knowledge of muscle names and locations to deduce the muscle that produces the action.

For example, if you wish to determine the prime mover for the action of raising the upper parts of the arms straight out to the sides, you infer that the muscle inserts on the humerus because this is the bone that moves. It moves toward the shoulder—that is, the clavicle and scapula—so the muscle probably has its origin on these bones. Because you know that the deltoid muscle fulfills these conditions, you conclude, and rightly so, that it is the muscle that raises the upper parts of the arms sideways.

IMPORTANT SKELETAL MUSCLES

The major skeletal muscles of the body are listed, grouped, and illustrated in the tables and figures that follow. Begin your study with an overview of important superficial muscles, shown in Figures 10-5 and 10-6. The remaining figures in this chapter illustrate individual muscles or important muscle groups.

Basic information about many muscles is given in Tables 10-6 to 10-18. Each table has a description of a group of muscles that move one part of the body. The actions listed for each muscle are those for which it is a prime mover. Remember, however, that a single muscle acting alone rarely accomplishes a given action. Instead, muscles act in groups as prime movers, synergists, antagonists, and fixators to bring about movements.

Muscles of Facial Expression

The muscles of facial expression (Table 10-6 and Figures 10-7 and 10-8) are unique in that at least one of their points of attachment is to the deep layers of the skin over the face or neck. Contraction of these muscles produces a variety of facial expressions.

The **occipitofrontalis** (ok-sip-i-toh-fron-TAL-is), or *epicranius*, is in reality two muscles. One portion lies over the forehead (frontal bone); the other covers the occipital bone in back of the head. The two muscular parts, or bellies, are joined by a connective tissue aponeurosis that covers the top of the skull. The frontal portion of the occipitofrontalis raises the eyebrows (surprise) and wrinkles the skin of the forehead horizontally. The **corrugator supercilii** (COR-uh-gay-tor su-per-SIL-ee-eye) draws the eyebrows together and produces vertical wrinkles above the nose (frowning). The **orbicularis oculi** (or-bik-u-LAIR-is OK-yoo-lye) encircles and closes the eye (blinking), whereas the **orbicularis oris** (OR-is) and **buccinator** (BUK-si-NA-tor) pucker the mouth (kissing) and press the lips and cheeks against the teeth. The **zygomaticus** (zye-goh-MAT-ik-us) **major** draws the corner of the mouth upward (laughing).

Muscles of Mastication

The muscles of **mastication** (mass-tih-KAY-shun) shown in Figure 10-9 are responsible for chewing movements. These powerful muscles (see Table 10-6) either elevate and retract the mandible (**masseter,** mass-EET-er, and **temporalis,** tem-poh-RAL-is) or open and protrude it while causing sideways movement (**pterygoids,** TER-i-goids). The pull of gravity helps open the mandible

Table 10-6 Muscles of Facial Expression and Mastication

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
Muscles of Facial Expression				
Occipitofrontalis (epicranius)	Occipital bone	Tissues of eyebrows	Raises eyebrows, wrinkles forehead horizontally	Cranial nerve VII
Corrugator supercilii	Frontal bone (superciliary ridge)	Skin of eyebrow	Wrinkles forehead vertically	Cranial nerve VII
Orbicularis oculi	Encircles eyelid		Closes eye	Cranial nerve VII
Zygomaticus major	Zygomatic bone	Angle of mouth	Laughing (elevates angle of mouth)	Cranial nerve VII
Orbicularis oris	Encircles mouth		Draws lips together	Cranial nerve VII
Buccinator	Maxillae	Skin of sides of mouth	Permits smiling Blowing, as in playing a trumpet	Cranial nerve VII
Muscles of Mastication				
Masseter	Zygomatic arch	Mandible (external surface)	Closes jaw	Cranial nerve V
Temporalis	Temporal bone	Mandible	Closes jaw	Cranial nerve V
Pterygoids (lateral and medial)	Undersurface of skull	Mandible (medial surface)	Grates teeth	Cranial nerve V

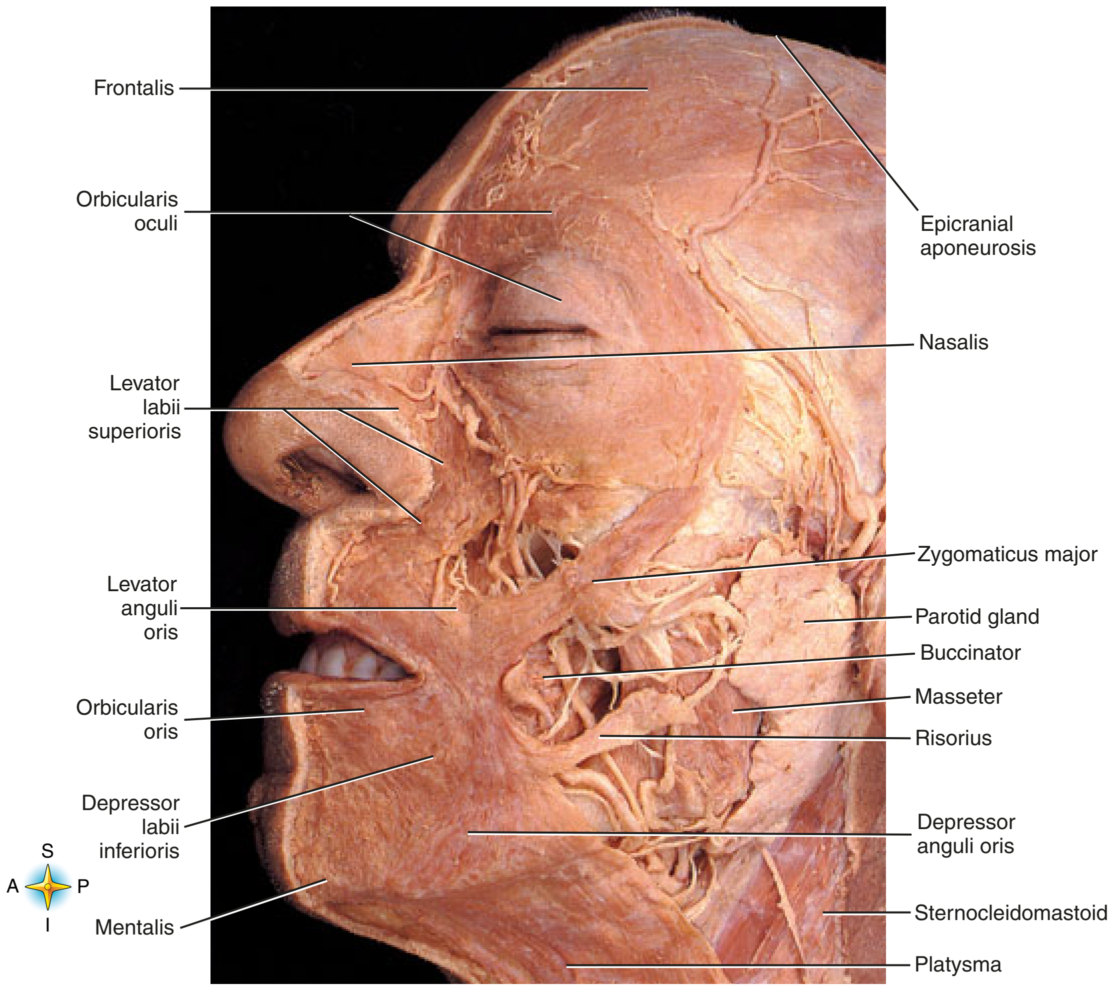

Figure 10-7 ***Muscles of facial expression.*** The skin and subcutaneous fat have been removed.

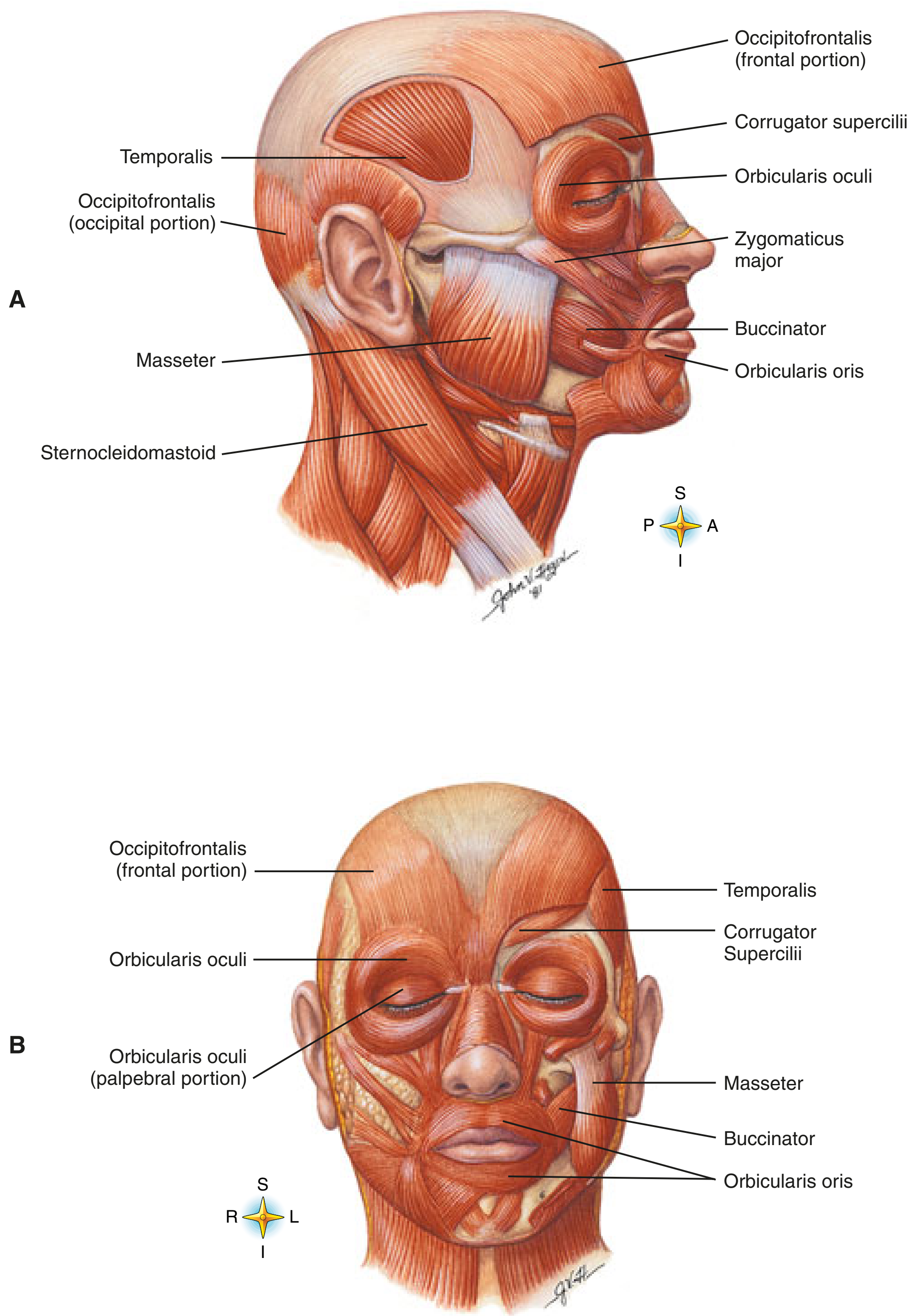

Figure 10-8 ***Muscles of facial expression and mastication.*** **A,** Lateral view. **B,** Anterior view.

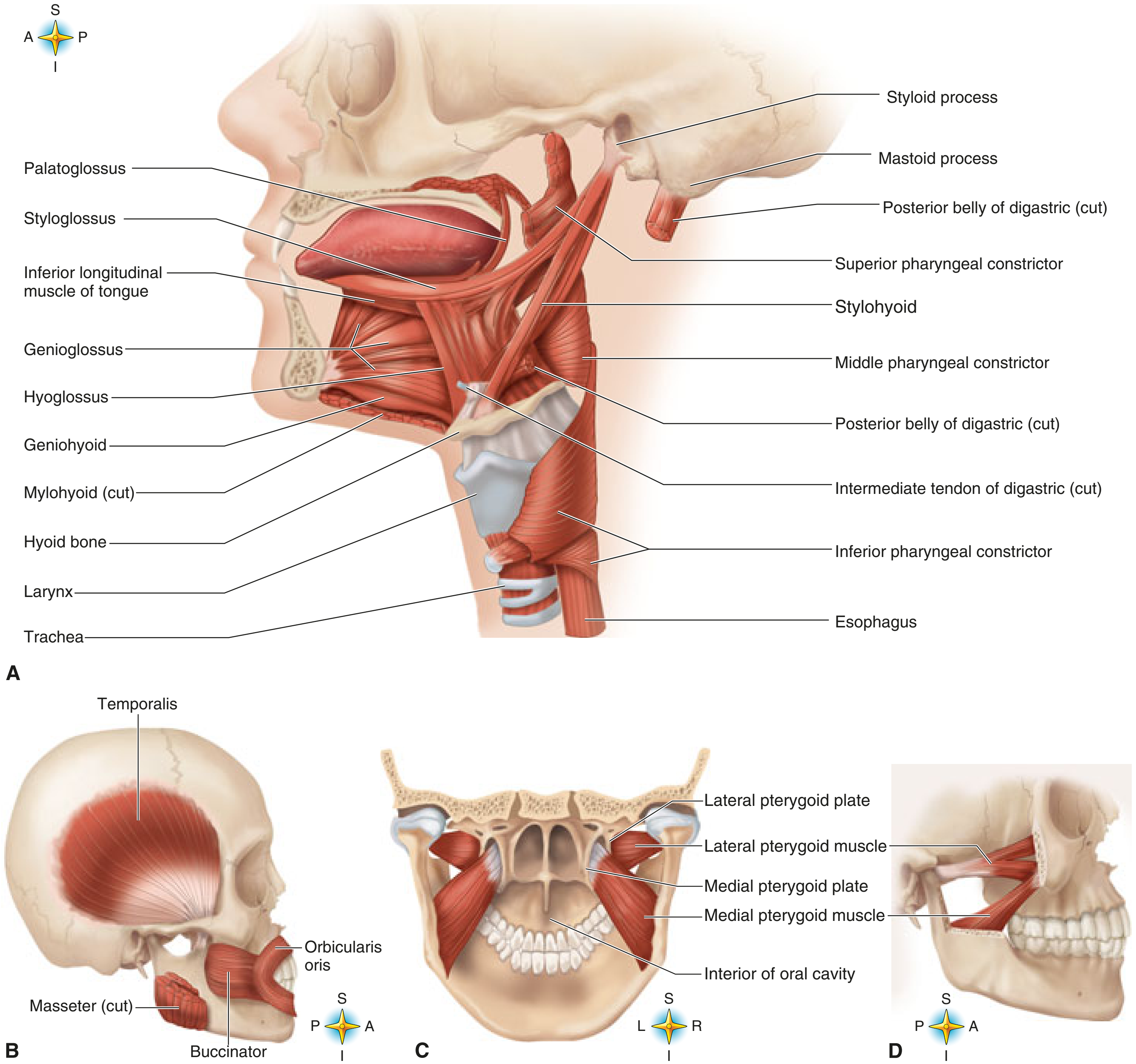

Figure 10-9 ***Muscles of mastication.*** **A,** Muscles of the tongue and pharynx. **B,** Right lateral dissection view showing the insertion of the temporalis muscle on the mandible—the masseter muscle is cut and part of the zygomatic arch has been removed. **C,** Lateral and medial pterygoid muscles viewed from the right side after removal of the zygomatic arch. **D,** View of the pterygoids in a posterior dissection view.

during mastication, and the buccinator muscles play an important function by holding food between the teeth as the mandible moves up and down and from side to side.

Muscles That Move the Head

Paired muscles on either side of the neck are responsible for head movements (Figure 10-10). Note the points of attachment and functions of important muscles in this group listed in Table 10-7. When both **sternocleidomastoid** (STERN-oh-KLYE-doh-MAS-toyd) muscles (see Figure 10-8) contract at the same time, the head is flexed on the thorax—hence the name "prayer muscle." If only one muscle contracts, the head and face are turned to the opposite side. The broad *semispinalis capitis* (sem-ee-spi-NAL-is KAP-i-tis) is an extensor of the head and helps bend it laterally. Acting together, the **splenius capitis** (SPLE-ne-us KAP-i-tis) muscles serve as strong extensors that return the head to the upright po-

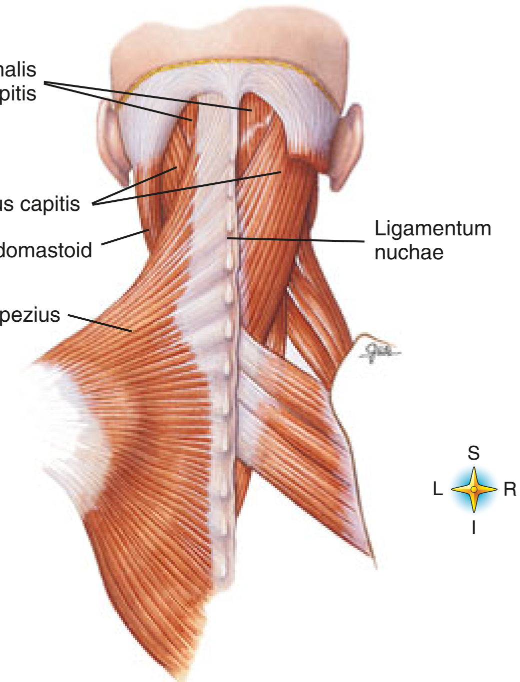

Figure 10-10 ***Muscles that move the head.*** Posterior view of muscles of the neck and the back.

Table 10-7 Muscles That Move the Head

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
Sternocleidomastoid	Sternum	Temporal bone (mastoid process)	Flexes head (prayer muscle)	Accessory nerve
	Clavicle		One muscle alone, rotates head toward opposite side; spasm of this muscle alone or associated with trapezius called *torticollis,* or wryneck	
Semispinalis capitis	Vertebrae (transverse processes of upper six thoracic, articular processes of lower four cervical)	Occipital bone (between superior and inferior nuchal lines)	Extends head; bends it laterally	First five cervical nerves
Splenius capitis	Ligamentum nuchae	Temporal bone (mastoid process)	Extends head	Second, third, and fourth cervical nerves
	Vertebrae (spinous processes of upper three or four thoracic)	Occipital bone	Bends and rotates head toward same side as contracting muscle	
Longissimus capitis	Vertebrae (transverse processes of upper six thoracic, articular processes of lower four cervical)	Temporal bone (mastoid process)	Extends head Bends and rotates head toward contracting side	Multiple innervation

sition after flexion. When either muscle acts alone, contraction results in rotation and tilting toward that side. The bandlike **longissimus capitis** (lon-JIS-i-mus KAP-i-tis) muscles are covered and not visible in Figure 10-10. They run from the neck vertebrae to the mastoid process of the temporal bone on either side and cause extension of the head when acting together. One contracting muscle will bend and rotate the head toward the contracting side.

QUICK CHECK

12. What is meant by the terms *origin* and *insertion?*
13. Which muscle of facial expression has two parts, one lying over the forehead and the other covering the back of the skull?
14. What group of muscles provides chewing movements?
15. What is the action of the sternocleidomastoid muscle?

TRUNK MUSCLES

Muscles of the Thorax

The muscles of the thorax are of critical importance in respiration (discussed in Chapter 24). Note in Figure 10-11 and Table 10-8 that the **internal** and **external intercostal** (IN-ter-KOS-tal) **muscles** attach to the ribs at different places and their fibers are oriented in different directions. As a result, contraction of the external intercostals elevates and contraction of the internal intercostals depresses the ribs—important in the breathing process. During inspiration the dome-shaped **diaphragm** (DYE-ah-fram) flattens, thus increasing the size and volume of the thoracic cavity. As a result, air enters the lungs.

Muscles of the Abdominal Wall

The muscles of the anterior and lateral abdominal wall (Figures 10-12 and 10-13; Table 10-9) are arranged in three layers, with the fibers in each layer running in different directions much like the layers of wood

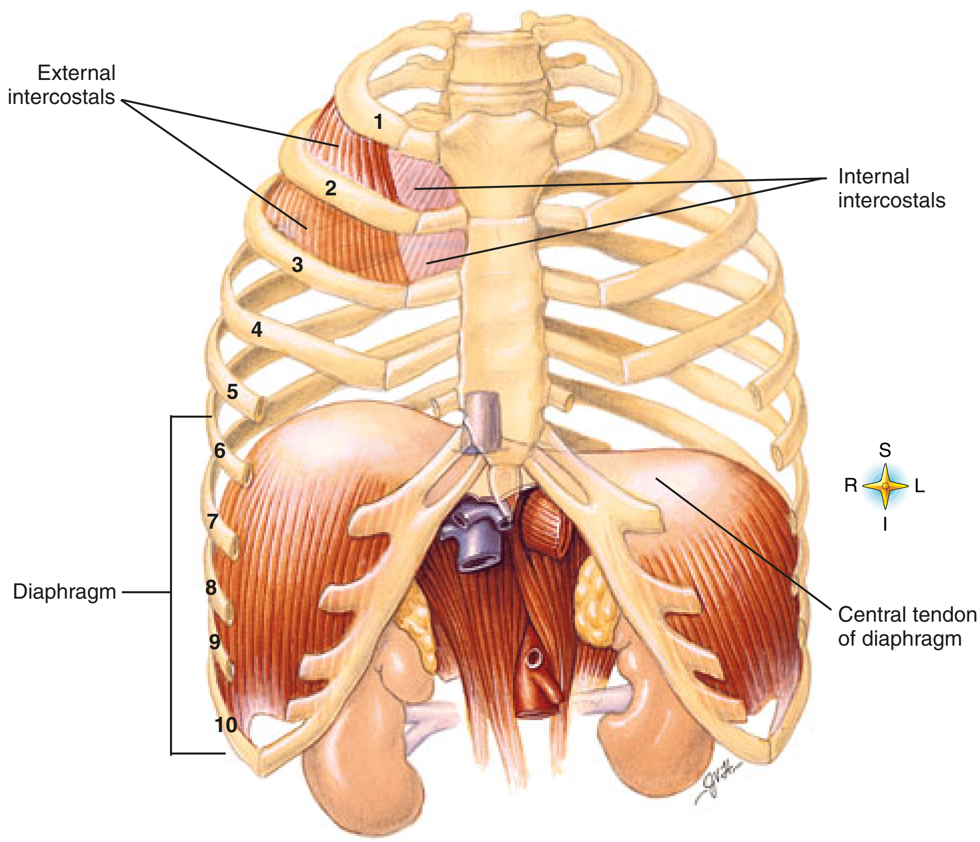

Figure 10-11 ***Muscles of the thorax.*** Anterior view. Note the relationship of the internal and external intercostal muscles and placement of the diaphragm.

Table 10-8 Muscles of the Thorax

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
External intercostals	Rib (lower border; forward fibers)	Rib (upper border of rib below origin)	Elevate ribs	Intercostal nerves
Internal intercostals	Rib (inner surface, lower border; backward fibers)	Rib (upper border of rib below origin)	Depress ribs	Intercostal nerves
Diaphragm	Lower circumference of thorax (of rib cage)	Central tendon of diaphragm	Enlarges thorax, thereby causing inspiration	Phrenic nerves

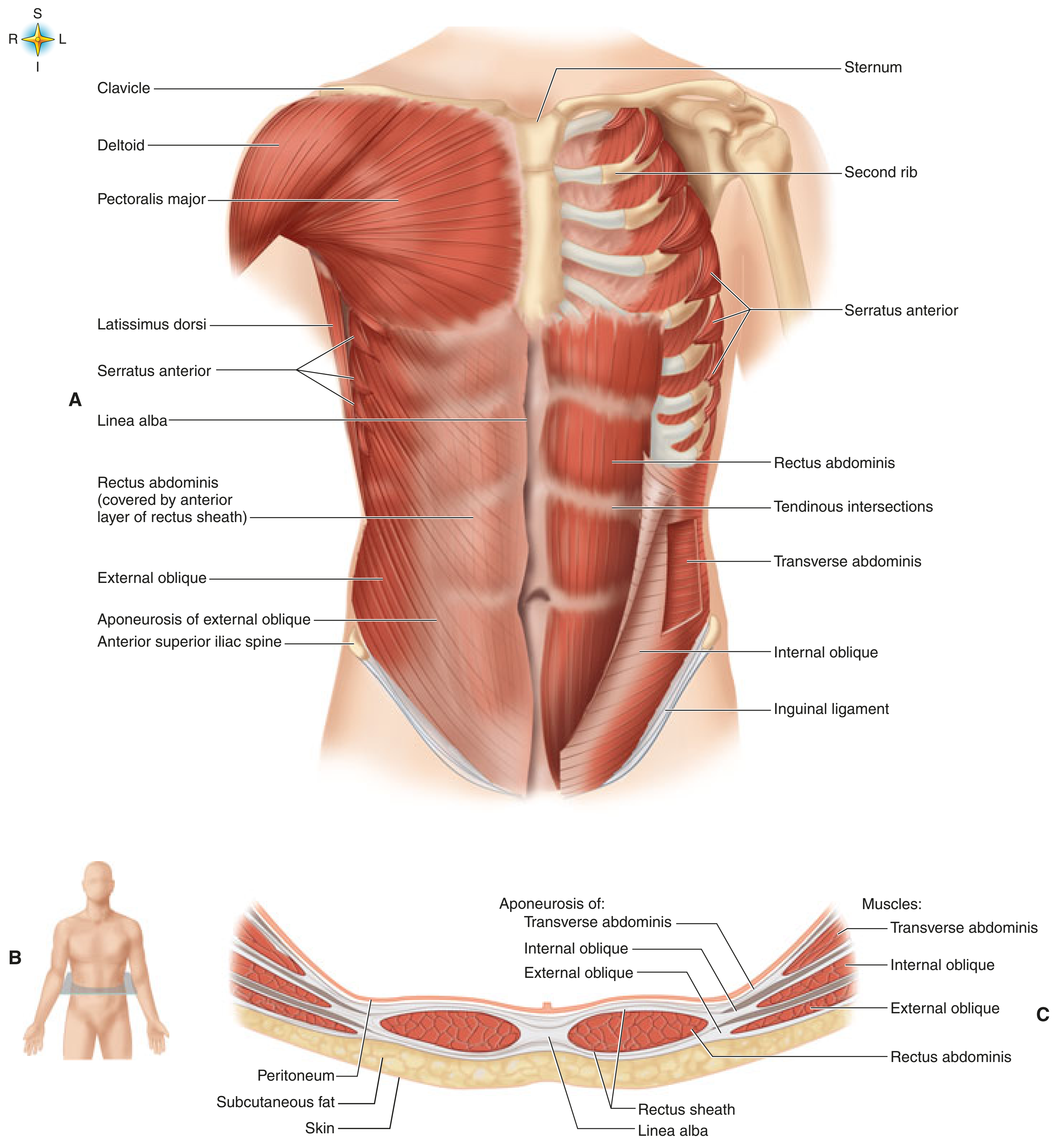

Figure 10-12 ***Muscles of the trunk and abdominal wall.*** **A,** Superficial view. **B,** Deep view. Note that a number of superficial structures have been cut or partially removed. See text for details. **C,** Transverse section of the anterior wall above the umbilicus. See text for details.

Figure 10-13 ***Dissection photo of the abdominal wall.*** The covering rectus sheaths, the left oblique muscles, and part of the left rectus have been removed.

in a sheet of plywood. The result is a very strong "girdle" of muscle that covers and supports the abdominal cavity and its internal organs.

The fibers in the three layers of muscle in the anterolateral wall are arranged to provide maximum strength. In the **external oblique** the muscle fascicles or fibers extend inferiorly and medially, whereas the fibers of the middle muscle layer, the **internal oblique,** run almost at right angles to those of the external oblique above it. The fibers of the **transversus abdominis,** the innermost muscle layer, are, as the name implies, directed transversely. In addition to these sheetlike muscles, the band- or strap-shaped rectus abdominis muscle runs down the midline of the abdomen from the thorax to the pubis. Note in Figure 10-12 that its parallel running fibers are "interrupted" by three tendinous intersections. When a surgeon "opens" or "closes" an incision through the anterolateral wall, attempts are made to maintain the inherent strength of the wall after surgery by sparing important nerves and blood vessels and by using suturing techniques during closure that will restore the direction of fibers in the cut layers of muscle.

In Figure 10-12, *B*, a number of superficial structures have been cut or partially removed. For example, part of the internal oblique has been removed to expose the underlying transversus abdominis, and the anterior (superficial) layer of the **rectus sheath** has been removed to better visualize the rectus abdominis muscle and its tendinous intersections. Note also in Figure 10-12, *C*, that the aponeuroses of the external oblique, internal oblique, and transversus abdominis muscles form the rectus sheaths that cover the rectus abdominis muscles and then fuse in the midline to form a tough band of connective tissue called the **linea alba** (white line), that extends from the xiphoid process to the pubis. Occasionally, a surgical procedure will permit an incision through the linea alba rather than through abdominal musculature. Since the linea alba is essentially avascular in some areas, blood loss in such procedures is generally less than what may occur in other approaches.

Working as a group, the abdominal muscles not only protect and hold the abdominal viscera in place, they are responsible for a number of vertebral column movements, including flexion, lateral bending, and some rotation. These important muscles are also involved in respiration and in helping "push" a baby through the birth canal during delivery. They also play a role in assisting in urination, defecation, and vomiting.

Muscles of the Back

Considering the large number of us who suffer from back pain, strain, and injury either occasionally or chronically, you can imagine the importance of the back muscles to health and fitness. Statistics show that 80% of the population in most areas of the world experience backache at some time in their lives. Although symptoms may vary from mild to disabling, "back problems" continue to plague large numbers of individuals and pose significant financial, social, and health care problems. The superficial back muscles play a major role in moving the head and limbs and are illustrated in Figure 10-14, *A*. The deep back muscles (Figure 10-14, *B*) not only allow us to move our vertebral column, thus helping us bend this way and that, but also stabilize our trunk so that

Table 10-9 Muscles of the Abdominal Wall

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
External oblique	Ribs (lower eight)	Pelvis (iliac crest and pubis by way of the inguinal ligament)	Compresses abdomen	Lower seven intercostal nerves and iliohypogastric nerves
		Linea alba by way of an aponeurosis	Rotates trunk laterally	
Internal oblique	Pelvis (iliac crest and inguinal ligament)	Ribs (lower three)		
	Lumbodorsal fascia	Linea alba	Important postural function of all abdominal muscles is to pull the front of the pelvis upward, thereby flattening the lumbar curve of the spine; when these muscles lose their tone, common figure faults of protruding abdomen and lordosis develop	
Transversus abdominis	Ribs (lower six) Pelvis (iliac crest, inguinal ligament)	Pubic bone Linea alba	Same as external oblique	Last three intercostal nerves; iliohypogastric and ilioinguinal nerves
	Lumbodorsal fascia	Ribs (costal cartilage of fifth, sixth, and seventh ribs)	Same as external oblique	Last five intercostal nerves; iliohypogastric and ilioinguinal nerves
Rectus abdominis	Pelvis (pubic bone and symphysis pubis)	Sternum (xiphoid process)	Same as external oblique; because abdominal muscles compress the abdominal cavity, they aid in straining, defecation, forced expiration, childbirth, etc.; abdominal muscles are antagonists of the diaphragm, relaxing as it contracts and vice versa Flexes trunk	Last six intercostal nerves
Quadratus lumborum	Iliolumbar ligament; iliac crest	Last rib; transverse process of vertebrae (L1-L4)	Flexes vertebral column laterally; depresses last rib	Lumbar

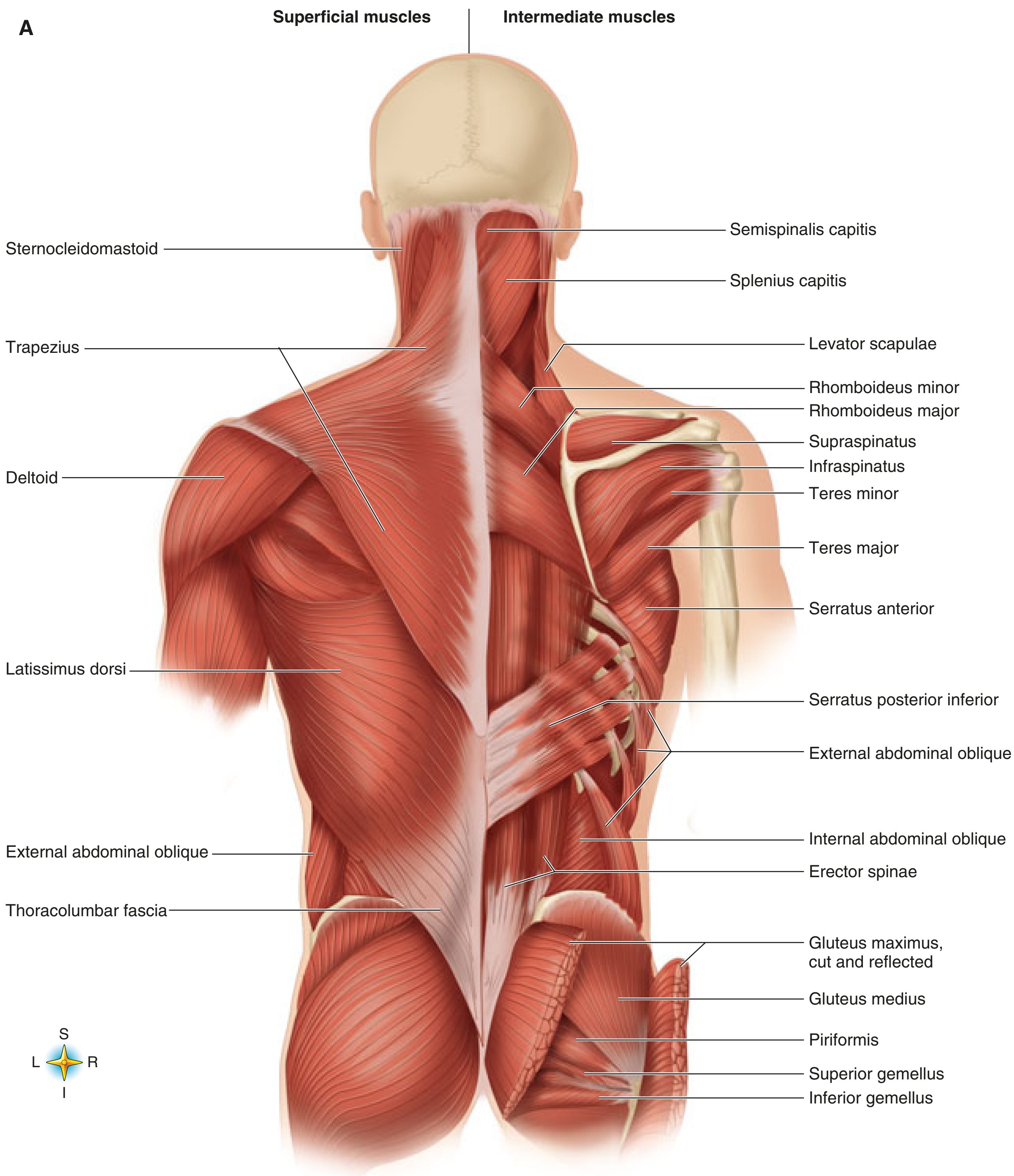

Figure 10-14 ***Muscles of the back.*** **A,** Superficial *(left)* and intermediate *(right)* muscle dissection of the back—posterior view. The illustration shows a two-stage dissection. Superficial muscles of the neck and back are shown on the left side and an intermediate-depth dissection is shown on the right.

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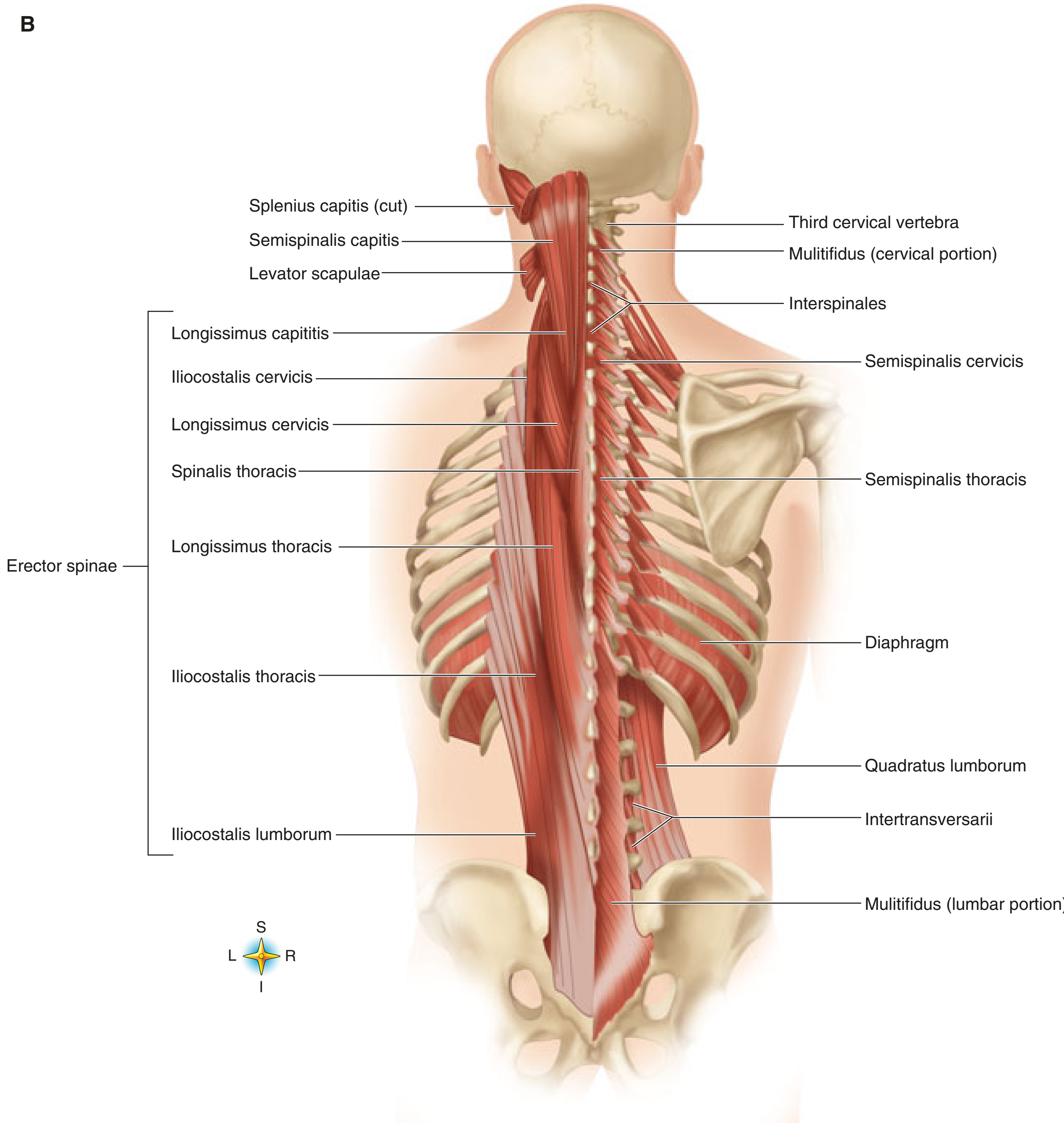


Figure 10-14, cont'd ***Muscles of the back.*** **B,** Deep muscle dissection of the back—posterior view. The superficial and intermediate muscles have been removed. The muscles in the gluteal region have been removed to expose the pelvic insertion of the multifidus.

we can maintain a stable posture. These muscles really get a workout when we lift something heavy because they have to hold the body straight while the load is trying to bend the back.

The **erector spinae** group consists of a number of long, thin muscles that travel all the way down our backs (Figure 10-14). These muscles extend (straighten or pull back) the vertebral column and also flex the back laterally and rotate it a little. Even deeper than the erector spinae muscles are several additional back muscles. The **interspinales** and **multifides groups,** for example, each connect one vertebra to the next; they also help extend the back and neck or flex them to the side. Table 10-10 and Figure 10-14 summarize some of the important deep back muscles.

Muscles of the Pelvic Floor

Structures in the pelvic cavity are supported by a reinforced muscular floor that guards the outlet below. The muscular pelvic floor filling the diamond-shaped outlet is called the **perineum** (pair-ih-NEE-um). Passing through the floor are the anal canal and urethra in both sexes and the vagina in the female.

The two **levator ani** and **coccygeus** muscles form most of the pelvic floor. They stretch across the pelvic cavity like a hammock. This diamond-shaped outlet can be divided into two triangles by a line drawn from side to side between the ischial tuberosities. The **urogenital triangle** is anterior (above) to this line and extends to the symphysis pubis, and the **anal triangle** is posterior (behind it) and ends at the coccyx. Note in Figure 10-15 that structures in the urogenital triangle include the **ischiocavernosus** and **bulbospongiosus** muscles associated with the penis in the male and the vagina in the female. Constriction of muscles called the **sphincter urethrae,** which encircle the urethra in both sexes, helps control urine flow. The anal triangle allows passage of the anal canal. The terminal portion of the canal is surrounded by the **external anal sphincter,** which regulates defecation. The origin, insertion, function, and innervation of important muscles of the pelvic floor are listed in Table 10-11. The coccygeus muscles lie behind the levator ani and are not visible in Figure 10-15.

QUICK CHECK

16. Name the skeletal muscles that produce respiratory movements.
17. Name two functions of the rectus abdominis muscle.
18. What is the perineum?

UPPER LIMB MUSCLES

The muscles of the upper limb include those acting on the shoulder or pectoral girdle and muscles located in the arm, forearm, and hand.

Muscles Acting on the Shoulder Girdle

Attachment of the upper extremity to the torso is by muscles that have an anterior location (chest) or posterior placement (back and neck). Six muscles (Table 10-12; Figure 10-16) that pass from the axial skeleton to the shoulder or pectoral girdle (scapula and

Table 10-10 Muscles of the Back

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
Erector spinae group				
Iliocostalis group	Various regions of the pelvis and ribs	Ribs and vertebra (superior to the origin)	Extends, laterally flexes the vertebral column	Spinal, thoracic, or lumbar nerves
Longissimus group	Cervical and thoracic vertebrae, ribs	Mastoid process, upper cervical vertebrae, or upper lumbar vertebrae	Extends head, neck, or vertebral column	Cervical or thoracic and lumber nerves
Spinalis group	Lower cervical or lower thoracic/upper lumbar vertebrae	Upper cervical or middle/upper thoracic vertebrae (superior to the origin)	Extends the neck or vertebral column	Cervical or thoracic nerves
Transversospinalis group				
Semispinalis group	Transverse processes of vertebrae (T2-T11)	Spinous processes of vertebrae (C2-T4)	Extends neck or vertebral column	Cervical or thoracic nerves
Multifidus group	Transverse processes of vertebrae; sacrum and ilium	Spinous processes of (next superior) vertebrae	Extends, rotates vertebral column	Spinal nerves
Rotatores group	Transverse processes of vertebrae	Spinous processes of (next superior) vertebrae	Extends, rotates vertebral column	Spinal nerves
Splenius	Spinous processes of vertebrae (C7-T1 or T3-T6)	Lateral occipital/mastoid or transverse processes of vertebrae (C1-C4)	Rotates, extends neck and flexes neck laterally	Cervical nerves
Interspinales group	Spinous processes of vertebrae	Spinous processes (of next superior vertebra)	Extends back and neck	Spinal nerves

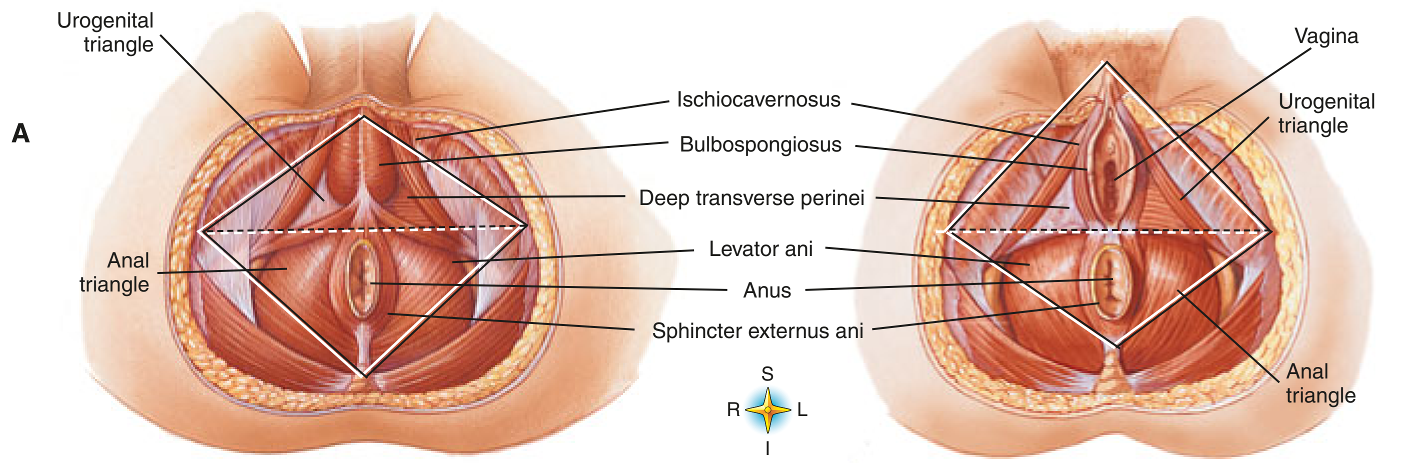


Figure 10-15 ***Muscles of the pelvic floor.*** **A,** Male, inferior view. **B,** Female, inferior view.

Table 10-11 Muscles of the Pelvic Floor

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
Levator ani	Pubis and spine of the ischium	Coccyx	Together with the coccygeus muscles form the floor of the pelvic cavity and support the pelvic organs	Pudendal nerve
Ischiocavernosus	Ischium	Penis or clitoris	Compress the base of the penis or clitoris	Perineal nerve
Bulbospongiosus				
Male	Bulb of the penis	Perineum and bulb of the penis	Constricts the urethra and erects the penis	Pudendal nerve
Female	Perineum	Base of the clitoris	Erects the clitoris	Pudendal nerve
Deep transverse perinei	Ischium	Central tendon (median raphe)	Support the pelvic floor	Pudendal nerve
Sphincter urethrae	Pubic ramus	Central tendon (median raphe)	Constricts the urethra	Pudendal nerve
Sphincter ani externus	Coccyx	Central tendon (median raphe)	Closes the anal canal	Pudendal and S4

clavicle) serve to not only "attach" the upper extremity to the body but do so in such a way that extensive movement is possible. The clavicle can be elevated and depressed and moved forward and back. The scapula is capable of an even greater variety of movements.

The **pectoralis** (pek-toh-RAL-is) **minor** lies under the larger pectoralis major muscle on the anterior chest wall. It helps "fix" the scapula against the thorax and also raises the ribs during forced inspiration. Another anterior chest wall muscle—the **serratus** (ser-RAY-tus) **anterior**—helps hold the scapula against the thorax to prevent "winging" and is a strong abductor that is useful in pushing or punching movements.

The posterior muscles acting on the shoulder girdle include the **levator scapulae** (leh-VAY-tor SCAP-yoo-lee), which elevates the scapula; the **trapezius** (trah-PEE-zee-us), which is used to "shrug" the shoulders; and the **rhomboideus** (rom-BOYD-ee-us) **major** and **minor** muscles, which serve to adduct and elevate the scapula.

Muscles That Move the Upper arm

The shoulder is a synovial joint of the ball-and-socket type. As a result, extensive movement is possible in every plane of motion. Muscles that move the upper part of the arm can be grouped according to function as flexors, extensors, abductors, adductors, and medial and lateral rotators (Table 10-13; Figure 10-17). The actions listed in Table 10-13 include primary actions and important secondary functions.

The **deltoid** (DEL-toyd) is a good example of a multifunction muscle. It has three groups of fibers and may act as three separate muscles. Contraction of the anterior fibers will flex the arm, whereas the lateral fibers abduct and the posterior fibers serve as extensors. Four other muscles serve as both a structural and functional cap or cuff around the shoulder joint and are referred to as the **rotator cuff muscles** (Figure 10-18). They include the **infraspinatus, supraspinatus, subscapularis,** and **teres minor.**

BOX 10-2: SPORTS AND FITNESS

Shoulder Joint Stability

The disparity in size between the large and nearly hemispheric head of the humerus and the much smaller and shallow glenoid cavity of the scapula is of great clinical significance. Because the head of the humerus is more than two times larger than the shallow glenoid concavity that receives it, only about a quarter of the articular surface of the humeral head is in contact with the fossa in any given position of the joint. This anatomical fact helps explain the inherent instability of the shoulder—our most mobile joint. The soft tissues surrounding the shoulder, such as the joint capsule, ligaments, and adjacent muscles, provide the primary restraint against excessive motion and potential dislocation.

Unfortunately, only a thin articular capsule surrounds the shoulder joint. It is extremely loose and does not function to keep the articulating bones of the joint in contact. This fact is obviously correlated with both the great range of motion (ROM) possible at this articulation and its tendency to dislocate as a result of athletic injury or other trauma. The tendons of the supraspinatus, infraspinatus, teres minor, and subscapularis muscles (called the SITS muscles) all blend with and strengthen the articular capsule. The musculotendinous cuff resulting from this fusion is called the rotator cuff (see Figure 10-18). The **rotator cuff** provides the necessary strength to help prevent anterior, superior, and posterior displacement of the humeral head during most types of activity.

Table 10-12 Muscles Acting on the Shoulder Girdle

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
Trapezius	Occipital bone (protuberance)	Clavicle	Raises or lowers the shoulders and shrugs them	Spinal accessory; second, third, and fourth cervical nerves
	Vertebrae (cervical and thoracic)	Scapula (spine and acromion)	Extends the head when the occiput acts as the insertion	
Pectoralis minor	Ribs (second to fifth)	Scapula (coracoid)	Pulls the shoulder down and forward	Medial and lateral anterior thoracic nerves
Serratus anterior	Ribs (upper eight or nine)	Scapula (anterior surface, vertebral border)	Pulls the shoulder down and forward; abducts and rotates it upward	Long thoracic nerve
Levator scapulae	C1-C4 (transverse processes)	Scapula (superior angle)	Elevates and retracts the scapula and abducts the neck	Dorsal scapular nerve
Rhomboid				
Major	T1-T4	Scapula (medial border)	Retracts, rotates, and fixes the scapula	Dorsal scapular nerve
Minor	C6-C7	Scapula (medial border)	Retracts, rotates, elevates, and fixes the scapula	Dorsal scapular nerve

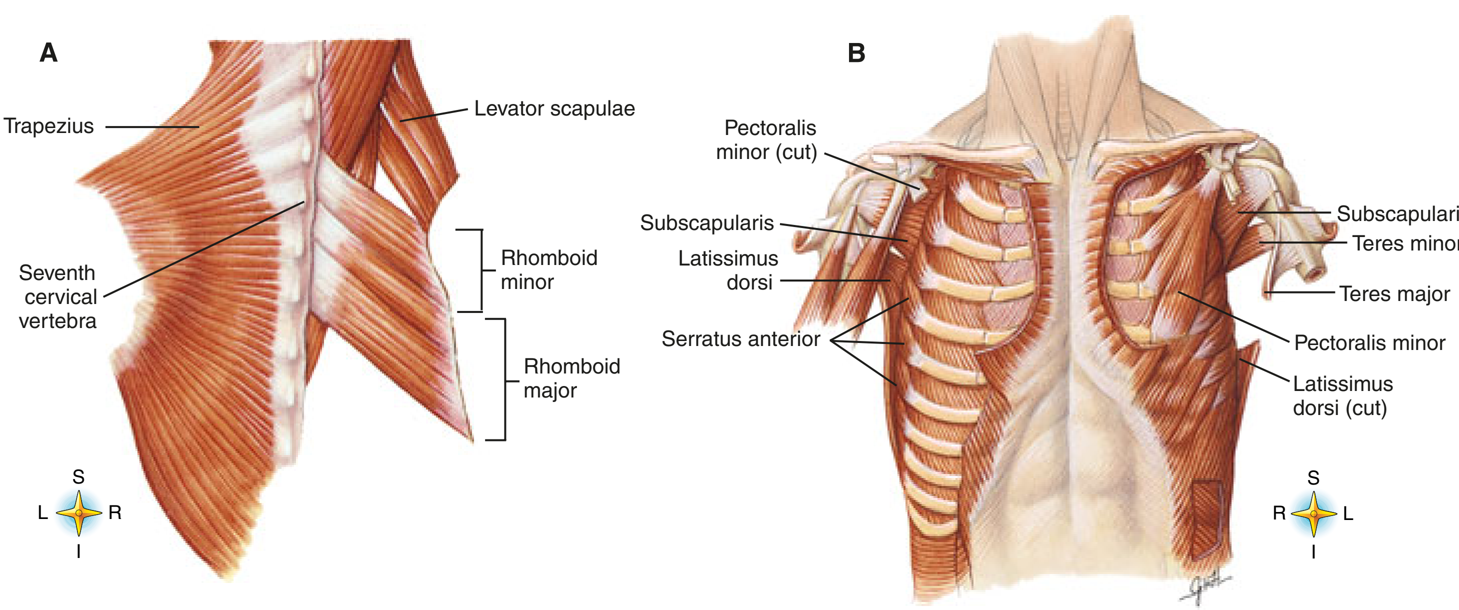


Figure 10-16 ***Muscles acting on the shoulder girdle.*** **A,** Posterior view. The trapezius has been removed on the right to reveal the deeper muscles. **B,** Anterior view. The pectoralis major has been removed on both sides. The pectoralis minor has also been removed on the right side.

Table 10-13 Muscles That Move the Upper Arm

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
Axial*				
Pectoralis major	Clavicle (medial half) Sternum Costal cartilages of the true ribs	Humerus (greater tubercle)	Flexes the upper arm Adducts the upper arm anteriorly; draws it across the chest	Medial and lateral anterior thoracic nerves
Latissimus dorsi	Vertebrae (spines of the lower thoracic, lumbar, and sacral) Ilium (crest) Lumbodorsal fascia	Humerus (intertubercular groove)	Extends the upper arm Adducts the upper arm posteriorly	Thoracodorsal nerve
Scapular*				
Deltoid	Clavicle Scapula (spine and acromion)	Humerus (lateral side about half-way down—deltoid tubercle)	Abducts the upper arm Assists in flexion and extension of the upper arm	Axillary nerve
Coracobrachialis	Scapula (coracoid process)	Humerus (middle third, medial surface)	Adduction; assists in flexion and medial rotation of the arm	Musculocutaneous nerve
Supraspinatus†	Scapula (supraspinous fossa)	Humerus (greater tubercle)	Assists in abducting the arm	Suprascapular nerve
Teres minor†	Scapula (axillary border)	Humerus (greater tubercle)	Rotates the arm outward	Axillary nerve
Teres major	Scapula (lower part, axillary border)	Humerus (upper part, anterior surface)	Assists in extension, adduction, and medial rotation of the arm	Lower subscapular nerve
Infraspinatus†	Scapula (infraspinatus border)	Humerus (greater tubercle)	Rotates the arm outward	Suprascapular nerve
Subscapularis†	Scapula (subscapular fossa)	Humerus (lesser tubercle)	Medial rotation	Suprascapular nerve

**Axial* muscles originate on the axial skeleton. *Scapular* muscles originate on the scapula.
†Muscles of the rotator cuff.

Muscles That Move the Forearm

Selected superficial and deep muscles of the upper extremity are shown in Figures 10-19 and 10-20. Recall that most muscles acting on a joint lie proximal to that joint. Muscles acting directly on the forearm, therefore, are found proximal to the elbow and attach the bones of the forearm (ulna and radius) to the humerus or scapula above. Table 10-14 lists the muscles acting on the lower part of the arm and gives the origin, insertion, function, and innervation of each. Figure 10-21 shows the detail of attachment of several important muscles in this group.

Muscles That Move the Wrist, Hand, and Fingers

Muscles that move the wrist, hand, and fingers can be **extrinsic muscles** or **intrinsic muscles.** The term *extrinsic* means *from the outside* and refers to muscles originating outside of the part of the skeleton moved. Extrinsic muscles originating in the forearm can pull on their insertions in the wrist, hand, and fingers to move them. The term *intrinsic*, meaning *from within*, refers to muscles that are actually within the part moved. Muscles that begin and end at different points within the hand can produce fine finger movements, for example.

Extrinsic muscles acting on the wrist, hand, and fingers are located on the anterior or the posterior surfaces of the forearm (Figure 10-22). In most instances, the muscles located on the anterior surface of the forearm are flexors and those on the posterior surface are extensors of the wrist, hand, and fingers (Table 10-15).

A number of intrinsic muscles are responsible for precise movements of the hand and fingers. Examples include the **lumbrical** (LUM-brik-al) and **interosseous** (in-ter-OSS-ee-us) muscles, which originate from and fill the spaces between the metacarpal bones and then insert on the phalanges of the fingers.

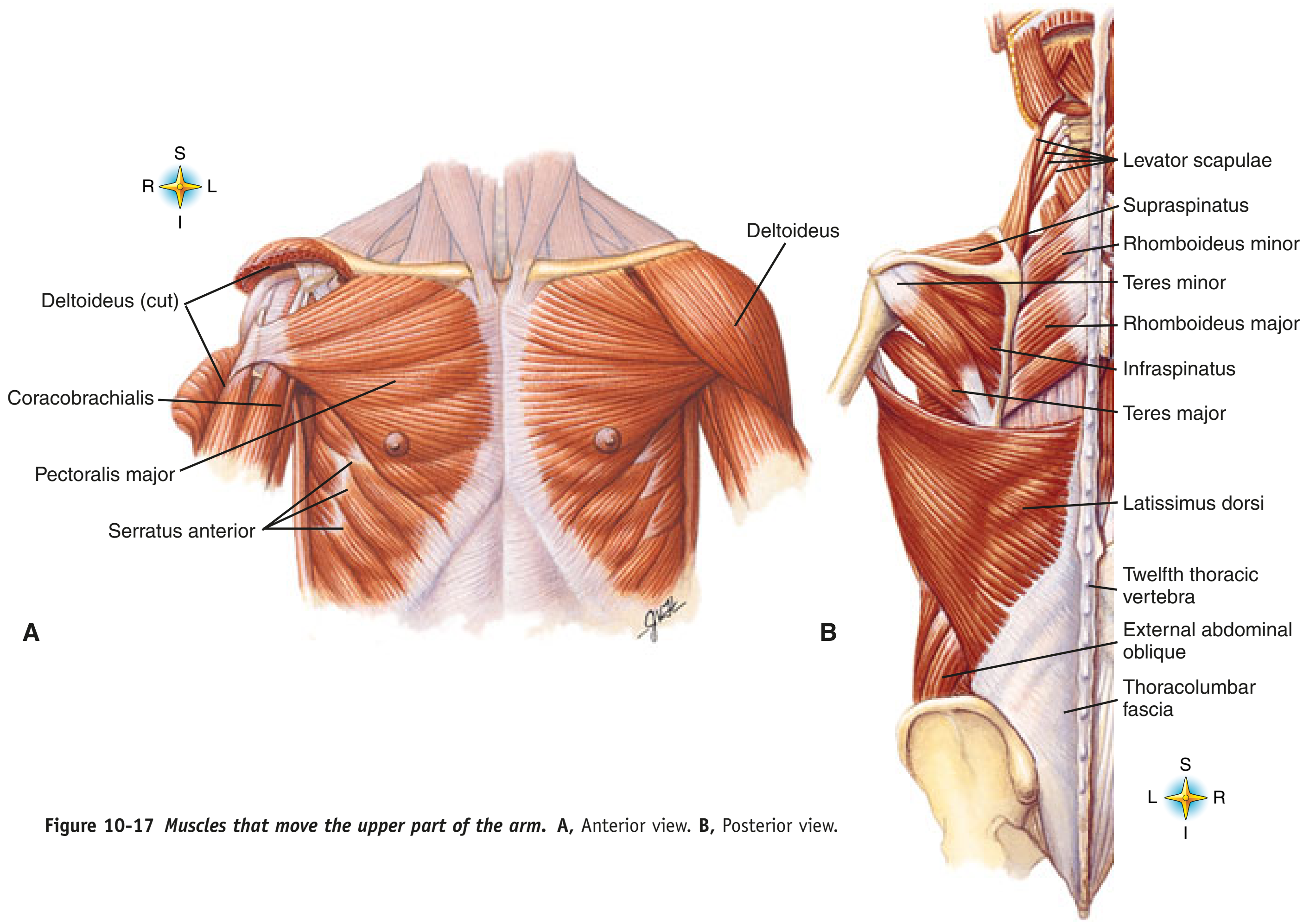


Figure 10-17 ***Muscles that move the upper part of the arm.*** **A,** Anterior view. **B,** Posterior view.

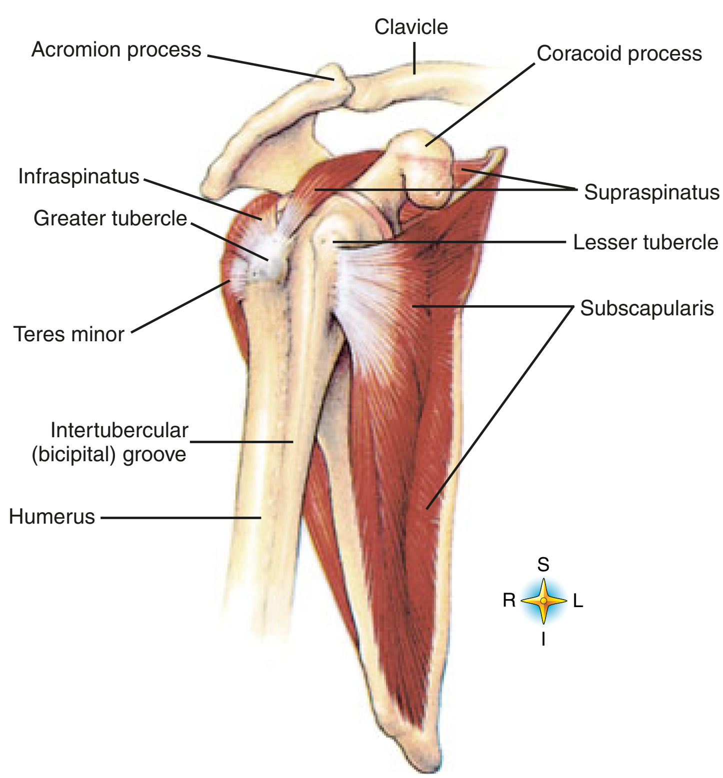


Figure 10-18 ***Rotator cuff muscles.*** Note the tendons of the teres minor, infraspinatus, supraspinatus, and subscapularis muscles surrounding the head of the humerus.

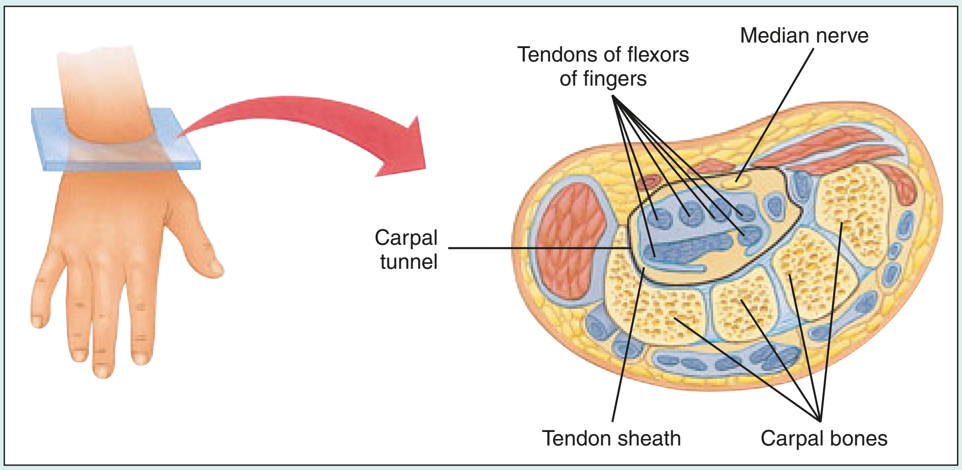
BOX 10-3: HEALTH MATTERS

Carpal Tunnel Syndrome

Some epidemiologists specialize in the field of occupational health, the study of health matters related to work or the workplace. Many problems seen by occupational health experts are caused by repetitive motions of the wrists or other joints. Word processors (typists) and meat cutters, for example, are at risk for conditions caused by repetitive motion injuries.

One common problem often caused by such repetitive motion is **tenosynovitis** (ten-oh-sin-oh-VYE-tis)—inflammation of a tendon sheath. Tenosynovitis can be painful, and the swelling characteristic of this condition can limit movement in affected parts of the body. For example, swelling of the tendon sheath around tendons in an area of the wrist known as the *carpal tunnel* can limit movement of the wrist, hand, and fingers. The figure shows the relative positions of the tendon sheath and median nerve within the carpal tunnel. If this swelling, or any other lesion in the carpal tunnel, presses on the *median nerve,* a condition called **carpal tunnel syndrome** may result. Because the median nerve connects to the palm and radial side (thumb side) of the hand, carpal tunnel syndrome is characterized by weakness, pain, and tingling in this part of the hand. The pain and tingling may also radiate to the forearm and shoulder. Prolonged or severe cases of carpal tunnel syndrome may be relieved by injection of anti-inflammatory agents. A permanent cure is sometimes accomplished by surgical cutting or removal of the swollen tissue pressing on the median nerve.

The procedure called carpal tunnel release is the most common hand operation in the United States. First introduced in 1933 as an "open" surgical procedure, it is now performed more than 200,000 times every year. A less invasive endoscopic approach was introduced in 1989 and many other innovative surgical techniques and advances are now being used.



The carpal tunnel. The median nerve and muscles that flex the fingers pass through a concavity in the wrist called the carpal tunnel.

As a group, the intrinsic muscles abduct and adduct the fingers and aid in flexing them. Eight additional muscles serve the thumb and enable it to be placed in opposition to the fingers in tasks requiring grasping and manipulation. The **opponens pollicis** (oh-POH-nenz POL-i-cis) is a particularly important thumb muscle. It allows the thumb to be drawn across the palm to touch the tip of any finger—a critical movement for many manipulative-type activities. Figure 10-23 shows the placement and points of attachment for various individual extrinsic muscles acting on the wrist, hand, and fingers. Figure 10-24 provides a detailed illustration of many of the intrinsic muscles of the hand.

QUICK CHECK

19. What are the functions of the deltoid muscle?
20. What is the function of the biceps brachii muscle?
21. Distinguish the extrinsic from the intrinsic muscles of the hand and wrist.

LOWER LIMB MUSCLES

The musculature, bony structure, and joints of the pelvic girdle and lower extremity function in locomotion and maintenance of stability. Powerful muscles at the back of the hip, at the front of the thigh, and at the back of the leg also serve to raise the full body weight from a sitting to a standing position. The muscles of the lower limb include those acting on the hip or pelvic girdle, as well as muscles located in the thigh, leg, and foot. Unlike the highly mobile shoulder girdle, the pelvic girdle is essentially fixed. Therefore, our study of muscles in the lower extremity begins with those arising from the pelvic girdle and passing to the femur; they produce their effects at the hip joint by moving the thigh.

Muscles That Move the Thigh and Lower leg

Table 10-16 identifies muscles that move the thigh and lists the origin, insertion, function, and nerve supply of each (Figure 10-25). Refer to Figures 10-5 and 10-6 and Figures 10-25 through 10-29, which show individual muscles, as you study the information provided in the table. Muscles acting on the thigh can be divided into

Text continued on p. 383

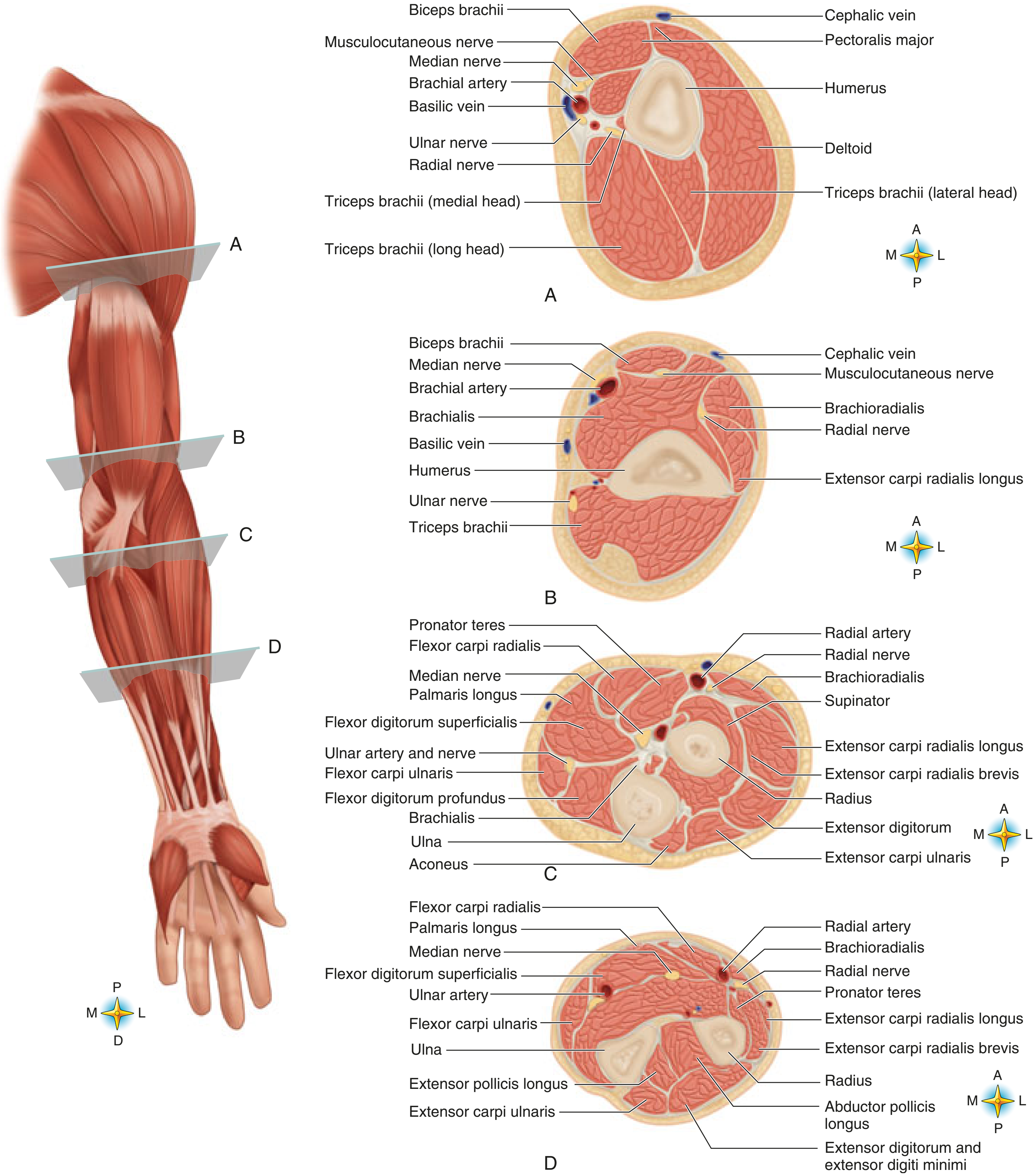


Figure 10-19 ***Cross sections (proximal to distal) through the upper extremity.*** **A,** Section at the junction of the proximal and middle thirds of the humerus. **B,** Section just proximal to the medial epicondyle of the humerus. **C,** Section at the level of the radial tuberosity. **D,** Section at the middle of the forearm. In each section you are viewing the superior (proximal) aspect of the specimen.

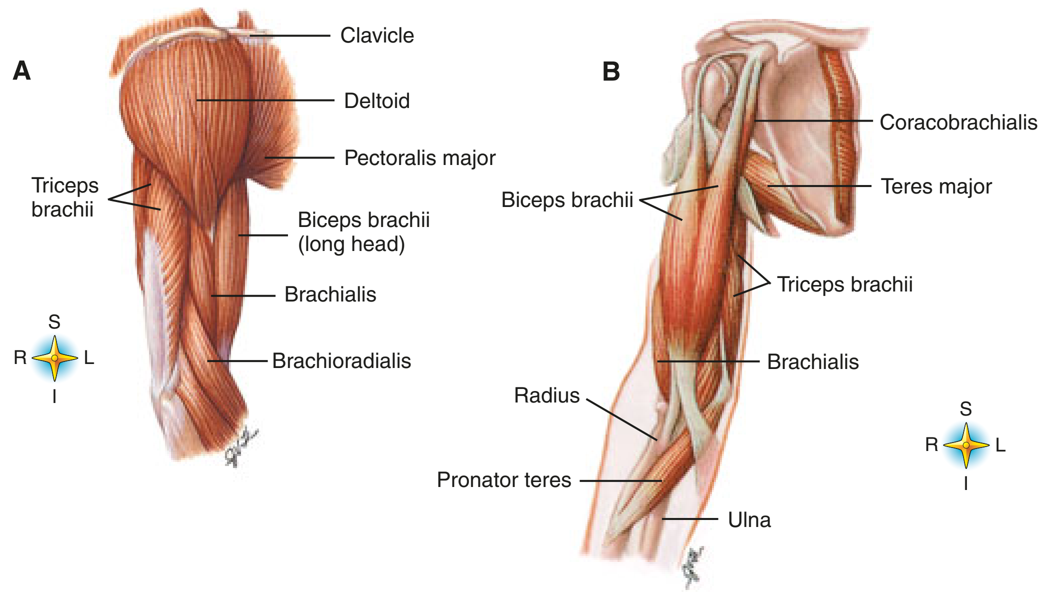


Figure 10-20 ***Muscles acting on the forearm.*** **A,** Lateral view of the right shoulder and arm. **B,** Anterior view of the right shoulder and arm (deep). The deltoid and pectoralis major muscles have been removed to reveal deeper structures.

Table 10-14 Muscles That Move the Forearm

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
Flexors				
Biceps brachii	Scapula (supraglenoid tuberosity) Scapula (coracoid)	Radius (tubercle at the proximal end)	Flexes the supinated forearm Supinates the forearm and hand	Musculocutaneous nerve
Brachialis	Humerus (distal half, anterior surface)	Ulna (front of the coronoid process)	Flexes the pronated forearm	Musculocutaneous nerve
Brachioradialis	Humerus (above the lateral epicondyle)	Radius (styloid process)	Flexes the semipronated or semisupinated forearm; supinates the forearm and hand	Radial nerve
Extensor				
Triceps brachii	Scapula (infraglenoid tuberosity) Humerus (posterior surface—lateral head above the radial groove; medial head, below)	Ulna (olecranon process)	Extends the lower arm	Radial nerve
Pronators				
Pronator teres	Humerus (medial epicondyle) Ulna (coronoid process)	Radius (middle third of the lateral surface)	Pronates and flexes the forearm	Median nerve
Pronator quadratus	Ulna (distal fourth, anterior surface)	Radius (distal fourth, anterior surface)	Pronates the forearm	Median nerve
Supinator				
Supinator	Humerus (lateral epicondyle) Ulna (proximal fifth)	Radius (proximal third)	Supinates the forearm	Radial nerve

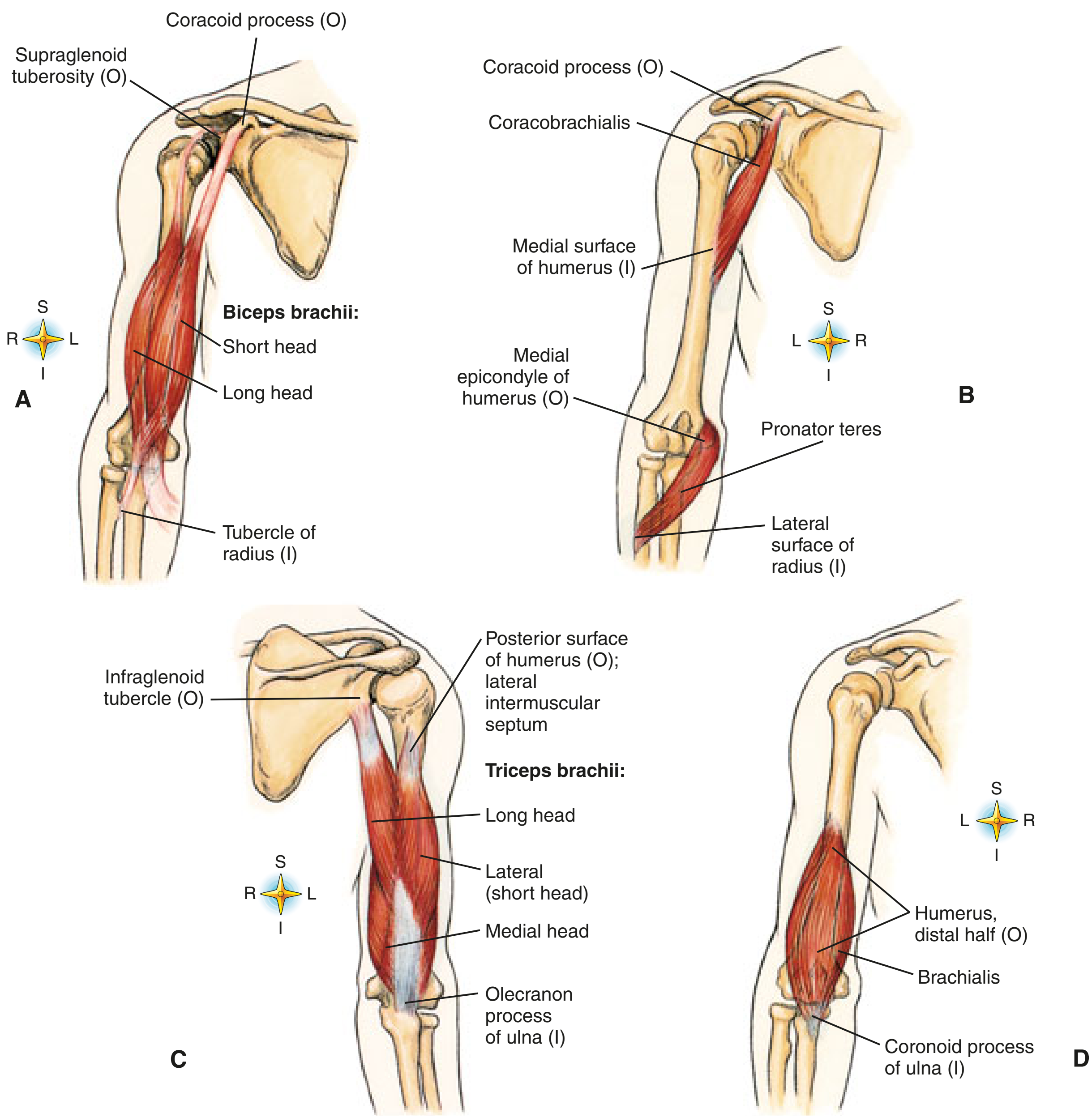


Figure 10-21 ***Muscles acting on the forearm.*** **A,** Biceps brachii. **B,** Triceps brachii. **C,** Coracobrachialis and pronator teres. **D,** Brachialis. *O,* Origin; *I,* insertion.

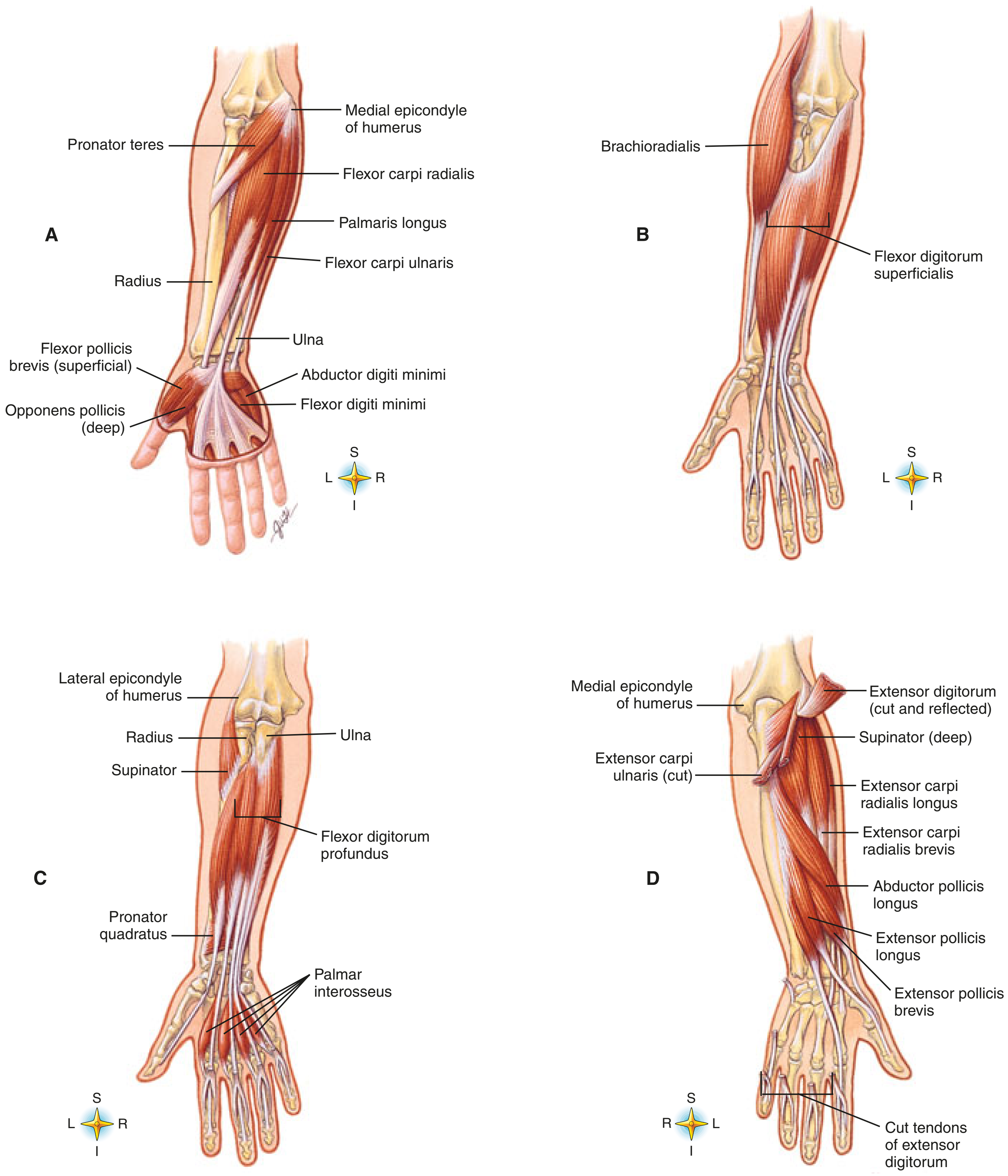


Figure 10-22 ***Muscles of the forearm.*** **A,** Anterior view showing the right forearm (superficial). The brachioradialis muscle has been removed. **B,** Anterior view showing the right forearm (deeper than *A*). The pronator teres, flexor carpi radialis and ulnaris, and palmaris longus muscles have been removed. **C,** Anterior view showing the right forearm (deeper than *A* or *B*). The brachioradialis, pronator teres, flexor carpi radialis and ulnaris, palmaris longus, and flexor digitorum superficialis muscles have been removed. **D,** Posterior view showing the deep muscles of the right forearm. The extensor digitorum, extensor digiti minimi, and extensor carpi ulnaris muscles have been cut to reveal deeper muscles.

Table 10-15 Muscles That Move the Wrist, Hand, and Fingers

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
Extrinsic				
Flexor carpi radialis	Humerus (medial epicondyle)	Second metacarpal (base of)	Flexes the hand Flexes the forearm	Median nerve
Palmaris longus	Humerus (medial epicondyle)	Fascia of the palm	Flexes the hand	Median nerve
Flexor carpi ulnaris	Humerus (medial epicondyle) Ulna (proximal two thirds)	Pisiform bone Third, fourth, and fifth metacarpals	Flexes the hand Adducts the hand	Ulnar nerve
Extensor carpi radialis longus	Humerus (ridge above the lateral epicondyle)	Second metacarpal (base of)	Extends the hand Abducts the hand (moves toward the thumb side when the hand is supinated)	Radial nerve
Extensor carpi radialis brevis	Humerus (lateral epicondyle)	Second, third metacarpals (bases of)	Extends the hand	Radial nerve
Extensor carpi ulnaris	Humerus (lateral epicondyle) Ulna (proximal three fourths)	Fifth metacarpal (base of)	Extends the hand Adducts the hand (moves toward the little finger side when the hand is supinated)	Radial nerve
Flexor digitorum profundus	Ulna (anterior surface)	Distal phalanges (fingers 2 to 5)	Flexes the distal interphalangeal joints	Median and ulnar nerves
Flexor digitorum superficialis	Humerus (medial epicondyle) Radius Ulna (coronoid process)	Tendons of the fingers	Flexes the fingers	Median nerve
Extensor digitorum	Humerus (lateral epicondyle)	Phalanges (fingers 2 to 5)	Extends the fingers	Radial nerve
Intrinsic				
Opponens pollicis	Trapezium	Thumb metacarpal	Opposes the thumb to the fingers	Median nerve
Abductor pollicis brevis	Trapezium	Proximal phalanx of the thumb	Abducts the thumb	Median nerve
Adductor pollicis	Second and third metacarpals Trapezoid Capitate	Proximal phalanx of the thumb	Adducts the thumb	Ulnar nerve
Flexor pollicis brevis	Flexor retinaculum	Proximal phalanx of the thumb	Flexes the thumb	Median and ulnar nerves
Abductor digiti minimi	Pisiform	Proximal phalanx of the fifth finger (base of)	Abducts the fifth finger Flexes the fifth finger	Ulnar nerve
Flexor digiti minimi brevis	Hamate	Proximal and middle phalanx of the fifth finger	Flexes the fifth finger	Ulnar nerve
Opponens digiti minimi	Hamate Flexor retinaculum	Fifth metacarpal	Opposes the fifth finger slightly	Ulnar nerve
Interosseous (palmar and dorsal)	Metacarpals	Proximal phalanges	Adducts the second, fourth, and fifth fingers (palmar) Abducts the second, third, and fourth fingers (dorsal)	Ulnar nerve
Lumbricales	Tendons of the flexor digitorum profundus	Phalanges (2 to 5)	Flexes the proximal phalanges (2 to 5) Extends the middle and distal phalanges (2 to 5)	Median nerve (phalanges 2 and 3) Ulnar nerve (phalanges 4 and 5)

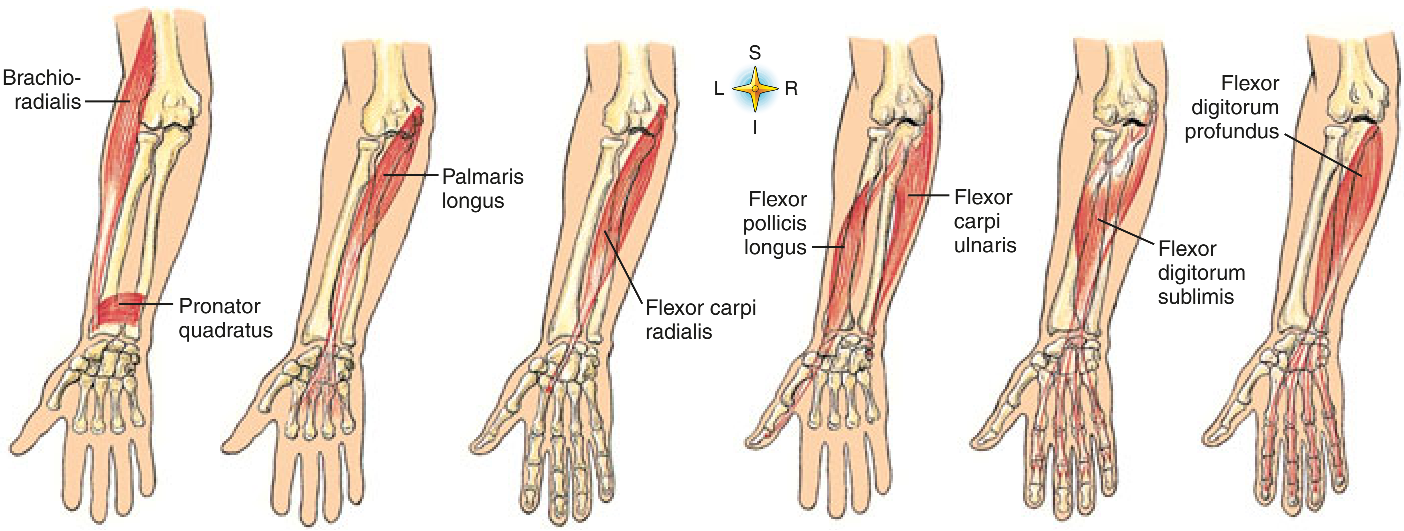


Figure 10-23 ***Some muscles of the anterior aspect of the right forearm.***

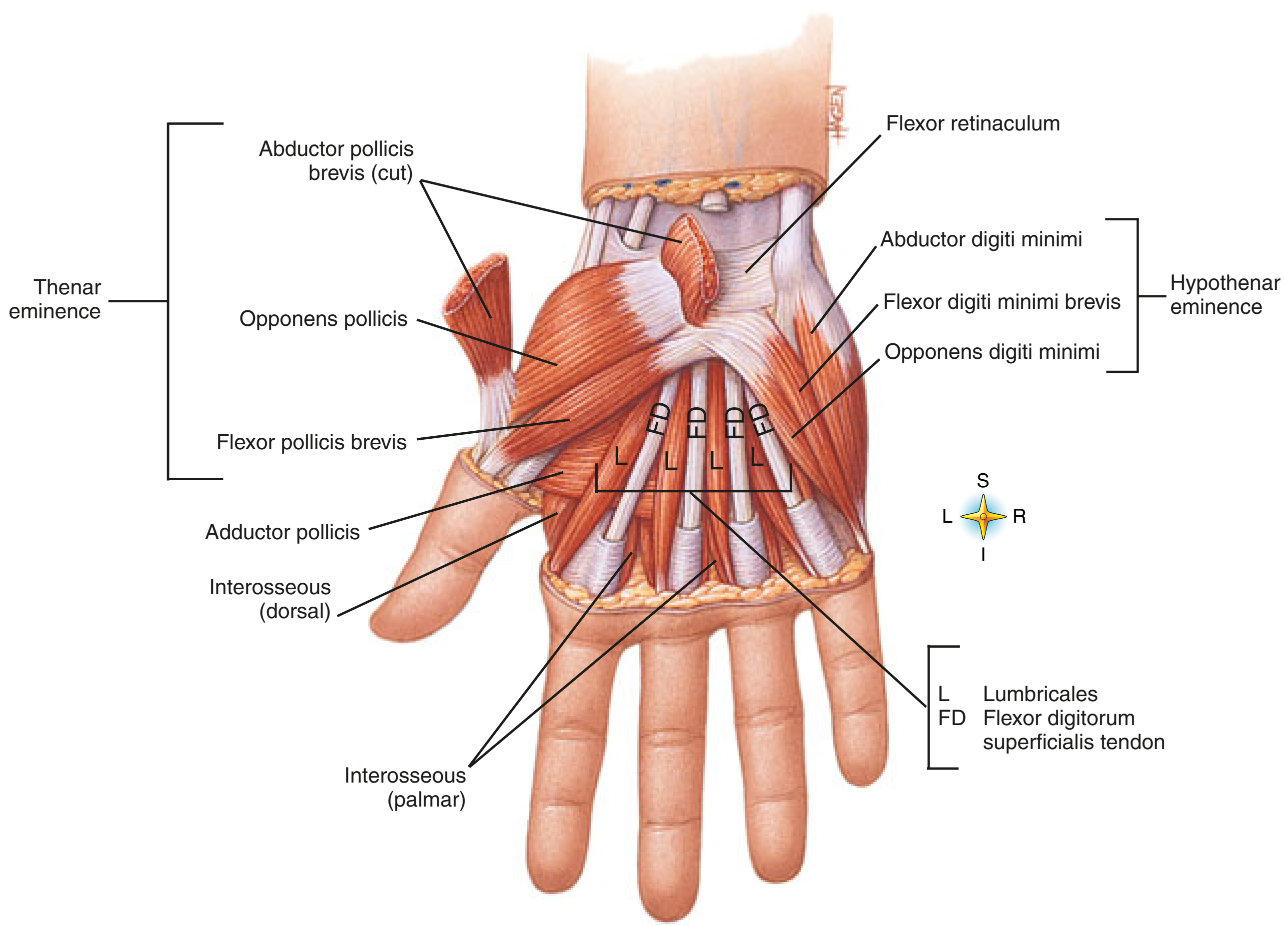


Figure 10-24 ***Intrinsic muscles of the hand—anterior (palmar) view.***

Table 10-16 Muscles That Move the Thigh

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
Iliopsoas (iliacus, psoas major, and psoas minor)	Ilium (iliac fossa)	Femur (lesser trochanter)	Flexes the thigh	Femoral and second to fourth lumbar nerves
	Vertebrae (bodies of twelfth thoracic to fifth lumbar)		Flexes the trunk (when the femur acts as the origin)	
Rectus femoris	Ilium (anterior, inferior spine)	Tibia (by way of the patellar tendon)	Flexes the thigh Extends the lower leg	Femoral nerve
Gluteal group				
Maximus	Ilium (crest and posterior surface) Sacrum and coccyx (posterior surface) Sacrotuberous ligament	Femur (gluteal tuberosity) Iliotibial tract	Extends the thigh—rotates outward	Inferior gluteal nerve
Medius	Ilium (lateral surface)	Femur (greater trochanter)	Abducts the thigh—rotates outward; stabilizes the pelvis on the femur	Superior gluteal nerve
Minimus	Ilium (lateral surface)	Femur (greater trochanter)	Abducts the thigh; stabilizes the pelvis on the femur Rotates the thigh medially	Superior gluteal nerve
Tensor fasciae latae	Ilium (anterior part of the crest)	Tibia (by way of the iliotibial tract)	Abducts the thigh Tightens the iliotibial tract	Superior gluteal nerve
Adductor group				
Brevis	Pubic bone	Femur (linea aspera)	Adducts the thigh	Obturator nerve
Longus	Pubic bone	Femur (linea aspera)	Adducts the thigh	Obturator nerve
Magnus	Pubic bone	Femur (linea aspera)	Adducts the thigh	Obturator nerve
Gracilis	Pubic bone (just below the symphysis)	Tibia (medial surface behind the sartorius)	Adducts the thigh and flexes and adducts the leg	Obturator nerve

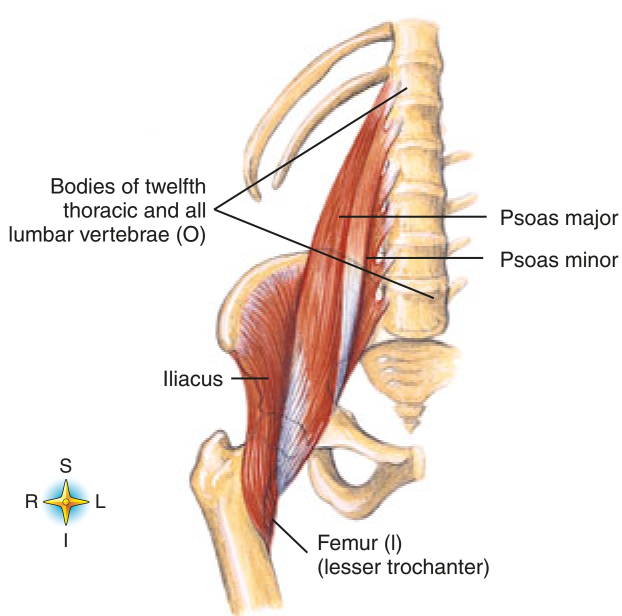


Figure 10-25 ***Iliopsoas muscle (iliacus, psoas major, and psoas minor muscles).*** *O,* Origin; *I,* insertion.

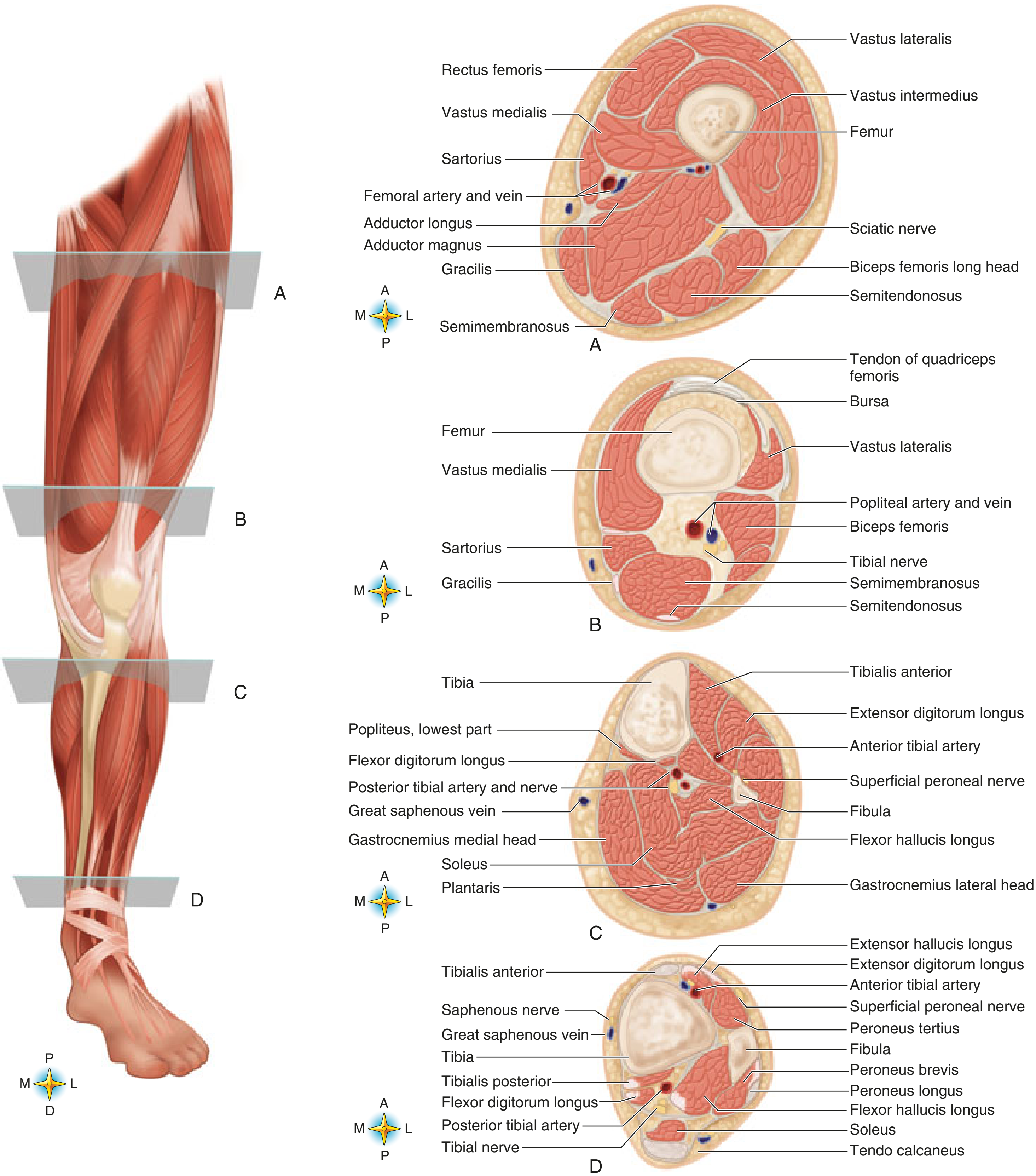


Figure 10-26 ***Cross sections (proximal to distal) through the lower extremity.*** **A,** Section through the middle of the femur. **B,** Section about 4 cm above the adductor tubercle of the femur. **C,** Section about 10 cm distal to the knee joint. **D,** Section about 6 cm above the medial malleolus. In each section you are viewing the superior (proximal) aspect of the specimen.

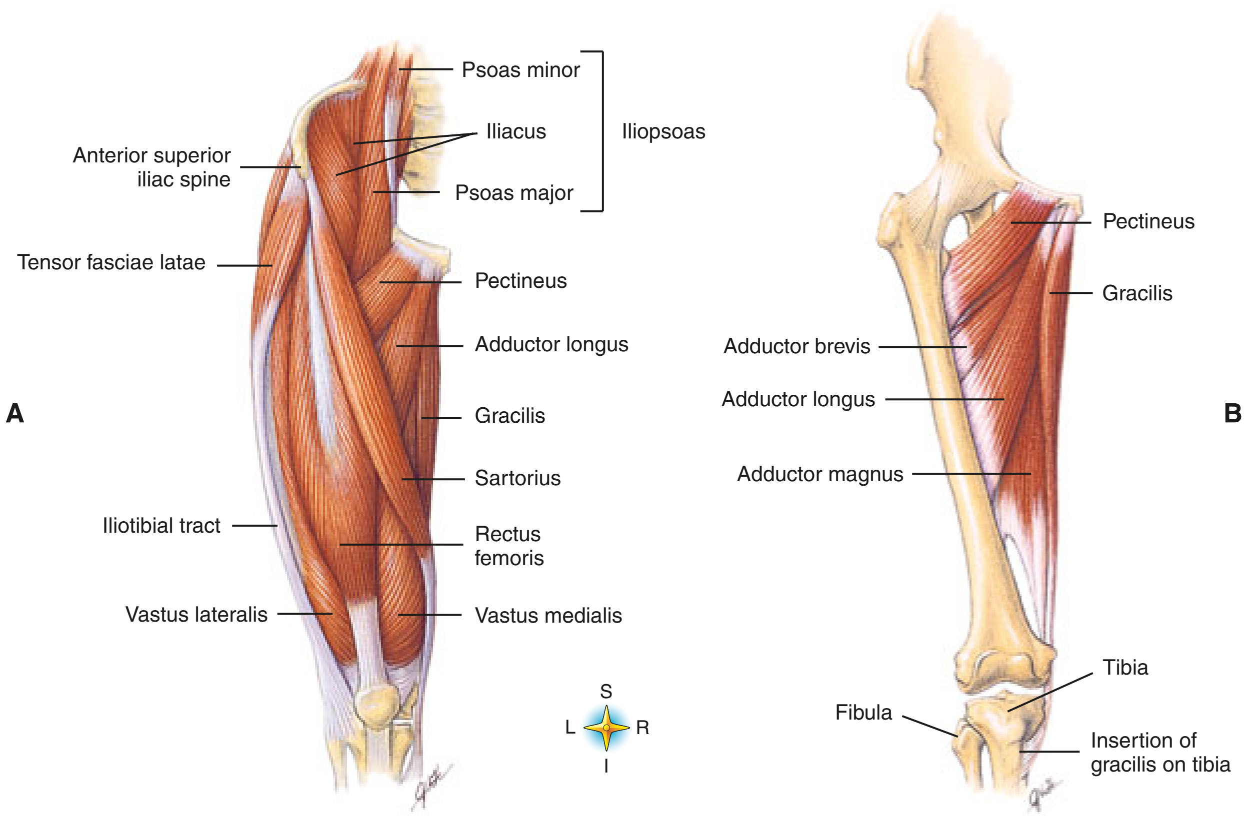


Figure 10-27 ***Muscles of the anterior aspect of the thigh.*** **A,** Anterior view of the right thigh. **B,** Adductor region of the right thigh. The tensor fasciae latae, sartorius, and quadriceps muscles have been removed.

three groups: (1) muscles crossing the front of the hip, (2) the three **gluteal** (GLOO-tee-al) muscles, and the **tensor fasciae latae** (TEN-sor FASH-ee LAT-tee), and (3) the thigh adductors.

Table 10-17 identifies muscles that move the lower part of the leg. Again, see Figures 10-5 and 10-6 and refer to Figures 10-30 and 10-31 as you study the table.

Muscles That Move the Ankle and Foot

The muscles listed in Table 10-18 and shown in Figure 10-32 are responsible for movements of the ankle and foot. These muscles, called **extrinsic foot muscles,** are located in the leg but exert their actions by pulling on tendons that insert on bones in the ankle and foot. Extrinsic foot muscles are responsible for such movements as dorsiflexion, plantar flexion, inversion, and eversion of the foot. Muscles located within the foot itself are called **intrinsic foot muscles** (Figure 10-33). They are responsible for flexion, extension, abduction, and adduction of the toes.

The extrinsic muscles listed in Table 10-18 may be divided into four functional groups: (1) dorsal flexors, (2) plantar flexors, (3) invertors, and (4) evertors of the foot.

The superficial muscles located on the posterior surface of the leg form the bulging "calf." The common tendon of the **gastrocnemius** (GAS-trok-NEE-mee-us) and **soleus** is called the **calcaneal,** or *Achilles,* **tendon.** It inserts into the calcaneus, or heel bone. By acting together, these muscles serve as powerful flexors (plantar flexion) of the foot.

Dorsal flexors of the foot, located on the anterior surface of the leg, include the **tibialis** (tib-ee-AL-is) **anterior, peroneus tertius** (per-o-NEE-us TER-shus), and **extensor digitorum longus.** In addition to functioning as a dorsiflexor of the foot the extensor digitorum longus also everts the foot and extends the toes.

QUICK CHECK

22. Name the three gluteal muscles.
23. What is the function of the gastrocnemius muscle?

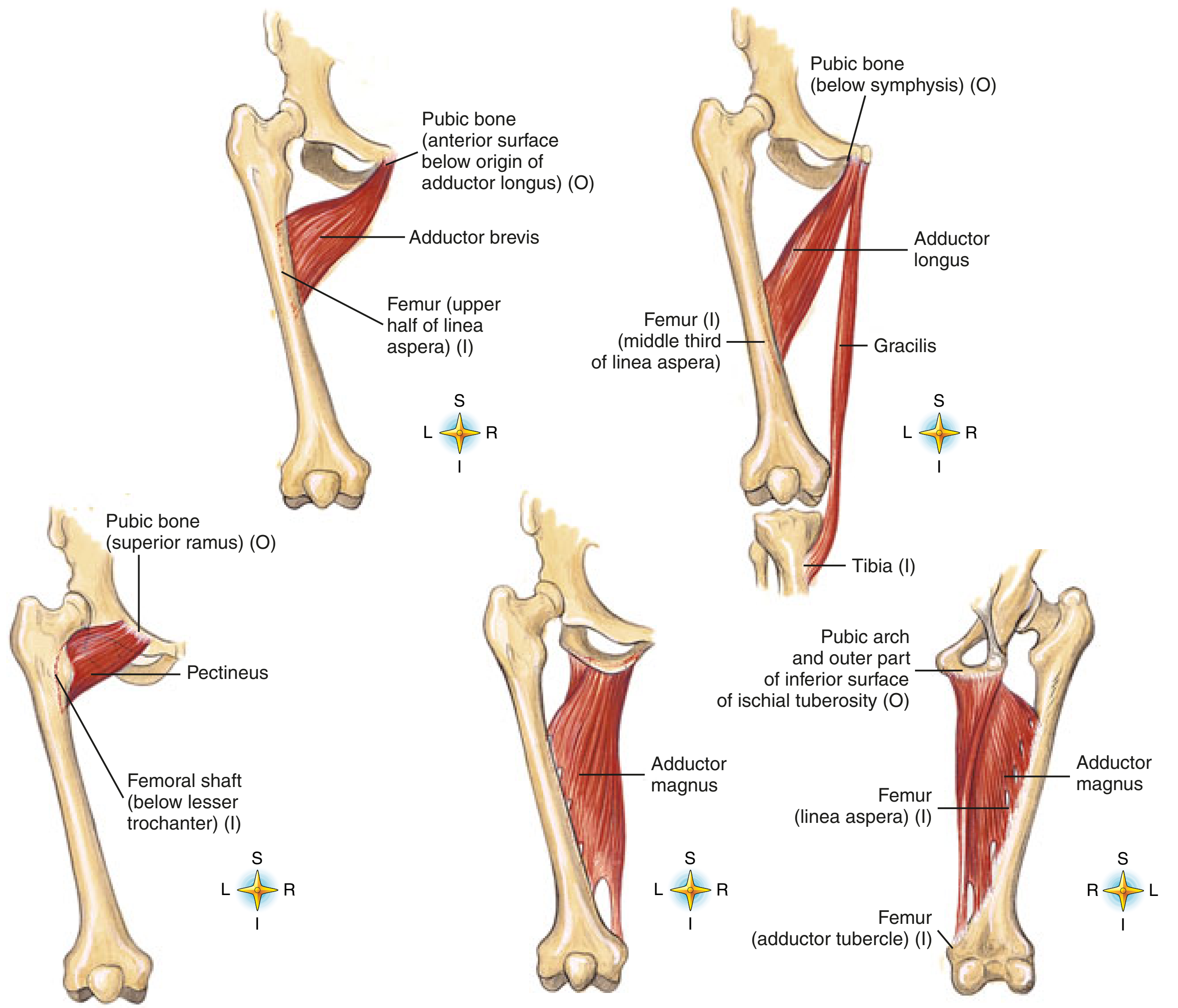


Figure 10-28 ***Muscles that adduct the thigh.*** *O,* Origin; *I,* insertion.

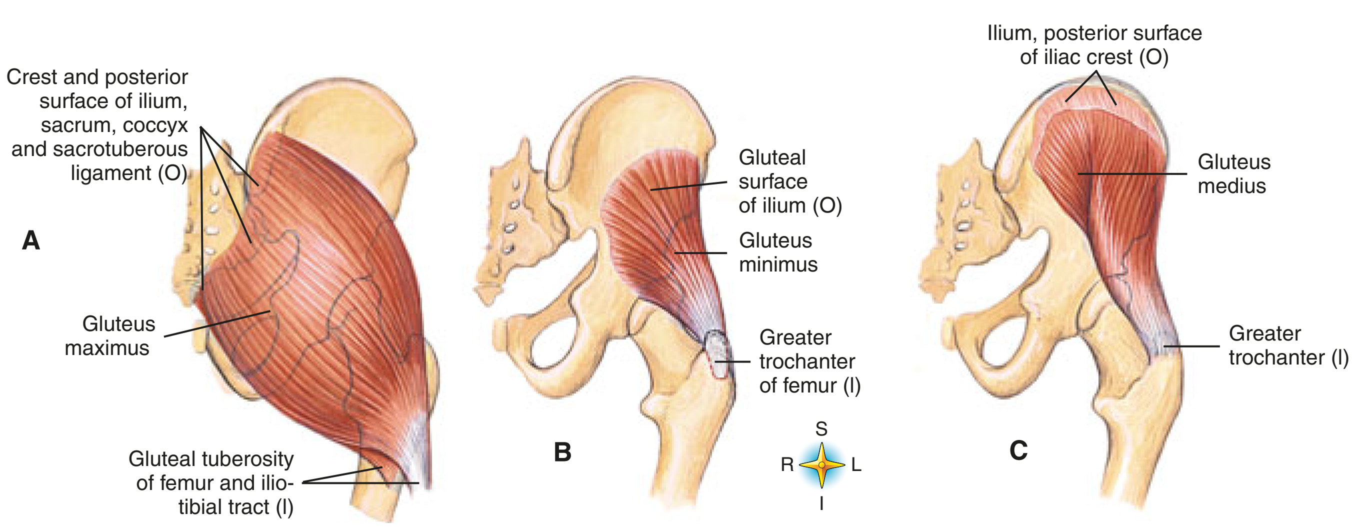


Figure 10-29 ***Gluteal muscles.*** **A,** Gluteus maximus. **B,** Gluteus minimus. **C,** Gluteus medius.

Table 10-17 Muscles That Move the Lower Leg

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
Quadriceps femoris group				
Rectus femoris	Ilium (anterior inferior spine)	Tibia (by way of patellar tendon)	Flexes the thigh Extends the leg	Femoral nerve
Vastus lateralis	Femur (linea aspera)	Tibia (by way of the patellar tendon)	Extends the leg	Femoral nerve
Vastus medialis	Femur	Tibia (by way of the patellar tendon)	Extends the leg	Femoral nerve
Vastus intermedius	Femur (anterior surface)	Tibia (by way of the patellar tendon)	Extends the leg	Femoral nerve
Sartorius	Coxal (anterior superior iliac spines)	Tibia (medial surface of the upper end of the shaft)	Adducts and flexes the leg Permits crossing of the legs tailor fashion	Femoral nerve
Hamstring group				
Biceps femoris	Ischium (tuberosity)	Fibula (head of)	Extends the thigh	Hamstring nerve (branch of the sciatic nerve)
	Femur (linea aspera)	Tibia (lateral condyle)		Hamstring nerve
Semitendinosus	Ischium (tuberosity)	Tibia (proximal end, medial surface)	Extends the thigh	Hamstring nerve
Semimembranosus	Ischium (tuberosity)	Tibia (medial condyle)	Extends the thigh	Hamstring nerve

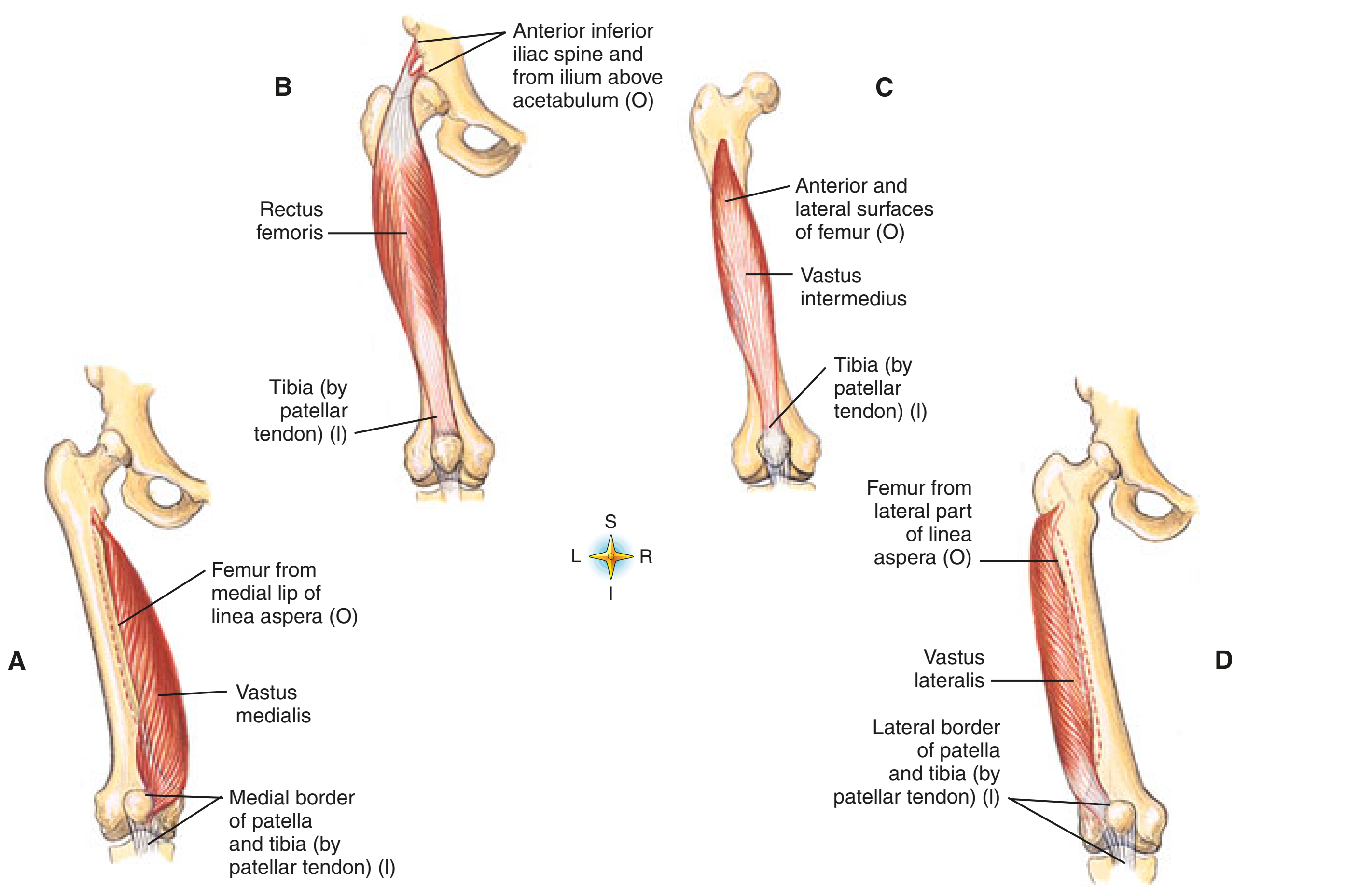


Figure 10-30 ***Quadriceps femoris group of thigh muscles.*** **A,** Rectus femoris. **B,** Vastus intermedius. **C,** Vastus medialis. **D,** Vastus lateralis. *O,* Origin; *I,* insertion.

Table 10-18 Muscles That Move the Foot

MUSCLE	ORIGIN	INSERTION	FUNCTION	NERVE SUPPLY
Extrinsic				
Tibialis anterior	Tibia (lateral condyle of the upper body)	Tarsal (first cuneiform)	Flexes the foot	Common and deep peroneal nerves
		Metatarsal (base of first)	Inverts the foot	
Gastrocnemius	Femur (condyles)	Tarsal (calcaneus by way of the Achilles tendon)	Extends the foot Flexes lower leg	Tibial nerve (branch of the sciatic nerve)
Soleus	Tibia (underneath the gastrocnemius) Fibula	Tarsal (calcaneus by way of the Achilles tendon)	Extends the foot (plantar flexion)	Tibial nerve
Peroneus longus	Tibia (lateral condyle)	First cuneiform	Extends the foot (plantar flexion)	Common peroneal nerve
	Fibula (head and shaft)	Base of the first metatarsal	Everts the foot	
Peroneus brevis	Fibula (lower two thirds of the lateral surface of the shaft)	Fifth metatarsal (tubercle, dorsal surface)	Everts the foot Flexes the foot	Superficial peroneal nerve
Peroneus tertius	Fibula (distal third)	Fourth and fifth metatarsals (bases of)	Flexes the foot Everts the foot	Deep peroneal nerve
Extensor digitorum longus	Tibia (lateral condyle) Fibula (anterior surface)	Second and third phalanges (four lateral toes)	Dorsiflexion of the foot; extension of the toes	Deep peroneal nerve
Intrinsic				
Lumbricales	Tendons of the flexor digitorum longus	Phalanges (2 to 5)	Flex the proximal phalanges Extend the middle and distal phalanges	Lateral and medial plantar nerve
Flexor digiti minimi brevis	Fifth metatarsal	Proximal phalanx of the fifth toe	Flexes the fifth (small) toe	Lateral plantar nerve
Flexor hallucis brevis	Cuboid Medial and lateral cuneiform	Proximal phalanx of the first (great) toe	Flexes the first (great) toe	Medial and lateral plantar nerve
Flexor digitorum brevis	Calcaneus Plantar fascia	Middle phalanges of the toes (2 to 5)	Flexes toes 2 through 5	Medial plantar nerve
Abductor digiti minimi	Calcaneus	Proximal phalanx of the fifth (small) toe	Abducts the fifth (small) toe Flexes the fifth toe	Lateral plantar nerve
Abductor hallucis	Calcaneus	First (great) toe	Abducts the first (great) toe	Medial plantar nerve

POSTURE

We have already discussed the major role of muscles in movement and heat production. We shall now turn our attention to a third way in which muscles serve the body as a whole—that of maintaining the posture of the body. Let us consider a few aspects of this important function.

The term **posture** means simply maintaining optimal body position. "Good posture" means many things. It means body alignment that most favors function; it means the position that requires the least muscular work to maintain, specifically, the position that places the least strain on muscles, ligaments, and bones; and often it means keeping the body's center of gravity over its base. Good posture in the standing position, for example, means the head and chest held high; the chin, abdomen, and buttocks pulled in; the knees bent slightly; and the feet placed firmly on the ground about 6 inches (15 cm) apart. Good posture in a sitting position varies with the position that one is trying to maintain. Good posture during exercise, such as riding a horse or dribbling a basketball, means moving or tensing different parts of the body frequently to avoid falling.

How Posture is Maintained

Gravity pulls on the various parts of the body at all times, and because bones are too irregularly shaped to balance themselves on each other, the only way the body can be held in any particular position is for muscles to exert a continual pull on bones in the opposite direction from gravity or other forces that pull on body parts. When the body is in a standing position, gravity tends to pull the head and trunk forward and downward; muscles (head and trunk extensors) must therefore pull backward and upward on them. For instance, gravity pulls the lower jaw downward; muscles must pull upward on it. Muscles exert this pull against gravity by virtue of

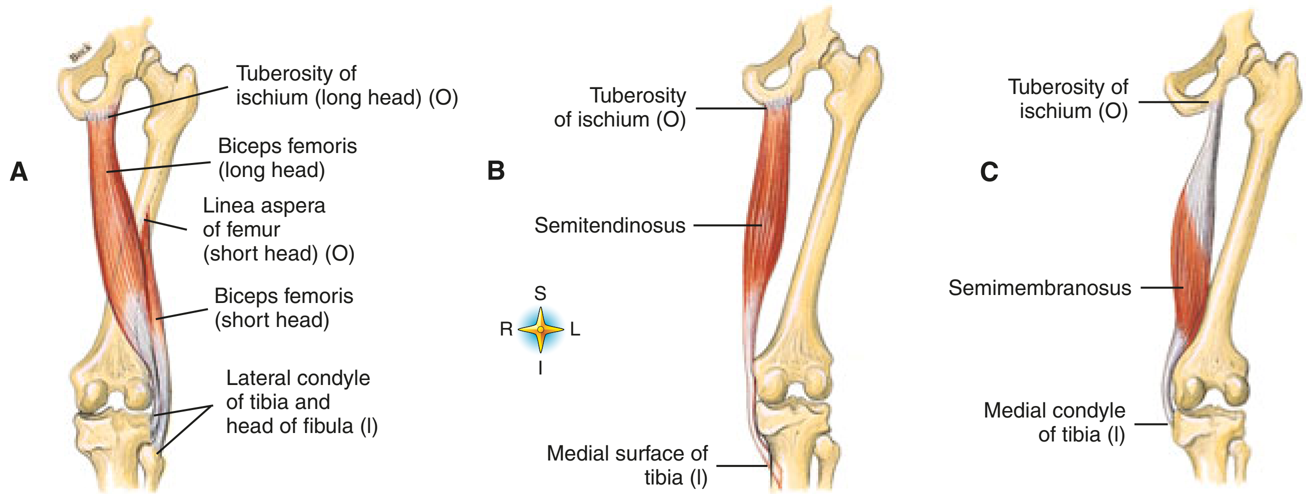


Figure 10-31 ***Hamstring group of thigh muscles.*** **A,** Biceps femoris. **B,** Semitendinosus. **C,** Semimembranosus. *O,* Origin; *I,* insertion.

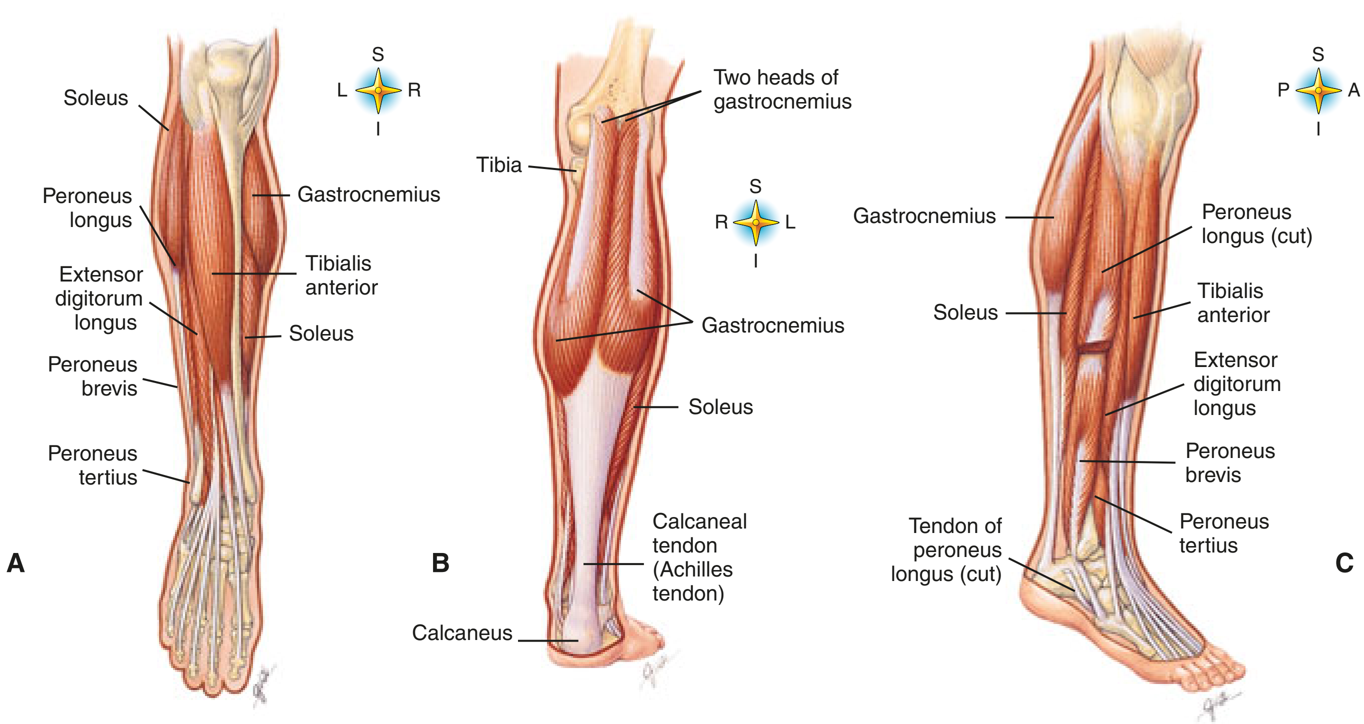


Figure 10-32 ***Superficial muscles of the leg.*** **A,** Anterior view. **B,** Posterior view. **C,** Lateral view.

their property of **tonicity.** Tonicity, or **muscle tone,** literally means *tension* and refers to the continuous, low level of sustained contraction maintained by all skeletal muscles. Because tonicity is absent during deep sleep, muscle pull does not then counteract the pull of gravity. Hence, we cannot sleep standing up. Interestingly, astronauts in the low-gravity conditions of space station missions can sleep in a standing position, as long as they are secured inside special sleeping bags on the wall of the space station.

Many structures other than muscles and bones play a part in the maintenance of posture. The nervous system is responsible for the existence of muscle tone and also regulates and coordinates the amount of pull exerted by the individual muscles. The respiratory, digestive, circulatory, excretory, and endocrine systems all contribute something toward the ability of muscles to maintain posture. This is one of many examples of the important principle that all body functions are interdependent.

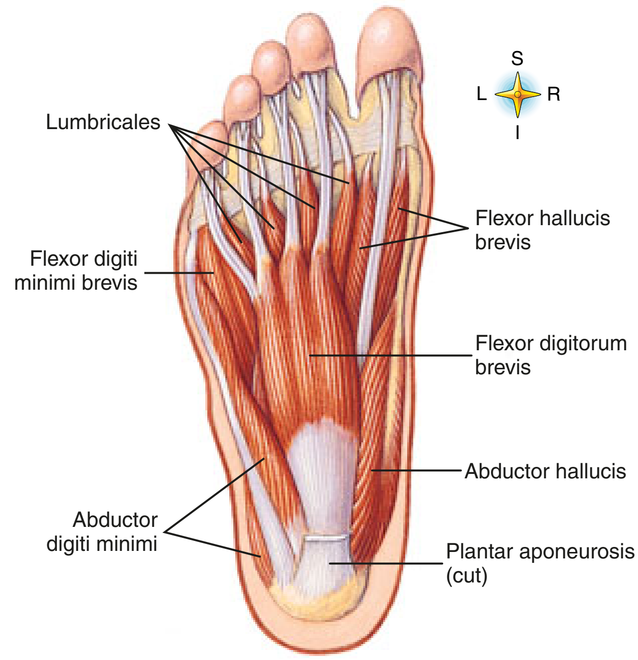


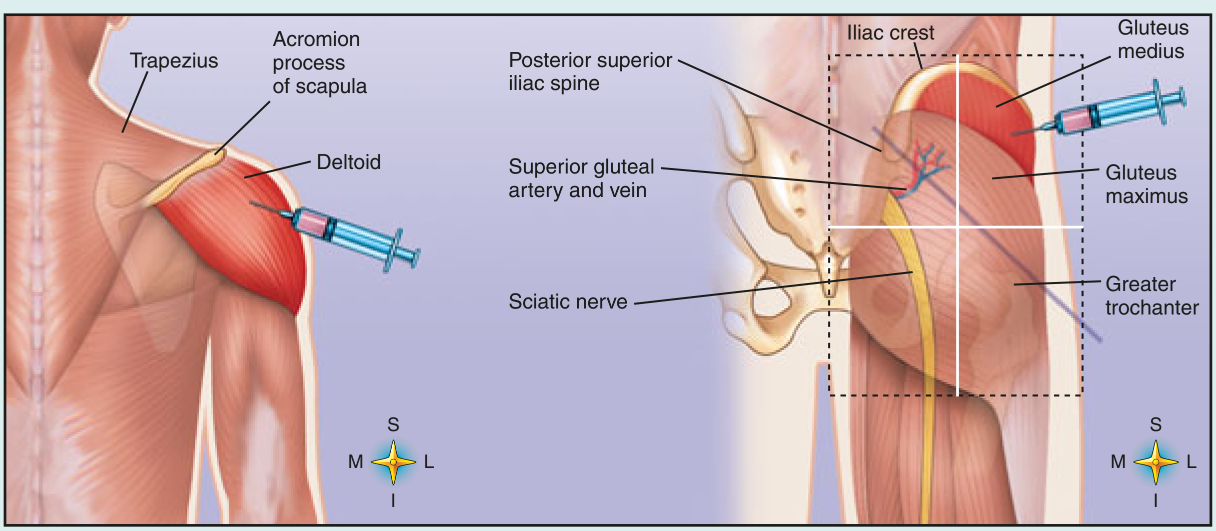
Figure 10-33 ***Intrinsic muscles of the foot.*** Inferior (plantar) view.

BOX 10-4: HEALTH MATTERS

Intramuscular Injections

Many drugs are administered by intramuscular injection. If the amount to be injected is 2 ml or less, the deltoid muscle is often selected as the site of injection. Note that in part *A* of this figure the needle is inserted into the muscle about two fingers' breadth below the acromion process of the scapula and lateral to the tip of the acromion. If the amount of medication to be injected is 2 to 3 ml, the gluteal area shown in part *B* of the figure is often used. Injections are made into the gluteus medius muscle near the center of the upper outer quadrant. Another technique of locating the proper injection site is to draw an imaginary diagonal line from a point of reference on the back of the bony pelvis (posterior superior iliac spine) to the greater trochanter of the femur. The injection is given about three fingers' breadth above and one third of the way down the line. It is important to avoid the sciatic nerve and the superior gluteal blood vessels during the injection. Proper technique requires knowledge of the underlying anatomy.

A



B

Intramuscular injection sites. **A,** Deltoid injection site for small doses. **B,** Gluteal injection site for larger doses.

The importance of posture can perhaps be best evaluated by considering some of the effects of poor posture. Poor posture throws more work on muscles to counteract the pull of gravity and therefore leads to fatigue more quickly than good posture does. Poor posture puts more strain on ligaments. It puts abnormal strain on bones and may eventually produce deformities. It also interferes with various functions such as respiration, heart action, and digestion.

Cycle of Life

Muscular System

Acting together, the muscular, skeletal, and nervous systems permit us to move in a coordinated and controlled way. However, it is the contraction, or shortening, of muscles that ultimately provides the actual movement necessary for physical activity. Dramatic changes occur in the muscular system throughout the cycle of life. Muscle cells may increase or decrease in size and in their ability to shorten most effectively at different periods in life. In addition to age-related changes, many pathological conditions occurring at different ages may also affect the muscular system.

Because of the functional interdependence of the musculoskeletal and nervous systems, life cycle changes affecting the muscles are often manifested in other components of the functional unit. During infancy and childhood, the ability to coordinate and control the strength of muscle contraction permits a sequential series of developmental steps to occur. A developing youngster learns to hold the head up, roll over, sit up, stand alone, and then walk and run as developmental changes permit better control and coordination of muscular contraction.

Degenerative changes associated with advancing age often result in replacement of muscle cell volume with nonfunctional connective tissue. As a result, the strength of muscular contraction diminishes. Recent findings show that much, if not all of this age-related decrease in muscle strength actually results from disuse atrophy (see Box 11-6 in Chapter 11) and may thus be avoidable. Pathological conditions associated with specific age ranges can also affect one or more components of the functional unit that permits us to move smoothly and effortlessly.

THE BIG PICTURE

Skeletal Muscles and the Whole Body

As you read through this chapter, what struck you most was probably the large number of individual muscles and their many actions. Although learning the names, locations, origins, insertions, and other details of the major muscles is a worthwhile endeavor, such an activity can cause you to lose sight of the "big picture." Step back from the details a moment to appreciate the fact that the muscles work as coordinated teams of biological engines that move the various components of the flexible skeleton.

As a matter of fact, in this chapter you learned that the fibrous wrappings of each muscle are continuous with its tendons, which in turn are continuous with the fibrous structure of the bone to which they are attached. Thus, we can see that the muscular and skeletal systems are in essence a *single structure*. This fact is very important in seeing a "big picture" comprising many individual muscles and bones. The entire *skeletomuscular system,* as it is often called, is actually a single, continuous structure that provides a coordinated, dynamic framework for the body.

Taking another step back, an even bigger picture comes into focus. Other systems of the body must play a role in the actions of the skeletomuscular system. For example, the nervous system senses changes in body position and degrees of movement—thereby permitting integration of feedback loops that ultimately regulate the muscular contractions that maintain posture and produce movements. The cardiovascular system maintains blood flow in the muscles, and the urinary and respiratory systems rid the body of wastes produced in the muscles. The respiratory and digestive systems bring in the oxygen and nutrients necessary for muscle function.

The picture is still not complete, however. We will see even more when Chapter 11 continues the story of muscle function by delving into the details of how each muscle works as an engine to drive the movement of the body.

LANGUAGE OF SCIENCE

(Cont'd from page 347)

fascia (FAY-shah) [*fasci* band or bundle of fibrous tissue]
fixator muscle (fik-SAY-tor) [*figere* to fasten]
fusiform muscles (FYOO-si-form) [*fusus-* spindle, *-forma* form]
gastrocnemius muscle (GAS-trok-NEE-mee-us) [*gastroknemia* calf of the leg]
gluteal muscles (GLOO-tee-al MUSS-els) [*gloutos* buttocks]
infraspinatus muscle (IN-frah-spy-nah-tus) [*infra-* occurring beneath, *-spina* spine]
insertion [*inserere* to join to]
internal intercostal muscle (in-TER-nal in-ter-KOS-tal) [*internus* inward, *costa* rib]
internal oblique muscle (in-TER-nal oh-BLEEK) [*internus* inward, *obliquus* slanted]
interosseous muscles (in-ter-OSS-ee-us) [*inter-* between, *-os* bone]
interspinales group (in-ter-spy-NAH-leez) [*inter-* between, *-spina* spine]
intrinsic foot muscles (in-TRIN-sik) [*intrinsecus* inside]
intrinsic muscles (in-TRIN-sik) [*instrinsecus* inside]
ischiocavernosus muscle (iss-kee-oh-KAV-er-no-sus) [*ischio-* the ischium or hip, *-caverna* hollow space]
levator ani muscle (leh-VAY-tor) [*levare* to lift up]
levator scapulae (leh-VAY-tor SCAP-yoo-lee) [*levare* to lift up, *scapula* shoulder blade]
lever
lever systems
linea alba (LIN-ee-ah AL-bah) [*linea* line, *albus* white]
longissimus capitis muscle (lon-JIS-i-mus KAP-i-tis) [*longissumus* longest or very long, *capit* head]
lumbrical muscle (LUM-bri-kal) [*lumbrical* resembling a worm]
masseter (mah-SEE-ter) [*masseter* one who chews]
mastication (mass-ti-KAY-shun) [*masticare* to chew]
multifides group (mul-TIF-i-deez) [*multi-* many, *-findere* to split]
muscle tone
muscular system
occipitofrontalis (ok-sip-i-too-fron-TAL-is)
opponens pollicis muscle (oh-POH-nenz POL-i-cis MUSS-el) [*oppenens* opposing, *poli* pole]
orbicularis oculi muscle (or-bik-yoo-LAIR-is OK-yoo-lye MUSS-el) [*orbiculus* little circle, *ocul* pertaining to the eye]
orbicularis oris muscle (or-bik-yoo-LAR-is OR-iss) [*orbiculus* little circle, *oris* mouth]
origin (OR-i-jin)
parallel muscles
pectoralis minor (pek-toh-RAL-is) [*pector-* breast, *-alis* pertaining to]
pennate muscles (PEN-ayt) [*pennate* having feathers]
perimysium (pair-i-MEE-see-um) [*peri-* around, *-mys* muscle]
perineum (pair-i-NEE-um)
peroneus tertius muscle (per-oh-NEE-us TER-tee-us) [*peroneo* related to the fibula, *tertius* third]
posture (POS-chur)
prime mover
pterygoid muscle (TER-i-goid) [*pteryx-* wing, *-oid* resembling]
rectus abdominis muscle (REK-tus ab-DOM-i-nus) [*rectus* straight, *abdominis* abdomen]
rectus sheath (REK-tus sheeth) [*rectus* straight]
rhomboideus major/minor muscle (rom-BOYD-ee-us) [*rhombos* rhombus]
rotator cuff muscles (roh-TAY-tor) [*rot* turned or to turn]
serratus anterior muscle (ser-AYT-us) [*serra* saw teeth, *ante + prior* foremost]
soleus muscle (SOH-lee-us) [*solea* sole of foot]
sphincter urethrae muscles (SFINGK-ter yoo-REE-three) [*spingein* to bind]
spiral muscles
splenius capitis (SPLEH-nee-us KAP-i-tis) [*splen* spleen, *capitis* head]
sternocleidomastoid muscle (STERN-oh- KLYE-doh-MAS-toyd) [*sterno-* sternum, *-kleis-* key, *-masto-* breast, *-oid* resembling]
subscapularis muscle (sub-SKAP-yoo-lar-is) [*sub-* beneath, *-scapulae* shoulder blades]
supraspinatus muscle (SOO-prah-spy-nah-tus) [*supra-* above, *-spina* spine]
synergist (SIN-er-jist) [*syn-* together, *-ergein* to work]
temporalis muscle (tem-poh-RAL-is) [*tempo-* temples, *-alis* pertaining to]
tendon [*tendere* to stretch]
tendon sheaths (sheeths) [*tendere* to stretch]
tensor fasciae latae muscle (TEN-sor FASH-ee LAT-tee) [*tendere* to stretch, *fasci* band or bundle]
teres minor (TER-eez) [*teres* rounded]
tibialis anterior muscle (tib-ee-AL-is) [*tibia* the tibia, *ante + prior* foremost]
tonicity (toh-NIS-i-tee) [*tonos* stretching]
trapezius muscle (trah-PEE-zee-us) [*trapezion* small table]
urogenital triangle (YOO-roh-JEN-ih-tal) [*uro-* urine, *-genit-* birth or reproduction, *-al* pertaining to, *triangulus* three-cornered]
zygomaticus major muscle (zye-goh-MAT-ik-us) [*zygoma* bolt or bar]

LANGUAGE OF MEDICINE

carpal tunnel syndrome (KAR-pul TUN-el SIN-drohm) [*carp* wrist]
intramuscular injections (in-trah-MUSS-kyoo-lar in-JEK-shuns) [*intra* occurring within]
tenosynovitis (ten-oh-sin-oh-VYE-tis) [*teno-* tendon, *-synovi-* joint fluid, *-itis* inflammation]

CASE STUDY

Patricia Rider, age 42, came to the health clinic complaining of pain in her right hand and fingers for the past 2 months, especially at night. She works as a sewing machine operator at a local factory making men's pants. Ms. Rider thinks of herself as being in good health. She walks daily and follows a low-fat diet. Her family history is negative for cancer, arthritis, heart disease, and diabetes. Her physical examination reflects a positive Tinel sign (tingling sensation radiating from the wrist to the hand) with gentle tapping on the inside of her right wrist with a reflex hammer.

1. After a complete physical examination, carpal tunnel syndrome is diagnosed. Which of the following nerves is usually involved with this diagnosis?
   A. Femoral
   B. Median
   C. Ulna
   D. Radial
2. The physician has ordered that Ms. Rider wear a right wrist splint held in place by an Ace bandage. Which one of the following is the BEST rationale for this treatment?
   A. It will stabilize the joint, thus reducing the pain in this area at night, while allowing Ms. Rider to remove the splint and continue her work as a sewing machine operator during the day.
   B. It will decrease the swelling associated with the injury.
   C. It will remind Ms. Rider to avoid heavy lifting with this extremity and thus decrease the likelihood of reinjury to the area.
   D. It will decrease the repetitive motions of the wrist and prevent continuous injury.
3. During the routine examination, Ms. Rider is found to have a slight separation of muscle when she is asked to lift her head off the examination table while in a supine position. Which muscle do you expect to show this separation based on the above description?
   A. External oblique
   B. Internal oblique
   C. Rectus abdominis
   D. Transversus abdominis
4. During the physical examination, the physician tests Ms. Rider's right brachialis muscle strength. Which one of the following correctly describes this procedure?
   A. The forearm should be flexed at the elbow.
   B. The forearm should be extended at the elbow.
   C. Ms. Rider is asked to extend her elbow and push against a hard surface.
   D. Ms. Rider is asked to lift a heavy object above her head.

CHAPTER SUMMARY

INTRODUCTION (FIGURES 10-5 AND 10-6)

A. There are more than 600 skeletal muscles in the body
B. From 40% to 50% of our body weight is skeletal muscle
C. Muscles, along with the skeleton, determine the form and contour of our body

SKELETAL MUSCLE STRUCTURE (FIGURE 10-1)

A. Connective tissue components
   1. Endomysium—delicate connective tissue membrane that covers specialized skeletal muscle fibers
   2. Perimysium—tough connective tissue binding together fascicles
   3. Epimysium—coarse sheath covering the muscle as a whole
   4. These three fibrous components may become a tendon or an aponeurosis
B. Size, shape, and fiber arrangement (Figure 10-2)
   1. Skeletal muscles vary considerably in size, shape, and fiber arrangement
   2. Size—range from extremely small to large masses
   3. Shape—variety of shapes, such as broad, narrow, long, tapering, short, blunt, triangular, quadrilateral, irregular, flat sheets, or bulky masses
   4. Arrangement—variety of arrangements, such as parallel to a long axis, converging to a narrow attachment, oblique, pennate, bipennate, or curved; the direction of fibers is significant because of its relationship to function
C. Attachment of muscles (Figure 10-3)
   1. Origin—point of attachment that does not move when the muscle contracts
   2. Insertion—point of attachment that moves when the muscle contracts
D. Muscle actions
   1. Most movements are produced by the coordinated action of several muscles; some muscles in the group contract while others relax
      a. Prime mover (agonist)—a muscle or group of muscles that directly performs a specific movement
      b. Antagonist—muscles that when contracting, directly oppose prime movers; relax while the prime mover (agonist) is contracting to produce movement; provide precision and control during contraction of prime movers
      c. Synergists—muscles that contract at the same time as the prime movers; they facilitate prime mover actions to produce a more efficient movement
      d. Fixator muscles—joint stabilizers

E. Lever systems
   1. In the human body, bones serve as levers and joints serve as fulcrums; contracting muscle applies a pulling force on a bone lever at the point of the muscle's attachment to the bone, which causes the insertion bone to move about its joint fulcrum
   2. Lever system—composed of four component parts (Figure 10-4)
      a. Rigid bar (bone)
      b. Fulcrum (F) around which the rod moves (joint)
      c. Load (L) that is moved
      d. Pull (P) that produces movement (muscle contraction)
   3. First-class levers
      a. Fulcrum lies between the pull and the load
      b. Not abundant in the human body; serve as levers of stability
   4. Second-class levers
      a. Load lies between the fulcrum and the joint at which the pull is exerted
      b. Presence of these levers in the human body is a controversial issue
   5. Third-class levers
      a. Pull is exerted between the fulcrum and load
      b. Permit rapid and extensive movement
      c. Most common type of lever found in the body

HOW MUSCLES ARE NAMED

A. Muscle names can be in Latin or English (this book uses English)
B. Muscles are named according to one or more of the following features:
   1. Location, function, shape (Tables 10-1; 10-2; 10-3)
   2. Direction of fibers—named according to fiber orientation (Table 10-4)
   3. Number of heads or divisions (Table 10-4)
   4. Points of attachment—origin and insertion points
   5. Relative size—small, medium, or large (Table 10-5)
C. Hints on how to deduce muscle actions

IMPORTANT SKELETAL MUSCLES

A. Muscles of facial expression—unique in that at least one point of attachment is to the deep layers of the skin over the face or neck (Figures 10-7 and 10-8; Table 10-6)
B. Muscles of mastication—responsible for chewing movements (Figure 10-9; Table 10-6)
C. Muscles that move the head—paired muscles on either side of the neck are responsible for head movements (Figure 10-10; Table 10-7)

TRUNK MUSCLES

A. Muscles of the thorax—critical importance in respiration (Figure 10-11; Table 10-8)
B. Muscles of the abdominal wall—arranged in three layers, with fibers in each layer running in different directions to increase strength (Figure 10-12; Table 10-9)
C. Muscles of the back—bend or stabilize the back (Figure 10-14; Table 10-10)
D. Muscles of the pelvic floor—support the structures in the pelvic cavity (Figure 10-15; Table 10-11)

UPPER LIMB MUSCLES

A. Muscles acting on the shoulder girdle—muscles that attach the upper extremity to the torso are located anteriorly (chest) or posteriorly (back and neck); these muscles also allow extensive movement (Figure 10-16; Table 10-12)
B. Muscles that move the upper part of the arm—the shoulder is a synovial joint allowing extensive movement in every plane of motion (Figure 10-17; Table 10-13)
C. Muscles that move the forearm—found proximal to the elbow and attach to the ulna and radius (Figures 10-20 and 10-21; Table 10-14)
D. Muscles that move the wrist, hand, and fingers—these muscles are located on the anterior or posterior surfaces of the forearm (Figures 10-22 through 10-24; Table 10-15)

LOWER LIMB MUSCLES

A. The pelvic girdle and lower extremity function in locomotion and maintenance of stability
B. Muscles that move the thigh and lower part of the leg (Figures 10-5, 10-6, and 10-25 through 10-31; Tables 10-16 and 10-17)
C. Muscles that move the ankle and foot (Figures 10-32 and 10-33; Table 10-18)
   1. Extrinsic foot muscles are located in the leg and exert their actions by pulling on tendons that insert on bones in the ankle and foot; responsible for dorsiflexion, plantar flexion, inversion, and eversion
   2. Intrinsic foot muscles are located within the foot; responsible for flexion, extension, abduction, and adduction of the toes

POSTURE

A. Maintaining the posture of the body is one of the major roles muscles play
B. "Good posture"—body alignment that most favors function; achieved by keeping the body's center of gravity over its base and requires the least muscular work to maintain
C. How posture is maintained
   1. Muscles exert a continual pull on bones in the opposite direction from gravity
   2. Structures other than muscle and bones have a role in maintaining posture
      a. Nervous system—responsible for the existence of muscle tone and also for regulation and coordination of the amount of pull exerted by individual muscles
      b. Respiratory, digestive, excretory, and endocrine systems all contribute to maintain posture

CYCLE OF LIFE: MUSCULAR SYSTEM

A. Muscle cells—increase or decrease in number, size, and ability to shorten at different periods
B. Pathological conditions at different periods may affect the muscular system

C. Life cycle changes—manifested in other components of functional unit:
   1. Infancy and childhood—coordination and control of muscle contraction permit sequential development steps
D. Degenerative changes of advancing age result in replacement of muscle cells with nonfunctional connective tissue
   1. Diminished strength

REVIEW QUESTIONS

1. Define the terms *endomysium*, *perimysium*, and *epimysium*.
2. Identify and describe the most common type of lever system found in the body.
3. Give an example of a muscle named by location, function, shape, fiber direction, number of heads, points of attachment.
4. Name the main muscles of the back, chest, abdomen, neck, shoulder, upper part of the arm, lower part of the arm, thigh, buttocks, leg, and pelvic floor.
5. Name the main muscles that flex, extend, abduct, and adduct the upper part of the arm; that raise and lower the shoulder.
6. Name the main muscles that flex and extend the lower part of the arm; that flex and extend the wrist and hand.
7. Name the main muscles that flex, extend, abduct, and adduct the thigh; that flex and extend the lower part of the leg and thigh; that flex and extend the foot.
8. Name the main muscles that flex, extend, abduct, and adduct the head.
9. Name the main muscles that move the abdominal wall; that move the chest wall.

CRITICAL THINKING QUESTIONS

1. Identify the muscles of facial expression. What muscles permit smiling and frowning?
2. How do the origin and insertion of a muscle relate to each other in regard to actual movement?
3. When the biceps brachii contracts, the elbow flexes. When the triceps brachii contracts, the elbow extends. Explain the role of both muscles in terms of agonist and antagonist in both of these movements.
4. Can you describe how posture is maintained?
5. Describe the clinical significance regarding the difference in size between the large head of the humerus and the small and shallow glenoid cavity of the scapula.
6. If a typist complained of weakness, pain, and tingling in the palm and thumb side of the hand, what type of problem might that typist be experiencing? Explain specifically what was happening to cause this discomfort.
7. Baseball players, particularly pitchers, often incur rotator cuff injuries. List the muscles that make up the rotator cuff and explain the importance of these muscles and their role in joint stability.