Learning Outcomes
These Learning Outcomes correspond by number to this chapter’s sections and indicate what you should be able to do after completing the chapter.

11-1 Describe the arrangement of fascicles in the various types of muscles, and explain the resulting functional differences. p. 337
11-2 Describe the classes of levers, and explain how they make muscles more efficient. p. 339
11-3 Predict the actions of a muscle on the basis of its origin and insertion, and explain how muscles interact to produce or oppose movements. p. 339
11-4 Explain how the name of a muscle can help identify its location, appearance, or function. p. 343
11-5 Compare and contrast the axial and appendicular muscles. p. 344
11-6 Identify the principal axial muscles of the body, plus their origins, insertions, actions, and innervation. p. 347
11-7 Identify the principal appendicular muscles of the body, plus their origins, insertions, actions, and innervation, and compare the major functional differences between the upper and lower limbs. p. 362
11-8 Explain the functional relationship between the muscular system and other body systems, and explain the role of exercise in producing various responses in other body systems. p. 382
An Introduction to the Muscular System

In this chapter we describe the gross anatomy of the muscular system and consider functional relationships between muscles and bones of the body. Most skeletal muscle fibers contract at similar rates and shorten to the same degree, but variations in their microscopic and macroscopic organization can dramatically affect the power, range, and speed of movement produced when a whole muscle contracts.

11-1 Fascicle arrangement is correlated with muscle power and range of motion

Learning Outcome Describe the arrangement of fascicles in the various types of muscles, and explain the resulting functional differences.

Muscle fibers in a skeletal muscle form bundles called fascicles (FAS-ih-kulz). p. 293 The muscle fibers in a single fascicle are parallel, but the arrangement of fascicles in skeletal muscles can vary, as can the relationship between the fascicles and the associated tendon. Based on the patterns of fascicle arrangement, we can classify skeletal muscles as parallel muscles, convergent muscles, pennate muscles, and circular muscles (Figure 11–1).

Parallel Muscles

In a parallel muscle, the fascicles are parallel to the long axis of the muscle. Most of the skeletal muscles in the body are parallel muscles. Some are flat bands with broad attachments (aponeuroses; ap-ō-nû-RÖ-séz) at each end. Others are plump and cylindrical, with tendons at one or both ends. Such a muscle is spindle shaped, with a central body, also known as the belly. For example, the biceps brachii of the arm is a parallel muscle with a central body (Figure 11–1a). When a parallel muscle contracts, it shortens and gets larger in diameter. When you flex your elbow, you can see the bulge of the contracting biceps brachii on the anterior surface of your arm. Other parallel muscles include the rectus abdominis (Figure 11–1b) and supinator (Figure 11–1c).

A skeletal muscle fiber can contract until it has shortened about 30 percent. The entire parallel muscle shortens by this amount when its fibers contract together, because these fibers are parallel to the long axis of the muscle. Thus, if the muscle is 10 cm (3.9 in.) long and one end is held in place, the other end will move 3 cm when the muscle contracts. The tension developed during this contraction depends on the total number of myofibrils the muscle contains. p. 315

Convergent Muscles

In a convergent muscle, muscle fascicles extending over a broad area come together, or converge, on a common attachment site. The muscle may pull on a tendon, an aponeurosis, or a slender band of collagen fibers known as a raphe (RĀ-fé; seam). The muscle fibers typically spread out, like a fan or a broad triangle, with a tendon at the apex. Examples include the prominent pectoralis muscles of the chest (Figure 11–1d).

A convergent muscle can adapt to different activities because the stimulation of different portions of the muscle can change the direction it pulls. However, when the entire muscle contracts, the muscle fibers do not pull as hard on the attachment site as would a parallel muscle of the same size. Why? The reason is that convergent muscle fibers pull in different directions, rather than all pulling in the same direction as in parallel muscles.

Pennate Muscles

In a pennate muscle (PEN-ä; penna, feather), the fascicles form a common angle with the tendon. Because the muscle fibers pull at an angle, contracting pennate muscles do not move their tendons as far as parallel muscles do. But
a pennate muscle contains more muscle fibers—and thus more myofibrils—than does a parallel muscle of the same size. For this reason, the pennate muscle produces more tension.

There are three types of pennate muscles, depending on the arrangement of the fascicles with the tendon. If all the muscle fascicles are on the same side of the tendon, the pennate muscle is unipennate. The extensor digitorum, a forearm muscle that extends the finger joints, is unipennate (Figure 11-1e). More commonly, a pennate muscle has fascicles on both sides of a central tendon. Such a muscle is called bipennate. The rectus femoris, a prominent muscle that extends the knee, is bipennate (Figure 11-1f). If the tendon branches within a pennate muscle, the muscle is said to be multipennate. The triangular deltoid of the shoulder is multipennate (Figure 11-1g).

**Circular Muscles**

In a circular muscle, or sphincter (SFINK-ter), the fascicles are concentrically arranged around an opening. When the muscle contracts, the diameter of the opening becomes smaller. Circular muscles surround body openings or hollow organs and act as valves in the digestive and urinary tracts. An example is the orbicularis oris of the mouth (Figure 11-1h).
A familiar example of a second-class lever is a loaded wheelbarrow. The load lies between the applied force and the fulcrum (Figure 11–2b). The weight is the load, and the upward lift on the handle is the applied force. We can describe the positions as F–L–AF. In this arrangement, a small force can move a larger weight because the force is always farther from the fulcrum than the load is. That is, the effective force is increased. Notice, however, that when a force moves the handle, the load moves more slowly and covers a shorter distance. In other words, the effective force is increased at the expense of speed and distance. The body has few second-class levers. Ankle extension (plantar flexion) by the calf muscles involves a second-class lever (see Figure 11–2b).

In a third-class lever, such as a pair of tongs, the applied force is between the load and the fulcrum (Figure 11–2c). We can describe the positions as F–AF–L. Third-class levers are the most common levers in the body. The effect is the reverse of that for a second-class lever: Speed and distance traveled are increased at the expense of effective force.

Not every muscle is part of a lever system, but the presence of levers provides speed and versatility far in excess of what we would predict for the body on the basis of muscle physiology alone.

Checkpoint

4. Define a lever, and describe the three classes of levers.
5. The joint between the occipital bone of the skull and the first cervical vertebra (atlas) is a part of which class of lever?

See the blue Answers tab at the back of the book.

11-3 The origins and insertions of muscles determine their actions

Learning Outcome Predict the actions of a muscle on the basis of its origin and insertion, and explain how muscles interact to produce or oppose movements.

To understand the actions of skeletal muscles, we need to understand where they are connected to the bones that act as levers and which joints they cross.

Origins and Insertions

In Chapter 10 we noted that when both ends of a myofibril are free to move, the ends move toward the center during a contraction. In the body, the ends of a skeletal muscle are always attached to other structures that limit their movement. In most cases one end is fixed in position, and during a contraction the other end moves toward the fixed end. The less movable end is called the origin of the muscle. The more movable end is called the insertion of the muscle. The origin is typically proximal to the insertion. Almost all skeletal muscles either originate or insert on the skeleton.
The decision as to which end is the origin and which is the insertion is usually based on movement from the anatomical position. As an example, consider the gastrocnemius, a calf muscle that extends from the distal portion of the femur to the calcaneus. As Figure 11–2b shows, when the gastrocnemius contracts, it pulls the calcaneus toward the knee. As a result, we say that the gastrocnemius has its origin at the femur and its insertion at the calcaneus. Part of the fun of studying the muscular system is that you can actually do the movements and think about the muscles involved. As a result, laboratory activities focusing on muscle actions are often like disorganized aerobics classes.

When we cannot easily determine the origins and insertions on the basis of movement from the anatomical position, we have other rules to use. If a muscle extends between a broad aponeurosis and a narrow tendon, the aponeurosis is the origin and the
tendon is the insertion. If several tendons are at one end and just one is at the other, the muscle has multiple origins and a single insertion. However, these simple rules cannot cover every situation. Knowing which end is the origin and which is the insertion is ultimately less important than knowing where the two ends attach and what the muscle accomplishes when it contracts.

Most muscles originate at a bone, but some originate at a connective tissue sheath or band. Examples of these sheaths or bands include intermuscular septa (components of the deep fascia that may separate adjacent skeletal muscles), tendinous inscriptions that join muscle fibers to form long muscles such as the rectus abdominis, the interosseous membranes of the forearm or leg, and the fibrous sheet that spans the obturator foramen of the pelvis.

**Actions**

When a muscle contracts, it produces a specific action, or movement. As introduced in Chapter 9, when a muscle moves a portion of the skeleton, that movement may involve flexion, extension, adduction, abduction, pronation, retraction, elevation, depression, rotation, circumduction, and supination, inversion, eversion, lateral flexion, opposition, or reposition. (Before proceeding, you may want to review the discussions of planes of motion and Figures 9–3 and 9–5.)

We can describe actions in two ways, one focused on the bone and one on the joint. The first way describes actions in terms of the bone or region affected. For example, we say a muscle such as the biceps brachii performs “flexion of the forearm.” However, specialists such as kinesiologists and physical therapists increasingly use the second way, which identifies the joint involved. In this approach, we say the action of the biceps brachii is “flexion at (or of) the elbow.” Examples of muscle action are presented in SpotLight Figure 11–3.

In complex movements, muscles commonly work in groups rather than individually. Their cooperation improves the efficiency of a particular movement. For example, large muscles of the limbs produce flexion or extension over an extended range of motion. These muscles cannot produce powerful movements at full extension due to the positions of the articulating bones, but they are usually paired with one or more smaller muscles that provide assistance until the larger muscle can perform at maximum efficiency. At the start of the movement, the smaller muscle produces maximum tension, while the larger muscle produces minimum tension. The importance of the smaller “assistant” decreases as the movement proceeds and the effectiveness of the primary muscle increases.

To describe how muscles work together, we can use the following four functional types: agonist, antagonist, synergist, and fixator.

- **An agonist**, or prime mover, is a muscle whose contraction is mostly responsible for producing a particular movement. The biceps brachii is an agonist that produces flexion at the elbow.
- **An antagonist** is a muscle whose action opposes that of a particular agonist. The triceps brachii is an agonist that extends the elbow. For this reason, it is an antagonist of the biceps brachii. Likewise, the biceps brachii is an antagonist of the triceps brachii.

Agonists and antagonists are functional opposites. If one produces flexion, the other produces extension. When an agonist contracts to produce a particular movement, the corresponding antagonist is stretched, but it usually does not relax completely. Instead, it contracts eccentrically, with just enough tension to control the speed of the movement and ensure its smoothness. p. 318

You may find it easiest to learn about muscles in agonist–antagonist pairs (flexors–extensors, abductors–adductors) that act at a specific joint. This method highlights the functions of the muscles involved, and it can help organize the information into a logical framework. The tables in this chapter are arranged to support such an approach.

- **When a synergist** (syn-, together + ergon, work) contracts, it helps a larger agonist work efficiently. Synergists may provide additional pull near the insertion or may stabilize the point of origin. Their importance in assisting a particular movement may change as the movement progresses. In many cases, they are most useful at the start, when the agonist is stretched and unable to develop maximum tension. For example, the latissimus dorsi is a large trunk muscle that extends, adducts, and medially rotates the arm at the shoulder joint. A much smaller muscle, the teres (TER-ez) major, assists in starting such movements when the shoulder joint is at full flexion.

A **fixator** is a synergist that assists an agonist by preventing movement at another joint, thereby stabilizing the origin of the agonist. Recall that the biceps brachii is an agonist that produces flexion at the elbow. It has two tendons that originate on the scapula and one that inserts on the radius. During flexion, the trapezius and rhomboid act as fixators by stabilizing and preventing the movement of the scapula.

**Checkpoint**

6. The gracilis attaches to the anterior surface of the tibia at one end, and to the pubis and ischium of the pelvis at the other. When the muscle contracts, flexion occurs at the hip. Which attachment point is considered the muscle’s origin?

7. Muscle A abducts the humerus, and muscle B adducts the humerus. What is the relationship between these two muscles?

8. Define the term synergist as it relates to muscle action.

See the blue Answers tab at the back of the book.

Go to MasteringA&P™ > Study Area > Menu > Animations & Videos > A&Plix > Origins, Insertions, Actions, Innervations
The action produced by a muscle at any one joint is largely dependent upon the structure of the joint and the location of the insertion of the muscle relative to the axis of movement at the joint. The direction, or geometric paths, of the action produced by a muscle—called lines of action—is often represented by an arrow (or more than one arrow in fan-shaped muscles).

**Flexion and Extension**

At joints that permit flexion and extension, muscles whose lines of action cross the anterior side of a joint are flexors of that joint, and muscles whose lines of action cross the posterior side of a joint are extensors of that joint.

**Abduction and Adduction**

At joints that permit adduction and abduction, muscles whose lines of action cross the medial side of a joint are adductors of that joint, and muscles whose lines of action cross the lateral side of a joint are abductors of that joint.

**Medial and Lateral Rotation**

At joints that permit rotation, movement or turning of the body part occurs around its axis. The shoulder joint is a ball-and-socket joint that permits rotation. The subscapularis has lines of action that cross the anterior aspect of the shoulder joint. When the subscapularis contracts it produces medial rotation at the joint. The teres minor has lines of action that cross the posterior aspect of the shoulder joint. When the teres minor contracts, it produces lateral rotation at the shoulder.
**Table 11–1 Muscle Terminology**

<table>
<thead>
<tr>
<th>Terms Indicating Specific Regions of the Body</th>
<th>Terms Indicating Position, Direction, or Fascicle Arrangement</th>
<th>Terms Indicating Structural Characteristics of the Muscle</th>
<th>Terms Indicating Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal (abdomen)</td>
<td>Anterior (front)</td>
<td>NATURE OF ORIGIN</td>
<td>GENERAL</td>
</tr>
<tr>
<td>Ancon (elbow)</td>
<td>External (on the outside)</td>
<td>Biceps (two heads)</td>
<td>Abductor (movement away)</td>
</tr>
<tr>
<td>Auricular (ear)</td>
<td>Extrinsic (outside the structure)</td>
<td>Triceps (three heads)</td>
<td>Adductor (movement toward)</td>
</tr>
<tr>
<td>Brachial (arm)</td>
<td>Inferior (below)</td>
<td>Quadriceps (four heads)</td>
<td>Depression (lowering movement)</td>
</tr>
<tr>
<td>Capitis (head)</td>
<td>Internal (away from the surface)</td>
<td></td>
<td>Extensor (straightening movement)</td>
</tr>
<tr>
<td>Carpi (wrist)</td>
<td>Intrinsic (within the structure)</td>
<td></td>
<td>Flexor (bending movement)</td>
</tr>
<tr>
<td>Cervicis (neck)</td>
<td>Lateral (on the side)</td>
<td></td>
<td>Levator (raising movement)</td>
</tr>
<tr>
<td>Coccygeal (coccyx)</td>
<td>Medial (middle)</td>
<td></td>
<td>Pronator (turning into prone position)</td>
</tr>
<tr>
<td>Costal (rib)</td>
<td>Oblique (slanting)</td>
<td></td>
<td>Supinator (turning into supine position)</td>
</tr>
<tr>
<td>Cutaneous (skin)</td>
<td>Posterior (back)</td>
<td></td>
<td>Tensor (tensing movement)</td>
</tr>
<tr>
<td>Femoris (thigh)</td>
<td>Profundus (deep)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glossal (tongue)</td>
<td>Rectus (straight)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hallux (great toe)</td>
<td>Superficial (toward the surface)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illium (groin)</td>
<td>Superior (toward the head)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ingualis ( groin)</td>
<td>Transverse (crosswise)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumbar (lumbar region)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasalis ( nose)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuchal (back of neck)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ocular (eye)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oris (mouth)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palpebra (eyelid)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollex (thumb)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Popliteal (posterior to knee)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psoas (loin)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radial (forearm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scapular (scapula)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporal ( temple)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thoracic (thorax)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tibial (tibia; shin)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ulnar (ulna)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Other Striking Features**

- Alba (white)
- Brevis (short)
- Gracilis (slender)
- Latae (wide)
- Latissimus (widest)
- Longissimus (longest)
- Longus (long)
- Magnus (large)
- Major (larger)
- Maximus (largest)
- Minimus (smallest)
- Minor (smaller)
- Vastus (great)
Figure 11–4  An Overview of the Major Skeletal Muscles.
Figure 11–4  An Overview of the Major Skeletal Muscles. (continued)
Position, Direction, or Fascicle Arrangement

Muscles visible at the body surface are often called externus or superficialis. Deeper muscles are termed internus or profundus. Superficial muscles that position or stabilize an organ are called extrinsic. Muscles located entirely within an organ are intrinsic.

Muscle names may be directional indicators. For example, transversus and oblique indicate muscles that run across (transversus) or at a slanting (oblique) angle to the longitudinal axis of the body.

A muscle name may refer to the orientation of the muscle fascicles within a particular skeletal muscle. Rectus means "straight," and most rectus muscles have fascicles that run along the longitudinal axis of the muscle. Because we have several rectus muscles, the name typically includes a second term that refers to a precise region of the body. For example, the rectus abdominis of the abdomen is an axial muscle that has straight fascicles that run along its long axis. However, in the case of the rectus femoris, rectus refers to "straight muscle of the thigh" and not to its fascicles (which are bipennate).

Structural Characteristics

Some muscles are named after distinctive structural features, such as multiple tendons, shape, and size.

Origin and Insertion

The biceps brachii, for example, is named after its origin. It has two tendons of origin (bi-, two + caput, head). Similarly, the triceps brachii has three, and the quadriceps femoris has four.

Many muscle names include terms for body places that tell you the specific origin and insertion of each muscle. In such cases, the first part of the name indicates the origin, the second part the insertion. The genioglossus, for example, originates at the chin (geneion) and inserts in the tongue (glossus). The names may be long and difficult to pronounce, but see Table 11–1 and the anatomical terms introduced in Chapter 1 can help you identify and remember them.  

Shape and Size

Shape is sometimes an important clue to the name of a muscle. For example, the trapezius (tra-PÉ-zē-us), deltoid, rhomboid (ROM-boyd), and orbicularis (or-bik-ū-LĀ-ris) look like a trapezoid, a triangle (like the Greek letter delta, Δ), a rhomboid, and a circle, respectively.

Many terms refer to muscle size. Long muscles are called longus (long) or longissimus (longest). Teres muscles are both long and round. Short muscles are called brevis. Large ones are called magnus (big), major (bigger), or maximus (biggest). Small ones are called minor (smaller) or minimus (smallest).

Action

Many muscles are named flexor, extensor, pronator, abductor, adductor, and rotator (see Spotlight Figure 11–3). These are such common actions that the names almost always include other clues as to the appearance or location of the muscle. For example, the extensor carpi radialis longus is a long muscle along the radial (lateral) border of the forearm. When it contracts, its primary function is extension at the carpus (wrist).

A few muscles are named after the specific movements associated with special occupations or habits. The buccinator (BUK-si-nā-tor) on the face compresses the cheeks—when, for example, you purse your lips and blow forcefully. Buccinator translates as "trumpeter." Another facial muscle, the risorius (ri-SOR-ē-us), was supposedly named after the mood expressed: The Latin word risor means "one who laughs." However, a more appropriate description for the effect would be "a grimace." The sartorius (sar-TOR-ē-us), the longest in the body, is active when you cross your legs. Before sewing machines were invented, a tailor would sit on the floor cross-legged. The name of this muscle was derived from sartor, the Latin word for "tailor."

Checkpoints

9. Identify the kinds of descriptive information used to name skeletal muscles.

10. What does the name flexor carpi radialis longus tell you about this muscle?

See the blue Answers tab at the back of the book.

11-5 Axial muscles position the axial skeleton, and appendicular muscles support and move the appendicular skeleton

Learning Outcome  Compare and contrast the axial and appendicular muscles.

The separation of the skeletal system into axial and appendicular divisions serves as a useful guideline for subdividing the muscular system:

- The axial muscles arise on the axial skeleton. This category includes approximately 60 percent of the skeletal muscles in the body. They position the head and vertebral column; move the rib cage, which assists the movements that make breathing possible; and form the pelvic floor.
- The appendicular muscles stabilize or move structures of the appendicular skeleton. Forty percent of skeletal muscles are appendicular muscles, including those that move and support the pectoral (shoulder) and pelvic girdles and the upper and lower limbs.

Figure 11–4 provides an overview of the major axial and appendicular muscles of the human body. These are superficial muscles, which tend to be rather large. The superficial muscles cover deeper, smaller muscles that we cannot see unless the underlying muscles are removed, or reflected—that is, cut and pulled out of the way. Later figures that show deep muscles in specific regions will indicate whether superficial muscles have been reflected.
Next we study examples of both muscular divisions. Pay attention to patterns of origin, insertion, and action. In the figures in this chapter, you will find that some bony and cartilaginous landmarks are labeled to provide orientation.

The tables that follow also contain information about the innervation of the individual muscles. **Innervation** is the distribution of nerves to a region or organ. The tables indicate the nerves that control each muscle. Many of the muscles of the head and neck are innervated by cranial nerves, which originate in the brain and pass through the foramina of the skull. In addition, spinal nerves are connected to the spinal cord and pass through the intervertebral foramina. For example, spinal nerve L₂ passes between vertebrae L₁ and L₂. Spinal nerves may form a complex network called a plexus after exiting the spinal cord. One branch of this network may contain axons from several spinal nerves. Many tables identify the spinal nerves involved as well as the names of their specific branches.

**Checkpoint**

11. Describe the location and general functions of axial muscles.

12. Describe the location and general functions of appendicular muscles.

See the blue Answers tab at the back of the book.

**11-6 Axial muscles are muscles of the head and neck, vertebral column, trunk, and pelvic floor**

**Learning Outcome** Identify the principal axial muscles of the body, plus their origins, insertions, actions, and innervation.

The axial muscles fall into logical groups on the basis of location, function, or both. The groups do not always have distinct anatomical boundaries. For example, a function such as extension of the vertebral column involves muscles along its entire length and movement at each of the intervertebral joints. We will discuss the axial muscles in four groups:

- **The Muscles of the Head and Neck**: This group includes muscles that move the face, tongue, and larynx. They are responsible for verbal and nonverbal communication—laughing, talking, frowning, smiling, whistling, and so on. You also use these muscles while eating—especially in suckling and chewing—and even while looking for food, as some of them control your eye movements. This group does not include muscles of the neck that are involved with movements of the vertebral column.

- **The Muscles of the Vertebral Column**: This group includes numerous flexors, extensors, and rotators of the vertebral column.

- **The Oblique and Rectus Muscles**: This group forms the muscular walls of the trunk between the first thoracic vertebra and the pelvis. In the thoracic area the ribs separate these muscles, but over the abdominal surface the muscles form broad muscular sheets. The neck also has oblique and rectus muscles. They do not form a complete muscular wall, but they share a common developmental origin with the oblique and rectus muscles of the trunk.

- **The Muscles of the Pelvic Floor**: These muscles extend between the sacrum and pelvic girdle. This group forms the perineum (per-ih-NĒ-um), a region anterior to the sacrum and coccyx between the inner thighs.

**Muscles of the Head and Neck**

We can divide the muscles of the head and neck into several functional groups. The muscles of facial expression, the muscles of mastication (chewing), the muscles of the tongue, and the muscles of the pharynx originate on the skull or hyoid bone.

Muscles involved with sight and hearing also are based on the skull. Here, we will consider the extrinsic eye muscles—those associated with movements of the eye. In Chapter 17 we discuss the intrinsic eye muscles, which control the diameter of the pupil and the shape of the lens, and the tiny skeletal muscles associated with the auditory ossicles.

Among the muscles of the anterior neck, the extrinsic muscles of the larynx adjust the position of the hyoid bone and larynx. We examine the intrinsic laryngeal muscles, including those of the vocal cords, in Chapter 23.

**Muscles of Facial Expression**

The muscles of facial expression originate on the surface of the skull (Figure 11–5). At their insertions, the fibers of the epimysium are woven into those of the superficial fascia and the dermis of the skin. For this reason, when these muscles contract, the skin moves.

Among the extrinsic eye muscles, the extrinsic muscles of the pharynx and the cervical muscles control movements of the pharynx. The muscles of facial expression originate on the surface of the skull.

Now take another look at Figure 11–5 with Table 11–2, which summarizes the muscles of facial expression by region. Focus on identifying the location and function of each of the major muscles named in this discussion.
Given its name, what does the levator anguli oris do?
### Extrinsic Eye Muscles

Six **extrinsic eye muscles**, also known as the *oculomotor muscles*, originate on the surface of the orbit and control the position of each eye. These muscles, shown in Figure 11–6, are the *inferior rectus, medial rectus, superior rectus, lateral rectus, inferior oblique*, and *superior oblique*. Compare the illustrations in Figure 11–6 with the details on these muscles in Table 11–3.

Table 11–2  Muscles of Facial Expression (Figure 11–5)

<table>
<thead>
<tr>
<th>Region and Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MOUTH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buccinator</td>
<td>Alveolar process of maxilla and alveolar part of the mandible</td>
<td>Blends into fibers of orbicularis oris</td>
<td>Compresses cheeks</td>
<td>Facial nerve (VII)*</td>
</tr>
<tr>
<td>Depressor labii inferioris</td>
<td>Mandible between the anterior midline and the mental foramen</td>
<td>Skin of lower lip</td>
<td>Depresses lower lip</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Levator labii superioris</td>
<td>Inferior margin of orbit, superior to the infra-orbital foramen</td>
<td>Orbicularis oris</td>
<td>Elevates upper lip</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Levator anguli oris</td>
<td>Maxilla below the infra-orbital foramen</td>
<td>Corner of mouth</td>
<td>Elevates corner of mouth</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Mentalis</td>
<td>Incisive fossa of mandible</td>
<td>Skin of chin</td>
<td>Elevates and protrudes lower lip</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Orbicularis oris</td>
<td>Maxilla and mandible</td>
<td>Lips</td>
<td>Compresses, purses lips</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Risorius</td>
<td>Fascia surrounding parotid salivary gland</td>
<td>Angle of mouth</td>
<td>Draws corner of mouth to side</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Depressor anguli oris</td>
<td>Anterolateral surface of mandibular body</td>
<td>Skin at angle of mouth</td>
<td>Depresses corner of mouth</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Zygomaticus major</td>
<td>Zygomatic bone near zygomaticomaxillary suture</td>
<td>Angle of mouth</td>
<td>Retracts and elevates corner of mouth</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Zygomaticus minor</td>
<td>Zygomatic bone posterior to zygomaticotemporal suture</td>
<td>Upper lip</td>
<td>Retracts and elevates upper lip</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td><strong>EYE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrugator supercilii</td>
<td>Orbital rim of frontal bone near nasal suture</td>
<td>Eyebrow</td>
<td>Pulls skin inferiorly and anteriorly; wrinkles brow</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Levator palpebrae superioris (Figure 11–6a,b)</td>
<td>Tendinous band around optic foramen</td>
<td>Upper eyelid</td>
<td>Elevates upper eyelid</td>
<td>Oculomotor nerve (III)**</td>
</tr>
<tr>
<td>Orbicularis oculi</td>
<td>Medial margin of orbit</td>
<td>Skin around eyelids</td>
<td>Closes eye</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td><strong>NOSE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procerus</td>
<td>Nasal bones and lateral nasal cartilages</td>
<td>Aponeurosis at bridge of nose and skin of forehead</td>
<td>Moves nose, changes position and shape of nostrils</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Nasalis</td>
<td>Maxilla and nasal cartilages</td>
<td>Dorsum of nose</td>
<td>Compresses bridge, depresses tip of nose; elevates corners of nostrils</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td><strong>EAR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporoparietalis</td>
<td>Fascia around external ear</td>
<td>Epicranial aponeurosis</td>
<td>Tenses scalp, moves auricle of ear</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td><strong>SCALP (EPICRANIUM)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occipitofrontalis</td>
<td>Epicranial aponeurosis</td>
<td>Skin of eyebrow and bridge of nose</td>
<td>Raises eyebrows, wrinkles forehead</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Frontal belly</td>
<td>Occipital bone and mastoid region of temporal bones</td>
<td>Epicranial aponeurosis</td>
<td>Tenses and retracts scalp</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Occipital belly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NECK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platsyma</td>
<td>Superior thorax between cartilage of 2nd rib and acromion of scapula</td>
<td>Mandible and skin of cheek</td>
<td>Tenses skin of neck; depresses mandible; pulls lower lip down</td>
<td>Facial nerve (VII)</td>
</tr>
</tbody>
</table>

*A A Roman numeral refers to a cranial nerve.

**This muscle originates in association with the extrinsic eye muscles, so its innervation is unusual.
Six muscles control eye movement. How many of these muscles can you see from the lateral surface and how many can you see from the medial surface, respectively?

### Table 11–3 Extrinsic Eye Muscles (Figure 11–6)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inferior rectus</td>
<td>Sphenoid around optic canal</td>
<td>Inferior, medial surface of eyeball</td>
<td>Eye looks inferiorly</td>
<td>Oculomotor nerve (III)</td>
</tr>
<tr>
<td>Medial rectus</td>
<td>Sphenoid around optic canal</td>
<td>Medial surface of eyeball</td>
<td>Eye looks medially</td>
<td>Oculomotor nerve (III)</td>
</tr>
<tr>
<td>Superior rectus</td>
<td>Sphenoid around optic canal</td>
<td>Superior surface of eyeball</td>
<td>Eye looks superiorly</td>
<td>Oculomotor nerve (III)</td>
</tr>
<tr>
<td>Lateral rectus</td>
<td>Sphenoid around optic canal</td>
<td>Lateral surface of eyeball</td>
<td>Eye looks laterally</td>
<td>Abducens nerve (VI)</td>
</tr>
<tr>
<td>Inferior oblique</td>
<td>Maxilla at anterior portion of orbit</td>
<td>Inferior, lateral surface of eyeball</td>
<td>Eye rolls, looks superiorly and laterally</td>
<td>Oculomotor nerve (III)</td>
</tr>
<tr>
<td>Superior oblique</td>
<td>Sphenoid around optic canal</td>
<td>Superior, lateral surface of eyeball</td>
<td>Eye rolls, looks inferiorly and laterally</td>
<td>Trochlear nerve (IV)</td>
</tr>
</tbody>
</table>
The Muscular System

Table 11–4  Muscles of Mastication (Figure 11–7)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masseter</td>
<td>Zygomatic arch</td>
<td>Lateral surface of mandibular ramus</td>
<td>Elevates mandible and closes the jaws</td>
<td>Trigeminal nerve (V), mandibular division</td>
</tr>
<tr>
<td>Temporals</td>
<td>Along temporal lines of skull</td>
<td>Coronoid process of mandible</td>
<td>Elevates mandible</td>
<td>Trigeminal nerve (V), mandibular division</td>
</tr>
<tr>
<td>Pterygoids (medial and lateral)</td>
<td>Lateral pterygoid plate</td>
<td>Medial surface of mandibular ramus</td>
<td>Medial: Elevates the mandible and closes the jaws, or slides the mandible from side to side (lateral excursion)</td>
<td>Trigeminal nerve (V), mandibular division</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lateral: Opens jaws, protrudes mandible, or performs lateral excursion</td>
<td>Trigeminal nerve (V), mandibular division</td>
</tr>
</tbody>
</table>

Muscles of Mastication

The muscles of mastication move the mandible at the temporomandibular joint (TMJ) (Figure 11–7). The large masseter is the strongest jaw muscle. The temporals assist in elevating the mandible. You can feel these muscles in action by clenching your teeth while resting your hand on the side of your face below and then above the zygomatic arch. The pterygoids (TER-ih-goyd) muscles, used in various combinations, can elevate, depress, or protract the mandible or slide it from side to side, a movement called lateral excursion. These movements are important in making efficient use of your teeth while you chew foods of various consistencies. Now go ahead and compare Figure 11–7 with the summary information on these muscles in Table 11–4.

Tips & Tools

The medial and lateral pterygoid muscles are named for their origin on the pterygoid ("winged") portion of the sphenoid bone. The pterodactyl was a prehistoric winged reptile.
Muscles of the Tongue

The four muscles of the tongue have names ending in glossus, the Greek word for “tongue.” The **palatoglossus** originates at the palate, the **styloglossus** at the styloid process of the temporal bone, the **genioglossus** at the chin, and the **hyoglossus** (hi-ō-GLOS-us) at the hyoid bone (Figure 11–8). These muscles, used in various combinations, move the tongue in the delicate and complex patterns necessary for speech. They also maneuver food within the mouth in preparation for swallowing. Now please compare the illustrations of these muscles in Figure 11–8 with the summary in Table 11–5.

Muscles of the Pharynx

The muscles of the pharynx are responsible for initiating the swallowing process (Figure 11–9). The **pharyngeal** (fa-RIN-jē-al) **constrictor** muscles (**superior**, **middle**, and **inferior**) move food (in the form of a compacted mass called a **bolus**) into the esophagus by constricting the pharyngeal walls. The two **palatal** muscles— the **tensor veli palatini** and the **levator veli palatini**—elevate the soft palate and adjacent portions of the pharyngeal wall and also pull open the entrance to the auditory tube. The **laryngeal elevators** raise the larynx. As a result, swallowing repeatedly can help you adjust to pressure changes when you fly or dive by opening the entrance to the auditory tube. Used together, the illustrations in Figure 11–9 and the summary in Table 11–6 will give you a more complete understanding of these muscles.

Table 11–5  **Muscles of the Tongue (Figure 11–8)**

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genioglossus</td>
<td>Medial surface of mandible</td>
<td>Body of tongue, hyoid bone</td>
<td>Depresses and protracts tongue</td>
<td>Hypoglossal nerve (XII)</td>
</tr>
<tr>
<td></td>
<td>around chin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyoglossus</td>
<td>Body and greater horn of hyoid bone</td>
<td>Side of tongue</td>
<td>Depresses and retracts tongue</td>
<td>Hypoglossal nerve (XII)</td>
</tr>
<tr>
<td>Palatoglossus</td>
<td>Anterior surface of soft palate</td>
<td>Side of tongue</td>
<td>Elevates tongue, depresses soft palate</td>
<td>Internal branch of accessory nerve (XI)</td>
</tr>
<tr>
<td>Stylloglossus</td>
<td>Styloid process of temporal bone</td>
<td>Along the side to tip and base of tongue</td>
<td>Retracts tongue, elevates side of tongue</td>
<td>Hypoglossal nerve (XII)</td>
</tr>
</tbody>
</table>
The posterior belly continues from the hyoid bone to the mastoid portion of the temporal bone. Depending on which belly contracts and whether fixator muscles are stabilizing the position of the hyoid bone, the digastric can open the mouth by depressing the mandible, or it can elevate the larynx by raising the hyoid bone.

The muscles of the anterior neck include (1) muscles that control the position of the larynx, (2) muscles that depress the mandible and tense the floor of the mouth, and (3) muscles that provide a stable foundation for muscles of the tongue and pharynx (Figure 11–9).

The digastric (di-GAS-trik) is one of the main muscles that controls the position of the larynx. This muscle has two bellies, as the name implies (di-, two + gaster, stomach). The anterior belly extends from the chin to the hyoid bone. The posterior belly continues from the hyoid bone to the mastoid portion of the temporal bone. Depending on which belly contracts and whether fixator muscles are stabilizing the position of the hyoid bone, the digastric can open the mouth by depressing the mandible, or it can elevate the larynx by raising the hyoid bone.

The digastric covers the broad, flat mylohyoid, which elevates the floor of the mouth or depresses the jaw when the

**Table 11–6  Muscles of the Pharynx (Figure 11–9)**

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHARYNGEAL CONstrictors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior constrictor</td>
<td>Pterygoid process of sphenoid, medial surfaces of mandible</td>
<td>Median raphe attached to occipital bone</td>
<td>Constricts pharynx to propel bolus into esophagus</td>
<td>Branches of pharyngeal plexus (from CN X)</td>
</tr>
<tr>
<td>Middle constrictor</td>
<td>Horns of hyoid bone</td>
<td>Median raphe</td>
<td>Constricts pharynx to propel bolus into esophagus</td>
<td>Branches of pharyngeal plexus (from CN X)</td>
</tr>
<tr>
<td>Inferior constrictor</td>
<td>Cricoid and thyroid cartilages of larynx</td>
<td>Median raphe</td>
<td>Constricts pharynx to propel bolus into esophagus</td>
<td>Branches of pharyngeal plexus (from CN X)</td>
</tr>
<tr>
<td>PALATAL MUSCLES</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Levator veli palatini</td>
<td>Petrous part of temporal bone; tissues around the auditory tube</td>
<td>Soft palate</td>
<td>Elevates soft palate</td>
<td>Branches of pharyngeal plexus (from CN X)</td>
</tr>
<tr>
<td>Tensor veli palatini</td>
<td>Sphenoidal spine; tissues around the auditory tube</td>
<td>Soft palate</td>
<td>Elevates soft palate</td>
<td>Trigeminal nerve (V)</td>
</tr>
<tr>
<td>LARYNGEAL ELEVATORS*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ranges from soft palate, to cartilage around inferior portion of auditory tube, to styloid process of temporal bone</td>
<td>Thyroid cartilage</td>
<td>Elevate larynx</td>
<td>Branches of pharyngeal plexus (from CN IX and CN X)</td>
</tr>
</tbody>
</table>

*Refers to the palatopharyngeus, salpingopharyngeus, and stylopharyngeus, assisted by the thyrohyoid, geniohyoid, stylohyoid, and hyoglossus, discussed in Tables 11–5 and 11–7.

**Muscles of the Anterior Neck**

The anterior muscles of the neck include (1) muscles that control the position of the larynx, (2) muscles that depress the mandible and tense the floor of the mouth, and (3) muscles that provide a stable foundation for muscles of the tongue and pharynx (Figure 11–10).

The digastric (di-GAS-trik) is one of the main muscles that controls the position of the larynx. This muscle has two bellies, as the name implies (di-, two + gaster, stomach). The anterior belly extends from the chin to the hyoid bone. The posterior belly continues from the hyoid bone to the mastoid portion of the temporal bone. Depending on which belly contracts and whether fixator muscles are stabilizing the position of the hyoid bone, the digastric can open the mouth by depressing the mandible, or it can elevate the larynx by raising the hyoid bone.

The digastric covers the broad, flat mylohyoid, which elevates the floor of the mouth or depresses the jaw when the bloodstream can have fatal consequences. Damage to a nerve can cause motor paralysis or sensory loss. For these reasons, the site of the injection must be selected with care. Bulky muscles that contain few large vessels or nerves are ideal sites. The gluteus medius or the posterior, lateral, superior part of the gluteus maximus is commonly selected. The deltoid of the arm, about 2.5 cm (1 in.) distal to the acromion, is another effective site. From a technical point of view, the vastus lateralis of the thigh is a good site. Injections into this thick muscle will not encounter vessels or nerves, but may cause pain later when the muscle is used in walking. This is the preferred injection site in infants before they start walking, as their gluteal and deltoid muscles are relatively small. The site is also used in elderly patients or others with atrophied gluteal and deltoid muscles.

**Clinical Note  Intramuscular Injections**

Drugs are commonly injected into muscle or adipose tissues rather than directly into the bloodstream. (Accessing blood vessels is more complicated.) An intramuscular (IM) injection introduces a drug into the mass of a large skeletal muscle. Depending on the size of the muscle, up to 5 mL of fluid may be injected at one time. This fairly large volume of drug then enters the circulation gradually. Uptake is generally faster and accompanied by less tissue irritation than when drugs are administered intradermally (injected into the dermis) or subcutaneously (injected into the subcutaneous layer). A decision on the injection technique and the injection site is based on the type of drug and its concentration.

For IM injections, the most common complications involve accidental injection into a blood vessel or nerve. The sudden entry of massive quantities of drug into the bloodstream can have fatal consequences. Damage to a nerve can cause motor paralysis or sensory loss. For these reasons, the site of the injection must be selected with care. Bulky muscles that contain few large vessels or nerves are ideal sites. The gluteus medius or the posterior, lateral, superior part of the gluteus maximus is commonly selected. The deltoid of the arm, about 2.5 cm (1 in.) distal to the acromion, is another effective site. From a technical point of view, the vastus lateralis of the thigh is a good site. Injections into this thick muscle will not encounter vessels or nerves, but may cause pain later when the muscle is used in walking. This is the preferred injection site in infants before they start walking, as their gluteal and deltoid muscles are relatively small. The site is also used in elderly patients or others with atrophied gluteal and deltoid muscles.
hyoid bone is fixed. It is aided by the deeper **geniohyoid** (je-ne-o-HI-oyd) that extends between the hyoid bone and the chin. The **stylohyoid** forms a muscular connection between the hyoid bone and the styloid process of the skull.

The **sternocleidomastoid** (ster-no-ki-di-MAST-oyd) extends from the clavicle and the sternum to the mastoid region of the skull and turns the head obliquely to the opposite side (see **Figure 11–10**). The **omohyoid** attaches to the scapula, the clavicle and first rib, and the hyoid bone. The other members of this group are strap-like muscles that extend between the sternum and larynx (**sternothyroid**) or hyoid bone (**sternohyoid**), and between the larynx and hyoid bone (**thyrohyoid**).

Now take a look at the muscles discussed here and depicted in **Figure 11–10** with the summary details in **Table 11–7**.

**Figure 11–10**  **Muscles of the Anterior Neck.**  **ATLAS:** Plates 3a–d; 17; 18a–c; 25

**Muscles of the Vertebral Column**

The muscles of the vertebral column are covered by more superficial back muscles, such as the trapezius and latissimus dorsi (look back at **Figure 11–4b**). The main muscles of this group are the **erector spinae** (SPI-nē) muscles, which include superficial and deep layers. The superficial layer can be divided into **spinalis**, **longissimus** (lon-JIS-ih-mus), and **iliocostalis** (i-li-o-kos-TAL-is) groups (**Figure 11–11**). In the inferior lumbar and sacral regions, the boundary between the longissimus and iliocostalis is indistinct. When contracting together, the erector spinae extend the vertebral column. When the muscles on only one side contract, the result is lateral flexion of the vertebral column.
Deep to the spinalis muscles, smaller muscles interconnect and stabilize the vertebrae. These muscles include the semispinalis group; the multifidus (mul-TIF-ih-dus); and the interspinales, intertransversarii (in-ter-tranz-ver-SAR-e-i), and rotatores (ró-teh-TOR-ez) (see Figure 11–11). In various combinations, they produce slight extension or rotation of the vertebral column. They are also important in making delicate adjustments in the positions of individual vertebrae, and they stabilize adjacent vertebrae. If injured, these muscles can start a cycle of pain and stabilize the vertebrae. These muscles include the semispinalis, interspinales, intertransversarii, multifidus, rotatores, and others.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digastric</td>
<td>Two bellies: anterior from inferior surface of mandible at chin; posterior from mastoid region of temporal bone</td>
<td>Hyoid bone</td>
<td>Depresses mandible or elevates larynx</td>
<td>Anterior belly: Trigeminal nerve (V), mandibular division Posterior belly: Facial nerve (VII)</td>
</tr>
<tr>
<td>Geniohyoid</td>
<td>Medial surface of mandible at chin</td>
<td>Hyoid bone</td>
<td>As above and pulls hyoid bone anteriorly</td>
<td>Cervical nerve C1 by hypoglossal nerve (XII)</td>
</tr>
<tr>
<td>Mylohyoid</td>
<td>Mylohyoid line of mandible</td>
<td>Median connective tissue band (raphe) that runs to hyoid bone</td>
<td>Elevates floor of mouth and hyoid bone or depresses mandible</td>
<td>Trigeminal nerve (V), mandibular division</td>
</tr>
<tr>
<td>Omohyoid (superior and inferior bellies united at central tendon anchored to clavicle and first rib)</td>
<td>Superior border of scapula near scapular notch</td>
<td>Hyoid bone</td>
<td>Depresses hyoid bone and larynx</td>
<td>Cervical spinal nerves C2–C3</td>
</tr>
<tr>
<td>Sternohyoid</td>
<td>Clavicle and manubrium</td>
<td>Hyoid bone</td>
<td>Depresses hyoid bone and larynx</td>
<td>Cervical spinal nerves C1–C3</td>
</tr>
<tr>
<td>Sternothyroid</td>
<td>Dorsal surface of manubrium and first costal cartilage</td>
<td>Thyroid cartilage of larynx</td>
<td>Depresses hyoid bone and larynx</td>
<td>Cervical spinal nerves C1–C3</td>
</tr>
<tr>
<td>Stylohyoid</td>
<td>Styloid process of temporal bone</td>
<td>Hyoid bone</td>
<td>Elevates larynx</td>
<td>Facial nerve (VII)</td>
</tr>
<tr>
<td>Thyrohyoid</td>
<td>Thyroid cartilage of larynx</td>
<td>Hyoid bone</td>
<td>Elevates thyroid, depresses hyoid bone</td>
<td>Cervical spinal nerves C2–C3 by hypoglossal nerve (XII)</td>
</tr>
<tr>
<td>Sternocleidomastoid</td>
<td>Two bellies: clavicular head attaches to sternal end of clavicle; sternal head attaches to manubrium</td>
<td>Mastoid region of skull and lateral portion of superior nuchal line</td>
<td>Together, they flex the neck; alone, one side flexes head toward shoulder and rotates face to opposite side</td>
<td>Accessory nerve (XI) and cervical spinal nerves (C2–C3) of cervical plexus</td>
</tr>
</tbody>
</table>

Now use the illustrations in Figure 11–11 together with the details in Table 11–8 for a further understanding of these muscles.

### Clinical Note: Signs of Stroke

A stroke, or cerebrovascular accident, may manifest in the muscular system. This happens, for example, when a clot in a blood vessel interrupts blood flow to the brain, and a muscle does not receive the signal to contract. Early recognition and treatment of a stroke can make all the difference in the outcome of this threatening disorder. Public service announcements by the National Stroke Association alert the public about stroke by means of a catchy phrase—“Act FAST”—where

- **F** stands for **F**ace: Ask the person to smile and look for a droop in the facial muscles on the affected side.
- **A** stands for **A**rm: Ask the person to raise both arms and see if he or she has the strength to do this.
- **S** stands for **S**peech: Ask the person to repeat a few words and listen for slurred speech to determine if pharyngeal and laryngeal muscles are affected.
- **T** stands for **T**ime: If you observe any of these signs, it’s time to call 9-1-1 for help.
Figure 11–11   Muscles of the Vertebral Column.

**Erector Spinae, Deep Layer**

**Semispinalis Group**
- Semispinalis capitis
- Semispinalis cervicis
- Semispinalis thoracis

**Intertransversarii**

**Rotatores**

**Interspinales**

**Transverse process of vertebra**

**Spinous process of vertebra**

**Multifidus**

**Erector Spinae, Superficial Layer**

**Spinalis, Longissimus, and Iliocostalis Groups**
- Longissimus capitis
- Spinalis cervicis
- Longissimus cervicis
- Iliocostalis cervicis
- Iliocostalis thoracis
- Longissimus thoracis
- Spinalis thoracis
- Iliocostalis lumborum

**Quadratus lumborum**

**Thoracodorsal fascia**

**Flexors of the Anterior Cervical and Thoracic Spine**

- Longus capitis
- Longus coli
### Muscles of the Vertebral Column (Figure 11–11)

<table>
<thead>
<tr>
<th>Group and Muscles</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUPERFICIAL LAYER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Erector spinae</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Splenius (spleinis capitis, splenius cervicis)</td>
<td>Spinal processes and ligaments connecting inferior cervical and superior thoracic vertebrae</td>
<td>Mastoid process, occipital bone of skull, and superior cervical vertebrae</td>
<td>Together, the two sides extend neck; alone, each rotates and laterally flexes neck to that side</td>
<td>Cervical spinal nerves</td>
</tr>
<tr>
<td>Spinalis cervicis</td>
<td>Superior borders of vertebrosternal ribs near the angles</td>
<td>Superior borders of inferior seven ribs medial to the angles</td>
<td>Extends vertebral column</td>
<td>Cervical and thoracic spinal nerves</td>
</tr>
<tr>
<td>Spinalis thoracis</td>
<td>Transverse processes of inferior thoracic and superior lumbar vertebrae</td>
<td>Superior borders of inferior seven ribs medial to the angles</td>
<td>Extends vertebral column</td>
<td>Thoracic and lumbar spinal nerves</td>
</tr>
<tr>
<td>Longissimus capitis</td>
<td>Transverse processes of inferior cervical and superior thoracic vertebrae</td>
<td>Transverse processes of middle and superior cervical vertebrae</td>
<td>Together, the two sides extend head; alone, each rotates and laterally flexes neck to that side</td>
<td>Cervical and thoracic spinal nerves</td>
</tr>
<tr>
<td>Longissimus cervicis</td>
<td>Transverse processes of superior thoracic vertebrae</td>
<td>Transverse processes of middle and superior cervical vertebrae</td>
<td>Together, the two sides extend head; alone, each rotates and laterally flexes neck to that side</td>
<td>Cervical and thoracic spinal nerves</td>
</tr>
<tr>
<td>Longissimus thoracis</td>
<td>Broad aponeurosis and transverse processes of inferior thoracic and superior lumbar vertebrae; joins ilioacostals</td>
<td>Transverse processes of superior vertebrae and inferior surfaces of ribs</td>
<td>Extends or laterally flexes neck, elevates ribs</td>
<td>Thoracic and lumbar spinal nerves</td>
</tr>
<tr>
<td>Iliocostalis cervicis</td>
<td>Superior borders of vertebrosternal ribs near the angles</td>
<td>Superior borders of inferior seven ribs medial to the angles</td>
<td>Extends or laterally flexes neck, elevates ribs</td>
<td>Cervical and superior thoracic spinal nerves</td>
</tr>
<tr>
<td>Iliocostalis thoracis</td>
<td>Transverse processes of inferior cervical and superior thoracic vertebrae</td>
<td>Upper ribs and transverse process of last cervical vertebra</td>
<td>Stabilizes thoracic vertebrae in extension</td>
<td>Thoracic spinal nerves</td>
</tr>
<tr>
<td>Iliocostalis lumborum</td>
<td>Iliac crest, sacral crests, and spinous processes</td>
<td>Inferior surfaces of inferior seven ribs near their angles</td>
<td>Extends vertebral column, depresses ribs</td>
<td>Inferior thoracic and lumbar spinal nerves</td>
</tr>
<tr>
<td><strong>DEEP LAYER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semispinalis capitis</td>
<td>Anterior and transverse processes of superior thoracic vertebrae; joins iliocostalis</td>
<td>Occipital bone, between nuchal lines</td>
<td>Together, the two sides extend neck; alone, each extends and laterally flexes neck</td>
<td>Cervical spinal nerves</td>
</tr>
<tr>
<td>Semispinalis cervicis</td>
<td>Transverse processes of T1–T5</td>
<td>Spinosus processes of C2–C6</td>
<td>Extends vertebral column and rotates toward opposite side</td>
<td>Cervical spinal nerves</td>
</tr>
<tr>
<td>Semispinalis thoracis</td>
<td>Transverse processes of T6–T10</td>
<td>Spinosus processes of C7–T4</td>
<td>Extends vertebral column and rotates toward opposite side</td>
<td>Thoracic spinal nerves</td>
</tr>
<tr>
<td>Multifidus</td>
<td>Sacrum and transverse processes of each vertebra</td>
<td>Spinous processes of the third or fourth more superior vertebrae</td>
<td>Extends vertebral column and rotates toward opposite side</td>
<td>Cervical, thoracic, and lumbar spinal nerves</td>
</tr>
<tr>
<td>Rotatores</td>
<td>Transverse processes of each vertebra</td>
<td>Spinous processes of adjacent, more superior vertebra</td>
<td>Extends vertebral column and rotates toward opposite side</td>
<td>Cervical, thoracic, and lumbar spinal nerves</td>
</tr>
<tr>
<td>Interspinales</td>
<td>Transverse processes of each vertebra</td>
<td>Spinous processes of more superior vertebra</td>
<td>Extends vertebral column</td>
<td>Cervical, thoracic, and lumbar spinal nerves</td>
</tr>
<tr>
<td>Intertransversarii</td>
<td>Transverse processes of each vertebra</td>
<td>Transverse process of more superior vertebra</td>
<td>Lateral flexes the vertebral column</td>
<td>Cervical, thoracic, and lumbar spinal nerves</td>
</tr>
<tr>
<td><strong>SPINAL FLEXORS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longus capitis</td>
<td>Transverse processes of cervical vertebrae</td>
<td>Base of the occipital bone</td>
<td>Together, the two sides flex the neck; alone, each rotates head to that side</td>
<td>Cervical spinal nerves</td>
</tr>
<tr>
<td>Longus colli</td>
<td>Anterior surfaces of cervical and superior thoracic vertebrae</td>
<td>Transverse processes of superior cervical vertebrae</td>
<td>Flexes or rotates neck; limits hyperextension</td>
<td>Cervical spinal nerves</td>
</tr>
<tr>
<td>Quadratus lumborum</td>
<td>Ilium crest and iliolumbar ligament</td>
<td>Last rib and transverse processes of lumbar vertebrae</td>
<td>Together, they depress ribs; alone, each side laterally flexes vertebral column</td>
<td>Thoracic and lumbar spinal nerves</td>
</tr>
</tbody>
</table>
Oblique and Rectus Muscles and the Diaphragm

The oblique and rectus muscle groups of the anterior body wall share developmental origins. We include the diaphragm here because it develops in association with the other muscles of the chest wall.

Oblique and Rectus Muscles

The oblique and rectus muscle groups lie within the body wall, between the spinous processes of vertebrae and the ventral midline (look back at Figure 11–4a for an overview, and then take a first look at Figure 11–12). The oblique muscles compress underlying structures or rotate the vertebral column, depending
on whether one or both sides contract. The rectus muscles are important flexors of the vertebral column, acting in opposition to the erector spinae. We can subdivide each of these groups into cervical, thoracic, and abdominal regions (Table 11–9).

The oblique group includes the scalene muscles of the neck (Figure 11–12a) and the intercostal and transversus muscles of the thorax (Figure 11–12b,c). The scalene muscles (anterior, middle, and posterior) elevate the first two ribs and assist in flexion of the neck. In the thorax, the oblique muscles extend between the ribs, with the external intercostal muscles covering the internal intercostal muscles. Both groups of intercostal muscles aid in breathing movements of the ribs. A small transversus thoracis (THOR-ah-sis) crosses the posterior surface of the sternum and is separated from the pleural cavity by the parietal pleura, a serous membrane. ☞ p. 140

The sternum occupies the place where we might otherwise expect thoracic rectus muscles to be.

The same basic pattern of musculature extends unbroken across the abdominopelvic surface (Figure 11–12b, d). Here, the muscles are the external oblique, internal oblique, transversus abdominis, and rectus abdominis (commonly called the “abs”). The rectus abdominis inserts at the xiphoid process and originates near the pubic symphysis. This muscle is longitudinally divided by the linea alba (white line), a median collagenous partition (see Figure 11–12b). The rectus abdominis is separated into segments by transverse

Table 11–9 Oblique and Rectus Muscle Groups (Figure 11–12)

<table>
<thead>
<tr>
<th>Group and Muscles</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OBLIQUE GROUP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cervical region</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scalenes (anterior, middle, and posterior)</td>
<td>Transverse and costal processes of cervical vertebrae</td>
<td>Superior surfaces of first two ribs</td>
<td>Elevate ribs or flex neck</td>
<td>Cervical nerves</td>
</tr>
<tr>
<td><strong>Thoracic region</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External intercostals</td>
<td>Inferior border of each rib</td>
<td>Superior border of more inferior rib</td>
<td>Elevate ribs</td>
<td>Intercostal nerves (branches of thoracic nerves)</td>
</tr>
<tr>
<td>Internal intercostals</td>
<td>Superior border of each rib</td>
<td>Inferior border of the preceding rib</td>
<td>Depress ribs</td>
<td>Intercostal nerves (branches of thoracic nerves)</td>
</tr>
<tr>
<td>Transversus thoracis</td>
<td>Posterior surface of sternum</td>
<td>Cartilages of ribs</td>
<td>Depress ribs</td>
<td>Intercostal nerves (branches of thoracic nerves)</td>
</tr>
<tr>
<td>Serratus posterior superior (Figure 11–14b)</td>
<td>Spinous processes of C7–T3 and ligamentum nuchae</td>
<td>Superior borders of ribs 2–5 near angles</td>
<td>Elevates ribs, enlarges thoracic cavity</td>
<td>Thoracic nerves (T1–T4)</td>
</tr>
<tr>
<td>Serratus posterior inferior (Figure 11–14b)</td>
<td>Aponeurosis from spinous processes of T8–L1</td>
<td>Inferior borders of ribs 8–12</td>
<td>Pulls ribs inferiorly; also pulls outward, opposing diaphragm</td>
<td>Thoracic nerves (T9–T12)</td>
</tr>
<tr>
<td><strong>Abdominal region</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External oblique</td>
<td>External and inferior borders of ribs 5–12</td>
<td>Linea alba and iliac crest</td>
<td>Compresses abdomen, depresses ribs, flexes or bends spine</td>
<td>Intercostal, iliohypogastric, and ilioinguinal nerves</td>
</tr>
<tr>
<td>Internal oblique</td>
<td>Thoracolumbar fascia and iliac crest</td>
<td>Inferior ribs, xiphoid process, and linea alba</td>
<td>Compresses abdomen, depresses ribs, flexes or bends spine</td>
<td>Intercostal, iliohypogastric, and ilioinguinal nerves</td>
</tr>
<tr>
<td>Transversus abdominis</td>
<td>Cartilages of ribs 6–12, iliac crest, and thoracolumbar fascia</td>
<td>Linea alba and pubis</td>
<td>Compresses abdomen</td>
<td>Intercostal, iliohypogastric, and ilioinguinal nerves</td>
</tr>
<tr>
<td><strong>RECTUS GROUP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cervical region</strong></td>
<td>See muscles in Table 11–6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thoracic region</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diaphragm</td>
<td>Xiphoid process, cartilages of ribs 4–10, and anterior surfaces of lumbar vertebrae</td>
<td>Central tendinous sheet</td>
<td>Contraction expands thoracic cavity and compresses abdominopelvic cavity</td>
<td>Phrenic nerve (C3–C5)</td>
</tr>
<tr>
<td><strong>Abdominal region</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectus abdominis</td>
<td>Superior surface of pubis around symphysis</td>
<td>Inferior surfaces of costal cartilages (ribs 5–7) and xiphoid process</td>
<td>Depresses ribs, flexes vertebral column, compresses abdomen</td>
<td>Intercostal nerves (T7–T12)</td>
</tr>
</tbody>
</table>

*Where appropriate, spinal nerves involved are given in parentheses.
There are no differences in the deep musculature between the female and male.
bands of collagen fibers called \textit{tendinous inscriptions}. Each segment contains muscle fibers that extend longitudinally, originating and inserting on the tendinous inscriptions. The bulging of enlarged muscle fibers of the rectus abdominis between these tendinous inscriptions produces what we call a "six-pack."

\textbf{The Diaphragm}

The term \textit{diaphragm} refers to any muscular sheet that forms a wall. When used without a modifier, however, \textit{diaphragm} specifies the muscular partition that separates the abdominopelvic and thoracic cavities (see \textbf{Figure 11–12c}). The diaphragm is a major muscle used in breathing and is further discussed in Chapter 23.

Now that you have been introduced to \textbf{Figure 11–12}, please study it together with the summary details presented in \textbf{Table 11–9}.

\textbf{Muscles of the Pelvic Floor}

The muscles of the pelvic floor extend from the sacrum and coccyx to the ischium and pubis (\textbf{Figure 11–13}). These muscles (1) support the organs of the pelvic cavity, (2) flex the sacrum and coccyx, and (3) control the movement of materials through the urethra and anus. They are summarized in \textbf{Table 11–10}.

The boundaries of the \textit{perineum} are formed by the inferior margins of the pelvis. A line drawn between the ischial

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
\textbf{Group and Muscle} & \textbf{Origin} & \textbf{Insertion} & \textbf{Action} & \textbf{Innervation*} \\
\hline
\textbf{UROGENITAL TRIANGLE} & & & & \\
Bulbospongiosus & Collagen sheath at base of penis; fibers cross over urethra & Median raphe and central tendon of perineum & Compresses base and stiffens penis; ejects urine or semen & Pudendal nerve, perineal branch (S\textsubscript{2}–S\textsubscript{4}) \\
\textbf{Superficial muscles} & Females & Collagen sheath at base of clitoris; fibers run on either side of urethral and vaginal opening & Central tendon of perineum & Compresses and stiffens clitoris; narrows vaginal opening & Pudendal nerve, perineal branch (S\textsubscript{2}–S\textsubscript{4}) \\
Ischiocavernosus & Ischial ramus and tuberosity & Pubic symphysis anterior to base of penis or clitoris & Compresses and stiffens penis or clitoris & Pudendal nerve, perineal branch (S\textsubscript{2}–S\textsubscript{4}) \\
\textbf{Superficial transverse perineal muscle} & Ischial ramus & Central tendon of perineum & Stabilizes central tendon of perineum & Pudendal nerve, perineal branch (S\textsubscript{2}–S\textsubscript{4}) \\
\textbf{Deep muscles} & Ischial ramus & Central tendon of perineum & Stabilizes central tendon of perineum & Pudendal nerve, perineal branch (S\textsubscript{2}–S\textsubscript{4}) \\
External urethral sphincter & Ischial and pubic rami & To median raphe at base of penis; inner fibers encircle urethra & Closes urethra; compresses prostate and bulbourethral glands & Pudendal nerve, perineal branch (S\textsubscript{2}–S\textsubscript{4}) \\
\textbf{Deep muscles} & Females & Ischial and pubic rami & To median raphe; inner fibers encircle urethra & Closes urethra; compresses vagina and greater vestibular glands & Pudendal nerve, perineal branch (S\textsubscript{2}–S\textsubscript{4}) \\
\hline
\textbf{ANAL TRIANGLE} & & & & \\
Pelvic diaphragm & Ischial spine & Lateral, inferior borders of sacrum and coccyx & Flexes coccygeal joints; tenses and supports pelvic floor & Inferior sacral nerves (S\textsubscript{2}–S\textsubscript{5}) \\
Coccygeus & Ischial spine, pubis & Coccyx and median raphe & Tenses floor of pelvis; flexes coccygeal joints; elevates and retracts anus & Pudendal nerve (S\textsubscript{2}–S\textsubscript{4}) \\
\textbf{Pelvic diaphragm} & \\
\textbf{Levator ani} & \\
\textbf{Iliococcygeus} & Inner margins of pubis & Coccyx and median raphe & Tenses floor of pelvis; flexes coccygeal joints; elevates and retracts anus & Pudendal nerve (S\textsubscript{2}–S\textsubscript{4}) \\
Pubococcygeus & By tendon from coccyx & Encircles anal opening & Closes anal opening & Pudendal nerve, hemorrhoidal branch (S\textsubscript{2}–S\textsubscript{4}) \\
\hline
\end{tabular}
\caption{Muscles of the Pelvic Floor (Figure 11–13)}
\end{table}

*Where appropriate, spinal nerves involved are given in parentheses.
tuberosities divides the perineum into two triangles: an anterior urogenital triangle and a posterior anal triangle (see Figure 11–13). The superficial muscles of the urogenital triangle are the muscles of the external genitalia. They cover deeper muscles that strengthen the pelvic floor and encircle the urethra. An even more extensive muscular sheet, the pelvic diaphragm, forms the muscular foundation of the anal triangle. This layer extends as far as the pubic symphysis.

The urogenital and pelvic diaphragms do not completely close the pelvic outlet. The urethra and anus (in males and females), as well as the vagina in females, pass through them to open on the exterior. Muscular sphincters surround the passageways, and the external sphincters permit voluntary control of urination and defecation. Muscles, nerves, and blood vessels also pass through the pelvic outlet as they travel to or from the lower limbs.

Once again, please compare the illustrations in Figure 11–13 with the specific details in Table 11–10.

**Checkpoint**

13. If you were contracting and relaxing your massester muscle, what would you probably be doing?

14. Which facial muscle is well developed in a professional trumpet player?

15. Why can swallowing help alleviate the pressure sensations at the eardrum when you are in an airplane that is changing altitude?

16. Damage to the external intercostal muscles would interfere with what important process?

17. If someone hit you in your rectus abdominis, how would your body position change?

18. After spending an afternoon carrying heavy boxes from his basement to his attic, Joe complains that the muscles in his back hurt. Which muscles are most likely sore?

See the blue Answers tab at the back of the book.

### 11-7 Appendicular muscles are muscles of the shoulders, upper limbs, pelvis, and lower limbs

**Learning Outcome** Identify the principal appendicular muscles of the body, plus their origins, insertions, actions, and innervation, and compare the major functional differences between the upper and lower limbs. They are summarized in Table 11–10.

The appendicular musculature positions and stabilizes the pectoral and pelvic girdles and moves the upper and lower limbs. There are two major groups of appendicular muscles: (1) the muscles of the shoulders (pectoral girdles) and upper limbs and (2) the muscles of the pelvis (pelvic girdle) and lower limbs.

The functions and required ranges of motion are very different between these groups. The muscular connections between the pectoral girdles and the axial skeleton increase the mobility of the arms and also act as shock absorbers. For example, while you jog, you can still perform delicate hand movements, because the muscular connections between the axial and appendicular components of the skeleton smooth out the bounces in your stride. In contrast, the pelvic girdle has evolved to transfer weight from the axial to the appendicular skeleton. Rigid, bony articulations are essential, because the emphasis is on strength rather than versatility, and a muscular connection would reduce the efficiency of the transfer.

Figure 11–14 and Table 11–11 provide an introduction to the organization of the appendicular muscles of the trunk.

### Table 11–11 Muscles That Position the Pectoral Girdle (Figures 11–14 and 11–15)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Levator scapula</strong></td>
<td>Transverse processes of first four cervical vertebrae</td>
<td>Vertebral border of scapula near superior angle</td>
<td>Elevates scapula</td>
<td>Cervical nerves C2–C4 and dorsal scapular nerve (C4)</td>
</tr>
<tr>
<td><strong>Pectoralis minor</strong></td>
<td>Anterior–superior surfaces of ribs 2–4, 2–5, or 3–5 depending on anatomical variation</td>
<td>Coracoid process of scapula</td>
<td>Depresses and protracts shoulder; rotates scapula so glenoid cavity moves inferiorly (downward rotation); elevates ribs if scapula is stationary</td>
<td>Medial pectoral nerve (C8, T1)</td>
</tr>
<tr>
<td><strong>Rhomboid major</strong></td>
<td>Spinous processes of superior thoracic vertebrae</td>
<td>Vertebral border of scapula from spine to inferior angle</td>
<td>Adducts scapula and performs downward rotation</td>
<td>Dorsal scapular nerve (C4)</td>
</tr>
<tr>
<td><strong>Rhomboid minor</strong></td>
<td>Spinous processes of vertebrae C2–T2</td>
<td>Vertebral border of scapula near spine</td>
<td>Adducts scapula and performs downward rotation</td>
<td>Dorsal scapular nerve (C4)</td>
</tr>
<tr>
<td><strong>Serratus anterior</strong></td>
<td>Anterior and superior margins of ribs 1–8 or 1–9</td>
<td>Anterior surface of vertebral border of scapula</td>
<td>Protracts shoulder; rotates scapula so glenoid cavity moves superiorly (upward rotation)</td>
<td>Long thoracic nerve (C5–C7)</td>
</tr>
<tr>
<td><strong>Subclavius</strong></td>
<td>First rib</td>
<td>Clavicle (inferior border)</td>
<td>Depresses and protracts shoulder</td>
<td>Nerve to subclavius (C5–C6)</td>
</tr>
<tr>
<td><strong>Trapezius</strong></td>
<td>Occipital bone, ligamentum nuchae, and spinous processes of thoracic vertebrae</td>
<td>Clavicle and scapula (acromion and scapular spine)</td>
<td>Depends on active region and state of other muscles; may (1) elevate, retract, depress, or rotate scapula upward, (2) elevate clavicle, or (3) extend neck</td>
<td>Accessory nerve (X) and cervical nerves (C2–C4)</td>
</tr>
</tbody>
</table>

*Where appropriate, spinal nerves involved are given in parentheses.*

---

Go to MasteringA&P® > Study Area > Menu > Animations & Videos > Origins, Insertions, Actions, Innervations: Rectus abdominis
Muscles of the Shoulders and Upper Limbs

We can divide the muscles associated with the shoulders and upper limbs into four groups: (1) muscles that position the pectoral girdle, (2) muscles that move the arm, (3) muscles that move the forearm and hand, and (4) muscles that move the fingers.

Muscles That Position the Pectoral Girdle

The large, superficial trapezius, commonly called the “traps,” cover the back and portions of the neck, reaching to the base of the skull. This muscle originates along the midline of the neck and back and inserts on the clavicles and the scapular spines (Figure 11–15). The trapezius is innervated by more than one nerve. For this reason, specific regions can be made to contract independently, and their actions are quite varied.

On the chest, the serratus (seh-RÄ-tus) anterior originates along the anterior surfaces of several ribs (see Figure 11–15a,b). This fan-shaped muscle inserts along the anterior margin of the vertebral border of the scapula. When the serratus anterior contracts, it abducts (protracts) the scapula and swings the shoulder anteriorly.

Two other deep chest muscles arise along the anterior surfaces of the ribs on either side. The subclavius (sub-KLÄ-vē-us; sub-, below + clavius, clavicle) inserts on the inferior border of the
clavicle (see Figure 11–15a). When it contracts, it depresses and protracts the scapular end of the clavicle. Because ligaments connect this end to the shoulder joint and scapula, those structures move as well. The pectoralis (pek-tō-RA-lis) minor attaches to the coracoid process of the scapula. The contraction of this muscle generally acts as a synergist to the subclavius.

Removing the trapezius reveals the rhomboid major, rhomboid minor, and levator scapulae (see Figure 11–15b). These muscles are attached to the posterior surfaces of the cervical and thoracic vertebrae. They insert along the vertebral border of each scapula, between the superior and inferior angles. Contraction of a rhomboid adducts (retracts) the scapula on that side. The levator scapulae, as its name implies, elevates the scapula.

Now take a look at how Figure 11–15 compares with the summary in Table 11–11.

**Muscles That Move the Arm**

Muscles that move the arm have their actions at the shoulder joint (Figure 11–16 and Table 11–12). The deltoid is the major abductor, but the supraspinatus (sū-prá-spī-NA-tus) acts as a synergist at the start of this movement. The subscapularis and teres major produce medial rotation at the shoulder, whereas the infraspinatus and the teres minor produce...
Figure 11–15  Muscles That Position the Pectoral Girdle.

Muscles That Position the Pectoral Girdle

- Trapezius
- Levator scapulae
- Subclavius
- Pectoralis minor

Muscles That Position the Pectoral Girdle

- Pectoralis minor (cut)
- Serratus anterior
- Biceps brachii, short head
- Biceps brachii, long head

Superficial Dissection

- Trapezius

Deep Dissection

- Levator scapulae
- Rhomboid minor
- Rhomboid major
- Serratus anterior
- Triceps brachii

Go to MasteringA&P™ > Study Area > Menu > Animations & Videos > Group Muscle Actions & Joints: Muscles of the pectoral girdle
Table 11–12  Muscles That Move the Arm (Figures 11–14 to 11–16)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deltoid</td>
<td>Clavicle and scapula (acromion and adjacent scapular spine)</td>
<td>Deltoid tuberosity of humerus</td>
<td>Whole muscle: abduction at shoulder; anterior part: flexion and medial rotation; posterior part: extension and lateral rotation</td>
<td>Axillary nerve (C₅–C₆)</td>
</tr>
<tr>
<td>Supraspinatus</td>
<td>Supraspinous fossa of scapula</td>
<td>Greater tubercle of humerus</td>
<td>Abduction at the shoulder</td>
<td>Suprascapular nerve (C₅)</td>
</tr>
<tr>
<td>Subscapularis</td>
<td>Subscapular fossa of scapula</td>
<td>Lesser tubercle of humerus</td>
<td>Medial rotation at shoulder</td>
<td>Subscapular nerves (C₅–C₆)</td>
</tr>
<tr>
<td>Teres major</td>
<td>Inferior angle of scapula</td>
<td>Passes medially to reach the medial lip of intertubercular sulcus of humerus</td>
<td>Extension, adduction, and medial rotation at shoulder</td>
<td>Lower subscapular nerve (C₅–C₆)</td>
</tr>
<tr>
<td>Infraspinatus</td>
<td>Infraspinous fossa of scapula</td>
<td>Greater tubercle of humerus</td>
<td>Lateral rotation at shoulder</td>
<td>Suprascapular nerve (C₅)</td>
</tr>
<tr>
<td>Teres minor</td>
<td>Lateral border of scapula</td>
<td>Passes laterally to reach the greater tubercle of humerus</td>
<td>Lateral rotation at shoulder</td>
<td>Axillary nerve (C₅)</td>
</tr>
<tr>
<td>Coracobrachialis</td>
<td>Coracoid process</td>
<td>Medial margin of shaft of humerus</td>
<td>Adduction and flexion at shoulder</td>
<td>Musculocutaneous nerve (C₅–C₆)</td>
</tr>
<tr>
<td>Pectoralis major</td>
<td>Cartilages of ribs 2–6, body of sternum, and inferior, medial portion of clavicle</td>
<td>Crest of greater tubercle and lateral lip of intertubercular sulcus of humerus</td>
<td>Flexion, adduction, and medial rotation at shoulder</td>
<td>Pectoral nerves (C₂–T₁)</td>
</tr>
<tr>
<td>Latissimus dorsi</td>
<td>Spinosous processes of inferior thoracic and all lumbar vertebrae, ribs 8–12, and thoracolumbar fascia</td>
<td>Floor of intertubercular sulcus of the humerus</td>
<td>Extension, adduction, and medial rotation at shoulder</td>
<td>Thoracodorsal nerve (C₆–C₇)</td>
</tr>
<tr>
<td>Triceps brachii</td>
<td>See Table 11–13</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Where appropriate, spinal nerves involved are given in parentheses.

lateral rotation. All these muscles originate on the scapula. The small coracobrachialis (KOR-uh-brä-ké-AH-ih) is the only muscle attached to the scapula that produces flexion and adduction at the shoulder (see Figure 11–16a).

The pectoralis major extends between the anterior portion of the chest and the crest of the greater tubercle of the humerus (see Figure 11–16a). The latissimus dorsi (la-TIS-i-mus DOR-se) extends between the thoracic vertebrae at the posterior midline and the intertubercular sulcus of the humerus (see Figure 11–16b). The pectoralis major produces flexion at the shoulder joint, and the latissimus dorsi produces extension. These muscles, commonly known as the “pecs” and the “lats,” can also work together to produce adduction and medial rotation of the humerus at the shoulder.

Collectively, the supraspinatus, infraspinatus, teres minor, and subscapularis and their associated tendons form the rotator cuff. Sports that involve throwing a ball, such as baseball or football, place considerable strain on the rotator cuff, and rotator cuff injuries are common.

**Tips & Tools**

The acronym SITS is useful in remembering the four muscles of the rotator cuff.

See how the illustrations in Figure 11–16 relate to the summary information in Table 11–12.

**Muscles That Move the Forearm and Hand**

The forearm is the region of the upper limb between the elbow and the hand, and the hand is the region distal to the radiocarpal joint, comprising the wrist, palm, and fingers. The muscles of this region can be grouped according to their actions at the elbow and hand, and include flexors, extensors, pronators, and supinators.

**Action at the Elbow.** Most of the muscles that move the forearm and hand originate on the humerus and insert on the forearm and wrist. There are two exceptions: the biceps brachii and triceps brachii. The biceps brachii and the long head of the triceps brachii originate on the scapula and insert on the bones of the forearm (Figure 11–17).
Figure 11–16  Muscles That Move the Arm. ATLAS: Plates 39a–d; 40a–b

Superficial Dissection

Deep Dissection

Muscles That Move the Arm

- Pectoralis major
- Deltoid
- Supraspinatus*
- Infraspinatus*
- Teres minor*
- Teres major
- Thoracolumbar fascia
- Coracobrachialis
- Biceps brachii, short head
- Biceps brachii, long head
- Triceps brachii, long head
- Triceps brachii, lateral head
- Subscapularis*

(*Rotator cuff muscle)

a Anterior view

b Posterior view

Go to MasteringA&P™ > Study Area > Menu > Animations & Videos > Origins, Insertions, Actions, Innervations: Biceps Brachii
Figure 11–17  Muscles That Move the Forearm and Hand. ATLAS: Plates 27a–c; 29a; 30; 33a–d; 37a,b

Give the origins of the heads of the triceps brachii.

Go to MasteringA&P > Study Area > Menu > Animations & Videos > Group Muscle Actions & Joints: Muscles of the elbow joint

Copyright Pearson
The triceps brachii inserts on the olecranon of the ulna. Contraction of the triceps brachii extends the elbow, as when you do push-ups. The biceps brachii inserts on the radial tuberosity, a roughened bump on the anterior surface of the radius. The biceps brachii is important in stabilizing the shoulder joint. The short head originates on the coracoid process and supports the posterior surface of the joint capsule. The long head originates at the supraglenoid tubercle, inside the shoulder joint. After crossing the head of the humerus, it passes along the intertubercular sulcus. In this position, the tendon helps to hold the head of the humerus within the glenoid cavity while arm movements are under way.

More muscles than these are shown in Figure 11–17 and summarized in Table 11–13. As you study these muscles, notice
Figure 11–18  Muscles That Move the Hand and Fingers.

Muscles That Flex the Fingers and Thumb
- Median nerve
- Pronator teres (cut)
- Brachial artery
- Flexor carpi ulnaris (retracted)
- Flexor digitorum superficialis
- Flexor digitorum profundus
- Flexor pollicis longus
- Cut tendons of flexor digitorum superficialis

Muscles That Move the Thumb
- Extensor pollicis longus
- Abductor pollicis longus
- Pronator quadratus
- Pronator teres
- Ulna
- Radius

Muscles That Move the Forearm
- Supinator
- Pronator teres
- Pronator quadratus
- Ulna
- Radius

SUPINATOR AND PRONATORS

LATERAL MUSCLES
- Biceps brachii
- Brachialis
- Radial nerve
- Brachioradialis (retracted)
- Brachioradialis (retracted)

MEDIAL MUSCLES
- Flexor carpi ulnaris (retracted)
- Flexor carpi ulnaris (retracted)
- Pronator teres (cut)
- Supinator
- Flexor digitorum profundus
- Pronator quadratus
- Pronator teres (cut)
- Pronator quadratus

Anterior view, middle layer
Anterior view, deepest layer
Posterior view, middle layer
Posterior view, deepest layer
Supination and pronation
that, in general, the extensor muscles lie along the posterior and lateral surfaces of the arm, whereas the flexors are on the anterior and medial surfaces. Connective tissue partitions separate major muscle groups, dividing the muscles into compartments formed by dense collagenous sheets.

The brachialis and brachioradialis (BRÁ-kē-ō-ră-de-AH-lis) flex the elbow and are opposed by the anconeus and the triceps brachii, respectively.

**Supination and Pronation.** Supination and pronation involve changes in the relationship between the bones of the forearm, the radius and ulna. Such changes also result in movement of the palm of the hand. For this reason, the muscles involved in supination and pronation are shown in Figure 11–18e. The supinator and pronator teres originate on both the humerus and ulna. These muscles rotate the radius without either flexing or extending the elbow. The square-shaped pronator quadratus originates on the ulna and assists the pronator teres in opposing the actions of the supinator or biceps brachii. During pronation, the tendon of the biceps brachii rotates with the radius. As a result, this muscle cannot assist in flexion of the elbow when the forearm is pronated.

**Action at the Hand.** The flexor carpi ulnaris, flexor carpi radialis, and palmaris longus are superficial muscles that work together to produce flexion of the wrist. The flexor carpi radialis flexes and abducts, and the flexor carpi ulnaris flexes and adducts. Pitcher’s arm is an inflammation at the origins of the flexor carpi muscles at the medial epicondyle of the humerus. This condition results from forcibly flexing the wrist just before releasing a baseball.

The extensor carpi radialis and the extensor carpi ulnaris have a similar relationship to that between the flexor carpi muscles. That is, the extensor carpi radialis produces extension and abduction, whereas the extensor carpi ulnaris produces extension and adduction.

Please take a look at the detailed summary listed in Table 11–13, and compare it with the illustrations in Figure 11–17 and Figure 11–18e.

Several superficial and deep muscles of the forearm flex and extend the finger joints (Figure 11–18 and Table 11–14). These large muscles end before reaching the wrist, and only their tendons cross the articulation. This arrangement ensures maximum mobility at both the wrist and hand. The tendons that cross the posterior and anterior surfaces of the wrist pass through synovial tendon sheaths, elongated bursae that reduce friction. See p. 269

The fascia of the forearm thickens on the posterior surface of the wrist, forming the extensor retinaculum.

---

Table 11–14 Muscles That Move the Hand and Fingers (Figure 11–18)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abductor pollicis longus</strong></td>
<td>Proximal dorsal surfaces of ulna and radius</td>
<td>Lateral margin of first metacarpal bone</td>
<td>Abduction at joints of thumb and wrist</td>
<td>Deep radial nerve (C7–C8)</td>
</tr>
<tr>
<td><strong>Extensor digitorum</strong></td>
<td>Lateral epicondyle of humerus</td>
<td>Posterior surfaces of the phalanges, fingers 2–5</td>
<td>Extension at finger joints and wrist</td>
<td>Deep radial nerve (C5–C8)</td>
</tr>
<tr>
<td><strong>Extensor pollicis brevis</strong></td>
<td>Shaft of radius distal to origin of abductor pollicis longus</td>
<td>Base of proximal phalanx of thumb</td>
<td>Extension at joints of thumb; abduction at wrist</td>
<td>Deep radial nerve (C5–C8)</td>
</tr>
<tr>
<td><strong>Extensor pollicis longus</strong></td>
<td>Posterior and lateral surfaces of ulna and interosseous membrane</td>
<td>Base of distal phalanx of thumb</td>
<td>Extension at joints of thumb; abduction at wrist</td>
<td>Deep radial nerve (C5–C8)</td>
</tr>
<tr>
<td><strong>Extensor indicis</strong></td>
<td>Posterior surface of ulna and interosseous membrane</td>
<td>Posterior surface of phalanges of index finger (2), with tendon of extensor digitorum</td>
<td>Extension and adduction at joints of index finger</td>
<td>Deep radial nerve (C5–C8)</td>
</tr>
<tr>
<td><strong>Extensor digiti minimi</strong></td>
<td>By extensor tendon to lateral epicondyle of humerus and from intermuscular septa</td>
<td>Posterior surface of proximal phalanx of little finger (5)</td>
<td>Extension at joints of little finger</td>
<td>Deep radial nerve (C5–C8)</td>
</tr>
<tr>
<td><strong>Flexor digitorum superficialis</strong></td>
<td>Medial epicondyle of humerus; adjacent anterior surfaces of ulna and radius</td>
<td>Midlateral surfaces of middle phalanges of fingers 2–5</td>
<td>Flexion at proximal interphalangeal, metacarpophalangeal, and wrist joints</td>
<td>Median nerve (C7–T1)</td>
</tr>
<tr>
<td><strong>Flexor digitorum profundus</strong></td>
<td>Medial and posterior surfaces of ulna, medial surface of coronoid process, and interosseous membrane</td>
<td>Bases of distal phalanges of fingers 2–5</td>
<td>Flexion at distal interphalangeal joints and, to a lesser degree, proximal interphalangeal joints and wrist</td>
<td>Palmar interosseous nerve, from median nerve, and ulnar nerve (C5–T1)</td>
</tr>
<tr>
<td><strong>Flexor pollicis longus</strong></td>
<td>Anterior shaft of radius, interosseous membrane</td>
<td>Base of distal phalanx of thumb</td>
<td>Flexion at joints of thumb</td>
<td>Median nerve (C5–T4)</td>
</tr>
</tbody>
</table>

*Where appropriate, spinal nerves involved are given in parentheses.*
Intrinsic Muscles of the Hand

- Flexor digitorum profundus
- Flexor digitorum superficialis
- Tendon of flexor pollicis longus
- Tendon of extensor digiti minimi
- Tendon of extensor carpi ulnaris
- Tendon of extensor carpi radialis brevis
- Tendon of extensor pollicis brevis
- Tendon of extensor pollicis longus
- Tendon of extensor digiti minimi
- Tendon of flexor carpi radialis
- Tendon of flexor carpi ulnaris
- Tendon of flexor retinaculum
- Flexor retinaculum
- Flexor digiti minimi brevis
- Opponens digitii minimi
- Palmaris brevis (cut)
- Abductor digiti minimi
- Flexor digiti minimi brevis
- Opponens digitii minimi
- Abductor digiti minimi
- Flexor digiti minimi brevis
- Opponens digitii minimi
- Palmaris brevis (cut)
- Abductor digiti minimi
- Flexor digiti minimi brevis
- Opponens digitii minimi
- Palmaris brevis (cut)

Which two intrinsic thumb muscles are an agonist-antagonist pair?
Table 11–15  Intrinsic Muscles of the Hand (Figure 11–19)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmaris brevis</td>
<td>Palmar aponeurosis</td>
<td>Skin of medial border of hand</td>
<td>Moves skin on medial border toward midline of palm</td>
<td>Ulnar nerve, superficial branch (C8)</td>
</tr>
<tr>
<td>Adduction/Abduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adductor pollicis** (3–4)</td>
<td>Metacarpal and carpel bones</td>
<td>Proximal phalanx of thumb</td>
<td>Adduction of thumb</td>
<td>Ulnar nerve, deep branch (C8–T1)</td>
</tr>
<tr>
<td>Palmar interosseus** (3–4)</td>
<td>Sides of metacarpal bones II, IV, and V</td>
<td>Bases of proximal phalanges of fingers 2, 4, and 5</td>
<td>Adduction at metacarpophalangeal joints of fingers 2 and 4; flexion at metacarpophalangeal joints; extension at interphalangeal joints</td>
<td>Ulnar nerve, deep branch (C8–T1)</td>
</tr>
<tr>
<td>Abductor pollicis brevis</td>
<td>Transverse carpal ligament, scaphoid, and trapezium</td>
<td>Radial side of base of proximal phalanx of thumb</td>
<td>Abduction of thumb</td>
<td>Median nerve (C6–C7)</td>
</tr>
<tr>
<td>Dorsal interosseus (4)</td>
<td>Each originates from opposing faces of two metacarpal bones (I and II, II and III, III and IV, IV and V)</td>
<td>Bases of proximal phalanges of fingers 2–4</td>
<td>Abduction at metacarpophalangeal joints of fingers 2 and 4; flexion at metacarpophalangeal joints; extension at interphalangeal joints</td>
<td>Ulnar nerve, deep branch (C8–T1)</td>
</tr>
<tr>
<td>Abductor digiti minimi</td>
<td>Pisiform</td>
<td>Proximal phalanx of little finger</td>
<td>Abduction of little finger and flexion at its metacarpophalangeal joint</td>
<td>Ulnar nerve, deep branch (C8–T1)</td>
</tr>
<tr>
<td>Flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexor pollicis brevis</td>
<td>Flexor retinaculum, trapeziun, capitae, and ulnar side of first metacarpal bone</td>
<td>Radial and ulnar sides of proximal phalanx of thumb</td>
<td>Flexion and adduction of thumb</td>
<td>Branches of median and ulnar nerves</td>
</tr>
<tr>
<td>Lumbricals (4)</td>
<td>Tendons of flexor digitorum profundus</td>
<td>Tendons of extensor digitorum to digits 2–5</td>
<td>Flexion at metacarpophalangeal joints 2–5; extension at proximal and distal interphalangeal joints, digits 2–5</td>
<td>Median nerve (lumbricals 1 and 2); ulnar nerve, deep branch (lumbricals 3 and 4)</td>
</tr>
<tr>
<td>Flexor digiti minimi brevis</td>
<td>Hamate</td>
<td>Proximal phalanx of little finger</td>
<td>Flexion at joints of little finger</td>
<td>Ulnar nerve, deep branch (C8–T1)</td>
</tr>
<tr>
<td>Opposition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opponens pollicis</td>
<td>Trapeziun and flexor retinaculum</td>
<td>First metacarpal bone</td>
<td>Opposition of thumb</td>
<td>Median nerve (C8–C1)</td>
</tr>
<tr>
<td>Opponens digiti minimi</td>
<td>Trapeziun and flexor retinaculum</td>
<td>Fifth metacarpal bone</td>
<td>Opposition of fifth metacarpal bone</td>
<td>Ulnar nerve, deep branch (C8–T1)</td>
</tr>
</tbody>
</table>

*Where appropriate, spinal nerves involved are given in parentheses.
**The deep, medial portion of the flexor pollicis brevis originating on the first metacarpal bone is sometimes called the first palmar interosseus muscle; it inserts on the ulnar side of the phalanx and is innervated by the ulnar nerve.

(ret-i-NAK-ū-lum; plural, retinacula), a wide band of connective tissue. The extensor retinaculum holds the tendons of the extensor muscles in place. On the anterior surface, the fascia also thickens to form another wide band of connective tissue, the flexor retinaculum, which stabilizes the tendons of the flexor muscles.

Inflammation of the retinacula and synovial tendon sheaths can restrict movement and put pressure on the distal portions of the median nerve, a mixed (sensory and motor) nerve that innervates the hand. This condition, known as carpal tunnel syndrome, causes tingling, numbness, weakness, and chronic pain. A common cause is repetitive hand or wrist movements.  

Please compare Figure 11–18 with the information summarized in Table 11–14 before you go on.

Muscles That Move the Fingers
The muscles of the forearm provide strength and gross motor movement of the hand and fingers. These muscles are known as the extrinsic muscles of the hand. Fine motor movement of the hand involves small intrinsic muscles, which originate on the carpal and metacarpal bones. No muscles originate on the phalanges, and only tendons extend across the distal joints of the fingers. The intrinsic muscles of the hand are detailed in Figure 11–19 and Table 11–15.

Muscles of the Pelvis and Lower Limbs
The pelvic girdle is tightly bound to the axial skeleton, permitting little movement. Few muscles of the axial musculature can influence the position of the pelvis. However, the muscles...
that position the lower limbs provide a range of movements in these limbs. These muscles can be divided into three functional groups: (1) muscles that move the thigh, (2) muscles that move the leg, and (3) muscles that move the foot and toes.

Muscles That Move the Thigh

Gluteal muscles cover the lateral surfaces of the ilia (Figure 11–20a–c). The *gluteus maximus* is the largest and most posterior of the gluteal muscles. Its origin includes parts of the ilium; the sacrum, and coccyx; and the thoracolumbar fascia. Acting alone, this massive muscle produces extension and lateral rotation at the hip joint (see Table 11–16).

The gluteus maximus shares an insertion with the *tensor fasciae latae* (FASH-ee-EE-lah TAH), which originates on the iliac crest and the anterior superior iliac spine. Together, these muscles pull on the *iliotibial tract* (il-ee-TI-bul Ul), a band of collagen

---

**Table 11–16 Muscles That Move the Thigh (Figure 11–20)**

<table>
<thead>
<tr>
<th>Group and Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GLUTEAL GROUP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gluteus maximus</td>
<td>Iliac crest, posterior gluteal line, and lateral surface of ilium; sacrum, coccyx, and thoracolumbar fascia</td>
<td>Iliotibial tract and gluteal tuberosity of femur</td>
<td>Extension and lateral rotation at hip</td>
<td>Inferior gluteal nerve (L₅–S₂)</td>
</tr>
<tr>
<td>Gluteus medius</td>
<td>Anterior iliac crest of ilium, lateral surface between posterior and anterior gluteal lines</td>
<td>Greater trochanter of femur</td>
<td>Abduction and medial rotation at hip</td>
<td>Superior gluteal nerve (L₄–S₁)</td>
</tr>
<tr>
<td>Gluteus minimus</td>
<td>Lateral surface of ilium between inferior and anterior gluteal lines</td>
<td>Greater trochanter of femur</td>
<td>Abduction and medial rotation at hip</td>
<td>Superior gluteal nerve (L₄–S₁)</td>
</tr>
<tr>
<td>Tensor fasciae latae</td>
<td>Iliac crest and lateral surface of anterior superior iliac spine</td>
<td>Iliotibial tract</td>
<td>Extension of the knee and lateral rotation of the leg acting through the iliotibial tract; abduction*** and medial rotation of the thigh</td>
<td>Superior gluteal nerve (L₄–S₁)</td>
</tr>
<tr>
<td><strong>LATERAL ROTATOR GROUP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obturators (externus and internus)</td>
<td>Lateral and medial margins of obturator foramen</td>
<td>Trochanteric fossa of femur (externus); medial surface of greater trochanter (internus)</td>
<td>Lateral rotation at hip</td>
<td>Obturator nerve (externus: L₅–L₆) and special nerve from sacral plexus (internus: L₄–S₁)</td>
</tr>
<tr>
<td>Piriformis</td>
<td>Anterolateral surface of sacrum</td>
<td>Greater trochanter of femur</td>
<td>Lateral rotation and abduction at hip</td>
<td>Branches of sacral nerves (S₁–S₂)</td>
</tr>
<tr>
<td>Gemellus (superior and inferior)</td>
<td>Ischial spine and tuberosity</td>
<td>Medial surface of greater trochanter with tendon of obturator internus</td>
<td>Lateral rotation at hip</td>
<td>Nerves to obturator internus and quadratus femoris</td>
</tr>
<tr>
<td>Quadratus femoris</td>
<td>Lateral border of ischial tuberosity</td>
<td>Intertrochanteric crest of femur</td>
<td>Lateral rotation at hip</td>
<td>Special nerve from sacral plexus (L₅–S₂)</td>
</tr>
<tr>
<td><strong>ADDUCTOR GROUP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adductor brevis</td>
<td>Inferior ramus of pubis</td>
<td>Linea aspera of femur</td>
<td>Adduction, flexion, and medial rotation at hip</td>
<td>Obturator nerve (L₆–L₇)</td>
</tr>
<tr>
<td>Adductor longus</td>
<td>Inferior ramus of pubis anterior to adductor brevis</td>
<td>Linea aspera of femur</td>
<td>Adduction, flexion, and medial rotation at hip</td>
<td>Obturator nerve (L₆–L₇)</td>
</tr>
<tr>
<td>Adductor magnus</td>
<td>Inferior ramus of pubis posterior to adductor brevis and ischial tuberosity</td>
<td>Linea aspera and adductor tubercle of femur</td>
<td>Adduction at hip; superior part produces flexion and medial rotation; inferior part produces extension and lateral rotation</td>
<td>Obturator and sciatic nerves</td>
</tr>
<tr>
<td>Pectineus</td>
<td>Superior ramus of pubis</td>
<td>Pectineal line inferior to lesser trochanter of femur</td>
<td>Flexion, medial rotation, and adduction at hip</td>
<td>Femoral nerve (L₅–L₆)</td>
</tr>
<tr>
<td>Gracilis</td>
<td>Inferior ramus of pubis</td>
<td>Medial surface of tibia inferior to medial condyle</td>
<td>Flexion at knee; adduction and medial rotation at hip</td>
<td>Obturator nerve (L₅–L₆)</td>
</tr>
<tr>
<td><strong>ILIOPSOAS GROUP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iliacus</td>
<td>Iliac fossa of ilium</td>
<td>Femur distal to lesser trochanter with that of psoas major</td>
<td>Flexion at hip</td>
<td>Femoral nerve (L₅–L₆)</td>
</tr>
<tr>
<td>Psoas major</td>
<td>Anterior surfaces and transverse processes of vertebrae (T₁₇–L₅)</td>
<td>Lesser trochanter in company with iliacus</td>
<td>Flexion at hip or lumbar intervertebral joints</td>
<td>Branches of the lumbar plexus (L₅–L₆)</td>
</tr>
</tbody>
</table>

*Where appropriate, spinal nerves involved are given in parentheses.
**The iliacus and iliacus are often considered collectively as the iliopsoas.
***Role in abduction is debatable.
Figure 11–20  Muscles That Move the Thigh.  

**Gluteal region, posterior view**

- Iliac crest
- Gluteus medius (cut)
- Gluteus maximus (cut)
- Obturator internus
- Sacrum

**Gluteal Group**
- Gluteus maximus
- Gluteus medius
- Gluteus minimus
- Tensor fasciae latae

**Iliopsoas Group**
- Psoas major
- Iliacus

**Lateral Rotator Group**
- Piriformis
- Superior gemellus
- Obturator internus
- Obturator externus
- Inferior gemellus
- Quadratus femoris
- Ischial tuberosity
- Iliotibial tract

**Adductor Group**
- Pectineus
- Adductor brevis
- Adductor longus
- Adductor magnus
- Gracilis

**Lateral view**

- Sartorius
- Rectus femoris
- Patella
- Plantaris
- Head of fibula
- Patellar ligament

**Anterior view of the iliopsoas and adductor groups**

- Obturator externus
- Inguinal ligament

**Posterior view, deep muscles**

- Superior gemellus
- Inferior gemellus
- Quadratus femoris
- Ischial tuberosity
- Iliotibial tract

**ATLAS: Plates 68a–c; 72a,b; 73a,b**
fibers that extends along the lateral surface of the thigh and inserts on the tibia. This tract provides a lateral brace for the knee that becomes particularly important when you balance on one foot.

The gluteus medius and gluteus minimus (see Figure 11–20a–c) originate anterior to the origin of the gluteus maximus and insert on the greater trochanter of the femur. The anterior gluteal line on the lateral surface of the ilium marks the boundary between these muscles.

The lateral rotators originate at or inferior to the horizontal axis of the acetabulum. There are six lateral rotator muscles in all. The piriformis (pir-i-FOR-mis) and the obturator are dominant (Figure 11–20c,d).

The adductors (see Figure 11–20c,d) originate inferior to the horizontal axis of the acetabulum. This muscle group includes the pectineus (pek-ti-NÉ-us), adductor magnus, adductor brevis, adductor longus, and gracilis (GRAS-i-lis). All but the adductor magnus originate both anterior and inferior to the joint, so they perform hip flexion as well as adduction. The adductor magnus can produce either adduction and flexion or adduction and extension, depending on the region stimulated. The adductor magnus can also produce medial or lateral rotation at the hip. The other muscles, which insert on low ridges along the posterior surface of the femur, produce medial rotation. When an athlete suffers a pulled groin, the problem is a strain—a muscle tear—in one of these adductor muscles.

A pair of muscles controls the internal surface of the pelvis. The large psoas (SŌ-us) major originates alongside the inferior thoracic and lumbar vertebrae. Its insertion lies on the lesser trochanter of the femur. Before reaching this insertion, its tendon merges with that of the iliacus (il-ī-ah-kus), which nests within the iliac fossa. These two powerful hip flexors are often grouped together and collectively referred to as the iliopsoas (il-ē-ō-SŌ-us) (see Figure 11–20d).

Please compare Figure 11–20 with Table 11–16 to understand the muscles that move the thigh.

### Muscles That Move the Leg

As in the upper limb, muscle distribution in the lower limb has a pattern: Extensor muscles are located along the anterior and lateral surfaces of the leg, and flexors lie along the posterior and medial surfaces (Figure 11–21). As in the upper limb, sturdy connective tissue partitions divide the lower limb into separate muscular compartments. The flexors and adductors originate on the pelvic girdle, but most extensors originate on the femoral surface.

The flexors of the knee include the biceps femoris, semitendinosus (sem-ē-ten-di-NŌ-sus), semimembranosus (sem-ē-mem-bra-NŌ-sus), and sartorius (see Figure 11–21a and Table 11–17). These muscles originate along the edges of the pelvis and insert on the tibia and fibula. The sartorius is the only knee flexor that originates superior to the acetabulum. Its insertion lies along the medial surface of the tibia.

### Table 11–17 Muscles That Move the Leg (Figure 11–21)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FLEXORS OF THE KNEE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps femoris</td>
<td>Ischial tuberosity and linea aspera of femur</td>
<td>Head of fibula, lateral condyle of tibia</td>
<td>Flexion at knee; extension and lateral rotation at hip</td>
<td>Sciatic nerve; tibial portion (S₁–S₂; to long head) and common fibular branch (L₅–S₂; to short head)</td>
</tr>
<tr>
<td>Semitendinosus</td>
<td>Ischial tuberosity</td>
<td>Proximal, medial surface of tibia near insertion of gracilis</td>
<td>Flexion at knee; extension and medial rotation at hip</td>
<td>Sciatic nerve (tibial portion; L₂–S₂)</td>
</tr>
<tr>
<td>Semimembranosus</td>
<td>Ischial tuberosity</td>
<td>Posterior surface of medial condyle of tibia</td>
<td>Flexion at knee; extension and medial rotation at hip</td>
<td>Sciatic nerve (tibial portion; L₂–S₂)</td>
</tr>
<tr>
<td>Sartorius</td>
<td>Anterior superior iliac spine</td>
<td>Medial surface of tibia near tibial tuberosity</td>
<td>Flexion at knee; flexion and lateral rotation at hip</td>
<td>Femoral nerve (L₂–L₅)</td>
</tr>
<tr>
<td>Popliteus</td>
<td>Lateral condyle of femur</td>
<td>Posterior surface of proximal tibial shaft</td>
<td>Medial rotation of tibia (or lateral rotation of femur); flexion at knee</td>
<td>Tibial nerve (L₅–S₂)</td>
</tr>
<tr>
<td><strong>EXTENSORS OF THE KNEE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectus femoris</td>
<td>Anterior inferior iliac spine and superior acetabular rim of ilium</td>
<td>Tibial tuberosity by patellar ligament</td>
<td>Extension at knee; flexion at hip</td>
<td>Femoral nerve (L₂–L₅)</td>
</tr>
<tr>
<td>Vastus intermedius</td>
<td>Anterolateral surface of femur and linea aspera (distal half)</td>
<td>Tibial tuberosity by patellar ligament</td>
<td>Extension at knee</td>
<td>Femoral nerve (L₂–L₅)</td>
</tr>
<tr>
<td>Vastus lateralis</td>
<td>Anterior and inferior to greater trochanter of femur and along linea aspera (proximal half)</td>
<td>Tibial tuberosity by patellar ligament</td>
<td>Extension at knee</td>
<td>Femoral nerve (L₂–L₅)</td>
</tr>
<tr>
<td>Vastus medialis</td>
<td>Entire length of linea aspera of femur</td>
<td>Tibial tuberosity by patellar ligament</td>
<td>Extension at knee</td>
<td>Femoral nerve (L₂–L₅)</td>
</tr>
</tbody>
</table>

*Where appropriate, spinal nerves involved are given in parentheses.
Figure 11-21  Muscles That Move the Leg.  

ATLAS: Plates 69a,b; 70a,b; 72a,b; 74; 76a,b; 78a-g

a Hip and thigh, posterior view

b Quadriceps femoris and thigh muscles, anterior view

c Sectional view

Which quadriceps femoris muscle is not visible from the superficial anterior thigh?
### Table 11–18 Extrinsic Muscles That Move the Foot and Toes (Figure 11–22)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACTION AT THE ANKLE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexors (dorsiflexors)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tibialis anterior</td>
<td>Lateral condyle and proximal shaft of tibia</td>
<td>Base of first metatarsal bone and medial cuneiform bone</td>
<td>Flexion (dorsiflexion) at ankle; inversion of foot</td>
<td>Deep fibular nerve (L₄–S₁)</td>
</tr>
<tr>
<td>Fibularis tertius</td>
<td>Distal anterior surface of fibula and interosseus membrane</td>
<td>Dorsal surface of fifth metatarsal bone</td>
<td>Flexion (dorsiflexion) at ankle; eversion of foot</td>
<td>Deep fibular nerve (L₄–S₁)</td>
</tr>
<tr>
<td><strong>Extensors (plantar flexors)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastrocnemius</td>
<td>Femoral condyles</td>
<td>Calcaneus by calcaneal tendon</td>
<td>Extension (plantar flexion) at ankle; flexion at knee</td>
<td>Tibial nerve (S₁–S₂)</td>
</tr>
<tr>
<td>Fibularis brevis</td>
<td>Midlateral margin of fibula</td>
<td>Base of fifth metatarsal bone</td>
<td>Eversion of foot and extension (plantar flexion) at ankle</td>
<td>Superficial fibular nerve (L₄–S₁)</td>
</tr>
<tr>
<td>Fibularis longus</td>
<td>Lateral condyle of tibia, head and proximal shaft of fibula</td>
<td>Base of first metatarsal bone and medial cuneiform bone</td>
<td>Eversion of foot and extension (plantar flexion) at ankle; supports longitudinal arch</td>
<td>Superficial fibular nerve (L₄–S₁)</td>
</tr>
<tr>
<td>Plantaris</td>
<td>Lateral supracondylar ridge</td>
<td>Posterior portion of calcaneus</td>
<td>Extension (plantar flexion) at ankle; flexion at knee</td>
<td>Tibial nerve (L₄–S₁)</td>
</tr>
<tr>
<td>Soleus</td>
<td>Head and proximal shaft of fibula and adjacent posteromedial shaft of tibia</td>
<td>Calcaneus by calcaneal tendon (with gastrocnemius)</td>
<td>Extension (plantar flexion) at ankle</td>
<td>Sciatic nerve, tibial branch (S₁–S₂)</td>
</tr>
<tr>
<td>Tibialis posterior</td>
<td>Intersosseous membrane and adjacent shafts of tibia and fibula</td>
<td>Tarsal and metatarsal bones</td>
<td>Adduction and inversion of foot; extension (plantar flexion) at ankle</td>
<td>Sciatic nerve, tibial branch (S₁–S₂)</td>
</tr>
<tr>
<td><strong>ACTION AT THE TOES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital flexors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexor digitorum longus</td>
<td>Posteromedial surface of tibia</td>
<td>Inferior surfaces of distal phalanges, toes 2–5</td>
<td>Flexion at joints of toes 2–5</td>
<td>Sciatic nerve, tibial branch (L₄–S₁)</td>
</tr>
<tr>
<td>Flexor hallucis longus</td>
<td>Posterior surface of fibula</td>
<td>Inferior surface, distal phalanx of great toe</td>
<td>Flexion at joints of great toe</td>
<td>Sciatic nerve, tibial branch (L₄–S₁)</td>
</tr>
<tr>
<td>Digital extensors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extensor digitorum longus</td>
<td>Lateral condyle of tibia, anterior surface of fibula</td>
<td>Superior surfaces of phalanges, toes 2–5</td>
<td>Extension at joints of toes 2–5</td>
<td>Deep fibular nerve (L₄–S₁)</td>
</tr>
<tr>
<td>Extensor hallucis longus</td>
<td>Anterior surface of fibula</td>
<td>Superior surface, distal phalanx of great toe</td>
<td>Extension at joints of great toe</td>
<td>Deep fibular nerve (L₄–S₁)</td>
</tr>
</tbody>
</table>

*Where appropriate, spinal nerves involved are given in parentheses.*

The sartorius crosses over two joints and its contraction produces flexion at the knee and lateral rotation at the hip. This happens when you cross your legs.

Three of these muscles—the biceps femoris, semitendinosus, and semimembranous—are often called the **hamstrings**. Because they originate on the pelvic surface inferior and posterior to the acetabulum, their contractions produce not only flexion at the knee, but also extension at the hip. A **pulled hamstring** is a common sports injury caused by a strain affecting one of the hamstring muscles.

**Tips & Tools**

To remember that three muscles make up the **hamstrings**, think “the three little pigs.” These three muscles are portions of the cut of meat known as ham.

The knee joint can be locked at full extension by a slight lateral rotation of the tibia. The small **popliteus** (pop-Ι-tē-us) originates on the femur near the lateral condyle and inserts on the posterior tibial shaft (see Figure 11–22a). When flexion is started, this muscle contracts to produce a slight medial rotation of the tibia that unlocks the knee joint.

Collectively, four **knee extensors**—the three **vastus muscles**, which originate along the shaft of the femur, and the **rectus femoris**—make up the **quadriceps femoris** (the “quads”). Together, the vastus muscles cradle the rectus femoris the way a bun surrounds a hot dog (Figure 11–21c). All four muscles insert on the patella by way of the quadriceps tendon. The force of their contraction is relayed to the tibial tuberosity by way of the patellar ligament. The rectus femoris originates on
Figure 11–22  Extrinsic Muscles That Move the Foot and Toes. ATLAS: Plates 81a,b; 82a,b; 84a,b
380 UNIT 2 Support and Movement

Clinical Note  Hernia

When the abdominal muscles contract forcefully, pressure in the abdominopelvic cavity can increase dramatically, applying pressure to internal organs. If the person exhales at the same time, the pressure is relieved because the diaphragm, the muscle that separates the thoracic and abdominopelvic cavities, can move upward as the lungs deflate. But during vigorous isometric exercises or when lifting a weight while holding one’s breath, pressure in the abdominopelvic cavity can rise to roughly 100 times the normal pressure. A pressure that high can cause a hernia. A hernia develops when a visceral organ or part of an organ protrudes abnormally through an opening in a surrounding muscular wall. There are many types of hernias. Here we will consider only inguinal (groin) hernias and diaphragmatic hernias.

In adult males, the spermatic cords penetrate the abdominal musculature through the inguinal canals on their way to the abdominal reproductive organs. In an inguinal hernia, the inguinal canal enlarges, and organs, such as a portion of the intestine, or (more rarely) urinary bladder, enter the inguinal canal. If these structures become trapped or twisted, surgery may be required.

In a diaphragmatic hernia, abdominal organs protrude through a weakness in the diaphragm. If these organs protrude through the esophageal hiatus, the passageway used by the esophagus, a hiatal hernia (hi-Á-tal; hiatus, opening) exists. Hiatal hernias are very common. Most go unnoticed, although they may increase the gastric acid entry into the esophagus, causing heartburn.

Tips & Tools

Think of the quadriceps femoris as “the four at the fore.”

Now compare the illustrations in Figure 11–21 with the summary of these muscles in Table 11–17.

Muscles That Move the Foot and Toes

The extrinsic muscles that move the foot and toes are shown in Figure 11–22 (p. 379) and summarized in Table 11–18 (p. 378). Most of the muscles that move the ankle produce the plantar flexion involved with walking and running movements. The gastrocnemius (gas-trok-NÉ-mé-us; gaster, stomach + kneme, knee) of the calf is an important plantar flexor, but the slow muscle fibers of the underlying soleus (SÔ-lé-us) are better suited for making continuous postural adjustments against the pull of gravity.

These muscles are best seen in posterior and lateral views (see Figure 11–22a,b). The gastrocnemius arises from two heads located on the medial and lateral epicondyles of the femur just proximal to the knee. The fabella, a sesamoid bone, is occasionally present in the tendon of the lateral head of the gastrocnemius.

Tips & Tools

The soleus is so named because it resembles the flat-bodied fish we call sole.

The gastrocnemius and soleus share a common tendon, the calcaneal tendon, commonly known as the Achilles tendon.

the anterior inferior iliac spine and the superior acetabular rim—so in addition to extending the knee, it assists in flexion of the hip.

Tips & Tools

Think of the quadriceps femoris as “the four at the fore.”
### Table 11–19  Intrinsic Muscles of the Foot (Figure 11–23)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FLEXION/EXTENSION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexor hallucis brevis</td>
<td>Cuboid and lateral cuneiform bones</td>
<td>Proximal phalanx of great toe</td>
<td>Flexion at metatarsophalangeal joint of great toe</td>
<td>Medial plantar nerve (L₄–L₅)</td>
</tr>
<tr>
<td>Flexor digitorum brevis</td>
<td>Calcaneus (tuberosity on inferior surface)</td>
<td>Sides of middle phalanges, toes 2–5</td>
<td>Flexion at proximal interphalangeal joints of toes 2–5</td>
<td>Medial plantar nerve (L₄–L₅)</td>
</tr>
<tr>
<td>Quadratus plantae</td>
<td>Calcaneus (medial, inferior surfaces)</td>
<td>Tendon of flexor digitorum longus</td>
<td>Flexion at joints of toes 2–5</td>
<td>Lateral plantar nerve (L₄–L₅)</td>
</tr>
<tr>
<td>Lumbricals (4)</td>
<td>Tendons of flexor digitorum longus</td>
<td>Tendons of extensor digitorum longus</td>
<td>Flexion at metatarsophalangeal joints; extension at proximal interphalangeal joints of toes 2–5</td>
<td>Medial plantar nerve (lumbrical 1), lateral plantar nerve (lumbricals, 2, 3, and 4)</td>
</tr>
<tr>
<td>Flexor digiti minimi brevis</td>
<td>Base of metatarsal bone V</td>
<td>Lateral side of proximal phalanx of toe 5</td>
<td>Flexion at metatarsophalangeal joint of toe 5</td>
<td>Lateral plantar nerve (S₁–S₃)</td>
</tr>
<tr>
<td>Extensor digitorum brevis</td>
<td>Calcaneus (superior and lateral surfaces)</td>
<td>Dorsal surfaces of toes 1–4</td>
<td>Extension at metatarsophalangeal joints of toes 1–4</td>
<td>Deep fibular nerve (L₅–S₁)</td>
</tr>
<tr>
<td>Extensor hallucis brevis</td>
<td>Superior surface of anterior calcaneus</td>
<td>Dorsal surface of the base of proximal phalanx of great toe</td>
<td>Extension of great toe</td>
<td>Deep fibular nerve (L₅–S₁)</td>
</tr>
</tbody>
</table>

**ADDUCTION/ABDUCTION**

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Innervation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adductor hallucis</td>
<td>Bases of metatarsal bones II–IV and plantar ligaments</td>
<td>Proximal phalanx of great toe</td>
<td>Adduction at metatarsophalangeal joint of great toe</td>
<td>Lateral plantar nerve (S₁–S₃)</td>
</tr>
<tr>
<td>Abductor hallucis</td>
<td>Calcaneus (tuberosity on inferior surface)</td>
<td>Medial side of proximal phalanx of great toe</td>
<td>Abduction at metatarsophalangeal joint of great toe</td>
<td>Medial plantar nerve (L₄–L₅)</td>
</tr>
<tr>
<td>Plantar interosseus (3)</td>
<td>Bases and medial sides of metatarsal bones</td>
<td>Medial sides of toes 3–5</td>
<td>Adduction at metatarsophalangeal joints of toes 3–5</td>
<td>Lateral plantar nerve (S₁–S₃)</td>
</tr>
<tr>
<td>Dorsal interosseus (4)</td>
<td>Sides of metatarsal bones</td>
<td>Medial and lateral sides of toe 2; lateral sides of toes 3 and 4</td>
<td>Abduction at metatarsophalangeal joints of toes 3 and 4</td>
<td>Lateral plantar nerve (S₁–S₃)</td>
</tr>
<tr>
<td>Abductor digiti minimi</td>
<td>Inferior surface of calcaneus</td>
<td>Lateral side of proximal phalanx, toe 5</td>
<td>Abduction at metatarsophalangeal joint of toe 5</td>
<td>Lateral plantar nerve (L₄–L₅)</td>
</tr>
</tbody>
</table>

*Where appropriate, spinal nerves involved are given in parentheses.

---

tendon. This term comes from Greek mythology, as Achilles was a warrior who was invincible but for one vulnerable spot: the calcaneal tendon. Outside mythology, damage to the calcaneal tendon isn’t a fatal problem. Although it is among the largest, strongest tendons in the body, its rupture is common. The applied forces increase markedly during rapid acceleration or deceleration. Sprinters can rupture the calcaneal tendon pushing off from starting blocks, and the elderly often snap this tendon during a stumble or fall. Surgery may be necessary to reposition and reconnect the torn ends of the tendon to promote healing.

Deep to the gastrocnemius and soleus are a pair of fibularis muscles, longus, and brevis, or peroneus (see Figure 11–22a,b). The fibularis produces eversion and extension (plantar flexion) at the ankle. Inversion is caused by the contraction of the tibialis (tib-ë-AH-lis) muscles. The large tibialis anterior flexes the ankle and opposes the gastrocnemius (see Figure 11–22b,c).

Important digital muscles originate on the surface of the tibia, the fibula, or both (see Figure 11–22c,d). Large synovial tendon sheaths surround the tendons of the tibialis anterior, extensor digitorum longus, and extensor hallucis longus, where they cross the ankle joint. The positions of these sheaths are stabilized by superior and inferior extensor retinacula.

The summary listed in Table 11–18 can be compared with Figure 11–22 for a more complete understanding of these muscles.

Intrinsic muscles of the foot originate on the tarsal and metatarsal bones (Figure 11–23 and Table 11–19). Their contractions move the toes and maintain the longitudinal arch of the foot.  

---
Figure 11–23  Intrinsic Muscles of the Foot. ATLAS: Plates 84a; 85a,b; 86c; 87a–c; 89

Intrinsic Muscles of the Foot

Dorsal view

Superficial Muscles of the Sole of the Foot

Deep Muscles of the Sole of the Foot

Intrinsic Muscles of the Foot

Tendons of flexor digitorum brevis

Lumbricals

Flexor hallucis brevis

Flexor digiti minimi brevis

Abductor hallucis

Quadratus plantae

Flexor digitorum brevis

Abductor digiti minimi

Plantar aponeurosis (cut)

Calcaneus

Tendon of flexor digitorum longus

Tendon of flexor hallucis longus

Tendon of flexor digitorum longus

Tendon of flexor hallucis brevis

Abductor hallucis

Extensor hallucis brevis

Abductor digiti minimi

Inferior extensor retinaculum

Tendon of fibularis tertius

Medial malleolus of tibia

Tendon of tibialis anterior

Tendon of extensor hallucis brevis

Flexor digitorum brevis

Abductor hallucis

Tendon of fibularis longus

Superior extensor retinaculum

Calcaneus

Lateral malleolus of fibula

Inferior extensor retinaculum

Tendon of fibularis tertius

Tendons of extensor digitorum brevis

Abductor digiti minimi

Superior extensor retinaculum

Tendons of extensor digitorum longus

Abductor digiti minimi

Quadratus plantae

Flexor digitorum brevis

Abductor digiti minimi

Inferior extensor retinaculum

Tendon of fibularis tertius

Tendons of extensor digitorum brevis

Abductor hallucis

Extensor hallucis brevis

Abductor hallucis

Calcaneus

Figure 11–23  Intrinsic Muscles of the Foot. ATLAS: Plates 84a; 85a,b; 86c; 87a–c; 89
speed up oxygen and nutrient delivery to and carbon dioxide removal from the muscle. They also bring heat to the skin for radiation into the environment.

- **Respiratory System**: Respiratory rate and depth of respiration increase. Air moves into and out of the lungs more quickly, keeping pace with the increased rate of blood flow through the lungs.

- **Integumentary System**: Blood vessels dilate, and sweat gland secretion increases. This combination increases evaporation at the skin surface and removes the excess heat generated by muscular activity.

- **Nervous and Endocrine Systems**: The responses of other systems are directed and coordinated through neural and endocrine (hormonal) adjustments in heart rate, respiratory rate, sweat gland activity, and mobilization of stored nutrient reserves.

Even when the body is at rest, the muscular system has extensive interactions with other systems. Build Your Knowledge Figure 11–24 summarizes the range of interactions between the muscular system and other body systems studied so far.

### Checkpoint

19. Shrugging your shoulders uses which muscles?
20. Baseball pitchers sometimes suffer from rotator cuff injuries. Which muscles are involved in this type of injury?
21. An injury to the flexor carpi ulnaris would impair which two movements?
22. Which leg movement would be impaired by injury to the obturator?
23. To what does a “pulled hamstring” refer?
24. How would a torn calcaneal tendon affect movement of the foot?

See the blue Answers tab at the back of the book.

### 11-8 Exercise of the muscular system produces responses in multiple body systems

**Learning Outcome** Explain the functional relationship between the muscular system and other body systems, and explain the role of exercise in producing various responses in other body systems.

To operate at maximum efficiency, the muscular system must be supported by many other systems. The changes that take place during exercise provide a good example of such interaction. As noted earlier, active muscles consume oxygen and generate carbon dioxide and heat. The immediate effects of exercise on various body systems include the following:

- **Cardiovascular System**: Blood vessels in active muscles and the skin dilate, and heart rate increases. These adjustments speed up oxygen and nutrient delivery to and carbon dioxide removal from the muscle. They also bring heat to the skin for radiation into the environment.

- **Respiratory System**: Respiratory rate and depth of respiration increase. Air moves into and out of the lungs more quickly, keeping pace with the increased rate of blood flow through the lungs.

- **Integumentary System**: Blood vessels dilate, and sweat gland secretion increases. This combination increases evaporation at the skin surface and removes the excess heat generated by muscular activity.

- **Nervous and Endocrine Systems**: The responses of other systems are directed and coordinated through neural and endocrine (hormonal) adjustments in heart rate, respiratory rate, sweat gland activity, and mobilization of stored nutrient reserves.

See the blue Answers tab at the back of the book.
**Integumentary System**
- The Integumentary System removes excess body heat, synthesizes vitamin D₃ for calcium and phosphate absorption, and protects underlying muscles.
- The muscular system includes facial muscles that pull on the skin of the face to produce facial expressions.

**Skeletal System**
- The Skeletal System provides mineral reserves for maintaining normal calcium and phosphate levels in body fluids, supports skeletal muscles, and provides sites of muscle attachment.
- The muscular system provides skeletal movement and support, and stabilizes bones and joints. Stresses exerted by tendons maintain normal bone structure and bone mass.

**Muscular System**
- The muscular system performs these primary functions for the human body:
  - It produces skeletal movement
  - It helps maintain posture and body position
  - It supports soft tissues
  - It guards entrances and exits to the body
  - It helps maintain body temperature
Chapter 11 The Muscular System

11-6 Axial muscles are muscles of the head and neck, vertebral column, trunk, and pelvic floor p. 347

12. The axial muscles fall into logical groups on the basis of location, function, or both.

13. Important muscles of facial expression include the orbicularis oris, buccinator, occipitofrontalis, and platysma. (Figure 11–5; Table 11–2)

14. Six extrinsic eye muscles (oculomotor muscles) control eye movements: the inferior and superior rectus, the lateral and medial rectus, and the inferior and superior oblique. (Figure 11–6; Table 11–3)

15. The muscles of mastication (chewing) are the masseter, temporalis, and pterygoid muscles. (Figure 11–7; Table 11–4)

16. The four muscles of the tongue are necessary for speech and swallowing and assist in mastication. They are the palatoglossus, styloglossus, genioglossus, and hyoglossus. (Figure 11–8; Table 11–5)

17. The muscles of the pharynx constrict the pharyngeal walls (pharyngeal constrictors), raise the larynx (laryngeal elevators), or raise the soft palate (palatal muscles). (Figure 11–9; Table 11–6)

18. The anterior muscles of the neck control the position of the larynx, depress the mandible, and provide a foundation for the muscles of the tongue and pharynx. The neck muscles include the digastric and sternocleidomastoid and seven muscles that originate or insert on the hyoid bone. (Figure 11–10; Table 11–7)

19. The superficial muscles of the spine can be classified into the spinalis, longissimus, and iliocostalis groups. (Figure 11–1; Table 11–8)

20. Other muscles of the spine include the longus capitis and longus colli of the neck, the small intervertebral muscles of the deep layer, and the quadratus lumborum of the lumbar region. (Figure 11–11; Table 11–8)

21. The oblique muscles include the scalene muscles and the intercostal and transversus muscles. The external and internal intercostal muscles are important in respiratory (breathing) movements of the ribs. Also important to respiration is the diaphragm. (Figures 11–11, 11–12; Table 11–9)

22. The perineum can be divided into an anterior urogenital triangle and a posterior anal triangle. The pelvic floor contains the muscles comprising the pelvic diaphragm. (Figure 11–13; Table 11–10)


**11-7 Appendicular muscles are muscles of the shoulders, upper limbs, pelvis, and lower limbs** p. 362

23. The **trapezius** affects the positions of the shoulder girdle, head, and neck. Other muscles inserting on the scapula include the **rhomboid**, **levator scapulae**, **serratus anterior**, **subclavius**, and **pectoralis minor**. (Figures II–14, II–16; Table II–11)

24. Among muscles that move the arm, the **deltoid** and the **supraspinatus** are important abductors. The **subscapularis** and **teres major** produce medial rotation at the shoulder; the **infraspinatus** and **teres minor** produce lateral rotation; and the **coracobrachialis** produces flexion and adduction at the shoulder. (Figures II–14, II–15, II–16; Table II–12)

25. The **pectoralis major** flexes the shoulder joint, and the **latissimus dorsi** extends it. (Figures II–14, II–15, II–16; Table II–12)

26. Among muscles that move the forearm and hand, the actions of the **biceps brachii** and the **triceps brachii** (long head) affect the elbow joint. The **brachialis** and **brachioradialis** flex the elbow, opposed by the **anconeus**. The **flexor carpi ulnaris**, **flexor carpi radialis**, and **palmaris longus** cooperate to flex the wrist. The **extensor carpi radialis** and the **extensor carpi ulnaris** oppose them. The **pronator teres** and **pronator quadratus** pronate the forearm and are opposed by the **supinator**. (Figures II–16 to II–19; Tables II–13 to II–15)

27. Among muscles that move the thigh, the **gluteal muscles** cover the lateral surfaces of the ilia. The largest is the **gluteus maximus**, which shares an insertion with the **tensor fasciae latae**. Together, these muscles pull on the **iliotibial tract**. (Figure II–20; Table II–16)

28. The **piriformis** and the **obturator** are the most important lateral rotators. The **adductors** can produce a variety of movements. (Figure II–20; Table II–16)

29. The **psosas major** and *iliacus* merge to form the **iliopsoas**, a powerful flexor of the hip. (Figures II–20, II–21; Table II–16)

30. Among muscles that move the leg, the flexors of the knee include the **biceps femoris**, **semimembranosus**, and **semitendinosus** (the three hamstrings) and the **sartorius**. The **popliteus** unlocks the knee joint. (Figures II–21, II–22a; Table II–17)

31. Collectively, the knee extensors are known as the **quadriceps femoris**. This group consists of the three **vastus** muscles (intermedius, lateralis, medialis) and the **rectus femoris**. (Figure II–21; Table II–17)

32. Among muscles that move the foot and toes, the **gastrocnemius** and **soleus** produce plantar flexion (ankle extension). The **fibularis brevis** and **longus** produce eversion as well as extension (plantar flexion) at the ankle. The **fibularis tertius** produces eversion and flexion (dorsiflexion) at the ankle. (Figure II–22; Table II–18)

33. Smaller muscles of the calf and shin (tibia) position the foot and move the toes. Muscles originating at the tarsal and metatarsal bones provide precise control of the phalanges. (Figure II–23; Table II–19)

**11-8 Exercise of the muscular system produces responses in multiple body systems** p. 382

34. Exercise illustrates the integration of the muscular system with the cardiovascular, respiratory, integumentary, nervous, and endocrine systems. (Figure II–24)

---

**Review Questions**

**LEVEL 1 Reviewing Facts and Terms**

1. Name the three pennate muscles in the following figure, and for each muscle indicate the type of pennate muscle based on the relationship of muscle fascicles to the tendon.

   (a) ___________
   (b) ___________
   (c) ___________

2. Label the three visible muscles of the rotator cuff in the following posterior view of the deep muscles that move the arm.

   (a) ___________
   (b) ___________
   (c) ___________

3. The bundles of muscle fibers within a skeletal muscle are called (a) muscles, (b) fascicles, (c) fibers, (d) myofilaments, (e) groups.
4. Levers make action more versatile by all of the following, except (a) changing the location of the muscle’s insertion, (b) changing the speed of movement produced by an applied force, (c) changing the distance of movement produced by an applied force, (d) changing the strength of an applied force, (e) changing the direction of an applied force.

5. The more movable end of a muscle is the (a) insertion, (b) belly, (c) origin, (d) proximal end, (e) distal end.

6. The muscles of facial expression are innervated by cranial nerve (a) VII, (b) V, (c) IV, (d) VI.

7. The strongest masticatory muscle is the (a) pterygoid, (b) masseter, (c) temporalis, (d) mandible.

8. The muscle that rotates the eye medially is the (a) superior oblique, (b) inferior rectus, (c) medial rectus, (d) lateral rectus.

9. Important flexors of the vertebral column that act in opposition to the erector spinae are the (a) rectus abdominis, (b) longus capitis, (c) longus colli, (d) scalene.

10. The major extensor of the elbow is the (a) triceps brachii, (b) biceps brachii, (c) deltoid, (d) subscapularis.

11. The muscles that rotate the radius without producing either flexion or extension of the elbow are the (a) brachialis and brachioradialis, (b) pronator teres and supinator, (c) biceps brachii and triceps brachii, (d) a, b, and c.

12. The powerful flexor of the hip is the (a) piriformis, (b) obturator, (c) pectineus, (d) iliopsoas.

13. Knee extensors known as the quadriceps femoris consist of the (a) three vastus muscles and the rectus femoris, (b) biceps femoris, gracilis, and sartorius, (c) popliteus, iliotibialis, and gracilis, (d) gastrocnemius, tibialis, and peroneus.

14. List the four patterns of fascicle arrangement used to classify the different types of skeletal muscles.

15. What is an aponereous? Give two examples.

16. Which four muscle groups make up the axial musculature?

17. What three functions are accomplished by the muscles of the pelvic floor?

18. On which bones do the four rotator cuff muscles originate and insert?

19. What three functional groups make up the muscles of the lower limbs?

LEVEL 2 Reviewing Concepts

20. Of the following actions, the one that illustrates that of a second-class lever is (a) knee extension, (b) ankle extension (plantar flexion), (c) flexion at the elbow, (d) none of these.

21. Compartment syndrome can result from all of the following except (a) compressing a nerve in the wrist, (b) compartments swelling with blood due to an injury involving blood vessels, (c) torn ligaments in a given compartment, (d) pulled tendons in the muscles of a given compartment, (e) torn muscles in a particular compartment.

22. A(n) _______ develops when an organ protrudes through an abnormal opening.

23. Elongated bursae that reduce friction and surround the tendons that cross the posterior and anterior surfaces of the wrist form ______.

24. The muscles of the vertebral column include many posterior extensors but few anterior flexors. Why?

25. Why does a convergent muscle exhibit more versatility when contracting than does a parallel muscle?

26. Why can a pennate muscle generate more tension than can a parallel muscle of the same size?

27. Why is it difficult to lift a heavy object when the elbow is at full extension?

28. Which types of movements are affected when the hamstrings are injured?

LEVEL 3 Critical Thinking and Clinical Applications

29. Mary sees Jill coming toward her and immediately contracts her frontal and procerus. She also contracts her right levator labii. Is Mary glad to see Jill? How can you tell?

30. Mary’s newborn is having trouble suckling. The doctor suggests that it may be a problem with a particular muscle. What muscle is the doctor probably referring to? (a) orbicularis oris, (b) buccinator, (c) masseter, (d) risorius, (e) zygomaticus.

31. While unloading her car trunk, Amy strains a muscle and as a result has difficulty moving her arm. The doctor in the emergency room tells her that she strained her pectoralis major. Amy tells you that she thought the pectoralis major was a chest muscle and doesn’t understand what that has to do with her arm. What should you tell her?

CLINICAL CASE Wrap-Up Downward-Facing Dog

At his 3-month visit, the nurse practitioner evaluates Rick’s gains following the regular, low-intensity yoga exercise program. She conducts a review of systems, with a focus on his musculoskeletal system. She is looking for improved muscular strength and increased range of motion at the joints. She’ll also inquire about Rick’s arthritis pain level and how successfully he is able to perform his ADLs, or activities of daily living.

She observes that his muscle tone has improved overall. He can flex and extend more freely at joints in his arms and legs. He can get up from a chair and sit down with smoother motion than he could at the last visit. He is still working on balance issues, but he can reach up and around, as in putting on his coat. “I was a gymnast for my college team, back in the day,” Rick tells her. “This is the best I’ve felt in years!”

1. Look at the photo of the person executing Downward-Facing Dog. Which muscles are contracting in this pose?

2. Which of Rick’s muscles will help him maintain better posture as he goes about his day?

See the blue Answers tab at the back of the book.
Related Clinical Terms

**charley horse:** Common name for a muscle spasm, especially in the leg.

**compartment syndrome:** A condition in which increased pressure within the muscle compartment of a limb produces ischemia or “blood starvation.”

**fibromyositis:** Chronic illness characterized by widespread musculoskeletal aches, pains, and stiffness, and soft tissue tenderness.

**groin pull:** An injury that is due to a strain of the muscles of the inner thigh.

**impingement syndrome:** Pain on elevation of the shoulder due to an injured or inflamed tendon or bursa coming into contact with the overlying acromial process.

**physical therapist:** Healthcare professional who uses specially designed exercises and equipment to help patients regain or improve their physical abilities.

**plantar fasciitis:** Inflammation of the plantar fascia causing foot or heel pain.

**shin splints:** Pain along the shinbone (tibia) caused by an overload on the tibia and connective tissues that connect muscle to the bone.

**tenosynovitis:** Inflammation of a tendon and the sheath that covers it.

**torticollis:** A shortening or contraction of the muscles of the neck resulting in the head being tipped to one side with the chin turned to the other side.