9: MUSCULAR SYSTEM

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CHAPTER OVERVIEW

9: Muscular System

9.1: Introduction to the Muscular System

Chapter Learning Objectives

After studying this chapter, you will be able to:

- Describe the actions and roles of agonists and antagonists
- Explain the structure and organization of muscle fascicles and their role in generating force
- Explain the criteria used to name skeletal muscles
- Identify the skeletal muscles and their actions on the skeleton and soft tissues of the body
- Identify the origins and insertions of skeletal muscles and the movements they cause

Think about the things that you do each day—talking, walking, sitting, standing, and running—all of these activities require movement of particular skeletal muscles. Skeletal muscles are even used during sleep. The diaphragm is a sheet of skeletal muscle that has to contract and relax for you to breathe day and night. If you recall from your study of the skeletal system and joints, body movement occurs around the joints in the body. The focus of this chapter is on skeletal muscle organization. The system to name skeletal muscles will be explained; in some cases, the muscle is named by its shape, and in other cases it is named by its location or attachments to the skeleton. If you understand the meaning of the name of the muscle, often it will help you remember its location and/or what it does. This chapter also will describe how skeletal muscles are arranged to accomplish movement, and how other muscles may assist, or be arranged on the skeleton to resist or carry out the opposite movement. The actions of the skeletal muscles will be covered in a regional manner, working from the head down to the toes.

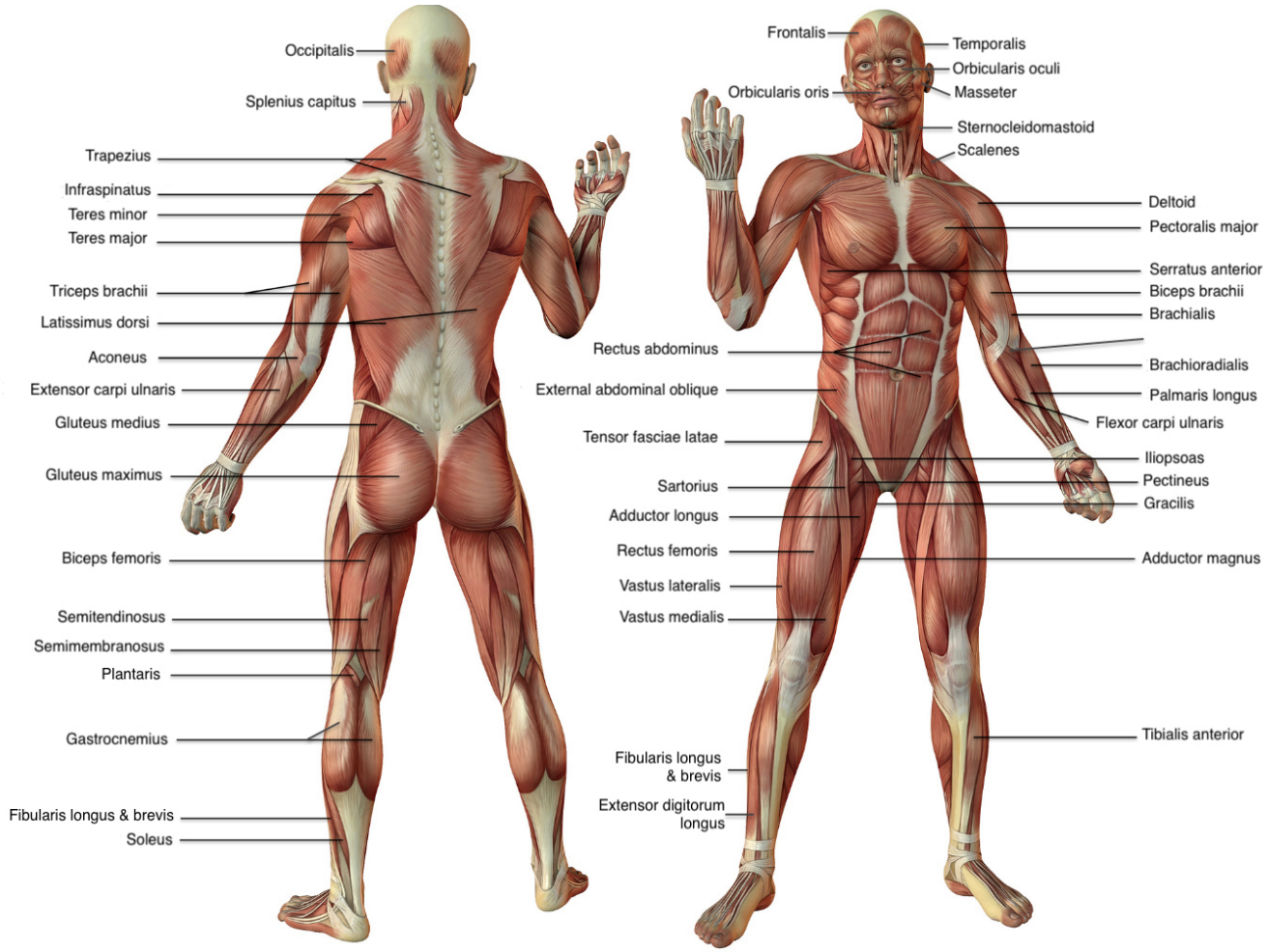

Figure 9.1.1: Muscles of the Body - Anterior and Posterior Views. *(Image credit: "Muscles of the Human Body" by Jennifer Lange, based on original by Homme en Noir is licensed by Creative Commons Attribution-Share Alike 4.0 International)*

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9.2: Interactions of Skeletal Muscles, Their Fascicle Arrangement, and Their Lever Systems

By the end of this section, you will be able to:

- Compare and contrast agonist and antagonist muscles
- Describe how fascicles are arranged within a skeletal muscle
- Explain the three types of muscle lever systems

To move the skeleton, the tension created by the contraction of the fibers in most skeletal muscles is transferred to the tendons. The tendons are strong bands of dense, regular connective tissue that connect muscles to bones. The bone connection is why this muscle tissue is called skeletal muscle.

Interactions of Skeletal Muscles in the Body

To pull on a bone, that is, to change the angle at its synovial joint by moving the skeleton, a skeletal muscle must also be attached to a fixed part of the skeleton. The end of the muscle attached to a fixed (stabilized) bone is called the **origin** and the moveable end of the muscle that attaches to the bone being pulled is called the muscle's **insertion**. The muscle's line of pull indicates the direction the body part will move when the insertion point is brought closer to the origin point (Figure 9.2.1).

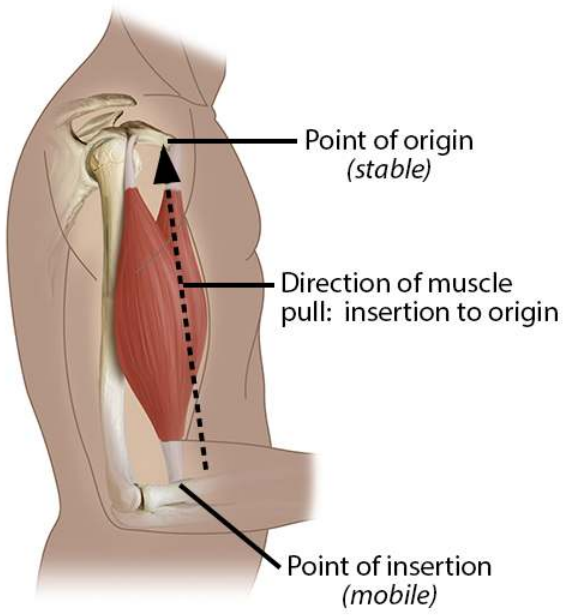

Figure 9.2.1: Origin and Insertion Points. When a muscle contracts and shortens, the bone at the point of insertion will move toward the bone at the point of origin. *(Image credit: "Origin and Insertion" by Justin Greene and Jennifer Lange is licensed under CC BY-NC-SA 4.0.)*

Although a number of muscles may be involved in an action, the principal muscle involved is called the **prime mover**, or **agonist**. During forearm **flexion** (bending the elbow), such as lifting a cup, a muscle called the biceps brachii is actually the prime mover; however, because it can be assisted by the brachialis, the brachialis is called a **synergist** in this action (Figure 9.2.2). Also involved is the brachioradialis which assists the brachialis, and is also considered a synergist. A synergist can also be a **fixator** that stabilizes the bone that is the attachment for the prime mover's origin.

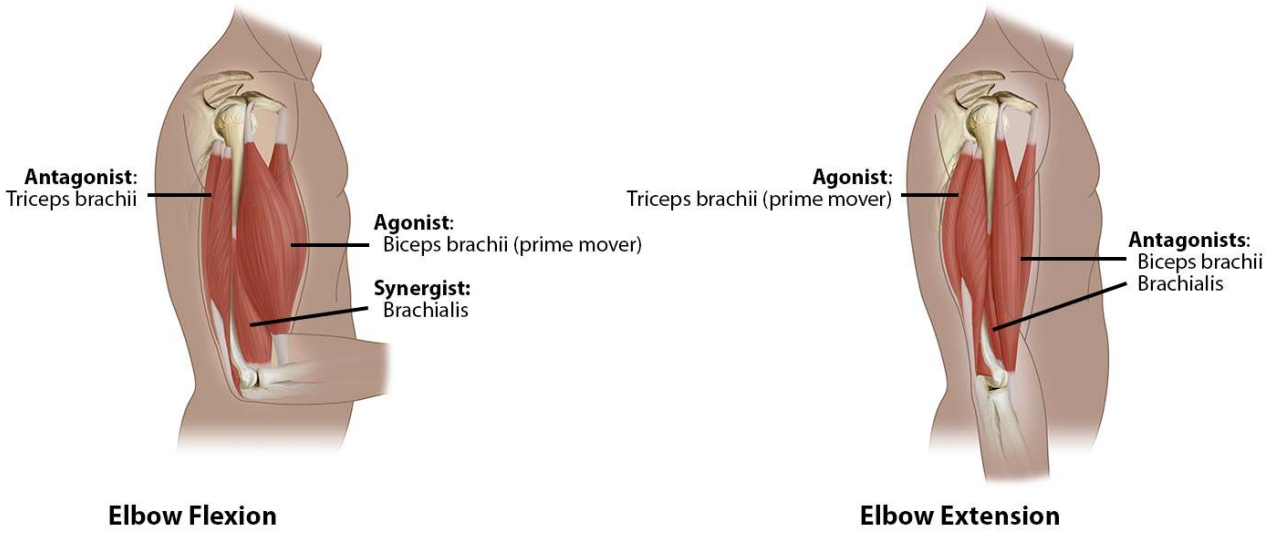

Figure 9.2.2: Functional Interactions. The biceps brachii flexes the forearm and the triceps brachii extends the arm, making them an agonist/antagonist pair. The brachialis is a synergist of biceps brachii that aids in its motions. *(Image credit: "Agonist and Antagonist" by Justin Greene and Jennifer Lange is licensed under CC BY-NC-SA 4.0.)*

A muscle with the opposite action of the prime mover is called an **antagonist**. Antagonists play two important roles in muscle function: (1) they maintain body or limb position, such as holding the arm out or standing erect; and (2) they control rapid movement, as in shadow boxing without landing a punch or the ability to check the motion of a limb.

For example, to extend the knee, a group of four muscles called the quadriceps femoris in the anterior compartment of the thigh are activated (and would be called the agonists of knee extension). However, to flex the knee joint, an opposite or antagonistic set of muscles called the hamstrings is activated.

As you can see, these terms would also be reversed for the opposing action. If you consider the first action as the knee bending, the hamstrings would be called the agonists and the quadriceps femoris would then be called the antagonists. See Table 9.2.1 for a list of some agonists and antagonists.

***Table* 9.2.1*:* Agonist and Antagonist Skeletal Muscle Pairs**

Agonist	Antagonist	Movement
Biceps brachii: in the anterior compartment of the arm	Triceps brachii: in the posterior compartment of the arm	The biceps brachii flexes the forearm, whereas the triceps brachii extends it.
Hamstrings: group of three muscles in the posterior compartment of the thigh	Quadriceps femoris: group of four muscles in the anterior compartment of the thigh	The hamstrings flex the leg, whereas the quadriceps femoris extend it.
Flexor digitorum superficialis and flexor digitorum profundus: in the anterior compartment of the forearm	Extensor digitorum: in the posterior compartment of the forearm	The flexor digitorum superficialis and flexor digitorum profundus flex the fingers and the hand at the wrist, whereas the extensor digitorum extends the fingers and the hand at the wrist.

There are also skeletal muscles that do not pull against the skeleton for movements. For example, there are the muscles that produce facial expressions. The insertions and origins of facial muscles are in the skin, so that certain individual muscles contract to form a smile or frown, form sounds or words, and raise the eyebrows. There also are skeletal muscles in the tongue, and the external urinary and anal sphincters that allow for voluntary regulation of urination and defecation, respectively. In addition, the diaphragm contracts and relaxes to change the volume of the pleural cavities but it does not move the skeleton to do this.

EVERYDAY CONNECTIONS

Exercise and Stretching

When exercising, it is important to first warm up the muscles. Stretching pulls on the muscle fibers and it also results in an increased blood flow to the muscles being worked. Without a proper warm-up, it is possible that you may either damage some of the muscle fibers or pull a tendon. A pulled tendon, regardless of location, results in pain, swelling, and diminished function; if it is moderate to severe, the injury could immobilize you for an extended period.

Recall the discussion about muscles crossing joints to create movement. Most of the joints you use during exercise are synovial joints, which have synovial fluid in the joint space between two bones. Exercise and stretching may also have a beneficial effect on synovial joints. Synovial fluid is a thin, but viscous film with the consistency of egg whites. When you first get up and start moving, your joints feel stiff for a number of reasons. After proper stretching and warm-up, the synovial fluid may become less viscous, allowing for better joint function.

Patterns of Fascicle Organization

Skeletal muscle is enclosed in connective tissue scaffolding at three levels. Each muscle fiber (cell) is covered by endomysium and the entire muscle is covered by epimysium. When a group of muscle fibers is "bundled" as a unit within the whole muscle by an additional covering of a connective tissue called perimysium, that bundled group of muscle fibers is called a **fascicle**. Fascicle arrangement by perimysia is correlated to the force generated by a muscle; it also affects the range of motion of the muscle. Based on the patterns of fascicle arrangement, skeletal muscles can be classified in several ways. Figure 9.2.3 shows some of the most common fascicle arrangements.

Parallel muscles have fascicles that are arranged in the same direction as the long axis of the muscle. The majority of skeletal muscles in the body have this type of organization. Some parallel muscles are flat sheets that expand at the ends to make broad attachments. Other parallel muscles are rotund with tendons at one or both ends. Muscles that seem to be plump have a large mass of tissue located in the middle of the muscle, between the insertion and the origin, which is known as the central body, or **belly**. When a muscle contracts, the contractile fibers shorten it to an even larger bulge. For example, extend and then flex your biceps brachii muscle; the large, middle section is the belly (Figure 9.2.2). When a parallel muscle has a central, large belly that is spindle-shaped, meaning it tapers as it extends to its origin and insertion, it sometimes is called **fusiform**. Parallel muscles that do not have have a spindle-shape, but instead have a more consistent diameter throughout the length of the muscle, such as sartorius of the upper leg, are non-fusiform.

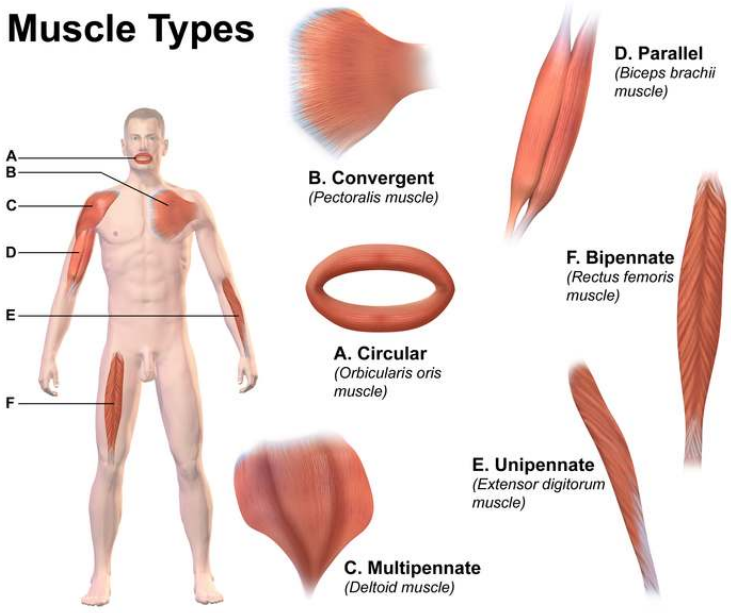

Figure 9.2.3: Muscle Shapes and Fascicle Arrangement. The skeletal muscles of the body typically come in six different general shapes. *(Image credit: "Muscle Types" by BruceBlaus is licensed under CC-BY-SA 4.0 International.*

Circular muscles are also called sphincters (Figure 9.2.3). When they relax, the sphincters' concentrically arranged bundles of muscle fibers increase the size of the opening, and when they contract, the size of the opening shrinks to the point of closure. The orbicularis oris muscle is a circular muscle that goes around the mouth. When it contracts, the oral opening becomes smaller, as when puckering the lips for whistling. Another example is the orbicularis oculi, one of which surrounds each eye. Consider, for example, the names of the two orbicularis muscles (orbicularis oris and orbicularis oculi), where part of the first name of both muscles is the same. The first part of orbicularis, orb (orb = "circular"), is a reference to a round or circular structure; it may also make one think of orbit, such as the moon's path around the earth. The word oris (oris = "oral") refers to the oral cavity, or the mouth. The word oculi (ocular = "eye") refers to the eye.

When a muscle has a widespread expansion over a sizable area, but then the fascicles come to a single, common attachment point, the muscle is called **convergent**. The attachment point for a convergent muscle could be a tendon, an aponeurosis (a flat, broad tendon), or a raphe (a very slender tendon). The large muscle on the chest, the pectoralis major, is an example of a convergent muscle because it converges on the greater tubercle of the humerus via a tendon. The temporalis muscle of the cranium is another.

Pennate muscles (penna = "feathers") blend into a tendon that runs through the central region of the muscle for its whole length, somewhat like the quill of a feather with the muscle arranged similar to the feathers. Due to this design, the muscle fibers in a pennate muscle can only pull at an angle, and as a result, contracting pennate muscles do not move their tendons very far. However, because a pennate muscle generally can hold more muscle fibers within it, it can produce relatively more tension for its size. There are three subtypes of pennate muscles.

In a **unipennate** muscle, the fascicles are located on one side of the tendon. The extensor digitorum of the forearm is an example of a unipennate muscle. A **bipennate** muscle has fascicles on both sides of the tendon, as seen in rectus femoris of the upper leg. In some pennate muscles, the muscle fibers wrap around the tendon, sometimes forming individual fascicles in the process. This arrangement is referred to as **multipennate**. A common example is the deltoid muscle of the shoulder, which covers the shoulder but has a single tendon that inserts on the deltoid tuberosity of the humerus.

Because of the fascicle arrangement, a portion of a multipennate muscle like the deltoid can be stimulated by the nervous system to change the direction of the pull. For example, when the deltoid muscle contracts, the arm **abducts** (moves away from midline in the sagittal plane), but when only the anterior fascicles are stimulated, the arm will abduct and flex (move anteriorly at the shoulder joint).

The Lever System of Muscle and Bone Interactions

Skeletal muscles do not work by themselves. Muscles are arranged in pairs based on their functions. For muscles attached to the bones of the skeleton, the connection determines the force, speed, and range of movement. These characteristics depend on each other and can explain the general organization of the muscular and skeletal systems.

The skeleton and muscles act together to move the body. Have you ever used the back of a hammer to remove a nail from wood? The handle acts as a lever and the head of the hammer acts as a fulcrum, the fixed point that the force is applied to when you pull back or push down on the handle. The effort applied to this system is the pulling or pushing on the handle to remove the nail, which is the load, or "resistance" to the movement of the handle in the system. Our musculoskeletal system works in a similar manner, with bones being stiff levers and the articular endings of the bones—encased in synovial joints—acting as fulcrums. The load would be an object being lifted or any resistance to a movement (your head is a load when you are lifting it), and the effort, or applied force, comes from contracting skeletal muscle.

Lever systems in the human body are classified based on the arrangement pattern of the fulcrum, resistance, and the applied force (Figure 9.2.4):

- **First Class Lever:** When the fulcrum lies between the resistance and the applied force, it is considered to be a first class lever (Figure 9.2.4.*a*). Tilting your head back uses a first class lever. In this motion the atlanto-occipital joint is the fulcrum, the head is the resistance, and the applied force is generated by the trapezius muscle of the neck.
- **Second Class Lever:** A second class lever is arranged with the resistance between the fulcrum and the applied force (Figure 9.2.4.*b*). When you stand on your tip toes, a second class lever is in use. The the body (resistance), lies between the metatarsophalangeal joints (fulcrum), and the applied forced from several lower leg muscles including gastrocnemius.
- **Third Class Lever:** The arrangement of a third class lever has the applied force between the fulcrum and the resistance (Figure 9.2.4.*c*). Flexion at the elbow, with the biceps brachii muscle (applied force) between the elbow joint (fulcrum) and the lower arm (resistance), is an example of motion using a third class lever.

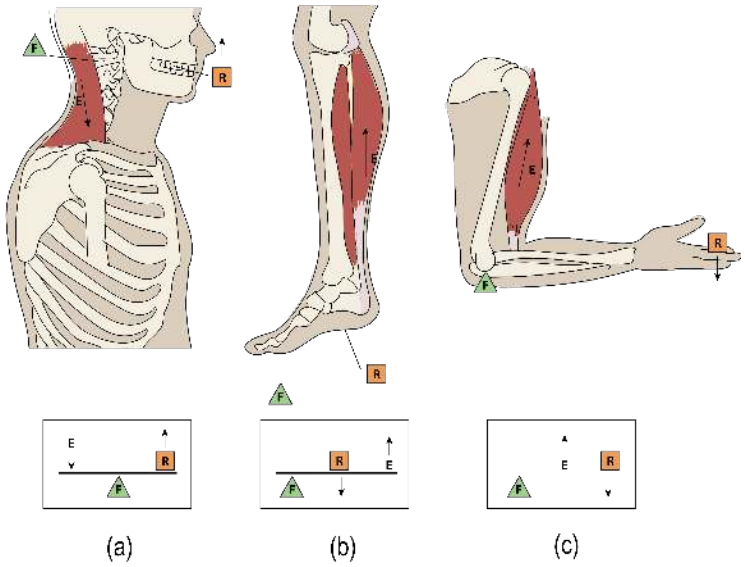

Figure 9.2.4: Lever Systems of the Human Body. (a) First class lever. (b) Second class lever. (c) Third class lever. The arrangement of the fulcrum (F), resistance (R), and effort, or applied force (E), determines the lever type found in the human body. *(Image credit: "Lever Systems of the Human Body" by Daniel Donnelly is licensed under CC BY 4.0, recolored by Jennifer Lange)*

Concept Review

Skeletal muscles each have an origin and an insertion. The end of the muscle that attaches to the bone being pulled is called the muscle's insertion and the end of the muscle attached to a fixed, or stabilized, bone is called the origin. The muscle primarily responsible for a movement is called the prime mover, and muscles that assist in this action are called synergists. A synergist that makes the insertion site more stable is called a fixator. Meanwhile, a muscle with the opposite action of the prime mover is called an antagonist. Several factors contribute to the force generated by a skeletal muscle. One is the arrangement of the fascicles in the

skeletal muscle. Fascicles can be parallel, circular, convergent, or pennate. Each arrangement has its own range of motion and ability to do work.

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9.3: Naming Skeletal Muscles

By the end of this section, you will be able to:

- Describe the criteria used to name skeletal muscles
- Explain how understanding the muscle names helps describe shapes, location, and actions of various muscles

The Greeks and Romans conducted the first studies done on the human body in Western culture. The educated class of subsequent societies studied Latin and Greek, and therefore the early pioneers of anatomy continued to apply Latin and Greek terminology or roots when they named the skeletal muscles. The large number of muscles in the body and unfamiliar words can make learning the names of the muscles in the body seem daunting, but understanding the etymology can help. Etymology is the study of how the root of a particular word entered a language and how the use of the word evolved over time. Taking the time to learn the root of the words is crucial to understanding the vocabulary of anatomy and physiology. When you understand the names of muscles it will help you remember where the muscles are located and what they do (Figure 9.3.1, Table 9.3.1, and Table 9.3.2). Pronunciation of words and terms will take a bit of time to master, but after you have some basic information the correct names and pronunciations will become easier.

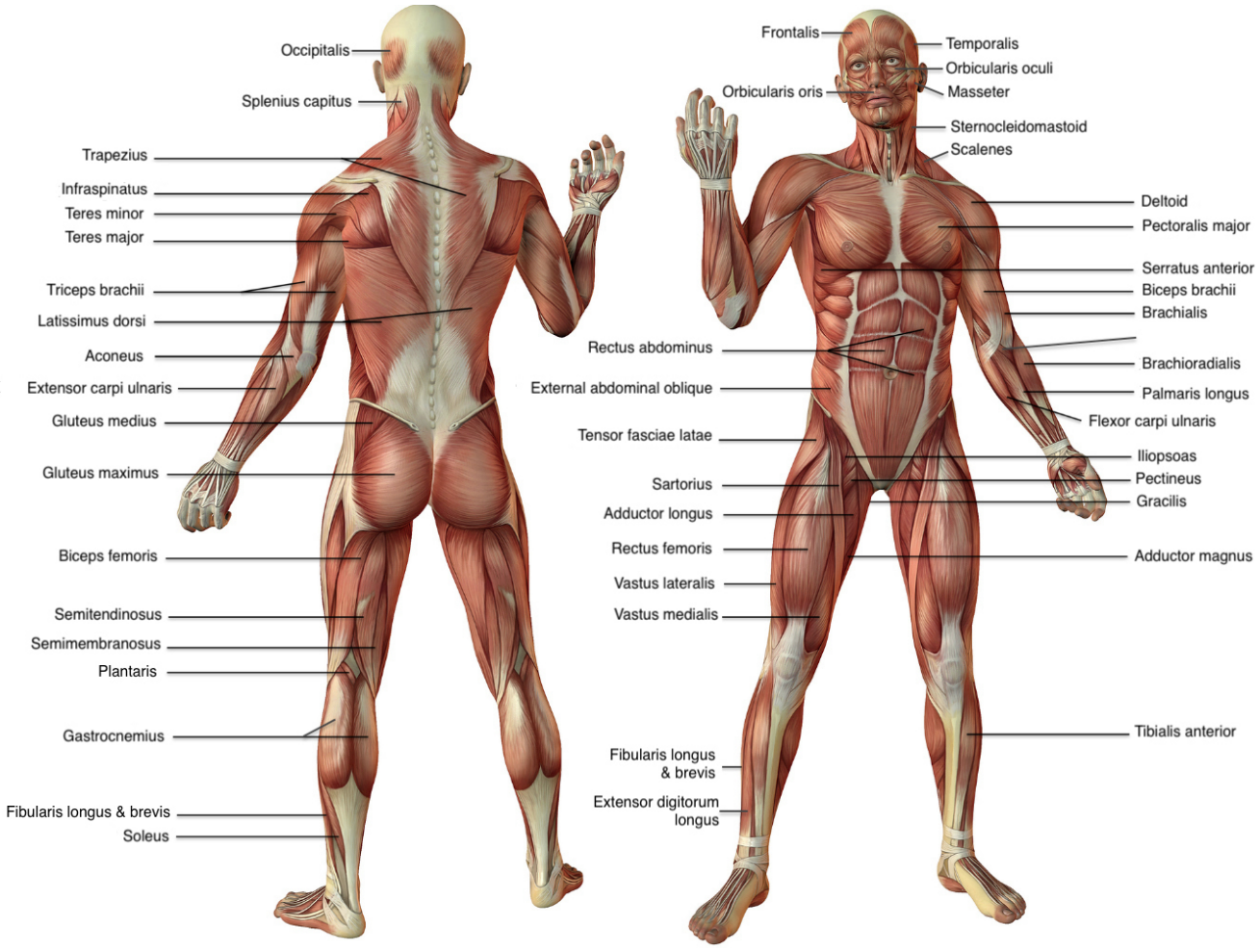

Figure 9.3.1: Muscles of the Body - Anterior and Posterior Views. (Image credit: "Muscles of the Human Body" by Jennifer Lange, based on original by Homme en Noir is licensed by Creative Commons Attribution-Share Alike 4.0 International)

Table 9.3.1: Understanding a Muscle Name from the Latin

Example	Word	Latin Root 1	Latin Root 2	Meaning	Translation
abductor digiti minimi	abductor	ab = away from	duct = to move	a muscle that moves away from	A muscle that moves the little finger or toe

Example	Word	Latin Root 1	Latin Root 2	Meaning	Translation
	digiti	digitus = digit		refers to a finger or toe	away from the midline
	minimi	minimus = mini, tiny		little	
adductor digiti minimi	adductor	ad = to, toward	duct = to move	a muscle that moves toward	A muscle that moves the little finger or toe toward the midline
	digiti	digitus = digit		refers to finger or toe	
	minimi	minimus = mini, tiny		little	

Table 9.3.2: Mnemonic Device for Latin Roots

Example	Latin or Greek Translation	Mnemonic Device
ad	to; toward	ADvance toward your goal
ab	away from	n/a
sub	under	SUBmarines move under water.
ductor	something that moves	A conDUCTOR makes a train move.
anti	against	If you are antisocial, you are against engaging in social activities.
epi	on top of	n/a
apo	to the side of	n/a
longissimus	longest	“Longissimus” is longer than the word “long.”
longus	long	long
brevis	short	brief
maximus	large	max
medius	medium	“Medius” and “medium” both begin with “med.”
minimus	tiny; little	mini
rectus	straight	To RECTify a situation is to straighten it out.
multi	many	If something is MULTIcolored, it has many colors.
uni	one	A UNIcorn has one horn.
bi/di	two	If a ring is DIcast, it is made of two metals.
tri	three	TRIple the amount of money is three times as much.
quad	four	QUADruplets are four children born at one birth.
externus	outside	EXternal

Example	Latin or Greek Translation	Mnemonic Device
internus	inside	INternal

Anatomists name the skeletal muscles according to a number of criteria, each of which describes the muscle in some way. These include naming the muscle after its shape, its size compared to other muscles in the area, its location in the body or the location of its attachments to the skeleton, how many origins it has, or its action.

- The skeletal muscle's anatomical location or its relationship to a particular bone often determines its name. For example: the frontalis muscle is located on top of the frontal bone of the skull; the brachialis is in the brachial region; the tibialis anterior runs along the tibia.
- The shapes of some muscles are very distinctive and the names, such as orbicularis, reflect the shape ('orb' = circular). The deltoid is a large, triangular-shaped muscle that covers the shoulder. It is so-named because the Greek letter delta looks like a triangle.
- The size of the muscles influences the names: gluteus **maximus** (largest), gluteus **medius** (medium), and the gluteus **minimus** (smallest).
- Names indicate length—**brevis** (short), **longus** (long)
- Names identify position relative to the midline: **lateralis** (to the outside away from the midline), and **medialis** (toward the midline). **Intermedius** is inbetween medial and lateral.
- The direction of the muscle fibers and fascicles are used to describe muscles relative to the midline, such as the **rectus** (straight) abdominis, or the **oblique** (at an angle) muscles of the abdomen, or the **transversus** (horizontal) abdominus
- Some muscle names indicate the number of muscles in a group. One example of this is the quadriceps, a group of four muscles located on the anterior (front) thigh. Other muscle names can provide information as to how many origins a particular muscle has, such as the biceps brachii. The prefix **bi** indicates that the muscle has two origins and **tri** indicates three origins.
- The location of a muscle's attachments can also appear in its name. When the name of a muscle is based on the attachments, the origin is always named first. For instance, the sternocleidomastoid muscle of the neck has a dual origin on the sternum (sterno) and clavicle (cleido), and it inserts on the mastoid process of the temporal bone.
- When muscles are named for the movement they produce, one can find action words in their name. Some examples are **flexor** (decreases the angle at the joint), **extensor** (increases the angle at the joint), **abductor** (moves the bone away from the midline), or **adductor** (moves the bone toward the midline).

Concept Review

Muscle names are based on many characteristics. The location of a muscle in the body is important. Some muscles are named based on their size and location, such as the gluteal muscles of the buttocks. Other muscle names can indicate the location in the body or bones with which the muscle is associated, such as the tibialis anterior. The shapes of some muscles are distinctive; for example, the direction of the muscle fibers is used to describe muscles of the body midline. The origin and/or insertion can also be features used to name a muscle; examples are the biceps brachii, triceps brachii, and the pectoralis major.

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9.4: Axial Muscles of the Head, Neck, and Back

By the end of this section, you will be able to:

- Identify the major axial muscles of the face, head, neck, and vertebral column
- Identify the movement caused by these muscles

The skeletal muscles are divided into **axial** (muscles of the trunk and head) and **appendicular** (muscles of the arms and legs) categories. This system reflects the bones of the skeleton system, which are also arranged in this manner. The axial muscles are grouped based on location, function, or both. Some of the axial muscles may seem to blur the boundaries because they cross over to the appendicular skeleton. The first grouping of the axial muscles you will review includes the muscles of the head and neck, including those involving eye movements and swallowing, then you will review the muscles of the vertebral column.

Muscles That Create Facial Expression

The origins of the muscles of facial expression are on the surface of the skull (remember, the origin of a muscle does not move). The insertions of these muscles have fibers intertwined with connective tissue and the dermis of the skin. Because the muscles insert in the skin rather than on bone, when they contract, the skin moves to create facial expression (Figure **9.4.1**).

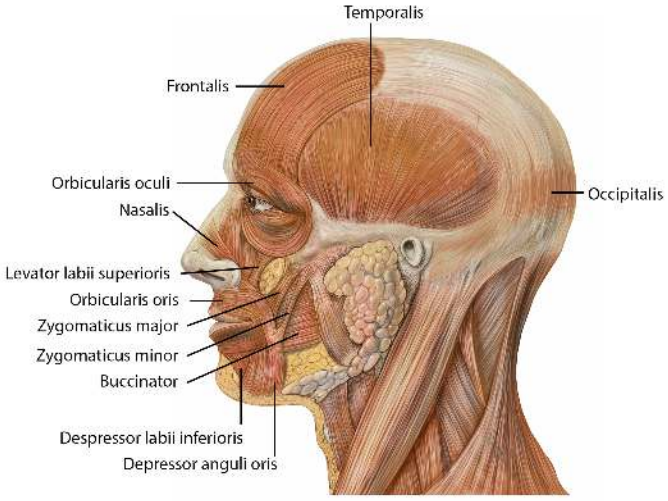


Figure **9.4.1**: Muscles of Facial Expression. Many of the muscles of facial expression insert into the skin surrounding the eyelids, nose and mouth, producing facial expressions by moving the skin rather than bones. *(Image credit: "Muscles of Facial Expression" by Jennifer Lange, modified from original images by Patrick J. Lynch, http://patricklynch.net, licensed under CC-BY Attribution 2.5)*

Forehead and Orbit

The **occipitofrontalis** muscle moves the skin of the scalp and eyebrows in a superior direction. The muscle has a frontal belly and an occipital belly located near the respective bones. In other words, there is a muscle on the forehead (**frontalis**) and one on the back of the head (**occipitalis**), but there is no muscle across the top of the head. Instead, the two bellies are connected by a broad tendon called the **epicranial aponeurosis**, or galea aponeurosis (galea = “apple”). The physicians originally studying human anatomy thought the skull looked like an apple. This muscle is the prime mover of the eyebrows. Gently place your finger on your eyebrows then raise your eyebrows as if you were surprised and allow them to come back to rest. With these movements, you can feel the action of the occipitofrontalis. If you watch yourself in a mirror you will see that your forehead is wrinkling as the skin moves.

The **orbicularis oculi** is a circular muscle that surrounds the orbit. When this muscle contracts the eyelid closes. Pretend that a bug just flew into your eye - you will close the eyelid quickly and scrunch the skin around your eye socket using your orbicularis oculi. Want to close your eyelid gently, as if peacefully sleeping? This is caused by the relaxation of another muscle - the **levator palpebrae superioris**. When this muscle contracts is pulls your upper eyelid open, so relaxing it allows the eyelid to close.

Nose, Mouth and Cheeks

The mouth is used for both a variety of facial expressions as well as forming words while speaking and assisting in swallowing, so it has multiple muscles inserting into the surrounding skin. The largest of these muscles is the **orbicularis oris**, whose fibers encircle the lips and can keep them tightly closed. Contracting the orbicularis oris when pulling in more from the corners will produce a puckered, kissing, expression. Two primary muscles pull the skin and lips in an inferior direction - **depressor labii inferioris** pulls the lip down while **depressor anguli oris** pulls the corners of the mouth down and slightly laterally creating a frowning expression. Three primary muscles pull the skin and lips in a superior direction - the **levator labii superioris** pulls your lip upwards toward your nose while the **zygomaticus major and minor** pull the corners of the mouth up and lateral to cause you to smile. If you practice contracting the zygomaticus muscles you will get the perfect, on the spot smile for pictures!

Your nose itself does not move much, but you can flare your nostrils and compress the nasal cartilage using the **nasalis muscle**.

The largest muscle of the cheeks is the **buccinator** muscle, which compresses the cheek and allows you to whistle, blow, and suck. It also contributes to the actions of chewing and swallowing. Additional muscles of facial expression are presented in Table **9.4.1**.

Table 9.4.1: Muscles of Facial Expression

Muscle	Origin	Insertion	Movement
Brow			
Occipitofrontalis (frontal belly/frontalis)	Epicranial aponeurosis	Skin of eyebrow	Furrowing (wrinkling) brow
Occipitofrontalis (occipital belly/occipitalis)	Occipital bone; mastoid process (temporal bone)	Epicranial aponeurosis	Retracts scalp
Orbit and Eyelid			
Orbicularis oculi	Medial wall of orbit	Skin surrounding eyelids	Closes eyelids (blinking, squinting, winking)
Levator palpebrae superioris	Sphenoid bone	Skin of superior eyelid	Elevates superior eyelid
Nose			
Nasalis	Maxilla	Skin of nostrils, nasal aponeurosis	Flaring nostrils
Mouth and Cheeks			
Buccinator	Maxilla, mandible	Orbicularis oris	Lateral movement of cheeks (e.g. sucking on a straw; also used to compress air in mouth while blowing)
Depressor anguli oris	Mandible	Skin at corners of mouth	Draws corners of mouth inferior and lateral (e.g. frowning)
Depressor labii inferioris	Mandible	Skin of lower lip	Lowering lower lip
Levator labii superioris	Maxilla	Skin of the of upper lip; orbicularis oris	Raising upper lip
Mentalis	Mandible	Skin of chin	Protrusion of lower lip (e.g. pouting expression)
Orbicularis oris	Maxilla, mandible; fibers of other facial muscles	Skin surrounding lips	Compresses and purses lips (e.g. kiss)
Zygomaticus major and minor	Zygomatic bone	Skin at superolateral corners of mouth and lip	Smiling

Muscles That Move the Eyes

The movement of the eyeball is under the control of the **extrinsic eye muscles** (extraocular muscles) that originate within the orbit and insert onto the superficial surface of the white of the eye. These muscles are located inside the eye socket and cannot be seen on any part of the visible eyeball (Figure 9.4.2 and Table 9.4.2). If you have ever been to a doctor who held up a finger and asked you to follow it up, down, and to both sides, he or she is checking to make sure your eye muscles are acting in a coordinated pattern.

Each of these six muscles are named for their position relative to the eyeball and the orientation of their myofibers:

- **Superior oblique muscle** - passes through fibrous trochlea, which is attached to the superiomedial aspect of the orbit
- **Inferior oblique muscle**
- **Superior rectus muscle**
- **Inferior rectus muscle**
- **Medial rectus muscle**
- **Lateral rectus muscle**

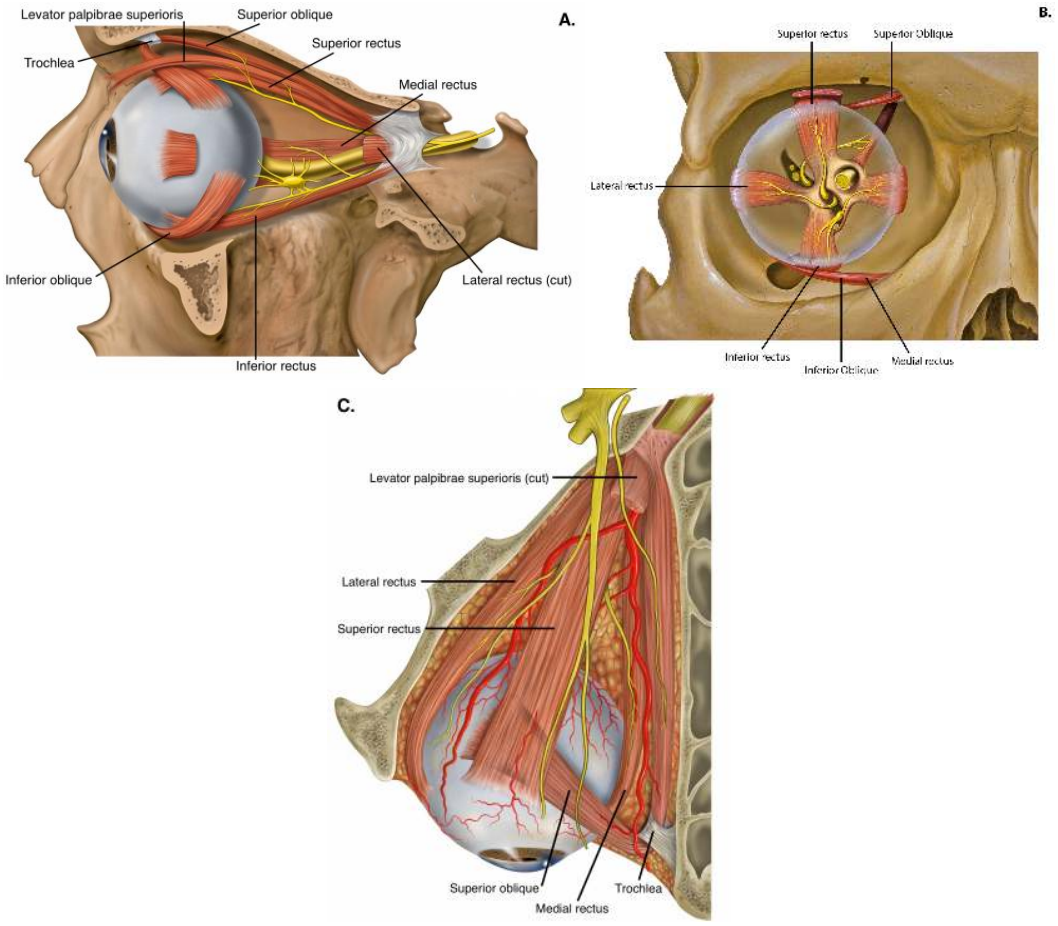
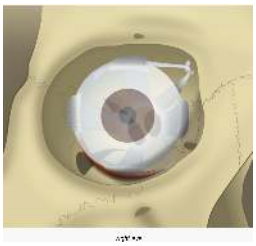
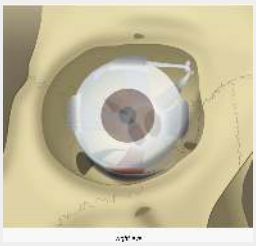
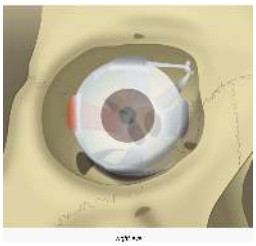
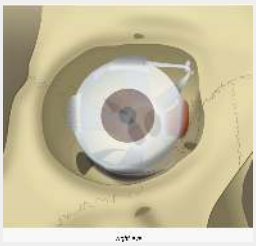
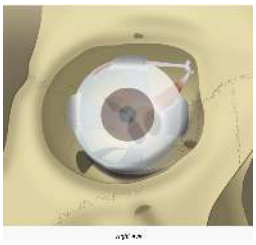
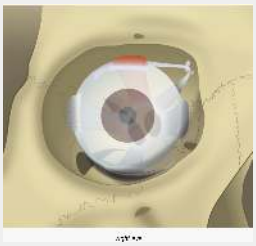


Figure 9.4.2: Extrinsic Eye Muscles. This six muscles control the movements of the eye within the socket. The four rectus muscles originate from a common tendon that surround the optic nerve while the two oblique muscles originate from the medial wall of the orbit. A. Left eye, lateral view. B. Right eye, superior view. C. Right eye, superior view. *(Image credit: "Extrinsic Eye Muscles" by Jennifer Lange, modified from original images by Patrick J. Lynch, http://patricklynch.net, licensed under CC-BY Attribution 2.5)*

Table 9.4.2: Muscles of the Eyes

Muscle	Origin	Insertion	Movement	Image(s)
Inferior oblique	Floor of orbit (maxilla)	Surface of eyeball between inferior rectus and lateral rectus	Moves eyes up and away from nose; rotates eyeball from 12 o'clock to 9 o'clock	
Inferior rectus	Common tendinous ring (ring attaches to optic foramen)	Inferior surface of eyeball	Moves eyes down and toward nose; rotates eyes from 6 o'clock to 3 o'clock	
Lateral rectus	Common tendinous ring (ring attaches to optic foramen)	Lateral surface of eyeball	Moves eyes away from nose	
Medial rectus	Common tendinous ring (ring attaches to optic foramen)	Medial surface of eyeball	Moves eyes toward nose	
Superior oblique	Sphenoid bone	Surface of eyeball between superior rectus and lateral rectus	Moves eyes down and away from nose; rotates eyeball from 6 o'clock to 9 o'clock	
Superior rectus	Common tendinous ring (ring attaches to optic foramen)	Superior surface of eyeball	Moves eyes up and toward nose; rotates eyes from 1 o'clock to 3 o'clock	

Muscles That Move the Lower Jaw at the Temporomandibular Joint

In anatomical terminology, chewing is called **mastication**. Muscles involved in chewing must be able to exert enough pressure to bite through and then chew food before it is swallowed (Figure **9.4.3** and Table **9.4.3**). The **masseter** muscle is the main muscle used

for chewing because it elevates the mandible (lower jaw) to close the mouth, and it is assisted by the **temporalis** muscle, which retracts the mandible. You can feel the temporalis move by putting your fingers to your temple as you chew.

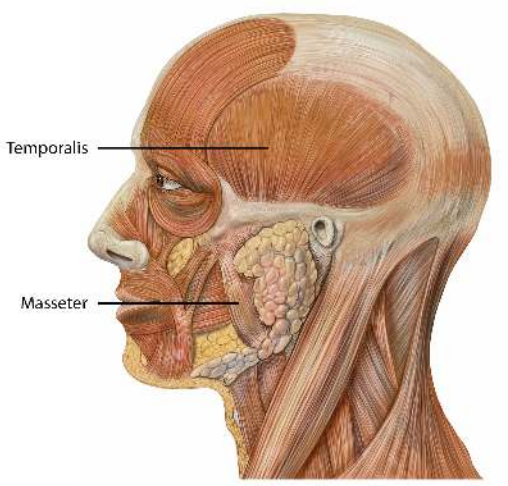


Figure **9.4.3**: Muscles of Mastication. The muscles that move the mandible at the temporomandibular joint are typically located within the cheek and originate from processes in the skull. This provides the muscles with the large amount of leverage needed for chewing. *(Image credit: "Muscle of Mastication" by Jennifer Lange, modified from original images by Patrick J. Lynch, http://patricklynch.net, licensed under CC-BY Attribution 2.5)*

Table 9.4.3: Muscles of Mastication

Muscle	Origin	Insertion	Movement
Masseter	Zygomatic arch	Mandible, coronoid process and lateral surface	Closes mouth; elevation of mandible
Temporalis	Temporal bone	Mandible, coronoid process	Closes mouth; elevation and retraction of mandible

Muscles That Move the Tongue

Although the tongue is obviously important for tasting food, it is also necessary for mastication, **deglutition** (swallowing), and speech (Figure **9.4.4** and Table **9.4.4**). Because it is so moveable, the tongue facilitates complex speech patterns and sounds.

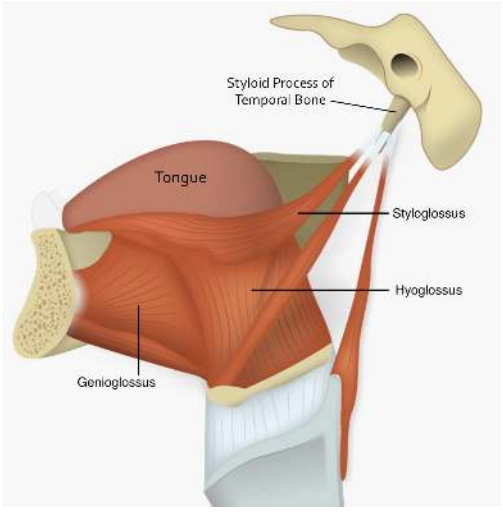


Figure **9.4.4**: Muscles that Move the Tongue. The muscles that move the tongue allow for swallowing and speech. *(Image credit: "Extrinsic Tongue Muscles" by Jennifer Lange, modified from original by University of British Columbia Clinical Anatomy is licensed under CC BY-NC-SA 4.0)*

Table 9.4.4: Muscles for Tongue Movement, Swallowing, and Speech

Muscle	Origin	Insertion	Movement
Tongue			
Genioglossus	Mandible	Tongue undersurface; hyoid bone	Moves tongue down; sticks tongue out of mouth
Hyoglossus	Hyoid Bone	Sides of tongue	Flattens tongue
Styloglossus	Styloid process of temporal bone	Tongue undersurface and sides	Moves tongue up; retracts tongue back into mouth
Swallowing and Speaking			
Digastric	Mandible; temporal bone	Hyoid bone	Raises hyoid bone in a way that also raises the larynx, allowing the epiglottis to cover the glottis during deglutition; also assists in opening the mouth by depressing the mandible
Mylohyoid	Mandible	Hyoid bone; median raphe	Raises hyoid bone in a way that presses the tongue against the roof of the mouth, pushing food back into the pharynx during deglutition
Sternohyoid	Clavicle	Hyoid bone	Depresses the hyoid bone during swallowing and speaking

Tongue muscles can be extrinsic or intrinsic. Extrinsic tongue muscles insert into the tongue from outside origins, and the intrinsic tongue muscles insert into the tongue from origins within it. The extrinsic muscles move the whole tongue in different directions, whereas the intrinsic muscles allow the tongue to change its shape (such as, curling the tongue in a loop or flattening it).

The extrinsic muscles all include the word root glossus (glossus = “tongue”), and the muscle names are derived from where the muscle originates. The **genioglossus** (genio = “chin”) originates on the mandible and allows the tongue to move downward and forward. The **styloglossus** originates on the styloid bone, and allows upward and backward motion. The **hyoglossus** originates on the hyoid bone to move the tongue downward and flatten it.

EVERYDAY CONNECTIONS

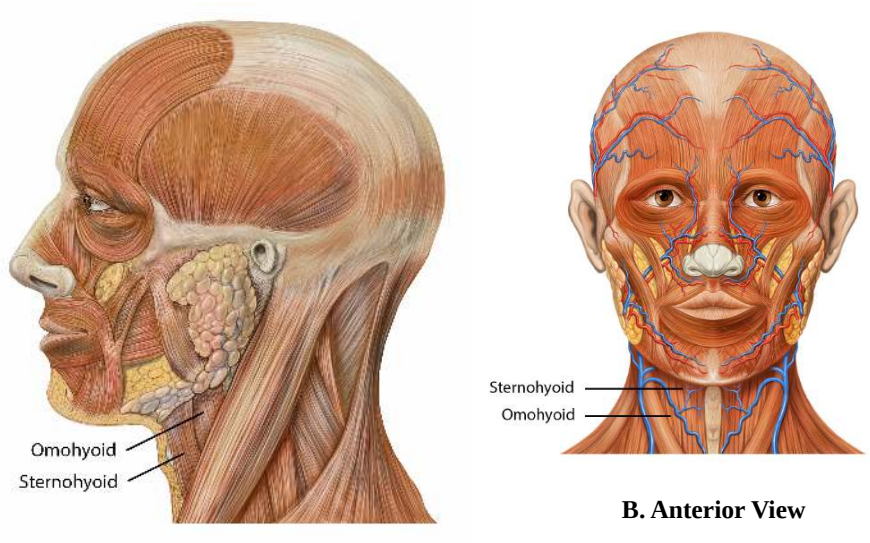
Anesthesia and the Tongue Muscles

Before surgery, a patient must be made ready for general anesthesia. The normal homeostatic controls of the body are put “on hold” so that the patient can be prepped for surgery. Control of respiration must be switched from the patient’s homeostatic control to the control of the anesthesiologist. The drugs used for anesthesia relax a majority of the body’s muscles.

Among the muscles affected during general anesthesia are those that are necessary for breathing and moving the tongue. Under anesthesia, the tongue can relax and partially or fully block the airway, and the muscles of respiration may not move the diaphragm or chest wall. To avoid possible complications, the safest procedure to use on a patient is called endotracheal intubation. Placing a tube into the trachea allows the doctors to maintain a patient’s (open) airway to the lungs and seal the airway off from the oropharynx. Post-surgery, the anesthesiologist gradually changes the mixture of the gases that keep the patient unconscious, and when the muscles of respiration begin to function, the tube is removed. It still takes about 30 minutes for a patient to wake up, and for breathing muscles to regain control of respiration. After surgery, most people have a sore or scratchy throat for a few days.

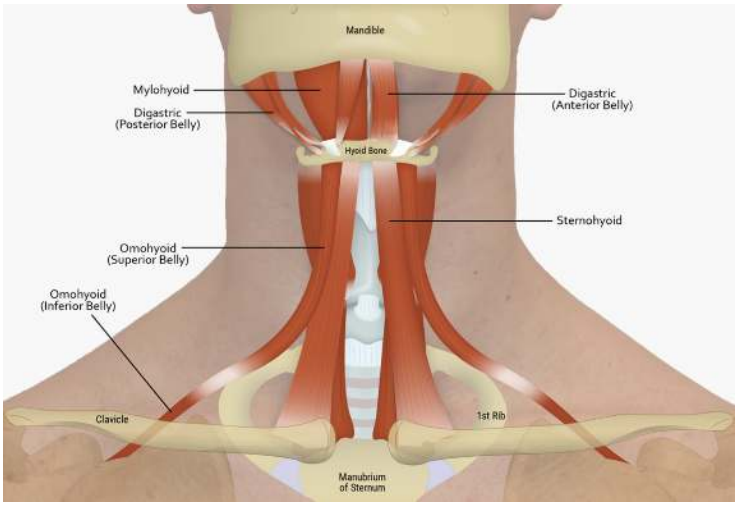
Muscles of Swallowing and Speaking

The muscles of the anterior neck assist in deglutition (swallowing) and speech by controlling the positions of the larynx (voice box), and the hyoid bone, a horseshoe-shaped bone that functions as a solid foundation on which the tongue can move. The muscles of the neck are categorized according to their position relative to the hyoid bone (Figure 9.4.5). **Suprahyoid muscles** are superior to it, and the **infrahyoid muscles** are located inferiorly.



A. Lateral View

B. Anterior View



C. Anterior View of Inferior Chin

Figure 9.4.5: Infrahyoid and Suprahyoid Muscles. The anterior muscles of the neck facilitate swallowing and speech. Each of these muscles originate on or insert into the hyoid bone. From both anterior and lateral view points (A & B) only the superficial infrahyoid muscles can be seen. To see the suprahyoid muscles you need to view from a more inferior angle to see under the chin (C). *(Image credit: "Infrahyoid Muscles" by Jennifer Lange - A & B modified from original images by Patrick J. Lynch, http://patricklynch.net, licensed under CC-BY Attribution 2.5. Image C "Hyoid Muscles" by University of British Columbia Clinical Anatomy is licensed under CC BY-NC-SA 4.0 International.)*

The suprahyoid muscles raise the hyoid bone, the floor of the mouth, and the larynx during swallowing. Examples of these include the **digastric** muscle, which has anterior and posterior bellies that work to elevate the hyoid bone and larynx when one swallows; it also depresses the mandible. The **mylohyoid** muscle lifts the hyoid and helps press the tongue to the top of the mouth.

The strap-like infrahyoid muscles generally depress the hyoid bone and control the position of the larynx. For example, the **omohyoid** muscle, which has superior and inferior bellies, depresses the hyoid bone in conjunction with the **sternohyoid** muscles.

Muscles That Move the Head and Vertebral Column

The skull, attached to the top of the vertebral column, is balanced, moved, and rotated by muscles located in the neck. (Table **9.4.5**). Muscles that insert into the skull move the head at the atlanto-occipital joint and they also move the neck at the cervical intervertebral joints. Additional muscles that insert into the cervical vertebrae also cause neck movements.

When these muscles act unilaterally (on one side), the joints of the head and cervical vertebrae rotate and laterally flex. When they contract bilaterally (both right and left sides), the joints of the head and cervical vertebrae flex or extend. The major muscle that, when contracting on only one side, causes lateral flexion and rotation is the **sternocleidomastoid**. When both sides contract together the joints flex. Place your fingers on both sides of the neck and tilt your head to the left and to the right. You will feel the movement originate there. (Figure **9.4.6**).

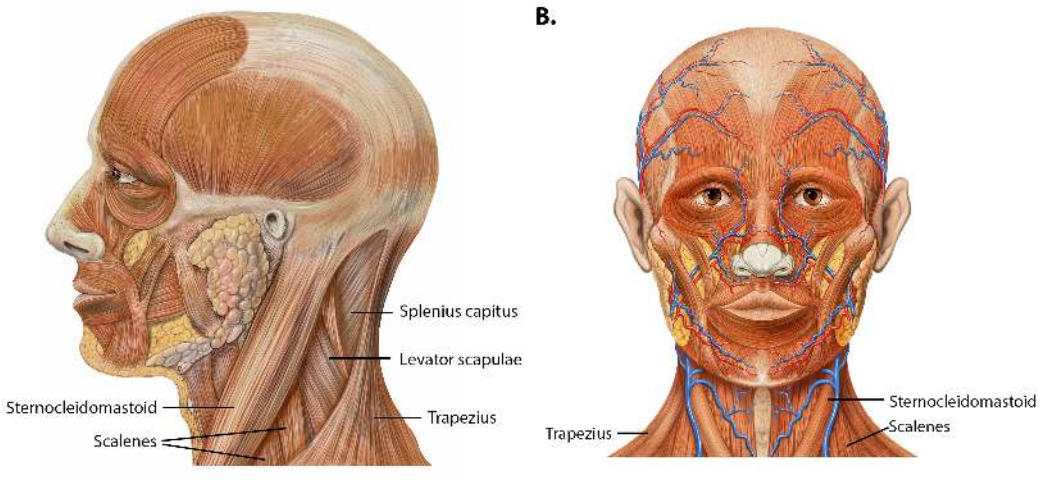
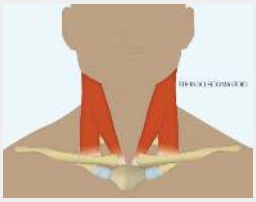


Figure **9.4.6**: Lateral and Anterior Views of Neck Muscles. The superficial and deep muscles of the neck are responsible for moving the head, cervical vertebrae, and scapulae. (*Image credit: "Lateral and Anterior Neck Muscles" by Jennifer Lange, modified from original images by Patrick J. Lynch, http://patricklynch.net, licensed under CC-BY Attribution 2.5.*)

Table 9.4.5: Muscles That Move the Head

Muscle	Origin	Insertion	Movement	Image(s)
Longissimus capitis	Transverse and articular processes of cervical and thoracic vertebrae	Mastoid process of temporal bone	Rotates and tilts head to the side; tilts head backward	
Semispinalis capitis	Transverse and articular processes of cervical and thoracic vertebrae	Occipital bone	Rotates and tilts head backward	
Splenius capitis	Spinous process of cervical and thoracic vertebrae	Mastoid process of temporal bone; occipital bone	Rotates and tilts head to the side; tilts head backward	
Sternocleidomastoid	Sternum; clavicle	Mastoid process of temporal bone; occipital bone	Rotates and tilts head to the side; tilts head forward	

The muscles that insert into the skull are concerned with head movements and neck movements. The neck and back muscles that insert into vertebrae both stabilize and move the vertebral column. They are grouped according to the lengths and direction of the fascicles.

The **splenius** muscles originate at the midline and run laterally and superiorly to their insertions. From the sides and the back of the neck, the **splenius capitis** inserts onto the head region, and the **splenius cervicis** extends onto the cervical region. These muscles can extend the head, laterally flex it, and rotate it (Figure **9.4.7**).

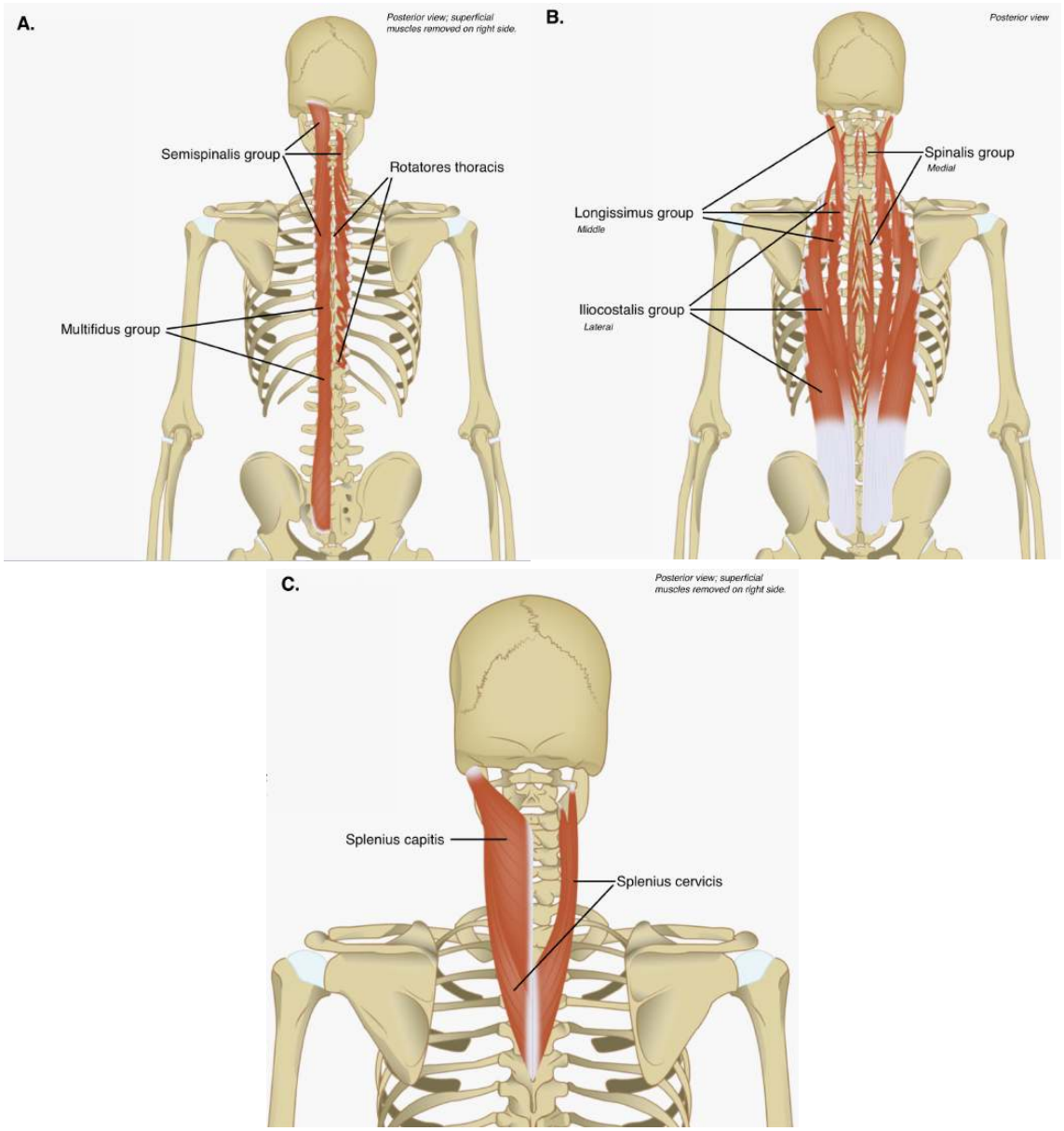


Figure **9.4.7**: Muscles of the Posterior Neck and Back. The muscles of the along the posterior trunk work to both stabilize and move the vertebral column and some also move the head. They are arranged into two main groups based on their depth and function. A. Transversospinalis group, B. Erector spinae group, C. Splenius group. *(Image credit: "Muscles of the Posterior Neck and Back" by Jennifer Lange, modified from originals by University of British Columbia Clinical Anatomy is licensed under CC BY-NC-SA 4.0 International)*

The **erector spinae group** forms the majority of the muscle mass of the back and it is the primary extensor of the vertebral column. It controls flexion, lateral flexion, and rotation of the vertebral column, and maintains the lumbar curve. The erector spinae comprises the **iliocostalis** (laterally placed) **group**, the **longissimus** (intermediately placed) **group**, and the **spinalis** (medially placed) **group**.

The muscles in the **transversospinales group** run from the transverse processes to the spinous processes of the vertebrae and they function to stabilize and move the vertebral column. Similar to the erector spinae muscles, the **semispinalis muscles** and **multifidus muscles** in this group are named for the areas of the body with which they are associated. An additional muscle, rotatores thoracis, also rotates the vertebral column. All three muscle groups extend the vertebral column.

Finally, the **scalene muscles** work together to flex, laterally flex, and rotate the head. They also contribute to deep inhalation. The scalene muscles include the **anterior scalene** muscle (anterior to the middle scalene), the **middle scalene** muscle (the longest,

intermediate between the anterior and posterior scalenes), and the **posterior scalene** muscle (the smallest, posterior to the middle scalene).

Concept Review

Muscles are either axial muscles or appendicular depending upon the location of the joints they move. The axial muscles move joints in the axial skeleton and are grouped based on location, function, or both. Groups include:

- **Facial expression:** The muscles in the face create expressions by inserting into the skin rather than onto bone.
- **Extraocular:** Muscles that move the eyeballs are extrinsic, meaning they originate outside of the eye and insert onto it.
- **Mastication:** The muscles that insert into the mandible are used for chewing, with the strongest ones elevating the mandible to close the jaw. They also play a role in speaking.
- **Tongue:** Tongue muscles are both extrinsic and intrinsic. They create complex movements that allow the tongue to move in all three planes as well as flatten and curl. These movements are used for directing food during chewing and swallowing.
- **Swallowing and speech:** The muscles of the anterior neck facilitate swallowing and speech, stabilize the hyoid bone and position the larynx.
- **Neck:** The muscles of the neck stabilize and move the head and move the joints between the cervical vertebrae.
- **Back and neck:** The muscles of the back and neck move the vertebral column can be divided into multiple groups including:
  - the splenius group in the posterior neck,
  - the erector spinae group run the length of the vertebral column to keep up upright; this group has three subgroups: the iliocostalis group, the longissimus group and the spinalis group,
  - the transversospinales group are shorter muscles that originate on the transverse processes in all regions,
  - the scalenes group in the lateral neck.

Review Questions

Critical Thinking Questions

Glossary

Contributors and Attributions

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9.5: Axial Muscles of the Abdominal Wall and Thorax

By the end of this section, you will be able to:

- Identify the major skeletal muscles of the abdominal wall and thorax
- Identify the movements caused by these muscles

It is a complex job to balance the body on two feet and walk upright. The muscles of the vertebral column, thorax, and abdominal wall extend, flex, and stabilize different parts of the body's trunk. The deep muscles of the core of the body help maintain posture as well as carry out other functions. The brain sends out electrical impulses to these various muscle groups to control posture by alternate contraction and relaxation. This is necessary so that no single muscle group becomes fatigued too quickly. If any one group fails to function, body posture will be compromised.

Muscles of the Abdomen

There are four pairs of abdominal muscles that cover the anterior and lateral abdominal region and meet at the anterior midline: the external obliques, the internal obliques, the transversus abdominis, and the rectus abdominis (Figure 9.5.1, Figure 9.5.2 and Table 9.5.1).

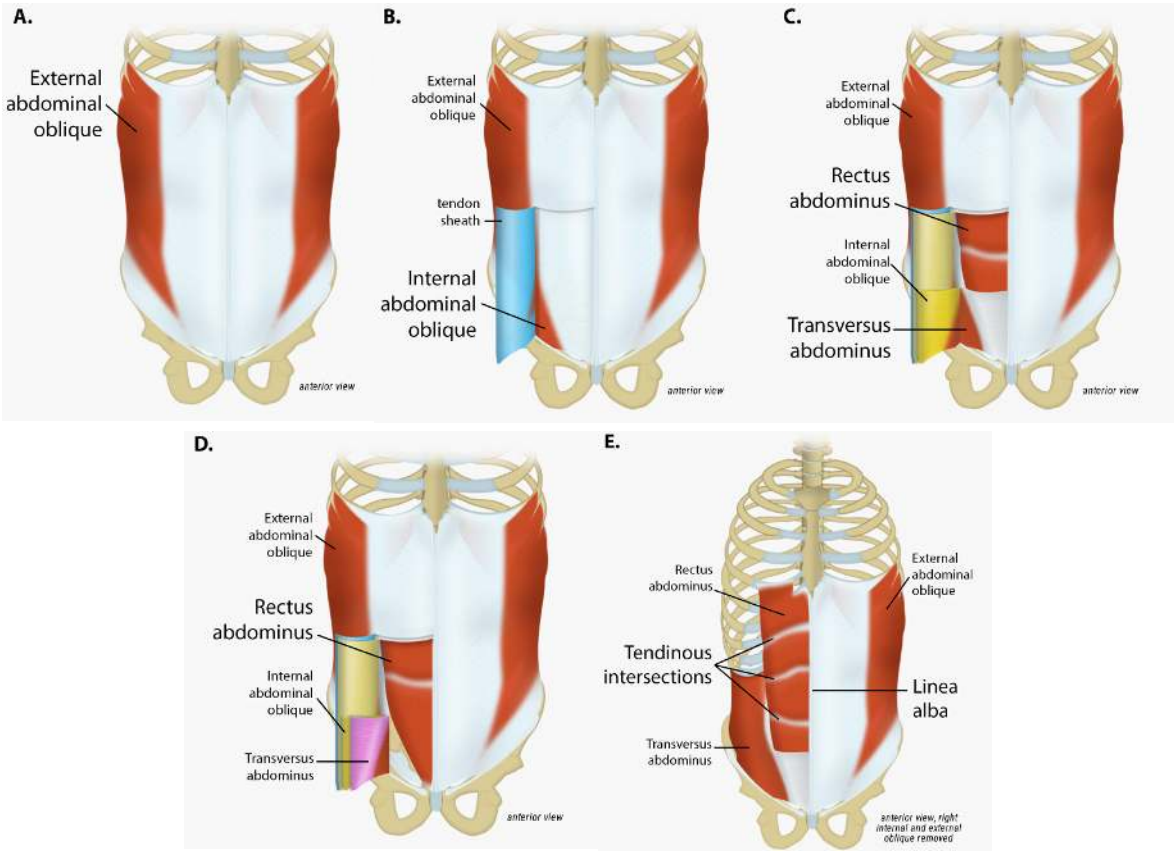

Figure 9.5.1: Muscles of the Abdomen. On the lateral and posterior walls the abdomen has three layers of muscles. From superficial to deep they are: A. external abdominal oblique, B. internal abdominal oblique, and C. transversus abdominus. In images C and D you can see the anteromedial muscle, the rectus abdominus. Tendon associated with these muscles are the tendinous intersections and the linea alba (image E). *(Image credits: "Abdominal Muscles" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy)*

There are three flat skeletal muscles in the antero-lateral wall of the abdomen. The **external oblique**, closest to the surface, extend inferiorly and medially, in the direction of sliding one's four fingers into pants pockets. Perpendicular to it is the intermediate **internal oblique**, extending superiorly and medially, the direction the thumbs usually go when the other fingers are in the pants pocket. The deep muscle, the **transversus abdominis**, is arranged transversely around the abdomen, similar to the front of a belt on

a pair of pants. This arrangement of three bands of muscles in different orientations allows various movements and rotations of the trunk. The three layers of muscle also help to protect the internal abdominal organs in an area where there is no bone.

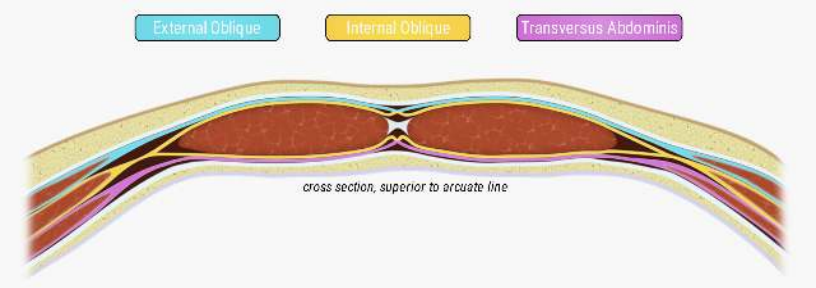

Figure 9.5.2: Muscles of the Abdomen - Cross Section. When viewed in cross section the relative positions of the lateral muscles can easily be seen. The tendon of the external oblique passes superficial to the rectus abdominus while the tendon of the transversus abdominus passes deep. The tendon of the internal oblique splits to pass around both sides.

The **linea alba** is a white, fibrous band that is made of the bilateral **rectus sheaths** that join at the anterior midline of the body. These enclose the **rectus abdominis** muscles (a pair of long, linear muscles, commonly called the "sit-up" muscles) that originate at the pubic crest and symphysis, and extend the length of the body's trunk. Each muscle is segmented by three transverse bands of collagen fibers called the **tendinous intersections**. This results in the look of "six-pack abs," as each segment hypertrophies on individuals at the gym who do many sit-ups.

Table 9.5.1: Muscles of the Abdomen

Muscle	Origin	Insertion	Movement	Image(s)
Internal oblique	Lumbar fascia, inguinal ligament and iliac crest	Linea alba, inferior rib surfaces 9-12, costal cartilages 8-10	Bilateral: Flexes vertebral column Unilateral: Lateral flexion and rotation of vertebral column	
External oblique	Ilium; ribs 5 - 12	Ilium; linea alba; ribs 7 - 10	Bilateral: Flexes vertebral column Unilateral: Lateral flexion and rotation of vertebral column	
Rectus abdominis	Pubis	Ribs 5 and 7; sternum	Flexion of vertebral column	
Transverse abdominus	Ilium; ribs 5 - 10	Linea alba; pubis; sternum	Squeezing abdomen during forceful exhalations, defecation, urination, and childbirth	

CAREER CONNECTIONS

Physical Therapist and Physical Therapy Assistant

Those who have a muscle or joint injury will most likely be sent to a physical therapist (PT) after seeing their regular doctor. PTs have a master's degree or doctorate, and are highly trained experts in the mechanics of body movements. Many PTs also specialize in sports injuries.

If you injured your shoulder the first thing a physical therapist would do during your first visit is to assess the functionality of the joint. The range of motion of a particular joint refers to the normal movements the joint performs. The PT will ask you to abduct and adduct, circumduct, and flex and extend the arm. The PT will note the shoulder's degree of function, and based on the assessment of the injury, will create an appropriate physical therapy plan. This plan can involve visits to the clinic to work with a Physical Therapy Assistant (PTA) who will help guide you through the appropriate exercises. Most likely, you also will be instructed to do a series of exercises to continue the therapy at home, followed by icing to decrease inflammation and swelling, which will continue for several weeks.

When physical therapy is complete, the PT will do an exit exam and send a detailed report on the improved range of motion and return of normal limb function to your doctor. Gradually, as the injury heals, the shoulder will begin to function correctly. Both Physical Therapists and Physical Therapy Assistants work closely with patients to help them get back to their normal level of physical activity.

Physical therapy technician Troy Hopkins assists retired Maj. Gen. William L. Moore Jr. at the Center for the Intrepid, Brooke Army Medical Center's outpatient rehabilitation facility on Joint Base San Antonio-Fort Sam Houston in San Antonio, Sept. 3, 2015. *(U.S. Army photo by Robert T. Shields/Released to Public Domain)*

Sierra Stout, a physical therapist with Global Outreach Doctors teaches a mobility exercise to a boy with scoliosis at a temporary medical treatment site in Point Fortin, Trinidad, Sept. 7, 2019. Comfort is working with health and government partners in Central America, South America, and the Caribbean to provide care on the ship and at land-based medical sites, helping to relieve pressure on national medical systems.

(U.S. Navy photo by Mass Communication Specialist Seaman Jordan R. Bair/Released to Public Domain)\

Muscles of Respiration

The muscles of the chest serve to facilitate breathing by changing the size of the thoracic cavity (Table 9.5.2). Movement of the ribs in a superior direction is called elevation of the ribs at both the sternocostal and vertebrocostal joints. Your chest expands drawing air into your lungs. Movement of the ribs in an inferior direction is called depression of the ribs, at the same joints. For your resting breathing no muscular contraction is necessary due to elasticity, but for deep exhalation muscles will pull the ribs downward and inward to decrease the size of the thoracic cavity.

Table 9.5.2: Muscles of the Thorax

Muscle	Origin	Insertion	Movement
Diaphragm	Lumbar vertebrae; ribs 6 - 12; sternum	Central tendon	Inhalation; compression of abdominopelvic cavity
Internal intercostals	Rib inferior to each intercostal muscle	Rib superior to each intercostal muscle	Forced exhalation
External intercostals	Rib superior to each intercostal muscle	Rib inferior to each intercostal muscle	Inhalation; elevation of ribs
Scalenes	Transverse processes of cervical vertebrae	Superior surface of 1st and 2nd rib	Elevate 1st and 2nd rib during forced inhalation

The change in volume of the thoracic cavity during breathing is due to the alternate contraction and relaxation of the **diaphragm**. It separates the thoracic and abdominal cavities, and is dome-shaped at rest (Figure 9.5.3). The superior surface of the diaphragm is convex, creating the elevated floor of the thoracic cavity. The inferior surface is concave, creating the curved roof of the abdominal cavity. Defecating, urination, and even childbirth involve cooperation between the diaphragm and abdominal muscles (this cooperation is referred to as the “Valsalva maneuver”). You hold your breath by a steady contraction of the diaphragm; this stabilizes the volume and pressure of the peritoneal cavity. When the abdominal muscles contract, the pressure cannot push the diaphragm up, so it increases pressure on the intestinal tract (defecation), urinary tract (urination), or reproductive tract (childbirth).

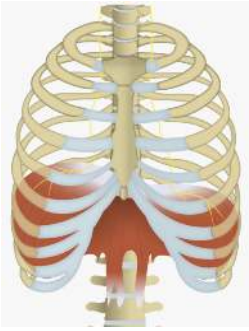

Figure 9.5.3: Diaphragm. The diaphragm is a dome-shaped muscle that serves as the divider between the thoracic cavity and the abdominal cavity. It is the primary muscle of breathing. *(Image credit: "The Diaphragm" by University of British Columbia Clinical Anatomy are licensed under CC BY-NC-SA 4.0 International)*

The central of the diaphragm is its tendon. To the sides of the tendon are the skeletal muscle portions of the diaphragm, which insert into the tendon while having a number of origins including the xiphoid process of the sternum anteriorly, the inferior six ribs and their cartilages laterally, and the lumbar vertebrae and 12th ribs posteriorly. The central tendon of the diaphragm also includes three openings for the passage of structures between the thorax and the abdomen such as the inferior vena cava, aorta, and the esophagus.

Assisting the diaphragm during deep breathing are two sets of muscles, called **intercostal muscles**, that span each of the intercostal spaces. The principal role of the intercostal muscles is to assist in breathing by changing the dimensions of the rib cage (Figure 9.5.4).

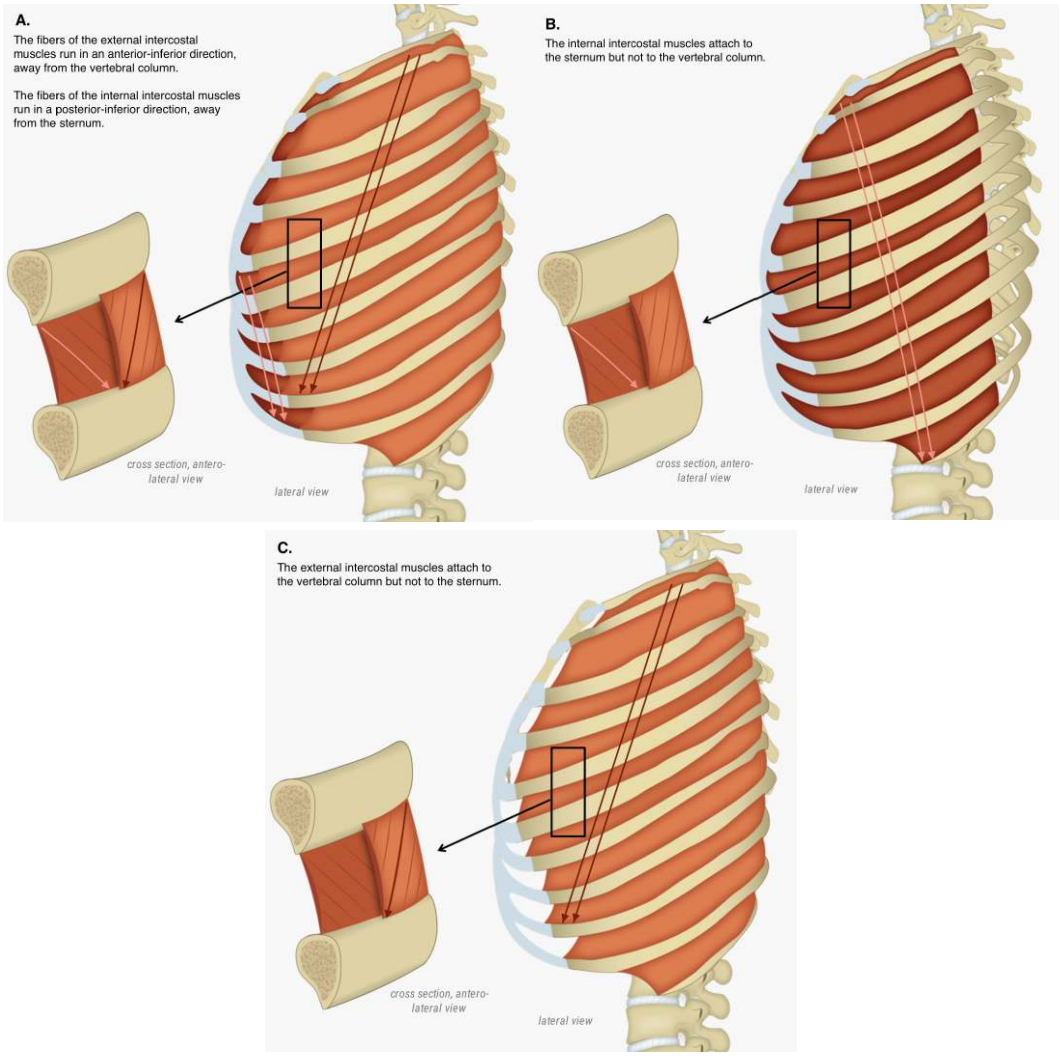

Figure 9.5.4: Intercostal Muscles. The internal and external intercostal muscles run between adjacent ribs. You can determine which is which by looking at their fiber angle and and their position relative to the sternum. *(Image credit: "External and Internal Intercostals" by Jennifer Lange, modified from originals by University of British Columbia Clinical Anatomy are licensed under CC BY-NC-SA 4.0 International)*

The 11 pairs of superficial **external intercostal** muscles aid in inspiration of air during breathing because when they contract, they raise the ribs, which expands the thoracic cavity. The 11 pairs of **internal intercostal** muscles, just deep to the externals, are used for forced (deep) expiration because they draw the ribs together to constrict the rib cage. The movement of the ribs caused by the intercostals is visualized using to analogies: a bucket handle and a pump handle.

Muscles of the Pelvic Floor

The pelvic floor is a muscular sheet that defines the inferior portion of the pelvic cavity. The **pelvic diaphragm**, spanning anteriorly to posteriorly from the pubis to the coccyx, comprises the levator ani and the ischiococcygeus. Its openings include the anal canal and urethra, and the vagina in females.

The large **levator ani** consists of two skeletal muscles, the **pubococcygeus** and the **iliococcygeus** (Figure 9.5.5). The levator ani is considered the most important muscle of the pelvic floor because it supports the pelvic viscera. It resists the pressure produced by contraction of the abdominal muscles so that the pressure is applied to the colon to aid in defecation and to the uterus to aid in childbirth (assisted by the **ischiococcygeus**, which pulls the coccyx anteriorly). This muscle also creates skeletal muscle sphincters at the urethra and anus. The posterior muscle of the of the pelvic floor is the **coccygeus**.

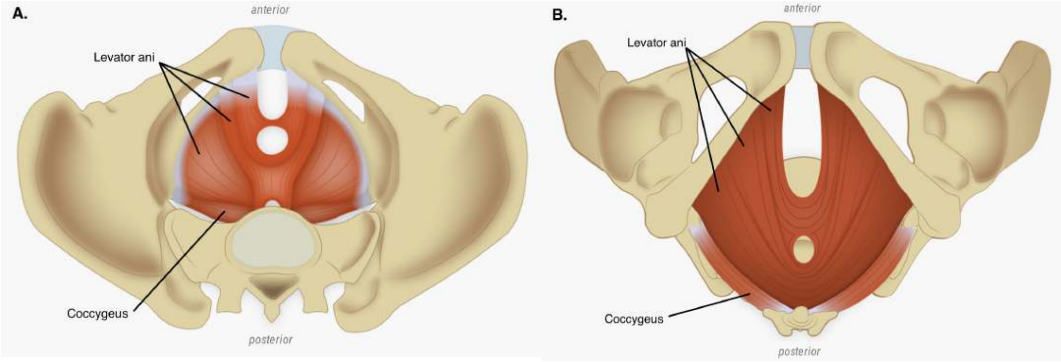

Figure 9.5.5: Muscles of the Pelvic Floor. The pelvic floor muscles support the pelvic organs, resist intra-abdominal pressure, and work as sphincters for the urethra, rectum, and vagina. *(Image credit: "Muscles of the Pelvic Floor" by Jennifer Lange, modified from originals by University of British Columbia Clinical Anatomy are licensed under CC BY-NC-SA 4.0 International)*

Concept Review

Made of skin, fascia, and four pairs of muscle, the anterior abdominal wall protects the organs located in the abdomen and moves the vertebral column. These muscles include the rectus abdominis, which extends through the entire length of the trunk, the external oblique, the internal oblique, and the transversus abdominus. The quadratus lumborum forms the posterior abdominal wall.

The muscles of the thorax play a large role in breathing, especially the dome-shaped diaphragm. When it contracts and flattens, the volume inside the pleural cavities increases, which decreases the pressure within them. As a result, air will flow into the lungs. The external and internal intercostal muscles span the space between the ribs and help change the shape of the rib cage and the volume-pressure ratio inside the pleural cavities during inspiration and expiration.

The perineum muscles play roles in urination in both sexes, ejaculation in men, and vaginal contraction in women. The pelvic floor muscles support the pelvic organs, resist intra-abdominal pressure, and work as sphincters for the urethra, rectum, and vagina.

Review Questions

Critical Thinking Questions

Glossary

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9.6: Appendicular Muscles of the Pectoral Girdle and Upper Limbs

By the end of this section, you will be able to:

- Identify the muscles of the pectoral girdle and upper limbs
- Identify the movement and function of the pectoral girdle and upper limbs

Muscles of the shoulder and upper limb can be divided into four groups: muscles that stabilize and position the pectoral girdle, muscles that move the arm, muscles that move the forearm, and muscles that move the wrists, hands, and fingers. The **pectoral girdle**, or shoulder girdle, consists of the lateral ends of the clavicle and scapula, along with the proximal end of the humerus, and the muscles covering these three bones to stabilize the shoulder joint. The girdle creates a base from which the head of the humerus, in its ball-and-socket joint with the glenoid fossa of the scapula, can move the arm in multiple directions.

Muscles That Move the Pectoral Girdle at the Sternoclavicular Joint

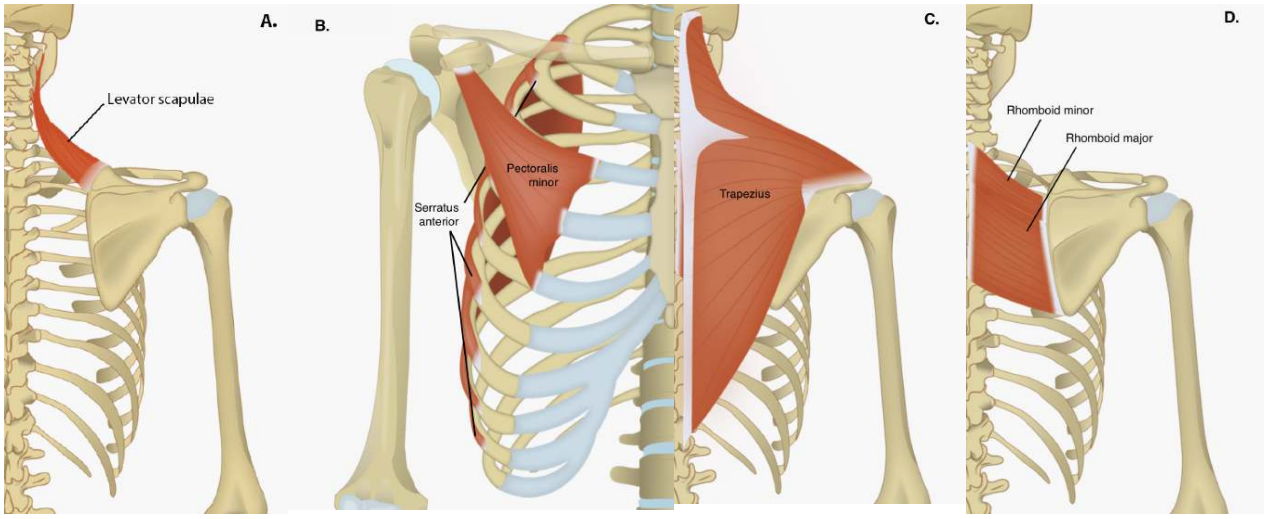

Figure 9.6.1: Muscles that Position the Pectoral Girdle. The muscles that stabilize the pectoral girdle make it a steady base on which other muscles can move the arm: A. Posterior muscle - deep, B. Anterior muscles - deep, C. Posterior muscles - superficial, D. Posterior muscles - deep. *(Image credit: "Muscles that Position the Pectoral Girdle" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy.)*

Muscles that position the pectoral girdle are located either on the anterior thorax or on the posterior thorax (Figure 9.6.1 and Table 9.6.1). The anterior muscles include the **subclavius**, **pectoralis minor**, and **serratus anterior**. The posterior muscles include the **trapezius**, **levator scapulae, rhomboid major**, and **rhomboid minor**. When the rhomboids are contracted, your scapula moves medially, which can pull the shoulder and upper limb posteriorly.

Table 9.6.1: Muscles that Position the Pectoral Girdle

Muscle	Origin	Insertion	Movement	Image(s)
Levator scapulae	Transverse processes of C_1-C_4	Superior, medial border of scapula	Elevates and inferiorly rotates scapula (video)	
Pectoralis minor	Anterior surfaces of certain ribs (2 - 4 or 3 - 5)	Coracoid process of scapula	Rotates shoulder anteriorly (throwing motion); assists with inhalation	
Rhomboid major	Thoracic vertebrae (T_2 - T_5)	Medial border of scapula	Retracts scapula (video)	
Rhomboid minor	Cervical and thoracic vertebrae (C7 and T1)	Medial border of scapula	Retracts scapula (video)	
Serratus anterior	Muscle slips from certain ribs (1 - 8 or 1 - 9)	Anterior surface of vertebral border of scapula	Protracts scapula (video)	
Trapezius	Skull; vertebral column	Acromion and spine of scapula; clavicle	Dependent upon which fibers are stimulated (video): 1. Elevate and rotate scapula, 2. Depress and rotate scapula, 3. Retract scapula	

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Muscles That Move the Humerus at the Shoulder Joint

Similar to the muscles that position the pectoral girdle, muscles that cross the shoulder joint and move the humerus bone of the arm include both axial and scapular muscles (Figure **9.6.2** and Table **9.6.2**). The two muscles that originate on the axial skeleton are the **pectoralis major** and the latissimus dorsi. The pectoralis major is thick and fan-shaped, covering much of the superior portion of the anterior thorax. The broad, triangular **latissimus dorsi** is located on the inferior part of the back, where it inserts into a thick connective tissue sheath called an aponeurosis.

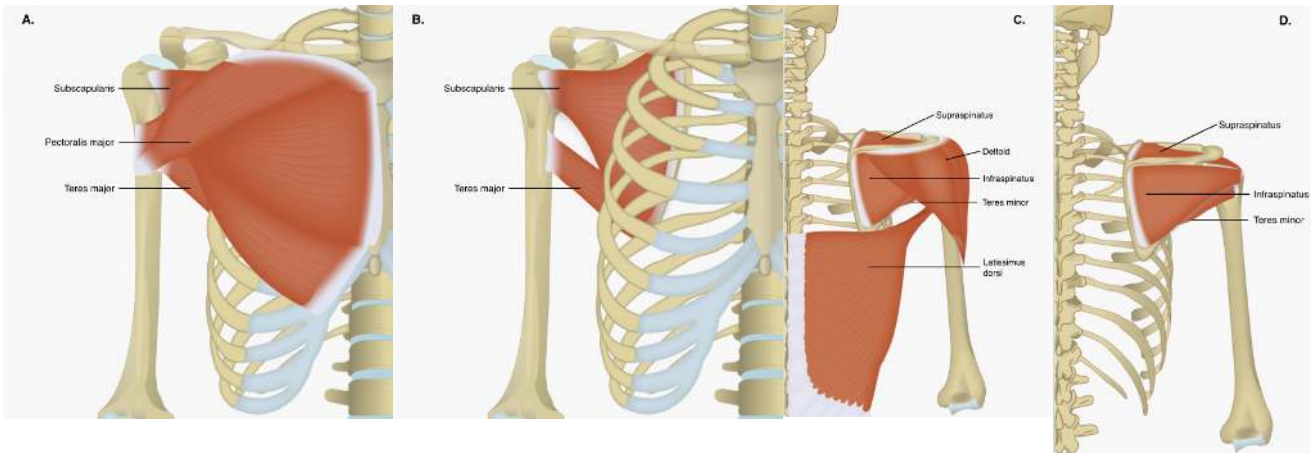
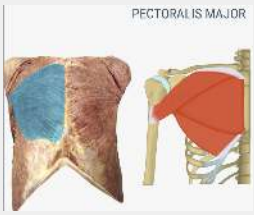
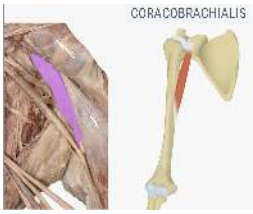
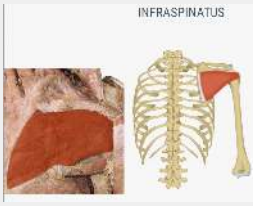


Figure **9.6.2**: Muscles That Move the Humerus. A. Anterior view, superficial. B. Anterior view, deep. C. Posterior view, superficial. D. Posterior view, deep *(Image credit: "Muscles that Move the Humerus" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy.)*

Table **9.6.2**: Muscles that Move the Humerus at the Shoulder Joint

Muscle	Origin	Insertion	Movement	Image(s)
Latissimus dorsi	Thoracic vertebrae (T7-T12); lumbar vertebrae; lower ribs (9-12); iliac crest	Intertubercular sulcus of humerus	Extends, adducts, and internally rotates shoulder (video)	
Pectoralis major	Clavicle; sternum; cartilage of certain ribs (1-6 or 1-7); aponeurosis of external oblique muscle	Greater tubercle of humerus	Flex, adduct, and internally rotate shoulder (video)	
Coracobrachialis	Coracoid process of scapula	Medial surface of humerus shaft	Flex and adduct shoulder	
Deltoid	Trapezius; clavicle; acromion and spine of scapula	Deltoid tuberosity of humerus	Extends, abducts, and flexes shoulder (video) - motion is dependent upon which fibers are activated	
Subscapularis (part of rotator cuff)	Subscapular fossa of scapula	Lesser tubercle of humerus	Adduct and internally rotate shoulder; stabilizes shoulder joint during movement of the pectoral girdle (video)	
Infraspinatus (part of rotator cuff)	Infraspinous fossa of scapula	Greater tubercle of humerus	Externally rotate shoulder (video)	
Supraspinatus (part of rotator cuff)	Supraspinous fossa of scapula	Greater tubercle of humerus	Abduct shoulder (video)	
Teres major	Posterior surface of scapula	Intertubercular sulcus of humerus	Adduct and internally rotate shoulder	

Muscle	Origin	Insertion	Movement	Image(s)
Teres minor (part of rotator cuff)	Lateral border of dorsal scapular surface	Greater tubercle of humerus	Externally rotate shoulder	

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The rest of the shoulder muscles originate on the scapula. The anatomical and ligamental structure of the shoulder joint and the arrangements of the muscles covering it, allows the arm to carry out different types of movements. The **deltoid**, the thick muscle that creates the rounded lines of the shoulder is the major abductor of the arm, but it also facilitates flexing and medial rotation, as well as extension and lateral rotation. The **subscapularis** originates on the anterior scapula and medially rotates the arm. Named for their locations, the **supraspinatus** (superior to the spine of the scapula) and the **infraspinatus** (inferior to the spine of the scapula) abduct the arm, and laterally rotate the arm, respectively. The thick and flat **teres major** is inferior to the teres minor and extends the arm, and assists in adduction and medial rotation of it. The long **teres minor** laterally rotates and extends the arm. Finally, the **coracobrachialis** flexes and adducts the arm.

The tendons of the subscapularis, supraspinatus, infraspinatus, and teres minor connect the scapula to the humerus, forming the **rotator cuff** (musculotendinous cuff), the circle of tendons around the shoulder joint. When baseball pitchers undergo shoulder surgery it is usually on the rotator cuff, which becomes pinched and inflamed, and may tear away from the bone due to the repetitive motion of bring the arm overhead to throw a fast pitch.

Muscles That Move the Forearm at the Elbow Joint

The forearm, containing the radius and ulna, has two actions at the hinge of the elbow joint: flexion, extension. The the muscles that cause flexion at the elbow joint include the **biceps brachii**, **brachialis**, and **brachioradialis**. The extensors are the **triceps brachii** and **anconeus**.

The biceps brachii, brachialis, and brachioradialis flex the forearm at the elbow. The two-headed **biceps brachii** crosses the shoulder and elbow joints to flex the forearm, also taking part in supinating the forearm at the radioulnar joints and flexing the arm at the shoulder joint. Deep to the biceps brachii, the **brachialis** provides additional power in flexing the forearm. Finally, the **brachioradialis** can flex the forearm quickly or help lift a load slowly. These muscles and their associated blood vessels and nerves form the **anterior compartment of the arm** (anterior flexor compartment of the arm) (Figure **9.6.3** and Table **9.6.3**).

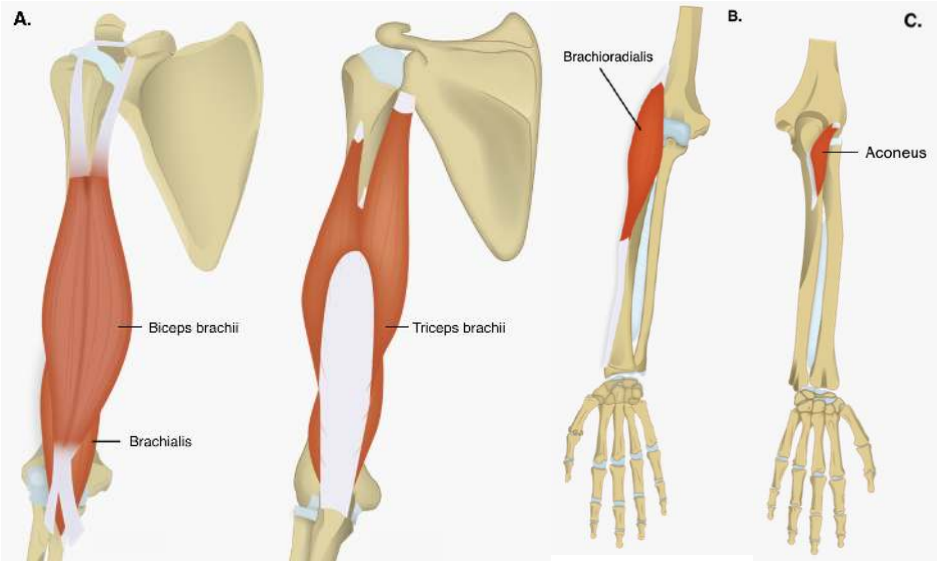
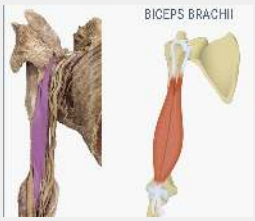
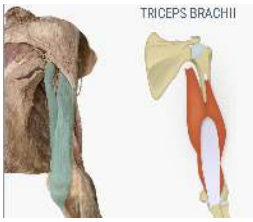


Figure 9.6.3: Muscles that Move the Forearm at the Elbow Joint. A. The prime movers of elbow flexion are in the anterior compartment - biceps brachii and brachialis. The prime mover of elbow extension is in the posterior compartment - triceps brachii. Muscles that assist in elbow movements are B. Brachioradialis and C. Aconeus. *(Image credit: "Muscles that Move the Forearm" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy.)*

Table 9.6.3: Muscles that Move the Forearm at the Elbow Joint

Muscle	Origin	Insertion	Movement	Image(s)
Anterior Muscles (Flexion)				
Biceps brachii	Coracoid process; tubercle above glenoid cavity	Radial tuberosity	1. Flexion of elbow joint 2. Pronation of radioulnar joint 3. Flexion of shoulder joint	
Brachialis	Front of distal humerus	Coronoid process of ulna	Elbow flexion	
Brachioradialis	Lateral supracondylar ridge at distal end of humerus	Base of styloid process of radius	Assists in elbow flexion	
Posterior Muscles (Extension)				
Anconeus	Lateral epicondyle of humerus	Lateral aspect of olecranon process of ulna	Assists in extending elbow joint	
Triceps brachii	Infraglenoid tubercle of scapula; posterior shaft of humerus; posterior humeral shaft distal to the radial groove	Olecranon process of ulna	Extends elbow and shoulder	

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Muscles That Move the Forearm at the Radioulnar Joints

The pronators are the **pronator teres** and the **pronator quadratus**, and the **supinator** is the only one that turns the forearm anteriorly. When the forearm faces anteriorly, it is supinated. When the forearm faces posteriorly, it is pronated. (Table **9.6.4**)

Table **9.6.4**: Muscles that Move the Forearm at the Elbow Joint

Muscle	Origin	Insertion	Movement	Image(s)
Anterior Muscles (Pronation)				
Pronator quadratus	Distal portion of anterior ulnar shaft	Distal surface of anterior radius	Assists in turning hand palm posterior (pronation of radioulnar joint)	
Pronator teres	Medial epicondyle of humerus; coronoid process of ulna	Lateral radius	Turns hand palm posterior (pronation of radioulnar joint)	
Posterior Muscles (Supination)				
Supinator	Lateral epicondyle of humerus; proximal ulna	Proximal end of radius	Turns hand palm anterior (supinator of radioulnar joint)	

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Muscles That Move the Wrist, Hand, and Fingers

Wrist, hand, and finger movements are facilitated by two groups of muscles. The forearm is the origin of the **extrinsic muscles of the hand**. The palm is the origin of the intrinsic muscles of the hand.

Muscles of the Forearm That Move the Wrists, Hands, and Fingers

The muscles in the **anterior compartment of the forearm** (anterior flexor compartment of the forearm) originate on the humerus and insert onto different parts of the hand. These make up the bulk of the forearm. From lateral to medial, the **superficial anterior compartment of the forearm** includes the **flexor carpi radialis**, **palmaris longus**, **flexor carpi ulnaris**, and **flexor digitorum superficialis**. The flexor digitorum superficialis flexes the hand as well as the digits at the knuckles, which allows for rapid finger movements, as in typing or playing a musical instrument (Figure 9.6.4 and Table 9.6.5). However, poor ergonomics can irritate the tendons of these muscles as they slide back and forth with the carpal tunnel of the anterior wrist and pinch the median nerve, which also travels through the tunnel, causing Carpal Tunnel Syndrome. The **deep anterior compartment** produces flexion and bends fingers to make a fist. These are the **flexor pollicis longus** and the **flexor digitorum profundus**.

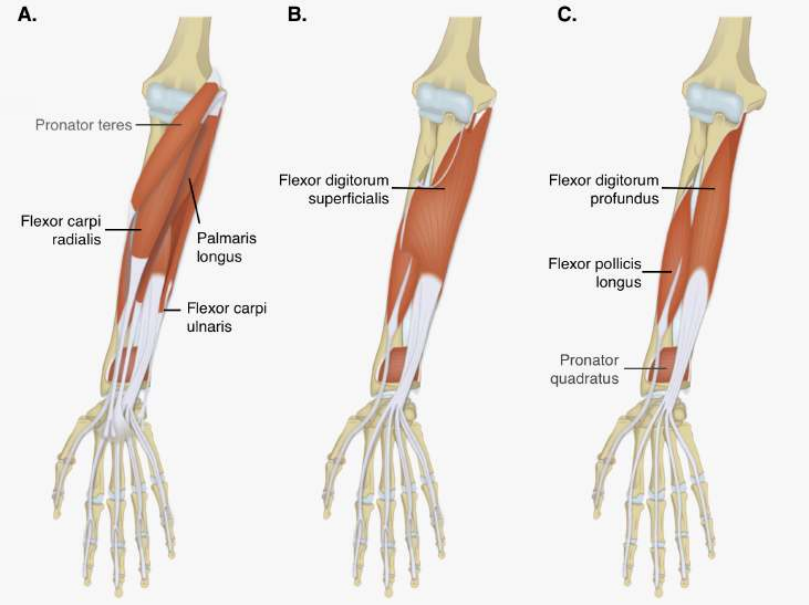

Figure **9.6.4**: Anterior Muscles that Move the Joints of the Wrist, Hand, and Fingers. Muscles in the anterior compartment of the forearm all cause flexion. Some have additional actions depending upon their insertion point. A. Superficial layer (grey indicates muscle belongs in another group), B. Intermediate layer, C. Deep layer. (Image credit: "Muscles that Move the Joints of the Wrist, Hand, and Fingers" by Jennifer Lange *are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy*.)

The muscles in the **superficial posterior compartment of the forearm** (superficial posterior extensor compartment of the forearm) originate on the humerus. These are the **extensor radialis longus**, **extensor carpi radialis brevis**, **extensor digitorum**, **extensor digiti minimi**, and the **extensor carpi ulnaris**.

The muscles of the **deep posterior compartment of the forearm** (deep posterior extensor compartment of the forearm) originate on the radius and ulna. These include the **abductor pollicis longus**, **extensor pollicis brevis**, **extensor pollicis longus**, and **extensor indicis** (Figure **9.6.5**, Table **9.6.5**).

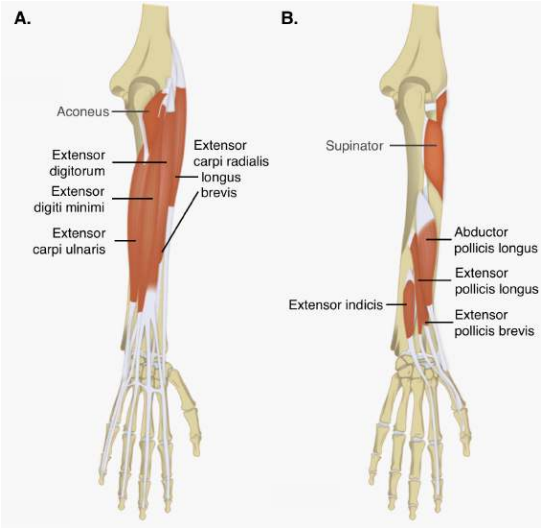

Figure **9.6.5**: Posterior Muscles that Move the Joints of the Wrist, Hand, and Fingers. Most muscles in the posterior compartment of the forearm cause extension. Some have additional or other actions depending upon their insertion point. (Grey indicates muscle belongs in another group) A. Superficial layer, B. Deep layer. *(Image credit: "Posterior Muscles that Move the Joints of the Wrist, Hand, and Fingers" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy.)*

Table **9.6.5**: Muscles that Move the Wrist, Hands, and Forearm

Prime Mover	Origin	Insertion	Movement	Image(s)
Superficial/Intermediate Anterior Compartment of Forearm				
Flexor carpi ulnaris	Medial epicondyle of humerus; olecranon process; posterior surface of ulna	Pisiform bone; hamate bone; base of fifth metacarpal	Assists in bending hand up toward shoulder; tilts hand to side away from body; stabilizes wrist	
Flexor carpi radialis	Medial epicondyle of humerus	Base of second and third metacarpals	Bends wrist toward body; tilts hand to side away from body	
Flexor digitorum superficialis	Medial epicondyle of humerus; coronoid process of ulna; shaft of radius	Middle phalanges of fingers 2 - 5	Bends fingers to make fist	
Palmaris longus	Medical epicondyle of humerus	Palmar aponeurosis; skin and fascia of palm	Assists in bending hand up toward shoulder	
Deep Anterior Compartment of Forearm				
Flexor digitorum profundus	Coronoid process; anteromedial surface of ulna; interosseous membrane	Distal phalanges of fingers 2 - 5	Bends fingers to make a fist; also bends wrist toward body	
Flexor pollicus longus	Anterior surface of radius; interosseous membrane	Distal phalanx of thumb	Bends tip of thumb	
Superficial Posterior Compartment of Forearm				
Extensor carpi radialis brevis	Lateral epicondyle of humerus	Base of third metacarpal	Assists extensor radialis longus in extending and abducting wrist; also stabilizes hand during finger flexion	
Extensor carpi ulnaris	Lateral epicondyle of humerus; posterior border of ulna	Base of fifth metacarpal	Straightens wrist away from body; tilts hand to side toward body	

Prime Mover	Origin	Insertion	Movement	Image(s)
Extensor digiti minimi	Lateral epicondyle of humerus	Extensor expansion; distal phalanx of finger 5 (little finger)	Extends finger 5 (little finger)	
Extensor digitorum	Lateral epicondyle of humerus	Extensor expansions; distal phalanges of fingers	Opens fingers and moves them sideways away from the body	
Extensor radialis longus	Lateral supracondylar ridge of humerus	Base of second metacarpal	Straightens wrist away from body	
Deep Posterior Compartment of Forearm				
Abductor pollicis longus	Posterior surface of radius and ulna; interosseous membrane	Base of first metacarpal; trapezium	Moves thumb sideways toward body; extends thumb; moves hand sideways toward body	
Extensor indicis	Posterior surface of distal ulna; interosseous membrane	Tendon of extensor digitorum of finger 2 (index finger)	Extends finger 2 (index finger); straightens wrist away from body	
Extensor pollicis brevis	Dorsal shaft of radius and ulna; interosseous membrane	Base of proximal phalanx of thumb	Extends thumb	
Extensor pollicis longus	Dorsal shaft of radius and ulna; interosseous membrane	Base of distal phalanx of thumb	Extends thumb	

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The tendons of the forearm muscles attach to the wrist and extend into the hand. Fibrous bands called **retinacula** sheath the tendons at the wrist. The **flexor retinaculum** extends over the palmar surface of the hand while the **extensor retinaculum** extends over the dorsal surface of the hand.

Intrinsic Muscles of the Hand

The **intrinsic muscles of the hand** both originate and insert within it (Figure 9.6.6, Table 9.6.6). These muscles allow your fingers to also make precise movements for actions, such as typing or writing. These muscles are divided into three groups. The **thenar** muscles are on the radial aspect of the palm. The **hypothenar** muscles are on the medial aspect of the palm, and the **intermediate** muscles are midpalmar.

The thenar muscles include the **abductor pollicis brevis**, **opponens pollicis**, **flexor pollicis brevis**, and the **adductor pollicis**. These muscles form the **thenar eminence**, the rounded contour of the base of the thumb, and all act on the thumb. The movements of the thumb play an integral role in most precise movements of the hand.

The hypothenar muscles include the **abductor digiti minimi**, **flexor digiti minimi brevis**, and the **opponens digiti minimi**. These muscles form the **hypothenar eminence**, the rounded contour of the little finger, and as such, they all act on the little finger. Finally, the intermediate muscles act on all the fingers and include the **lumbrical**, the **palmar interossei**, and the **dorsal interossei**.

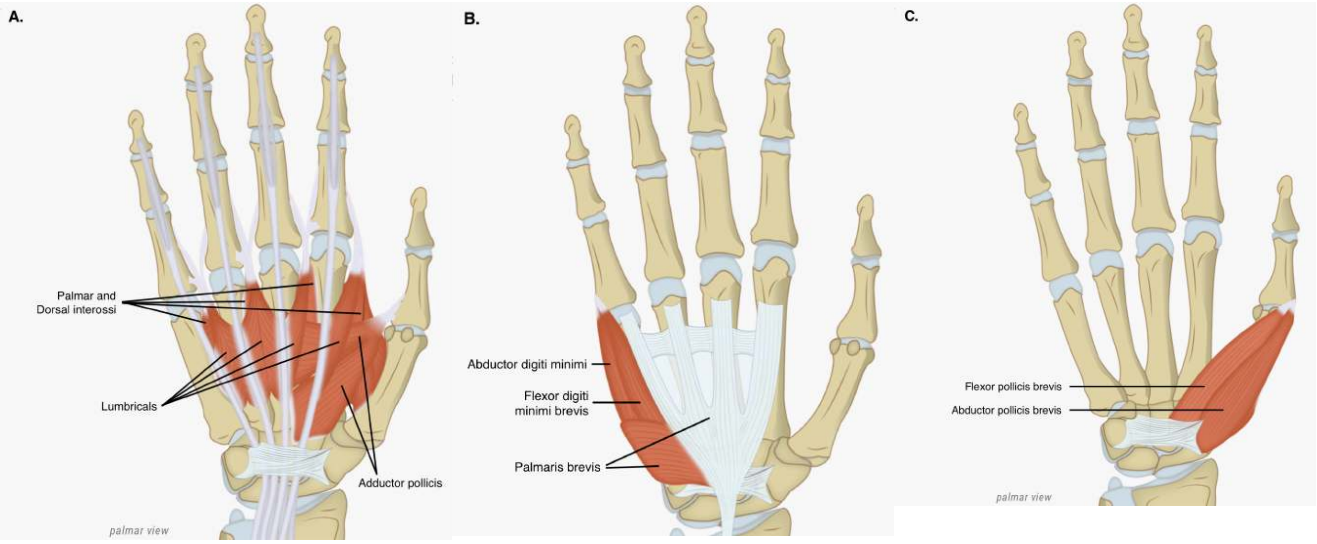

Figure 9.6.6: Intrinsic Muscles of the Hand. These muscles allow for fine motor control of the digits for activities such as writing and typing. A. Palmar view of the deep muscles. B. Palmar view of the hypothenar muscles. C. Palmar view of the thenar muscles. *(Image credit: "Intrinsic Muscles of the Hand" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy.)*

Table 9.6.6: Intrinsic Muscles of the Hand

Muscle	Origin	Insertion	Movement	Image(s)
Thenar Muscles (movements video)				
Abductor pollicis brevis	Flexor retinaculum; and nearby carpals	Lateral base of proximal phalanx of thumb	Abducts and flexes thumb	 
Adductor pollicis	Capitate bone; bases of metacarpals 2 - 4; front of metacarpal 3	Medial base of proximal phalanx of thumb	Adducts and flexes thumb	
Flexor pollicis brevis	Flexor retinaculum; trapezium	Lateral base of proximal phalanx of thumb	Flexes thumb	 

Muscle	Origin	Insertion	Movement	Image(s)
Opponens pollicis	Flexor retinaculum; trapezium	Anterior of first metacarpal	Opposes thumb (moves thumb across palm to touch other fingers)	
Hypothenar Muscles				
Abductor digiti minimi	Pisiform bone	Medial side of proximal phalanx of finger 5 (little finger)	Abducts and flexes MCP of 5th digit	 
Flexor digiti minimi brevis	Hamate bone; flexor retinaculum	Medial side of proximal phalanx of finger 5 (little finger)	Flexes MCP of 5th digit	
Opponens digiti minimi	Hamate bone; flexor retinaculum	Medial side of fifth metacarpal	Opposes digit 5 (moves little finger across palm to touch thumb)	
Deep Muscles				

Muscle	Origin	Insertion	Movement	Image(s)
Dorsal interossei	Sides of metacarpals	Both sides of finger 3; for each other finger, extensor expansion over first phalanx on side opposite finger 3	Abducts and flexes the three middle fingers at metacarpo-phalangeal joints; extends the three middle fingers at interphalangeal joints	
Lumbricals	Palm (lateral sides of tendons in flexor digitorum profundus)	Fingers 2–5 (lateral edges of extensional expansions on first phalanges)	Flexes each finger at metacarpo-phalangeal joints; extends each finger at interphalangeal joints	
Palmar interossei	Side of each metacarpal that faces metacarpal 3 (absent from metacarpal 3)	Extensor expansion on first phalanx of each finger (except finger 3) on side facing finger 3	Adducts and flexes each finger at metacarpo-phalangeal joints; extends each finger at interphalangeal joints	

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Concept Review

The clavicle and scapula make up the pectoral girdle, which provides a stable origin for the muscles that move the humerus. The muscles that position and stabilize the pectoral girdle are located on the thorax. The anterior thoracic muscles are the subclavius, pectoralis minor, and the serratus anterior. The posterior thoracic muscles are the trapezius, levator scapulae, rhomboid major, and rhomboid minor. Nine muscles cross the shoulder joint to move the humerus. The ones that originate on the axial skeleton are the pectoralis major and the latissimus dorsi. The deltoid, subscapularis, supraspinatus, infraspinatus, teres major, teres minor, and coracobrachialis originate on the scapula.

The forearm flexors include the biceps brachii, brachialis, and brachioradialis. The extensors are the triceps brachii and anconeus. The pronators are the pronator teres and the pronator quadratus. The supinator is the only one that turns the forearm anteriorly.

The extrinsic muscles of the hands originate along the forearm and insert into the hand in order to facilitate crude movements of the wrists, hands, and fingers. The superficial anterior compartment of the forearm produces flexion. These muscles are the flexor carpi radialis, palmaris longus, flexor carpi ulnaris, and the flexor digitorum superficialis. The deep anterior compartment produces flexion as well. These are the flexor pollicis longus and the flexor digitorum profundus. The rest of the compartments produce extension. The extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum, extensor digiti minimi, and

extensor carpi ulnaris are the muscles found in the superficial posterior compartment. The deep posterior compartment includes the abductor longus, extensor pollicis brevis, extensor pollicis longus, and the extensor indicis.

Finally, the intrinsic muscles of the hands allow our fingers to make precise movements, such as typing and writing. They both originate and insert within the hand. The thenar muscles, which are located on the lateral part of the palm, are the abductor pollicis brevis, opponens pollicis, flexor pollicis brevis, and adductor pollicis. The hypothenar muscles, which are located on the medial part of the palm, are the abductor digiti minimi, flexor digiti minimi brevis, and opponens digiti minimi. The intermediate muscles, located in the middle of the palm, are the lumbricals, palmar interossei, and dorsal interossei.

Review Questions

Critical Thinking Questions

Glossary

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9.7: Appendicular Muscles of the Pelvic Girdle and Lower Limbs

By the end of this section, you will be able to:

- Identify the major appendicular muscles of the pelvic girdle and lower limb
- Identify the movement caused by these muscles

The appendicular muscles of the lower body position and stabilize the **pelvic girdle**, which serves as a foundation for the lower limbs. Comparatively, there is much more movement at the pectoral girdle than at the pelvic girdle. There is very little movement of the pelvic girdle because of its connection with the sacrum at the base of the axial skeleton. The pelvic girdle is less range of motion because it was designed to stabilize and support the body.

Muscles of the Thigh

What would happen if the pelvic girdle, which attaches the lower limbs to the torso, were capable of the same range of motion as the pectoral girdle? For one thing, walking would expend more energy if the heads of the femurs were not secured in the acetabula of the pelvis. The body's center of gravity is in the area of the pelvis. If the center of gravity were not to remain fixed, standing up would be difficult as well. Therefore, what the leg muscles lack in range of motion and versatility, they make up for in size and power, facilitating the body's stabilization, posture, and movement.

Gluteal and Pelvic Muscles That Move the Femur

Most muscles that insert on the femur (the thigh bone) and move it, originate on the pelvic girdle (Table 9.7.1).

- The **psoas major** (the "p" is silent when pronouncing) and **iliacus** make up the **iliopsoas group**. These muscles originate on the posterior, interior of the pelvis and the vertebral column, pass over the pubis and insert into lesser trochanter of the femur. When they pass the inguinal ligament their fibers blend together so in the thigh the joined muscle is called the **iliopsoas**. Their anterior position relative to the hip joint makes them strong hip flexors (Figure 9.7.1).
- Some of the largest and most powerful muscles in the body are the gluteal muscles or **gluteal group**. From superficial to deep as well as largest to smallest these three muscles are the **gluteus maximus, gluteus medius**, and **gluteus minimus**. Gluteus maximus is the prime mover of hip extension as well as a lateral rotator. The gluteus medius and minimus both abduct and medially rotate the hip (Figure 9.7.1). The gluteus maximus has two insertion points: one in the posterior femur and one on the superior, lateral tibia via that **iliotibial (IT) band**.

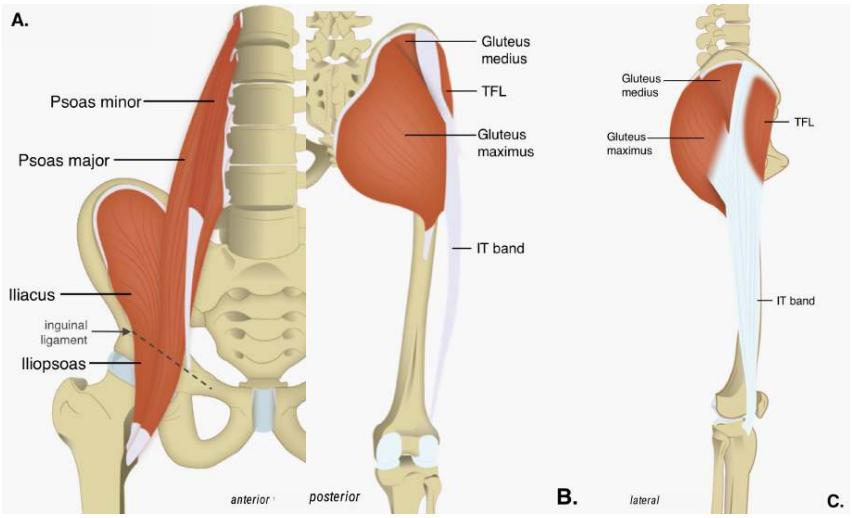


Figure 9.7.1: Muscles - Iliopsoas and Gluteal Groups. The primary of action of these muscles is hip flexion (A. iliopsoas group) and hip extension, abduction, and rotation (B. gluteal group). *(Image credits: "Iliopsoas and Gluteal Group Muscles" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy)*

- Also in the gluteal compartment, the **tensor fasciae latae** (TFL) is a thick, squarish muscle in the superior aspect of the lateral thigh. It acts as a synergist of the gluteus medius in abducting the thigh. It also helps stabilize the lateral aspect of the knee by

pulling on the iliotibial tract (band), making it taut (Figure 9.7.1).

- Deep to the gluteal muscles, the **piriformis**, **superior gemellus**, **obturator externus**, **inferior gemellus**, **obturator internus**, and **quadratus femoris** laterally rotate the femur at the hip (Figure 9.7.2).

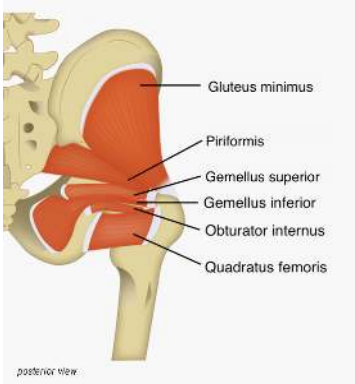


Figure 9.7.2: Muscles - Deep Gluteal Group. These small muscles stabilize the hip and help rotate it laterally. From superior to inferior they go in the the order of PG GO Q. *(Image credits: "Deep Gluteal Group Muscles" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy)*

Muscles of the Medial Compartment

Six muscles are located in the medial compartment of the thigh (Figure 9.7.3). Most of these muscles perform adduction at the hip joint, and each performs other actions as well. The **adductor longus**, **adductor brevis**, **gracilis,** and **pectineus** also flex the hip joint. **Adductor magnus**, depending on which fibers are activated, can flex, extend, and laterally rotate the thigh. Gracilis is the only one of this groups of muscles that does not insert into the femur, it inserts into the posterior, medial aspect of the superior tibia which also allows it to cause flexion at the knee joint. The only muscle in this compartment that does not adduct is the **obturator externus**, this muscle's action is to laterally rotate the hip.

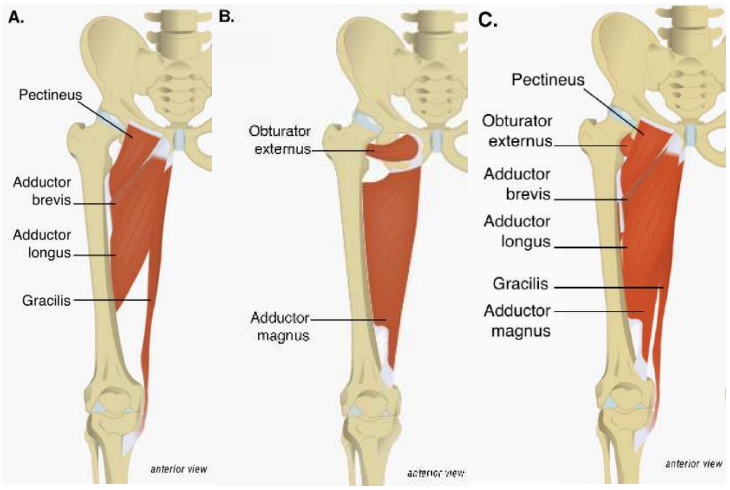
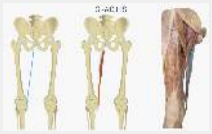


Figure 9.7.3: Muscles - Medial Thigh Compartment. All but one of the muscles in this group cause thigh adduction because they cross the hip joint on the medial side. Image A shows the more anterior muscles, image B shows the more posterior muscles, and image C shows them all. *(Image credits: "Medial Thigh Muscles" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy)*

Table 9.7.1: Muscles that Move the Hip Joint

Muscle	Origin		Insertion	Movement	Image(s)
Iliopsoas group					
Iliacus	Iliac fossa; iliac crest; lateral sacrum		Lesser trochanter of femur	Flexes hip	
Psoas major	Lumbar vertebrae (L_1 - L_5); thoracic vertebrae (T_{12})		Lesser trochanter of femur	Flexes hip	
Gluteal Group					
Gluteus maximus	Dorsal ilium; sacrum; coccyx		Gluteal tuberosity of femur; iliotibial tract	Extend and laterally rotates hip	
Gluteus medius	Lateral surface of ilium		Greater trochanter of femur	Abducts and medially rotates hip	
Gluteus minimus	External surface of ilium		Greater trochanter of femur	Abducts and medially rotates hip	
Tensor fascia lata	Anterior aspect of iliac crest; anterior superior iliac spine		Iliotibial tract	Abducts and medially rotates hip	
Deep Gluteal Muscles					
Inferior gemellus	Ischial tuberosity		Greater trochanter of femur	Laterally rotates hip; maintains posture by stabilizing hip joint	
Obturator externus	Outer surfaces of obturator membrane, pubis, and ischium; margins of obturator foramen		Trochanteric fossa of posterior femur	Laterally rotates hip; maintains posture by stabilizing hip joint	
Obturator internus	Inner surface of obturator membrane; greater sciatic notch; margins of obturator foramen		Greater trochanter in front of piriformis	Laterally rotates hip; maintains posture by stabilizing hip joint	

Muscle	Origin		Insertion	Movement	Image(s)
Piriformis	Anterolateral surface of sacrum		Greater trochanter of femur	Laterally rotates hip; maintains posture by stabilizing hip joint	
Quadratus femoris	Ischial tuberosity		Trochanteric crest of femur	Laterally rotates hip; maintains posture by stabilizing hip joint	
Superior gemellus	Ischial spine		Greater trochanter of femur	Laterally rotates hip; maintains posture by stabilizing hip joint	
Medial Muscles					
Adductor brevis	Body of pubis; inferior ramus of pubis		Linea aspera above adductor longus	Adducts and flexes hip	
Adductor longus	Pubis near pubic symphysis		Linea aspera	Adducts and flexes hip	
Adductor magnus	Ischial rami; pubic rami; ischial tuberosity		Linea aspera; adductor tubercle of femur	Adducts hip Posterior fibers: extends and laterally rotates hip Anterior fibers: flex hip	
Gracilis	Inferior ramus; body of pubis; ischial ramus		Medial surface of tibia	Adducts and flexes hip; flexes knee	
Pectineus	Pectineal line of pubis		Lesser trochanter to linea aspera of posterior aspect of femur	Adducts and flexes hip	

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Muscles of the Anterior Compartment

The muscles of the **anterior compartment of the thigh** flex the thigh and extend the leg. This compartment contains the **quadriceps femoris group**, which actually comprises four muscles that extend and stabilize the knee (Figure 9.7.4). The **rectus femoris** is on the anterior aspect of the thigh, the **vastus lateralis** is on the lateral aspect of the thigh, the **vastus medialis** is on the medial aspect of the thigh, and the **vastus intermedius** is between the vastus lateralis and vastus medialis and deep to the rectus

femoris. The tendon common to all four is the **quadriceps tendon** (patellar tendon), which inserts into the patella and continues below it as the **patellar ligament**. The patellar ligament attaches to the tibial tuberosity.

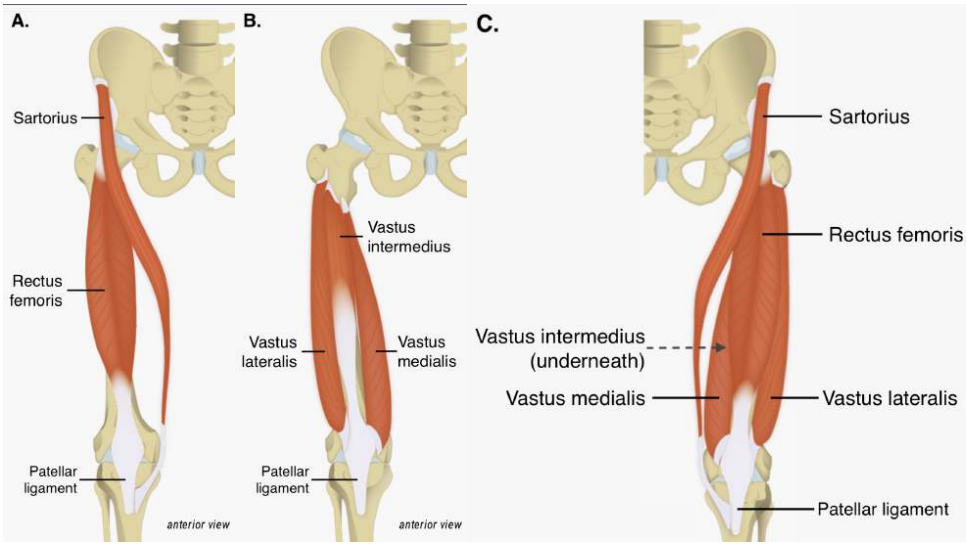
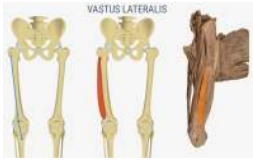


Figure 9.7.4: Muscles - Anterior Thigh. The two superficial muscles (A) act on both the hip and knee joints. The deeper muscles (B) only act on the knee joint. When all muscles are shown, the vastus intermedius cannot be seen (C) because it is deep to the rectus femoris. *(Image credits: "Anterior Thigh Muscles" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy)*

In addition to the quadriceps femoris, the **sartorius** is a band-like muscle that extends from the anterior superior iliac spine to the medial side of the proximal tibia (Figure 9.7.4). This versatile muscle flexes the leg at the knee and flexes, abducts, and laterally rotates the leg at the hip. This muscle allows us to sit cross-legged.

Table 9.7.2: Thigh Muscles That Move the Femur, Tibia, and Fibula

Muscle	Origin	Insertion	Movement	Image(s)
Anterior Compartment of Thigh: Quadricepts Femoris Group				
Rectus femoris	Anterior inferior iliac spine; superior margin of acetabulum	Patella; tibial tuberosity	Moves lower leg out in front of body, as when kicking; assists in raising knee	
Sartorius	Anterior superior iliac spine	Medial aspect of proximal tibia	Moves back of lower legs up and back toward the buttocks, as when kneeling; assists in moving thigh diagonally upward and outward as when mounting a bike	
Vastus intermedius	Proximal femur shaft	Patella; tibial tuberosity	Moves lower leg out in front of body, as when kicking	
Vastus lateralis	Greater trochanter; intertrochanteric line; linea apera	Patella; tibial tuberosity	Moves lower leg out in front of body, as when kicking	
Vastus medialis	Linea aspera; intertrochanteric line	Patella; tibial tuberosity	Moves lower leg out in front of body, as when kicking	
Posterior Compartment of Thigh: Hamstring Group				
Biceps femoris	Ischial tuberosity; linea aspera; distal femur	Head of fibula; lateral condyle of tibia	Moves back of lower legs up and back toward the buttocks, as when kneeling; moves thigh down and back; twists the thigh (and lower leg) outward	
Semimembranosus	Ischial tuberosity	Medial condyle of tibia; lateral condyle of femur	Moves back of lower legs up and back toward the buttocks, as when kneeling; moves thigh down and back; twists the thigh (and lower leg) outward	

Muscle	Origin	Insertion	Movement	Image(s)
Semitendinosus	Ischial tuberosity	Upper tibial shaft	Moves back of lower legs up and back toward the buttocks, as when kneeling; moves thigh down and back; twists the thigh (and lower leg) outward	

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Muscles of the Posterior Compartment

The **posterior compartment of the thigh** includes muscles that flex the leg and extend the thigh. The three long muscles on the back of the knee are the **hamstring group**, which flexes the knee and extends the hip. These are the **biceps femoris (long head)**, **semitendinosus**, and **semimembranosus**. The biceps femoris also has a **short head** that is not considered part of the hamstrings because it only flexes the knee and does not extend the hip (Figure 9.7.5). The tendons of these muscles form the **popliteal fossa**, the diamond-shaped space at the back of the knee.

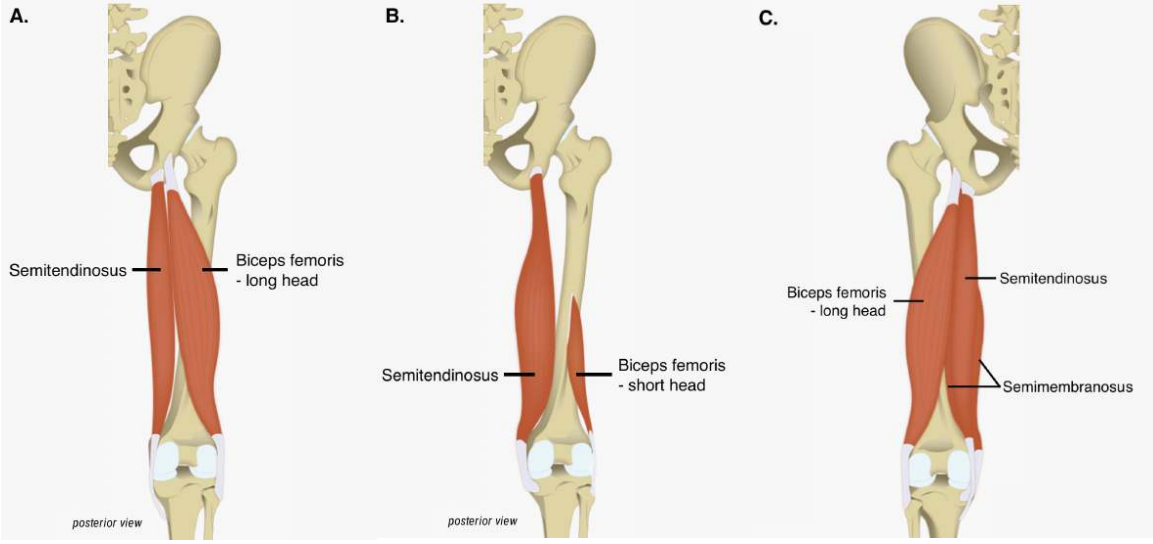

Figure 9.7.5: Muscles - Posterior Thigh. The superficial (A) and deep (B) muscles of the hamstring group cross both the hip and the knee joints. The short head of the biceps femoris (B) is not considered a hamstring because it does not do both of these functions, but it is located in the posterior thigh. When all muscles are shown, the short head cannot be seen (C) because it is deep to the long head. *(Image credits: "Posterior Thigh Muscles" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy)*

Muscles That Move the Feet and Toes

The muscles that move the ankle, foot, and toes and are located in the leg are called the crural muscles. Similar to the thigh muscles, the muscles of the leg are divided by fascia into compartments, although the leg has three: anterior, lateral, and posterior (Table 9.7.3).

Muscles of the Anterior Compartment

The muscles in the **anterior compartment of the leg**: the **tibialis anterior**, a long and thick muscle on the lateral surface of the tibia, the **extensor hallucis longus**, deep under it, and the **extensor digitorum longus**, lateral to it, all contribute to raising the front of the foot when they contract. Some, but not all, people have a third muscle in this group called the **fibularis tertius**

(*tertius="third"*), a small muscle that originates on the anterior surface of the fibula, is associated with the extensor digitorum longus and sometimes fused to it (Figure 9.7.6).

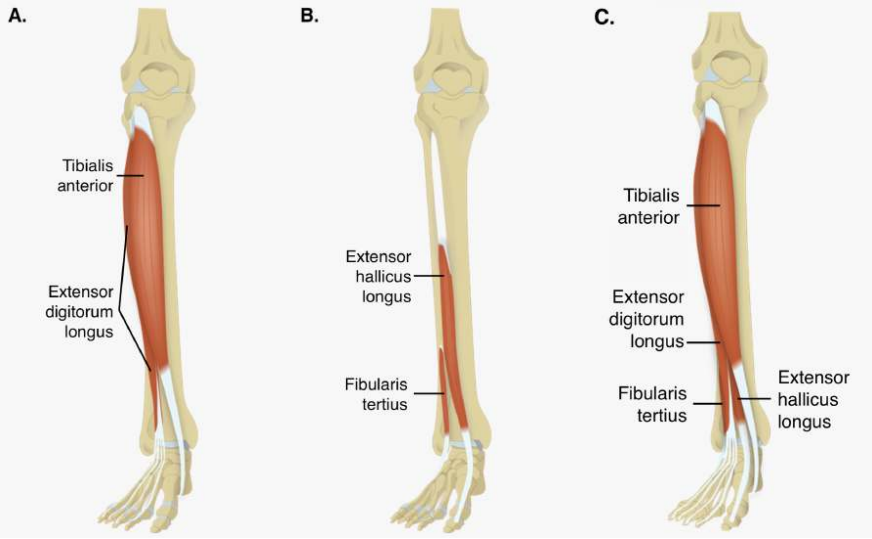

Figure 9.7.6: Muscles - Anterior Leg. The superficial (A) and deep (B) muscles of the anterior compartment of the leg cross both the ankle and joints in the foot. When all muscles are shown, only a small piece of the deep muscles can be seen (C), but you can easily identify the extensor hallicus longus because its tendon can be traced from the big toe. *(Image credits: "Anterior Leg Muscles" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy)*

Muscles of the Lateral Compartment

The **lateral compartment of the leg** includes two muscles: the **fibularis longus** (aka peroneus longus) and the **fibularis brevis** (aka peroneus brevis) (Figure 9.7.7). Fibularis longus is the more superficial of the two and it originates more proximally on the fibula than does the fibularis brevis. Both are strong everters of the foot and weak plantar flexors.

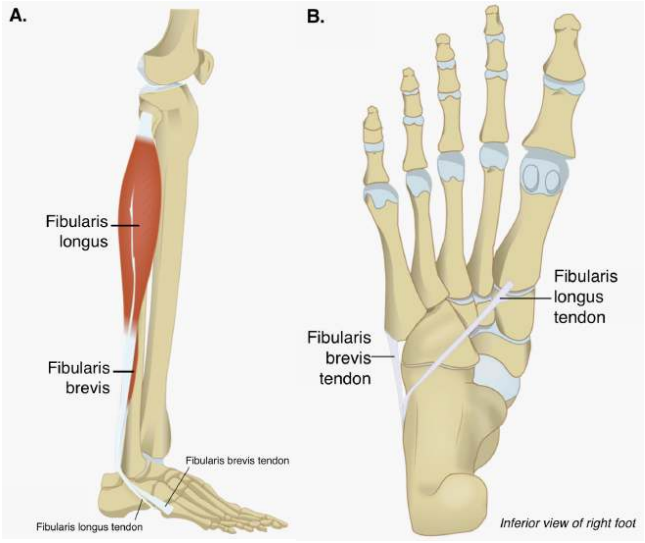

Figure 9.7.7: Muscles - Lateral Leg. The two muscles in the lateral compartment of the leg run along the length of the fibula (A). Based on their insertion points (B), both muscles cause eversion of the foot. *(Image credits: "Lateral Leg Muscles" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy)*

Muscles of the Posterior Compartment

The superficial muscles in the **posterior compartment of the leg** all insert onto the **calcaneal tendon** (Achilles tendon), a strong tendon that inserts into the posterior aspect of the calcaneus, and all are plantar flexors of the ankle joint. The most superficial and visible muscle of the calf is the **gastrocnemius**. This muscle originates superior to the knee and inserts into the calcaneous, so it is responsible for both knee flexion and ankle plantar flexion. The gastrocnemius has two wide muscle bellies called the **medial head** and the **lateral head**. Deep to the gastrocnemius is the wide, flat **soleus**. This muscle is named because it resembles a flatfish. The two heads of the gastrocnemius together with the soleus are

collectively called the triceps surae or, more commonly, the calf muscles. The **plantaris** is a small muscle with a long tendon that runs obliquely between the two large sural muscles; some people may have two of these muscles, whereas no plantaris is observed in about seven percent of other cadaver dissections.

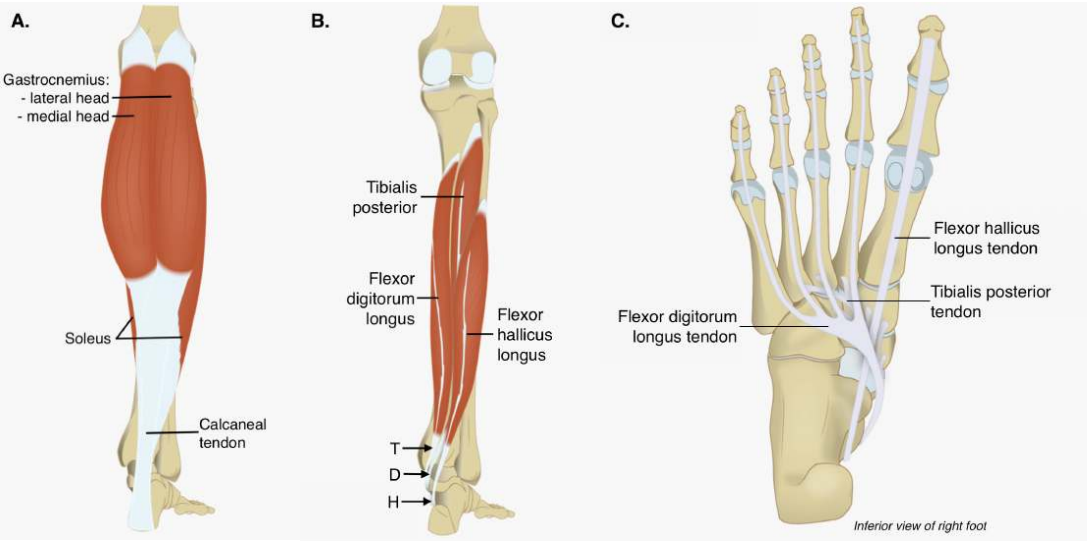

Figure 9.7.8: Posterior Leg Muscles. Superficial (A) and deep (B) views of the posterior compartment of the leg showing the muscles that plantar flex the ankle, invert the foot, and flex the toes as well as their tendinous insertions (C). *(Image credits: "Posterior Leg Muscles" by Jennifer Lange are licensed under CC BY-NC-SA 4.0, based on images by University of British Columbia Clinical Anatomy)*

There are four deep muscles in the posterior compartment of the leg: the **flexor digitorum longus**, **flexor hallucis longus**, **tibialis posterior** and **popliteus.** Popliteus is a small muscle that runs diagonally across the popliteal region. Its main function is to "unlock" the knee joint through slight medial rotation and flexion. The three remaining muscles are located along the posterior surface of the tibia and the fibula, deep to the triceps surae (Figure 9.7.8). All plantarflex the ankle joint. As their names suggest, flexor digitorum longus also flexes digits 2-5 and flexor hallucis longus also flexes the big toe. The secondary action of the tibialis posterior is inversion of the foot. The commonly used neumonic for the order of the tendons of these three muscles as they pass posterior to the medial malleolus is Tom, Dick, And Very Nervous Harry: T = **T**ibialis posterior, Dick = flexor **D**igitorum longus, A = **a**rtery, V = **v**ein, N = **n**erve, H = flexor **H**allicus longus.

Table 9.7.3: Muscles That Move the Feet and Toes

Prime Mover	Origin	Insertion	Movement	Image(s)
Anterior Compartment of Leg				
Extensor digitorum longus	Lateral condyle of tibia; proximal portion of fibula; interosseous membrane	Middle and distal phalanges of toes 2 - 5	Extends toes 2-4; dorsiflexion of ankle	
Extensor hallucis longus	Anteromedial fibula shaft; interosseous membrane	Distal phalanx hallux (big toe)	Extends the big toe; dorsiflexion of ankle	
Tibialis anterior	Lateral condyle and upper tibial shaft; interosseous membrane	Interior surface of medial cuneiform; first metatarsal bone	Dorsiflexion of ankle; inversion of intertarsal	
Lateral Compartment of Leg				
Fibularis (peroneus) brevis	Distal fibula shaft	Proximal end of fifth metatarsal	Eversion of intertarsal; plantarflexion of ankle	
Fibularis (peroneus) longus	Upper portion of lateral fibula	First metatarsal; medial cuneiform	Eversion of intertarsal, plantarflexion of ankle	
Posterior Compartment of Leg: Superficial Muscles				
Gastrocnemius	Medial and lateral condyles of femur	Posterior calcaneus	Plantarflexion of ankle; flexion of knee	
Soleus	Superior tibia; fibula; interosseous membrane	Posterior calcaneus	Plantarflexion of ankle	
Posterior Compartment of Leg: Deep Muscles				

Prime Mover	Origin	Insertion	Movement	Image(s)
Flexor digitorum longus	Posterior tibia	Distal phalanges of toes 2 - 5	Flexion of digits 2-5; plantarflexion of ankle	
Flexor hallucis longus	Midshaft of fibula; interosseous membrane	Distal phalanx of hallux (big toe)	Flexes big toe; plantarflexion of ankle	
Tibialis posterior	Superior tibia; fibula; interosseous membrane	Tarsals and metatarsals 2 - 4	Plantarflexion of ankle; inversion of intertarsal	

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The foot also has intrinsic muscles, which originate and insert within it (similar to the intrinsic muscles of the hand). These muscles primarily provide support for the foot and its arch, and contribute to movements of the toes. The principal support for the longitudinal arch of the foot is a deep fascia called **plantar aponeurosis**, which runs from the calcaneus bone to the toes (inflammation of this tissue is the cause of “plantar fasciitis,” which can affect runners.

Concept Review

The pelvic girdle attaches the legs to the axial skeleton. The hip joint is where the pelvic girdle and the leg come together. The hip is joined to the pelvic girdle by many muscles. In the gluteal region, the psoas major and iliacus form the iliopsoas. The large and strong gluteus maximus, gluteus medius, and gluteus minimus extend and abduct the femur. Along with the gluteus maximus, the tensor fascia lata muscle forms the iliotibial tract. The lateral rotators of the femur at the hip are the piriformis, obturator internus, obturator externus, superior gemellus, inferior gemellus, and quadratus femoris. On the medial part of the thigh, the adductor longus, adductor brevis, and adductor magnus adduct the thigh and medially rotate it. The pectineus muscle adducts and flexes the femur at the hip.

The thigh muscles that move the femur, tibia, and fibula are divided into medial, anterior, and posterior compartments. The medial compartment includes the adductors, pectineus, and the gracilis. The anterior compartment comprises the quadriceps femoris, quadriceps tendon, patellar ligament, and the sartorius. The quadriceps femoris is made of four muscles: the rectus femoris, the vastus lateralis, the vastus medius, and the vastus intermedius, which together extend the knee. The posterior compartment of the thigh includes the hamstrings: the biceps femoris, semitendinosus, and the semimembranosus, which all flex the knee.

The muscles of the leg that move the foot and toes are divided into anterior, lateral, superficial- and deep-posterior compartments. The anterior compartment includes the tibialis anterior, the extensor hallucis longus, the extensor digitorum longus, and the fibularis (peroneus) tertius. The lateral compartment houses the fibularis (peroneus) longus and the fibularis (peroneus) brevis. The superficial posterior compartment has the gastrocnemius, soleus, and plantaris; and the deep posterior compartment has the popliteus, tibialis posterior, flexor digitorum longus, and flexor hallucis longus.

Review Questions

Critical Thinking Questions

Glossary

Contributors and Attributions

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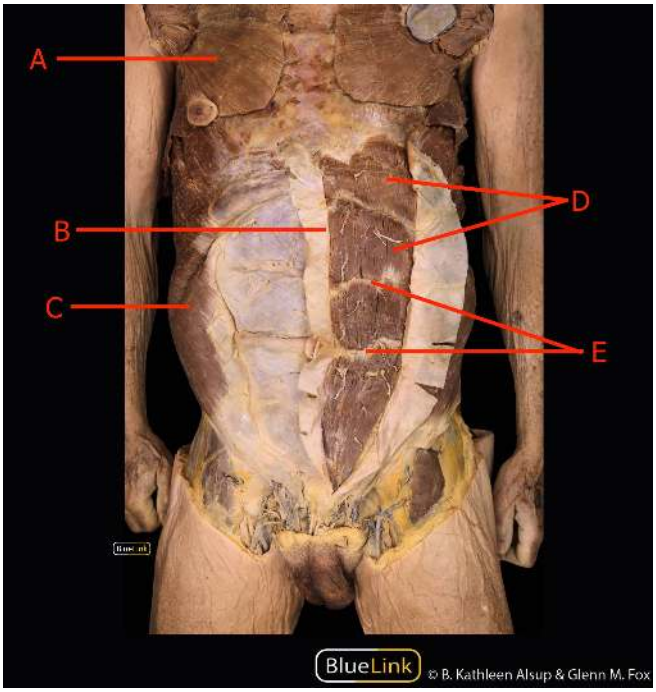
9.8: Anatomical Atlas - Muscular System

A compendium of anatomical images: slides, models, and/or cadavers.



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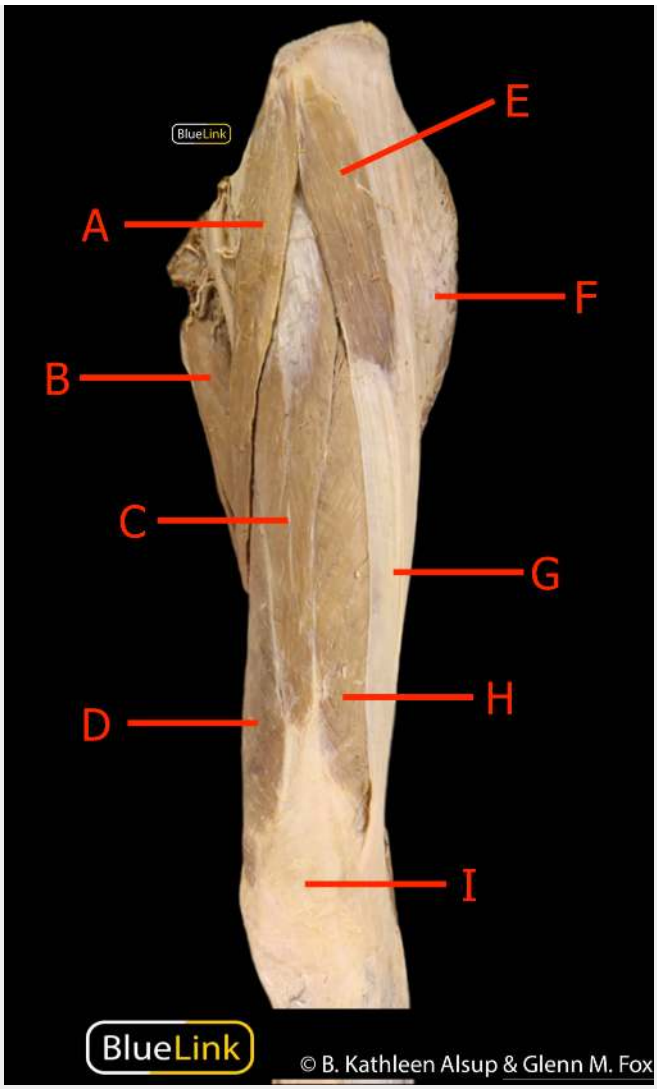
Answer Key (click to show/hide answers)

A - pectoralis major
B - linea alba
C - external oblique
D - rectus abdominus
E - tendinous intersections

Answer Key (click to show/hide answers)

A - sartorius
B - adductor longus
C - rectus femoris
D - vastus medialis
E - tensor fasciae latae
F - gluteus maximus
G - iliotibial tract/band
H - vastus lateralis
I - patella



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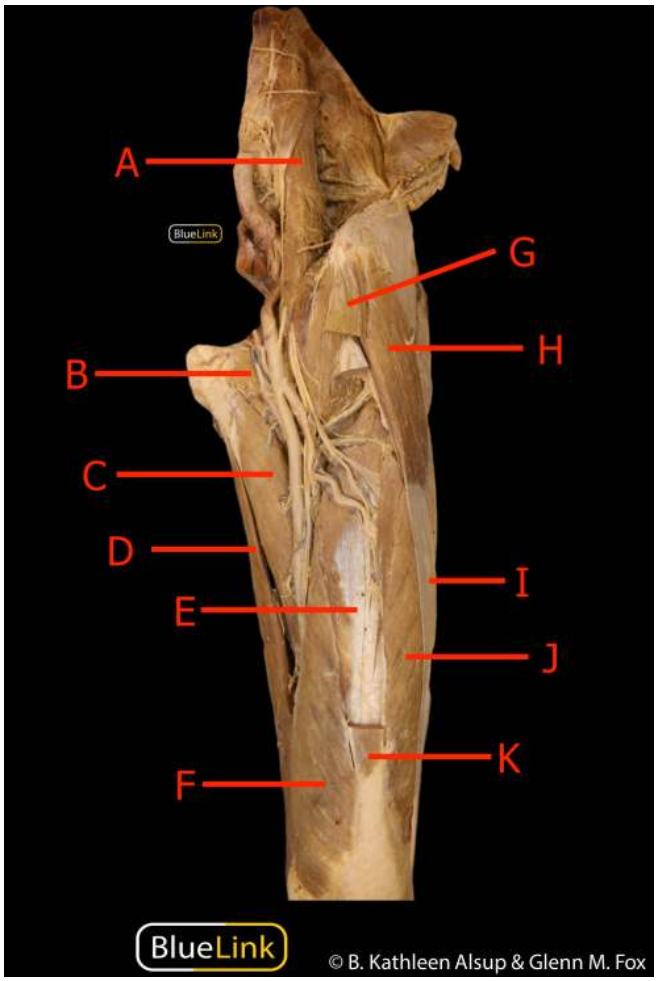

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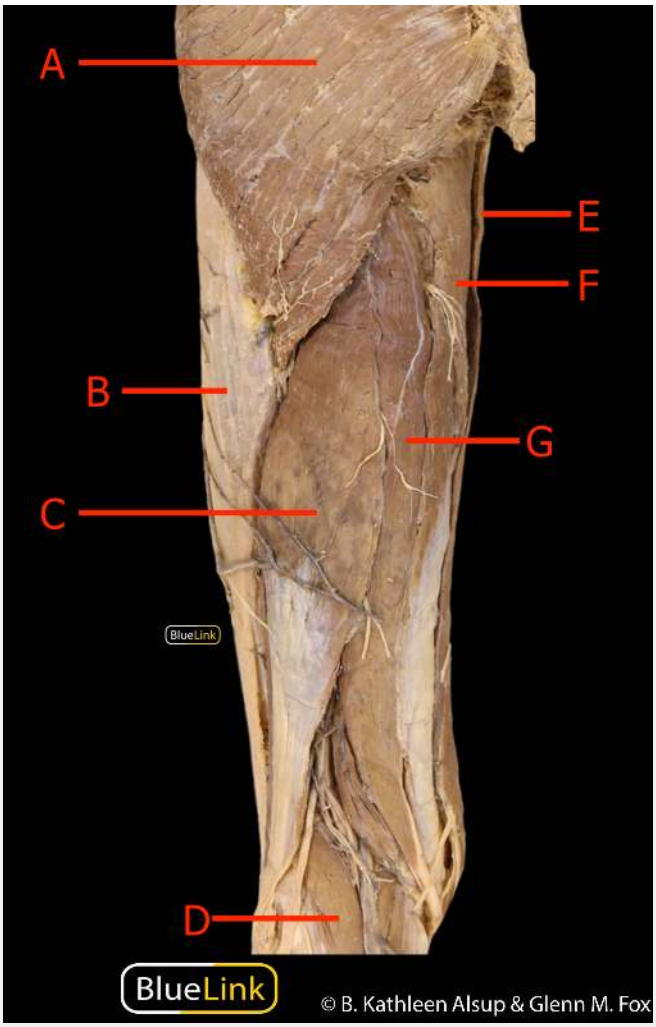
Answer Key (click to show/hide answers)

A - psoas major
B - pectineus
C - adductor longus
D - grascilis
E - vastus intermedius
F - vastus medialis
G - sartorius (cut)
H - tensor fasciae latae
I - iliotibial tract/band
J - vastus lateralis
K - rectus femoris (cut)

Answer Key (click to show/hide answers)

A - gluteus maximus
B - iliotibial tract/band
C - biceps femoris
D - popliteus
E - grascilis
F - semimembranosus
G - semitendinosus



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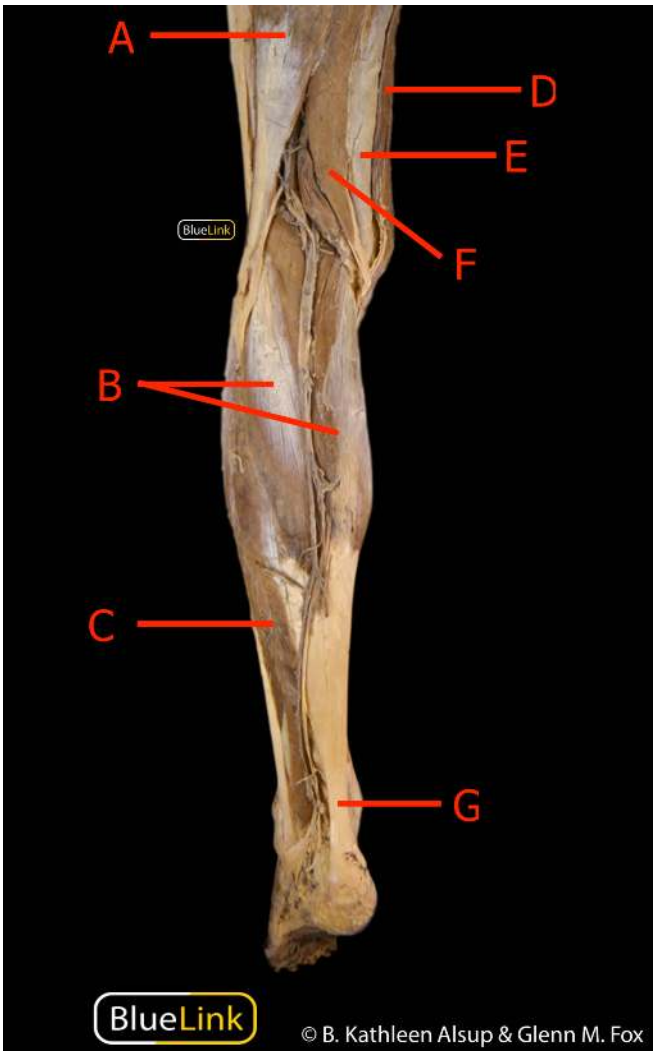
Answer Key (click to show/hide answers)

A - biceps femoris
B - gastrocnemius
C - soleus
D - grascilis
E - semimembranosus
F - semitendinosus
G - calcaneal (Achilles) tendon



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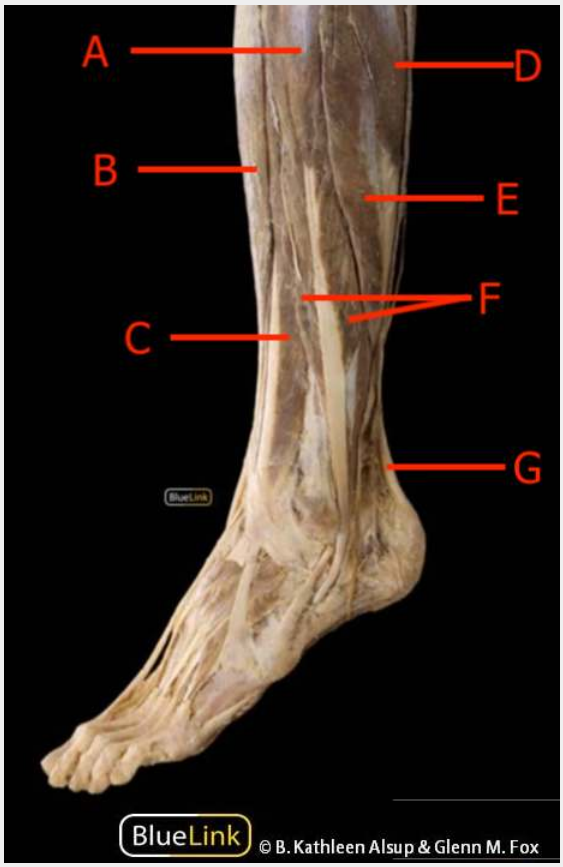

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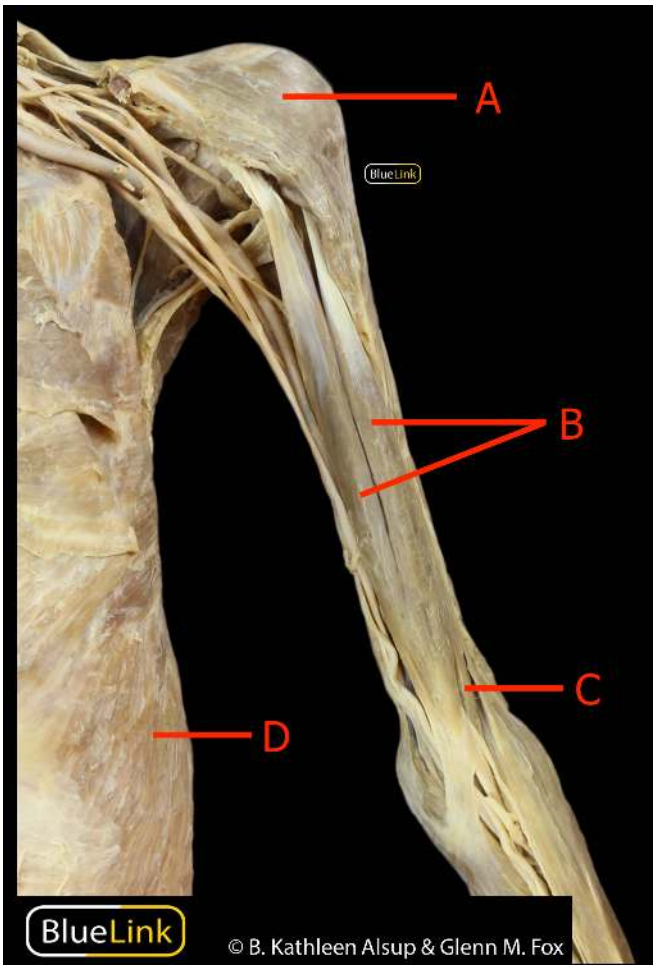
Answer Key (click to show/hide answers)

A - fibularis longus
B - tibialis anterior
C - extensor digitorum longus
D - gastrocnemius
E - soleus
F - fibularis brevis
G - calcaneal (Achilles) tendon

Answer Key (click to show/hide answers)

A - deltoid
B - biceps brachii
C - brachialis
D - external oblique



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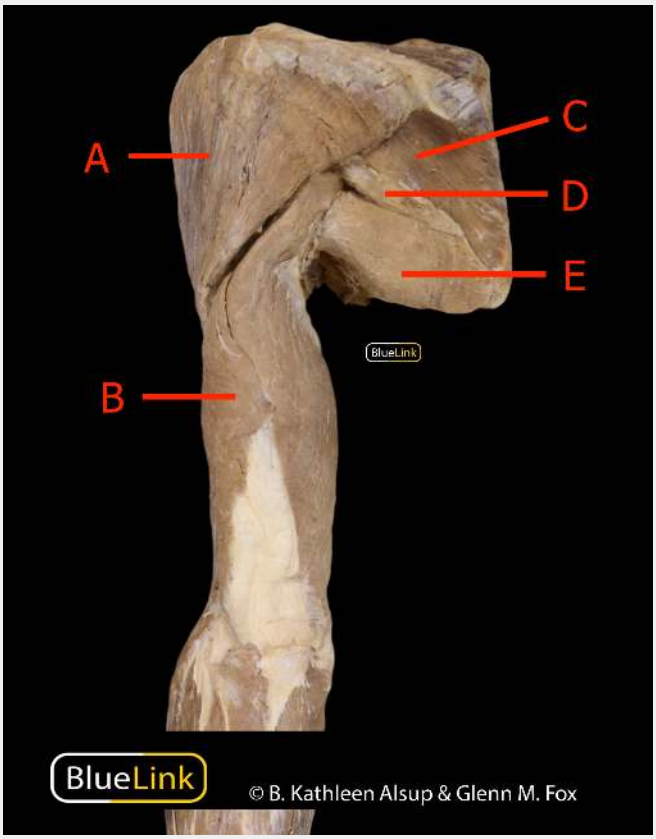

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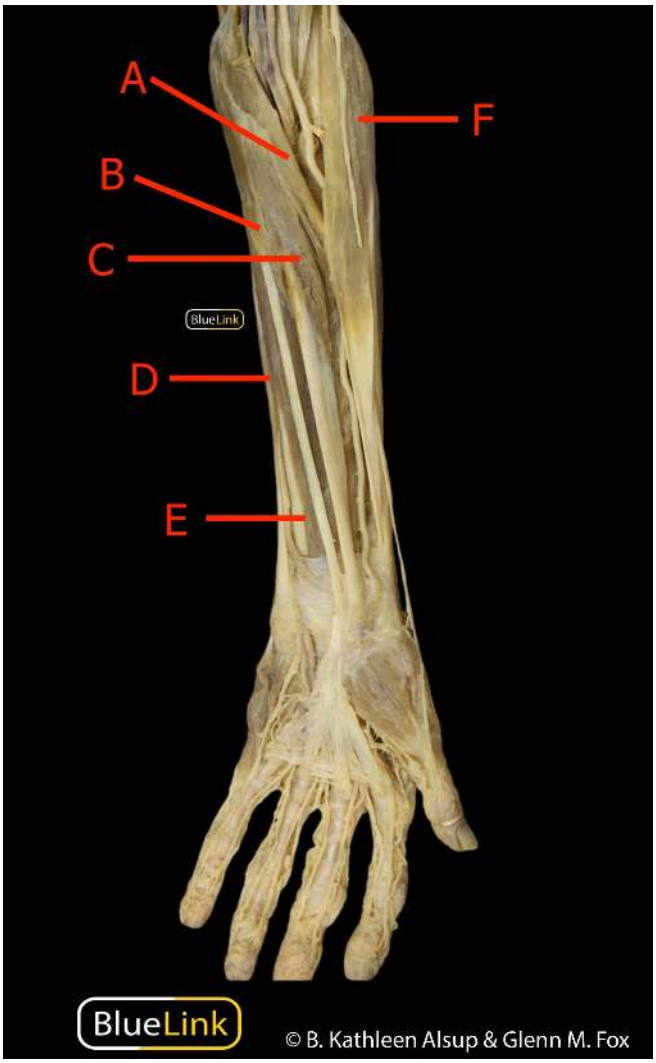
Answer Key (click to show/hide answers)

A - deltoid
B - triceps brachii
C - infraspinatus
D - teres minor
E - teres major

Answer Key (click to show/hide answers)

A - pronator teres
B - palmaris longus
C - flexor carpi radialis
D - flexor carpi ulnaris
E - flexor digitorum superficialis
F - brachioradialis



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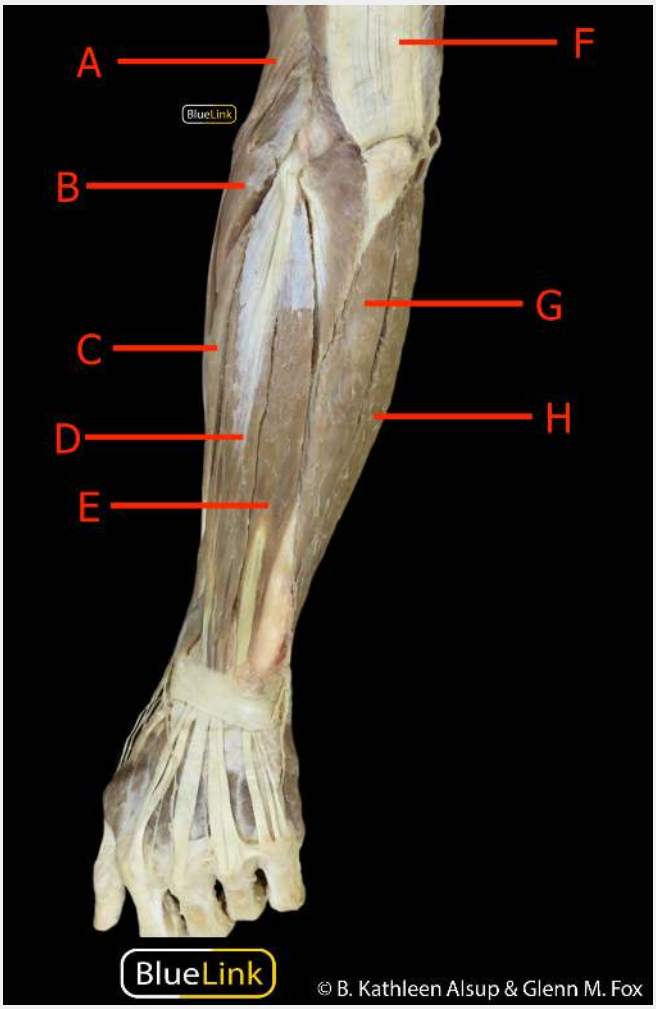

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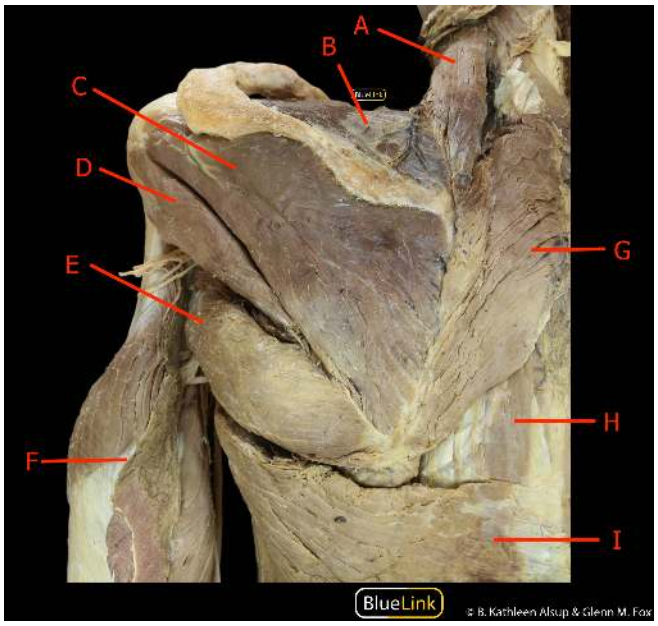
Answer Key (click to show/hide answers)

A - brachioradialis
B - extensor carpi radialis longus
C - extensor carpi radialis brevis
D - extensor digitorum
E - extensor carpi ulnaris
F - triceps brachii
G - flexor carpi ulnaris
H - palmaris longus



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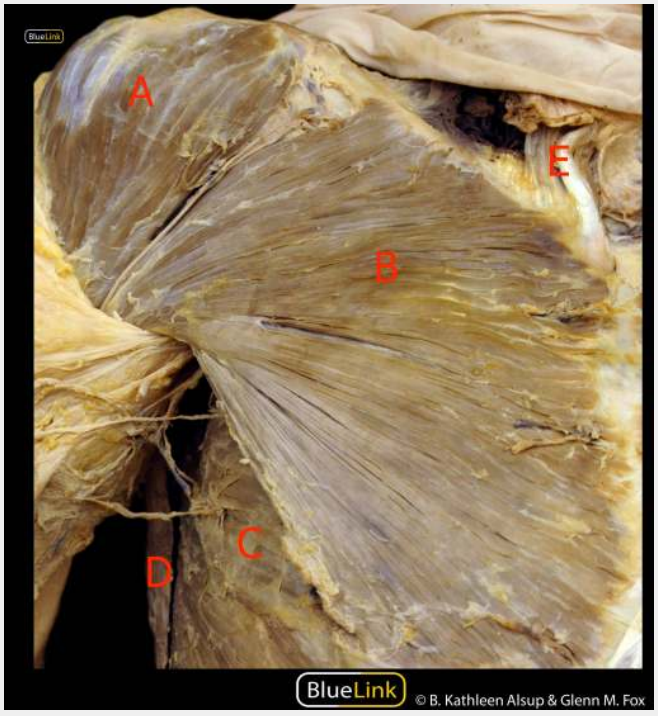
Answer Key (click to show/hide answers)

A - levator scapluae
B - supraspinatus
C - infraspinatus
D - teres minor
E - teres major
F - triceps brachii
G - rhomboid major
H - erector spinae (group)
I - latissimus dorsi



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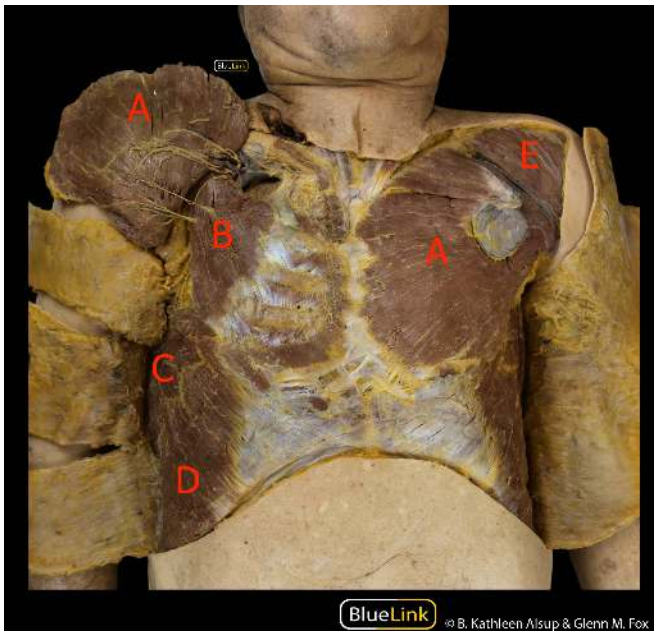
Answer Key (click to show/hide answers)

A - deltoid
B - pectoralis major
C - serratus anterior
D - latissimus dorsi
E - sternocleidomastoid



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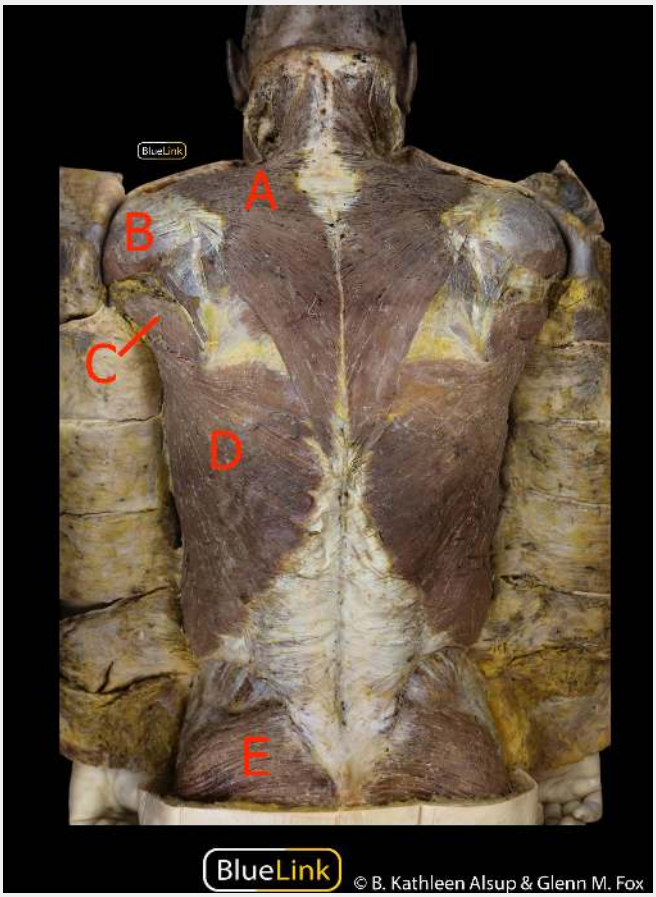
Answer Key (click to show/hide answers)

A - pectoralis major
B - pectoralis minor
C - serratus anterior
D - external oblique
E - deltoid



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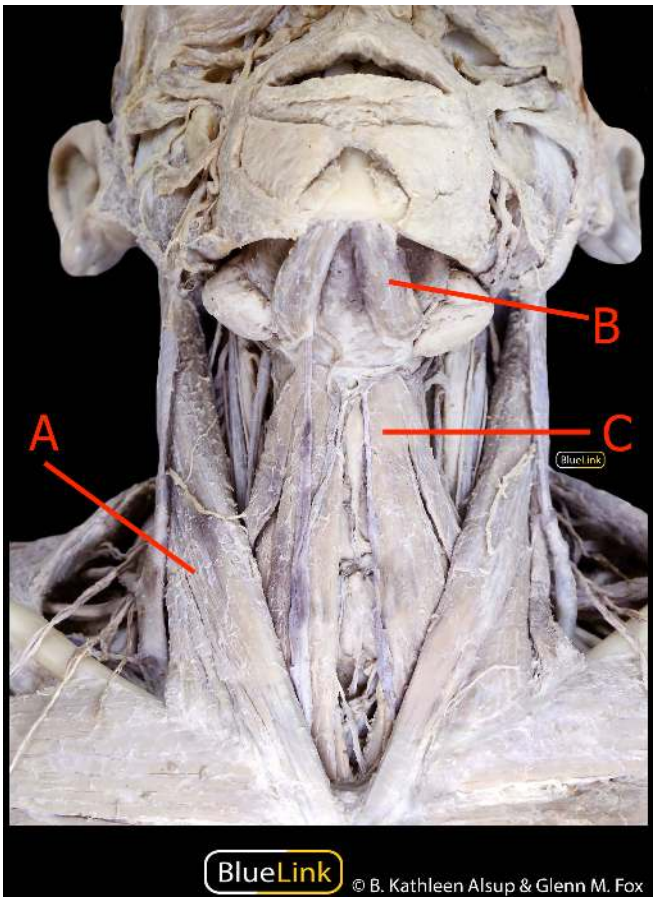
Answer Key (click to show/hide answers)

A - trapezius
B - deltoid
C - teres major
D - latissimus dorsi
E - gluteus maximus



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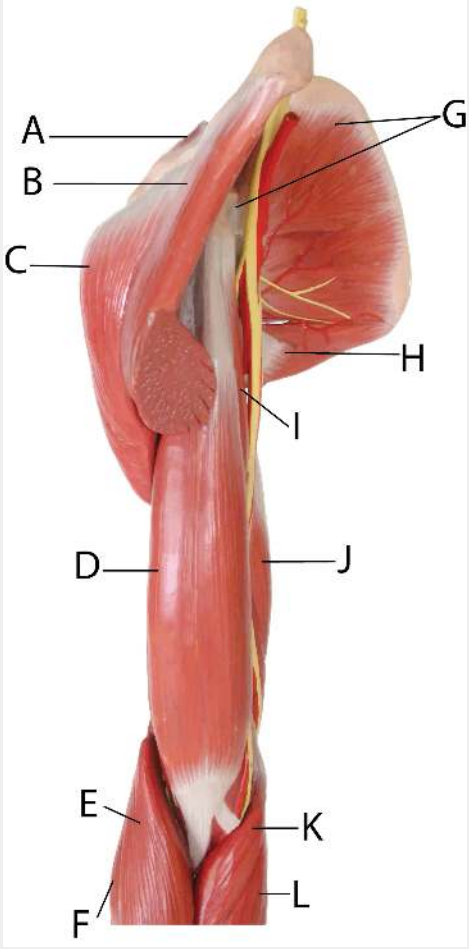
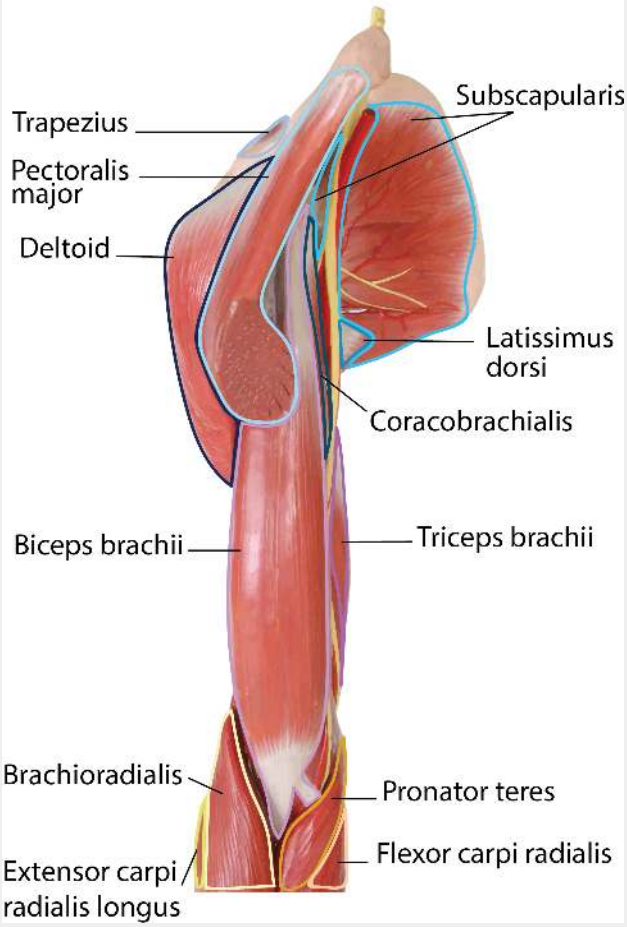
Answer Key (click to show/hide answers)

A - sternocleidomastoid
B - digastric
C - sternohyoid

Answer Key (click to show/hide answers)

Anterior View





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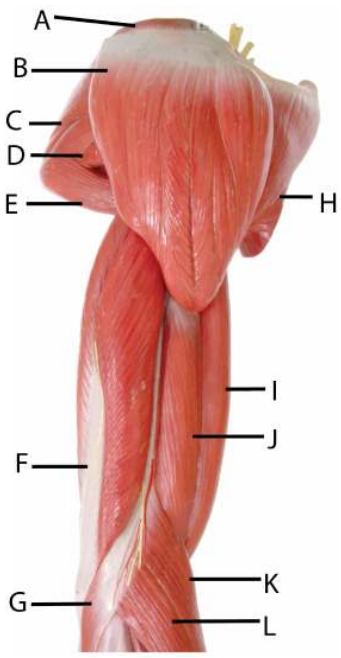

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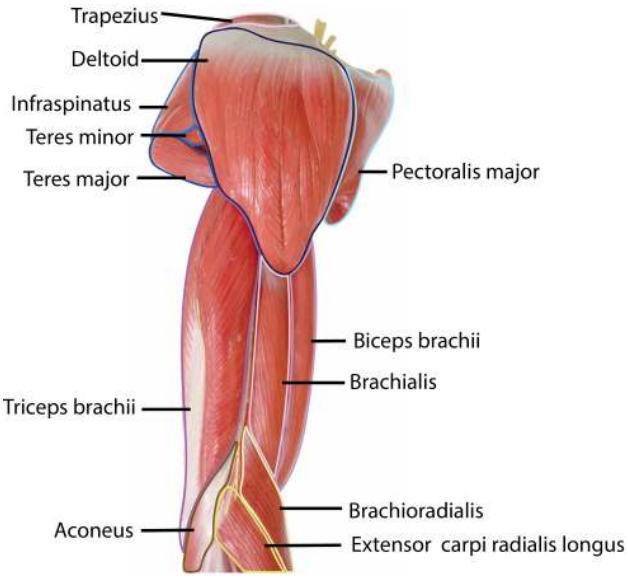
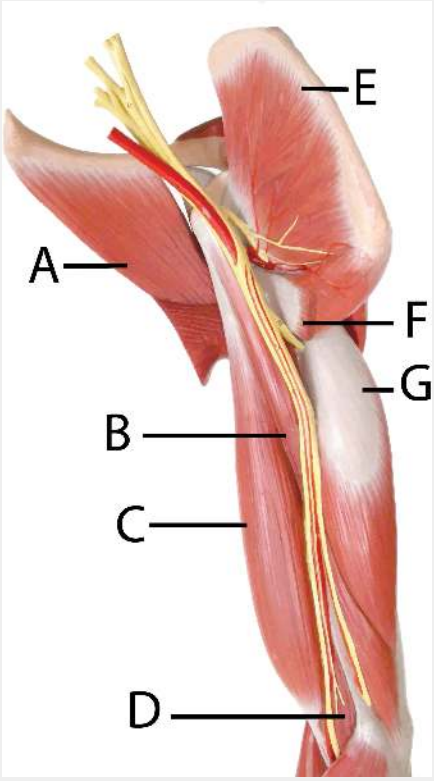
Answer Key (click to show/hide answers)

Lateral View





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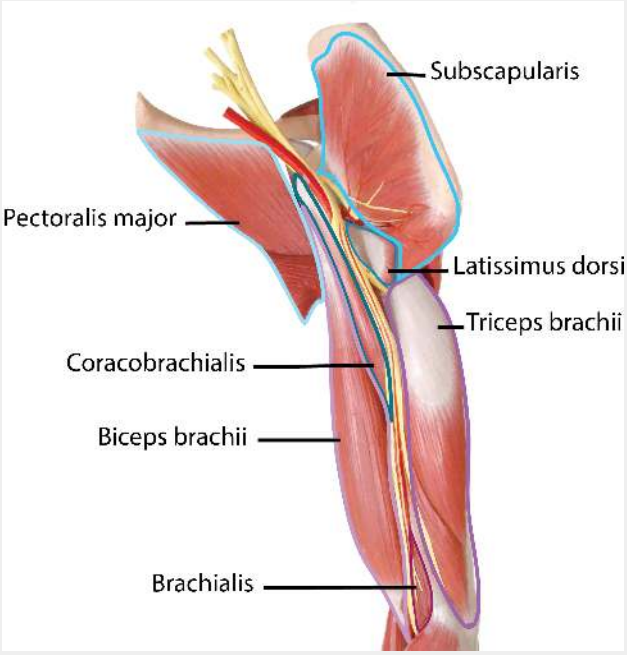
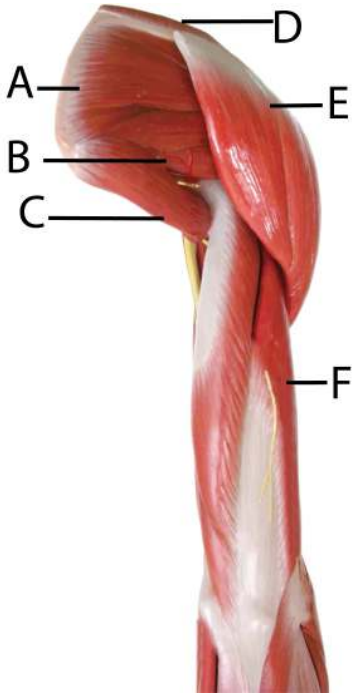
Answer Key (click to show/hide answers)

Anterior View





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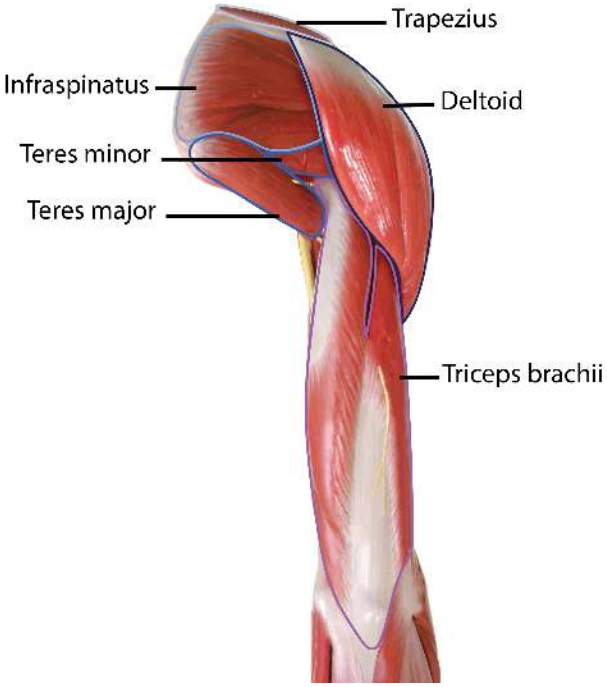
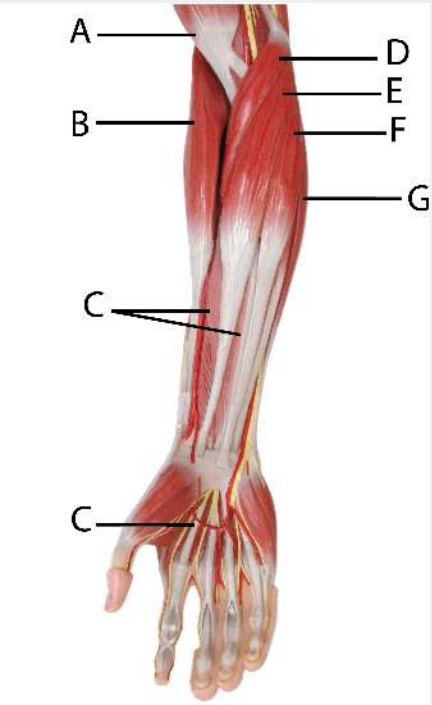
Answer Key (click to show/hide answers)

Posterior View





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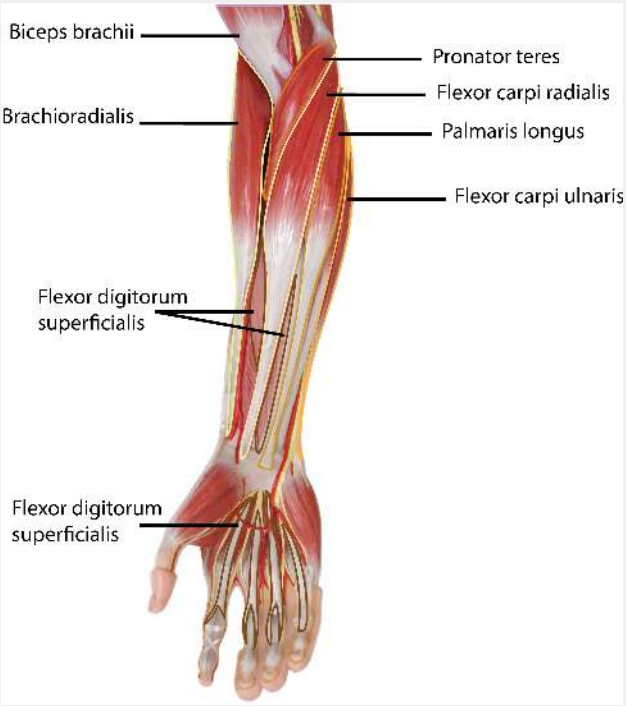
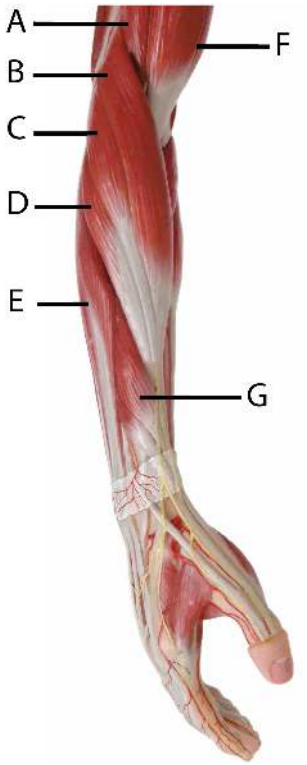
Answer Key (click to show/hide answers)

Anterior View





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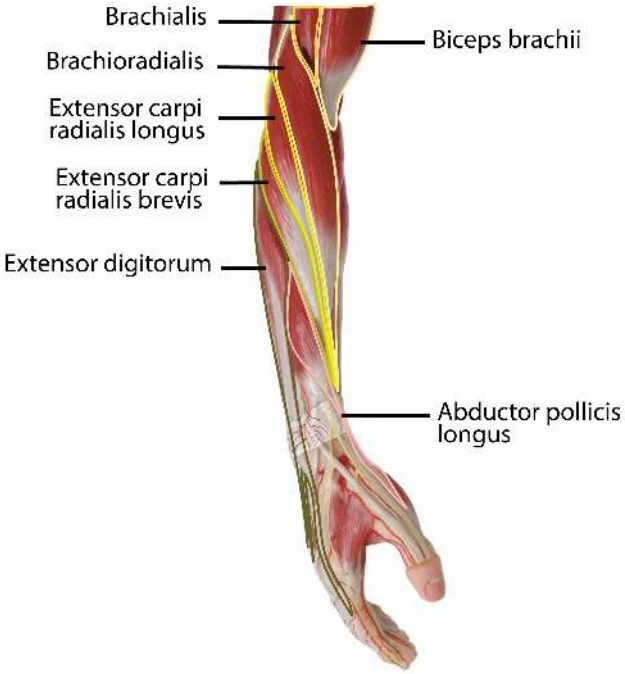
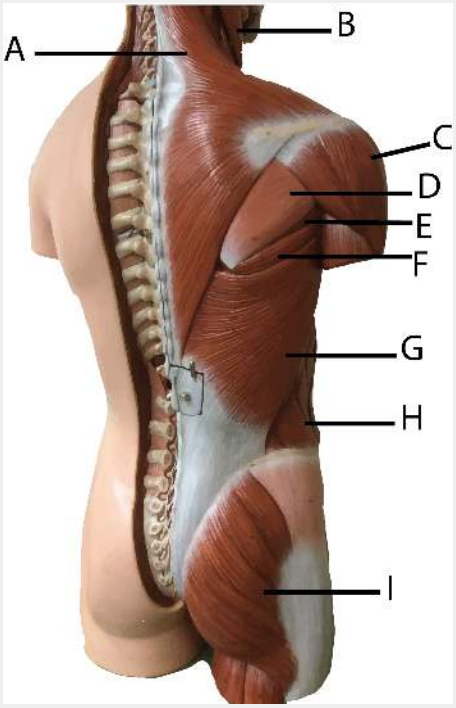
Answer Key (click to show/hide answers)

Medial View





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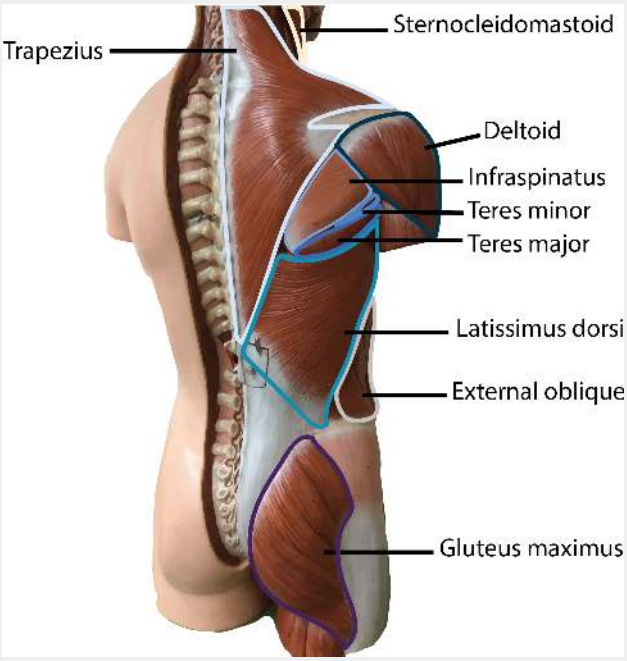

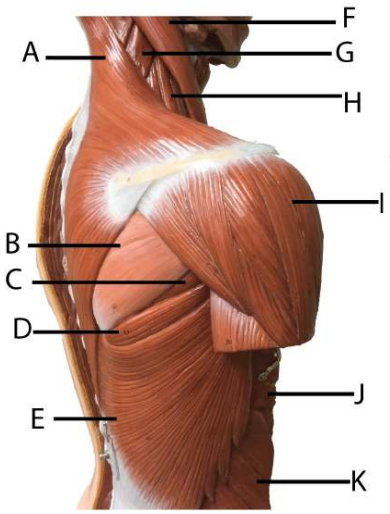

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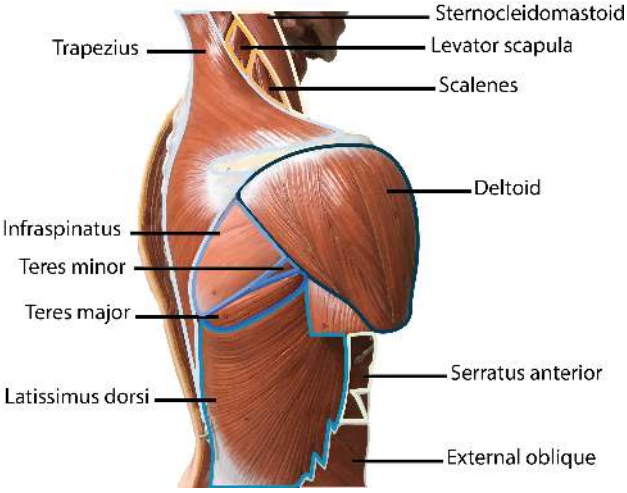

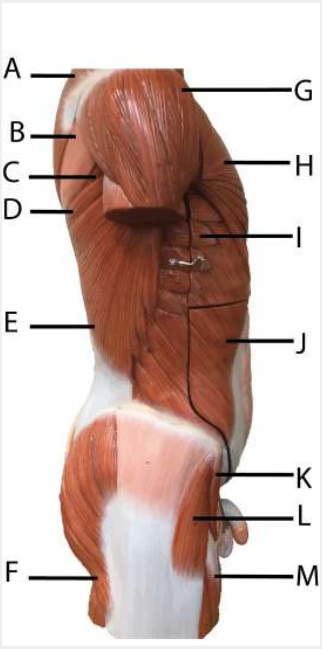

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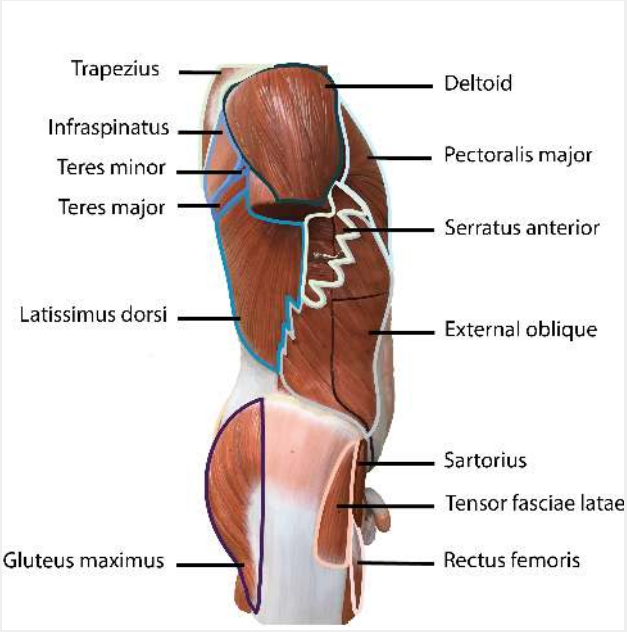

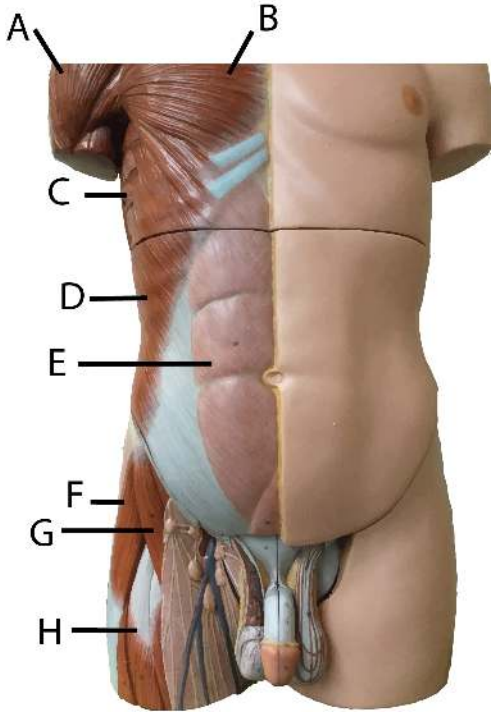

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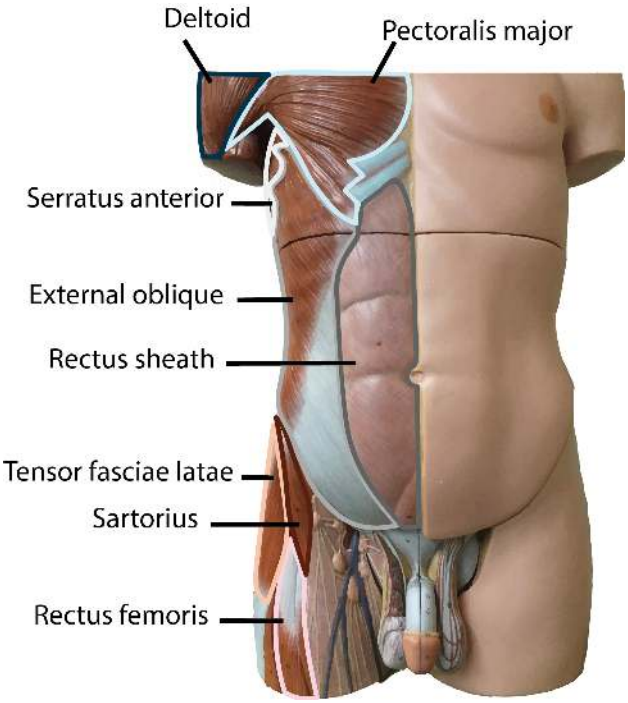

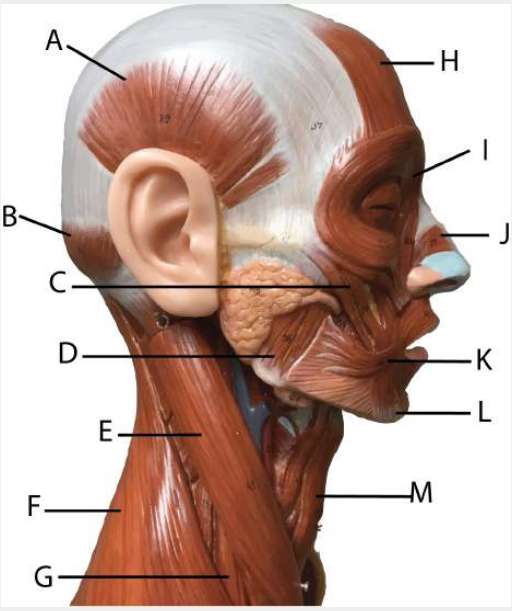

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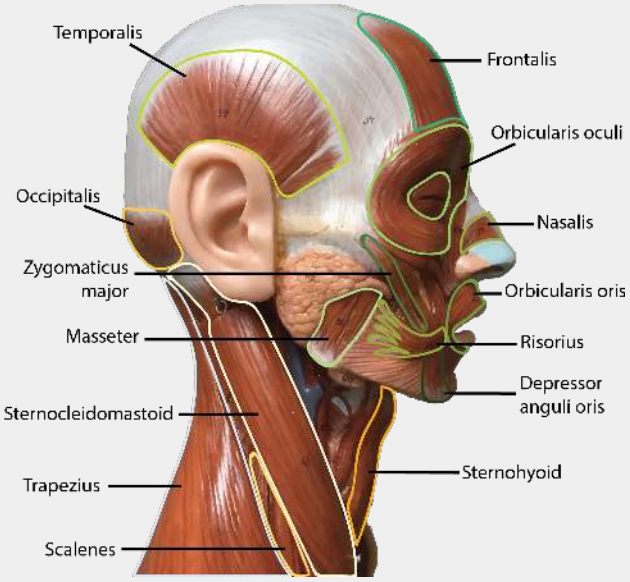

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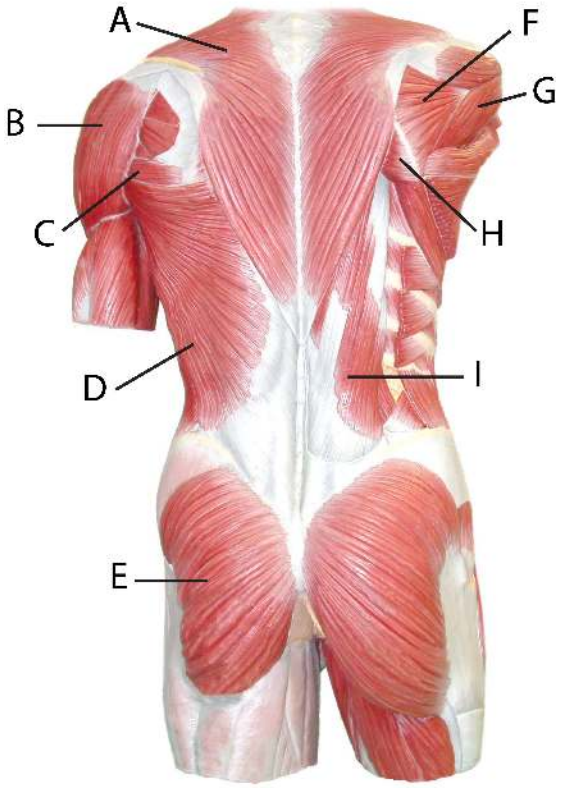

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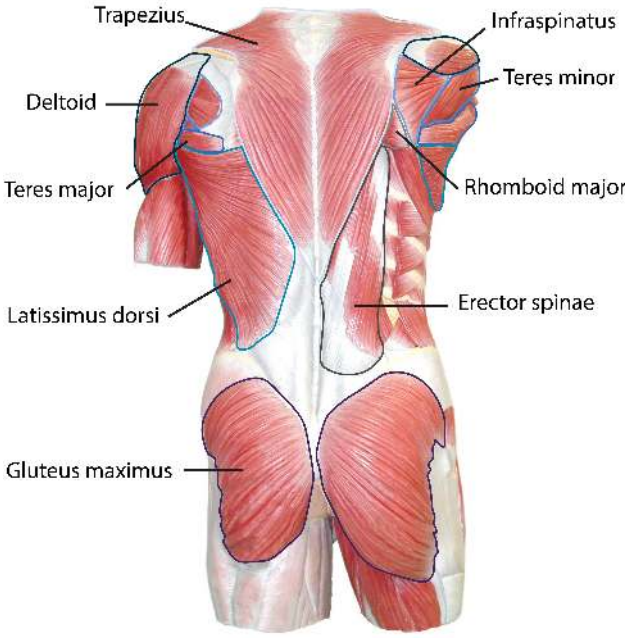

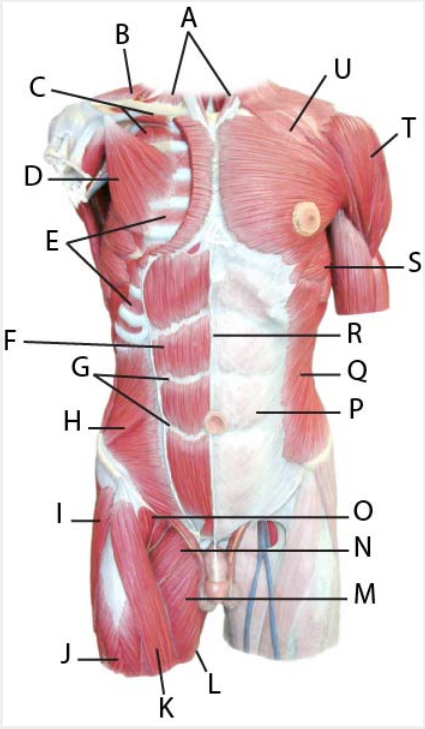

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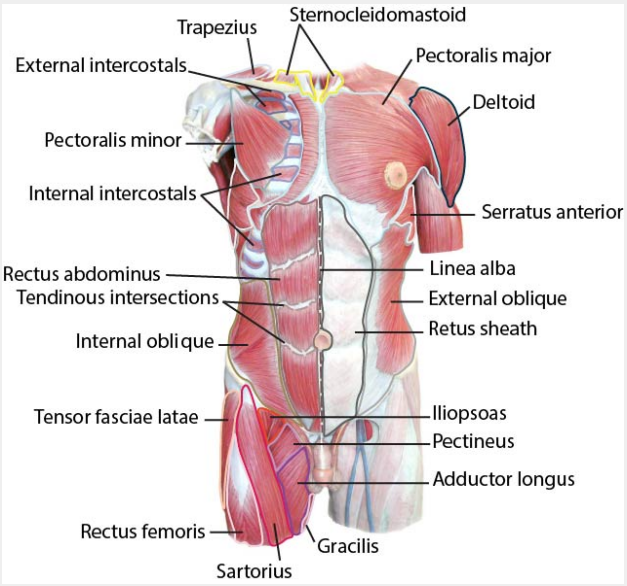

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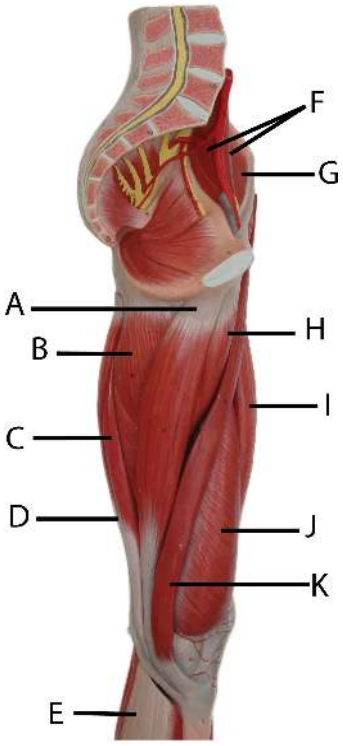

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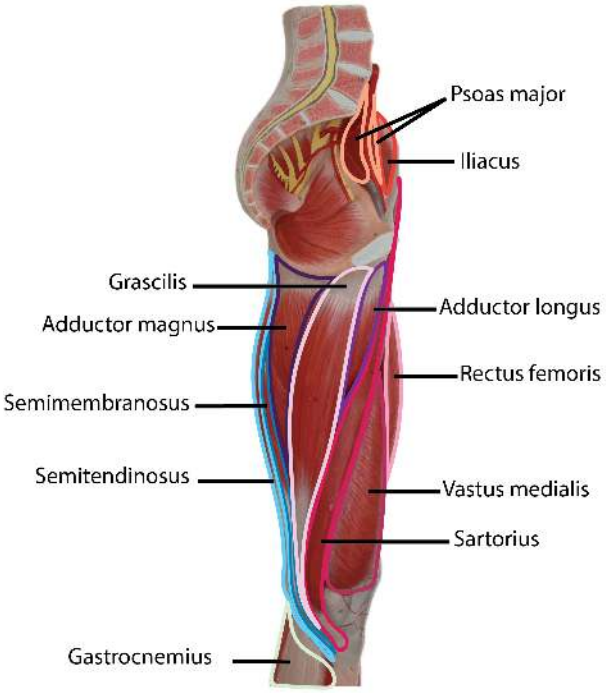
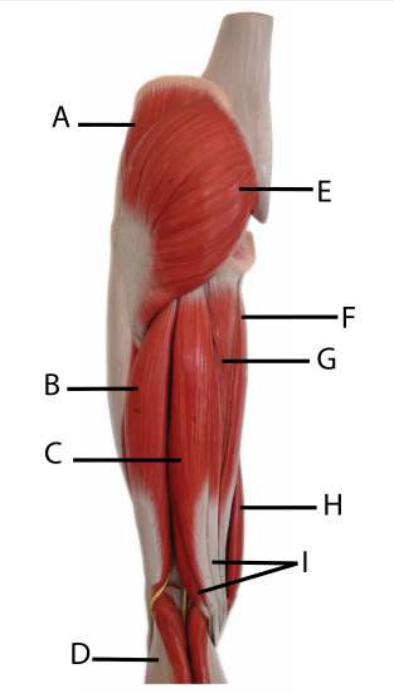
Answer Key (click to show/hide answers)

Medial View





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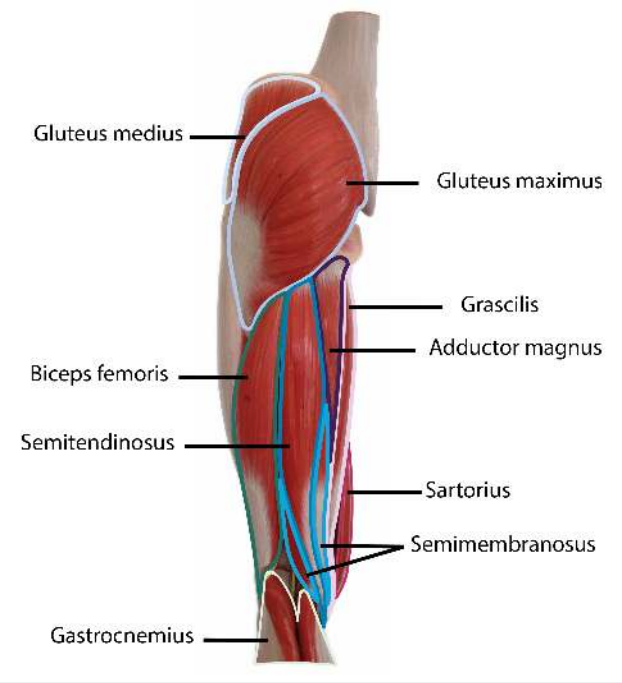
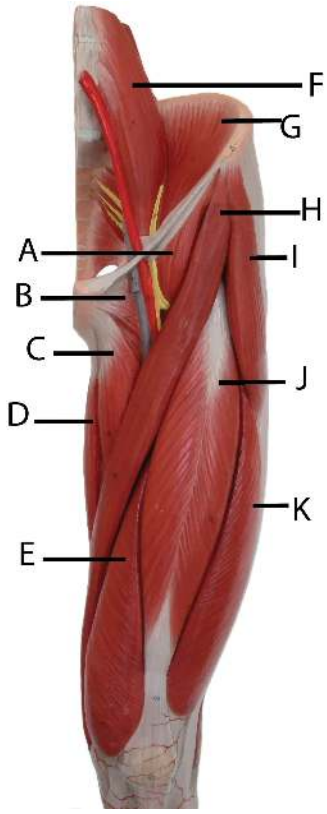
Answer Key (click to show/hide answers)

Posterior View





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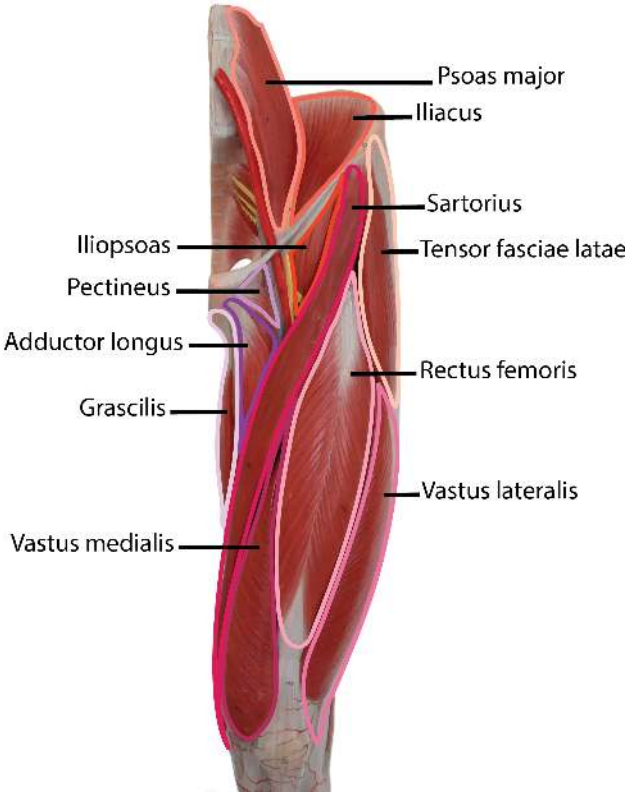
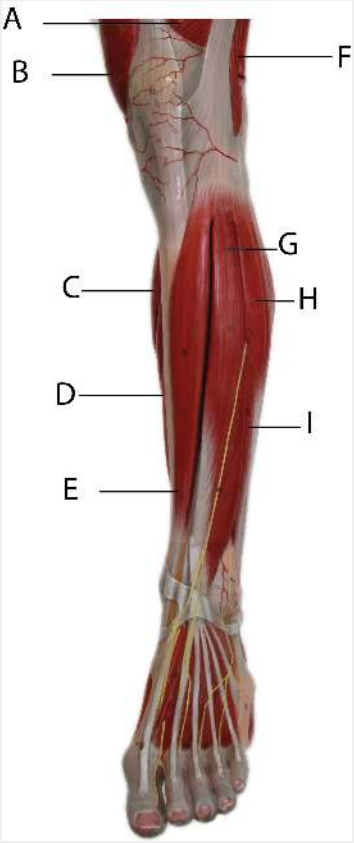
Answer Key (click to show/hide answers)

Anterior View





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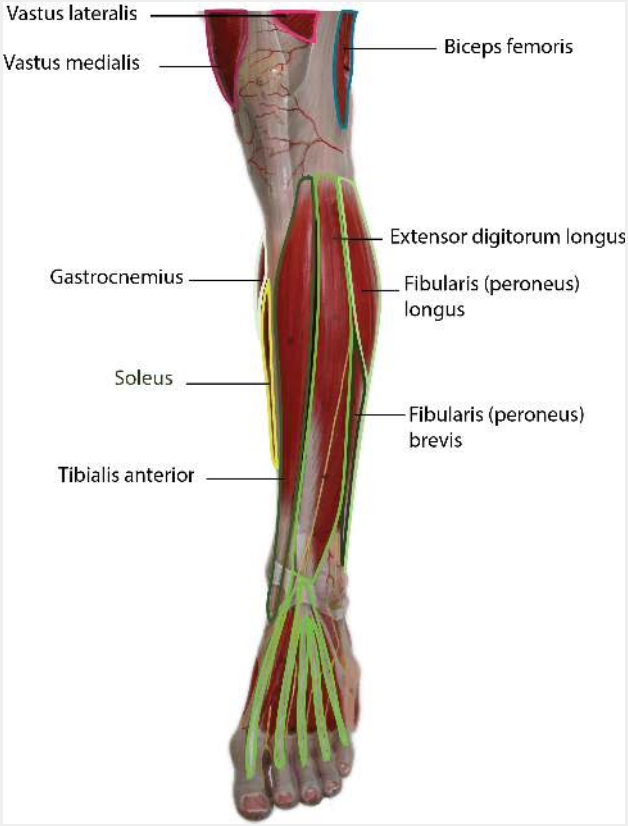
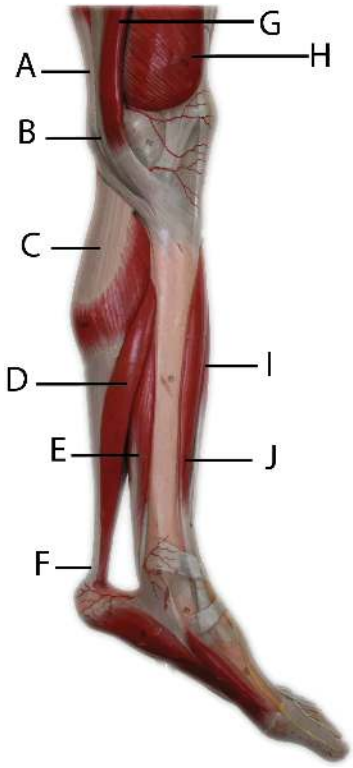
Answer Key (click to show/hide answers)

Anterior View





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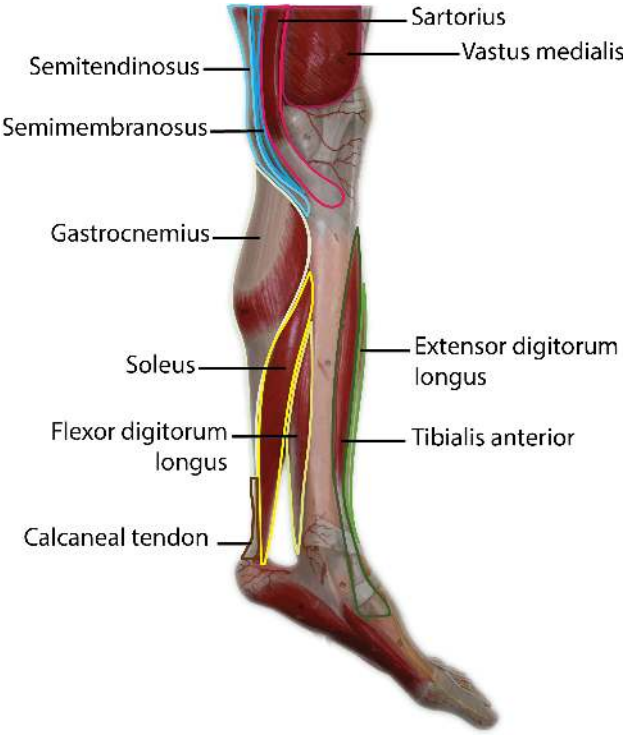
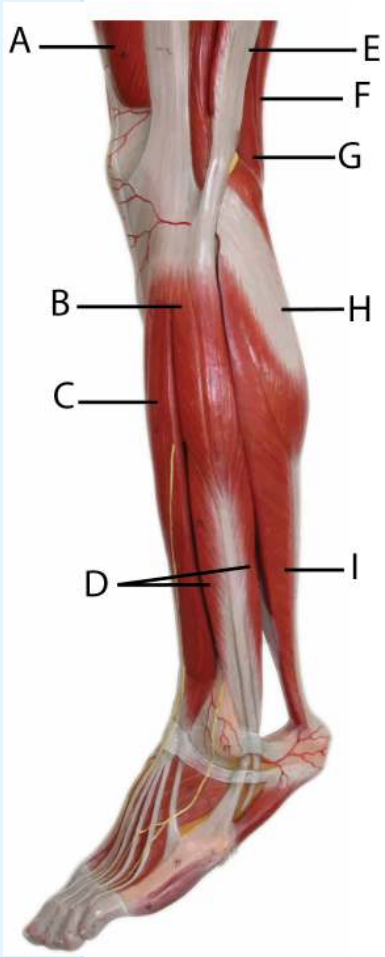
Answer Key (click to show/hide answers)

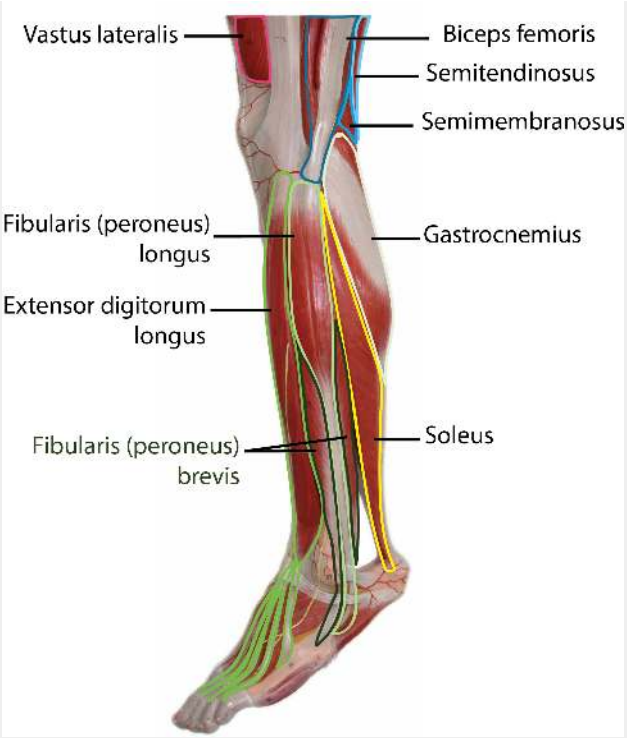
Medial View



Answer Key (click to show/hide answers)

Lateral View





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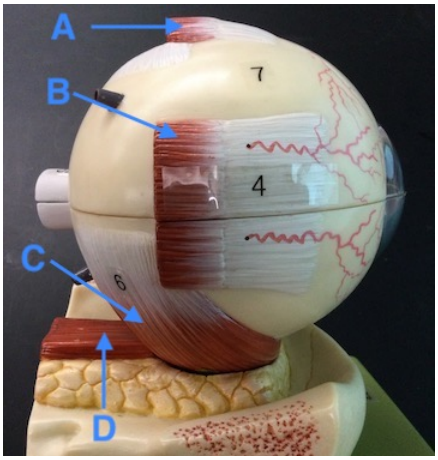

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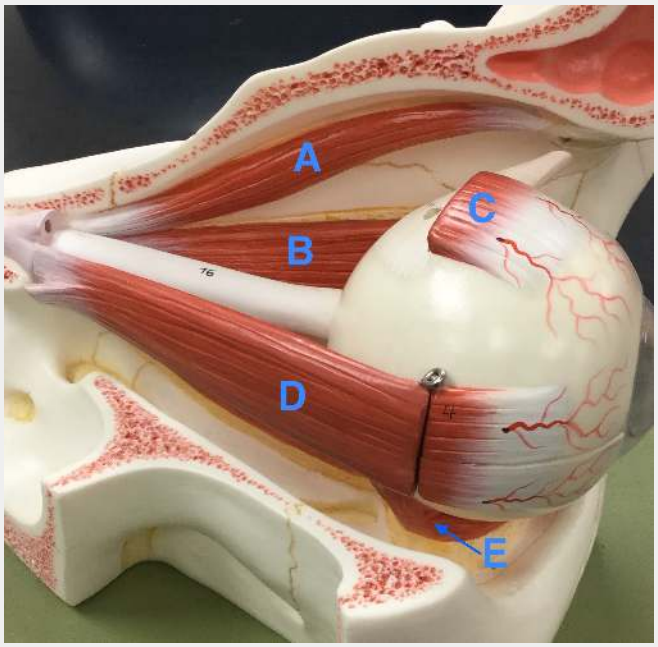
Answer Key (click to show/hide answers)

Lateral View

A - superior rectus
B - lateral rectus
C - inferior oblique
D - inferior rectus



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Answer Key (click to show/hide answers)

Superolateral View

A - superior oblique
B - medial rectus
C - superior rectus
D - lateral rectus
E - inferior oblique

9.9: Practice Practical- Muscles