Chapter 6
Getting in Gear: The Muscles

In This Chapter
► Understanding the functions and structure of muscles
► Classifying types of muscle
► Pulling together: Muscles as organs
► Breaking down muscle contractions, tone, and power
► Deciphering muscle names

Much of what we think of as “the body” centers around our muscles and what they can do, what we want them to do, and how tired we get trying to make them do it. With all that muscles do and are, it’s hard to believe the word “muscle” is rooted in the Latin word *musculus*, which is a diminutive of the word for “mouse.” Well, the muscle is a mouse that roars. Muscles make up most of the fleshy parts of the body and average 43 percent of the body’s weight. Layered over the skeleton, they largely determine the body's form. There are over 500 muscles large enough to be seen by the unaided eye, and thousands more are visible only through a microscope. Although there are three distinct types of muscle tissue, every muscle in the human body shares one important characteristic: *contractility*, the ability to shorten, or contract.

Flexing Your Muscle Knowledge

The study of muscles is called *myology* after the Greek word *mys*, which means “mouse.” Muscles perform a number of functions vital to maintaining life, including

▶ **Movement:** Skeletal muscles (those attached to bones) convert chemical energy into mechanical work, producing movement ranging from finger tapping to a swift kick of a ball by contracting, or shortening. Reflex muscle reactions protect your fingers when you put them too close to a fire and startle you into watchfulness when an unexpected noise sounds. Many purposeful movements require several sets, or groups, of muscles to work in unison.

▶ **Vital functions:** Without muscle activity, you die. Muscles are doing their job when your heart beats, when your blood vessels constrict, and when your intestines squeeze food along your digestive tract in *peristalsis*.

▶ **Antigravity:** Perhaps that’s overstating it, but muscles do make it possible for you to stand and move about in spite of gravity’s ceaseless pull. Did your mother tell you to improve your posture? Just think how bad it would be without any muscles!

▶ **Heat generation:** You shiver when you’re cold and stamp your feet and jog in place when you need to warm up. That’s because chemical reactions in muscles result in heat, helping to maintain the body’s temperature.

▶ **Keep the body together:** Muscles are the warp and woof of your body’s structure, binding one part to another.
As you may remember from studying tissues, muscle cells — called fibers — are some of the longest in the body. Fibers are held together by connective tissue and enclosed in a fibrous sheath called fascia. Some muscle fibers contract rapidly, whereas others move at a leisurely pace. Generally speaking, however, the smaller the structure to be moved, the faster the muscle action. Exercise can increase the thickness of muscle fibers, but it doesn’t make new fibers. Skeletal muscles have a rich vascular supply that dilates during exercise to give the working muscle the extra oxygen it needs to keep going.

Two processes are central to muscle development in the developing embryo: myogenesis, during which muscle tissue is formed; and morphogenesis, when the muscles form into internal organs. By the eighth week of gestation, a fetus is capable of coordinated movement.

Following are some important muscle terms to know:

- **Fascia**: Loose, or areolar, connective tissue that holds muscle fibers together to form a muscle organ
- **Fiber**: An individual muscle cell
- **Insertion**: The more movable attachment of a muscle
- **Ligament**: Elastic connective tissue that supports joints and anchors organs
- **Motor nerve**: Nerve that stimulates contraction of a muscle
- **Myofibril**: Fibrils within a muscle cell that contain protein filaments such as actin and myosin that slide during contraction, shortening the fiber (or cell)
- **Origin**: The immovable attachment of a muscle, or the point at which a muscle is anchored by a tendon to the bone
- **Sarcoplasm**: The cellular cytoplasm in a muscle fiber
- **Tendon**: Connective tissue made up of collagen, a fibrous protein that attaches muscles to bone; lets muscles apply their force at some distance from where a contraction actually takes place
- **Tone, or tonus**: State of tension present to a degree at all times, even when the muscle is at rest

Complete the following practice questions to see how well you understand the basics of myology:

1. Which of the following is not a true statement?
   a. Muscles represent 90 percent of the total body weight.
   b. The ancient Greek word mys means “mouse.”
   c. The muscles covering the bones largely determine the form of the body.
   d. Posture is an expression of muscle action.

2. Muscle functions include
   a. Support of the bony tissues of the body
   b. Blood formation
   c. Converting chemical energy into mechanical work
   d. Only a and c
3. A necessary property for a muscle to perform work is
   a. Extensibility
   b. Contractility
   c. Elasticity
   d. All of the above

4. The cellular unit in muscle tissue is the
   a. Filament
   b. Myofibril
   c. Fiber
   d. Fasciculus

5. A partial state of contraction, in part, defines
   a. Rigor
   b. Tonus
   c. Clovus
   d. Paralysis

6. It’s possible to completely relax every muscle in the body.
   a. True
   b. False

7. During embryonic development, tissue development is called
   a. Myogelosis
   b. Morphogenesis
   c. Myogenesis
   d. Morpholysis

8. Exercise forms new muscle fibers.
   a. True
   b. False

**Classifications: Smooth, Cardiac, and Skeletal**

Muscle tissue is classified in three ways based on the tissue’s function, shape, and structure:

✔️ **Smooth muscle tissue:** So-called because it doesn’t have the cross-striations typical of other kinds of muscle, the spindle-shaped fibers of smooth muscle tissue do have faint longitudinal striping. This muscle tissue forms into sheets and makes up the walls of hollow organs such as the stomach, intestines, and bladder. The tissue’s involuntary movements are relatively slow, so contractions last
longer than those of other muscle tissue, and fatigue is rare. Each fiber is about 6 microns in diameter and can vary from 15 microns to 500 microns long. If arranged in a circle inside an organ, contraction constricts the cavity inside the organ. If arranged lengthwise, contraction of smooth muscle tissue shortens the organ.

**Cardiac muscle tissue**: Found only in the heart, cardiac muscle fibers are branched, cross-striated, feature one central nucleus, and move through involuntary control. An electron microscope view of the tissue shows separate fibers tightly pressed against each other, forming cellular junctions called *intercalated discs* that look like tiny, dark-colored plates. Some experts believe intercalated discs are not cellular junctions but rather special structures that help move an electrical impulse throughout the heart.

**Skeletal muscle tissue**: This is the tissue that most people think of as muscle. It’s the only muscle subject to voluntary control through the central nervous system. Its long, striated cylindrical fibers contract quickly but tire just as fast. Skeletal muscle, which is also what’s considered meat in animals, is 20 percent protein, 75 percent water, and 5 percent organic and inorganic materials. Each multinucleated fiber is encased in a thin, transparent membrane called a *sarcolemma* that receives and conducts stimuli. The fibers, which vary from 10 microns to 100 microns in diameter and up to 4 centimeters in length, are subdivided lengthwise into tiny myofibrils roughly 1 micron in diameter that are suspended in the cell’s sarcoplasm.

The following practice questions test your knowledge of muscle classifications:

9. This type of muscle tissue lacks cross-striations.
   a. Cardiac
   b. Smooth
   c. Skeletal
   d. Contracting

10. Skeletal muscle fibers are encased in
    a. A sarcolemma
    b. Sarcoplasm
    c. Sarcomeres
    d. A sarcophagus

11. Which muscle type appears only in a single organ?
    a. Contractile
    b. Smooth
    c. Cardiac
    d. Skeletal

12. Intercalated discs
    a. Anchor cardiac muscle fibers to one another
    b. May play a role in moving electrical impulses through the heart
    c. Are found only in the muscles of the back
    d. Contribute to tactile perception
Contracting for a Contraction

Before we can explain how muscles do what they do, it’s important that you understand the anatomy of how they’re put together. Use Figure 6-1 as a visual guide as you read through this section.

We base this description of muscle on the most studied classification of muscle: skeletal. Each fiber packed inside the sarcolemma contains hundreds, or even thousands, of myofibril strands made up of alternating filaments of the proteins actin and myosin. Actin and myosin are what give skeletal muscles their striated appearance, with alternating dark and light bands. The dark bands are called anisotropic, or A-bands. The light bands are called isotropic, or I-bands. In the center of each I-band is a line called the Z-line that divides the myofibril into smaller units called sarcomeres. At the center of the A-band is a less-dense region called the H-zone.

Now, here’s where the actin and myosin come in. Each sarcomere contains thick filaments of myosin in the A-band and thin filaments of actin primarily in the I-band but extending a short distance between the myosin filaments into the A-band. Actin filaments don’t extend all the way into the central area of the A-band, which explains why the less-dense H-zone can be found there. Those thin actin filaments are anchored to the Z-line at their midpoints, which holds them in place and creates a structure against which the filaments exert their pull during contraction.

The theory of contraction called the Interdigitating Filament Model of Muscle Contraction, or the Sliding Theory of Muscle Contraction, says that the myosin of the thick filaments combines with the actin of the thin filaments, forming actomyosin and prompting the filaments to slide past each other. As they do so, the H-zone is reduced or obliterated, pulling the Z-lines closer together and reducing the I-bands. (The A-bands don’t change.) Voila! Contraction has occurred!
So you know how muscles contract. Now you need to figure out what stimulates them to do so. We cover the details of the nervous system in Chapter 15, but here you can find out what’s happening as an impulse stimulates a skeletal muscle.

The impulse, or stimulus, from the central nervous system is brought to the muscle through a nerve called the motor, or efferent, nerve. On entering the muscle, the motor nerve fibers separate to distribute themselves among the thousands of muscle fibers. Because the muscle has more fibers than the motor nerve, individual nerve fibers branch repeatedly so that a single nerve fiber innervates from 5 to as many as 200 muscle fibers. These small terminal branches penetrate the sarcolemma and form a special structure known as the motor end plate, or synapse. This neuromuscular unit consisting of one motor neuron and all the muscle fibers that it innervates is called the motor unit.

Interference — either chemical or physical — with the nerve pathway can affect the action of the muscle or stop the action altogether, resulting in muscle paralysis. There also are afferent, or sensory, nerves that carry information about muscle condition to the brain.

When an impulse moves through the synapse and the motor unit, it must arrive virtually simultaneously at each of the individual sarcomeres to create an efficient contraction. Enter the transverse system, or T-system, of tubules. The fiber’s membrane forms deep invaginations, or inward-folding sheaths, at the Z-line of the myofibrils. The resulting inward-reaching tubules ensure that the sarcomeres are stimulated at nearly the same time.

Does it matter whether the signal received is strong or weak? Nope. That’s the all-or-none law of muscle contraction. The fiber either contracts completely or not at all. In other words, if a single muscle fiber is going to contract, it’s going to do so to its fullest extent.

Following are some practice questions that deal with muscle anatomy and contraction:

13–17. Match each muscle component with the appropriate region.

13. _____ Myosin
   a. H-zone
14. _____ Segment of fibril from Z-line to Z-line
   b. Z-line
15. _____ Less-dense region of the A-band
   c. I-band
16. _____ Structure to which filaments are attached
   d. A-band
17. _____ Actin
   e. Sarcomere

18. Which of these terms doesn’t belong in the following list?
   a. Anisotropic
   b. Actin
   c. Myosin
   d. Isotropic
   e. Sarcolemma

19. This part of a muscle doesn’t change during contraction:
   a. The H-zone
   b. The A-bands
   c. The I-bands
   d. The Z-lines
20. A weak stimulus causes a muscle fiber to contract only partway.
   a. True
   b. False

Pulling Together: Muscles as Organs

A muscle organ has two parts:

- **The belly**, composed predominantly of muscle fibers
- **The tendon**, composed of fibrous, or collagenous, regular connective tissue. If the tendon is a flat, sheet-like structure attaching a wide muscle, it’s called an *aponeurosis*.

Each muscle fiber outside of the sarcolemma is surrounded by areolar connective tissue called *endomysium* that binds the fibers together into bundles called *fasciculi* (see Figure 6-2). Each bundle, or *fasciculus*, is surrounded by areolar connective tissue called *perimysium*. All the fasciculi together make up the belly of the muscle, which is surrounded by areolar connective tissue called the *epimysium*. Blood vessels, lymph vessels, and nerves pass into the fasciculus through areolar connective tissue called the *trabecula*. These blood vessels in turn branch off into capillaries that surround the muscle fibers in the endomysium.

21.–25. Match the muscle structures with their descriptions.

21. ____ Membrane covering a muscle fiber

22. ____ Bundles of muscle fibers

23. ____ Connective tissue that surrounds a bundle of muscle fibers

24. ____ Connective tissue through which arteries and veins enter muscle bundles

25. ____ Flat, sheet-like tendon that serves as insertion for a large flat muscle

   a. Perimysium
   b. Aponeurosis
   c. Trabecula
   d. Fasciculi
   e. Sarcolemma

*Figure 6-2: Connective tissue in a muscle.*

Illustration by Imagineering Media Services Inc.
Assuming the Right Tone

As we note earlier in this chapter, when it comes to contraction of a muscle fiber, it's an all-or-nothing affair. Nonetheless, it has been demonstrated that fewer action potentials — a weaker stimulus, as it were — causes fewer motor units to become involved in a contraction. Maximum stimulus, on the other hand, brings all motor units to bear together. So it's true that a muscle organ can have varying degrees of contraction depending on the level of stimulation. As for how this can be so, one theory proposes that individual fibers have specific thresholds of excitation; thus, those with higher thresholds only respond to stronger stimuli. The other theory holds that the deeper a fiber is buried in the muscle, the less accessible it is to incoming stimuli.

In physiology, a muscle contraction is referred to as a muscle twitch. A twitch is the fundamental unit of recordable muscular activity. Complete fatigue occurs when no more twitches can be elicited, even with increasing intensity of stimulation.

The short lapse of time between the application of a stimulus and the beginning of muscular response is called the latent period. In mammalian muscle, latency is about .001 second, or one one-thousandth of a second.

Two types of muscle contraction relate to tone:

- **Isometric:** Occurs when a contracting muscle is unable to move a load (or heft a piece of luggage or push a building to one side). It retains its original length but develops tension. No mechanical work is accomplished, and all energy involved is expended as heat.
- **Isotonic:** Occurs when the resistance offered by the load (or the gardening hoe or the cold can of soda) is less than the tension developed, thus shortening the muscle and resulting in mechanical work.

But muscles aren’t independent sole proprietors. Each muscle depends upon companions in a muscle group to assist in executing a particular movement. That’s why muscles are categorized by their actions. The brain coordinates the following groups through the cerebellum.

- **Prime movers:** Just as it sounds, these muscles are the workhorses that produce movement.
- **Antagonists:** These muscles exist in opposition to prime movers.
- **Fixators or fixation muscles:** These muscles serve to steady a part while other muscles execute movement. They don’t actually take part in the movement itself.
- **Synergists:** These muscles control movement of the proximal joints so that the prime movers can bring about movements of distal joints.

Flex your knowledge of muscle tone and function with these practice questions:

**Q.** Muscle movement that lifts an object involves an action known as

- a. Isometric
- b. Eccentric
- c. Isotonic

**A.** The correct answer is isotonic. When the tension leads to movement (actual work), it’s isotonic.
26. Muscles that tend to counteract or slow an action are called
   a. Antagonists
   b. Fixators
   c. Primary movers
   d. Synergists

27. Which of the following statements finishes this sentence and makes it not true: A contracting muscle unable to move a load
   a. Involves an action known as isometric
   b. Expends energy as heat
   c. Is exemplified in the effect of the force of gravity on muscle contraction
   d. Does no mechanical work and therefore doesn’t develop any tension
   e. Retains its original length

28. A muscle contraction is referred to as
   a. Latency
   b. Synergy
   c. A twitch
   d. Isotonic motion

Leveraging Muscular Power

Skeletal muscle power is nothing without lever action. The bone acts as a rigid bar, the joint is the fulcrum, and the muscle applies the force. Levers are divided into the weight arm, the area between the fulcrum and the weight; and the power arm, the area between the fulcrum and the force. When the power arm is longer than the weight arm, less force is required to lift the weight, but range, or distance, and speed are sacrificed. When the weight arm is longer, the range of action and speed increase, but power is sacrificed. Therefore, 90 degrees is the optimum angle for a muscle to attach to a bone and apply the greatest force.

Three classes of levers are at work in the body:

✔ Class I, or seesaw: The fulcrum is located between the weight and the force being applied. An example is a nod of the head: The head-neck joint is the fulcrum, the head is the weight, and the muscles in the back of the neck apply the force.

✔ Class II, or wheelbarrow: The weight is located between the fulcrum and the point at which the force is applied. An example is standing on your tiptoes: The fulcrum is the joint between the toes and the foot, the weight is the body, and the muscles in the back of the leg at the heel bone apply the force.

✔ Class III: The force is located between the weight and the fulcrum. An example is flexing your arm and showing off your biceps: The elbow joint is the fulcrum, the weight is the lower arm and hand, and the biceps insertion on the lower arm applies the force.
The direction in which the muscle fibers run also plays a critical role in leverage. Here are the possible directions:

- **Longitudinal**: Fibers run parallel to each other, or longitudinally, the length of the muscle. Example: sartorius.

- **Pennate**: Fibers attach to the sides of the tendon, which extends the length of the muscle. These come in subcategories:
  - **Unipennate**, where fibers attach to one side of the tendon; example: tibialis posterior
  - **Bipennate**, where fibers attach to two sides of the tendon; example: rectus femoris
  - **Multipennate**, where fibers attach to many sides of the tendon; example: deltoideus

- **Radiate**: Fibers converge from a broad area into a common point. Example: pectoralis major.

- **Sphincter**: Fibers are arranged in a circle around an opening. Example: orbicularis oculi.

The three types of fasciae, which Gray’s Anatomy describes as “dissectable, fibrous connective tissues of the body,” are as follows:

- **Superficial fasciae**: Found under the skin and consisting of two layers: an outer layer called the panniculus adiposus containing fat; and an inner layer made up of a thin, membranous, and highly elastic layer. Between the two layers are the superficial arteries, veins, nerves, and mammary glands.

- **Deep fasciae**: Holds muscles or structures together or separates them into groups that function in unison. It’s a system of splitting, rejoining, and fusing membranes involving
  - An outer investing layer that’s found under the superficial fasciae covering a large part of the body
  - An internal investing layer that lines the inside of the body wall in the torso, or trunk, region
  - An intermediate investing layer that connects the outer investing layer and the internal investing layer

- **Subserous fasciae**: Located between the internal investing layer of the deep fasciae and the peritoneum. It’s the serous membrane that lines the abdominopelvic cavity, also known as the peritoneal cavity.

Got all that? Then try your hand at the following questions:
29. Which of the following in Figure 6-3 is a Class II lever?

![Figure 6-3: The three classes of muscle levers.]

30. Which of the following would provide the force in a Class III lever?
   a. Biceps brachii
   b. Spenius capitus
   c. Triceps brachii
   d. Gastrocnemius

31. Which of the following would produce a wide range of movement with speed while sacrificing power?
   a. Power arm and weight arm of equal lengths
   b. Long weight arm, short power arm
   c. Long power arm, shorter weight arm
32. Identify the bipennate bundle arrangement.
   a. Sartorius
   b. Rectus femoris
   c. Pectoralis major
   d. Tibialis posterior
   e. Deltoideus

33. Which of the following is considered a dissectable connective tissue?
   a. Aponeurosis
   b. Bursae
   c. Fasciae
   d. Tendons
   e. Ligaments

34. The most extensive fascia in the body is
   a. Superficial
   b. Deep
   c. Subserous
   d. None is more extensive than the other

What’s In a Name? Identifying Muscles

It may seem like a jumble of meaningless Latin at first, but muscle names follow a strict convention that lets them be named for one or more of four things:

✔ **Function:** These muscle names usually have a verb root and end in a suffix (–or or –eus), followed by the name of the affected structure. Example: levator scapulae (elevates the scapulae).

✔ **Compounding points of attachment:** These muscle names blend the origin and insertion attachment with an adjective suffix (–eus or –is). Examples: sternocleidomastoideus (sternum, clavicle, and mastoid process) and sternohyoides (sternum and hyoid).

✔ **Shape or position:** These muscle names usually have descriptive adjectives that may be followed by the names of the locations of the muscles. Examples: rectus (straight) femoris, rectus abdominus, and serratus (sawtooth) anterior.

✔ **Figurative names:** These muscle names are based on the muscles’ resemblance to some objects. Examples: gastrocnemius (resembles the stomach) and trapezius (resembles a tablet).

Check out Table 6-1 for a rundown of prominent muscles in the body and key points to remember about each one.
<table>
<thead>
<tr>
<th><strong>Muscle</strong></th>
<th><strong>Origin</strong></th>
<th><strong>Insertion</strong></th>
<th><strong>Action</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Head</strong></td>
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<tr>
<td>Frontal</td>
<td>Galea aponeurotica</td>
<td>Eyebrow</td>
<td>Expression</td>
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<td>Buccinator</td>
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<td>Mastication</td>
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<td>Orbicularis oculi</td>
<td>Encircles eye</td>
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<td>Closes eye</td>
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<td>Encircles mouth</td>
<td></td>
<td>Closes mouth</td>
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<td>Masseter</td>
<td>Zygoma</td>
<td>Mandible</td>
<td>Mastication</td>
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<td>Temporalis</td>
<td>Temporal fossa</td>
<td>Mandible</td>
<td>Mastication</td>
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<td>Zygomaticus</td>
<td>Zygoma</td>
<td>Corner of mouth</td>
<td>Smiling</td>
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<td><strong>Neck</strong></td>
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<td>Sternocleidomastoid</td>
<td>Sternum, clavicle</td>
<td>Mastoid process of temporal bone</td>
<td>Rotation and flexion of the neck vertebrae</td>
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<td>Latissimus dorsi</td>
<td>Vertebral column</td>
<td>Humerus</td>
<td>Extends at shoulder joint</td>
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<td>Trapezius</td>
<td>Vertebral column</td>
<td>Clavicle, scapula</td>
<td>Rotates scapula</td>
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<td><strong>Pectoral girdle</strong></td>
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<td>Pectoralis major</td>
<td>Sternum, clavicle</td>
<td>Humerus</td>
<td>Adduction shoulder joint</td>
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<td>Deltoid</td>
<td>Clavicle, scapula</td>
<td>Humerus</td>
<td>Abduction shoulder joint</td>
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<td><strong>Abdominal wall</strong></td>
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<td>External abdominal oblique, internal abdominal oblique, transversus abdominus</td>
<td>Aponeurosis to linea alba</td>
<td>Stabilizes, protects, and supports internal viscera</td>
<td></td>
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<tr>
<td>Rectus abdominus</td>
<td>Pubis</td>
<td>Costal cartilage</td>
<td>Stabilizes, protects, and supports internal viscera</td>
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<td><strong>Thorax</strong></td>
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<tr>
<td>Diaphragm</td>
<td>Separates thoracic and abdominal cavities</td>
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<td>Respiration</td>
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<td>Between ribs</td>
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<td>Respiration</td>
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<td>Between ribs</td>
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<td>Respiration</td>
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(continued)
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<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
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</thead>
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<td><strong>Arm</strong></td>
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<td>Biceps brachii</td>
<td>Humerus, glenoid fossa of scapula</td>
<td>Radius</td>
<td>Flexion at elbow joint</td>
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<td>Scapula, humerus</td>
<td>Olecranon of ulna</td>
<td>Extension of elbow joint</td>
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<td>Flexor carpi radialis</td>
<td>Humerus</td>
<td>2nd to 3rd metacarpals</td>
<td>Flexor of wrist, abducts hand</td>
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<td>Flexor carpi ulnaris</td>
<td>Humerus, ulna</td>
<td>5th metacarpal</td>
<td>Flexor of wrist, adducts hand</td>
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<tr>
<td>Supinator</td>
<td>Humerus, ulna</td>
<td>Radius</td>
<td>Supinates forearm</td>
</tr>
<tr>
<td>Extensor carpi ulnaris</td>
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<td></td>
<td></td>
</tr>
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<td>Extensor carpi radialis longus</td>
<td>Humerus</td>
<td>2nd metacarpal</td>
<td>Extends and abducts wrist</td>
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<tr>
<td>Extensor carpi radialis brevis</td>
<td>Humerus</td>
<td>3rd metacarpal</td>
<td>Extends and abducts wrist, steadies wrist during finger flexion</td>
</tr>
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<td><strong>Leg</strong></td>
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<td></td>
</tr>
<tr>
<td>Quadriceps</td>
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<td></td>
<td></td>
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<tr>
<td>Rectus femoris</td>
<td>Acetabulum</td>
<td>Tibia (patella)</td>
<td>Extends knee joint and flexes at hip</td>
</tr>
<tr>
<td>Vastus lateralis, vastus medialis, vastus intermedialis</td>
<td>Femur</td>
<td>Tibia</td>
<td>Extends knee joint and flexes at hip</td>
</tr>
<tr>
<td>Sartorius</td>
<td>Ilium</td>
<td>Tibia</td>
<td>Flexes at knee and hip</td>
</tr>
<tr>
<td>Adductors</td>
<td>Pubis</td>
<td>Femur</td>
<td>Adduction at hip joint</td>
</tr>
<tr>
<td>Gracilis</td>
<td>Pubis</td>
<td>Tibia</td>
<td>Adduction at hip joint</td>
</tr>
<tr>
<td><strong>Hamstring group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps femoris</td>
<td>Ischium</td>
<td>Fibula</td>
<td>Flexion at knee joint</td>
</tr>
<tr>
<td>Semimembranosus</td>
<td>Ischium</td>
<td>Tibia</td>
<td>Flexion at knee joint</td>
</tr>
<tr>
<td>Semitendinosus</td>
<td>Ischium</td>
<td>Tibia</td>
<td>Flexion at knee joint</td>
</tr>
<tr>
<td>Gastrocnemius</td>
<td>Femur</td>
<td>Calcaneus by Achilles tendon</td>
<td>Flexion at knee and plantar</td>
</tr>
<tr>
<td>Soleus</td>
<td>Tibia</td>
<td>Calcaneus by Achilles tendon</td>
<td>Plantar flexion</td>
</tr>
</tbody>
</table>
35. In the naming of the muscles, the latissimus dorsi, the rectus abdominis, and the serratus anterior are names based upon
   a. Shape
   b. Attachment
   c. Figurative name
   d. Function

36. In the naming of muscles, the sternocleidomastoid is based upon
   a. Function
   b. Location
   c. Attachment
   d. Figurative name

37. In humans, the origin of the biceps brachii would best include which of the following?
   a. Scapula
   b. Clavicle
   c. Fibula
   d. Ulna

38. Which of the following are insertions for the triceps and biceps brachii?
   a. Humerus and ulna
   b. Radius and humerus
   c. Scapula and humerus
   d. Radius and ulna

39–43. Match the origins and insertions for the following muscles.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>39. _____ Semimembranosus</td>
<td>a. The pubis and the femur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40. _____ Gracilis</td>
<td>b. The femur and the calcaneus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41. _____ Sartorius</td>
<td>c. The ilium and the tibia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42. _____ Gastrocnemius</td>
<td>d. The ischium and the tibia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43. _____ Adductors</td>
<td>e. The pubis and the tibia</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

44–48. Match the muscles with their actions.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>44. _____ Semitendinosus</td>
<td>a. Rotates scapula</td>
</tr>
<tr>
<td>45. _____ Temporalis</td>
<td>b. Flexion of leg at knee joint</td>
</tr>
<tr>
<td>46. _____ Biceps brachii</td>
<td>c. Extension at shoulder joint</td>
</tr>
<tr>
<td>47. _____ Latissimus dorsi</td>
<td>d. Mastication</td>
</tr>
<tr>
<td>48. _____ Trapezius</td>
<td>e. Flexion of arm</td>
</tr>
</tbody>
</table>
**49–53.** Match the muscles with their locations.

49. _____ Latissimus dorsi a. Head
50. _____ Internal oblique b. Abdomen
51. _____ Quadriceps c. Back
52. _____ Masseter d. Neck
53. _____ Sternocleidomastoid e. Thigh

**54.** Which of the following is *not* included in the quadriceps group?

a. Vastus medialis
b. Vastus lateralis
c. Rectus abdominis
d. Rectus femoris

**55.** Where would you find the muscles called the biceps?

a. Arm
b. Neck
c. Leg
d. Back
e. Both a and c

**56.** What muscle divides the thoracic cavity from the abdominal cavity?

a. Diaphragm
b. External oblique
c. Transversus abdominis
d. Internal oblique
e. Rectus abdominis

**57.** The gastrocnemius and the soleus contribute to the

a. Dupuytren’s contracture
b. Volkmann’s contracture
c. Colles fracture
d. Klipped-Feil syndrome
e. Tendon of Achilles

**58.** Which of the following is *not* one of the muscles referred to as hamstrings?

a. Biceps femoris
b. Gracilis
c. Semimembranosus
d. Semitendinosus
Answers to Questions on Muscles

The following are answers to the practice questions presented in this chapter.

1. Which of the following is not a true statement? a. Muscles represent 90 percent of the total body weight. The average is less than half that, around 43 percent.

2. Muscle functions include c. converting chemical energy into mechanical work.

3. A necessary property for a muscle to perform work is b. contractility. If it doesn’t contract, it’s not a muscle.

4. The cellular unit in muscle tissue is the c. fiber. When it comes to muscle, fiber equals cell equals fiber.

5. A partial state of contraction, in part, defines b. tonus. That’s the elusive muscle “tone” for the flabby amongst us.

6. It’s possible to completely relax every muscle in the body. b. False. If every muscle in the body were to relax, the heart would stop beating and food would stop moving through the digestive system.

7. During embryonic development, tissue development is called c. myogenesis.

To remember this stage of development, combine the Greek myo with genesis, or new beginning.

8. Exercise forms new muscle fibers. b. False. Exercise can’t form new fibers, but it can thicken what’s already there.

9. This type of muscle tissue lacks cross-striations. b. Smooth. Without striations, this tissue can contract slowly and for a very long time.

10. Skeletal muscle fibers are encased in a. a sarcolemma. That’s a thin membrane that helps move stimuli.

11. Which muscle type appears only in a single organ? c. Cardiac. And that sole organ is the heart.

12. Intercalated discs b. may play a role in moving electrical impulses through the heart. There’s evidence that these structures help keep the heart synchronized.


14. Segment of fibril from Z-line to Z-line: e. Sarcomere


16. Structure to which filaments are attached: b. Z-line

17. Actin: c. I-band

18. Which of these terms doesn’t belong in the following list? e. Sarcolemma. This is the membrane encasing the myofibrils. All the other answer options refer to various protein structures.

19. This part of a muscle doesn’t change during contraction: b. The A-bands. All the other identified regions grow larger or smaller through the functions of myosin and actin.
A weak stimulus causes a muscle fiber to contract only partway. **b. False.** Muscle contractions are all-or-nothing; there’s no such thing as a partial contraction.

Membrane covering a muscle fiber: **e. Sarcolemma**

Bundles of muscle fibers: **d. Fasciculi**

Connective tissue that surrounds a bundle of muscle fibers: **a. Perimysium**

Connective tissue through which arteries and veins enter muscle bundles: **c. Trabecula**

Flat, sheet-like tendon that serves as insertion for a large flat muscle: **b. Aponeurosis**

Muscles that tend to counteract or slow an action are called **a. antagonists.**

The muscles are against the action, so think of them as antagonistic.

Which of the following statements finishes this sentence and makes it not true: A contracting muscle unable to move a load **d. does no mechanical work and therefore doesn’t develop any tension.** This statement is false because the contraction of the muscle causes tension in all cases.

A muscle contraction is referred to as **c. a twitch.** Keep in mind the twitch is the fundamental measure of muscle activity.

Which of the following in Figure 6-3 is a Class II lever? **b.**

Which of the following would provide the force in a Class III lever? **a. Biceps brachii.** It’s the Popeye weight-lifting class, after all.

Which of the following would produce a wide range of movement with speed while sacrificing power? **b. Long weight arm, short power arm.** The longer the weight arm, the greater the range of action and speed but the less power there is.

Identify the bipennate bundle arrangement. **b. Rectus femoris.** Keep in mind the muscle naming conventions.

Which of the following is considered a dissectable connective tissue? **c. Fasciae.** This connective tissue can be found in most of the body.

The most extensive fascia in the body is **b. deep.**

In the naming of the muscles, the latissimus dorsi, the rectus abdominis, and the serratus anterior are names based upon **a. shape. Latissimus stems from the Latin for “wide,” rectus from the Latin word for “straight,” and serratus from the Latin word for “notched” or “scalloped.”**

In the naming of muscles, the sternocleidomastoid is based upon **c. attachment.** You can figure out this answer by recalling that cleido stems from the Latin word for “collarbone.”

In humans, the origin of the biceps brachii would best include which of the following? **a. Scapula**

Which of the following are insertions for the triceps and biceps brachii? **d. Radius and ulna**
Semimembranosus: d. The ischium and the tibia
Gracilis: e. The pubis and the tibia
Sartorius: c. The ilium and the tibia
Gastrocnemius: b. The femur and the calcaneus
Adductors: a. The pubis and the femur
Semitendinosus: b. Flexion of leg at knee joint
Temporalis: d. Mastication
Biceps brachii: e. Flexion of arm
Latissimus dorsi: c. Extension at shoulder joint
Trapezius: a. Rotates scapula
Latissimus dorsi: c. Back
Internal oblique: b. Abdomen
Quadriceps: e. Thigh
Masseter: a. Head
Sternocleidomastoid: d. Neck

Which of the following is not included in the quadriceps group? c. Rectus abdominis. The term abdominis is the giveaway here because it should make you think of the abdomen. The rest of the quadriceps group is found in the upper leg, where they belong.

Where would you find the muscles called the biceps? e. Both a and c (arm and leg). Biceps is a muscle with two heads or points of origin. Although people usually think of the biceps brachii in the arm, you can’t forget about the biceps femoris at the back of the thigh.

What muscle divides the thoracic cavity from the abdominal cavity? a. Diaphragm. And without it, you couldn’t breathe.

The gastrocnemius and the soleus contribute to the e. tendon of Achilles. The soleus lies under the gastrocnemius in the calf of each leg.

Which of the following is not one of the muscles referred to as hamstrings? b. Gracilis. The other three answer options all are listed as hamstring muscles.