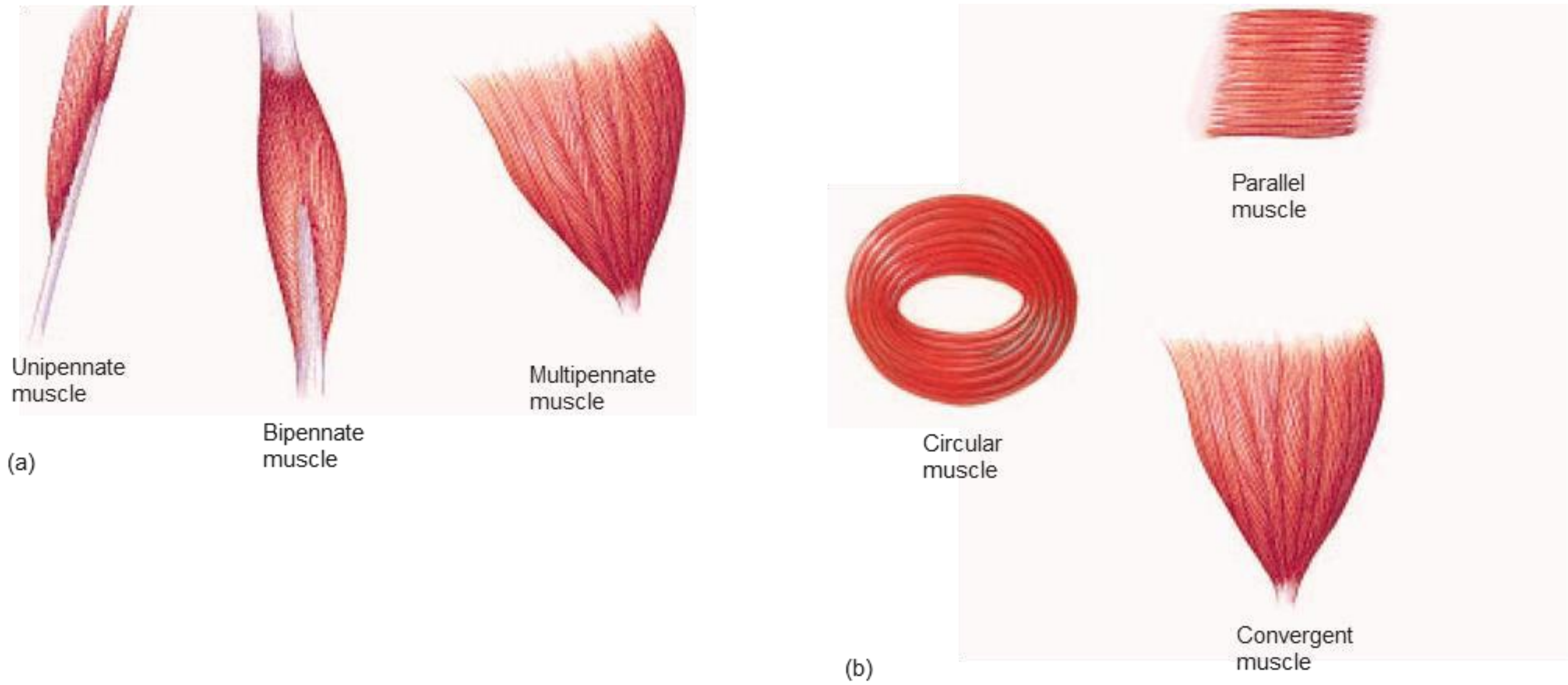
MUSCULAR SYSTEM
(GROSS ANATOMY)

GENERAL PRINCIPLES

- **Tendons** attach muscles to bones and other connective tissue. A very broad tendon is called an aponeurosis.
- The points of attachment for each muscle are the **origin** and **insertion**. The origin, also called the head, is normally that end of the muscle attached to the more stationary of the two bones, and the **insertion** is the end of the muscle attached to the bone undergoing the greatest movement. The largest portion of the muscle, between the origin and the insertion, is the **belly**.
- *Some muscles have multiple origins and a common insertion and are said to have multiple heads (such as a biceps, with two heads).* A muscle causing an action when it contracts is called an **agonist**. A muscle working in opposition to the agonist, moving a structure in the opposite direction, is an **antagonist**.
- Most muscles function as members of a functional group to accomplish specific movements. Furthermore, many muscles are members of more than one group, depending on the type of movement being considered. *For example, the anterior part of the deltoid muscle functions with the flexors of the arm, whereas the posterior part functions with the extensors of the arm.*
- Muscles that work together to cause a movement are **synergists**. Among a group of synergists, if one muscle plays the major role in accomplishing the desired movement, it is called the **prime mover**. The brachialis and biceps brachii are synergists in flexing the elbow, with the *brachialis as the prime mover*; the triceps brachii is the antagonist to the brachialis and extends the elbow.
- Other muscles, called **fixators**, may stabilize one or more joints crossed by the **prime mover**. The extensor digitorum is the prime mover in finger extension. The flexor carpi radialis and flexor carpi ulnaris are fixators that keep the wrist from extending as the fingers are extended.

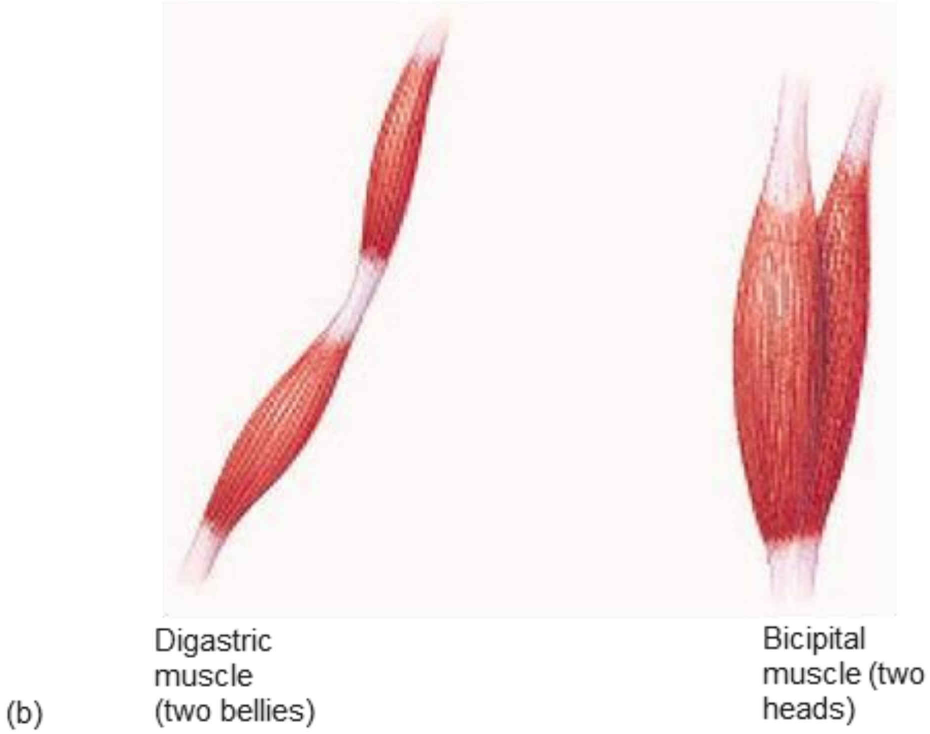
MUSCLE ARCHITECTURE



(a) Muscles with various pennate arrangements. (b) Muscles with various fascicular orientations.

- Muscles come in a wide variety of shapes. The shape and size of any given muscle greatly influences the degree to which it can contract and the amount of force it can generate. The large number of muscular shapes are grouped into four classes according to the orientation of the muscle fasciculi: pennate, parallel, convergent, and circular.
- A pennate muscle with fasciculi on one side of the tendon only is unipennate, one with fasciculi on both sides is bipennate, and a muscle with fasciculi arranged at many places around the central tendon is multipennate. *The pennate arrangement allows a large number of fasciculi to attach to a single tendon with the force of contraction concentrated at the tendon.* The muscles that extend the leg are examples of multipennate muscles.
- In other muscles, called parallel muscles, fasciculi are organized parallel to the long axis of the muscle. As a consequence, the muscles shorten to a greater degree than do pennate muscles because the fasciculi are in a direct line with the tendon; however, they contract with less force because fewer total fascicles are attached to the tendon.
- In convergent muscles, such as the deltoid muscle, the base is much wider than the insertion, giving the muscle a triangular shape and allowing it to contract with more force than could occur in a parallel muscle.
- Circular muscles, such as the *orbicularis oris* and *orbicularis oculi* have their fasciculi arranged in a circle around an opening and act as sphincters to close the opening.

MUSCLE SHAPES



Muscles may have specific shapes, such as quadrangular, triangular, rhomboidal, or fusiform. Muscles also may have multiple components, such as two bellies or two heads. A digastric muscle has two bellies separated by a tendon, whereas a bicipital muscle has two origins (heads) and a single insertion.

Examples of muscle shapes. a) Muscles with various shapes. b) Muscles with various components.

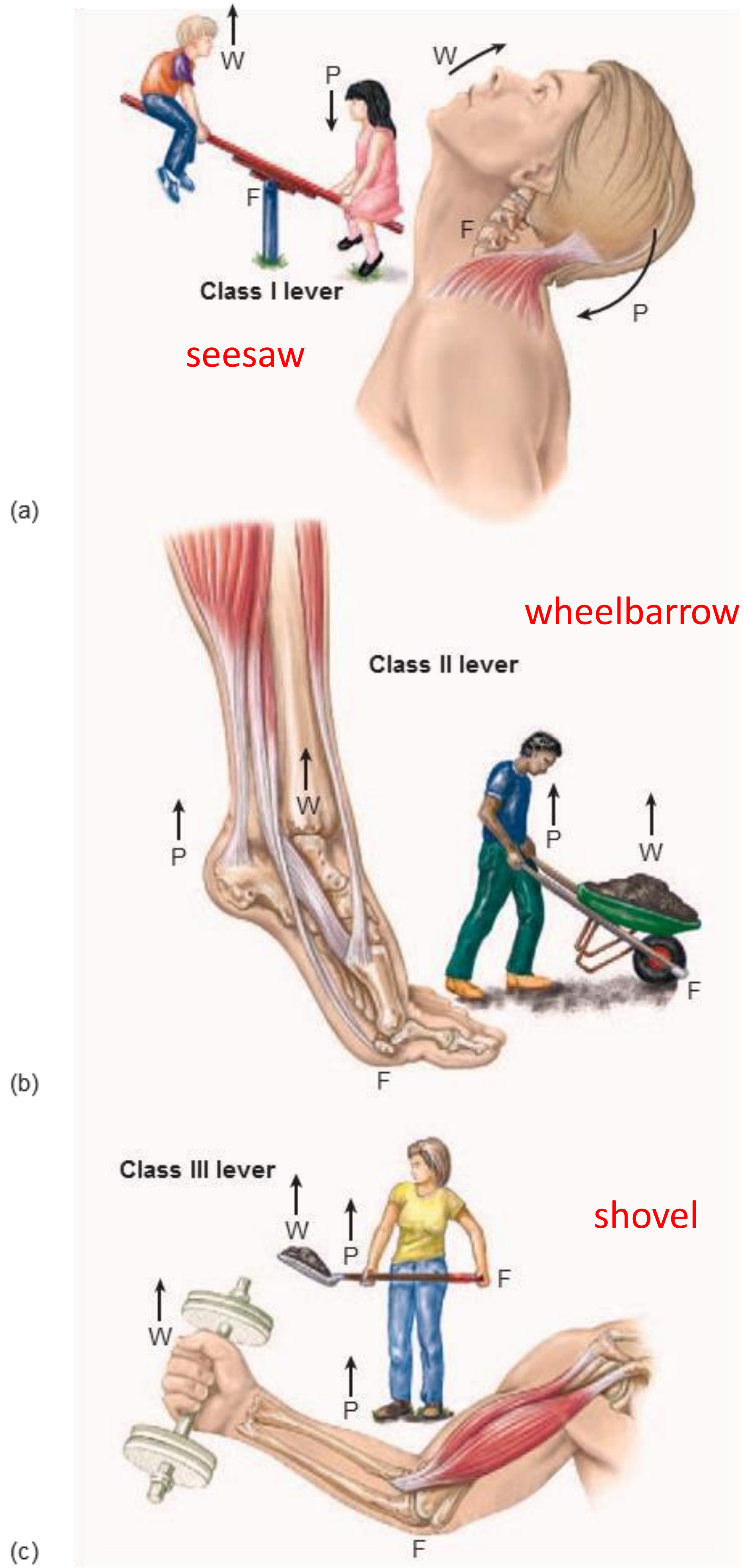
NOMENCLATURE

Muscles are named according to their location, size, shape, orientation of fasciculi, origin and insertion, number of heads, or function.

1. **Location.** Some muscles are named according to their location. For example, a pectoralis (chest) muscle is located in the chest, a gluteus (buttock) muscle is located in the buttock, and a brachial (arm) muscle is located in the arm.
2. **Size.** Muscle names may also refer to the relative size of the muscle. For example, the gluteus maximus (large) is the largest muscle of the buttock, and the gluteus minimus (small) is the smallest. A longus (long) muscle is longer than a brevis (short) muscle.
3. **Shape.** Some muscles are named according to their shape. The deltoid (triangular) muscle is triangular, a quadratus (quadrangular) muscle is rectangular, and a teres (round) muscle is round.
4. **Orientation.** Muscles are also named according to their fascicular orientation. A rectus (straight) muscle has muscle fasciculi running straight with the axis of the structure to which the muscle is associated, whereas the fasciculi of an oblique muscle lie oblique to the longitudinal axis of the structure.
5. **Origin and insertion.** Muscles may be named according to their origin and insertion. The sternocleidomastoid originates on the sternum and clavicle and inserts onto the mastoid process of the temporal bone. The brachioradialis originates in the arm (brachium) and inserts onto the radius.
6. **Number of heads.** The number of heads (origins) a muscle has may also be used in naming it. A biceps muscle has two heads, and a triceps muscle has three heads.
7. **Function.** Muscles are also named according to their function. An abductor moves a structure away from the midline, and an adductor moves a structure toward the midline. The masseter (a chewer) is a chewing muscle.

MOVEMENTS ACCOMPLISHED BY MUSCLES

- When muscles contract, the pull (P), or force, of muscle contraction is applied to levers, such as bones, resulting in movement of the levers. A lever is a rigid shaft capable of turning about a pivot point called a fulcrum (F) and transferring a force applied at one point along the lever to a weight (W), or resistance, placed at some other point along the lever. *The joints function as fulcrums*, *the bones function as levers, and the muscles provide the pull to move the levers*. Three classes of levers exist based on the relative positions of the levers, weights, fulcrums, and forces.
- **Class I Lever**
- In a class I lever system, the fulcrum is located between the force and the weight. The head is an example of this type of lever in the body. The atlanto-occipital joint is the fulcrum, the posterior neck muscles provide the pull depressing the back of the head, and the face, which is elevated, is the weight. With the weight balanced over the fulcrum, only a small amount of pull is required to lift a weight. For example, only a very small shift in weight is needed for one child to lift the other on a seesaw. This system is quite limited, however, as to how much weight can be lifted and how high it can be lifted.
- **Class II Lever**
- In a class II lever system, the weight is located between the fulcrum and the pull. An example is a wheelbarrow, where the wheel is the fulcrum and the person lifting on the handles provides the pull. In the body, an example of a class II lever is the foot of a person standing on the toes. The calf muscles pulling (force) on the calcaneus (end of the lever) elevate the foot and the weight of the entire body, with the ball of the foot acting as the fulcrum. A considerable amount of weight can be lifted by using this type of lever system, but the weight usually isn’t lifted very high.
- **Class III Lever**
- In a class III lever system, the most common type in the body, the pull is located between the fulcrum and the weight (figure 10.3c). In the body, the action of the biceps brachii muscle (force) pulling on the radius (lever) to flex the elbow (fulcrum) and elevate the hand (weight) is an example of a class III lever. This type of lever system doesn’t allow as great a weight to be lifted, but the weight can be lifted a greater distance.



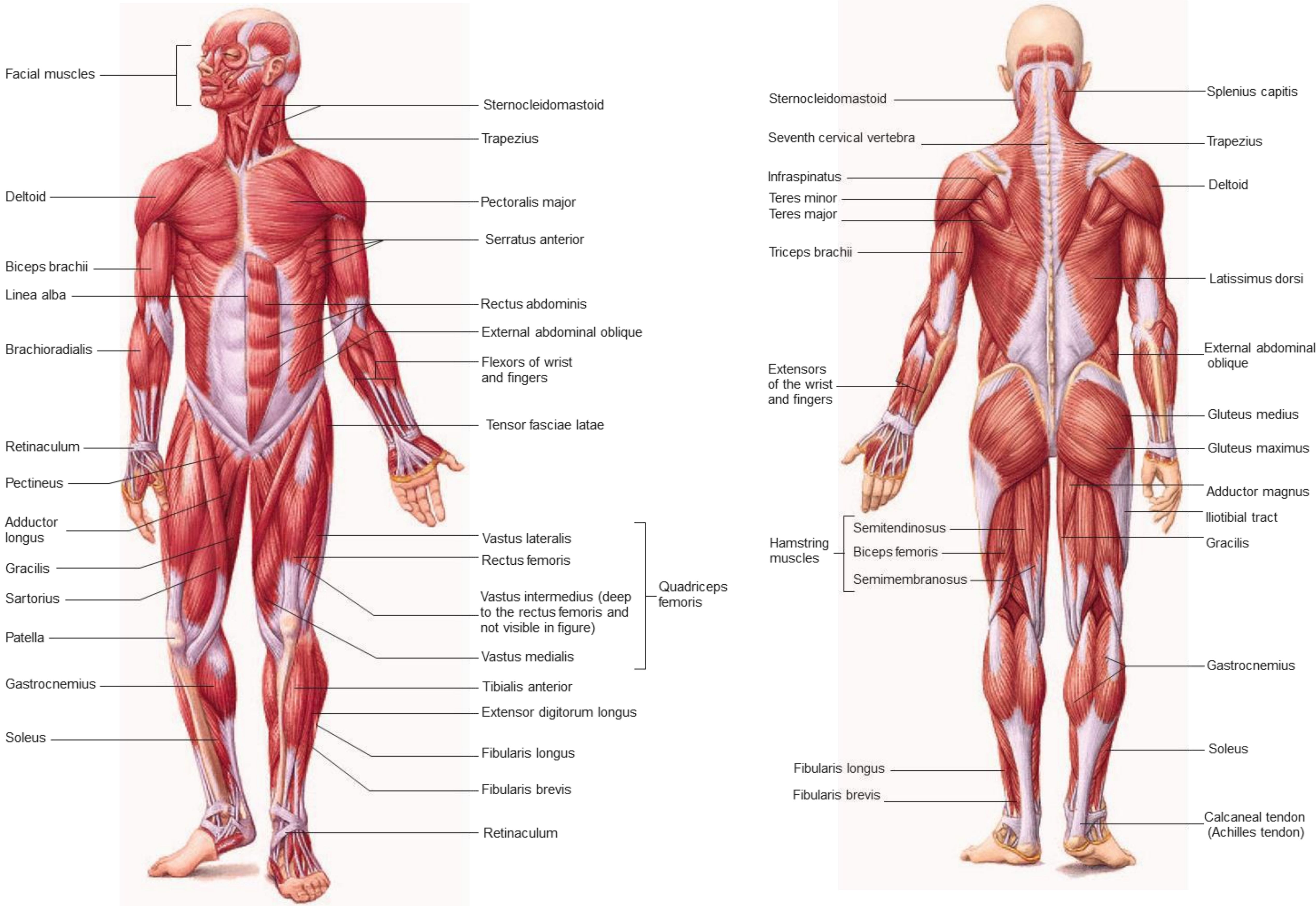
EXAMPLES OF DIFFERENT CLASSES OF LEVERS IN THE JOINTS

(a) Class I: The fulcrum (F) is located between the weight (W) and the force or pull (P). The pull is directed downward, and the weight, on the opposite side of the fulcrum, is lifted.

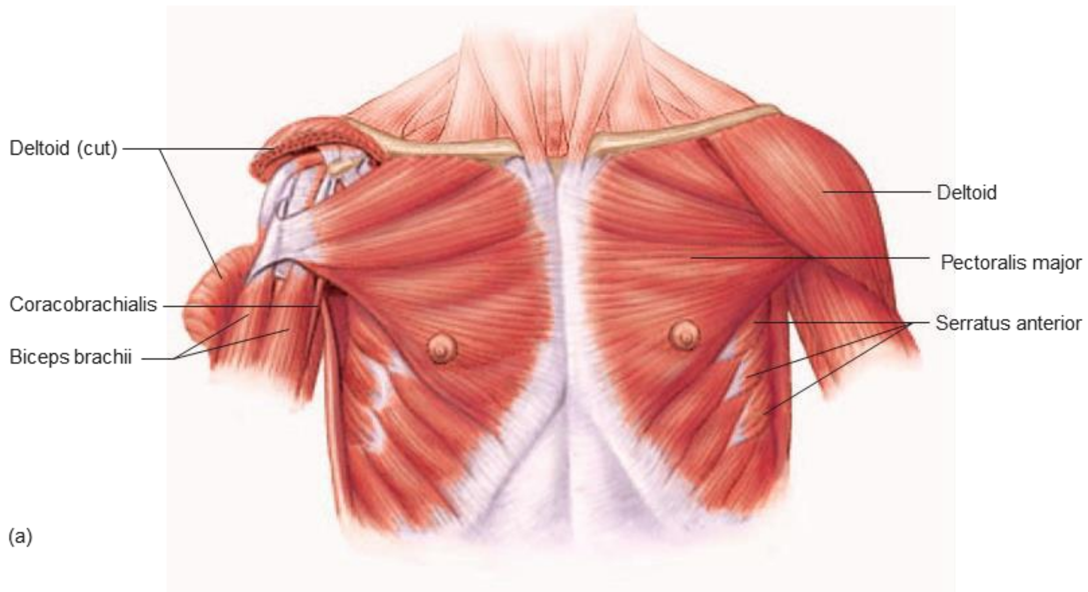
(b) Class II: The weight (W) is located between the fulcrum (F) and the force or pull (P). The upward pull lifts the weight.

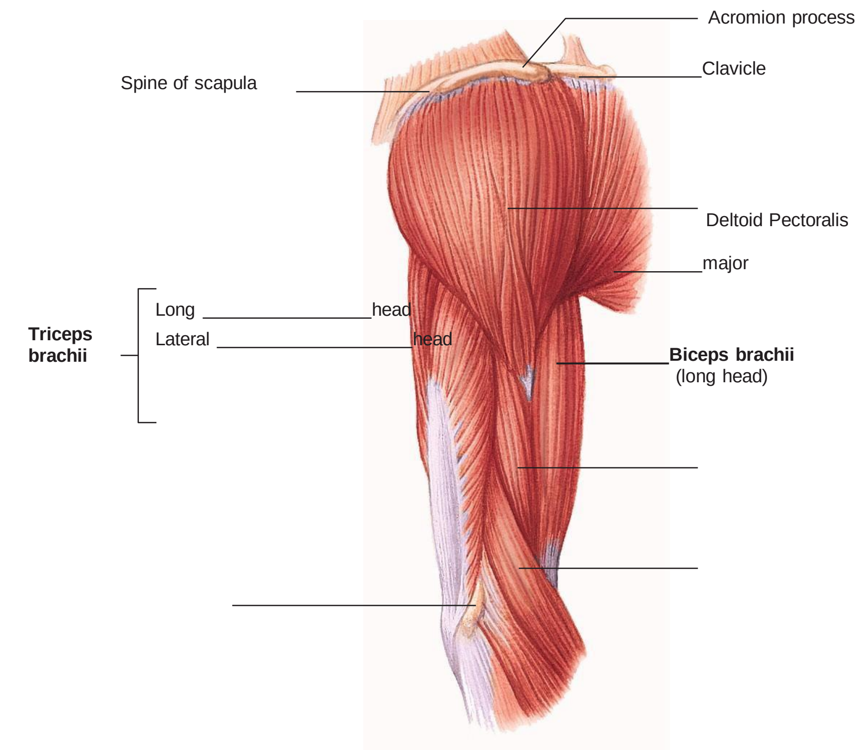
(c) Class III: The force or pull (P) is located between the fulcrum (F) and the weight (W). The upward pull lifts the weight.

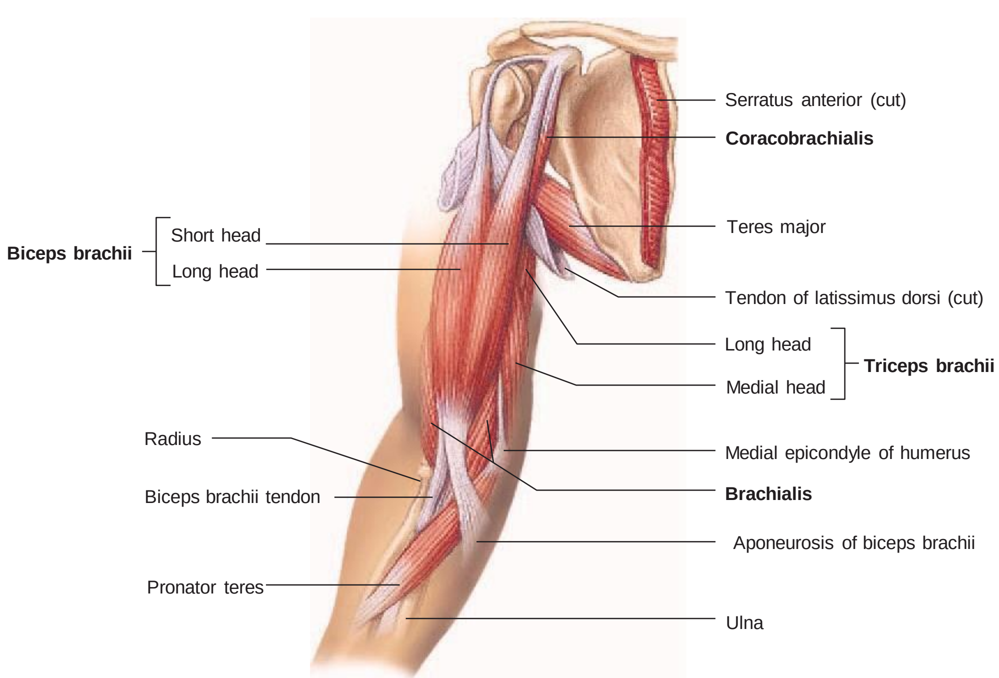
MUSCLE ANATOMY

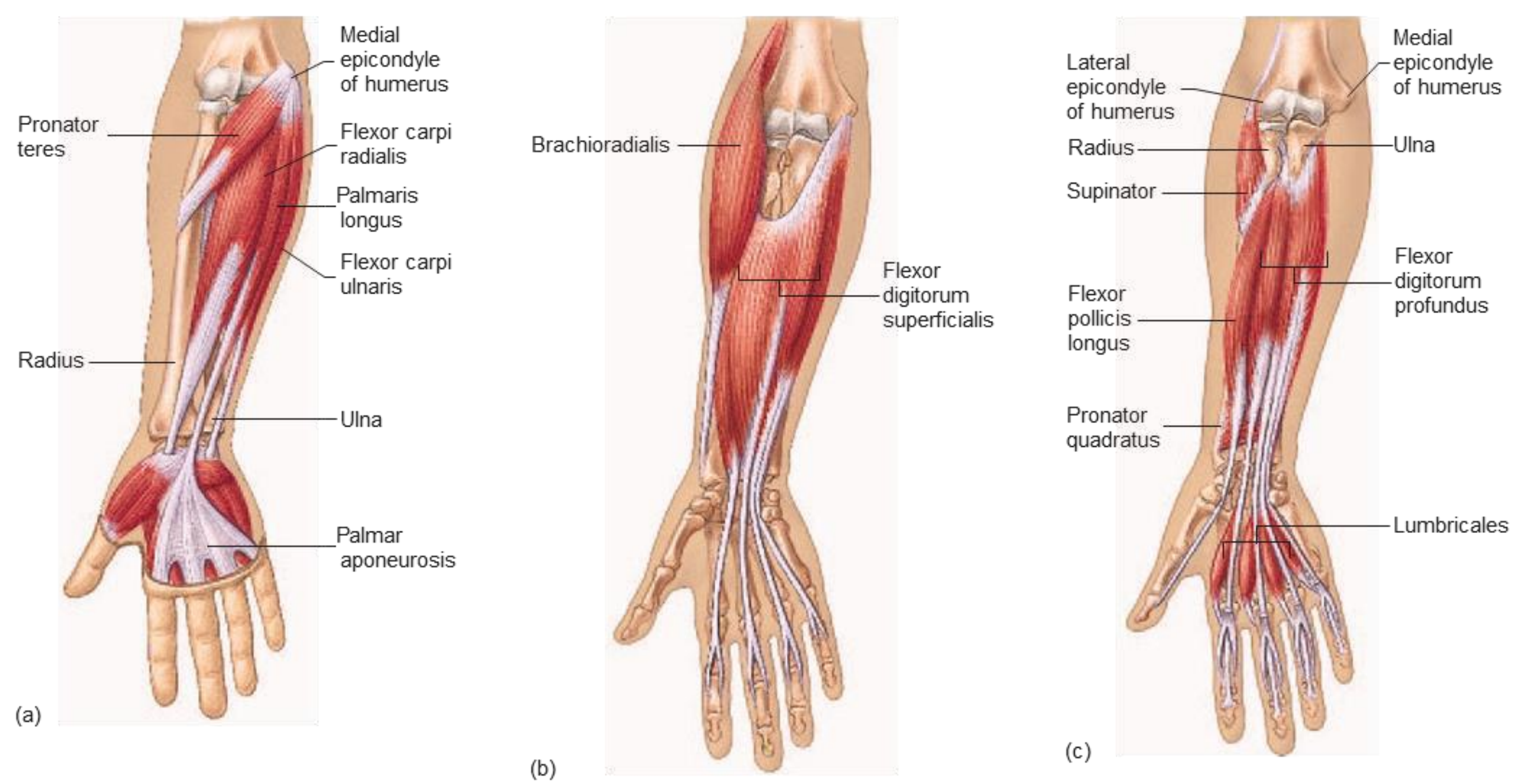


MUSCLES OF THE ARM

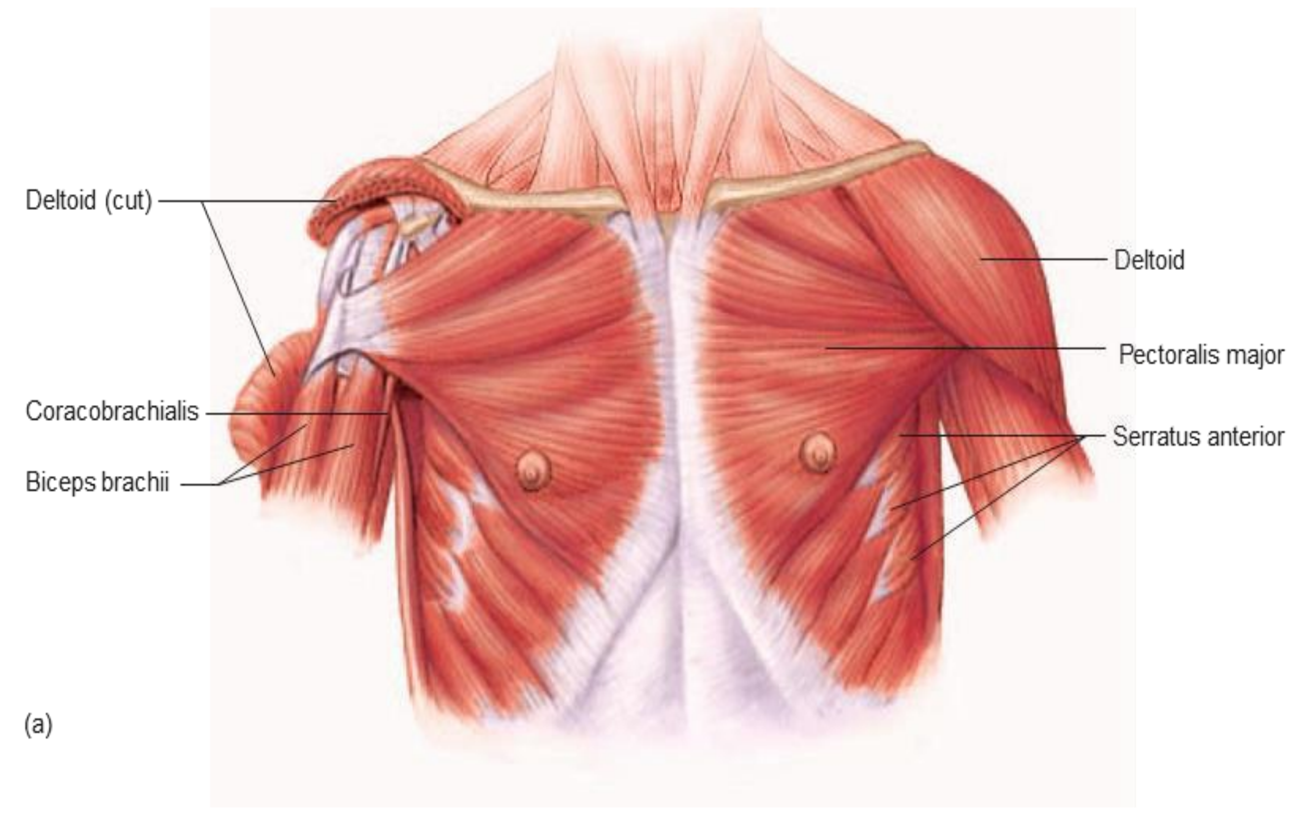




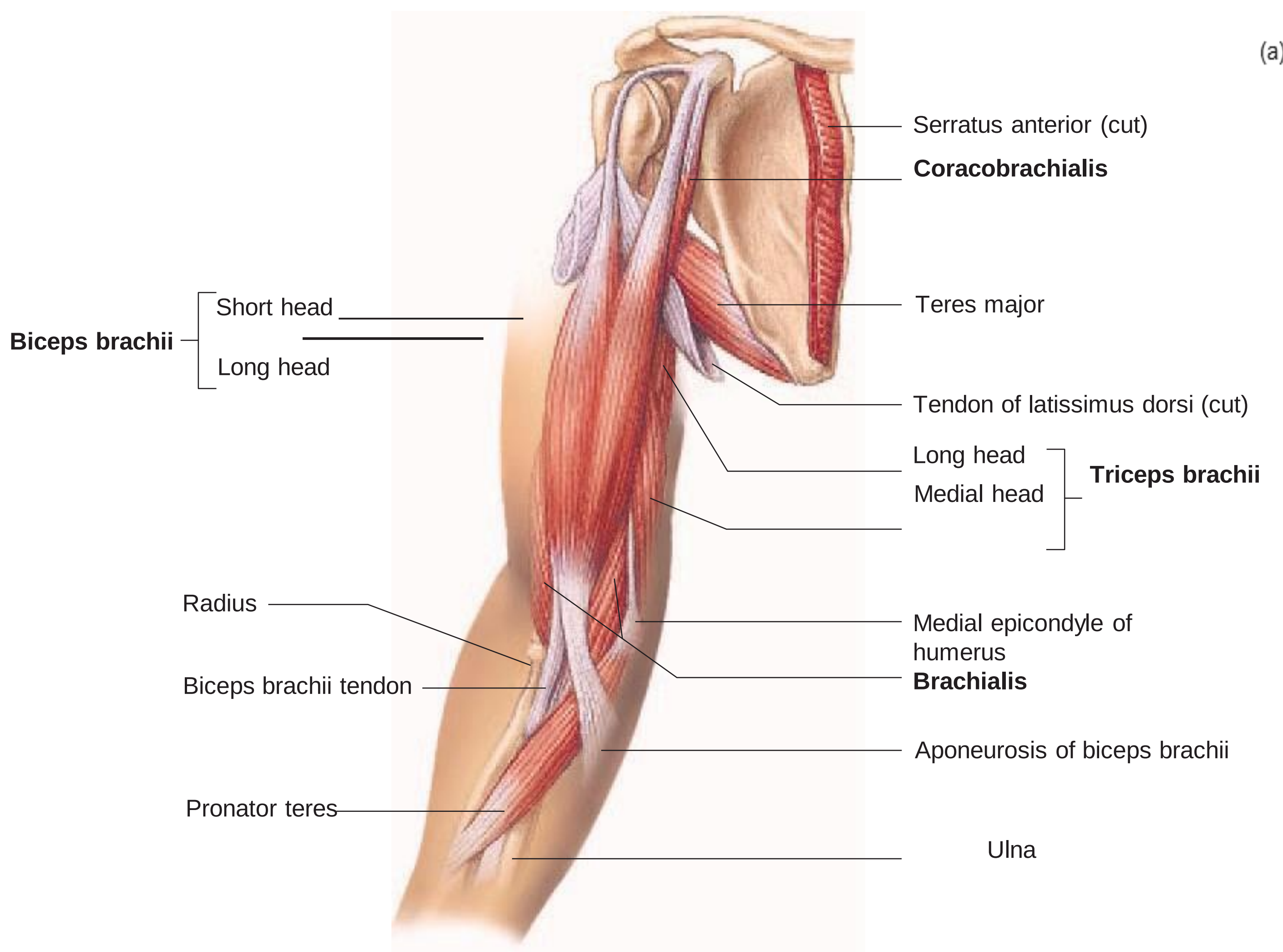




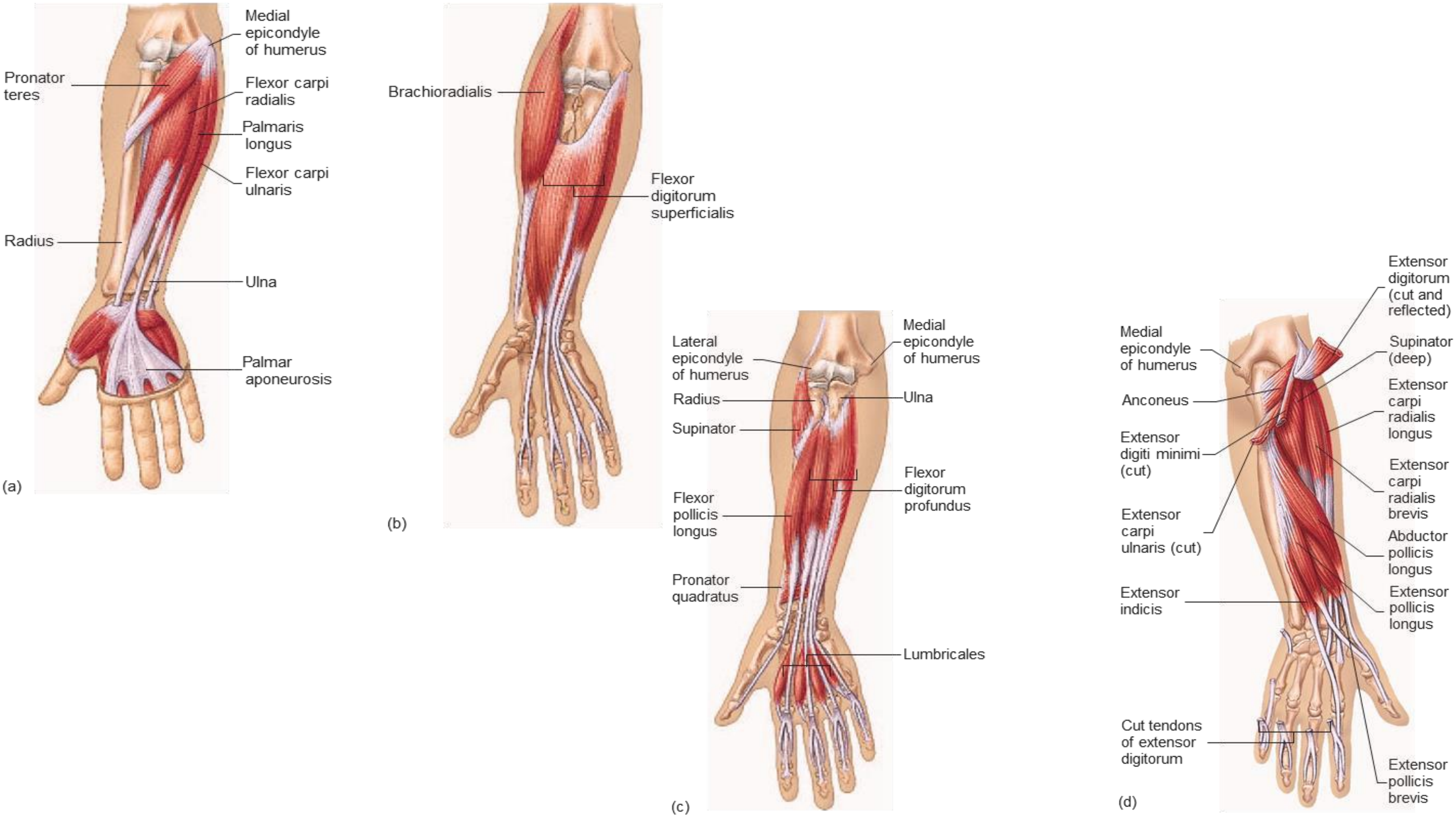
MUSCLES ACTING ON THE ARM AND FOREARM



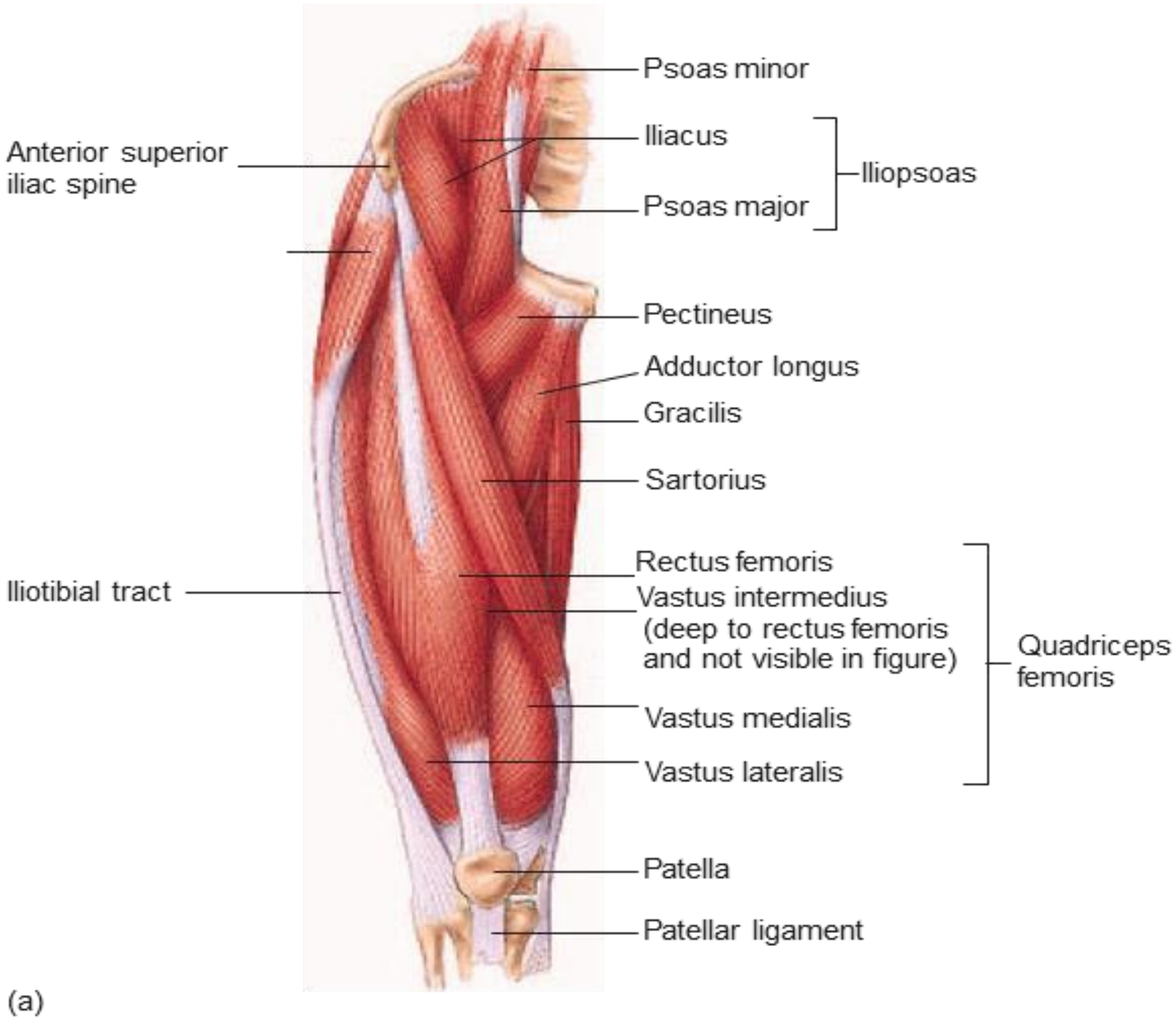
(a)

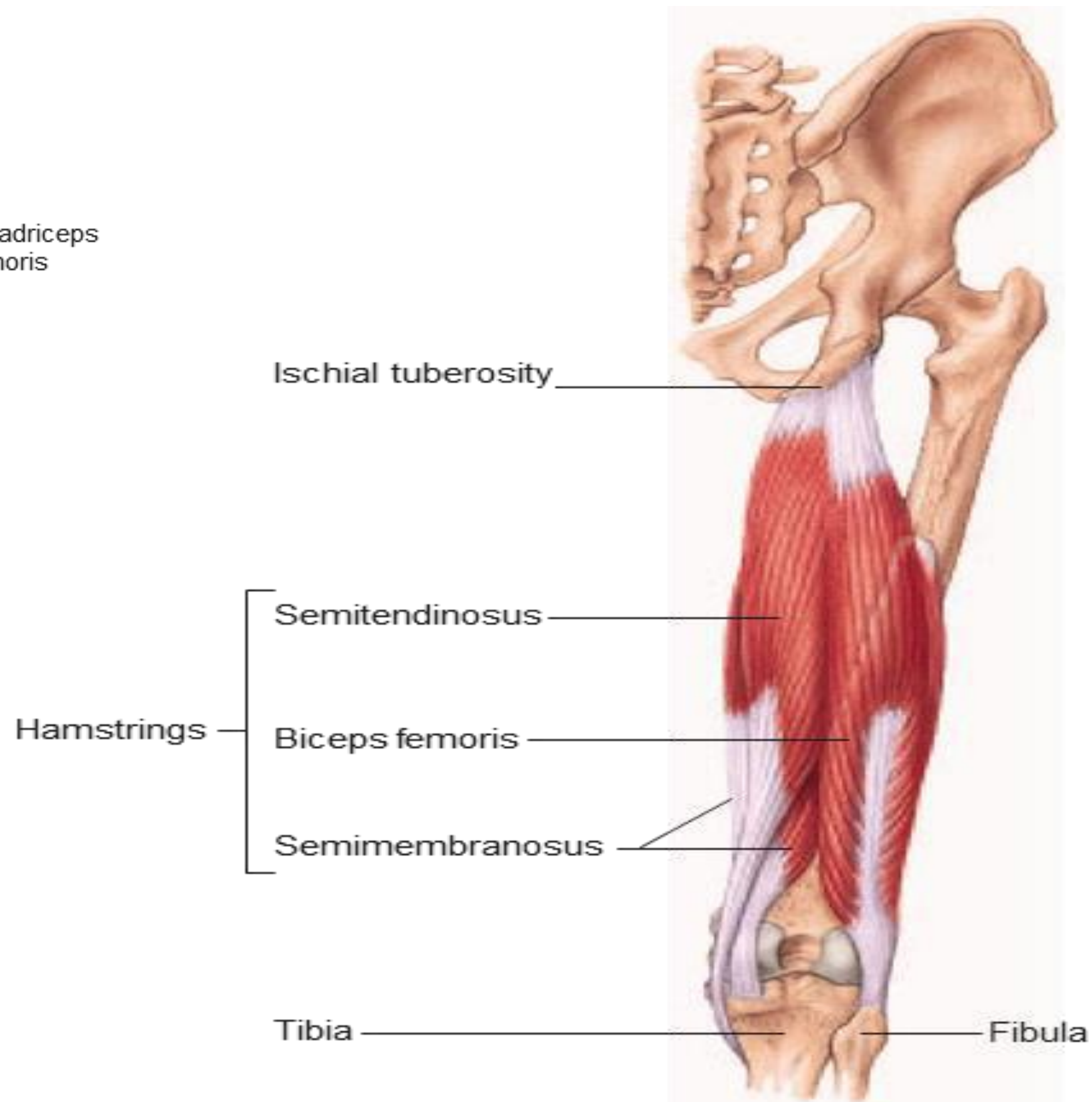


MUSCLES OF THE FOREARM ACTING ON THE WRIST, HAND, AND FINGERS

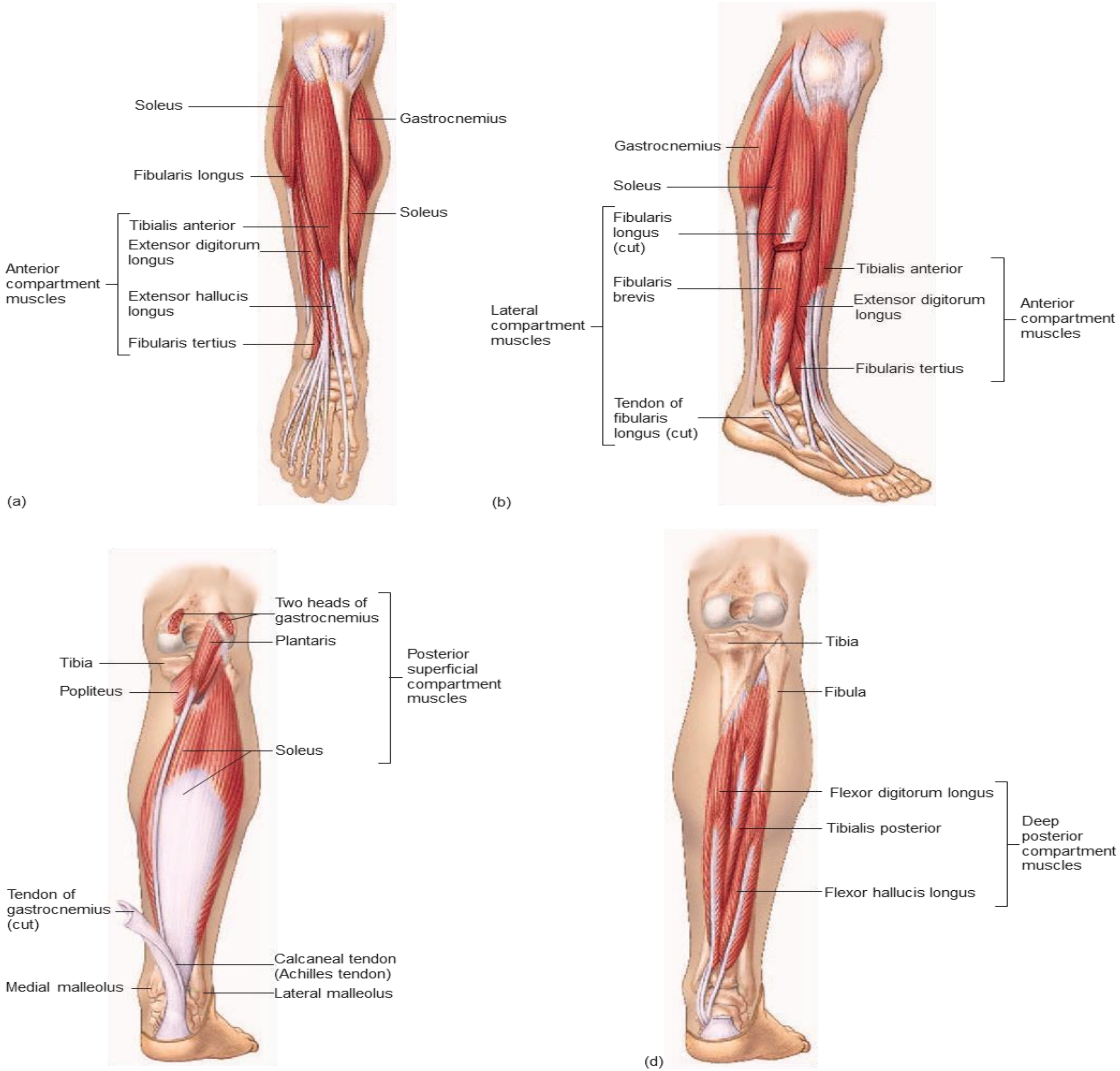


MUSCLES ACTING ON THE THIGH





MUSCLES OF THE LEG ACTING ON THE LEG, ANKLE, AND FOOT



REVIEW QUESTIONS

- Define the terms origin and insertion; agonist and antagonist; and synergist, prime mover, and fixator.
- Describe the different shapes of muscles. How are the shapes related to the force of contraction of the muscle and the range of movement the contraction produces?
- List the different criteria used to name muscles, and give an example of each.
- Using the terms fulcrum, lever, and force, explain how contraction of a muscle results in movement. Define the three classes of levers, and give an example of each in the body.
- How would paralysis of the quadriceps femoris of the left leg affect a person’s ability to walk?