Muscular System 2

The second of two complementary systems comprising what we recognize as the locomotory complex is the muscular system. We will be concentrating on what most of us recognize as "muscle," in ourselves and other vertebrates, i.e., the bulk of our body mass that gives our bodies shape and definition.

The function of muscle is contraction. In vertebrates, there are three types of muscle, smooth or involuntary, associated with systems not involved in body locomotion, e.g., the digestive system. Cardiac muscle, involuntary in function, occurs only in the heart. Skeletal or striated muscle which is voluntary in function is generally associated with visible body movements. It also aids in such activities as returning venous blood and lymphatic fluid, especially from the posterior limbs, toward the heart.

The tissues of the muscular system bring about not only externally visible locomotory movements, but also some important subtle, sophisticated, internal movements, such as food propulsion through the digestive tract, adjustment of blood vessel diameters to control blood volumes in various body regions, regulation of respiratory tube diameter, erection of hair follicles, and intrinsic eye functions such as dilation and constriction of the pupil.

The gross anatomy of a skeletal muscle includes the swollen middle region called the **belly**, the less movable end known as the **origin**, and the more movable end called the **insertion** [Figure 2–1]. In some muscles that are capable of several actions, the origin and insertion may be reversed during contraction. The points of origin and insertion are marked by the presence of dense connective tissue which anchor each muscle to a bone, straplike tendons, or to other muscles, by means of flat sheetlike aponeuroses.

Macroscopically, the structure of a muscle consists of a variable number of muscle cells (fibers) each encased in connective tissue, the endomysium, occurring in bundles called fasciculi and wrapped in connective tissue, the perimysium. Finally, groups of fasciculi surrounded by connective tissue, the epimysium, make up the whole muscle, e.g., the *Biceps brachii*. Microscopically, each of the muscle fibers contains two types of contractile proteins, actin

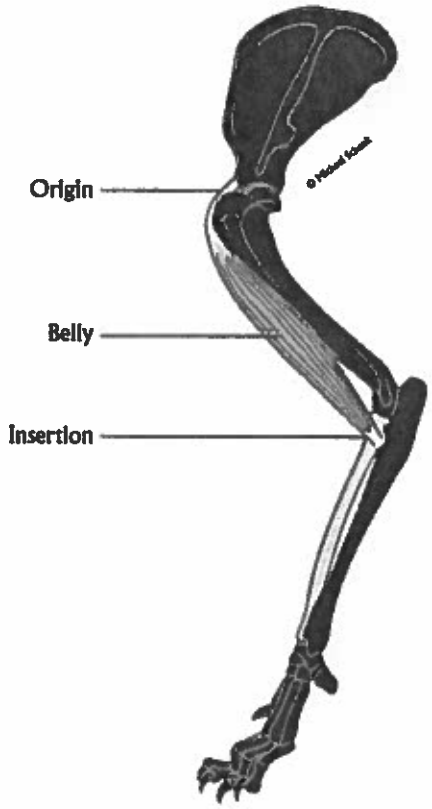


FIGURE 2-1 Gross anatomy of a muscle (Biceps brachii).

and myosin, which are organized into very regular and serially repetitive arrangements. This repetitive banding pattern is a prominent characteristic of striated muscle.

As you will learn during your study of muscles, muscle shapes vary, dependent primarily upon the arrangement of fibers within each muscle and its relationship with the tendon of insertion. Perhaps an arrangement with which you are most familiar is known as **convergent** [Figure 2–2A]. The fibers in this arrangement are basically parallel; however, they converge at either end of the muscle. The fibers are arranged in parallel throughout the length of **strap** muscles [Figure 2–2B]. Muscles whose architecture includes a straight blunt origin and a convergent insertion are called **fan-shaped** [Figure 2–2C]. An oblique arrangement of fibers inserting into a tendon or tendons constitutes the pennate class of muscle architecture. Within this group are **unipennate** [Figure 2–2D], where the fibers insert into one side of a tendinous insertion, **bipennate** [Figure 2–2E], where the muscle fibers insert into both sides of a centrally located tendon, and **multipennate** [Figure 2–2F], where the muscle fibers insert into several tendons whose orientation may vary and may appear as combinations of the unipennate and bipennate subgroups.

Muscles are capable of producing a variety of movements called actions. Actions of muscles associated with hinge joints, e.g., the elbow, produce actions known as **flexion**, causing reduction of the angle at the joint and **extension**, causing an increase in the angle of the joint. When appendages or portions of appendages, e.g., the digits, are moved away from a midline reference point or spread, the action is referred to as **abduction**. In contrast, movement toward the midline reference is called **adduction**. Movement of an appendage parallel to the longitudinal axis, producing an anterior action, e.g., swinging a leg forward, is known as **protraction** and the opposite action is known as **retraction**. **Rotation** involves the movement of a portion of the body around a central axis, e.g., the head on the neck. A specialized action involving rotation of the radial head in the ulnar notch produces actions known as **pronation** and **supination**. When the cat is standing, the manus is pronated or palm down, however, when grooming itself, the manus is supinated or palm up.

Individual muscles generally do not bring about actions by themselves. Most actions are the result of the combined effort of several muscles. Those muscles that affect the action directly are called **prime movers**. Prime movers, however, usually are assisted by others known as **synergists**. These muscles not only aid in bringing about the main action, but also may stabilize the joint or portions of the skeleton involved in the action and are known as **fixators**. Muscles whose actions oppose one another are called **antagonists**.

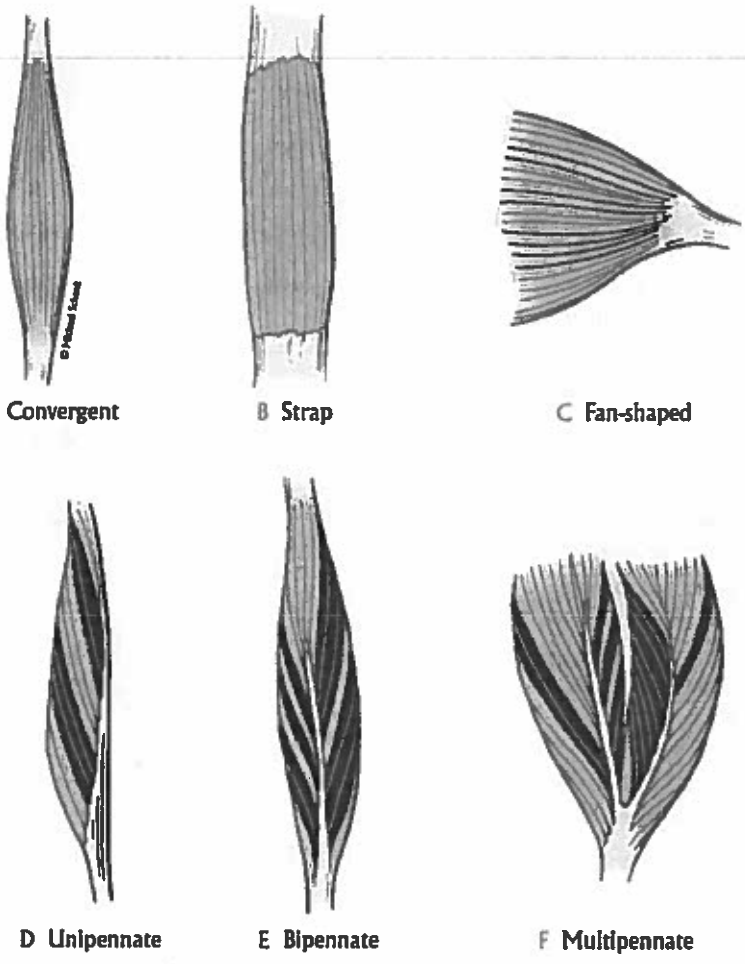


FIGURE 2–2 Muscle architecture.

EXTERNAL FEATURES

Cat specimens are usually packed individually in plastic bags, containing both the cat and some preservative fluid to aid in maintaining a moist environment. Carefully remove the specimen from the bag, retaining the fluid to keep the cat moist when it is returned to the bag for storage.

Lay the cat on its dorsal surface on a large dissecting tray. Now is the time for you to make a number of observations concerning your specimen and also plans for dissection. Note that the body is divided into several regions: a **head**, **neck**, **trunk**, and **tail**. A number of distinguishing features of the head, all associated with the concentration of special senses in this region, can be seen. Among them are the paired **external ears** or **pinnae**, the paired eyes with an **upper eyelid** or **superior palpebra**, and a **lower eyelid** known as the **inferior palpebra**, paired **nostrils** or **external nares**, and

tufts of coarse hairs known as **whiskers** or **vibrissae** on either side of the face. Note the **nictitating membrane** in the lower, medial corner of the eye [Figure 2–3].

The trunk can be divided into an anterior thoracic region delineated by the rib cage, a middle **abdominal** region, and a posterior pelvic region. Along the ventral surface of the trunk, or the belly, are two rows of paired **nipples**, associated with the mammary glands. They tend to be more prominent in females than in males, especially if the female is either pregnant or has been recently pregnant. Dorsal to the genital region in both sexes and located directly below the tail is the **anus**, the external terminal opening of the digestive system.

There are two sets of paired appendages, **forelimbs**, including the **manus** associated with the cranial portion of the trunk and **hindlimbs**, including the pes associated with the caudal end of the trunk [Figure 2–3]. Palpate the genital area to ascertain the sex of the cat. If it is a male, you will feel the testes enclosed within the scrotum; if it is a female, note the urogenital aperture.

SKINNING THE CAT

The cat will be skinned on *one side only* and the skin should be kept in a *single piece* so that it can be wrapped around the skinned surface when the cat is not being actively worked on. ***Your instructor may have alternative directions for skinning the cat.*** Before attempting to remove the skin, observe several possible areas on the body where skin may have been removed to facilitate the injection of blood vessels with latex, e.g., the neck region, the forearm, and the hindleg. Of all the injection sites, the muscles and the blood vessels of the neck region are most likely to be damaged. Another area that may influence your decision occurs in cats whose hepatic portal system has been injected since the incision in the abdominal area is usually stapled or sutured shut. In this case, you may want to skin the specimen on the opposite side. If the staples occur in the midventral line, simply choose either side for your incision and cut a flap around the stapled area. Before selection of the side that you wish to skin, observe the position of the injection sites discussed above and choose the pathway that allows you to avoid the majority of problem areas.

Since the success of the skinning process is closely correlated with your ability to complete clean, precise cuts, a new blade in your scalpel is essential. Make a careful, shallow incision, just deep enough to break the skin, beginning at the base of the neck 1/2 inch left or right of the midventral line to avoid any muscles whose origin or insertion is on the midline. Determine whether it is possible to pull the skin away from the underlying tissue. Use your fingers, a pair of forceps or a scalpel with the blade held parallel to the underlying muscle or toward the skin and sever the connective tissue from the skin. If your specimen is a female that has been pregnant recently, as you skin the thoracic and abdominal regions you may encounter the mammary glands that will appear as flattened, tannish masses that you might mistake for muscle. It is preferable to remove these glands with the skin. Continue caudally to a level approximately two inches anterior to the cranial edge of the hindlimb. Now angle your incision along the midline of the hindlimb continuing to a point just proximal to the digits where you will make an encircling incision around the pes. If your specimen is a male, exercise extreme caution because the spermatic cord is imbedded within the fat and connective tissue of the

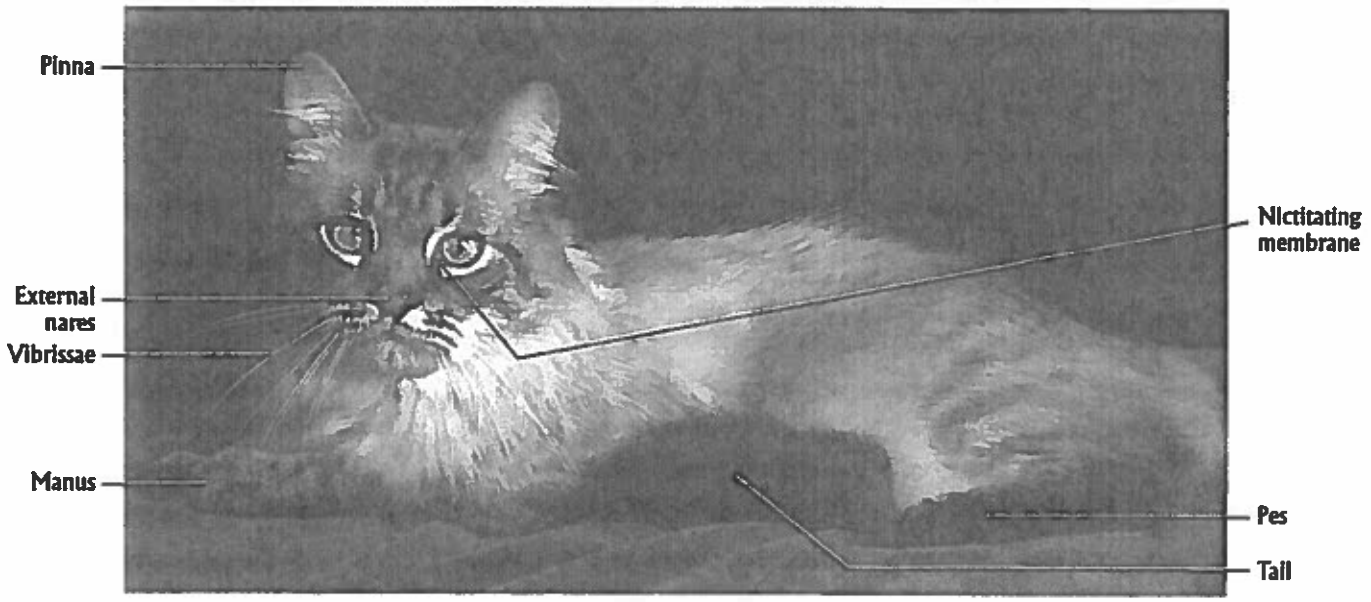


FIGURE 2–3 External features of a cat. (This cat was not used as a dissection specimen in this book.)

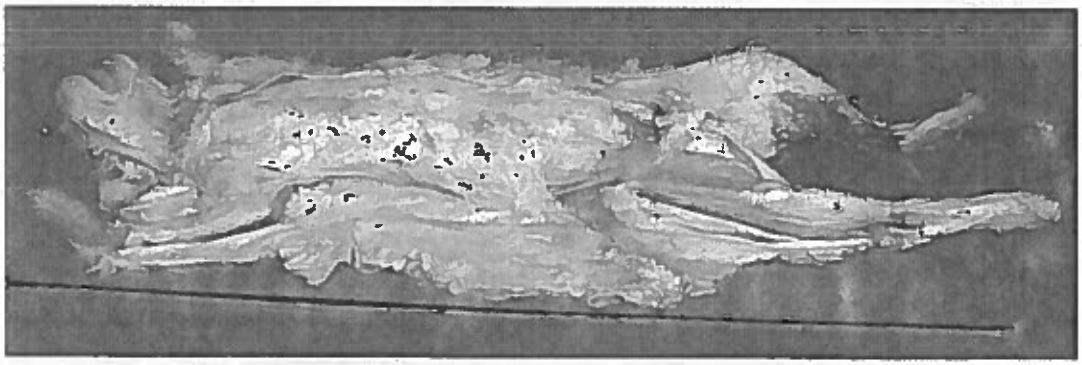
groin area and directly beneath the skin. Another reason for this care is that the leg skin is very thin and a major superficial vein, the saphenous, lies directly under the skin. Therefore, carefully sever the fascia from the skin in this area.

Return to the thoracic region and begin an incision opposite the forelimb, continuing down the medial aspect, and encircling the manus just proximal to the digits. Be exceptionally cautious when skinning the radial side of the lower forelimb since a thin, narrow muscle band, the brachioradialis m., a nerve, and blood vessels, adhere closely to the skin and may be mistakenly severed. In addition, along the lateral aspect of the forelimb, from the wrist to the shoulder, courses the cephalic vein, that can again, very easily, be removed along with the skin. It should not be, however! Carefully skin the body, hindlimb and forelimb. As the trunk is skinned, an extensive dermal muscle, the **cutaneous maximus** m., especially prominent in the axillary, pectoral, and abdominal regions, will be encountered. This is the muscle in horses that allows them to twitch and get rid of flies, dogs to shake water out of their coats, etc. It is best to remove this muscle with the skin, exerting great care in the axillary region. In the dorsal shoulder region, take care not to cut through a heavy white connective tissue (aponeurosis) between the paired acromiotrapezius muscles.

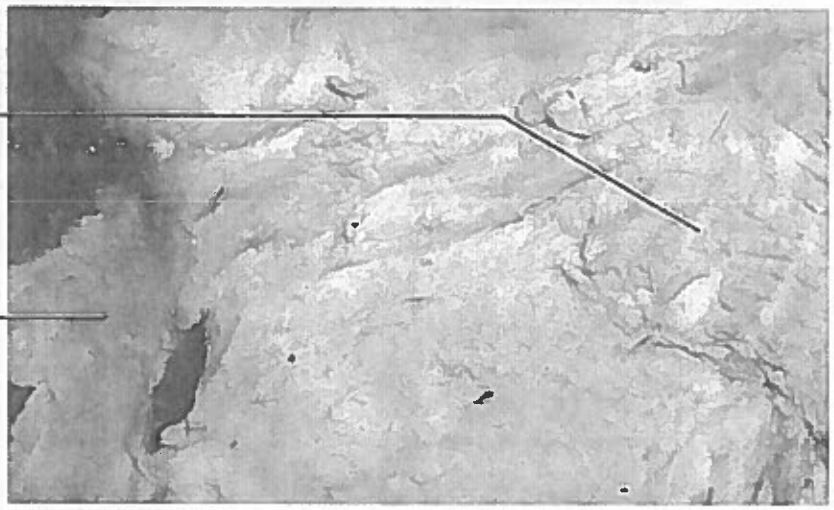
Concentrate now on the neck and head regions. Be careful of superficial blood vessels in the ventrolateral position in the neck. During your dissection of this area, note another dermal muscle, the **platysma** m., that adheres closely to the neck and head muscles. Again, it is desirable to remove the platysma with the skin. Notice that the skin in the head region is much thicker than other areas of the body. Extend the ventral incision to the base of the mandible, outlining the mouth, the nose, and the eye, continuing the incision to the midline of the forehead.

As you loosen the skin from the underlying tissues, make a circular incision around the ear and reflect the skin. Continue the skinning process to approximately 1/2 inch past the mid-dorsal line along the entire length of the cat [Figure 2–4A, Figure 2–4B, and Figure 2–4C].

A Proper skinning technique. The edge of the scalpel blade is held next to the skin.



B Cat properly skinned.



C Dermal muscles

FIGURE 2–4 Skinning the cat.

Humans lack a cutaneous maximus and, for this reason, they do not have the ability to twitch their skin, and scar much more easily than other mammals. The platysma, however, is well developed in humans. As you look in a mirror, grimace and note the tendinous, stringy appearance of your neck, the action of the platysma.

PREPARING THE CAT FOR MUSCLE DISSECTION

To properly separate and appreciate muscle relationships, it is necessary to remove extraneous tissues that tend to adhere to the surface of the superficial muscles [Figure 2–5A and Figure 2–5B]. Carefully remove fatty tissue lying on external muscle surfaces. Usually there is a very heavy deposit of fat in the groin area. If your specimen is a male, exercise extreme caution during the removal of fat in this region since the spermatic cord, a thin, small diameter tube lies in close proximity to this fat deposit. Another area where fat may accumulate is the region between the scapulae on the surface of the aponeurosis connecting the two acromiotrapezius muscles. Exert caution while removing this fatty tissue here so that the aponeurosis is not destroyed. There will be other areas on the body surface where heavy sheets of dense connective tissue covered by fatty tissue may occur (lumbosacral region, the insertion end of the tensor fascia latae muscle, biceps femoris muscle, etc.). Caution should always be exerted to avoid damaging these important areas of fascia and any other underlying structures. Fascia associated with muscle insertions should not be removed.

After skinning the cat, there may be pieces of the dermal muscles (platysma and cutaneus maximus) left adhering to the muscle surfaces. These should be carefully removed. The epitrochlearis muscle appears very much like a piece of cutaneus maximus on the medial surface of the brachium [Figure 2–27A]. Do not remove this muscle or the thin aponeurosis by which it inserts in the vicinity of the elbow.

A Before removal of overlying connective tissue.

B After removal of overlying connective tissue showing an example of differences in muscle fiber direction in contiguous or overlying muscles.

FIGURE 2–5 Chest muscles.

DIRECTION OF MUSCLE FIBERS

During the dissection of your specimen, it is very advantageous to be able to distinguish where one muscle ends and an adjacent or overlapping muscle begins. In order to identify individual muscles, look for the direction of muscle fiber orientation. For example, in muscles such as the abdominals, consisting of three sheetlike layers superimposed one on the other, it becomes essential to detect changes in fiber direction [Figure 2–10B]. Furthermore, most muscles are individually wrapped in layers of connective tissue called fascia and the areas where these layers abut one another can often be observed as distinct lines between muscles [Figure 2–5A, Figure 2–5B]. In order to separate muscles that overlap or abut one another, it is imperative to orient the probe or fingers within the fascia separating those muscles to ensure that one is not "creating" new muscles. There is nothing more frustrating than contending with several muscles where only one should exist. Your ability to distinguish and separate contiguous muscles will be greatly enhanced by training yourself to appreciate these relationships and will be greatly appreciated by your instructor.

SEWING AND CUTTING MUSCLES

Sewing a muscle may sound strange to you, but contending with the cut ends of several chest or leg muscles might change your mind. The sewing and cutting process maintains the integrity of the points of origin and insertion of the muscle. Since you will be identifying superficial and deep muscles, our solution is to first sew and cut the more superficial muscles and then separate the underlying muscles.

Before attempting to sew and cut any muscle, separate the muscle from the point of origin to the point of insertion and free it from contiguous muscles. You are now ready to sew the muscle:

1. With approximately 18 inches of thread, thread the needle leaving one end longer than the other.
2. Make a knot only in the longer of the two free ends.
3. Insert the needle approximately 1/2 inch from the midline between the origin and insertion of the muscle, pull it through and make a couple of overcast stitches to thoroughly anchor the thread [Figure 2–6A]. Since the muscle will always be cut perpendicular to the muscle fibers, orient your sewing points accordingly.
4. Insert the needle approximately 1/2 inch from the midline of the muscle on the other side. Notice that there will be about an inch of space between the two anchor points [Figure 2–6B].
5. Pull the thread through, leaving a loop approximately three inches in length [Figure 2–6B].

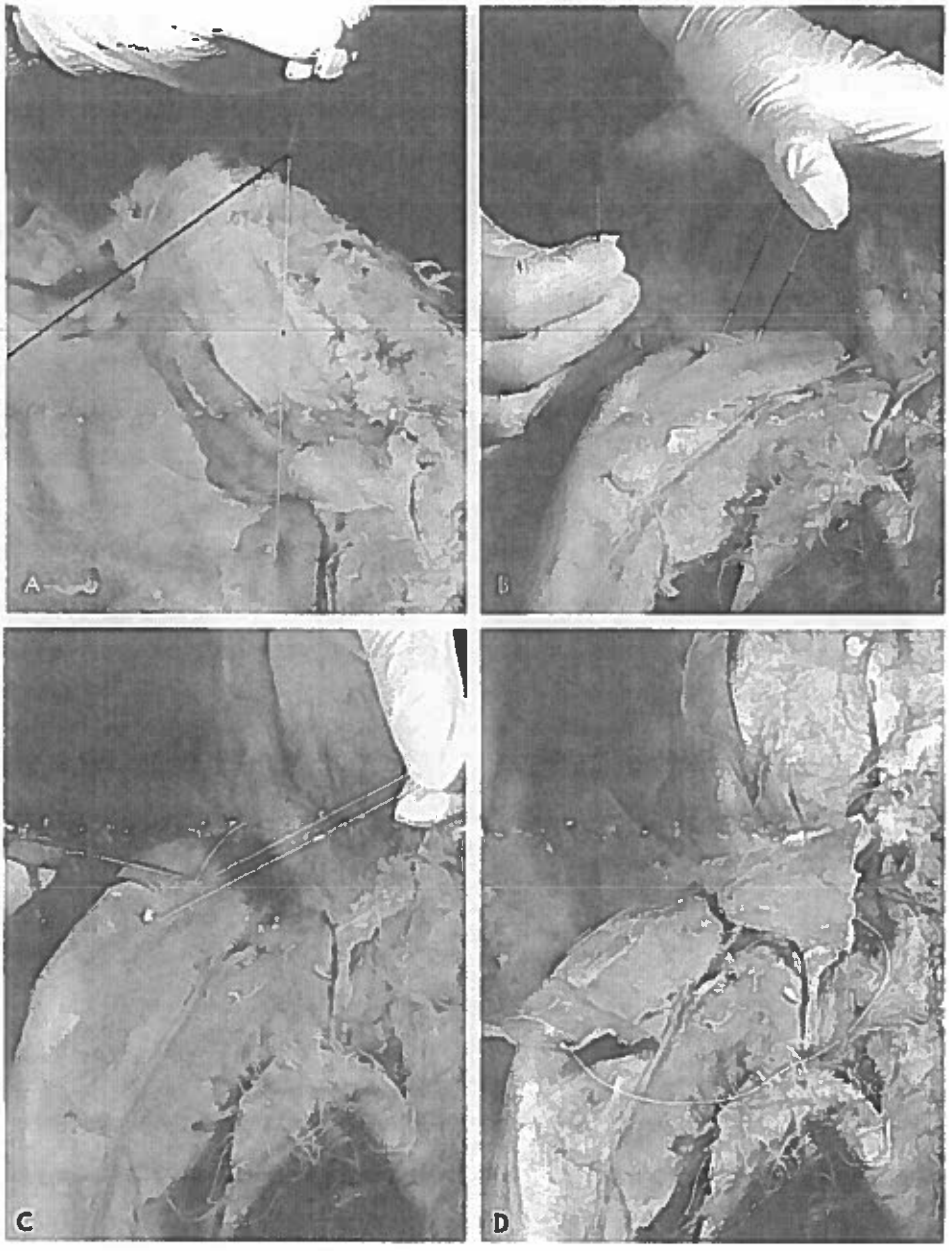
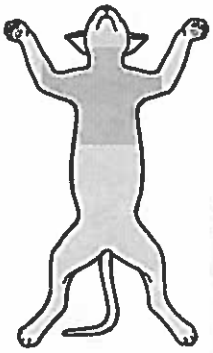


FIGURE 2–6 How to sew and cut a designated muscle.

6. Similar to the other side, make two to three overcast stitches to securely anchor the thread.
7. Cut the thread off at the second anchoring site, leaving the loop attached to the muscle.
8. Lift the muscle and carefully cut through the midline of the muscle only, leaving the loop of thread connecting the two ends [Figure 2–6C and Figure 2–6D]. Remember to cut each muscle perpendicular to the muscle fibers.

SUPERFICIAL THORACIC MUSCLES

This group of muscles has a tendency to adhere tightly to one another, therefore, care should be exercised when separating them. Watch for the changes in muscle fiber orientation and the subtle white lines created by the connective tissue surrounding each muscle that indicate the extent of individual muscles.



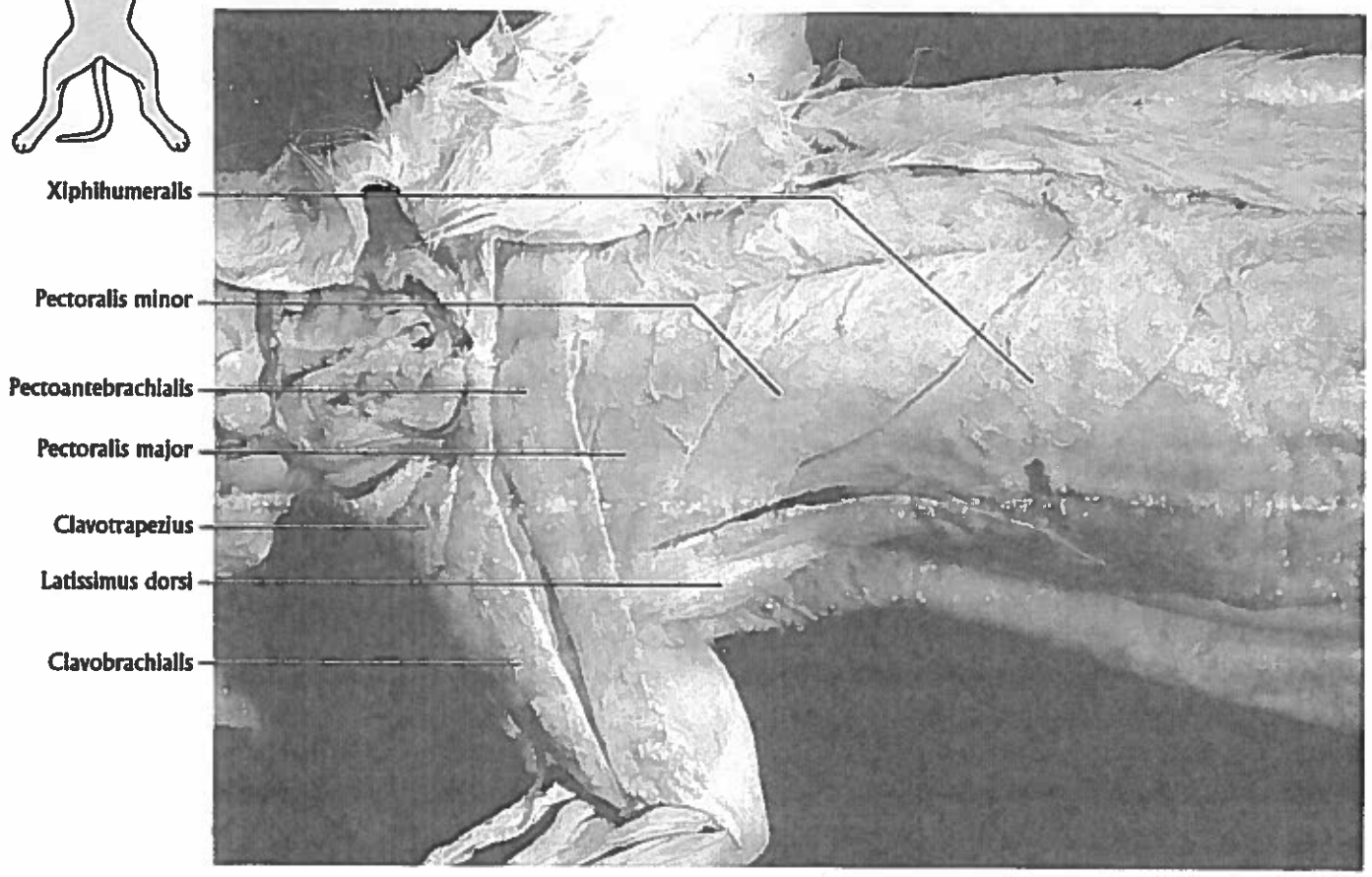


FIGURE 2–7 Superficial chest muscles.

Pectoantebrachialis m.

This is the most superficial of the chest or pectoral muscles. It is a narrow, *thin* band that extends from the midline of the body to the upper portion of the forelimb [Figure 2–7]. This muscle does not occur in man.

Origin: Manubrium of the sternum

Insertion: Flat tendon into the superficial fascia of the antebrachium above the elbow

Action: Draws the forelimb toward the midline

**Sew and cut this muscle.

Pectoralis major m.

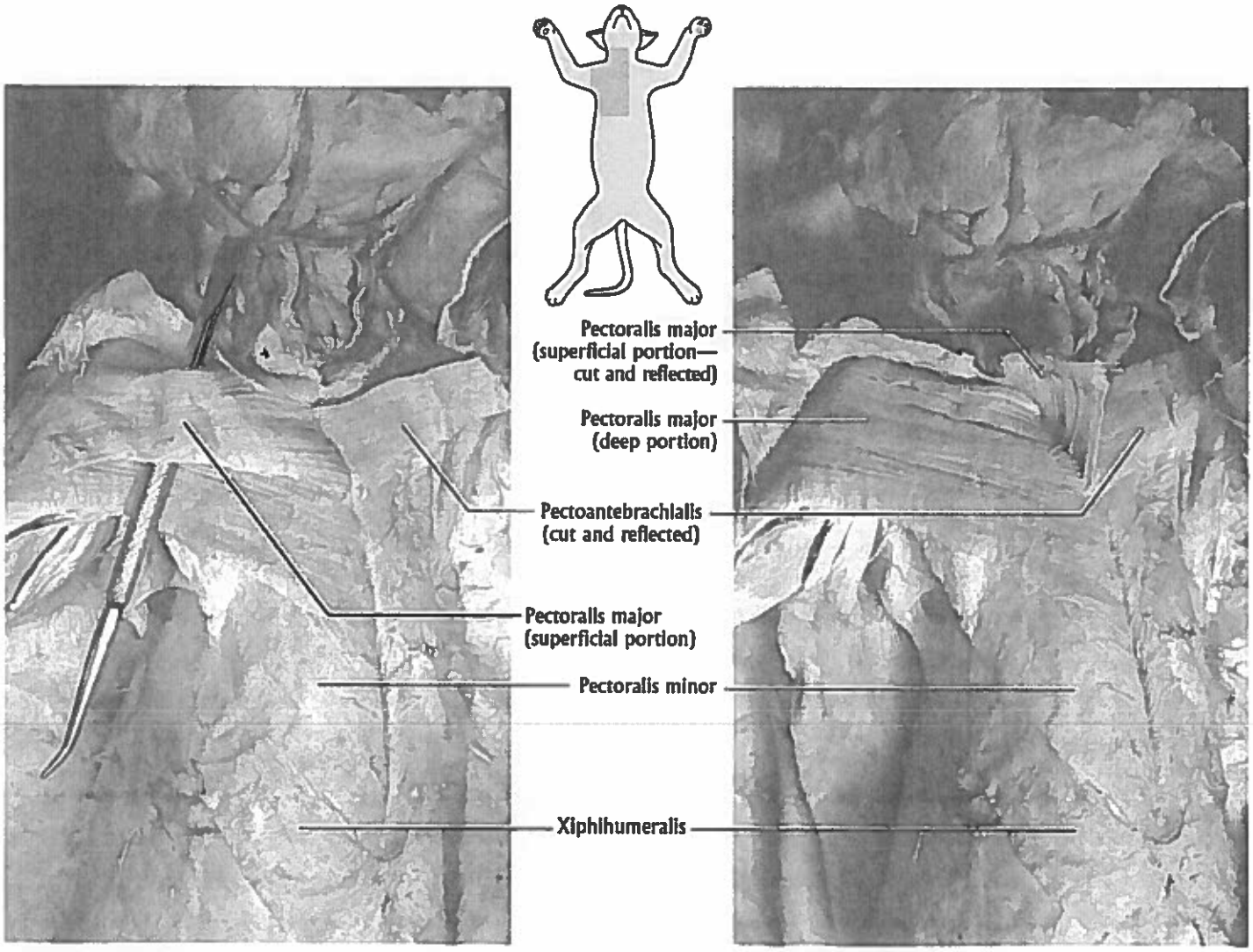
A superficial and deep portion of this muscle can be distinguished [Figure 2–7, Figure 2–8A, and Figure 2–8B].

Superficial Portion

Flat, thin band, approximately the same width as the pectoantebrachialis and partially hidden by that muscle [Figure 2–8A].

Origin: Midventral raphe and cranial half of the manubrium

Insertion: Middle third of the shaft of the humerus



A Superficial portion B Deep portion

FIGURE 2–8 Pectoralis major.

Deep Portion

Flat band, approximately three times the width of the superficial part [Figure 2–8B]. In order to see the entire extent of this portion, the clavotrapezius and the clavobrachialis should now be dissected (see pages 52 and 53). Exercise care while separating the clavotrapezius to avoid damaging the underlying pectoralis major. Furthermore, use care in separating this portion of the pectoralis major to avoid damaging the underlying pectoralis minor.

Origin: Cranial half of the sternum and midventral raphe

Insertion: Proximal third of the shaft of the humerus

Common Action of Both Portions: Draws the forelimb toward the midline and turns the manus forward

****Sew together and cut both portions of this muscle following careful separation of the two portions.**

Pectoralis minor m.

A thick, fan shaped muscle extending caudally to and beneath the deep portion of the pectoralis major [Figure 2–7 and Figure 2–9]. Exert care to preserve the xiphihumeralis that passes beneath the pectoralis minor [Figure 2–7, Figure 2–8A, and Figure 2–8B]. Additionally, with great care, separate the latissimus dorsi from the lateral border of the pectoralis minor [Figure 2–7].

Origin: From the six sternebrae and sometimes the xiphoid process, resulting in the appearance of several slips that appear to be separate muscles

Insertion: Ventral border of the humerus from the bicipital groove to the middle of the humerus

Action: Draws the forelimb toward the midline

****Sew and cut this muscle.**

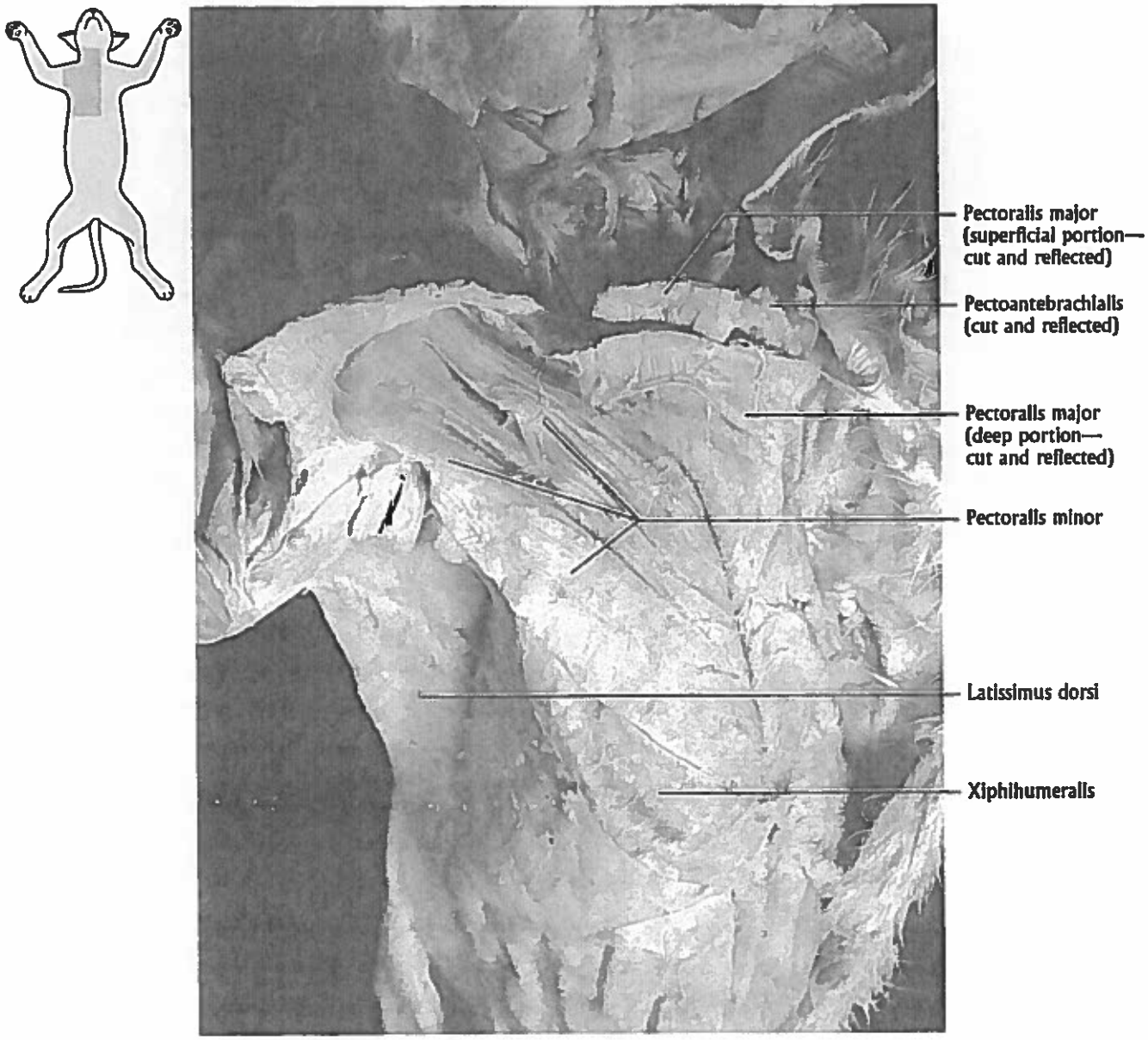


FIGURE 2–9 Pectoralis minor.

Xiphihumeralis m.

A long, very thin, narrow band of muscle, lying along the posterior border of the pectoralis minor and, according to some anatomists, actually a part of that muscle [Figure 2–7 and Figure 2–9]. The xiphihumeralis muscle is absent in humans.

Origin: Median raphe in the vicinity of the xiphoid process

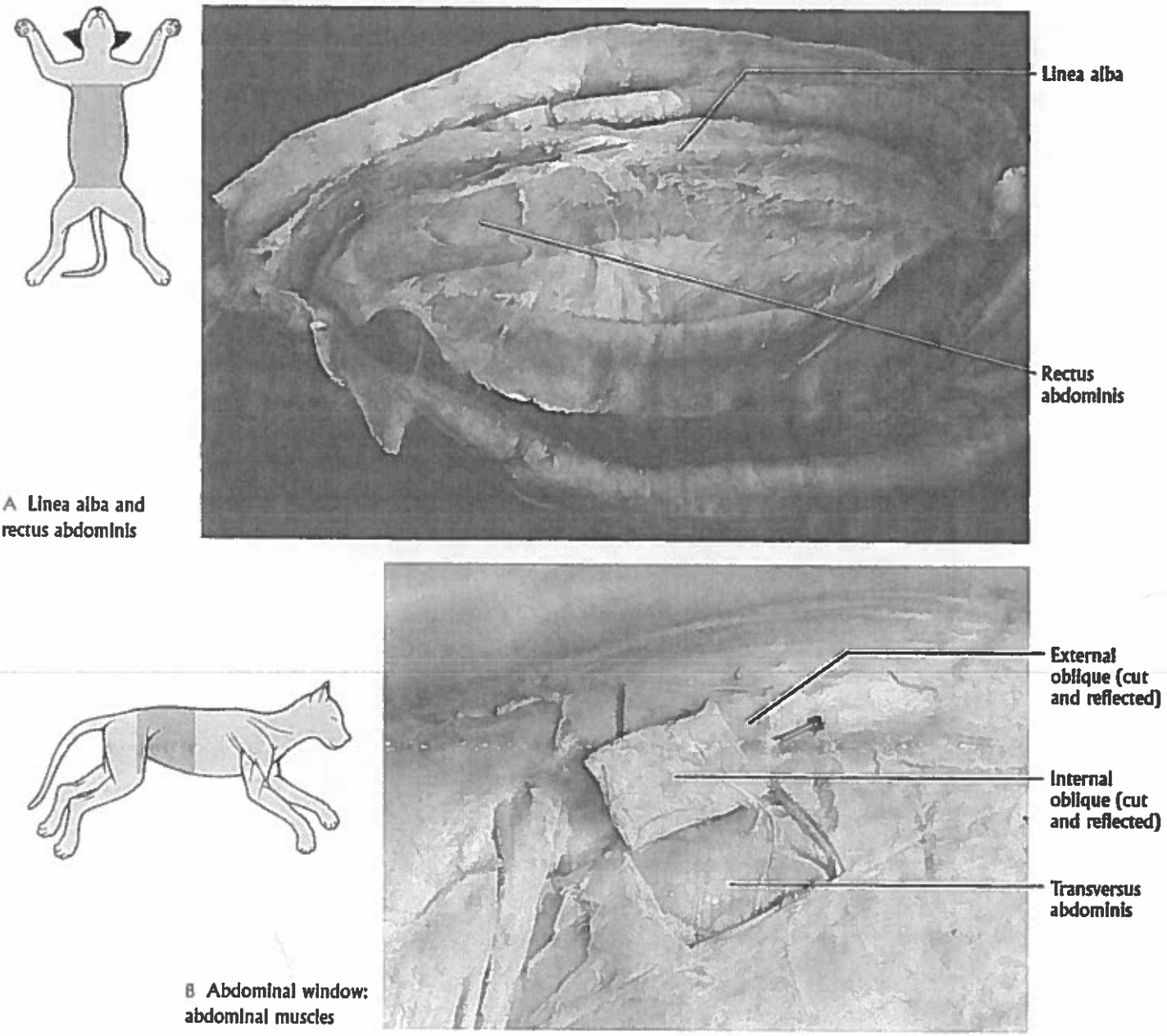
Insertion: Along the ventral border of the bicipital groove of the humerus

Action: Synergistic with the pectoralis minor in drawing the forelimb toward the midline

**Sew and cut this muscle.

ABDOMINAL MUSCLES

Three sheetlike muscles and a longitudinal, bandlike muscle make up this group. Note that the left and right portions of the abdominal muscles are separated by a longitudinal white line of connective tissue known as the **linea alba** [Figure 2–10A]. The sheetlike muscles are thin and quite extensive, supporting the entire abdominal area and a portion of the ventral thoracic region. These muscles are layered and adhere closely to one another by means of fascia. The direction of fibers within each sheet is distinctive and this feature is used as a tool to identify the individual muscles. To facilitate the dissection of these sheets, a three sided opening, one inch on each side should be made in the flank



A Linea alba and rectus abdominis

B Abdominal window: abdominal muscles

FIGURE 2–10

[Figure 2–10B]. Carefully separate and identify the sheets of muscle.

External oblique m.

The direction of the fibers of this muscle extend craniodorsally [Figure 2–10B]. This is the most superficial of the three sheetlike abdominal muscles.

Origin: Lumbodorsal fascia and the last 9 or 10 ribs

Insertion: Median raphe of distal portion of sternum, linea alba from sternum to pubis

Action: Compresses the abdominal region

Internal oblique m.

The direction of the fibers of this muscle extend caudodorsally [Figure 2–10B]. This sheetlike muscle lies directly beneath the external oblique.

Origin: Lumbodorsal fascia in common with the external oblique and iliac crest

Insertion: Linea alba by a thin aponeurosis in common with the external oblique and transversus abdominis

Action: Compresses the abdominal region

Transversus abdominis m.

Fibers of this muscle sheet extend nearly transversely between the origin and insertion [Figure 2–10B]. This muscle sheet lies directly beneath the internal oblique.

Origin: Aponeurosis from the costal cartilages of the vertebrochondral and vertebral ribs, transverse processes of lumbar vertebrae and ventral border of the ilium

Insertion: Linea alba in common with the two obliques

Action: Compresses the abdomen

Rectus abdominis m.

This muscle occurs as a longitudinally directed band of muscle on either side of the linea alba [Figure 2–10A]. This muscle is encased in a sheath formed by the aponeuroses of the other three abdominal muscles. In humans, this muscle is reduced at its anterior end.

Origin: Tubercle of pubis

Insertion: First and second costal cartilage, proximal end of sternum by a tendon passing dorsal to the transversus costarum

Action: Compresses the abdominal region, pulls sternum and ribs caudally causing flexion of the trunk.

SUPERFICIAL BACK MUSCLES

Clavotrapezius m.

This is a wide, flat muscle that covers most of the lateral portion of the neck [Figure 2–11 and Figure 2–12]. Take note that the levator scapulae ventralis passes below the clavotrapezius and must be separated from the clavotrapezius before the clavotrapezius is cut.

Origin: Lambdoidal ridge, middorsal raphe over spine of the axis

Insertion: Clavicle and raphe between clavotrapezius and clavobrachialis

Action: Protraction of the humerus

****Sew and cut this muscle.**

Clavobrachialis m.

This muscle appears to be a continuation of the clavotrapezius onto the forelimb and is considered by some anatomists to be the cranial portion of the deltoid and is called the clavodeltoid [Figure 2–13 and Figure 2–14]. The clavotrapezius and the clavobrachialis are separate muscles.

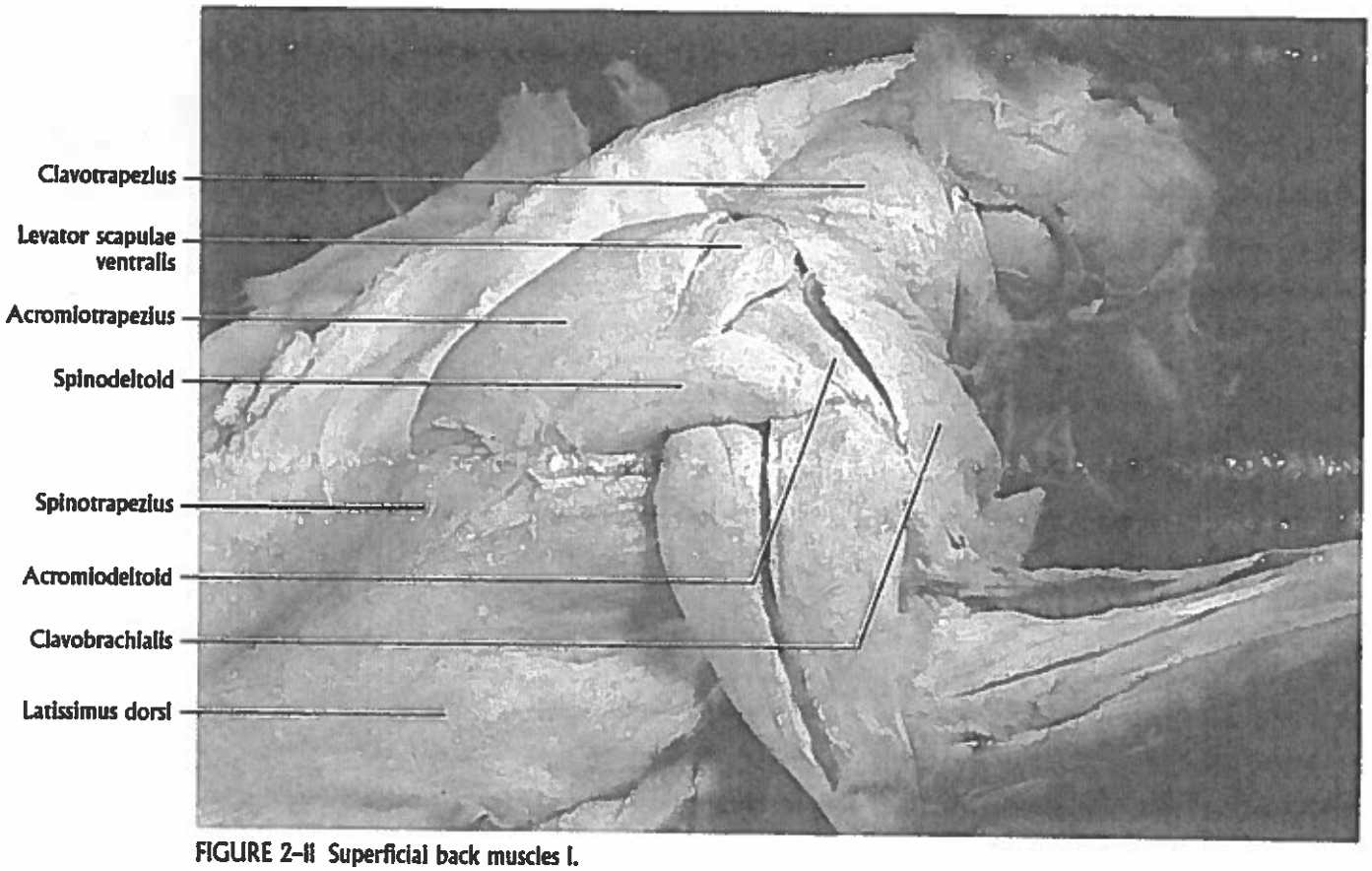


FIGURE 2–11 Superficial back muscles I.

Origin: Clavicle and raphe between clavotrapezius and clavobrachialis

Insertion: Commonly inserted with the brachialis through a tendon on the medial surface of the ulna distal to the semilunar notch

Action: Flexes the forearm

**Sew and cut this muscle.

Acromiotrapezius m.

This is a *thin* trapezoidal muscle lying over the scapulae [Figure 2–13 and Figure 2–14]. Extreme care must be exercised while dissecting this muscle to prevent damage to the whitish middorsal tendon and fascia that hold the left and right acromiotrapezius muscles together over the vertebral column.

Origin: Middorsal line from the spine of the axis to the spinous process of the fourth thoracic vertebra

Insertion: Metacromion process and spine of the scapula

Action: Adduct and stabilize the position of the scapulae

**Sew and cut this muscle, *not* the aponeurosis!

Spinotrapezius m.

This is a triangular muscle and the most posterior of the trapezius group [Figure 2–13 and Figure 2–14]. With great care, dissect this muscle from the craniodorsal surface of the latissimus dorsi.

Origin: Originates from the spinous processes of most of the thoracic vertebrae

Insertion: Fascia of supraspinatus and infraspinatus muscles on either side of the spine

Action: Pulls the scapula dorsally and caudally

The human trapezius is represented by a fusion of the three trapezius muscles in the cat.

**Sew and cut this muscle.

Latissimus dorsi m.

This is a large, thick, flat, triangular muscle just posterior to the trapezius group and covered craniodorsally by the spinotrapezius [Figure 2–11 and Figure 2–12]. The reason that the axillary region often appears to be so ragged is that the cutaneus maximus has its cranial origin in the axilla and has probably been cut off and left attached to the skin.

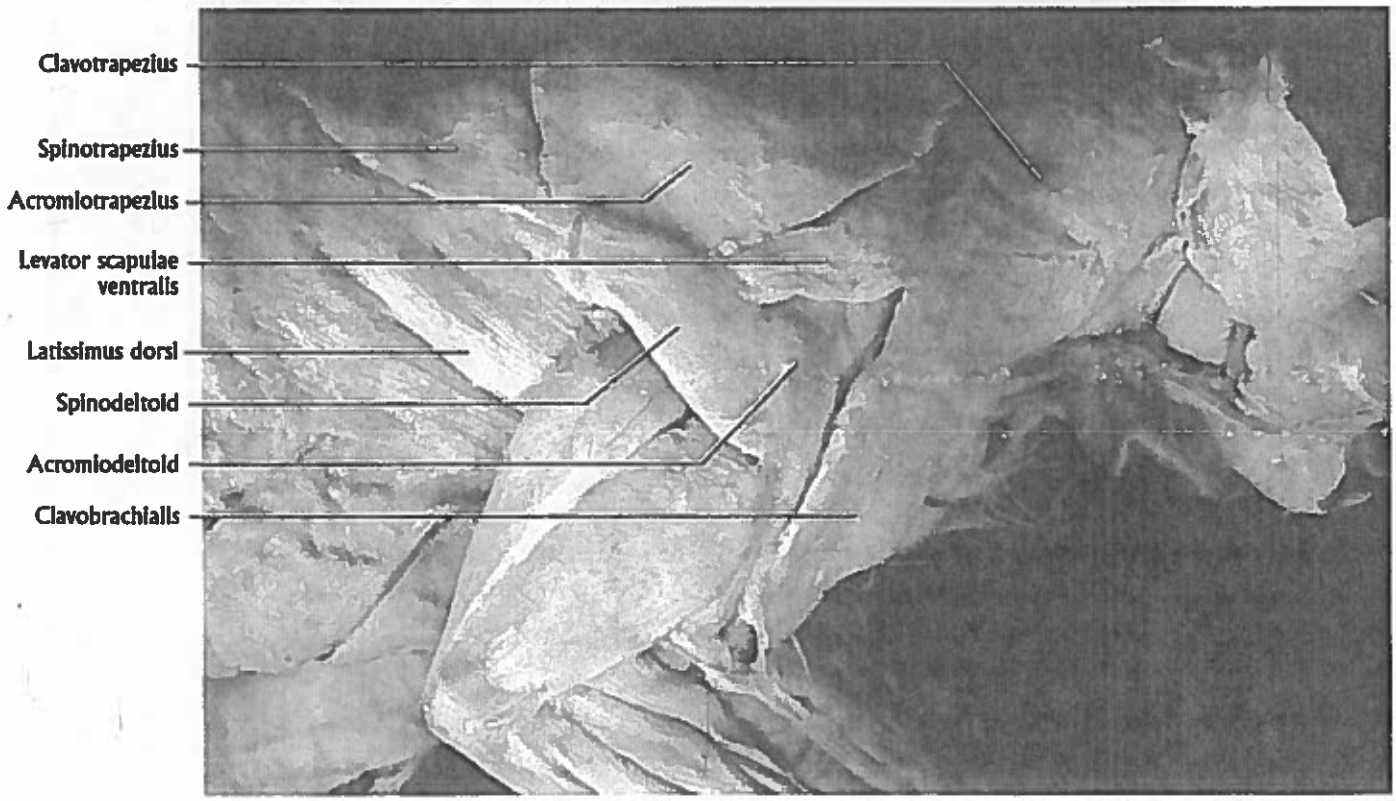


FIGURE 2–12 Superficial back muscles II.