Muscle Anatomy

The muscles are responsible for moving structures, modifying the function of other muscles, and stabilizing joints. Muscles originate and insert via tendons. The origin of a muscle is its fixed point while the insertion is typically the point that it moves. Muscles can attach via their tendons to bones, muscles, skin or eyes. Where known, the innervations of the muscles are reported. For reading ease, the designation of M., prior to muscles names, has been omitted. Names and key concepts are given in bold the first time the muscle is discussed.

Muscle functions are described with each figure. As they apply to sea turtles, these functions are as follows. Flexion bends one part relative to another at a joint; extension straightens those parts. Protraction moves one part (usually a limb) out and forward; retraction moves that part in and back. Abduction moves a part away from the ventral surface; adduction brings the part toward the body's ventral surface. Rotation turns a structure. Depressor muscles open (a special form of abduction) a structure, jaws in this case, while levators close jaws (a kind of adduction).

Muscle groups. The muscles described here are the major or large muscles (detailed discussion of most muscles can be found in the primary literature). For convenience, muscles are grouped by region; axial muscles, include the head muscles; ventral muscles include both proximal pectoral and pelvic muscles that are associated with the plastron; forelimb and respiratory muscles are those found on the flippers, carapace, and scapula involved in flipper movements and breathing. Posterior muscles are the large muscles of the hip, thigh, and lower leg. Muscles of the flipper blade and hind foot are not discussed or illustrated in detail here because they are obscured by extensive connective tissue and are difficult for most to identify, even with special dissection equipment and techniques.

Ventral Muscles. The massive ventral musculature is found after removing the plastron (Fig. 111). This musculature is dominated by a superficial muscle, the pectoralis major, which originates on the plastron and inserts on the lateral process and shaft of the humerus. Anterior to the pectoralis and ventral to the acromion processes are two muscles: the deltoideus (ventral part), which originates on the ventral scapula, acromion, and anterior plastron bones and the supracoracoideus, which has several subdivisions. Its anterior part originates on the acromion (Figs. 112-114). Both the deltoideus and the anterior part of the supracoracoideus insert on the lateral process of the humerus. These 3 ventral muscles function in swimming and respiration (by movement of the shoulders and plastron). Their innervations are via the supracoracoid nerve from the ventral portion of the brachial plexus (see Nervous System, Figs. 204-206).

After removing the pectoralis major, deep locomotor muscles are found associated with the pectoral girdle (Figs. 112-114). The biceps brachii has several subdivisions, or heads, in sea turtles. The superficial head (Figs. 112-114) originates on the coracoid and extends via a long tendon to insert on the radius and ulna; the profundus head inserts on the humerus and radius. Innervation is via the inferior brachial flexor and median nerves. The coracobrachialis magnus originates on the dorsal side of coracoid process and inserts on the medial process of the humerus. The posterior part of the supracoracoideus (Fig. 112) originates on the coracoid and its cartilage and inserts in the lateral process of the humerus. These muscles are innervated by the supracoracoid nerve. There is an extensive series of arteries and veins running within and between these very active muscles (Fig. 114).

A pair of superficial posterior muscles, the left and right rectus abdominis (Fig. 111) are found ventrally. Each originates on the lateral pubis and inserts on the plastron. They stabilize the pelvis and may function in compressing the plastron during breathing.
Figs. 111a and 111b. Superficial ventral muscles of the pectoral and pelvic girdles. The large pectoralis major is a forelimb retractor and adductor. Both the deltoideus and the supracoracoideus protract and abduct the humerus. The rectus abdominus is a pelvic stabilizer. Anterior is toward the top of the picture.
Figs. 112a and 112b. The deep pectoral muscles are exposed after removal of the pectoralis major. These forelimb retractors, separated on the animal’s left (right in picture), are the biceps brachii superficialis and coracobrachialis magnus. The posterior part of the supracoracoideus both adducts and retracts the flipper.
Fig. 113. Diagrams of cheloniid right shoulder muscles including locomotor and respiratory muscles. Superficial ventral muscles (top left), deep ventral muscles (bottom left), posterior muscles (bottom right), and lateral muscles (top right). The extensor digitorum, extensor radialis intermedius, tractor radii, and flexor carpi all control the extension and flexion of the flipper blade. Ext. = extensor; h. = head, Inf. = inferior, Interm. = intermedialis. (After Wyneken, 1988)
Figs. 114a and 114b. The deep pectoral muscles of the animal's right side are shown in detail. The supracoracoideus has two parts: posterior, which protracts and anterior, which retracts the forelimb.
Forelimb and Respiratory Muscles. The **latissimus dorsi/teres major complex**, the scapular head of the **deltoides**, and the **subscapularis** originate on the carapace and/or shoulder girdle and insert on the proximal humerus (Fig. 113). The latissimus dorsi and teres major together originate on the scapula and the carapace from the attachment point of the scapula, along the first pleural bone to the anterior peripheral bones. They insert via a common tendon just distal to the head of the humerus. The scapular head of the deltoideus arises from the anterior scapula and inserts on the lateral process and shaft of the humerus. The subscapularis muscle is very large, originates on the medial and posterior scapula, and inserts on the large medial process and the shaft of the humerus. These muscles are innervated by the deltoid nerve (a branch of the brachial plexus).

There are two sheet-like respiratory muscles located dorsally, which are often destroyed when removing the pectoral girdles (Figs. 113 and 115). These are the **testocoracoideus** (origin: carapace near the anterior inframarginals; insertion: dorsal coracoid) and **testoscapularis** (origin: carapace posterior to the latissimus dorsi; insertion: dorsal scapula and the scapular attachment to the carapace). They are innervated by cervical spinal nerves.

The remaining dorsal shoulder muscle, the **triceps brachii** (= triceps superficialis) has two heads in chelonid sea turtles (Figs. 113-116). The humeral head arises from the humerus, and the scapular head arises from the scapula. Both converge to form a common tendon inserting on the proximal ulna. This muscle may have only a humeral head in *Dermochelys*. The triceps is innervated by the superficial radial nerve (a branch from the superior brachial nerve of the brachial plexus).

![Fig. 115. Ventral pectoral muscles with arteries and veins. The pectoral artery is found running along the deep muscles of the shoulder. The testoscapularis, a respiratory muscle, is deep to the pectoralis. Other pectoral muscles originating on the coracoid are reflected medially (to the right) in this picture.](image-url)
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Fig. 116. Superficial dorsal forelimb muscles (right). The two heads of the triceps brachii, (triceps scapular head and triceps humeral head) are forelimb adductors, which twist the flipper. The more medial biceps and flexor carpi ulnaris muscles flex the flipper blade. The extensor digitorum muscle becomes diffuse in adults as fibrous connective tissue stiffens the flipper blade. Young turtles can extend the digits, somewhat mature turtles cannot.

Fig. 117. Ventral forelimb muscles (right). Most of the ventral muscles flex the flipper blade relative to the upper arm. The extensor radialis extends the flipper. The scapular head of the triceps may twist the flipper blade along its axis, or abduct the forearm.

Fig. 118. Dorsal forelimb muscles of an immature hawksbill. In young animals, the muscle divisions of the forearm and the flipper, particularly, are more obvious than in older animals. Less connective tissue is present and the digits can flex and extend to a limited extent.
Figs. 119a and 119b. Dorsal view of the pectoral musculature. The carapace, skin and fat have been removed (from left). The head, cut cervical vertebra, and scapular ends provide landmarks for orientation. The latissimus dorsi, a large sheet-like muscle, is shown intact (animal's right) and cut (animal's left). It, plus the teres major and deltoideus (scapular head, not shown), abduct and sometimes protract the flipper. The large subscapularis is a strong flipper protractor. The coracobrachialis, a ventral muscle, is seen extending from the shoulder posteriorly, toward its origin, the coracoid.
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The biceps muscle may have one or two parts (Figs. 112 and 114). When two heads are present, the biceps superficialis arises from the coracoid and inserts on the pisiform of the wrist. The muscle has two bellies in series, with a short tendon in the middle. The second and most prominent head, the biceps profundus, also originates on the posterior coracoid, but ventral to the biceps superficialis and inserts via a tendon with the brachialis on the ulna (Fig. 114). In Dermochelys and Lepidochelys, often there is just a single head inserting on the radius and ulna.

Figs. 120a and 120b. The pectoral muscles of the left shoulder, arm and flipper. The large subscapularis covers most of the scapula. The large coracobrachialis is seen ventrally, covering much of the coracoid. The biceps muscle has one or two heads (varying among species and among individuals). The biceps superficialis extends from the shoulder (mostly the coracoid) to the pisiform bone of the wrist, and probably helps control the twist or rotation of the flipper blade. The biceps profundus (seen only as a partial separation here) acts as a flipper retractor and a flexor of the flipper blade at the elbow.
**Axial Muscles.** Most axial muscles are associated with the neck and tail of sea turtles. The majority of the neck muscles are illustrated with the neck circulation (Figs. 131, 141, 143-153). These include the transverse cervical muscles, and the biventer cervical muscle. Here, the superficial muscles of the throat and the jaw muscles are described. The tail musculature is not discussed because it has not been studied in any detail.

The major deep muscles of the neck are the longus colli and retrahens colli. The longus colli muscles are short, segmentally arranged, and travel obliquely between successive cervical vertebrae; they serve to extend the neck. The retrahens colli originate on the cervical vertebrae and extend posteriorly to insert on the dorsal vertebral elements of the carapace. They are neck flexors and retractors, to the extent that marine turtles extend and retract the neck.

**Head Muscles.** Just beneath the skin of the throat is a thin layer of muscle, the intermandibularis, which has fibers running between the two dentary bones. It inserts on a flat midline tendon (raphe) that runs the length of the throat (Fig. 121). The intermandibularis becomes the constrictor colli posterior to the jaw joint (Fig. 121), originating on a dorsolateral cervical tendon. Just deep to the intermandibularis are muscles running obliquely between the jaws and inserting on the hyoid, the geniohyoideus. Posterior to the geniohyoideus is a pair of strap-like muscles, the coracohyoideus that extend to the hyoid apparatus from the coracoid (Figs. 122-123). These muscles assist in depressing the jaw, swallowing, and pumping the throat (gular flutter). They are innervated by the facial nerve. Muscles of the tongue, innervated by the hypoglossal nerve, and the glossopharyngeal nerve are not described here.

The jaw muscles of turtles are mostly located inside the skull. Because of these deep positions, most are described but not illustrated. Unlike mammals, turtles lack a mandibularis muscle; instead they have an adductor mandibulae with several heads. The heads originate on the parietal, supraoccipital, quadrate, prootic, and opisthotic bones (Fig. 31) and converge on a tendon that inserts primarily on the lower jaw (dentary, with small insertions on the squamosal bone posterior to the jaw joint). Medial to the adductor mandibulae complex is a pair of connected muscles. The intermandibularis muscle runs from the lower jaw to the tendon of the pseudotemporalis muscle which itself continues to the parietal bone. These jaw closing muscles are all innervated by the trigeminal nerve. The jaws

**Fig. 121. Ventral and superficial neck muscles.** The constrictor colli muscle of the ventral neck is exposed lateral to and overlying the trachea. Connective tissue that loosely attached the muscle to the skin is still present on the turtle’s anterior neck. The midline raphe (tendon) is visible along the anterior half of the muscle.
Figs. 122a and 122b. Dissection of the ventral neck muscles, showing the deep muscles (right in picture) and superficial muscles (left). The parallel fibers of the intermandibularis arise from the lower jaw, and terminate in the cut raphe (found overlying the hyoid body and anterior trachea). The branchiohyoideus is cut between the hyoid body and the hyoid process (process lateralis posterior) on the turtle’s left. The coracohyoideus travels along the trachea to the hyoid. The carotid artery lies deep to these muscles.

are opened by the **depressor mandibulae** muscle, which has several parts. The depressor mandibulae arises from the quadrate, quadratojugal, and squamosal bones and inserts on the articular of the lower jaw; in *Dermochelys* a portion also inserts on the auditory tube. These parts are innervated by the facial nerve.
Figs. 123a and 123b. This oblique axial section through the neck of a hawksbill, is just posterior to the jaw joint ventrally and supraoccipital crest dorsally. The muscles, major blood vessels, trachea, and esophagus can be identified. Their relative positions and extent are seen in this dissection.
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***Posterior Muscles.*** The major posterior muscles can be identified after removing the rectus abdominus and the skin covering the hind legs and tail. Ventrally, these are the **puboischiofemoralis externus** and **internus**, the **pubotibialis**, the **flexor tibialis** complex and the **ambiens** (Figs. 125-126; see also Nervous System). These ventral hip muscles are innervated by the obturator and tibial nerves of the sacral (=lumbosacral) plexus. The puboischiofemoralis externus, a thigh adductor, covers much of the ventral pelvis, and arises from the ventral pubis, ischium, and membrane covering the thyroid fenestrae (Fig. 106); it inserts on the femur’s minor trochantor. Different parts of this muscle can either protract or retract the leg. The puboischiofemoralis internus is large in cheloniids and has both superficial and deep components. It may be absent in *Dermochelys* and replaced in function and position by the **iliofemoralis**. When present, it originates on the dorsolateral pubis, ilium, and the sacral vertebrae. It inserts on the femur's major trochanter.

The **pubotibialis**, part of the flexor tibialis complex, is found in cheloniids but is absent in *Dermochelys*. This muscle originates on the pubic symphysis and lateral pubis; it inserts on the tibia with the **flexor tibialis internus**. The flexor tibialis internus, a Y-shaped muscle, originates on the sacral and postsacral vertebrae dorsally, and ventrally on the pelvic symphysis and lateral pubis. It passes distally and wraps around the **gastrocnemius** muscle to insert on the tibia. The **flexor tibialis externus** has two heads (Figs. 125-126) and is somewhat medial to the internus. The dorsal head arises from the ilium and the ventral head from the posterior ischium. Both converge to insert, via a single tendon, on the tibia and the gastrocnemius muscle of the shank; some fibers insert on the skin and connective tissues of the shank.

The **adductor femoris** (Fig. 126) originates on the lateral ischium and inserts on the posterior femoral shaft. The **ischiotrochantericus** (not shown), a leg retractor, originates on the anterior pubis and pubic symphysis. It inserts on the major trochanter of the femur. The dorsal hip and thigh muscles (illustrated in Circulatory Anatomy; Figs. 156-157 and Nervous System; Fig. 207), include the hip abductors: **iliotibialis**, **femorotibialis**, and **ambiens**. The ventrally positioned ambiens (Fig. 125) originates on the puboischiadic ligament, and inserts on the "patellar" tendon across the knee to the anterior tibia. The **iliotibialis** originates on the dorsal ilium and inserts with the ambiens on the patellar tendon. Deep to these two muscles, the **femorotibialis** (see Nervous System, Fig. 207), arises from the dorsal and anteroventral surfaces of the femur, and inserts with the iliotibialis and ambiens. The **peroneal** and **femoral** nerves of the **sacral plexus** innervate most of these dorsal hip muscles.

The hind foot extensors (Fig. 124) are large sheet-like muscles originating on the dorsal and lateral femur and inserting on the dorsal and anterior fibula and digits. They flex the lower leg or extend the digits.

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**Fig. 124.** Anterior and dorsal foot extensors of a loggerhead right hind limb. The leg is abducted and flexed at the knee. The foot extensors flex the lower leg or extend and spread the digits.
Figs. 125a and 125b. The superficial ventral hip muscles. The puboischiofemoralis externus is an adductor of the leg. The puboischiofemoralis internus (the anterior ventral portion is seen here) is a protractor and abductor of the leg. The flexor tibialis complex, including the.puboischiofemoralis externus and puboischiofemoralis internus, flexes and retracts the leg and controls the shape of the trailing edge of the foot, perhaps during steering. More anteriorly, the ambiens is a weak adductor and protractor of the hind leg and can extend the shank.
Figs. 126a and 126b. The deeper ventral hip muscles are shown after removing the superficial limb retractors. The adductor femoris and puboischiofemoralis internus are antagonistic muscles, with the former adducting the thigh and the later abducting it.