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chapter 3

The Skeleton

The skeletal system includes the bones, cartilage, teeth, and joints. The specific studies are osteology (Gr. *osteo*—bone; *logy*—study of), chondrology (Gr. *chondro*—cartilage), odontology (Gr. *odonto*—tooth) and arthrology (Gr. *arthro*—joint). Logically, it is the first system to be studied, for the skeleton forms the foundation upon which all the other systems are laid or built.

The skeletal system is divided into three parts, the appendicular skeleton, the axial skeleton, and the visceral skeleton. The appendicular skeleton consists of the bones of the limbs. The axial skeleton is composed of the skull, the vertebral column, the ribs and sternum. The visceral skeleton consists of such bones as may be developed in the soft tissue of certain organs or parts, such as the os cordis (Lat. *os*—bone; *cordis*—of the heart) in the ox and the os penis in the dog, mink, beaver and other animals.

THE APPENDICULAR SKELETON

The appendicular skeleton is attached to the axial skeleton by means of two bony structures, the pectoral (shoulder) girdle and pelvic (hip) girdle.

The pectoral girdle attaches the forelimbs to the body and is incomplete in domestic mammals. A complete pectoral girdle consists of six bones, the right and left scapulas, coracoids, and clavicles. One or more of these pairs is

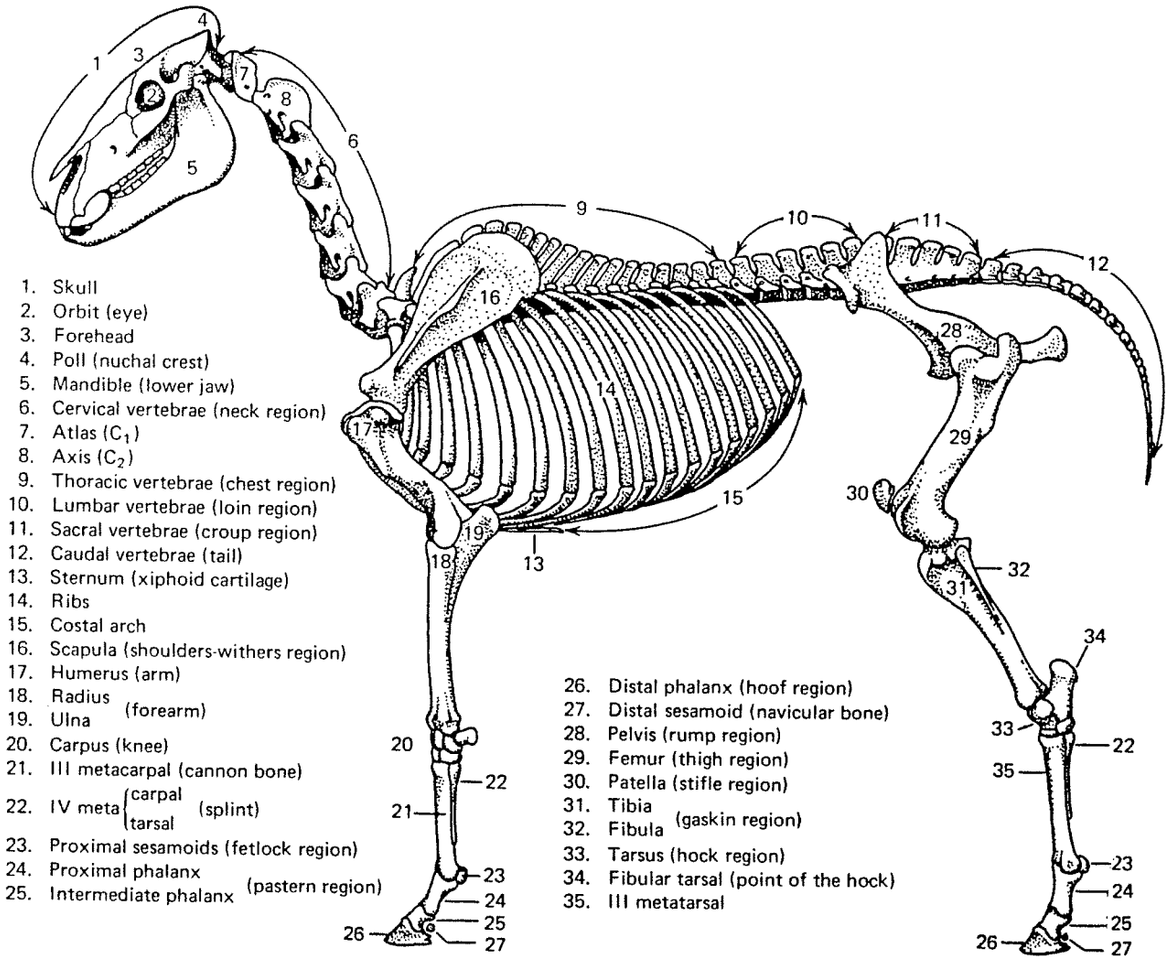


FIGURE 3-1 *Skeleton of the horse.*

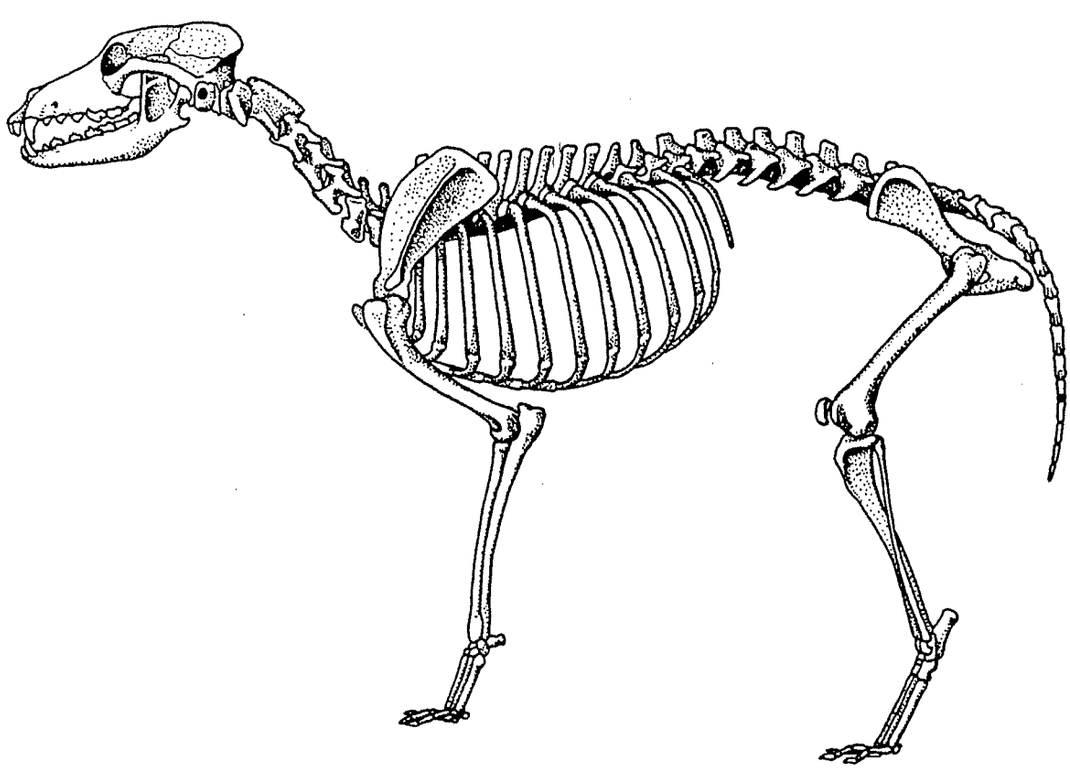


FIGURE 3-1 (Cont.) *Skeleton of the dog.*

usually missing in mammals. Climbing and burrowing mammals usually possess a scapula and clavicle, coursing and grazing mammals usually possess a scapula only. All three pairs of bones of the pectoral girdle are seen in birds, reptiles, and some of the lower mammalian forms. In animals which possess only a scapula, the attachment of the forelimb (pectoral limb) to the body is by means of fleshy and tendinous structures. A bony attachment of the forelimb to the body is found only in animals which possess two or more pairs of functional bones in the pectoral girdle.

The pelvic girdle usually consists of three pairs of bones; the right and left ilium, ischium, and pubis, and is present and complete in all domestic mammals. It connects the hind (pelvic) limbs to the body. The bones of the pelvic girdle are usually fused together into the right and left innominate bone or os coxa. The two innominate bones may be fused along the mid-ventral line to form the pelvic ring (pelvic girdle, "H" bone, hip bone). In some aquatic mammals and in birds the pelvic girdle does not form a complete ring.

The hindlimb (pelvic limb) is attached to the pelvis by a ball and socket joint. The pelvis in turn is firmly attached to the spinal column either by direct bony junction to the sacrum, as in the adult horse, or by strong ligament connections as in the cow, sheep, dog, and cat.

The pelvic limb, being the main propulsive limb of most terrestrial animals, requires this firm attachment to allow the powerful posterior muscles to act with maximum efficiency. The pectoral limb functions more to support the body than propel it, hence a strong bony attachment is not necessary. In burrowing and climbing animals where the pectoral limbs have more functions than support and propulsion, a bony attachment to the axial skeleton (the clavicle) is usually present.

A comparison of forelimbs and hindlimbs reveals that the bones of one limb have a corresponding or analogous bone in the other, with the exception of the kneecap or patella.

A number of sesamoid bones are present in both limbs, but are not listed in this table as their location and number vary greatly between (and within) species.

PECTORAL LIMB (FORELIMB)		*PELVIC LIMB (HINDLIMB)*	
1. Shoulder	Scapula	1. Rump or Hip	Ilium
	Clavicle†		Ischium
	Coracoid†		Pubis
2. Arm	Humerus	2. Thigh	Femur
3.		3. Kneecap	Patella
4. Forearm	Radius	4. Leg or Shank	Tibia
	Ulna		Fibula†
5. Wrist ("Knee")	Carpals*	5. Ankle (Hock)	Tarsals*
6. Manus (forefoot)	Metacarpals*	6. Pes (hindfoot)	Metatarsals*
	Phalanges*		Phalanges*

† may be absent

* one or more may be absent or fused

The Scapula

Classification: Modified long bone.

Location: The scapula covers the dorsal portion of the first four or five ribs. The long axis extends obliquely from the fourth thoracic spine to the sternal end of the first rib.

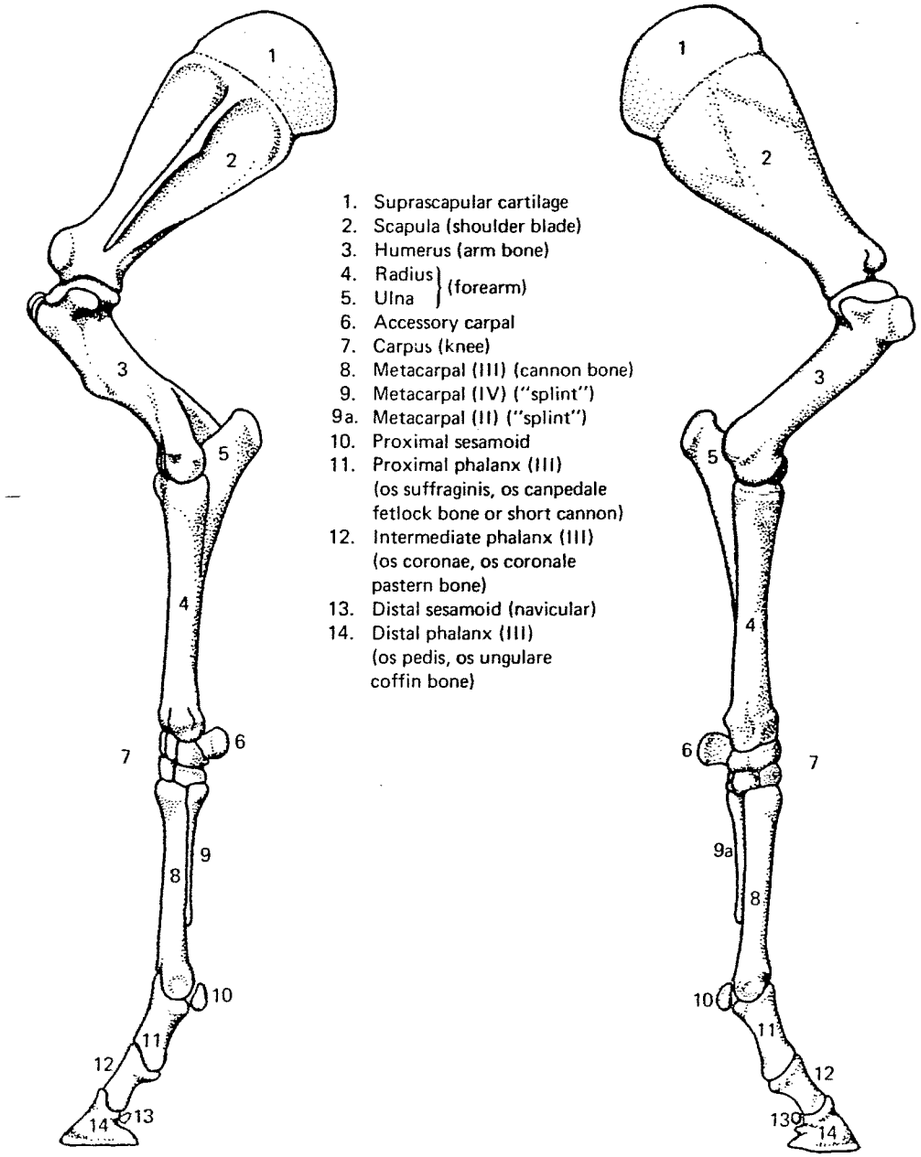


FIGURE 3-2 *Bones of the pectoral limb—horse.*

The surfaces are lateral and medial. The lateral surface is divided by the spine of the scapula into two unequal parts and possesses the following structures: the tuber spinae, which is located on and above the middle of the spine of the scapula; the supraspinous fossa, a depression anterior to the spine; the infraspinous fossa, a depression posterior to the spine; a nutrient foramen posterior to the spine and near the neck; and a vascular groove below the foramen and on the neck. The medial or costal surface is concave along its long axis. This concavity is called the subscapular fossa. Its borders converge to a point dorsally and separate two triangular areas. The lower third of the medial and lateral surfaces are marked by vascular grooves.

The borders are anterior, posterior, and dorsal. The anterior border is convex and rough in its dorsal portion, and concave and smooth ventrally. The posterior border is slightly concave, thick in the upper third, rough in the middle, and smooth ventrally. On the dorsal (vertebral) border is the suprascapular cartilage which becomes ossified or partly ossified in older animals.

The angles are anterior, posterior, and glenoid. The anterior angle is formed by the junction of the dorsal and anterior borders. The posterior angle is formed by the junction of the dorsal and posterior borders. The glenoid angle is formed by the posterior and anterior borders. It is attached to the body by the neck and bears a glenoid cavity for articulation with the head of the humerus.

In the horse scapula there are several structures which are either unique in equines or differ appreciably from those in other domestic animals, i.e., the glenoid notch which cuts the rim of the glenoid cavity anteriorly; the tuber scapulae (supraglenoid tubercle), a prominence anterior to the glenoid cavity which is relatively large in horses; and the coracoid process, a small projection medial to the tuber scapulae.

The acromion, a projecting mass of bone located on the distal end of the spine of the scapula, is not found in the horse but is present in the cow, sheep, pig, dog, man, and other animals. It is particularly well developed in those species which possess a clavicle or collar bone.

COMPARATIVE ANATOMY OF THE SCAPULA

Cattle. Compared to the horse the scapula of cattle is a more perfect triangle. It is wider at the proximal end, and narrower at the distal end. The spine is more prominent and set farther anteriorly which makes the supraspinous fossa narrow and tapering to a point ventrally. The spine bears an acromion on its distal end. The glenoid cavity does not possess a notch, and the tuber scapulae and coracoid process are much smaller than in the horse.

Sheep. The scapula of the sheep differs from the cow in size but only in minor structural details. The coracoid process is absent. It is virtually impossible to tell the scapula of a sheep from those of deer and goats by morphology alone.

in its middle portion and a small acromion distally. The suprascapular cartilage is not as extensive as in the horse and cow. The neck is well marked, the tuber scapulae small, and the coracoid process absent. The glenoid cavity is circular and does not possess a notch.

Dogs. In the dog the scapula is relatively narrow in proportion to its length. The anterior border is markedly convex, although not as much so as in the pig. The spine is thick, centrally located, and curves backwards. It increases in size ventrally and has an acromion at its distal end. The tuber spinae is insignificant. The neck is short and thick with a well-developed tuber scapulae. There is no coracoid process or glenoid notch. The suprascapular cartilage is reduced to a thin band, and the posterior border is thickened in the proximal (dorsal) part. On the medial surface the subscapular fossa is shallow.

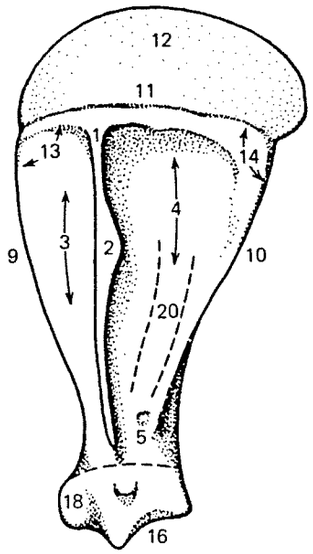
Cats. The scapula of the cat is more similar in outline to that of the pig than the dog. The anterior border is strongly convex, and the posterior border relatively straight. The spine is straight or slightly concave anteriorly and is located centrally. It increases in size ventrally and bears on its ventral portion a tuber spinae and acromion. The tuber scapulae curves medially to form a coracoid process. The glenoid cavity is roughly circular and does not possess a glenoid notch.

PHYSIOLOGY OF THE SCAPULA

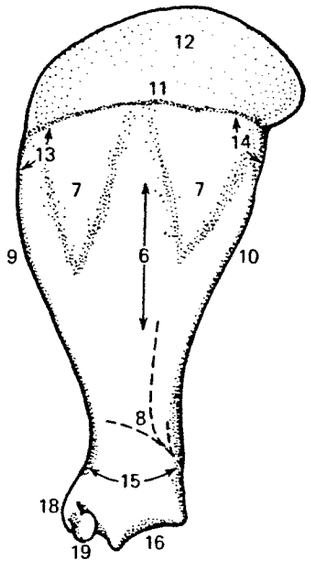
The scapula serves as the bony support and attachment for a sling of muscles and connective tissue that in turn supports the anterior parts of the body. It also serves to transmit motion of the forelimbs to the body. Hence there is a certain uniformity of shape in this structure throughout the Class Mammalia. Regardless of whether it is or is not directly connected to the axial skeleton, the scapula is located between layers of soft tissues which help determine its basic shape and surfaces.

There are sound physiological reasons for its shape. Situated as it is between layers of muscle, the bone must be flattened to slide easily back and forth along the muscular layers without causing distortion of the muscles or changes in direction of angular pull and consequent reduced mechanical efficiency of the limb. The medial surface must be smooth, since it slides for some distance across a surface composed of muscle and connective tissue. The lateral side is rough to provide for attachment of the muscles of the upper leg and shoulder, and the suspensory apparatus which holds it to the body and permits it to function in support and locomotion.

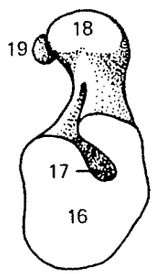
At this time it should be pointed out that it is a fairly constant rule that the superficial (closest to the surface) or lateral portions of bones will be rough, and the deep (farthest from the surface) or medial portions smooth.



Lateral View
Left Scapula



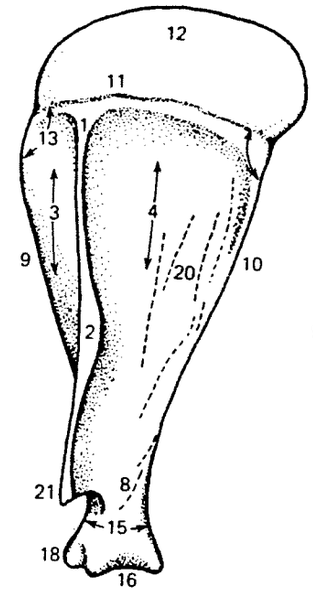
Medial View
Right Scapula



Distal View
Left Scapula

1. Spine of scapula
2. Tuber spinae
3. Supraspinous fossa
4. Infraspinous fossa
5. Nutrient foramen
6. Subscapular fossa
7. Triangular areas (facies serrata)
8. Vascular grooves
9. Anterior border
10. Posterior border
11. Dorsal border
12. Suprascapular cartilage
13. Anterior angle
14. Posterior angle
15. Glenoid angle
16. Glenoid cavity
17. Glenoid notch
18. Tuber scapulae (supraglenoid tubercle)
19. Coracoid process
20. Muscular lines

FIGURE 3-3 *Scapula of the horse.*



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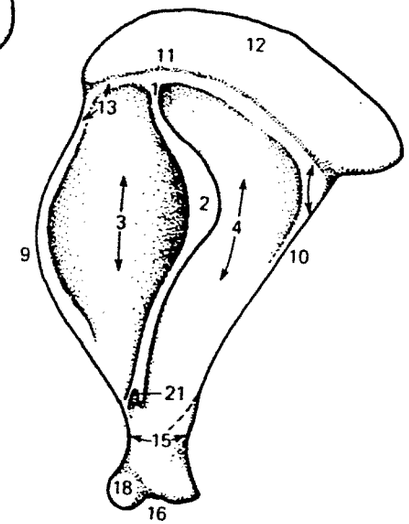
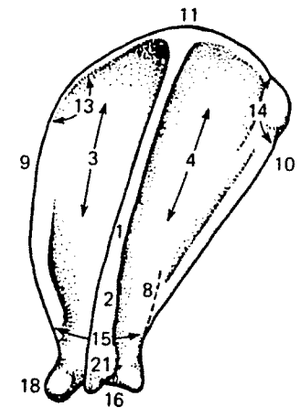
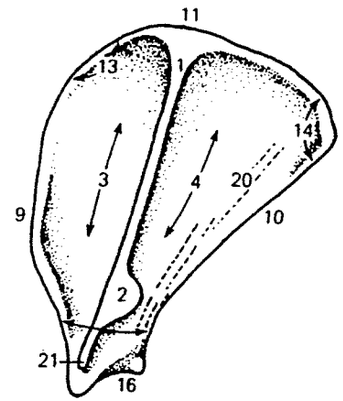


PIG

1. Spine of scapula
2. Tuber spinae
3. Supraspinous fossa
4. Infraspinous fossa
8. Vascular grooves
9. Anterior border
10. Posterior border
11. Dorsal border
12. Suprascapular cartilage
13. Anterior angle
14. Posterior angle
15. Glenoid angle
16. Glenoid cavity
18. Tuber scapulae
20. Acromion
21. Muscular lines



DOG



CAT

FIGURE 3-3 (Cont.) *Comparative anatomy—scapula—lateral views.*

This is particularly true of those bones which are close to or part of the axial skeleton. In the limbs, the lateral sides of the bones usually have the roughest surfaces and largest prominences.

The Humerus

Classification: Long bone.

Location: It lies between the scapula, and the radius and ulna.

Description: The humerus of the horse consists of a shaft and two extremities (proximal and distal). The shaft has four surfaces: lateral, medial, anterior, and posterior. The lateral surface is smooth and spirally curved to form the musculospiral groove. The medial surface is straight in length and rounded from side to side. Near the middle of the medial side of the shaft is the teres tuberosity, and below, in the distal third, is a nutrient foramen. The anterior surface is flattened and is wide and smooth above, and narrow and rough below. It is separated from the lateral surface by a crest which supports the deltoid tuberosity. The posterior surface is smooth and rounded.

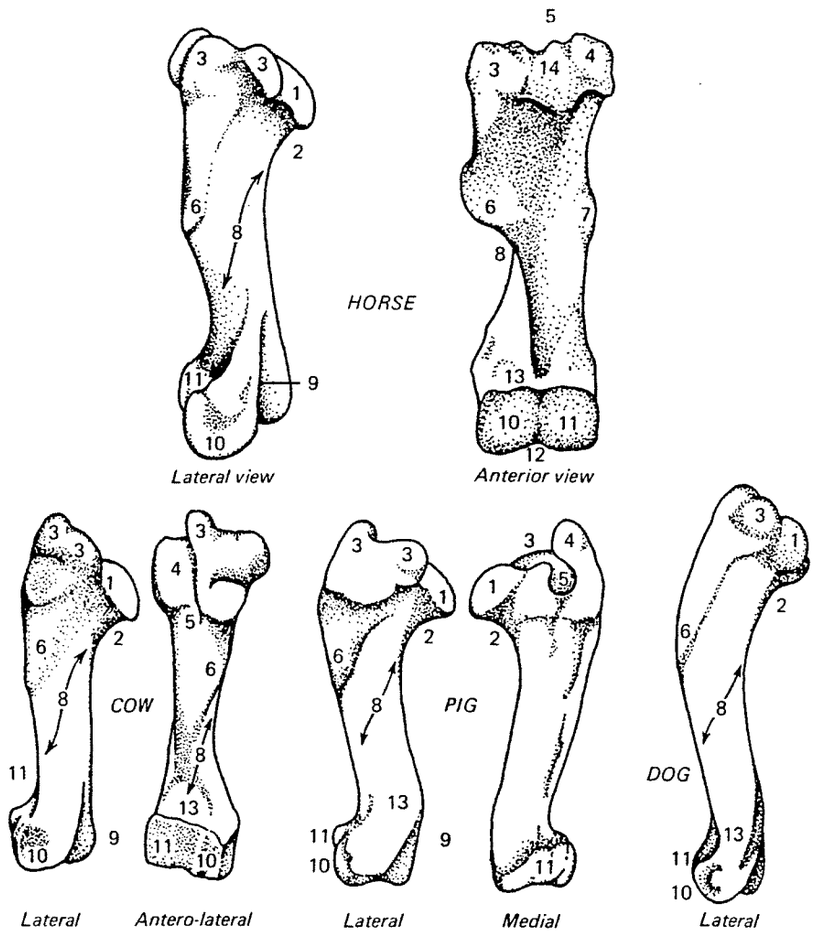
The proximal extremity consists of a head, neck, and two tuberosities (lateral and medial), separated by the bicipital groove (intertuberal groove). The head is a smooth, convex, articular surface in front of which is a fossa containing a number of small foramina. It is connected to the shaft by the neck. The lateral tuberosity is larger than the medial and is located antero-laterally. It consists of anterior and posterior parts. The anterior part forms the lateral boundary of the bicipital groove (intertuberal groove). The bicipital groove is anterior to the head and is bounded by the anterior parts of the lateral and medial tuberosities. Anteriorly it is divided by an intermediate ridge.

The distal extremity is an oblique articular surface consisting of two condyles* (lateral and medial) separated by a groove, two epicondyles (lateral and medial), a coronoid fossa, and an olecranon fossa. The lateral condyle is smaller and projects farther ventrally than the medial condyle and contains a shallow groove. The coronoid fossa (radial, supracondyloid, supratrochlear) is a depression located above the condyles and is bounded laterally and medially by the epicondyles.

COMPARATIVE ANATOMY OF THE HUMERUS

Cattle. The humerus of cattle is smoother than that of equines. The musculospiral groove is shallower and the deltoid tuberosity less prominent. The teres tuberosity is smaller. The lateral tuberosity of the head is quite

*The lateral condyle is called the capitellum or radial head in humans and the capitulum in recent veterinary texts. The medial condyle is called a trochlea in recent veterinary texts, although the term is not accurate for equines or ruminants. It is, however, a reasonably accurate description for the medial condyle of cats and dogs.



1. Head
2. Neck
3. Lateral tuberosity (greater tubercle)
4. Medial tuberosity (lesser tubercle)
5. Intertuberal (bicipital) groove
6. Deltoid tuberosity
7. Teres tuberosity
8. Musculospiral groove
9. Olecranon fossa
10. Lateral condyle (capitulum)
11. Medial condyle (trochlea)
12. Intercondyloid groove
13. Coronoid (supracondyloid, radial, supratrochlear) fossa
14. Intertuberal eminence (intermediate tubercle)

FIGURE 3-4 *Comparative anatomy—humerus.*

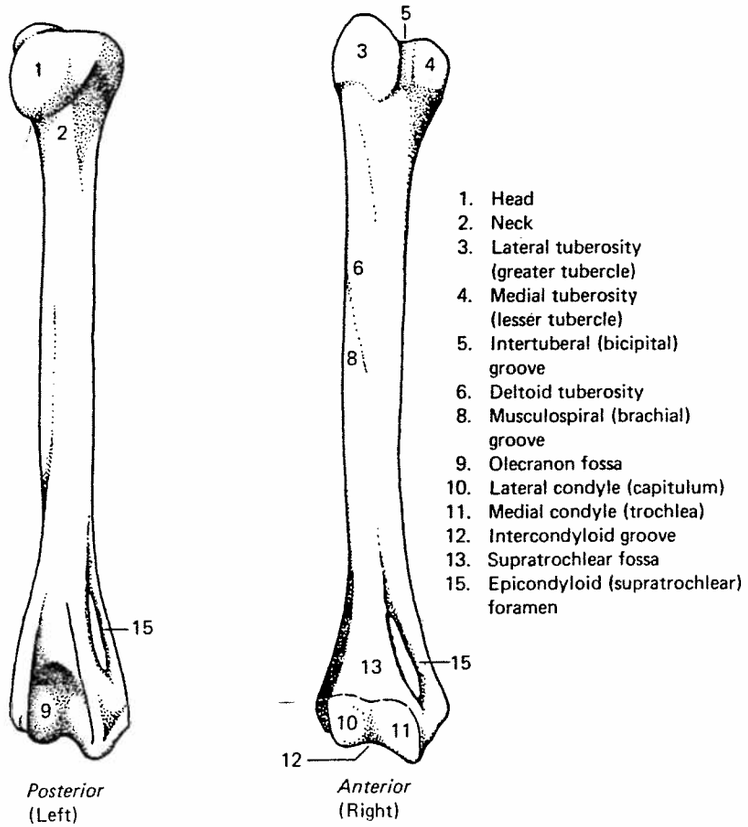


FIGURE 3-4 (Cont.) *Humerus of cat.*

large and curves medially over the intertuberal groove which is undivided. The distal articular surface is set somewhat obliquely to the shaft. The condyles and intercondyloid groove are well defined. The coronoid fossa and olecranon fossa are large and well defined.

Sheep. The humerus of sheep is smaller but otherwise similar to those of bovines. The deltoid tuberosity is closer to the proximal end and not as prominent. The lateral tuberosity of the head is smaller and does not extend as far medially over the intertuberal groove.

Swine. The humerus of swine is strongly curved and short. The shaft is laterally compressed, being flattest on the medial side. The musculospiral groove is shallow, and the deltoid tuberosity is relatively small. The teres tuberosity is absent. The head is relatively large, and the lateral tuberosity is extremely prominent, and divided into anterior and posterior parts. The anterior part curves sharply medially over the intertuberal groove. The distal

are of nearly equal size. The coronoid fossa and intercondyloid groove are prominent, and the olecranon fossa is narrow and deep. Occasionally the plate of bone which closes the bottom of the olecranon fossa and separates it from the coronoid fossa will be perforated, forming a supracondyloid foramen.

Dogs. The humerus of the dog is long and slender, has a slight spiral twist, and is somewhat S-shaped along its long axis. The deltoid tuberosity is small. The teres tuberosity is missing. The head is long and curved backwards. The intertuberal groove is shallow. The lateral condyle on the distal surface is prominent. The bony partition between the coronoid and olecranon fossae is usually absent, forming a large supracondyloid (supratrochlear) foramen.

Cats. The humerus of the cat is similar to that of the dog. The distal articular surface has a more prominent intercondyloid groove than does that of the dog. A supratrochlear (epicondyloid) foramen is present above the medial condyle. It is not similar to the structure of similar name in the dog, and is found in most members of the cat family.

PHYSIOLOGY OF THE HUMERUS

The function of the humerus is threefold. It serves as a connecting link between the scapula and the distal portions of the limb. It furnishes attachments for the origin and insertion of the major muscles that control the motions of the upper and lower parts of the forelimb. Its angular arrangement in relation to the scapula and the distal parts of the forelimb allows it to act as a shock absorbing device to cushion the impact of the forefeet against the ground. In man and the primates, this third function is not present to any marked degree, and it is reduced in four-footed animals which possess clavicles.

The Radius

Classification: Long bone.

Location: It lies between the humerus and the carpus. It is fused to the ulna along the posterolateral part of the shaft.

Description: The radius of the horse has a shaft and two extremities. The shaft has two surfaces and two borders. The surfaces are anterior and posterior. The anterior surface is smooth, convex lengthwise and rounded from side to side. Proximally there is a groove which combines with the shaft of the ulna to form the interosseous space. The borders are medial and lateral. Both borders are concave lengthwise.

The extremities are proximal and distal. The proximal extremity has an articular surface, two facets, and three tuberosities (radial, medial, and lateral). The proximal articular surface is crossed by a sagittal ridge which divides the surface into medial and lateral facets. There is a synovial fossa posteriorly and a prominent lip anteriorly. The lip is the coronoid process. There are two

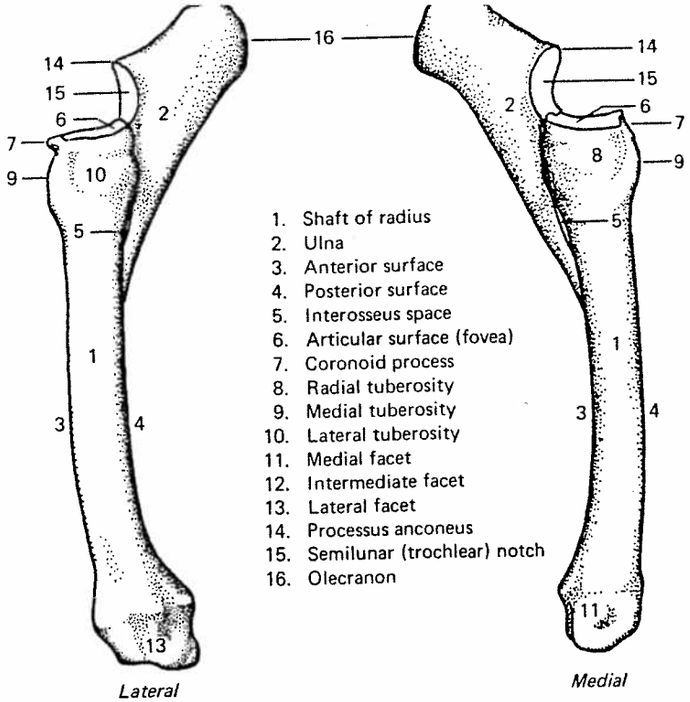


FIGURE 3-5 *Radius and ulna of the horse.*

facets for articulation with the ulna. They are separated by a depression, and are located below the posterior border of the articular surface. The radial tuberosity is located medially. The medial tuberosity is continuous medially with the radial, and extends around the anteromedial aspect. The lateral tuberosity is on the lateral side of the anterior surface.

The distal extremity articulates with the carpus and consists of three facets and two surfaces. The facets are medial, intermediate, and lateral. The medial facet is quadrilateral and largest in area. It is S-shaped when viewed from the side. It articulates with the radial carpal bone. The intermediate facet is similar to the medial but smaller. It articulates with the intermediate carpal bone. The lateral facet is smallest. It articulates with the ulnar carpal bone and the accessory carpal.

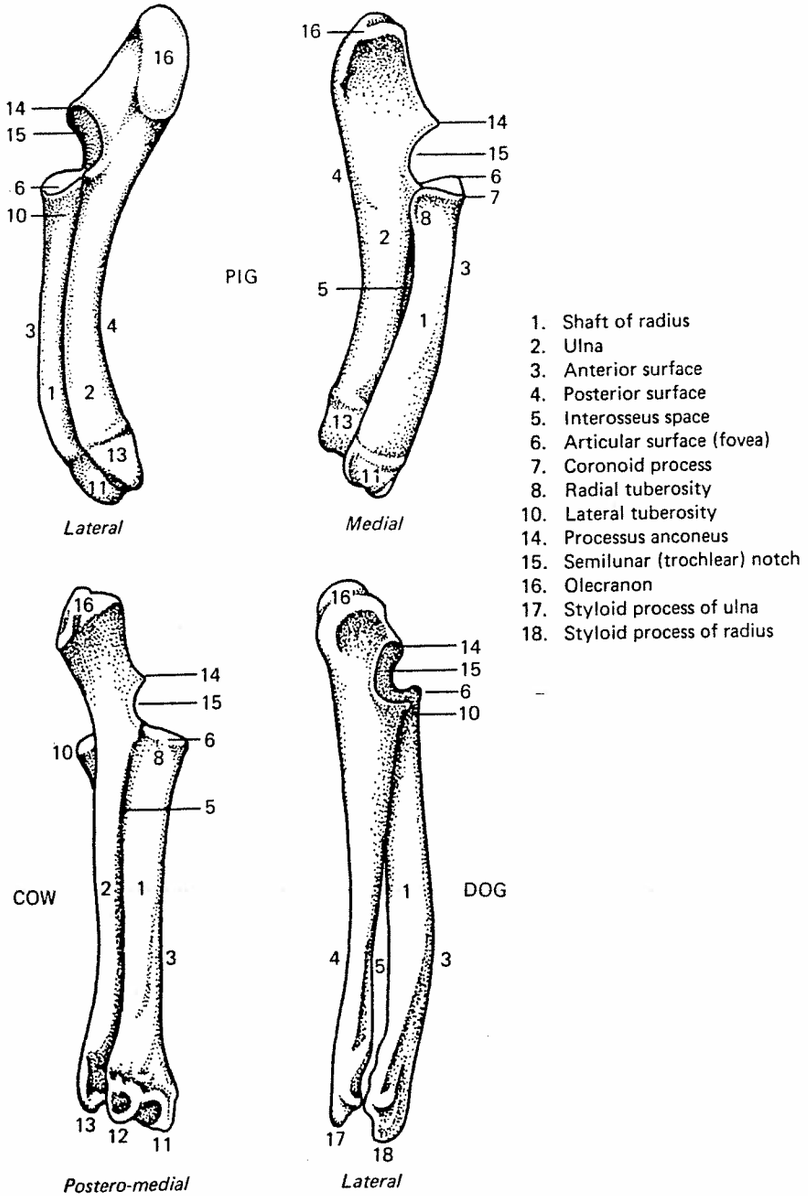
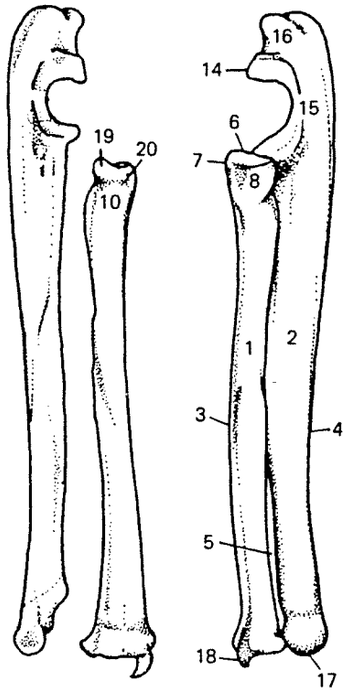


FIGURE 3-6 *Radius and ulna—comparative anatomy.*



1. Shaft of radius
2. Ulna
3. Anterior surface
4. Posterior surface
5. Interosseus space
6. Articular surface (fovea)
7. Coronoid process
8. Radial tuberosity
10. Lateral tuberosity
14. Processus anconeus
15. Semilunar (trochlear) notch
16. Olecranon
17. Styloid process of ulna
18. Styloid process of radius
19. Radial head
20. Neck

FIGURE 3-6 (Cont.) *Radius and ulna of cat.*

COMPARATIVE ANATOMY OF THE RADIUS

Cattle. The radius of cattle is shorter and wider than that of horses. The coronoid process is small. The proximal articular surface consists of two glenoid cavities separated by a groove. The distal extremity is enlarged and thick medially, giving the shaft an inward curving appearance. The ulna is normally fused to the posterolateral aspect of the radius in its middle and proximal portion, leaving proximal and distal interosseus spaces.

Sheep. The radius of the sheep is similar to that of the cow except for smaller size, and more pronounced curvature.

Swine. The radius of swine is short and thick and curved posteriorly. It increases in size distally and unites loosely with the shaft of the ulna.

Dogs. The radius of the dog is flattened anteroposteriorly and increases in size distally. The shaft curves backward and inward, and is separate from the ulna. The proximal end is small and consists of a head connected to the shaft by a neck. The radial tuberosity is small, but the lateral is large. The distal extremity has a projection along its medial border (the styloid process of the radius).

Cats. The radius of the cat is less curved but otherwise similar to that of the dog.

The Ulna

Classification: Long bone.

Location: It is attached to the posterolateral surface of the radius.*

Description: The ulna of the horse consists of a shaft and two extremities. The shaft is incomplete and tapers to a point distally, and has three surfaces and three borders. The surfaces are anterior, medial and lateral. The anterior surface is in contact with the posterior surface of the radius, except at the interosseus space. The area that goes into the formation of the interosseus space includes a nutrient foramen. The medial surface is smooth and slightly concave. The lateral surface is flattened. The borders are medial, lateral and posterior. The medial and lateral borders are thin and sharp, except at the interosseus space, where they are rounded. The posterior border is straight in length and rounded from side to side.

The extremities are proximal and distal. The proximal extremity (the olecranon) is a tuberosity that consists of a medial and a lateral surface, two borders, two facets, and a free extremity. The medial surface is concave and smooth, while the lateral surface is convex and rough. The borders are anterior and posterior. The anterior border bears on its middle the processus anconeus which overhangs the semilunar (trochlear) notch. The semilunar notch is a curved articular surface which is convex transversely, and articulates with the humerus. The posterior border blends into the posterior border of the shaft. Two facets are situated below the semilunar notch. These articulate with facets on the posterior part of the proximal end of the radius.

The distal extremity is fused with the radius.

COMPARATIVE ANATOMY OF THE ULNA

Cattle. The ulna of cattle is complete. The shaft is three-sided and fused with the radius except at the proximal and distal interosseus spaces. The olecranon is large and bears a rounded tuberosity. The distal end forms the styloid process which projects beyond the distal end of the radius.

Sheep. The ulna of the sheep is similar to that of cattle.

*This description is not adequate for cats and dogs and brachiating animals with separate ulnas.

radius. The posterior surface is smoothly concave and the anterior surface lies in close approximation to the radius to which it is attached by the interosseus ligament. In the proximal third a smooth concave area concurs with a similar area on the radius, forming the interosseus space. The proximal extremity is large and the olecranon is prominent. The distal extremity is small and tapers to a blunt point.

Dogs. In dogs the ulna is complete, straight, and larger than the radius. It diminishes in size distally, is completely separate from the radius and possesses an extensive interosseus space. The olecranon is grooved and has three bony prominences. The semilunar notch unites with the radius to form a compound joint. The distal end is small and bluntly pointed (styloid process of ulna).

Cats. The ulna of the cat is larger than the radius. It has an olecranon which is short and blunt, a shaft which decreases in size distally and is marked on its lateral surface by a number of prominent lines. The distal extremity of the shaft has an elongated styloid process and an articular facet.

PHYSIOLOGY OF THE RADIUS AND ULNA

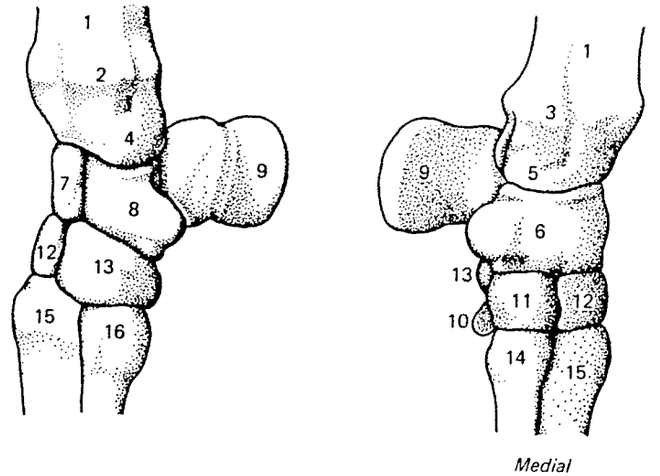
The radius and ulna have markedly different functions, depending upon the species and habits of the animal. The two bones may be partially or completely fused as in the horse, cow, pig, and sheep, or they may be separate and movable as in the dog, cat and man. In the first instance, the fusion of the bones prohibits rotation of the lower portion of the limb. Motion is restricted to a back and forth, hinge-like action which is adapted for propulsion, but very little else. In animals with a separate radius and ulna, the lower limb is capable of rotation as well as a hinge-like motion. This is of considerable advantage to carnivores, and climbing and burrowing animals, whose existence depends upon grasping and holding objects. The development of forearm rotation in terrestrial mammals is highest in the human.

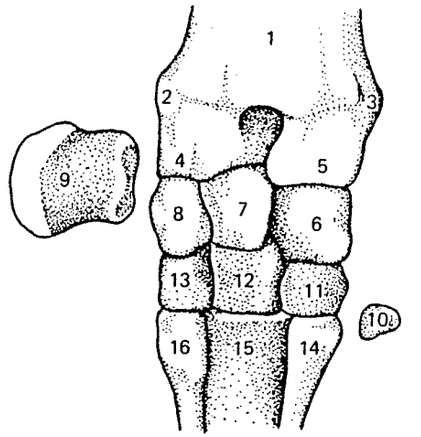
The Carpus

Classification: A group of short bones.

Location: The carpus lies between the radius and ulna and the metacarpals.

Description: The carpus consists of a group of six to eight bones, depending on the species of animal. It is commonly and incorrectly called the "knee" in animals. In man it is called the wrist. The knee is found only in the posterior limbs. The bones are arranged in two rows, proximal and distal, and are named and numbered as follows:





1. Radius
2. Lateral malleolus
3. Medial malleolus
4. Lateral facet
5. Medial facet
6. Radial carpal
7. Intermediate carpal
8. Ulnar carpal
9. Accessory carpal
10. 1st carpal
11. 2nd carpal
12. 3rd carpal
13. 4th carpal
14. II metacarpal
15. III metacarpal
16. IV metacarpal

FIGURE 3-7 *Carpus of the horse.*

PROXIMAL ROW

Radial Intermediate Ulnar Accessory

(MEDIAL SIDE) DISTAL ROW (LATERAL SIDE)

First Second Third Fourth

The first carpal bone is small and may be missing in about half of the horses examined. In those where it is present, it may be fused to the posterior surface of the second carpal bone.

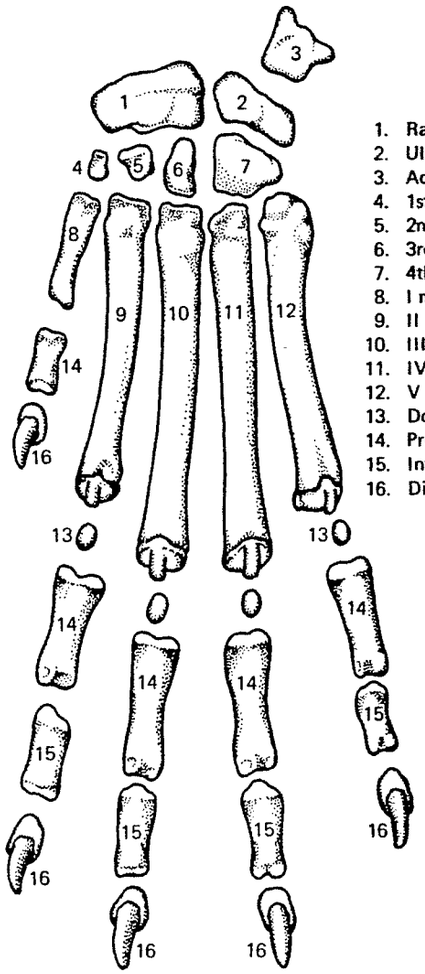


FIGURE 3-8 *Carpals, metacarpals, and digit of the dog—comparative anatomy. (Adapted from Miller, Guide to the Dissection of the Dog.)*

The carpus, while it is seldom studied intensively in courses of this nature, should not be dismissed as being of minor importance. Like the hock (tarsus) in the hind leg, it is an important structure in locomotion of cursorial animals since it functions both as a hinge joint, and as a shock absorbing device through the series of inclined planes that form its joint surfaces. The combined movement of its joints forms a major flexion area which transmits forward movement to the body and contributes to the length of the stride. So-called knee injuries in the carpi of race horses and saddle horses are problems of great difficulty to trainers and veterinarians, and can result in permanent lameness.

In brachiating animals, the wrist joint is equally important, but for different reasons. In these animals the flexibility of the wrist joint is more important than shock absorption or locomotion functions, but again, the complexity and delicacy of the joint make it easily subject to injury and hard to treat.

Since the bones are short, they have no true marrow cavity. The interior is filled with a cancellous structure composed of spicules and trabeculae. Physically, these bones are not as resistant to compression stresses as long bones and tend to develop bony growths or hairline fractures which are painful, restrict the movement of the joint, and often will not heal. The very complexity of the joint area restricts surgery and therapeutics to a great degree. It is one of the areas of the body that is being intensively studied by orthopedic surgeons.

COMPARATIVE ANATOMY OF THE CARPALS

SPECIES	*NUMBER*	*RADIAL*	*INTERMEDIATE*	*ULNAR*	*ACCESSORY*	*1st*	*2nd*	*3rd*	*4th*
Horse	7 or 8	x	x	x	x	x/0	x	x	x
Cow & Sheep	6	x	x	x	x	0	fused—fused		x
Pig	8	x	x	x	x	x	x	x	x
Dog	7	fused—fused		x	x	x	x	x	x

The Metacarpals

Classification: Long bones.

Location: The metacarpals are located between the distal row of the carpals and the proximal phalanx.

Description: Three bones are present in the horse, the second, third, and fourth (II, III, and IV). The first and fifth are absent. Of the three, the third is fully developed, articulating with the carpus and digit. It is commonly called the cannon bone. The second and fourth are greatly modified, being much reduced in size and are commonly called splints. Both the second and fourth metacarpals are enlarged at their proximal ends and are firmly attached to the posterior medial and lateral surfaces of the third metacarpal for about halfway down its shaft. The splints become more slender distally, enlarge at their distal extremities, and terminate about two-thirds of the way down the shaft of the third metacarpal.

The third metacarpal is composed of a shaft and two extremities. The shaft has two surfaces, anterior and posterior. The anterior surface is convex

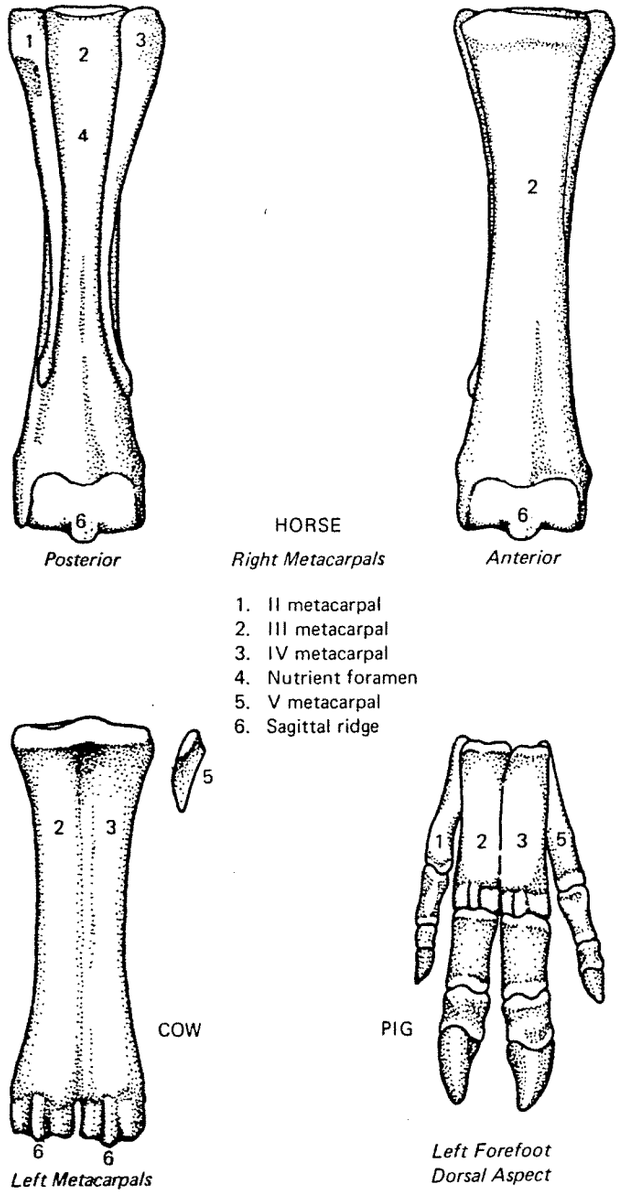


FIGURE 3-9 *Metacarpals—comparative anatomy.*

section. The shaft is slightly curved anteriorly, giving it a bowed appearance.

The extremities are proximal and distal. The proximal extremity of the third metacarpal articulates with the distal row of carpals. The distal extremity of the third metacarpal is formed into a condyle which possesses a raised central area or sagittal ridge.

COMPARATIVE ANATOMY OF THE METACARPALS

The metacarpals vary in number with the species of animals. Their number conforms to the number of functional or visible digits. In cloven-hoofed ruminants the III and IV metacarpals are functional but are fused together to form a single bone.

The Digit

This is a group of bones analogous to the fingers and toes of man. With the exception of slight modifications in size and shape, the digits of the front and hindlimbs are the same in the large domestic animals.

In the horse each digit is composed of three phalanges, two proximal sesamoid bones, and one distal sesamoid bone.

The digits have great variation in number and composition among the various species of domestic mammals, i.e., cow—two per foot; pig—four per foot; dog—five front and four or five rear; cat—five front and four rear; man—five hand and five foot. However, they all have some things in common:

Each digit except the first is composed of three phalanges.

The first digit is composed of two phalanges.

Each digit articulates proximally with a metacarpal or a metatarsal bone.

The digit ends distally with a horny claw, nail, or hoof.

Digital sesamoid bones are usually present in variable numbers.

Some animals (notably the cow and water buffalo among the domestic animals) possess false digits or dewclaws which do not articulate with a metacarpal or metatarsal bone and are remnants of digits which have nearly disappeared with the evolution of the animal to its modern form (for ergot and chestnut in the horse, see p. 432).

PROXIMAL (FIRST) PHALANX
(SHORT CANNON—OS SUFFRAGINIS, OS COMPEDALE)

Classification: Long bone.

Location: Between the III metacarpal (metatarsal) bone and the intermediate phalanx.

Description: The proximal phalanx consists of a shaft and two extremities. The shaft has anterior and posterior surfaces. The anterior surface

is convex from side to side, while the posterior surface is flattened. The proximal extremity consists of two facets separated by a groove and articulates with the third metacarpal (metatarsal) and the distal extremity articulates with the intermediate phalanx.

INTERMEDIATE (MIDDLE, SECOND) PHALANX (PASTERN BONE—OS CORONAE, OS CORONALE)

Classification: Long bone.

Location: Between the proximal phalanx and the distal phalanx.

Description: The intermediate phalanx is somewhat wider than it is long. It is composed of four surfaces: proximal, distal, anterior, and posterior. The proximal surface articulates with the proximal phalanx, the distal surface articulates with the distal phalanx and the navicular bone. The anterior surface is convex from side to side and the posterior surface is flattened.

DISTAL (THIRD) PHALANX (COFFIN BONE, OS PEDIS, OS UNGALARE)

Classification: Modified short bone.

Location: The distal phalanx articulates with the distal extremity of the intermediate phalanx and the navicular, and is enclosed in the horny structures of the hoof.

Description: In the horse the distal phalanx has three surfaces, three borders, and two angles. The surfaces are articular, anterior (dorsal) and posterior (volar or plantar). The articular surface faces upward and backward. On its posterior border it has a flattened area for articulation with the distal sesamoid (navicular) bone. The anterior surface slopes downward and forward, and is convex from side to side. The surface is rough and porous and contains many foramina. On either side a dorsal groove passes forward and ends at a large foramen. The posterior surface is arched and is divided into two unequal parts (sole surface and flexor surface) by a curved semilunar crest. The sole surface is the large crescent shaped area anterior to the crest. It is comparatively smooth. The flexor surface is smaller and semilunar in shape. It has a foramen on either side which leads into the semilunar canal.

The borders are proximal, distal, and posterior (volar* or plantar). The proximal or coronary border separates the dorsal and articular surfaces, and has an extensor process in its middle. The distal border is thin and irregular, and separates the dorsal and volar surfaces. The posterior border separates the articular and posterior surfaces.

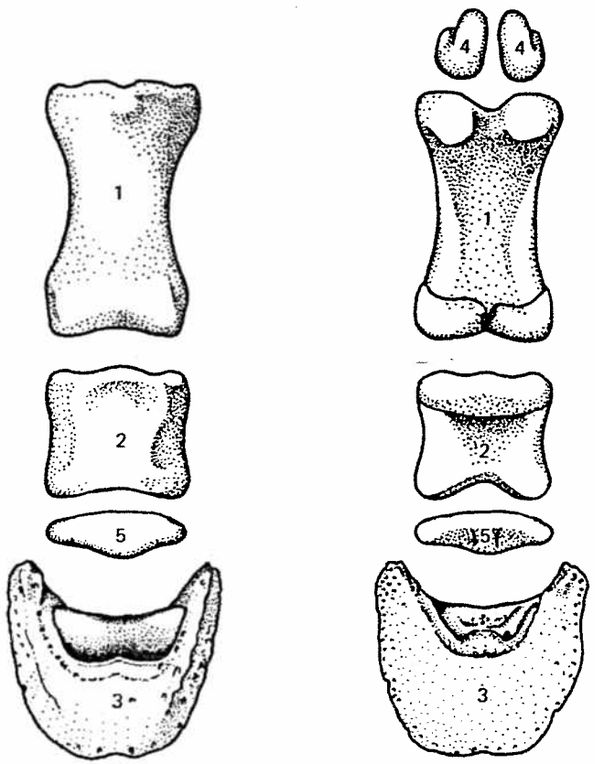
The angles or wings are masses of bone which project backward on the medial and lateral sides. The medial wing is usually shorter than the lateral. The proximal border of each wing carries cartilages (lateral cartilages).

*The volar surfaces and borders are also called palmar. The term solar is also used in place of sole.

Digital Sesamoid Bones

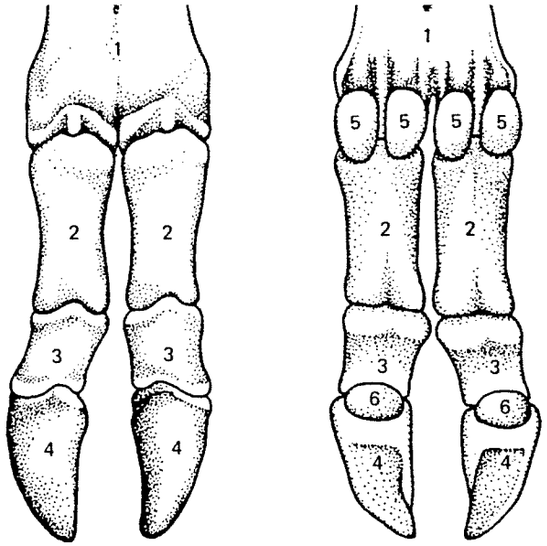
Classification: Short bones.

The digital sesamoids of the horse consist of three bones (two proximal and one distal). The proximal sesamoids are located behind the distal articular surfaces of the third metacarpal. The bases of the bones are distal and the apices proximal. The distal sesamoid (navicular) is located behind the junction of the intermediate and distal phalanges. It is shuttle or boat shaped, with its long axis lying transverse to the long axis of the limb. It enters into the formation of the coronary joint. Its flat surface aids the free movement of the deep digital flexor tendon. As has been previously mentioned in the discussion of



1. Proximal phalanx
2. Intermediate (middle) phalanx
3. Distal phalanx
4. Proximal sesamoids
5. Distal sesamoid

FIGURE 3-10 Digit of the horse.



Dorsal Aspect *Volar Aspect*

1. III and IV metacarpal
2. Proximal phalanx
3. Intermediate (middle) phalanx
4. Distal phalanx
5. Proximal sesamoids
6. Distal sesamoid

FIGURE 3-11 Digit of the cow.

the carpus, short bones are not as resistant to compression injury as long bones. The navicular, sandwiched between the much larger and more dense masses of the intermediate and distal phalanges, is very subject to damage from the type of crushing forces that occur in race horses, steeplechasers, and jumpers. The end result of such damage may be a condition known as navicular disease, a permanent, progressive, and ultimately disabling injury. Navicular disease may also arise from other causes, including contaminated puncture wounds.

COMPARATIVE ANATOMY OF THE DIGITAL SESAMOIDS

Cattle and Sheep. In cattle and sheep six sesamoids are present on each foot, three for each digit, and arranged as in horses. They are relatively smaller than equine sesamoids. The distal sesamoids are not flattened as in horses. In the sheep the abaxial sesamoids in the proximal row are compressed laterally. In cattle, accessory digits or dewclaws usually do not possess sesamoids or phalanges.

two for each accessory digit, making a total of 10 sesamoids in each foot. The distal sesamoids are absent in the accessory digits.

Dog. In the dog each paw possesses a maximum of 13 sesamoids, four dorsal and nine volar (plantar). In the forefoot, the volar sesamoids are located in pairs at the metacarpophalangeal joint, except for the first digit (thumb), which (when present) possesses a single sesamoid. The dorsal sesamoids are found embedded in the joint capsule of the II to IV metacarpophalangeal joints. The I metacarpophalangeal joint does not possess a dorsal sesamoid. The distal sesamoids are small cartilaginous masses. The sesamoids of hind and forepaws are alike in size and location. However the word, "metatarsophalangeal" is used to describe the sesamoids of the hind paw.

Cat. There are nine digital sesamoids in the forepaw of the cat and eight in the hind. They are located in pairs on the volar or plantar surface of the metacarpo(tarso)phalangeal joints. The hind paw possesses only a rudimentary I metatarsal and no sesamoid is present. The I metacarpal usually has one sesamoid on its distal extremity as in the dog.

Man. The digital sesamoids of man are irregular and may vary in number. Generally, nine sesamoids may be found in each hand and seven on each foot on the palm (volar) or sole (plantar) surface. Three sesamoids, two proximal and one distal, are found in the thumb, one proximal and one distal in the index finger, one proximal in the middle finger and ring finger, and two proximal in the little finger. Three sesamoids, two proximal and one distal, are found in the great toe; two, one proximal and one distal, in the first toe, and two proximal in the little toe.

PHYSIOLOGY OF THE SESAMOIDS

Functional sesamoid bones allow muscles to exert greater pull on the movable bones distal to the sesamoids. They give the tendons, which ride over the sesamoids, a greater amount of angular pull and consequently, greater leverage. In some locations, the sesamoids (dorsal sesamoids, fabellae) have no apparent purpose. In running animals, the proximal volar sesamoids of the digit, and the patella (kneecap) are very important to give force and power to the stride, improve muscle efficiency and increase speed.

The Pelvic Girdle

The pelvic girdle consists of right and left os coxae or innominate bones which are united to each other ventrally at the symphysis pelvis. The two os coxae are each formed by the fusion of their respective ilium, ischium, and pubis at the acetabulum. The pelvis articulates with the sacrum and the femur. The bony pelvis plus the soft tissues of the rectum, anus and reproductive system form the pelvic cavity. This structure is relatively smaller and narrower in males than in females.

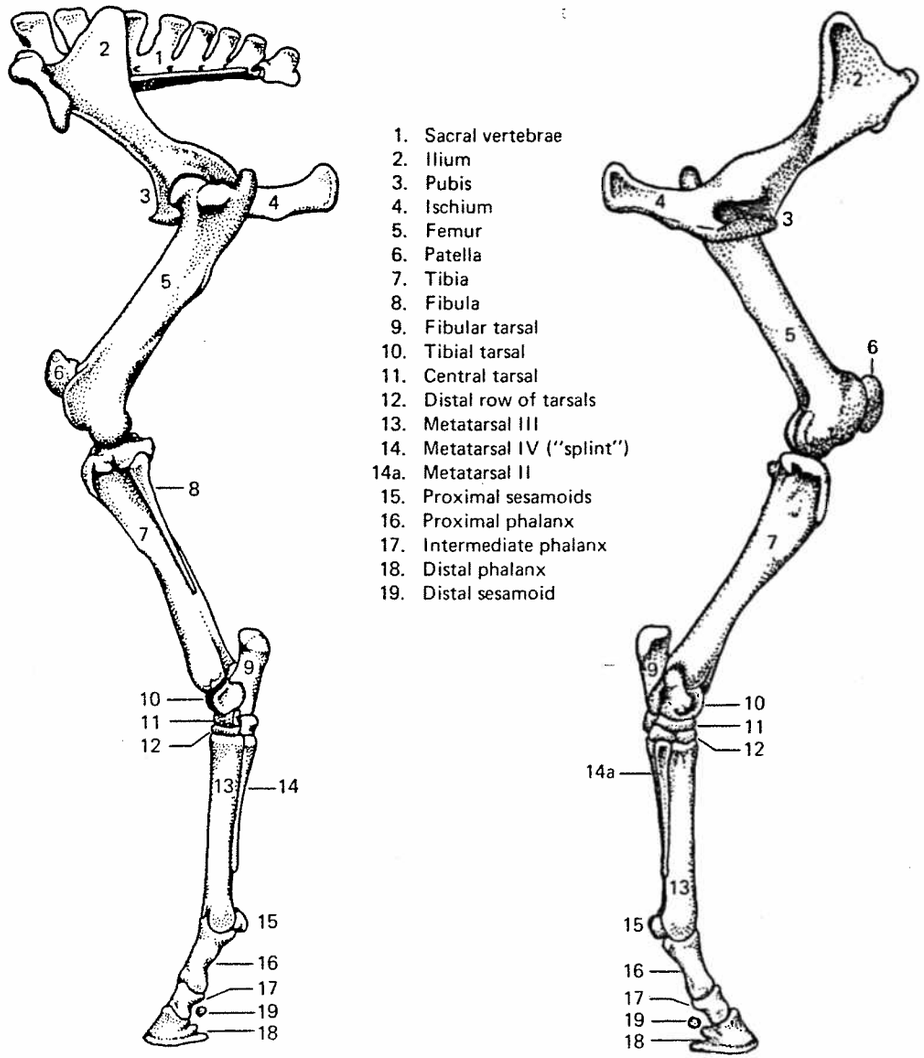


FIGURE 3-12 *Pelvic limb of the horse.*

THE ILIUM

Classification: Modified long bone.

Location: The ilium is irregularly triangular and has two surfaces, three borders, and three angles.

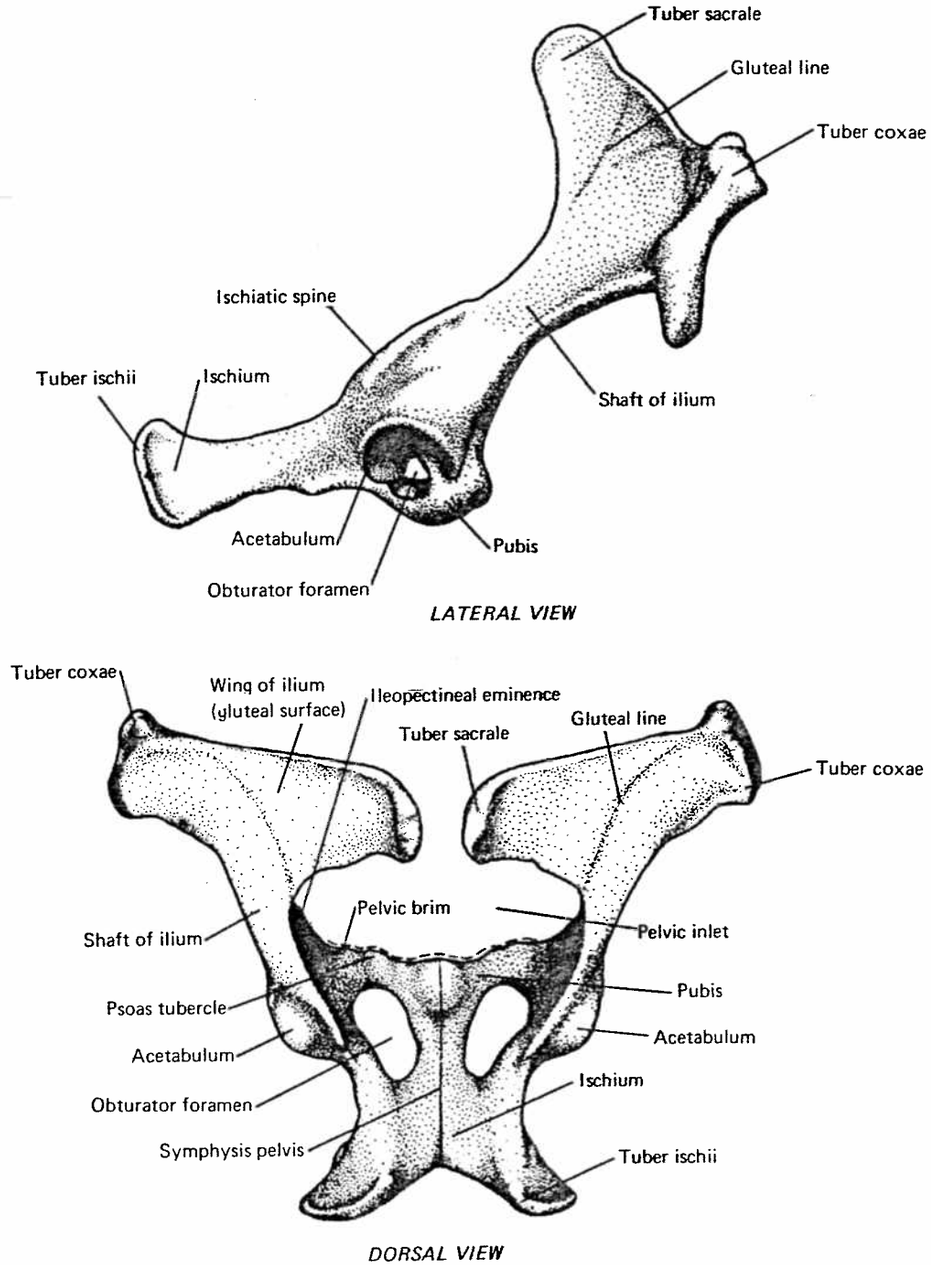


FIGURE 3-13 *Pelvis of the horse.*

dorsally and backward. It is wide and concave in front, narrow and convex behind. The gluteal surface bears the gluteal line, which crosses the wide part of the bone from the middle of the medial border toward the tuber coxae. The pelvic surface faces downward and forward, is convex, and consists of two parts; a medial triangular part and a lateral quadrilateral part. The medial (triangular) part is rough and bears an irregular facet—the auricular area for articulation with the sacrum. The lateral (quadrilateral) part is smooth and is crossed by the iliopectineal line which begins below the auricular area and continues on the shaft of the ilium to the anterior border of the pubis. The line is interrupted by vascular grooves. Below these grooves is the psoas tubercle.

The borders are anterior, medial, and lateral. The anterior border is concave, thick and rough. The medial border is concave and smooth. The middle of the medial border forms the greater sciatic notch and continues as the ischiatic spine. The lateral border is concave and rough. The anterior part is crossed by vascular grooves and the posterior part contains a nutrient foramen.

The angles are medial, lateral, and acetabular. The medial angle (tuber sacrale) curves upward and backward. The lateral angle (tuber coxae) is a large rectangular mass, narrow in the middle and enlarged at both ends. The acetabular angle meets the ischium and pubis at the acetabulum, and has a dorsal border and a shaft. The dorsal border forms part of the ischiatic spine which is rough laterally and smooth medially. The shaft is constricted and has three surfaces: the lateral surface is convex and rough; the pelvic surface is smooth and grooved by vessels and nerves; and the ventral surface is crossed by vascular grooves.

THE ISCHIUM

Classification: Modified long bone.

Location: The ischium forms the posterior part of the ventral floor of the pelvis, and joins the ilium and pubis at the acetabulum.

Description: The ischium is irregularly quadrilateral and has two surfaces, four borders, and four angles.

The surfaces are pelvic and ventral. The pelvic surface is smooth and concave from side to side. The ventral surface is flattened and rough.

The borders are anterior, posterior, medial, and lateral. The anterior border forms the posterior margin of the obturator foramen, and is smooth and concave. The posterior border is thick and rough, and forms half of the ischial arch. The medial border meets the opposite bone at the ischial portion of the symphysis pelvis. The lateral border forms the lesser sciatic notch.

The angles are anteromedial, anterolateral, posteromedial, and posterolateral. The anteromedial angle meets with the pubis to form the medial boundary of the obturator foramen. The anterolateral angle joins the ilium and pubis at the acetabulum and bears the ischiatic spine on its dorsal part. It is grooved medially by the obturator vessels. The posteromedial angle joins its (ischiatic tuberosity) and its lower border forms the ventral ischiatic spine.

THE PUBIS

Classification: Modified long bone.

Location: The pubis is joined posteriorly to the ischium. Anteriorly it meets the ilium and ischium at the acetabulum.

Description: The pubis has two surfaces, three borders, and three angles.

The surfaces are pelvic and ventral. The pelvic surface is convex anteriorly in young horses and in stallions, but is concave and smooth in mares and geldings. The ventral surface is convex and rough and is crossed by the pubic groove on the anterior border.

The borders are anterior, medial, and posterior. The anterior border is thin medially except in young animals and in stallions, and bears the psoas tubercle near the symphysis pubis. The medial border meets the opposite bone at the symphysis pubis. The posterior border is concave and forms the anterior margin of the obturator foramen.

The angles are medial, acetabular, and posterior. The medial angle meets its opposite number at the symphysis pubis. The acetabular angle joins the ilium and ischium at the acetabulum. The posterior angle joins the ischium and forms part of the medial boundary of the obturator foramen.

THE ACETABULUM

The acetabulum is a cotyloid cavity which encloses the head of the femur. It is formed by the junction of the ilium, ischium, and pubis, and faces ventrolaterally. It consists of two parts, an articular part, and a non-articular part. The articular part is crescent shaped and may be faceted. It is bounded internally by the acetabular fossa, which forms the non-articular part, and externally by the rim of the cavity. The medial part of the rim is cut by the acetabular notch.

Embryologically, the acetabulum of the horse includes a separate bone, the os acetabuli or cotyloid bone, which arises from a separate ossification center. The os acetabuli is most distinct in the three-month-old equine embryo and usually fuses to the acetabulum prior to birth.

In the cow, sheep and pig, a similar situation exists, but in the dog the bone exists after birth and fuses to the pubis about the third month of life. In the cat the os acetabuli persists into adult life, and although it ultimately fuses with the pubis, retains its identity. In man, the bone exists as a Y-shaped bar that ossifies and fuses to the ilium, ischium and pubis at about 18 years of age.

COMPARATIVE ANATOMY OF THE PELVIS

Cattle. In cattle, a ventral spinous process below the pelvic floor is present. The ischium is large with its long axis directed backward and upward, in contrast to the relatively horizontal axis in the horse. The transverse axes

series of rough lines on its lateral faces. The tuber ischii is massive and triangular with dorsal, lateral, and medial tuberosities.

The pubis is similar to that of the horse. The acetabulum is smaller than that of the horse, and is marked by two notches (posteromedial and anteromedial), and is usually faceted on the articular surface.

Sheep. The pelvis differs considerably from the bovine. The long axis of the ilium and ischium forms a relatively straight line. The tuber coxae is only slightly thickened, and the tuber sacrale is pointed. The floor of the pelvis is flatter than that of the bovine. The tuber ischii is flattened rather than triangular. The pelvic canal axis slants backward and downward.

Swine. The axis of the ilium and ischium forms almost a straight line. The wing of the ilium is directed outward and downward, forming a moderately acute angle with the medial plane. The ischia diverge laterally and posteriorly. The tuber ischii has three prominences. The acetabulum is set posteriorly, its rim is thick, and the acetabular notch, though narrow, is relatively deep.

Dog. The wing of the ilium is nearly parallel with the median plane. The ischium has a twisted appearance because the acetabular portion is nearly vertical, while the posterior parts are almost horizontal. The tuber ischii faces laterally. The floor of the pelvis is flattened.

The acetabulum has a broad and deep acetabular fossa whose open end is ventral. A thin plate of bone separates the medial surface of the acetabulum from the pelvic canal. The obturator foramen is roughly triangular. An os acetabuli is present in young animals but fuses to the larger bones early in life.

Cat. In the cat, the os coxae is composed of four definitive bones: the ilium, ischium, pubis, and the os acetabuli (cotyloid bone), which lies with its apex in the acetabulum and its angles and base articulating with the ilium, ischium, and pubis. There is a slight angle between the ilium and ischium, which gives the pelvic canal a curved appearance. The wings of the ilium are nearly parallel with the median plane and the tuber ischii faces laterally. The pelvis is set obliquely to the spinal axis and forms an acute angle with the frontal plane. The obturator foramina are large and oval. The acetabulum is set in the posterior third of the os coxae and possesses a deep acetabular notch. The acetabular fossa is shallow.

PHYSIOLOGY OF THE PELVIS

In the terrestrial mammals, the hind legs are chiefly adapted for propulsion. This requires a direct attachment between the hindlimb and the axial skeleton. The attachment is made through the pelvic girdle at the sacroiliac joint. The pelvis, in order to accommodate the forces involved, is usually fused into a solid bony ring that gives more efficient transmission of propulsive force to the body. Modifications in size and shape of the pelvis can be correlated

Since the central opening of the pelvis forms the birth canal in the female, the factor of reproduction enters into its structure. Further modifications depend upon the size of the offspring carried by the female. In females, the pelvic inlet is usually relatively larger in diameter and tends to be more circular than it is in males. This difference is so noticeable in cattle and sheep that one can determine the sex of carcasses from which all other identifying organs or structures have been removed.

The fusion of the pelvic bones and the subsequent distortions of pelvic shape to conform to the physical and physiological requirements of a given species produce a structure that is readily recognizable. It can be used to identify sex and species in the absence of other identifying remains.

The Femur

Classification: Long bone.

Location: It lies between the pelvis and the patella, tibia, and fibula.

Description: The femur has a shaft and two extremities.

The shaft is cylindrical, flattened on the posterior aspect and larger proximally than distally. It has four surfaces and two borders. The surfaces are anterior, medial, lateral, and posterior. The anterior, lateral, and medial surfaces are convex and smooth. The posterior surface is flattened and irregular, and has a number of prominences and depressions. The borders are medial and lateral. The medial border bears the trochanter minor (lesser trochanter) on the proximal part, a nutrient foramen below a rough area in the middle portion, and a medial supracondyloid crest in the distal third. The trochanter tertius occurs on the proximal part of the lateral border. A supracondyloid fossa is present on the posterolateral aspect of the distal third of the shaft.

The extremities are proximal and distal. The proximal extremity is large and consists of a head, a neck, and a trochanter major (greater trochanter). The head is on the medial side and faces inward, upward, and forward. The head is cut by a notch, the fovea capitis. The neck is distinct. The trochanter major is lateral and is divided into two parts, anterior and posterior. The anterior part is convex and rises a little above the head of the femur. The posterior part is higher and is separated from the anterior part by a notch. The posterior border of the trochanter major forms the lateral wall of the trochanteric fossa. The trochanteric fossa is a deep depression immediately below the trochanter major.

The distal extremity consists of a trochlea, two condyles and two epicondyles. The trochlea is composed of two articular ridges separated by a groove. It articulates with the patella. The medial ridge is wider and more prominent. The medial and lateral condyles are bulbous and are separated by an intercondyloid fossa. A ridge connects each condyle to the trochlea. The medial and lateral epicondyles are rounded prominences located beside the condyles.

Cattle. The femur of cattle is roughly similar to that of the horse, except that the shaft is smaller and smoother. The trochanter major is not divided into anterior and posterior parts. The trochanter minor is less distinct and oriented more posteriorly. The trochanter tertius is absent.

Sheep. The femur of sheep is slightly curved anteriorly. The trochanter major is small. The trochanter minor is reduced, and the trochanter tertius is absent.

Swine. The femur of swine is similar to that of the bovine. The trochanter minor, however, is less distinct, and the shaft is relatively heavier and more massive.

Dog. The femur of the dog is relatively longer and smoother than that of the cow or sheep. The shaft is more nearly cylindrical. The trochanter major is small; the trochanter minor is very small; and the trochanter tertius is missing. The supracondyloid fossa is absent. Two facets are present on the posterior aspect of the condyles for articulation with the fabellae.

Cat. The femur of the cat is similar to that of the dog.

PHYSIOLOGY OF THE FEMUR

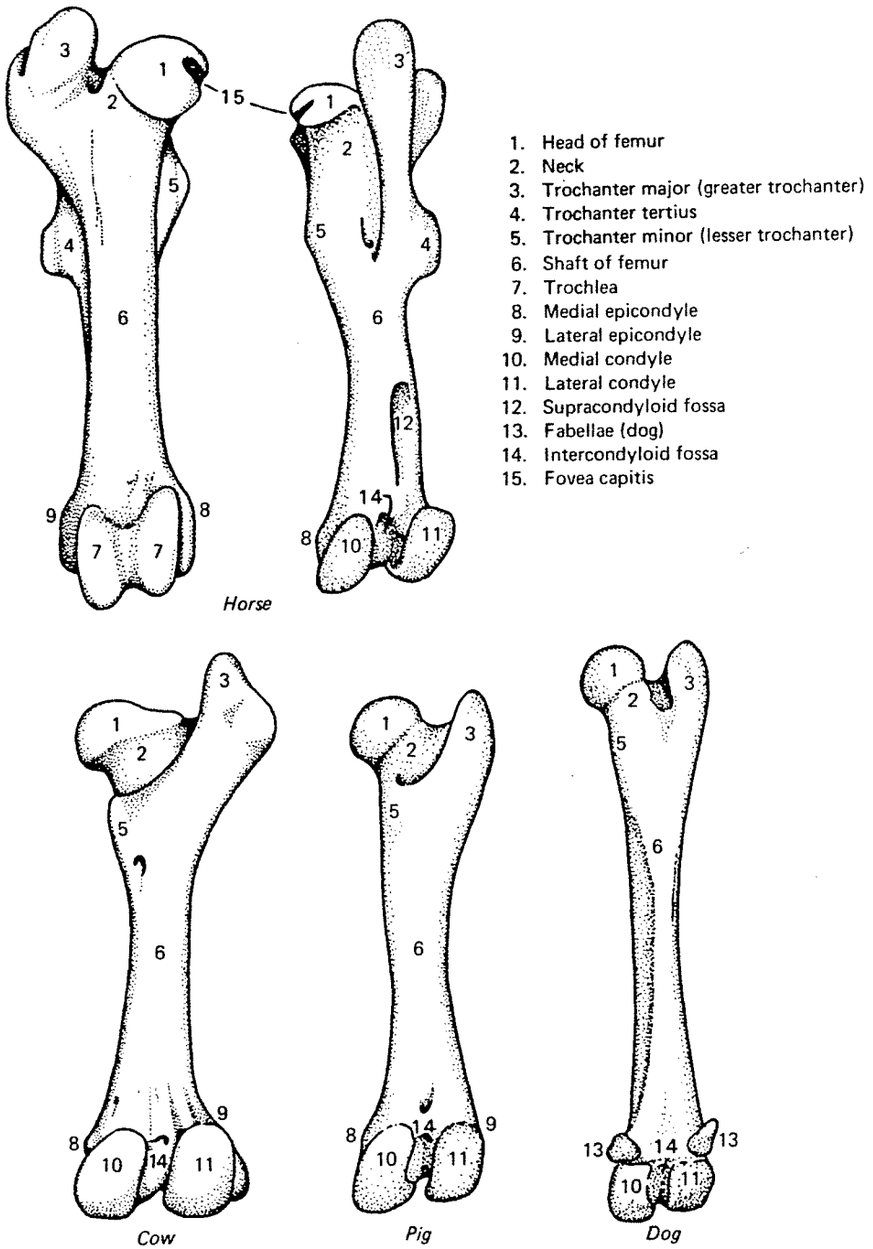
The function of the femur is fourfold. It serves to protect the pelvic viscera and support the birth canal. It is a connecting link between the pelvis and the distal portions of the hindlimb. It furnishes attachments for the origin and insertion of the major muscles that control its motion and the movements of the distal part of the limb. It gives a positive connection between the hindlimb and the axial skeleton resulting in a more efficient transfer of propulsive force to the body.

The Patella

Classification: Short bone.

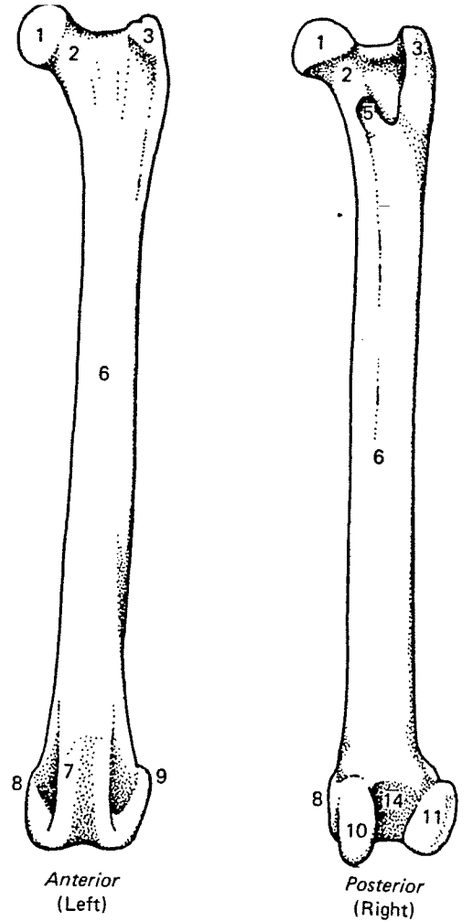
Location: The patella is found on the anterior distal surface of the femur and articulates with the trochlea of the femur.

Description: The patella is the largest of the sesamoid bones. It is quite specialized and has two surfaces, two borders, a base, and an apex. The surfaces are anterior and articular. The anterior, or free surface, is quadrilateral in form, and is convex, and rough. The articular surface is also quadrilateral in form, but is concave and smooth. It bears a low rounded ridge which separates it into medial and lateral areas. The medial area is the larger. The borders are medial and lateral, and converge below at the apex. The medial border is concave, the lateral border is convex, and is less prominent. The base faces



1. Head of femur
2. Neck
3. Trochanter major (greater trochanter)
4. Trochanter tertius
5. Trochanter minor (lesser trochanter)
6. Shaft of femur
7. Trochlea
8. Medial epicondyle
9. Lateral epicondyle
10. Medial condyle
11. Lateral condyle
12. Supracondyloid fossa
13. Fabellae (dog)
14. Intercondyloid fossa
15. Fovea capitis

FIGURE 3-14 *Right femur—comparative anatomy.*



1. Head of femur
2. Neck
3. Trochanter major (greater trochanter)
5. Trochanter minor (lesser trochanter)
6. Shaft of femur
7. Trochlea
8. Medial epicondyle
9. Lateral epicondyle
10. Medial condyle
11. Lateral condyle
14. Intercondyloid fossa

FIGURE 3-14 (Cont.) Femur of cat.

upward and backward. It is convex transversely and concave when viewed from the side. The apex is distal and is formed into a blunt point.

PHYSIOLOGY OF THE PATELLA

The structure of the patella and the femorotibial joint is designed for the maximum application of muscular force to extend the upper portions of the hindlimb. This results in a greater "kick" or drive of the hindlegs and a consequent increase in speed of movement. A corresponding structure does not exist in the foreleg, probably because of the greater adaptation of that limb to weight supporting (or manipulative) functions.

The Fabellae

Classification: Short bones.

Location: Fabellae are found on the posterior distal surface of the femur above the femoral condyles.

Description: The fabellae are specialized sesamoids which develop in the origin of the gastrocnemius muscle (calf muscle). In cats there are four fabellae; in most other animals with fabellae there are two. They are present in dogs, cats, and other carnivores, but are not found in horses, cattle, sheep, deer or swine. If only two fabellae are present, they articulate with the dorsal portion of the femoral condyles. If there are four, the additional pair are located along the posterior part of the proximal end of the tibia.

The Tibia

Classification: Long bone.

Location: The tibia extends obliquely downward and backward from the femur to the tarsus.

Description: The tibia has a shaft and two extremities. The shaft is large and three-sided proximally, becoming smaller and flatter in the middle portion, and widened and rectangular at the distal extremity. There are three surfaces: medial, lateral, and posterior; and three borders: anterior, medial, and lateral. The medial surface is broad and rough proximally; distally it narrows. The lateral surface is a smooth spiral curve. It is wide and concave in the proximal portion, narrow and convex centrally, wider and flatter distally. The posterior surface is flattened and divided into two parts by the popliteal line. Near the popliteal line is a nutrient foramen. The anterior border bears a crest in the proximal end.

The extremities are proximal and distal. The proximal extremity is large and three-sided, and bears two condyles (medial and lateral), and a tuberosity. The medial condyle is the larger and is slightly saddle-shaped. It is separated from the lateral condyle by the popliteal notch and the tibial spine. The lateral condyle has an overhanging margin below which is a facet for articulation of the fibula. The tuberosity is located on the proximal end of the crest and is separated from the lateral condyle by the sulcus muscularis.

The distal extremity is small and quadrilateral. It has an articular surface and two malleoli. The articular surface consists of two grooves, separated by a ridge. The two grooves face obliquely forward and laterally. The medial groove is narrower and deeper than the lateral groove. The malleoli are bony prominences on the outer margins of the articular grooves. The medial malleolus is smaller than the lateral, which is the distal extremity of the fibula.

Classification: Modified long bone.

Location: Along the lateral side of the tibia.

Description: The fibula has a shaft and two extremities. In the horse, the shaft is incomplete and is usually a slender rod that tapers to a point. It forms the lateral boundary of the interosseus space and generally terminates in the middle third of the tibia.

The extremities are proximal and distal. The proximal extremity is flattened transversely and has two surfaces (medial and lateral), and two borders (anterior and posterior). The medial surface bears a narrow articular area on the upper border. The lateral surface is rough, and the anterior and posterior borders are rounded.

The distal extremity is fused with the distal extremity of the tibia and forms the lateral malleolus.

COMPARATIVE ANATOMY OF THE FIBULA

Horse. The shaft is vestigial and incomplete. Both ends are fused with the tibia.

Cattle. No shaft is present. The ends are fused with the tibia. The proximal end is bluntly pointed.

Sheep. No shaft is present. The ends are fused with the tibia. The proximal end is incorporated into the tibial condyles.

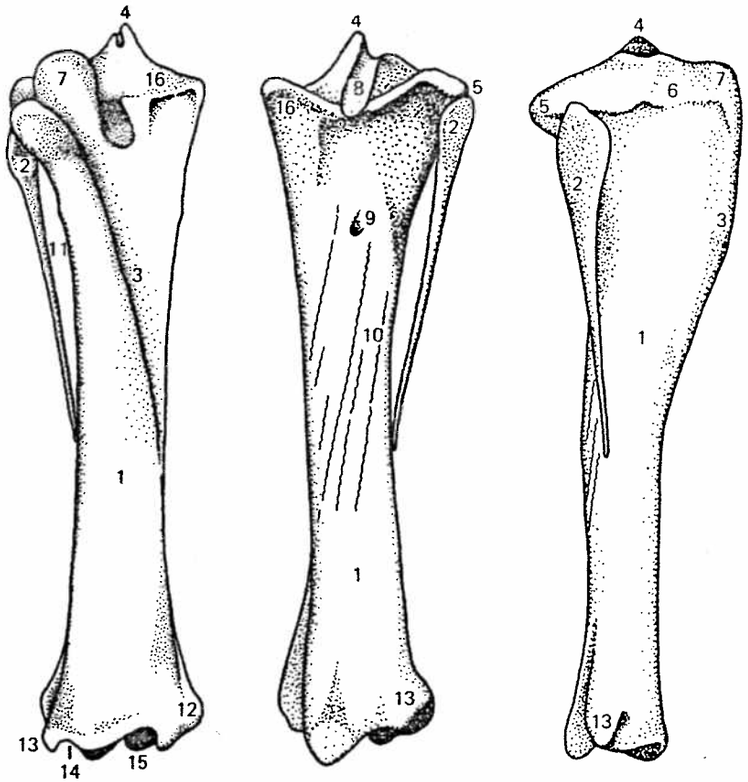
Pig. The bone is complete and smaller than the tibia. The ends are free at birth and become united to the tibia at two to three years of age.

Dog. The bone is complete and smaller than the tibia. The ends are free and articulate with the tibia.

Cat. The cat is similar to the dog.

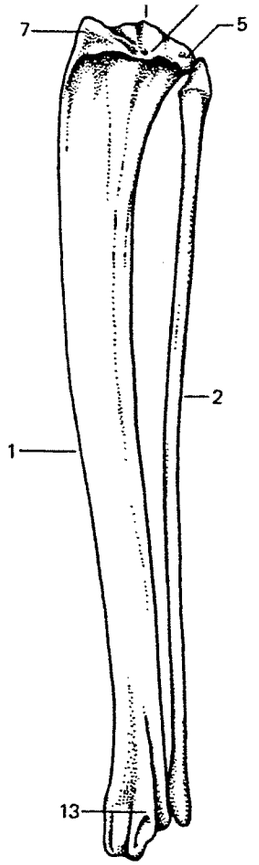
PHYSIOLOGY OF THE FIBULA

In all domestic mammals the fibula is gradually becoming vestigial. The degree of disappearance varies from virtually complete absence of this structure in cattle and sheep, to the physical (if not functional) persistence in the dog, cat, and man. In horses, the fibula is a common site for fractures and separation which produce lameness. It is often an incomplete structure, the shaft failing to develop in its middle portion. This results in the bone becoming three distinct parts—a head, middle piece, and lateral malleolus.



1. Tibia
2. Fibula
3. Tibial crest
4. Spine (intercondyloid eminence)
5. Lateral condyle
6. Sulcus muscularis (extensor sulcus)
7. Tuberosity
8. Intercondyloid fossa
9. Nutrient foramen
10. Popliteal line
11. Interosseus space
12. Medial malleolus
13. Lateral malleolus
14. Lateral articular groove
15. Medial articular groove
16. Medial condyle

FIGURE 3-15 *Tibia and fibula of the horse.*



1. Tibia
2. Fibula
3. Tibial crest
4. Spine
5. Lateral condyle
6. Sulcus muscularis
7. Tuberosity
13. Lateral malleolus

FIGURE 3-15 (Cont.) Tibia and fibula of cat—lateral view.

The Tarsus

Essentially, the tarsus performs the same functions for the hindlimb as the carpus does for the forelimb. The tarsus, however, flexes anteriorly while the carpus bends posteriorly. The tarsus of the horse consists of six or seven short bones arranged roughly in two rows, e.g.,

PROXIMAL ROW

(Tuber calcis) Fibular Tarsal — (Trochlea) Tibial Tarsal

Central Tarsal

(LATERAL SIDE) Fourth Tarsal — DISTAL ROW — Third Tarsal — Second Tarsal — (MEDIAL SIDE) First Tarsal

The first and second tarsal bones are usually fused in the horse. The largest bone of the tarsal group is the fibular tarsal (calcaneus) which is located laterally and posteriorly in the proximal row. This bone has a long bony process known as the tuber calcis (calcaneal tuber) to which is attached the Achilles tendon of the gastrocnemius (calf) muscle. The fibular tarsal articulates with the tibial tarsal, the central tarsal, and the fourth tarsal bones.

The tibial tarsal (talus) is the second largest bone of the tarsal group, and forms a fulcrum around which the hock joint is flexed and extended. It is characterized by a large pulley-like mass (the trochlea), which is located on its anterior surface and articulates with the distal end of the tibia. The two prominent oblique ridges of the trochlea curve forward, downward, and outward (laterally), and form an angle of about 15 degrees with the vertical. The trochlea is single in the horse, dog, and cat, but two trochleae (one on each end of the tibial tarsal) are found in the cow, elk, deer, sheep and swine. The tibial tarsal articulates with the tibia dorsally, the fibular tarsal posteriorly, and the central tarsal ventrally.

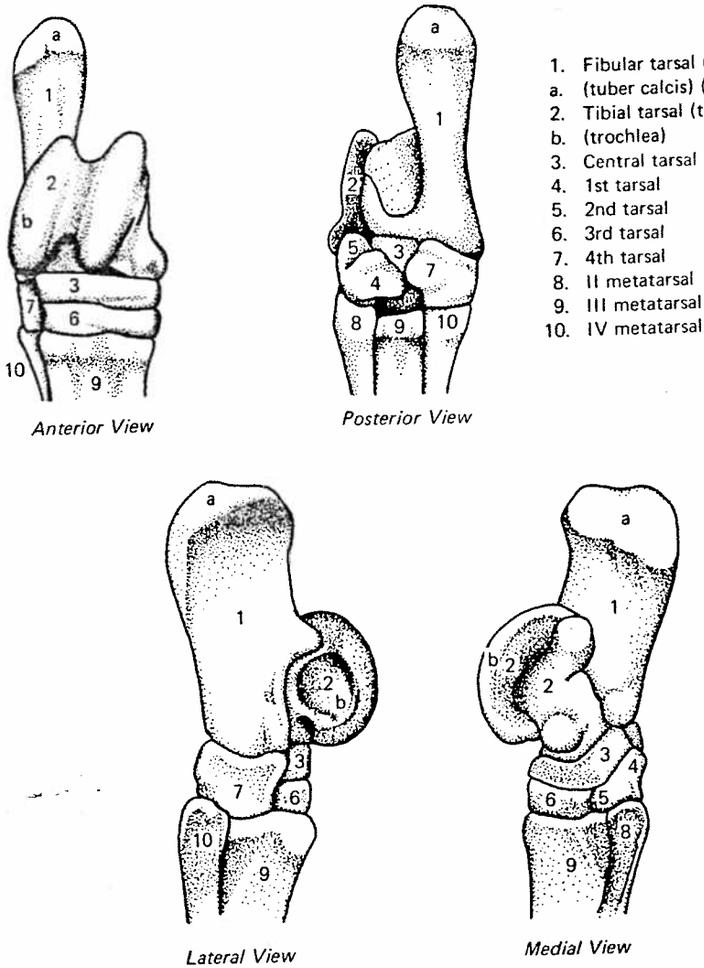
The central tarsal is a flattened, four-sided bone that lies between the tibial and fibular tarsals and the four distal tarsal bones. It articulates with the tibial and fibular tarsals dorsally and the four distal tarsal bones ventrally.

The first and second tarsal bones are normally fused in the horse. The third tarsal has a flattened oval shape. The fourth tarsal is an irregular prism-shaped bone. The first three distal tarsals articulate with each other and with the central tarsal dorsally, and the metatarsals ventrally. The fourth tarsal articulates with the fibular tarsal in addition to its articulation with the metatarsals ventrally.

As has been previously mentioned for the carpus, the tarsus is a locomotion and a shock absorption device. It is an important structure. Adapted as it is in cursorial animals to impart a high degree of leverage to the hind foot, the shape of the tarsus plays an important part in determining the speed and agility of an animal. Like the carpus, the tarsus is subject to injury and although hock injuries are seldom totally disabling, they often impair an animal's efficiency of movement.

COMPARATIVE ANATOMY OF THE TARSUS

SPECIES	*NO.*	*TIBIAL TARSAL*	*FIBULAR TARSAL*	*CENTRAL TARSAL*	*4TH*	*3RD*	*2ND*	*1ST*
Horse	6	Massive one trochlea	+	+	+	+	fused—fused	
Cow & Sheep	5	Long & narrow 2 trochleae	+	fused—fused		fused—fused		+
Pig	7	Long & narrow 2 trochleae	+	+	+	+	+	+
Dog & Cat	7	Body, neck & head, 1 trochlea	+	+	+	+	+	+



1. Fibular tarsal (calcaneus)
a. (tuber calcis) (calcaneal tuber)
2. Tibial tarsal (talus)
b. (trochlea)
3. Central tarsal
4. 1st tarsal
5. 2nd tarsal
6. 3rd tarsal
7. 4th tarsal
8. II metatarsal
9. III metatarsal
10. IV metatarsal

FIGURE 3-16 *Tarsus of the horse.*

In most animals, as long as the trochlear function is unimpaired, the tarsal joint will function well, even though all the remaining bones of the group are fused into a solid mass.

The Metatarsals

Classification: Long bones.

Location: The metatarsals occur between the distal row of tarsals and the proximal phalanx.

Description: Same as metacarpals ... the horse both anterior and posterior surfaces of the third metatarsal are curved, giving the bone a circular cross section. The shaft is straight rather than bowed anteriorly. The fourth metatarsal is attached intimately to the lateral posterior surface of the third metatarsal for a distance of one-quarter the length of the shaft. In general, in all ungulates, and in most plantigrade and digitigrade animals, the metatarsals are longer and less massive than the metacarpals.

The Digits

The hind digits are essentially similar in composition and structure to those of the forelimbs. The digits of multidigited animals also have considerable similarity. The dog, cat, and certain other digitigrade mammals usually have five digits on the front feet and four on the hind. Relics of a fifth digit (I phalanx) on the hind feet are much more frequent in dogs than in cats. When the digit is present, the bony attachment to the hind leg is usually vestigial or missing. The extra digit is generally called a "dewclaw" and is usually snipped off shortly after birth. It is a useless excrescence, a show defect, and almost invariably becomes either irritated or injured in working dogs where it may be allowed to remain. Cats rarely have this digit visible externally although vestigial bony remnants are often present and incorporated into the tarsometatarsal joint.

THE AXIAL SKELETON

The axial skeleton consists of the vertebrae, the ribs, the sternum, and the skull.

Classification: Irregular bones.

Location: Along the midline dorsal axis of the body.

Description: The vertebrae form a chain or column of dorsal, median, and unpaired bones extending from the skull to the tail. The column is divided into five regions: cervical (C) (neck); thoracic (T) (chest); lumbar (L) (waist); sacral (S) (rump); and coccygeal or caudal (Cy) (tail). The number of vertebrae in each region for a given species is quite constant except for the coccygeal. However, except for the cervical, there is a variation in number of vertebrae between species.

The vertebrae in the sacral region are fused together more or less completely into a solid mass which articulates with the pelvis. These are called fixed (false) vertebrae in contrast to the movable (true) vertebrae composing the remainder of the vertebral column.

The vertebrae in each region have certain characteristics which serve to distinguish them from those of other regions, and individual vertebrae within a given region may further be distinguished from each other. However, all have a common plan of structure consisting of three basic parts: a body, an arch, and processes.

The body is a cylindrical mass, oriented anteroposteriorly, upon which the other parts are built. The body connects anteriorly and posteriorly with the bodies of adjacent vertebrae through intervertebral discs or cartilages (menisci). In most mammals, the anterior faces of the bodies of the cervical, thoracic, and lumbar vertebrae are convex, while the posterior surfaces are concave. The bodies of the sacral vertebrae are fused and those of the caudal vertebrae are convex on both ends. The ventral portion of the body is rounded. The dorsal portion is flattened, and forms the floor of the vertebral canal. In the thoracic region the body has lateral facets on its anterior and posterior borders which articulate with part of the heads of two successive pairs of ribs.

The arch is composed of two lateral halves and is constructed dorsally to the body. The halves meet medially to form a bony ring called the vertebral foramen. Successive foramina, together with the soft tissues which unite them, form the vertebral canal which contains the spinal cord. The arches are notched before and behind, and the unions of adjacent vertebral notches form the intervertebral foramina through which the spinal nerves and vessels pass. There is considerable variation in the formation and location of the intervertebral foramina, particularly in the posterior thoracic vertebrae.

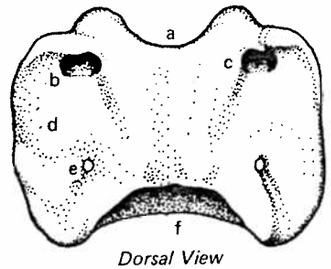
The processes can be divided into articular processes, of which there are usually two anterior and two posterior for each true vertebra; spinous processes, which are located dorsally and ventrally along the median plane; transverse processes, which project laterally from the arch or from the junction of arch and body; mammillary processes, which are found on posterior thoracic and anterior lumbar vertebrae between the transverse processes and anterior articular processes; and accessory processes, which are located between the transverse and the posterior articular processes. Caudal vertebrae of some species possess a ventral or hemal arch for passage of blood vessels.

The Cervical Vertebrae

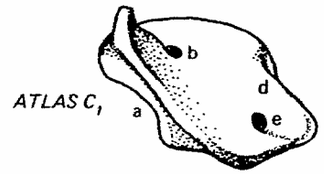
The cervical vertebrae, or neck bones, are seven in number for all terrestrial and arboreal mammals except for a species of tree sloth. Aquatic mammals such as whales and dolphins (cetaceae) and the manatee do not abide by this rule and will have one or more cervical vertebrae missing. The first two are greatly modified and are frequently designated by name (e.g., C_1 atlas, C_2 axis). The sixth and seventh cervical vertebrae are also modified but do not differ greatly from the remainder. With the exception of the atlas, the cervical vertebrae are roughly quadrangular, and are ordinarily longer through the body than vertebrae of other regions. The processes and structures of the cervical vertebrae are massive, but tend to become less so with each successive vertebrae. The length of the bodies decreases from C_2 to C_7.

Lateral to the body of most cervical vertebra are two openings, one on each side, running parallel with the vertebral foramen. These are called the foramina transversaria. Successive foramina transversaria form two lateral canals or canalis transversaria through which pass the vertebral vessels and nerves. The foramina begin with the sixth cervical vertebrae and end in the atlas.

The atlas, or first cervical vertebra, is formed as a strong flattened ring

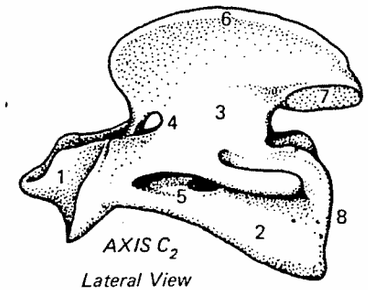


Dorsal View



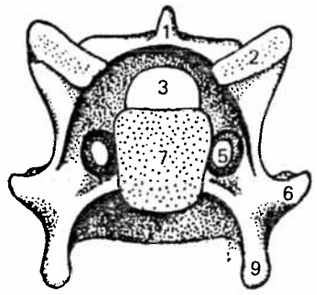
Lateral View

a. Anterior articular surface
b. Alar foramen
c. Lateral vertebral foramen
d. Wing of atlas
e. Foramen transversarium
f. Posterior articular surface

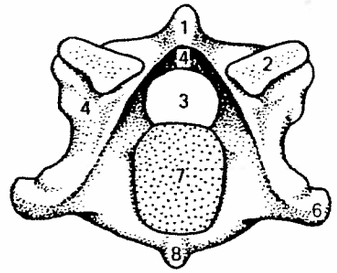


Lateral View

1. Dens (odontoid process)
2. Body
3. Arch
4. Intervertebral (lateral vertebral) foramen
5. Foramen transversarium
6. Spine
7. Articular facet
8. Posterior articular surface



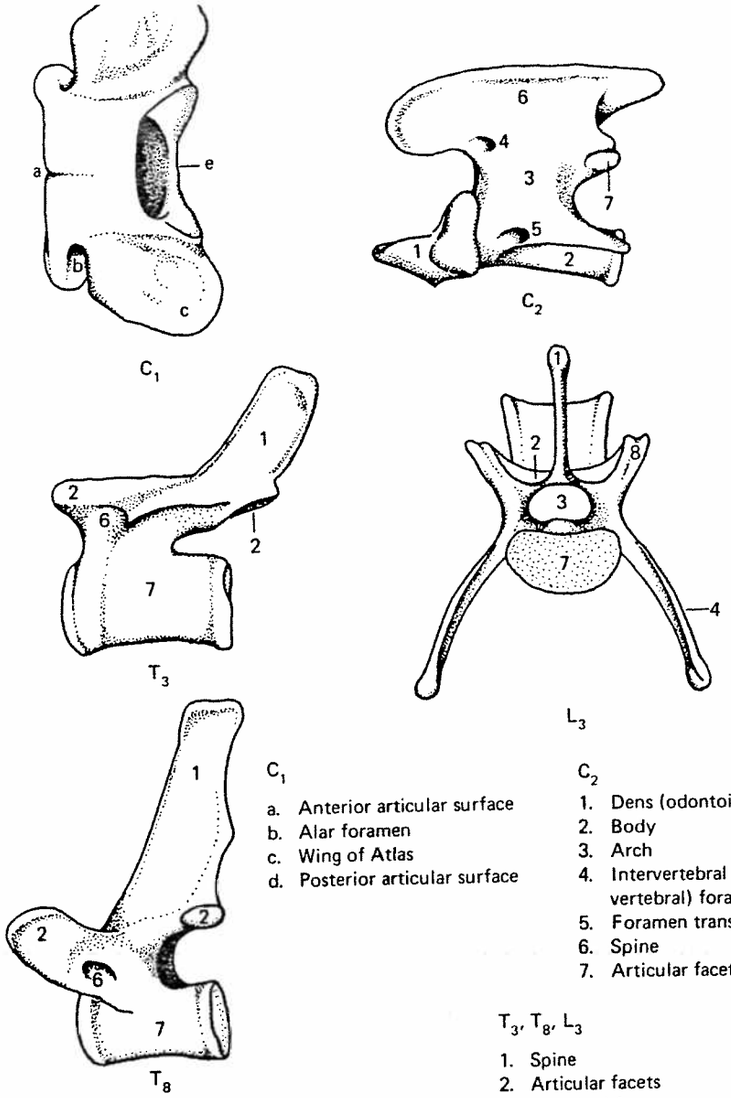
Anterior View C6



Anterior View C7

1. Dorsal spine
2. Anterior articular facets
3. Vertebral foramen
4. Arch
5. Foramen transversarium
6. Transverse process
7. Body
8. Ventral spine
9. Costal process

FIGURE 3-17 *Atlas, axis and cervical vertebrae of the horse.*



C_1

a. Anterior articular surface
b. Alar foramen
c. Wing of Atlas
d. Posterior articular surface

C_2

1. Dens (odontoid process)
2. Body
3. Arch
4. Intervertebral (lateral vertebral) foramen
5. Foramen transversarium
6. Spine
7. Articular facet

T_3, T_8, L_3

1. Spine
2. Articular facets
3. Vertebral foramen
4. Transverse process
5. Costal facet
6. Facet for articulation with tubercle of rib
7. Body
8. Mammillary process

FIGURE 3-17 (Cont.) *Vertebrae of cat.*

dorsal and ventral arches. The atlas articulates anteriorly with the occipital condyles of the skull and posteriorly with the dens or odontoid process of the axis. The atlas is an exception to the general rule that vertebral bodies of cervical vertebrae are convex anteriorly and concave posteriorly; both ends are concave.

The axis, or second cervical vertebra, has the longest body of the cervical vertebrae and is characterized by the dens or odontoid process on its anterior face which fits into the posterior part of the atlas. It has a heavy and strong dorsal spine which has an articular process on its flattened posterior end.

To a large extent, the atlas and axis control movement of the head. The skull articulates in a hinge (ginglymus) fashion with the atlas, permitting an up and down movement. The atlas articulates on a pivot (trochoid) joint with the axis, permitting rotation of the head.

The third, fourth, and fifth cervical vertebrae are very similar and progressively shorter in length. These vertebrae have well developed anterior and posterior articular processes; short, thick dorsal spines; a rudimentary ventral spine; and large, plate-like transverse processes which extend laterally and backward.

The sixth and seventh cervical vertebrae are somewhat different from the preceding three with larger vertebral foramina and more apparent spinous processes. The seventh, in addition, possesses facets on each side of the posterior articular surface of the body for articulation with the heads of the first pair of ribs. It does not possess foramina transversaria.

The Thoracic Vertebrae

There is considerable variation in numbers of thoracic vertebrae between species of mammals, and occasionally there is variation within a species.

The bodies are short. Anterior and posterior paired lateral facets (costal facets) for articulation with the heads of the ribs are present. The arches and articular processes are small. The transverse processes are short and thick, and possess facets for articulation with the tubercle of the rib which possess the same number as the vertebra, e.g., the tubercles of the first pair of ribs articulate with the body of T_1. In the horse the ventral spine is absent. The dorsal spine is prominent and is slanted backward. The length of the spines increases from the first to the fourth thoracic vertebrae and decreases from the fourth to the last. The summits of the spinous processes are expanded and rough.

The last thoracic vertebra usually lacks a posterior pair of costal (rib) facets. Exceptions to this are found in horses with floating ribs, and in swine and sheep with supernumerary ribs. Other species may also be an exception to this statement when there are more pairs of ribs than there are thoracic vertebrae.

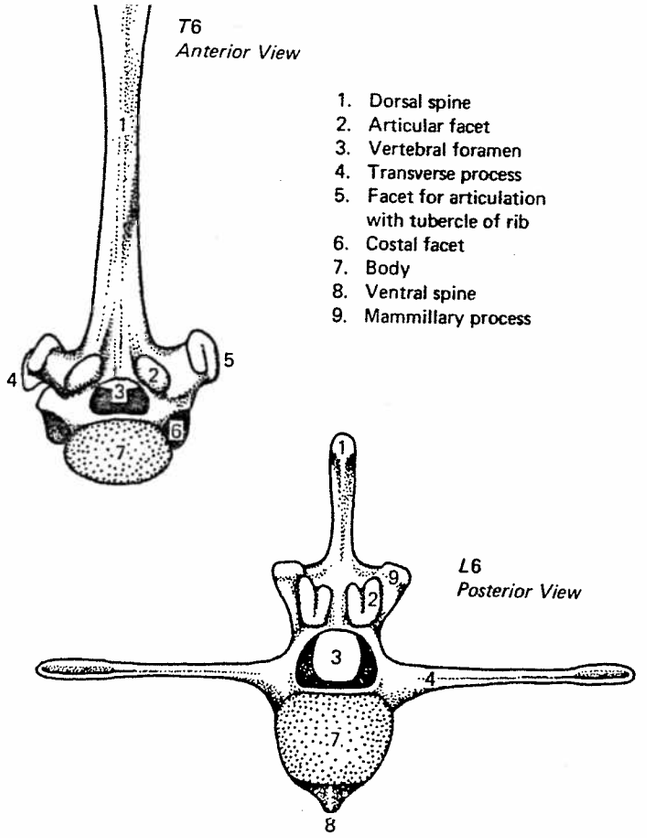


FIGURE 3-18 *Thoracic and lumbar vertebrae of the horse.*

The Lumbar Vertebrae

These vary in number between species and are characterized by dorsal spines which slant forward, large and well-formed transverse processes which are flattened dorsoventrally, a distinct ventral spine, and relative equality in size and shape.

In animals other than horses and cattle, the transverse processes are more likely to be oval in cross section, less prominent, and tend to slant downward and forward.

The lumbar vertebrae of the so-called rigid-spined mammals (e.g., horses, cattle, sheep, etc.) have an interlocking arrangement of the anterior and posterior articular facets that bind the lumbar vertebrae into a relatively inflexible bony mass. In horses the last one or two vertebrae often become fused to the sacral vertebrae through exostoses and ankylosis of their transverse processes.

These vary in number and shape among the domestic animals, but consist essentially of a fused or partially fused mass of two or more bones that have rather well-marked dorsal spines that slant posteriorly. Numerous dorsal and lateral foramina are present, and a well-developed, roughened, articular surface on the anterior lateral face exists for articulation with the pelvis.

The Caudal (Coccygeal) Vertebrae

These vary considerably in number, even within a species, and decrease progressively in size and complexity from the first to last.

THE VERTEBRAL FORMULA

A vertebral formula is a shorthand method of listing the number of vertebrae in a given species of animal. A typical example would appear as follows:

Horse: C_7 T_{18} L_6 S_5 Cy_{15-21}

This means that a horse has 7 cervical vertebrae, 18 thoracic, 6 lumbar, 5 sacral, and from 15 to 21 caudal vertebrae.

COMPARATIVE VERTEBRAL FORMULAE

	C	*T*	*L*	*S*	*Cy*
Horse	7	18	6	5	15-21
Cow	7	13	6	5	18-20
Sheep	7	13	6-7	4	16-18
Pig	7	14-15	6-7	4	20-23
Dog	7	13	7	3	20-23
Cat	7	13	7	3	5-23
Man	7	12	5	5	4

PHYSIOLOGY OF THE VERTEBRAL COLUMN

The vertebral column, while morphologically similar in the various species, exhibits some functional differences. Flexibility is perhaps the outstanding of these. In animals that depend upon running in order to eat or to avoid being eaten, the vertebral column is one of two functional types; a relatively rigid structure (e.g., involving the thoracic, lumbar and sacral segments) such as is found in horses, cattle and sheep, or the highly flexible spine of dogs and cats. In herbivores, the column not only serves to transmit the forces of the legs to the body, but it also serves to support a large digestive tract and a pregnant uterus in range or wild environments where the pregnant female carries one or more large fetuses for considerable distances during gestation.

need to travel such great distances to acquire food. Their habits tend to be more sessile, their ranges more restricted, and during the latter stages of pregnancy the females generally move only when absolutely necessary. The spine of the carnivore, thus freed from constant major weight bearing functions, tends to be more flexible and a greater aid in running. Where herbivores must depend principally upon their legs, the carnivore can, by flexing its spine, add considerable distance and force to its stride. The flexible spine also aids acceleration. The enormous acceleration developed by a charging lion (0-45 mph in five or six strides) appears to be aided by the flexibility of the spine as much as any other factor.

The Ribs (Costae)

Classification: Modified long bones.

Location: Between the thoracic vertebrae and the sternum. Each rib articulates dorsally with the bodies of two vertebrae, and is continued ventrally by a costal cartilage which may or may not attach directly to the sternum.

Description: The number and shape of ribs varies with the species of mammal. A typical rib is composed of a shaft and two extremities. In horses and other large mammals, the shaft is flattened and strongly curved. In small mammals the shaft is usually oval or round in cross section.

The proximal extremity consists of a head, neck, and tubercle. The head articulates with the bodies of two adjacent thoracic vertebrae. The neck is the bony junction of head and shaft. The tubercle projects backward at the junction of neck and shaft, and bears a small facet on its dorsomedial surface for articulation with the transverse process of its thoracic vertebra.

The distal or costal extremity is roughened for connection with the costal cartilages. Those ribs which are directly connected to the sternum (breastbone) by costal cartilages are known as sternal ribs (true ribs). The remainder are asternal ribs (false ribs). Ribs at the posterior end of the thorax which have their ventral ends free are known as floating ribs. Spaces between ribs are called intercostal spaces. The ribs contain spongy red marrow and are important throughout the life of the animal as blood forming organs. The ribs also function to protect the thoracic viscera, and together with their muscles act as respiratory aids.

The Costal Cartilages

These are bars of hyaline cartilage which serve to connect the ribs directly or indirectly to the sternum. The cartilages of asternal ribs overlap to form the costal arch. Cartilages of floating ribs are not attached to the costal arch. In mature animals, and most often in dogs, the costal cartilages may become partially ossified.

COMPARATIVE ANATOMY OF STERNAL AND ASTERNAL RIBS

	TOTAL NO.	STERNAL	ASTERNAL
Horse	18-19 pair	8 pair	10-11 pair (1 pr. floating when 11 pr. present)
Cow	13 pair	8 pair	5 pair
Sheep	13-14 pair	8 pair	5-6 pair
Pig	14-15 pair	7 pair	7-8 pair
Dog	13 pair	9 pair	4 pair
Cat	13 pair	9 pair	4 pair
Man	12 pair	7 pair	5 pair (2 pr. floating)

The Sternum

The sternum is formed by a group of medial, ventral, segmental, unpaired bones, which complete the thoracic skeleton ventrally. It is composed of three parts: the presternum (manubrium sterni) and cariniform cartilage; the mesosternum (body); and the metasternum and xiphoid (ensiform) cartilage.

The presternum has many shapes. These are determined to some extent by the presence or absence of a clavicle (collar bone). Animals with clavicles usually have a broad and strong presternum, while animals without clavicles normally possess a narrow (cow), laterally compressed (horse), or rudimentary (dog) presternum. The presternum has on its anterior surface a cariniform cartilage which is extensive in the horse, absent in the cow and sheep, and rudimentary or absent in most other animals. The body of the sternum of the horse consists of seven bony segments called sternabrae which are roughly cuboidal in shape. The metasternum is the posterior bony segment of the sternum and bears the xiphoid cartilage on its posterior end. The xiphoid cartilage is present in all animals though greatly variable in size and shape. It is called the ensiform cartilage in man.

THE COMPARATIVE ANATOMY OF THE STERNUM

		CARTILAGES	
STERNUM	NUMBER OF BONES	XIPHOID	CARINIFORM
Horse	7	+	+
Cow	7	+	-
Sheep	6-7	+	-
Pig	6	+	±
Dog	8	+	±
Cat	8	+	±
Man	6	+	-

The Thoracic Cavity

The thorax is a closed cavity. It is bounded by the thoracic vertebrae dorsally, the ribs and costal cartilages laterally, and the sternum ventrally. The anterior aperture, the thoracic inlet, is formed by the first thoracic vertebra, the first pair of ribs and costal cartilages, and the presternum. The posterior, or diaphragmatic aperture is composed of the last thoracic vertebra, the last pair of ribs, the costal arch, and the metasternum. The diaphragm forms a partition between the thoracic and abdominal cavities. The thorax contains the heart, lungs, diaphragm, thymus, portions of the esophagus and trachea, the pleural and pericardial membranes, the beginning and end of the blood vascular system, the termination of the lymphatic system, and other less important structures.

The Skull

Classification: A group of flat and irregular bones.

Location: At the anterior extremity of the vertebral column.

Description: The skull is divided into two parts, the cranium and the face. The cranium is composed of the bones of the skull which immediately surround the brain and which are incorporated into the floor and vault of the brain cavity.

The face consists of the bones of the skull which are not a part of the cranium.

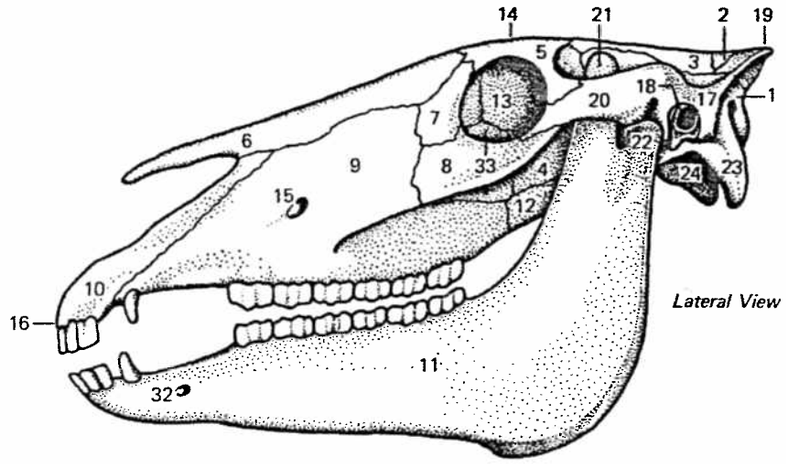
THE BONES OF THE CRANIUM

The bones of the cranium consist of the following single and paired bones:

SINGLE BONES	*PAIRED BONES*
1. Occipital	1. Interparietal
2. Sphenoid	2. Parietal
3. Ethmoid	3. Frontal
	4. Temporal

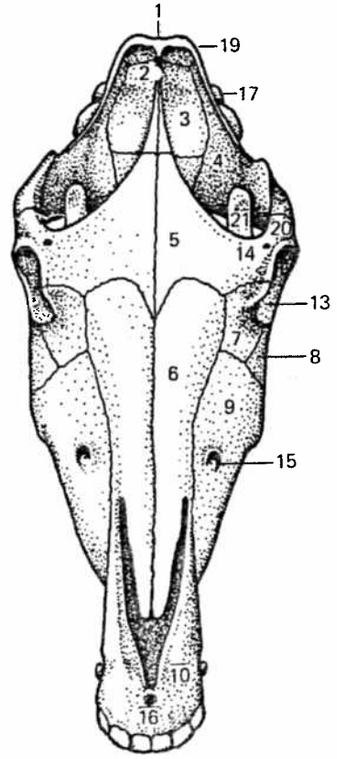
THE SINGLE BONES OF THE CRANIUM

The single bones of the cranium are highly modified anterior extensions of the vertebral column. The occipital bone is situated at the posterior part of the cranium, and forms the rear walls of the vault and floor of the cranial cavity. The ventral portion of the bone is perforated by a large foramen, the foramen magnum, through which the spinal cord passes. The foramen magnum marks the junction of the cranial cavity and the vertebral canal, and is bounded dorsally by the squamous part, laterally by the lateral parts, and



Lateral View

Dorsal View



1. Occipital
2. Interparietal
3. Parietal
4. Squamous temporal
5. Frontal
6. Nasal
7. Lacrimal
8. Malar (zygomatic)
9. Maxilla
10. Premaxilla (incisive)
11. Mandible
12. Palatine
13. Orbit
14. Supraorbital foramen
15. Infraorbital foramen
16. Foramen incisivum
17. Petrous temporal
18. External acoustic meatus
19. Nuchal crest
20. Zygomatic arch
21. Coronoid process of mandible
22. Condyle of mandible
23. Paramastoid process
24. Occipital condyle
32. Mental foramen
33. Lacrimal foramen

FIGURE 3-19 *Skull of the horse.*

occipital condyles, which articulate with the atlas (C_1). Lateral to the condyles are the paramastoid processes, blunt bony prominences which project ventrally. The basilar part extends anteriorly from the floor of the foramen magnum and attaches to the posterior aspect of the sphenoid.

The squamous part of the occipital bone is a roughly semicircular mass that lies above the foramen magnum. The external surface has a prominent ridge, the nuchal crest. The anterior borders unite with the parietal, interparietal, petrous temporal, and squamous temporal bones.

The sphenoid bone lies along the floor of the cranium anterior to the basilar part of the occipital. It consists of three parts; the body, the wings, and the pterygoid processes.

The body is medial, cylindrical, and flattened dorsoventrally. The anterior part of the body is concealed to some extent by the vomer and pterygoid bones. The posterior end articulates with the basioccipital. The body is hollowed anteriorly by the sphenopalatine sinus, and contains the optic canals and the pituitary fossa on its dorsal aspect.

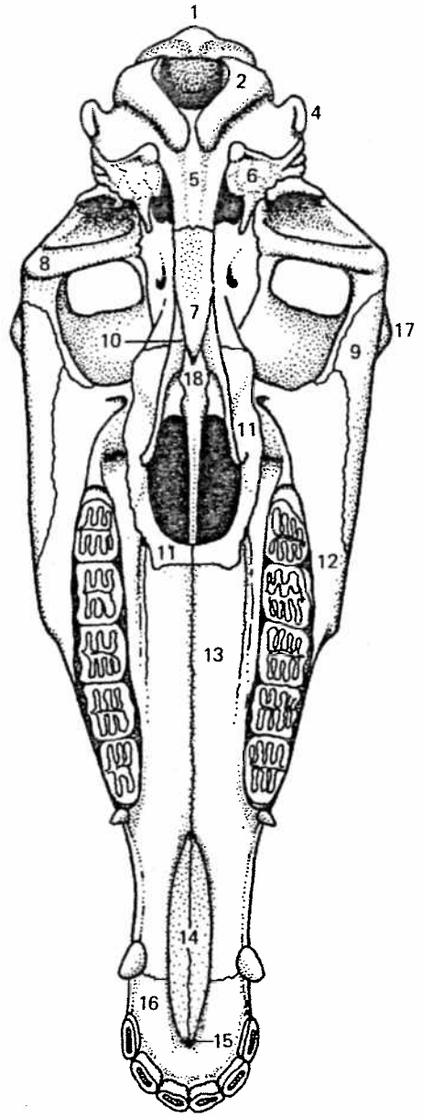
The wings are composed of two parts, the orbital wings, and the temporal wings. The orbital wings are larger and curve dorsolaterally from the sides of the presphenoid to unite dorsally with the frontal bone, anteriorly with the ethmoid bone, and posteriorly with the squamous temporal, and an overlapping portion of the temporal wings. The temporal wings extend laterodorsally from the postsphenoid to unite dorsally with the squamous temporal, anteriorly with the orbital wings, and posteriorly with the parietal bone. The pterygoid processes underlie the pterygoid bones.

The ethmoid bone is situated in front of the body and orbital wings of the sphenoid. It, too, consists of three parts; the cribriform plate, the lateral masses, and the perpendicular plate. The cribriform plate, a sieve-like partition, is located along a transverse plane between the cranial and nasal cavity. The lateral masses are cone-shaped structures composed of an extremely complex arrangement of coiled and folded sheets of thin bone covered with mucous membrane. The bases of the lateral masses are attached to the cribriform plate and are separated medially by the perpendicular plate. The entire complex that forms the lateral masses is called the ethmoid turbinates. Some 27 subsidiary parts have been recognized. Basically these consist of a primary group of 6 endoturbinates and a secondary group of 21 (or more) ectoturbinates. The perpendicular plate of the ethmoid is situated medially and runs along the median plane, and is continued anteriorly by the nasal septum.

THE PAIRED BONES OF THE CRANIUM

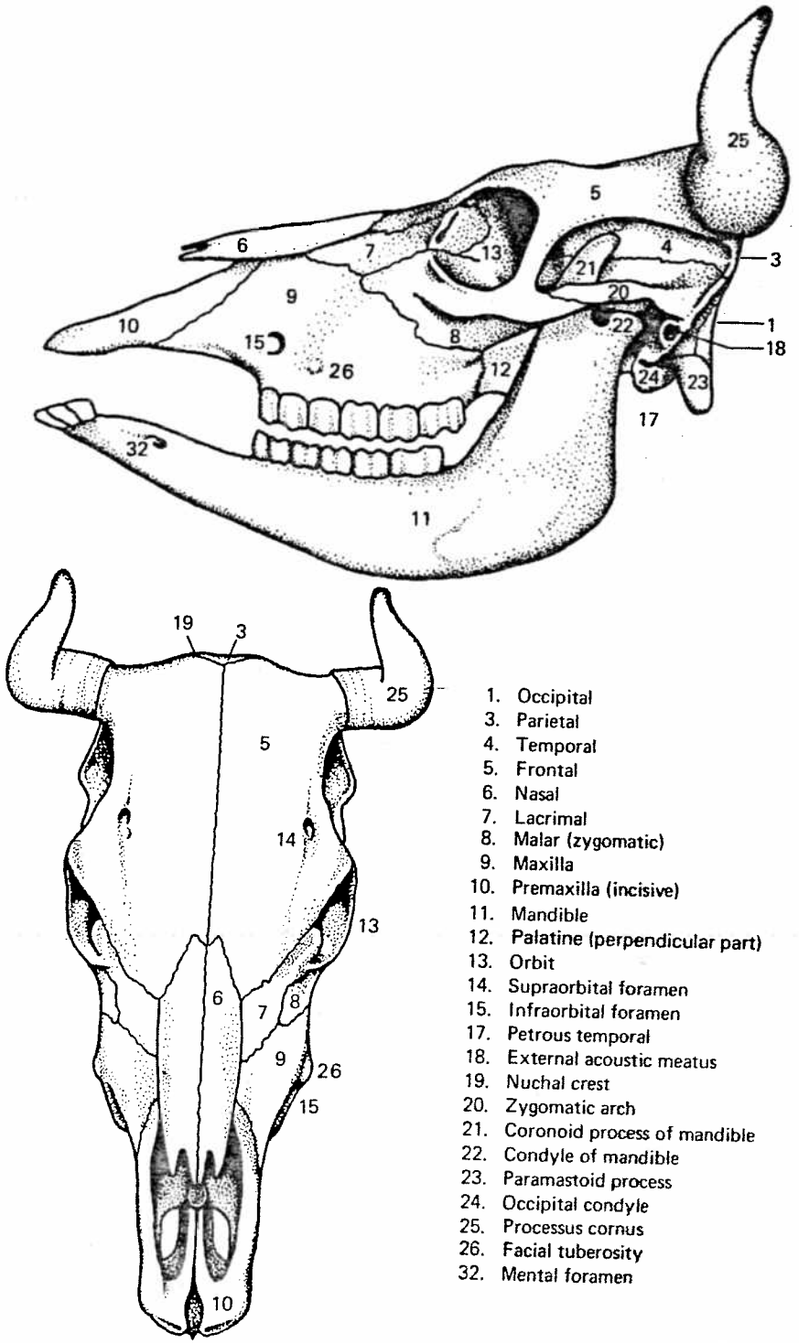
The interparietal bones are situated centrally between the squamous part of the occipital bone and the parietal bones. Generally there are two bones in the young, and one in the adult. They may be so completely fused to the parietal bones in older animals that they cannot be identified.

The parietal bones compose the greatest part of the vault of the cranium. They are quadrilateral in outline, and have two surfaces (outer and inner).



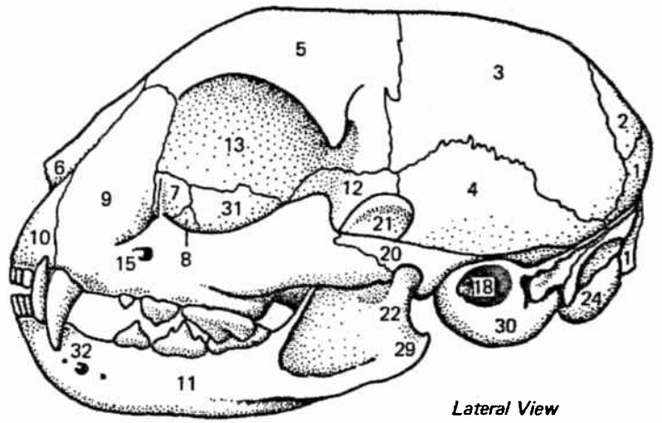
1. Nuchal crest
2. Occipital condyle
3. Foramen magnum
4. Paramastoid process
5. Basioccipital
6. Petrous temporal
7. Sphenoid
8. Temporal condyle
9. Malar (zygomatic)
10. Pterygoid
11. Palatine
12. Maxilla
13. Palatine process of maxilla
14. Palatine process of premaxilla
15. Foramen incisivum
16. Premaxilla (incisive)
17. Supraorbital process
18. Vomer

FIGURE 3-20 *Skull of the horse—ventral view.*



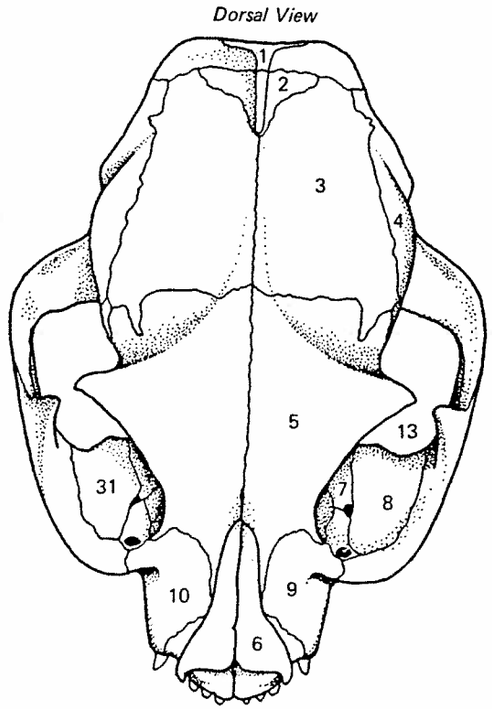
1. Occipital
3. Parietal
4. Temporal
5. Frontal
6. Nasal
7. Lacrimal
8. Malar (zygomatic)
9. Maxilla
10. Premaxilla (incisive)
11. Mandible
12. Palatine (perpendicular part)
13. Orbit
14. Supraorbital foramen
15. Infraorbital foramen
17. Petrous temporal
18. External acoustic meatus
19. Nuchal crest
20. Zygomatic arch
21. Coronoid process of mandible
22. Condyle of mandible
23. Paramastoid process
24. Occipital condyle
25. Processus cornus
26. Facial tuberosity
32. Mental foramen

FIGURE 3-21 Skull of the cow.



Lateral View

Dorsal View



1. Occipital
2. Interparietal
3. Parietal
4. Temporal
5. Frontal
6. Nasal
7. Lacrimal
8. Malar
9. Maxilla
10. Premaxilla
11. Mandible
12. Palatine
13. Orbit
15. Infraorbital foramen
18. External acoustic meatus
20. Zygomatic arch
21. Coronoid process of mandible
22. Condyle of mandible
24. Occipital condyle
29. Angular process of mandible
30. Tympanic bulla
31. Orbitosphenoid
32. Mental foramen

FIGURE 3-22 Skull of the cat.

with the squamous temporal bones. The anterior borders unite with the frontal bones. The posterior borders unite with the interparietals and the occipital bone.

The frontal bones are situated between the parietal, and the nasal bones at the border of the cranium and face. They enclose the frontal sinuses and consist of three parts: the nasofrontal, the orbital, and the temporal. The nasofrontal part forms the forehead. At its junction with the orbital part it gives off the supraorbital process. It unites with the zygomatic process of the temporal bones. The orbital part forms most of the medial wall of the orbit of the eye. It is separated from the nasofrontal part by a ridge that forms the dorsal margin of the optic cavity. The temporal part is separated from the orbital part by a groove that is covered by the orbital wing of the sphenoid.

The temporal bones form the greater part of the lateral wall of the cranium. They are bounded dorsally by the parietal bones, ventrally by the temporal wings of the sphenoid bone, anteriorly by the frontal and malar bones, and posteriorly by the occipital bone.

In the horse the temporal bones consist of two parts, the squamous temporal and petrous temporal. The squamous temporal bone is the larger of the two. From the ventrolateral surface of this bone the zygomatic process extends to join the posterior end of the malar bone and form the zygomatic arch. The zygomatic process bears a condyle and a glenoid cavity for articulation with the mandible. The petrous temporal bone is characterized by the presence of the external acoustic process and the opening in it, which is called the external acoustic meatus. The petrous temporal bone lies between the occipital and squamous temporal bones, and covers the mastoid processes and the structures of the middle ear. It is extremely dense and hard.

THE BONES OF THE FACE

The bones of the face consist of the following single and paired bones:

SINGLE BONES	*PAIRED BONES*
1. Vomer	1. Maxilla
2. Mandible	2. Premaxilla (incisive)
3. Hyoid	3. Palatine
	4. Pterygoid
	5. Nasal
	6. Lacrimal
	7. Malar (zygomatic)
	8. Dorsal turbinates (conchae)
	9. Ventral turbinates (conchae)

part of the septum nasi. It is grooved to receive the perpendicular plate of the ethmoid bone and the septal cartilage. The anterior extremity lies above the palatine process of the premaxilla.

The mandible is the largest bone of the face and forms the lower jaw. It is composed of two halves, which fuse anteriorly at the symphysis mandibulae and is considered as a single bone thenceforth. It contains the lower teeth, and articulates with the squamous temporal at the condyloid fossa. It consists of a body and two rami, and possesses two pair of major foramina; the mental foramina, which are located laterally on the body, midway between the first premolars and the canine teeth, and the mandibular foramina, which are located medially about halfway up the rami.

In the horse the hyoid bone is composed of 12 distinct parts, the styloid cartilages (2), the great cornu (2), the middle cornu (2), the small cornu (2), the body (1), the thyroid cornu (2) and the lingual process (1).* The temporal cartilages attach the hyoid to the styloid processes of the right and left petrous temporal bones. The various components of the hyoid are united by cartilage. Although technically the hyoid is a single bone, in actuality it is not. It supports the base of the tongue, pharynx and larynx, and through its cartilagenous "joints" aids the swallowing and breathing processes. Hyoids are similar in all domestic mammals, although the cat and dog do not possess a lingual process.

THE PAIRED BONES OF THE FACE

The maxillae form the basal part of the upper jaw and contain the sockets of the upper cheek teeth and canines. They articulate with almost all the facial bones, and the frontal and temporal bones of the cranium. They each consist of a body, zygomatic process, and palatine process, and enclose the maxillary sinuses. They possess two major foramina (the infraorbital foramina) which open on the lateral surfaces about three inches above the third premolars.

The premaxillae form the anterior part of the upper jaw and sockets for the incisor teeth. They articulate with the maxillae and nasal bones, and unite with each other anteromedially at the premaxillary symphysis. They each consist of a body, palatine process, and nasal process, and unite to form one major foramen, the foramen incisivum, which opens anteriorly on the line of union and lies dorsal to the central incisors.

The palatine bones are located on the sides of the posterior nares. They consist of two parts; a horizontal part (hard palate), and a perpendicular part which forms the majority of the lateral walls of the posterior nares.

The pterygoids are two very small flattened bones situated on either side of the posterior nares.

*Newer veterinary terminology calls these divisions of the hyoid the tymphanohyoid, stylohyoid, epihyoid, ceratohyoid, basihyoid, thyrohyoid, and lingual process.

The nasal bone forms the major portion of the roof of the nasal cavity. It is located anterior to the frontal bone and is triangular in outline, wide posteriorly, and narrow anteriorly. It forms the dorsal part of the nasal cavity.

The lacrimal bones are found in the anterior part of the orbit of the eye. They possess three surfaces; the facial surface, orbital surface, and nasal surface. The lacrimal bones are perforated by the lacrimal foramina which penetrate the orbital surfaces and form the posterior portions of the lacrimal ducts, which extend from the eyes to the anterior nares.

The malar bones (zygomatic bones) are ventral to the lacrimals. They possess three surfaces; the facial surface, orbital surface, and nasal surface. The posterior portion of the malars unites with the zygomatic processes of the squamous temporals to form the right and left zygomatic arches.

There are four turbinate bones arranged in two pairs, dorsal and ventral. These pairs are attached to the middle of the lateral walls of the nasal cavity and project into it, filling most of the open space. The dorsal turbinates are larger than the ventral. The bones are very thin and are rolled into a scroll-like formation, which is covered with mucous membrane. By their arrangement with each other and with other bones, they form four channels in the nasal cavity; the dorsal nasal meatus, the middle nasal meatus, the ventral nasal meatus, and the common nasal meatus. The dorsal meatus is the space between the dorsal turbinate and the nasal bone. The middle meatus separates the ventral turbinate and the palatine processes of the premaxilla and maxilla. The common meatus separates each pair of turbinates from the septum nasi and vomer bone. The ventral meatus lies between the ventral turbinates and the palatine processes of the premaxilla and maxilla.

THE VISCERAL SKELETON

The visceral skeleton is extremely variable in animals. It consists of bones that are developed in the soft tissues of the body. Among the domestic animals only a few species possess a visceral skeleton and one of these is open to question. The bones generally conceded to belong to the visceral skeleton are the os cordis, and the os penis. The os rostri of the pig is open to question as it is apparently derived from the nasal septum.

BONE	*LOCATION*	*SPECIES*
1. Os rostri	in the soft tissues of the external nares	Swine
2. Os cordis	around the origin of the aorta and pulmonary artery at the base of the heart	All members of the bovine family (*bovidae*) and sheep (*ovidae*)
3. Os penis	within the penis	All members of the dog family (*canidae*) Members of the mink family (*mustellidae*) Some rodent species (*rodentia*) Seals, walruses, and raccoons

chapter 4

Arthrology (Syndesmology)

There is a certain confusion of terms insofar as this chapter is concerned. At the moment "syndesmology" is the accepted term in the newer veterinary texts. "Arthrology" is the preferred term in human anatomy. Nomenclature committees have been waffling over these terms since 1893 when "syndesmology" was proposed as the name for the study of joints. Although the term is semantically incorrect, "syndesmology" persists in the literature because an initial name always carries some weight.

Arthrology literally means "the study of joints." Joints are divided into three major classes: synarthroses (immovable joints), diarthroses (movable joints), and amphiarthroses (partially movable joints).

Joints are formed when two or more bones come together and are united by fibrous, elastic, or cartilagenous tissue (or by a combination of two or more of these three uniting media).

Here, I think, I had better warn you that if you read beyond this text, you are going to have problems with terminology. Anatomy is passing through a period of change where—in an effort to standardize nomenclature—an international naming organization (the Nomina Anatomica) has settled upon Latin as the language of choice for Anatomy. There is a certain deadly parallel in this since Latin is static, dead and cumbersome, yet it is preferable to books whose authors believe they have carte blanche to alter terminology. An example of Latin terminology is given in Figures 5-2, 5-3, 5-4, 5-5 on pages 100-103.