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McFADYEAN'S

OSTEOLOGY & ARTHROLOGY

OF THE DOMESTICATED ANIMALS

MADE IN GREAT BRITAIN

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OF THE DOMESTICATED ANIMALS

FOURTH EDITION

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PREFACE

It was in 1887 that John McFadyean first published "The Comparative Anatomy of the Domesticated Animals—Part I, Osteology and Arthrology". The author planned to complete this work on Veterinary Anatomy by issuing a second volume, but his interest in the histological aspect of the subject attracted him to the study of Comparative Pathology, in which field he was later to become renowned, and his intentions in this respect were never fulfilled. Part I, however, passed through three editions during his lifetime, the last being in 1934.

During the last few decades what may be described as the food-producing species have assumed an increasingly important rôle in our national economy, with the result that the horse is no longer considered to be the chief concern of the Veterinary profession as it was when the work first appeared. Nevertheless, the Editors are of the opinion that the horse still remains the most valuable type animal for the study of Veterinary Anatomy, and for this reason it has been decided to prepare yet another edition for the use of students of Veterinary Science and others interested in Comparative Anatomy with no radical changes in the presentation of the subject. As in previous editions, the bones and joints are described in detail as they occur in the horse as the type, whilst the characteristic features of these structures in the other domestic animals are dealt with as they compare or contrast with those of the horse.

The Editors accept joint responsibility for the present work, but it should be stated that one of us (H.V.H.) has been largely concerned with the matter of the text, whereas the other (J.W.D.) has prepared the drawings from which the illustrations were made.

The original text has been thoroughly revised, and whilst it will be appreciated that in dealing with a number of different species it is impossible to be entirely consistent in the matter of terminology, it is hoped that the attempt to bring the nomenclature into line with modern trends will be acceptable to readers. More attention has been given to the development of the bones and it will be noted that in the consideration of this matter the bones of the various regions have been grouped together with a view to the presentation of a more consecutive account of this aspect of the subject.

It was found necessary to produce an entirely new series of figures and the number has been increased from 151 to 205. Most of the structures which were illustrated in the original work are represented in this edition, and the new figures which have been included refer particularly to the anatomy of the ox, pig and dog. The original drawings were made from specimens prepared by Mr. T. S. Fleming, Senior Technician in the Department of Veterinary Anatomy, University of Liverpool, to whom the warmest thanks of the Editors are due for his willing co-operation.

It is hoped that the Index, which has been lacking in previous editions, will be found useful for reference.

Lastly the Editors would wish to express their indebtedness to the Publishers who, throughout the preparation of the work, have afforded them every possible assistance in their endeavour to make this edition worthy of its predecessors.

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April 1953.

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INTRODUCTION

THE study of the bones is termed **Osteology,** and since bones form the framework of the vertebrate animal body it is natural that in the study of **Systematic Anatomy**—that method of study whereby the different groups, or systems as they are called, of similar organs are studied separately—the system of bones should receive first

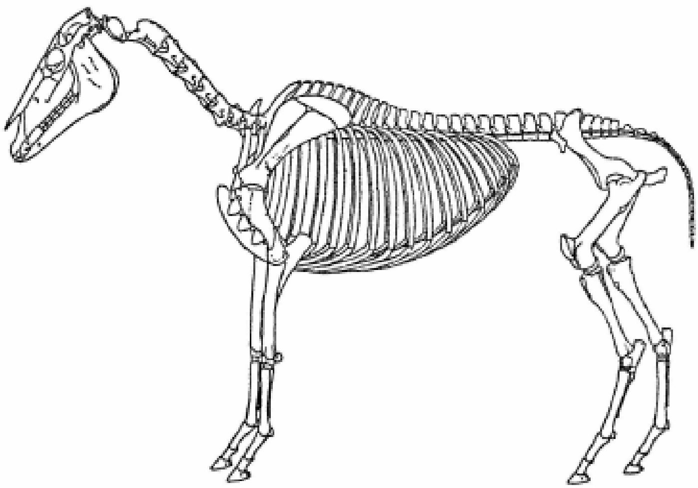


FIG. 1.—SKELETON OF HORSE

consideration. **Arthrology,** or the study of how bones are united together at the various joints or articulations, may well be considered next.

The following pages then are intended to present an introduction to the systematic anatomy of the common domesticated animals. These animals are included in two of the five classes into which the vertebrate group of animals is divided, viz. Aves and Mammalia.

The **Aves,** or birds, have been defined as air-breathing, homoiothermic, or warm-blooded, vertebrates which have epidermal appendages of the structure of feathers and which are always oviparous. They resemble the mammalia in being air-breathing and homoiothermic and in having a four-chambered heart, but their closest affinities are with the Reptilia with which they agree in having a single occipital condyle, the ankle joint in the middle of the tarsus, a single auditory ossicle, and oval nucleated red blood corpuscles.

Existing birds have been divided into two main groups, viz. the Ratitae and the Carinatae. The group of **Ratitae** comprises the running birds, e.g. the ostriches, kiwis and cassowaries, in which the sternum is flat or raft-like. In the **Carinatae** are grouped all the other existing birds. These are flying birds, and in them the sternum is provided with a pronounced mesial ridge or keel for the attachment of the pectoral muscles used for flight.

The **Mammalia** are air-breathing, homoiothermic, viviparous (except the *Prototheria* or *Monotremata*, e.g. the duck-billed platypus of Australia, which is oviparous) vertebrates with epidermal appendages in the form of hairs, which nourish their young

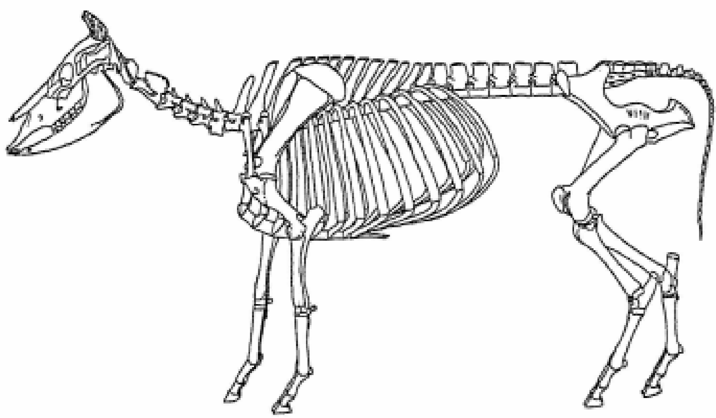


FIG. 2.—SKELETON OF OX

for a variable period after birth on the secretion of special glands termed the mammary glands. They differ further from the Aves in the possession of a perfect diaphragm, two occipital condyles, non-nucleated red blood corpuscles, and a band of transverse fibres, the corpus callosum, uniting the two cerebral hemispheres of the brain.

The existing Mammalia are divided into eleven orders, but the following two include all the ordinary domestic mammals.

1. Order **Ungulata.** In this order are included all the common domestic mammals except the dog and cat. All the members of the order agree in having their back teeth adapted for crushing and grinding their food, in being destitute of a clavicle, in never possessing five digits, and in having the terminal bone of each digit invested by a thick horny sheath or hoof. As a further character it may be mentioned that the stomach and intestines are relatively capacious. The existing Ungulata are divided into four sub-orders, of which two, the Perissodactyla and the Artiodactyla, include domesticated animals.

(*a*) Sub-Order **Perissodactyla,** or odd-toed ungulates. In this sub-order are included the horse, the ass, the zebra, the quagga, the rhinoceros and the tapir. In all of these the hind feet are odd-toed (one or three), and in general the fore feet also. The femur has a third trochanter, the thoracic and lumbar vertebrae together are not fewer than twenty-two, and the stomach forms a single undivided sac. When horns are present, as in the rhinoceros, they are mesially placed.

(*b*) Sub-Order **Artiodactyla,** or even-toed ungulates. In these the digits are either two or four in each extremity, the thoracic and

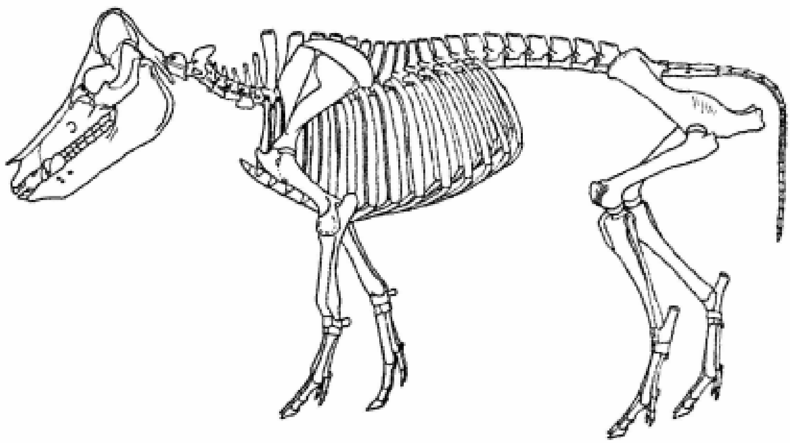


FIG. 3.—SKELETON OF PIG

lumbar vertebrae are together always fewer than twenty-two, the femur is devoid of a third trochanter, and the stomach is more or less sub-divided. The Artiodactyla have been divided into two groups, the Ruminantia and the Non-Ruminantia.

The **Ruminantia**. This group includes the ox, the sheep, the goat, the camel, and all other animals that ruminate or chew the cud. In these animals the stomach comprises three or four compartments, the front of the upper jaw is usually devoid of teeth, and bilaterally paired horns are usually present.

The **Non-Ruminantia.** In this group are included the pig, the peccary, the hippopotamus, etc. These ungulates do not chew the cud, the stomach is simpler than in the Ruminantia, and the front of the upper jaw carries teeth.

2. Order **Carnivora.** This order includes the dog, the cat, the seal, the walrus, and the great majority of the terrestrial beasts of prey. In all the members of the order canine, incisor, and molar teeth are present, and the canines are always distinguishable from

the other teeth by their size and form. The back teeth are more or less adapted for cutting or tearing an animal diet. Clavicles are

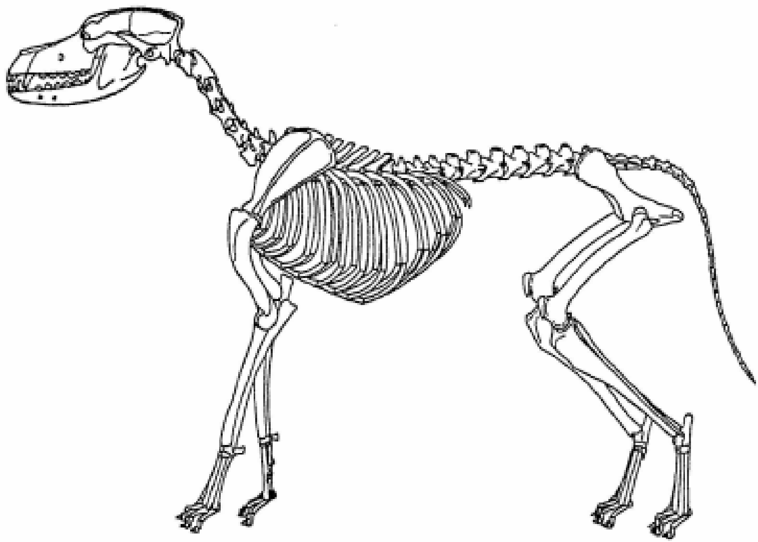


FIG. 4.—SKELETON OF DOG

absent or rudimentary, the scaphoid and lunate bones of the carpus are fused together, and the extremity of each digit is provided with a claw. The stomach is simple, and the capacity of the intestines relatively small.

Descriptive Terms

In the description of the bones which follows, the animal is assumed to be in the ordinary standing position. The surface or extremity directed towards the ground is termed **inferior,** as distinct from **superior** which faces in the opposite direction. These terms are sometimes used synonymously with the terms **ventral** and **dorsal** respectively. A plane extending through the length of the body dividing it into like halves is known as a **median** or **mesial** plane. That portion of a bone which lies in relation to the median plane is **medial** in contrast with the more distant portion which is **lateral.** Structures lying towards or away from the central axis of a limb are termed **axial** and **abaxial** respectively. The terms **external** and **internal** are used to describe the relationship of parts of a bone towards the centre of a cavity, e.g. the pleural cavity in the case of the ribs, or the cranial cavity in the case of some of the bones of the skull. In the same sense one may use the terms **superficial** and **deep** respectively. The **anterior** surface of a bone lies in front and is directed towards the head end of the body. The back of a bone, directed towards the tail end, is termed the **posterior** surface.[1] The words **dorsal** and **volar** are sometimes used in the description of bones of the limb as alternatives to the words anterior and posterior respectively. In descriptions of the limb bones, too, the terms **proximal** (nearer to) and **distal** (further away from) are used to indicate the relative distance from the root of the limb.

A number of terms are used to describe the various prominences, depressions, expansions, ètc., of bones. For example, the term **process** is used generally to describe a projection or outgrowth. A **spine** is a sharp, often pointed, projection, whilst a **crest** is a sharp, roughened ridge. A large rounded projection, which may be roughened or smooth, is termed a **tuberosity,** a smaller variety being designated a **tubercle.** A **foramen** is an opening, and a narrow passage leading from such an opening is referred to as a **canal.** A depression, or pit, or cavity is known as a **fossa,** the term **fovea** being used to denote a small pit. A **facet** is a small, usually flattened, articular surface. A larger rounded articular projection is termed a **condyle,** or, if pulley-like, a **trochlea.**

[1] The terms *cranial* (towards the head end of the body) and *caudal* (towards the tail end) are used by some authors synonymously with the terms anterior and posterior respectively.

SECTION I

OSTEOLOGY

CHAPTER I

GENERAL CONSIDERATIONS REGARDING THE BONES

THE SKELETON

THE framework of relatively hard textures, serving for the support and protection of the softer and more delicate parts of an animal constitutes its **skeleton.** In the case of the adult horse or other domesticated animal, the skeleton is the connected framework formed by the bones, with the addition at a few points of certain elements which retain the structure of cartilage. This framework is embedded within the softer parts of the body, and it is therefore termed an **endo-skeleton.** Such a skeleton in a more or less complete form is found throughout the vertebrate sub-kingdom. Among the invertebrata, on the other hand, the skeleton is very commonly placed superficially to the softer parts, as is the case in the lobster, for example, and a protective framework of this type is termed an **exo-skeleton.**

The skeleton of a horse or other mammal comprises an **axial** portion, forming the bony framework of the head, trunk and tail, and an **appendicular** portion, belonging to the limbs. Occasionally a bone is found detached from the general framework and embedded in some soft organ. To this the term **splanchno-skeleton** is applied, examples of which are furnished among the domestic animals by two small bones in the heart of the ox **(ossa cordis)** and one in the penis of the dog **(os penis).**

Before proceeding to the detailed description of the individual bones of the skeleton, it is desirable, as an introduction to the study of Osteology, to devote some space to the consideration of bones in general.

THE CLASSIFICATION OF BONES

It is customary to divide the bones according to their general shape into four classes.

(1) Long Bones

A long bone may be defined as one that possesses a **medullary** or **marrow cavity.** In general they are notably extended in one dimension, so that their length considerably exceeds their breadth or thickness. In every long bone there are recognised a central part termed the **shaft,** or **body,** and two **extremities.** The shaft is a hollow, bony cylinder surrounding the medullary cavity, which in the recent state is occupied by the **medulla** or **marrow.** The long bones are found exclusively in the limbs, and their form specially adapts them for bearing weight, for, with a given amount of material to be made into a pillar or support, the maximum strength is obtained when that material is made into the form of a hollow cylinder. They also provide the levers necessary for locomotion. Examples are the humerus, the radius, the femur and the tibia.

Some bones, although notably extended in one dimension, are yet devoid of a medullary cavity, and hence do not strictly conform to the definition of a long bone. An example is furnished by the ribs, and these are sometimes regarded as forming a separate class termed **elongated bones.** In some cases, however, the medullary cavity in bones of an elongated form is very small or even absent owing to arrest of development. The small metacarpal bones and the fibula of the horse, for example, are in reality long bones in a suppressed state of development.

(2) Flat or Tabular Bones

The bones of this class are extended in two dimensions in excess of the third, and they are therefore more or less plate-like. This flattening of bones may have for its object either to give an increase of surface for the attachment of muscles, as with the scapula, or to afford protection to subjacent structures, as in the case of the parietal and frontal bones of the cranium.

(3) Short Bones

The bones of this class are all of comparatively small size, and they generally approach the cubical in form. Examples are furnished by the bones of the carpus and tarsus. These collections of short bones play an important rôle in diminishing the risk of injury from concussion, for, by multiplying joints, they serve to distribute weight and pressure. In this class may be included the **sesamoid bones.** These are small bones situated near joints, their purpose being to give increased leverage to muscles with the tendons of which they are associated. The patella is a typical sesamoid bone.

(4) Irregular Bones

These bones, as the name of the class implies, are of very irregular shape, their irregularity being due to the projections or processes which are distributed over their surface. The majority of them are placed in the median plane, and are therefore symmetrical in themselves, and unpaired, while most of the bones of the other classes are paired bones, there being one of each on either side of the body. The vertebrae are examples of irregular bones.

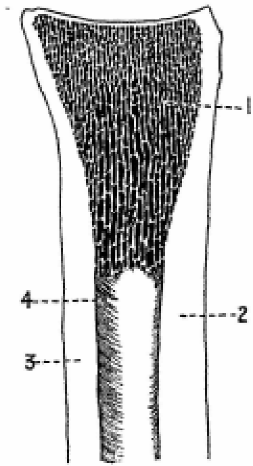
THE STRUCTURE OF BONE

A section through almost any bone of the body reveals the fact that two varieties of bone texture enter into its composition. These are termed compact tissue and spongy tissue.

Compact tissue is dense and close-grained. It forms an outer shell of varying thickness in all the bones. In long bones it occurs in greatest amount in the shaft, the centre of which is composed

FIG. 5.—LONGITUDINAL SECTION OF UPPER HALF OF LARGE METACARPAL BONE

1. Spongy tissue of superior extremity. 2. Thick layer of compact tissue on anterior aspect of shaft. 3. Thinner layer of compact tissue on posterior aspect of shaft. 4. Medullary cavity.



almost exclusively of this variety of tissue. As it is traced away from the centre of the shaft, its thickness gradually diminishes, until over the extremities of the bone it forms a mere shell enclosing a mass of spongy tissue. Compact tissue, it need hardly be said, is strong and resistant, and hence it is found aggregated in positions where there is the greatest strain on the bone. In illustration of this it ought to be observed that not only is the compact tissue thickest towards the centre of the shaft, where the bone would be most likely to give way under pressure, but that it is of unequal thickness on the two sides of the shaft. Thus, in the case of the large metacarpal bone of the fore limb of the horse, the layer on the front of the shaft is greater than that behind, and there is a greater thickness medially than laterally, in correspondence with the lines along which the weight of the body chiefly falls. In the other classes of bones the thickness of the outer shell of compact tissue varies in an irregular manner, but it never attains the proportion seen in the shaft of long bones.

Spongy tissue is light and porous in appearance. On close inspection it is seen to be composed of a multitude of little intersecting osseous plates, or **trabeculae,** surrounding spaces that are filled in the fresh bone by red marrow. In a long bone there is scarcely any spongy tissue at the centre of the shaft, but towards the ends of the marrow cavity it forms a lining of increasing thickness for the compact tissue, and it is responsible for nearly the total mass of the expanded extremities of the bone. This variety of bone texture is much less resistant than the compact, but from its lightness it is well adapted for giving to the extremities the expansion that is necessary to confer stability on the joints, without unnecessarily adding to the weight of the bones. Its trabeculae, too, are so arranged that they enable the bone to withstand the variety of stresses to which it may be subjected.

In the flat bones a varying thickness of spongy tissue nearly always intervenes between the two layers of compact bone, but at some points the spongy tissue may be very sparing in amount, or even entirely absent. The main mass of short and irregular bones is formed by spongy tissue, always, however, with an enveloping shell of compact bone.

In the bones composing the roof and lateral walls of the cranium the compact and spongy tissues are arranged in a way that calls for special notice. These bones are composed of three layers of different density, viz. (1) an outer layer of compact bone of moderate density, (2) a middle layer of spongy tissue, here termed **diploë,** and (3) an inner layer of compact tissue, thinner than the outer layer, and so dense and hard that the term **tabula vitrea** or **glassy layer** has been applied to it. In this arrangement there is apparent an admirable provision for lessening the risk of injury to the brain from blows delivered over the skull.

THE PHYSICAL PROPERTIES AND CHEMICAL COMPOSITION OF BONE

Bones are of a whitish colour, with a tinge of yellow unless they have been artificially bleached. When exposed in the living body the white is tinged with bluish pink, from the blood contained in the vessels of the bone.

Bone tissue is hard and resistant, these properties being indispensable in objects that are to be used for support or for the protection of delicate parts. At the same time even the hardest bones of the skeleton possess some degree of elasticity and toughness. The latter qualities are much more marked in some bones than in others. The ribs, for example, are the most elastic bones in the body, but the long bones of the limbs possess considerable pliability and elasticity. These characteristics are of the greatest importance, for shocks and jars are thereby broken, and the liability to fracture is greatly diminished.

With regard to the chemical composition of bone, it has been ascertained that bones are composed of solids and water in proportions which vary very considerably. The amount of water in fresh bone tissue may reach 50 per cent., but a representative figure would be about 25 per cent. The chemical composition of individual bones will depend upon their histological structure and upon such factors as the proportion of compact to spongy bone, or of yellow to red marrow. Generally speaking dried, marrow-free bone tissue consists of about two-thirds inorganic matter and one-third organic matter. The inorganic matter consists of various mineral salts chiefly calcium phosphate (about 85 per cent.), calcium carbonate (about 12 per cent.), and small amounts of magnesium phosphate, calcium fluoride and magnesium carbonate. There are also traces of chlorine, sodium, potassium, lithium and strontium. In the case of fowls' bones the proportion of calcium phosphate is somewhat higher. The chief physical properties of bones are largely dependent upon the proper admixture of their organic and inorganic constituents. To the inorganic salts are due the hardness, rigidity and strength of bones; while, on the other hand, their pliability and elasticity result from the presence of the organic matter.

By burning a bone in a furnace the whole of the organic matter is consumed, and it becomes white and chalky. In the process of combustion the bone loses about one-third of its weight, and it becomes completely deprived of its elasticity. By prolonged boiling of bones most of the organic matter can be extracted in the form of gelatin.

By steeping a bone in a dilute solution of hydrochloric acid the inorganic salts can be dissolved out, the bone in the process losing about two-thirds of its weight. At the same time the rigidity and weight-supporting power of the bone are lost, and it becomes supple and pliable.

It is believed that a continuous cycle of wear and replacement of bone occurs throughout life and it is likely that bones form an alkali reserve for the tissues of the body. In young animals and in certain diseased states, e.g. rickets and osteomalacia, the bones may undergo a process of decalcification as a result of a deficiency of calcium, phosphates and vitamin D in the other tissues of the body.

The rigidity of the bones is then greatly diminished, and they become distorted under the weight of the body or the traction of the muscles attached to them. In old animals, on the other hand, and also in some pathological conditions, the elasticity of the bones is markedly diminished, and their liability to fracture greatly increased. These differences in the physical properties of bone are generally ascribed to a disturbance of the proper proportion in which the inorganic and organic ingredients are combined in a state of health, but in part they may be due to variations in the relative amounts of compact and spongy tissue, an excess of the former rendering the bones more brittle, while an undue preponderance of spongy tissue would tend to make them more yielding.

THE MINUTE STRUCTURE OF BONE

When the outer surface of the shaft of a macerated and dried long bone is examined under low magnification, it shows a great many point-like openings, which are the mouths of fine canals of the compact tissue. These are the so-called **Haversian canals,** which permeate the entire thickness of the shaft. The direction of the main canals is longitudinal, but the ends of adjacent canals are connected by oblique or transverse branches. The outermost canals of the shaft open by one mouth on the free surface, while the deepest open in the same way into the medullary cavity, or into one of the spaces of the spongy tissue.

In a magnified transverse section of dried bone the compact tissue is seen to be arranged in the form of complete or imperfect rings, or lamellae. A variable number of such rings encircle in a concentric manner the mouth of each Haversian canal. These are the so-called **Haversian lamellae,** and each canal with its encircling lamellae constitutes a **Haversian system.**

In the angular spaces left between adjacent Haversian systems, there are other lamellae that look like fragments of larger systems. These are the so-called **interstitial lamellae.** Lastly, at the exterior of the shaft of a long bone a variable number of **circumferential lamellae** may be disposed parallel to the surface. These are sometimes referred to as **primary lamellae,** in contradistinction to the lamellae surrounding the Haversian canals in the deeper layer which may then be termed **secondary lamellae.**

The matrix or ground substance of a bone lamella is a fine fibrous reticulum, impregnated with lime salts. Here and there calcified nail-like processes pass from the surface inwards through the circumferential lamellae, which they appear to bolt together. These are the **perforating fibres of Sharpey**.

In a transverse section of dried bone viewed under the microscope by transmitted light, a number of dark spots are seen along the lines of apposition of adjacent lamellae. These are the **lacunae,** which in reality are empty spaces in the macerated and dried bone. Numerous fine **canaliculi** radiate from each lacuna, and, piercing the lamellae, unite with like canals from the neighbouring lacunae of the same system. The central canaliculi from the innermost row of lacunae in a Haversian system open into the Haversian canal.

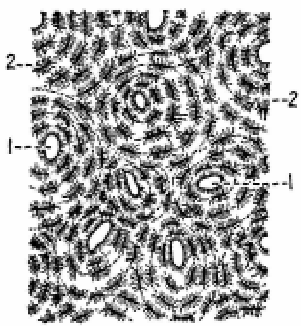


FIG. 6.—TRANSVERSE SECTION OF COMPACT BONE TISSUE
1. Haversian canals surrounded by Haversian lamellae. 2. Lacunae with canaliculi.

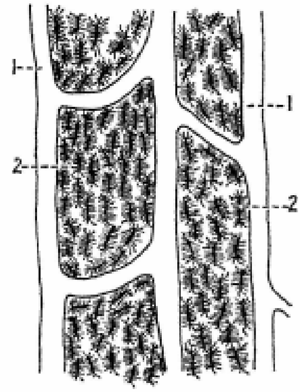


FIG. 7.—LONGITUDINAL SECTION OF COMPACT BONE TISSUE
1. Haversian canals. 2. Lacunae with canaliculi.

The structure of spongy tissue differs from that just described chiefly in the absence of Haversian canals in the thinnest plates of bone. The thin intersecting bars and plates are composed of irregular groups of lamellae, with intervening rows of lacunae and canaliculi, the innermost of which open into the spaces of the spongy bone. The honeycomb cavities of spongy tissue are termed **Haversian spaces.**

THE SOFT STRUCTURES ASSOCIATED WITH BONE

The foregoing description applies to the structure of a macerated and dried bone, but such a bone has been deprived of a number of highly important soft structures which must now be considered.

The Periosteum

This is a thin membrane which invests the outer surface of a bone everywhere except at articular surfaces and where tendons are attached. It comprises (1) a dense outer layer of white fibrous tissue, and (2) an inner layer of fine elastic fibres. In youth, when bones are growing, the periosteum is thicker and more vascular than is the case in later life, and it is separated from the bone by a so-called osteogenetic layer containing a number of granular cells which are directly concerned in the formation of new bone and which are therefore termed **osteoblasts.** From the vessels of the periosteum a fine branch passes into the open mouth of each Haversian canal, carrying with it a delicate prolongation from the osteogenetic layer.

The Bone Cells

In the fresh bones the lacunae are not empty spaces. Each is occupied by a nucleated cell from the periphery of which slender branching processes pass into the canaliculi. These are the so-called **bone cells** or **osteocytes.**

The Marrow

There are two varieties of marrow—yellow and red. The amount of **yellow marrow** increases with age. At birth the spaces of the spongy bone are everywhere filled with red marrow. In early youth yellow marrow appears in the medullary cavity of long bones and gradually replaces the red marrow until it occupies even their extremities. Yellow marrow also fills the spaces of the spongy tissue of the short bones, e.g. carpus and tarsus, but red marrow persists in the vertebrae, sternum, ribs and skull bones. Yellow marrow is composed principally of groups of fat cells supported by delicate vascular connective tissue. Interspersed through it are a few so-called **marrow cells,** or **myelocytes,** which are the precursors of the granular leucocytes of the blood.

Red marrow contains few fat cells, and it is of a reddish tint. The most abundant elements in it are the marrow cells. Scattered among these are other cells conspicuous for their large size and the numerous fused nuclei which they contain. These are the **giant cells,** or **myeloplaxes.** The red marrow also contains a large number of faintly coloured nucleated cells, termed **erythroblasts,** which are the progenitors of red blood corpuscles. A further variety of cell is one which resembles a small lymphocyte of the blood. These last are generally regarded as being carried into the marrow by the blood stream from their seat of origin, viz. the lymphoid tissue.

The delicate vascular tissue lying on the surface of the trabeculae of the spongy tissue, and lining the medullary cavity, is sometimes termed the **endosteum,** but it cannot be detached as a distinct membrane like the periosteum.

The Vessels of Bone

Bones are highly vascular. As already mentioned, each Haversian canal contains delicate vessels. These are in communication outwardly with the periosteal vessels, and inwardly with the vessels of the medulla. Numerous fine vessels ramify on the surface of the trabeculae of the spongy tissue and pass into the red marrow. At the extremities of some of the long bones there are numerous large foramina for the passage of vessels. Some of these transmit arteries, but the majority of them give exit to large veins returning blood from the spongy tissue. The shaft of each long bone is penetrated by a foramen, the so-called **nutrient foramen** through which runs a considerable artery commonly known as the **nutrient artery.** This vessel has also been termed the **medullary artery,** since it is chiefly expended in supplying the vessels of the yellow marrow. The nutrient artery is always directed towards that extremity of the bone which first joins the shaft during the process of ossification. One or two satellite veins run in company with the nutrient artery.

Lymph vessels form a network in the periosteum. Each Haversian canal contains one or two lymphatic vessels in company with the blood vessels. These Haversian lymphatic vessels are in communication with the canaliculi and lacunae, which thus serve as a series of irrigating canals for each Haversian system. Doubt exists as to whether lymphatic vessels occur in the bone marrow or not.

The Nerves of Bone

Both compact and spongy tissue, and also the marrow of bones, contain nerve fibres, which, however, appear to appertain chiefly to the blood vessels of these tissues. A considerable nerve generally accompanies the nutrient artery, and finer filaments enter along with the periosteal vessels.

Cartilage

Cartilage, or gristle, is a variety of connective tissue which is closely associated with bone. It is very abundant in the young animal for it is present in many situations where bones will subsequently develop, the cartilage in fact being to a greater or lesser extent replaced by bone. It is a firm elastic tissue, largely composed of collagen, and consisting of varying proportions of fibres and cells lying in a homogeneous matrix. A vascular fibrous membrane termed the **perichondrium** covers the surface of the cartilage (except at joint surfaces) and it is believed that its nourishment is derived from the vessels of this membrane. Three varieties of cartilage exist, viz. (1) hyaline cartilage, (2) white fibro-cartilage and (3) yellow fibro-cartilage.

(1) Hyaline Cartilage.—This form of cartilage is bluish-white in colour, and whilst it is elastic, it is relatively hard and firm in consistency. It occurs in developing bones where it is gradually replaced by bony tissue except at the articular surfaces where it persists throughout life, as the so-called **articular cartilage.** Other sites of hyaline cartilage are the downward prolongations of the ribs, termed the costal cartilages, and the cartilage lying between the several segments of the sternum. Hyaline cartilage has a clear transparent, or slightly granular, matrix without definite structure, but scattered throughout this matrix are numerous cells often arranged in pairs. Fine fibrils can also be discerned in the matrix.

(2) White Fibro-Cartilage.—This differs from hyaline cartilage in having a greater preponderance of white fibrous tissue, and it is for this reason tougher and more flexible. It is the main constituent of the intervertebral discs which separate the individual vertebrae, and other examples of the occurrence of the tissue are in the semilunar cartilages of the stifle joint, and the complementary cartilage of the first interphalangeal joint.

(3) Yellow Fibro-Cartilage.—Composed of cartilage with an admixture of yellow elastic fibres, this variety is much more elastic than the other two varieties of cartilage. It occurs very sparsely in the body, as, for example, in the region of the external ear and the larynx.

THE DEVELOPMENT OF BONE

In the embryo the future elements of the skeleton are derived from the **mesenchyme,** a variety of tissue which may be regarded as the embryonic connective tissue, and which is largely derived from the **mesoderm,** the middle of the primary germ layers. In the case of the great majority of the bones, cartilage is laid down in this membranous layer before ossification or bone formation takes place, but in the flat bones of the face and of the roof and side walls of the cranial cavity, ossification takes place directly in this membranous layer. A distinction has accordingly been drawn between intracartilaginous (endochondral) and intramembranous ossification, but the process is essentially the same in both cases.

The process of ossification does not take place simultaneously all over the cartilaginous or membranous representative of a future bone. On the contrary, it begins at one or more points, from which it extends until the entire soft tissue has been replaced by bone. These points are known as **centres of ossification.** In a fully developed long bone there is always one centre about the middle of its length. The process of ossification proceeding from this centre towards either extremity leads to the production of the bony **shaft** or **diaphysis.** In addition other centres appear at each of the extremities or at the outstanding parts or processes. These are known as **epiphyses.**[1] The process of ossification initiated towards the centre of the shaft eventually meets those which began at the epiphyses, and the ossification of the bone is then complete. It follows from what has just been said that, until the process of ossification has been completed, a macerated long bone will resolve itself into three

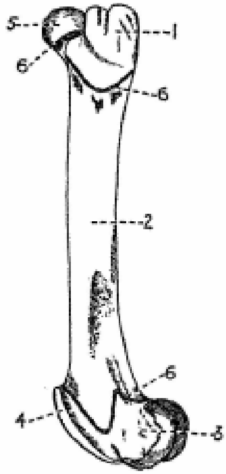


FIG. 8.—FEMUR OF YOUNG PIG (LATERAL ASPECT), SHOWING LINES OF EPIPHYSEAL CARTILAGE

1. Greater trochanter. 2. Shaft. 3. Lateral condyle. 4. Lateral lip of trochlea. 5. Head. 6. Lines of epiphyseal cartilage.

or more distinct pieces, which separate owing to the destruction of the as yet unossified cartilage. In Fig. 8 the narrow lines of persisting cartilage, called the **epiphyseal cartilage,** indicate the diaphysis and the three epiphyses, each of which had a separate centre of ossification. In a few months more the intervening layers of cartilage would have disappeared, and the ossification of the bone would have been complete. In flat, short and irregular bones the process is essentially the same, but the number of centres of ossification, although determinate for each individual bone, is more variable than in the class of long bones.

Intracartilaginous Ossification

In the shaft of a long bone the first step in the process of ossification consists in the enlargement of the cartilage cells in the region

[1] It should be noted that epiphyses are peculiar to mammals. The epiphysis at the upper extremity of the tibia in birds appears to be an exception to this rule.

of the centre of ossification. These cells later die, leaving irregular spaces in the cartilage which are termed **primary areolae.** The remaining thin partitions or trabeculae of the matrix between these spaces now become calcified as if to strengthen the part. Further strength comes from the deposition of new bone by the deeper layer of the perichondrium which is identical in structure with the osteogenetic layer of the periosteum.

The next stage consists in the growing inwards of processes of the perichondrium containing blood vessels and cells into the cartilage. Some of these cells, termed **osteoblasts,** are responsible for the laying down of new bone, whilst others, the **osteoclasts,** destroy bone. These processes pass through the outer layer of the newly formed bone and reach the calcified matrix, the osteoclasts absorbing the calcified tissue until the cavities of the primary areolae are transformed into large spaces known as the **secondary areolae,** or **medullary spaces.** These spaces are occupied by embryonic bone marrow. The osteoblast cells of the embryonic marrow now arrange themselves as a continuous layer on the calcified cartilage trabeculae, and assume a true osteogenetic function. Around each cell there is formed a zone of material which is at first soft and fibrous. This material speedily becomes hardened by the deposition of lime salts in it, and in this way the matrix of new bone is formed. Each osteoblast, which has in the meantime become branched, is thus enclosed in a space of the newly formed matrix. The space is a bone lacuna with its canaliculi, and the included osteoblast persists as a bone cell. As the formation of bone on the surface of the calcified cartilage trabeculae proceeds, the trabeculae themselves gradually become absorbed. In this manner the original cartilage becomes replaced by spongy bone tissue, the remnants of the embryonic marrow persisting as the red marrow of the new bone.

The miniature shaft of spongy bone which in the first instance takes the place of the original cartilage is not a permanent structure. By absorption of the trabeculae towards its interior, a small marrow canal is formed in it, and this continues to grow by absorption of the surrounding spongy bone. Hence, before birth the whole of the first-formed endochondral bone of the shaft has disappeared in the formation of the medullary cavity. But while this is being effected the thickness of the shaft is being augmented by the intramembranous formation of new bone by the deep layer of the periosteum.

By a process identical with that just described small epiphyses composed of endochondral bone are formed at the ends of the shaft, from which they remain separated by the epiphyseal cartilage. The subsequent growth of the bone in length, both before and after birth, takes place in the strata of cartilage interposed between the diaphysis and the epiphyses. While growth takes place in this cartilage, new (endochondral) bone is simultaneously formed at the plane of junction of the cartilage with the end of the already osseous shaft. The cells of the epiphyseal cartilage assume a more or less regular arrangement, being placed in longitudinal rows, with the long axis of each cell directed transversely to the length of the bone. Near the plane of ossification a thin stratum of the cartilage becomes more transparent by reason of the increased size of the cartilage lacunae. By absorption of the matrix along a plane nearer the shaft, the cartilage lacunae become opened up and placed in intercommunication, the cartilage cells themselves disappearing and their places being taken by osteoblasts and blood-vessels. Still deeper, the trabecular remains of the cartilage matrix become completely calcified. Osteoblasts arrange themselves on the surface of these calcified trabeculae, and clothe them with new bone. Finally, in a deeper plane complete absorption of the calcified trabeculae is effected, and new bone takes their place.

As long as an epiphyseal cartilage is present at one or both ends of the shaft of a long bone, a possibility of the growth in length of that bone exists, through the steps just described. At a period which differs not only for the individual bones, but also for the opposite ends of the same bone, the process of ossification overtakes the process of growth in the epiphyseal cartilage, which accordingly disappears. The epiphysis and diaphysis are then consolidated and growth in length arrested.

Intramembranous Ossification

After the whole of the cartilaginous shaft has been replaced by endochondral bone, it continues to grow in thickness by an addition of new bone to its outer surface. This new bone is formed in connection with the deep layer of the periosteum, and it is therefore intramembranous. Through the agency of the osteoblast cells of that layer new spongy bone is formed. Subsequently the Haversian spaces of this bone become enlarged by absorption of some of its trabeculae. At a still later date the marrow cells lying on the trabeculae of this spongy bone take on an osteoblastic function, and thus a lamella of new bone, with lacunae, canaliculi, and included bone cells, is formed. Successive layers of osteoblasts behaving in the same way gradually narrow a Haversian space, and convert it into a Haversian canal. In this manner the periosteal bone, which is at first spongy, becomes converted into compact tissue. The remains of the trabeculae of the first-formed spongy bone persist as the interstitial lamellae of the compact substance.

Ossification in the case of the so-called membrane bones, such as the tabular bones of the skull, is a process identical with the formation of periosteal bone. Moreover, it is apparent that intramembranous and intracartilaginous ossification are essentially similar processes. In both cases the active agents of bone formation are osteoblast cells, derived originally from the osteogenetic layer of the perichondrium or periosteum. In the one case the process is direct; in the other a miniature model of the future bone is laid down in cartilage, and this cartilage is piecemeal removed and replaced by bone, not converted into bone.

In the foregoing description of the process of bone formation, reference has more than once been made to an opposite process of bone absorption. In the case of a long bone the whole of the first-formed endochondral bone of the shaft soon disappears in the hollowing out of the medullary cavity. Moreover, well into the period of adult life a steady absorption of bone takes place immediately around this cavity, to compensate for the constant deposit of new periosteal bone on the surface of the shaft. The compact tissue of the deeper part of the shaft first returns by absorption to the condition of spongy bone, and then even the trabeculae of this spongy bone are themselves removed. These and all other instances of bone absorption appear to be brought about wholly or in part by the agency of the osteoclasts. In a similar manner the absorption of cartilage which necessarily takes place in the formation of endochondral bone is effected by cells which have been termed chondroclasts.

These osteoclasts and chondroclasts are identical with the already described myeloplaxes of red marrow. They are multinucleated giant cells. In a microscopic section of bone such cells may be seen in pits or spaces which appear to have been eroded by their agency. These pits are known as **Howship's lacunae.**

Chapter II

THE VERTEBRAL COLUMN

The fundamental part of the axial skeleton is the vertebral column or back-bone. This consists of a flexible chain of bones extending along the median plane of the animal, towards its dorsal aspect. At its anterior end the vertebral column is jointed to the skeleton of the head, while posteriorly it is prolonged beyond the trunk to form the skeleton of the tail.

The component bones of the vertebral column are termed **vertebrae,** and the number of such bones varies considerably in different species of animals.

The back-bone comprises five regions or groups of vertebrae, viz. **cervical, thoracic, lumbar, sacral,** and **coccygeal** or **caudal.** Speaking generally, it may be said that these belong respectively to the neck, back, loins, croup and tail. Save in the case of the sacral region the individual vertebrae remain freely movable, the adjacent bones being united by a fibro-elastic substance termed the **intervertebral disc.** In the sacral region, however, the vertebrae of the adult animal are rigidly and continuously fused together, and form what would popularly be regarded as a single bone.

The vertebrae of the same region have, in general, a close resemblance to one another, but the vertebrae of different regions exhibit very considerable differences in size and shape. Notwithstanding this latter fact, all the bones of the vertebral column are constructed after a common plan, and the diversity of shape exhibited by bones from different regions is produced in most cases by variations in the size and form of the component parts of what may be called a typical vertebra. In other instances diversity of shape is due to the total suppression of some of these parts. A typical vertebra comprises a body, an arch, and certain processes.

The **body** is the fundamental part of the vertebra, and the other parts are grouped around it. In general it has the form of a solid rod or prism, but occasionally it is so short as to be disc-like. In most cases the anterior extremity of the body is more or less rounded or convex, while the opposite extremity is correspondingly concave. The convex anterior extremity of the vertebra is adapted to the concave posterior end of the vertebra in front, and the opposed surfaces are united by the intervertebral discs. These form a very strong bond of union between the adjacent vertebrae, while at the same time they permit some degree of movement between them. The lower aspect of the body may be variously shaped, being sometimes rounded, and at other times flat or ridged. Its upper surface is flattened, and it forms the floor of a short tube termed the **vertebral foramen.**

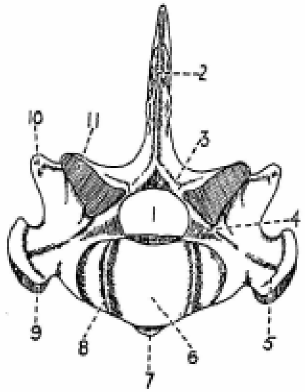


FIG. 9.—FIRST THORACIC VERTEBRA OF HORSE (POSTERIOR ASPECT), SHOWING COMPONENT PARTS OF TYPICAL VERTEBRA

1. Vertebral foramen. 2. Spinous process. 3. Lamina. 4. Posterior vertebral notch in pedicle. 5. Transverse process. 6. Posterior extremity of body. 7. Inferior spine. 8. Ridge separating posterior extremity of body from posterior demi-facet. 9. Facet on transverse process for articulation with tubercle of rib. 10. Anterior articular process. 11. Posterior articular process.

The **arch** of the vertebra is so named from its shape. It is superposed to the body, and with the latter it completes the vertebral foramen. The entire series of vertebral foramina makes up the **vertebral canal** in which the spinal cord with its coverings and nutrient vessels together with the superior longitudinal ligament are lodged. Each half of an arch comprises two portions, viz. a pedicle and a lamina. The **pedicle,** which forms the side of the arch, is an approximately vertical plate of bone, attached below to the side of the upper face of the body, and blended with the lamina superiorly. The **laminae,** on the other hand, form the roof or crown of the arch. Each is joined laterally to the pedicle of the same side, while in the median plane, and at a more or less open angle, it is fused with the opposite lamina. The anterior and posterior borders of each pedicle exhibit in most vertebrae a semi-circular outcut termed a **vertebral notch.** When the vertebrae are in position, the anterior notch of one vertebra is opposed to the posterior notch of the bone immediately in front, and the two together circumscribe a hole termed the **intervertebral foramen.** These foramina permit the passage of the spinal nerves, and they at the same time transmit the arteries, veins and lymphatics passing to and from the spinal cord.

The processes of a vertebra are much more inconstant in their presence and more variable in size and shape in the different regions of the spine than the body and arch. The following are the chief of these processes.

The **articular processes.** There are generally four of these. Two of them are placed on the anterior and two on the posterior border of the arch. The anterior pair present smooth articular surfaces which have an upward direction, and, when adjacent vertebrae are in position, meet and are overlapped by the posterior pair of the vertebra immediately in front, the direction of the latter pair being downwards. In the natural state these surfaces are covered by hyaline articular cartilage. The joints which they form permit considerable freedom of movement between adjacent vertebrae, and yet, from the overlapping of the bones, they do not diminish the strength of the bony column.

The **transverse processes.** There are generally two of these, one on each side of the vertebra, springing from the body, or from the lower part of the arch. They are named transverse from their proceeding more or less directly outwards in a lateral direction, and they vary greatly in size and shape in different regions of the vertebral column.

The **spinous process** or **spine.** This is a single median process projecting upwards from the arch. The process is sometimes very large and prominent, at other times scarcely observable, and occasionally it is bifid at its summit.

On the under surface of the body of many vertebrae and situated in the median plane lies a thickened ridge which has been referred to as an **inferior spine,** in contradistinction to the spinous process projecting from the arch which is then designated the **superior spine.**

THE VERTEBRAL COLUMN OF THE HORSE

The number of bones in each region of the vertebral column of the horse is indicated in the following formula, each region being denoted by its initial letter: $\mathbf{C_7T_{18}L_6S_5C_{18-20}}$. Variations, however, are not uncommon, particularly in the coccygeal region.

The Cervical Vertebrae

The cervical vertebrae, seven in number, form the skeleton of the neck. They receive numerical designations, as first, second, etc., but the first two and the last receive additional names, the first being termed the atlas, the second the axis or vertebra dentata, and the seventh the vertebra prominens. The first two vertebrae are so modified in order to form the joints which permit the head to move freely on the anterior end of the vertebral column that they cannot be considered to resemble what may be termed a typical cervical vertebra. They will therefore be described separately later. The third, fourth and fifth resemble each other very closely and may be regarded as characteristic of the cervical series. The sixth and seventh vertebrae differ only in minor respects from these last mentioned vertebrae.

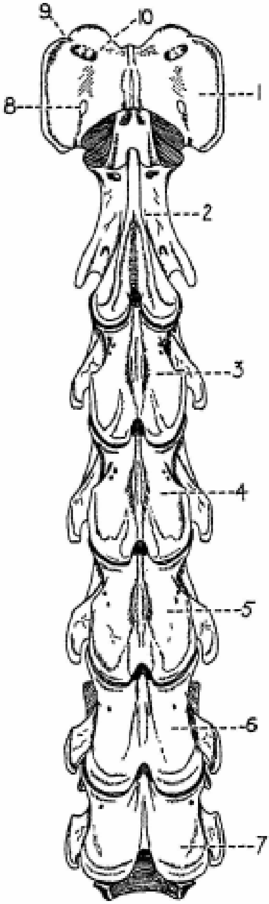


Fig. 10.—Cervical Vertebrae of Horse (viewed from above) 1-7. First to seventh cervical vertebrae. 8. Transverse foramen of first vertebra. 9. Alar foramen of first vertebra. 10. Intervertebral foramen of first vertebra.

The Third, Fourth and Fifth Cervical Vertebrae

The **bodies** of these vertebrae, when compared with those of other regions, are distinguished by their length. The inferior aspect of the body carries mesially the so-called **inferior spine.** This has the form of a sharp ridge becoming increasingly prominent as it is traced towards its posterior end, which is blunt and tuberculate. The lateral surfaces of the body are slightly concave, and carry some rough lines which, with the inferior spine, give attachment to fibres of the longus colli muscle. The upper surface of the body is flattened, and forms part of the floor of the vertebral canal. It shows a central, level, smooth area, constricted in the middle of its length and giving attachment to the superior longitudinal ligament of the vertebrae. On each side of this area, close to the pedicle, the upper surface of the body is depressed lengthways forming a shallow groove which lodges the superior longitudinal venous sinus. In these grooves are seen some foramina for the passage of the vessels of the bone. The anterior extremity of the body has the form of a projecting, smooth, articular surface, which is convex in all directions and which, through the medium of the intervertebral disc, is intimately united to the posterior extremity of the body of the preceding vertebra. The posterior extremity of the body presents a smooth, articular, rather deep cavity, which is like the impress or counterpart of the anterior articular surface. It is united by the intervertebral disc to the body of the succeeding vertebra. The marked convexity of the anterior extremity of the body, and the corresponding depth of the posterior extremity, are characteristic of the cervical vertebrae.

The **arch** in these vertebrae is strong, and the **notches** are very deep. The **vertebral foramen** is of considerable calibre, and its roof is smoothly rounded.

The **anterior articular processes** have extensive smooth surfaces directed upwards and towards the median plane, and are slightly rough on their lateral aspects for muscular attachment. The **posterior articular processes** are similar, save that their smooth surfaces are directed downwards and laterally. The articular processes attain their greatest dimension in the cervical region.

Each of the **transverse processes** is perforated where it springs from the vertebra by a foramen—the **transverse foramen** (*foramen transversarium*)—through which the vertebral vessels accompanied by sympathetic nerve fibres pass on their course along the length of the neck. Or, to describe the process otherwise, it may be said that it springs from the side of the vertebra by two roots, one from the side of the body and the other from the lower part of the arch, the transverse foramen being included between these two roots. The transverse foramen is peculiar to the vertebrae of the neck. Each transverse process possesses an anterior and a posterior division. The former projects obliquely downwards and forwards, while the latter, which is shorter and more tuberous, has an opposite direction. The transverse processes of these vertebrae are of medium size as compared with other regions, and they serve to give attachment to many of the muscles of the neck.

The **spine,** or **spinous process,** has the form of a low, rough ridge, narrow in front, and gradually diminishing in height but increasing in breadth as it passes backwards. It serves for muscular and ligamentous attachment, and, as compared with its size in other regions, the process is very slightly developed in these vertebrae.

Although the three vertebrae now being considered are very similar in appearance, still they are distinguishable. The body is longest in the third and shortest in the fifth. The outside width of the arch is least in the third and greatest in the fifth. In the case of the third vertebra a plate of bone, confluent with the posterior articular process, is continued horizontally forwards to near the middle of the arch; in the fifth this plate reaches quite forwards to the anterior articular process, whilst in the fourth the plate is of intermediate length, a notch being left between its anterior extremity and the anterior articular process. In the third bone the extreme anterior points of the transverse processes, anterior articular processes and body lie nearly in the same plane, so that the bone rests at once on these five points when placed on a table with these points downwards. When the other two bones are similarly placed, they touch by the articular and transverse processes, but the anterior extremity of the body remains a little distance above the surface of the table.

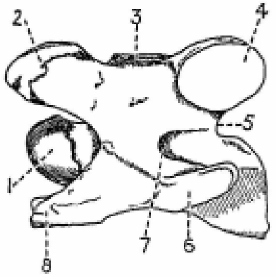


FIG. 11.—FIFTH CERVICAL VERTEBRA OF HORSE (LEFT LATERAL ASPECT)

1. Anterior extremity of body. 2. Anterior articular process 3. Spine. 4. Posterior articular process. 5. Posterior vertebral notch. 6. Posterior division of transverse process. 7. Posterior opening of transverse foramen. 8. Anterior division of transverse process.

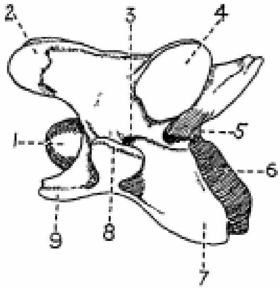


FIG. 12.—SIXTH CERVICAL VERTEBRA OF HORSE (LEFT POSTERO-LATERAL ASPECT)

1. Anterior extremity of body. 2. Anterior articular process. 3. Posterior opening of transverse foramen. 4. Posterior articular process. 5. Posterior vertebral notch. 6. Posterior extremity of body. 7-9. Three divisions of transverse process.

The Sixth Cervical Vertebra

This vertebra has a trifid **transverse process,** the superadded division being a plate-like part which projects below the level of the body at its posterior end. In other respects this bone has a close resemblance to the three vertebrae already described, but it is shorter and broader, and its **inferior spine** is less prominent.

The Seventh Cervical Vertebra [1]

This bone is specially distinguished by having a small and undivided **transverse process,** by the absence of the **transverse foramen,** by the greater height of its **spine,** and by the presence of a semicircular concave facet (sometimes called a **demi-facet)** at each side of the posterior extremity of the body. This superadded articular surface, together with the similar depression on the front of the first thoracic vertebra, forms a cup-shaped cavity for the head of the first rib. The **spine** of this vertebra is a triangular flattened plate with a slight forward inclination, and about an inch and a half high. It is from the greater height of the spine that this bone receives the additional name of **vertebra prominens.** The seventh vertebra is shorter but broader than the preceding bones, its **notches** are very large, and the **inferior spine** has the form of a mesially divided tubercle situated about the middle of the length of the bones.

[1] Sometimes termed the vertebra prominens.

Finally it may be remarked that this bone, in its size and shape, shows considerable resemblance to the early vertebrae of the thoracic region.

The First Cervical Vertebra

This vertebra, also termed the **atlas,** does not possess a body, and it may be best described as having the form of a short tube, or ring, composed of two solid lateral masses connected to each other above and below by two arches. From each of the lateral masses springs a considerable plate of bone termed the wing or ala.

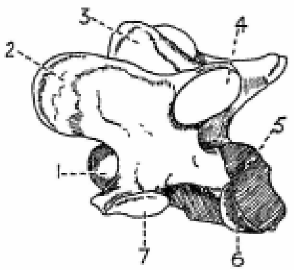


FIG. 13.—SEVENTH CERVICAL VERTEBRA OF HORSE (LEFT POSTERO-LATERAL ASPECT)

1. Anterior extremity of body. 2. Anterior articular process. 3. Spine. 4. Posterior articular process. 5. Posterior extremity of body. 6. Demi-facet. 7. Transverse process.

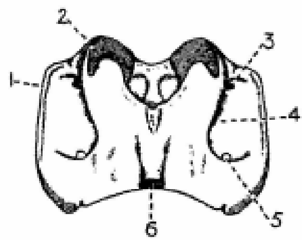


FIG. 14.—FIRST CERVICAL VERTEBRA OF HORSE (INFERIOR ASPECT)

1. Border of wing. 2. Articular cavity for condyle of occipital bone. 3. Alar foramen. 4. Central foramen of atlantal fossa, piercing lateral mass. 5. Transverse foramen. 6. Inferior tubercle.

The **lateral masses** present on the *anterior border* of each a deep articular cavity for a condyle of the occipital bone of the skull. This cavity is compounded of an upper and a lower facet—the two continuous with one another and circumscribed by a sharp edge with a deep notch laterally between the two facets. In the recent state these articular surfaces are covered by hyaline cartilage and they form synovial joints with the occipital condyles.

The *posterior border* of each mass shows an extensive undulated smooth surface for articulation with the next bone. The right and left articular surfaces are continuous with one another across the median plane on the posterior border and the upper surface of the inferior arch. These, like the other articular surfaces of the atlas, form synovial joints, this being a feature which distinguishes the atlas from all the other vertebrae.

The *medial surface* of the mass forms the lateral boundary of the vertebral canal which is here of large calibre, larger than in any other vertebra. It is irregularly depressed and shows a foramen which, passing through the thickness of the mass, transmits a vein from the vertebral canal to the exterior. Below this the bone is roughened for the attachment of fibres of the odontoid ligament.

The *lateral surface* has the wing attached to it along a line running obliquely downwards and backwards. On the under aspect of the bone, between this surface and the lateral border of the wing, there appears an irregular oval cavity, the **atlantal fossa,** in which three foramina open. The central and smallest of these is the foramen already mentioned which pierces the lateral mass. The anterior foramen is known as the alar foramen, and the most posterior of the three is the transverse foramen. These will be observed again in connection with the wing.

The **superior arch** is somewhat dome-shaped, being roughened and elevated in the position of the spine of other vertebrae to form the **superior tubercle.** Its *anterior border* shows a deep indentation between the articular cavities. The *posterior border* is sharper and shows a wider notch. Anteriorly, at its junction with the lateral mass, the arch is pierced by a large opening which represents the **intervertebral foramen** of succeeding vertebrae, and which transmits the first spinal nerve and the cerebro-spinal vessels.

The **inferior arch** is thicker and shorter than the superior arch. Its *superior surface* is rough in its anterior half where the odontoid ligament is attached. Behind that the surface is smooth and articular for the odontoid process of the next bone. On the *inferior surface* and in the median plane lies an obtuse eminence termed the **inferior tubercle.** This lies in series with the so-called inferior spine of the succeeding vertebrae and it gives insertion to the most anterior fibres of the longus colli muscle.

The **wings** or **alae** of the atlas represent the transverse processes of other vertebrae. Each is a nearly flat but slightly inclined plate of bone attached medially to the lateral mass and margined laterally by a thick rough border. This border, which slopes obliquely downwards and backwards, is placed almost immediately under the skin, and it forms a prominence which can be both seen and felt in the living horse. It gives attachment to certain muscles of the head and neck. In connection with each wing three foramina are to be observed. Two of these foramina are placed together towards the forepart of the wing, and they are connected by a short gutter. The more medial of the two is the **intervertebral foramen** already described. The other is the **alar foramen** which pierces the wing and gives passage to the inferior primary division of the first spinal nerve and to the occipital vessels. The third foramen found in connection with the wing pierces it towards its posterior part. It corresponds to the **transverse foramen** of the succeeding vertebrae and it gives passage to the recurrent, or descending, branch of the occipital artery.

The Second Cervical Vertebra[1]

This bone is also termed the **axis** and the **vertebra dentata.** The second of these designations is conferred upon it from a tooth-like process, the odontoid process, or dens, which it possesses in the human subject. It receives the name of axis because the atlas, carrying with it the head, rotates around this same tooth-like process.

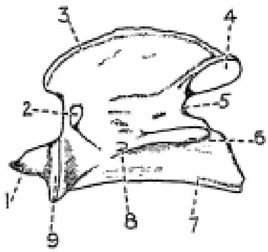


FIG. 15.—SECOND CERVICAL VERTEBRA OF HORSE (LEFT LATERAL ASPECT)

1. Odontoid process. 2. Intervertebral foramen. 3. Spine. 4. Posterior articular process. 5. Posterior vertebral notch. 6. Transverse process. 7. Inferior spine. 8. Transverse foramen. 9. Articular surface at anterior extremity of body.

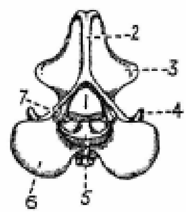


FIG. 16.—SECOND CERVICAL VERTEBRA OF HORSE (ANTERIOR ASPECT)

1. Vertebral foramen. 2. Spine. 3. Posterior articular process. 4. Transverse process. 5. Odontoid process. 6. Articular surface at anterior extremity of body. 7. Intervertebral foramen.

The **body** of the axis is longer than that of any other vertebra. Anteriorly it carries the **odontoid process.** The *superior surface* of this process, which is slightly concave from side to side, is rough, and it shows a shallow pit on each side of a central eminence. The odontoid ligament is attached to this surface. The *inferior surface,* which is convex from side to side, is smooth and articular. The surfaces of the process are separated by a sharp convex and slightly notched *edge.* The body also carries anteriorly, on each side of the root of the odontoid process, an extensive articular surface, convex from above to below, and slightly concave from side to side. These surfaces blend with the lower surface of the odontoid process, and the whole area articulates with the surfaces already described in connection with the atlas. The *superior* and *inferior surfaces* of the body and its *posterior extremity* have a close similarity to the same parts in the succeeding vertebrae of the series. The **inferior spine** is a sharp ridge ending posteriorly in a tubercle.

Each **pedicle** presents posteriorly the usual **vertebral notch,** but the place of the anterior notch is taken by a large oval foramen. The **vertebral foramen** is of rather small calibre.

[1] Formerly termed the epistropheus.

The posterior **articular processes** resemble those of the succeeding bones, and are placed on the posterior border of the arch. No articular processes are carried by the anterior border of the arch, the articular facets flanking the root of the odontoid process compensating for the absence of the anterior articular processes.

The **transverse processes,** which are smaller than in any of the other cervical vertebrae, are undivided and directed backwards. A small **transverse foramen** perforates the root of each.

The **spine** is a very strong process which completely covers the arch. Its upper border, single and narrow in front, is divided in its posterior two-thirds into two rough divergent ridges, each of which joins the upper aspect of the articular process of its own side, and serves to give attachment to one of the lamellae of the ligamentum nuchae.

The Thoracic Vertebrae

The vertebrae of this region, eighteen in number,[1] are also appropriately called **costal vertebrae,** since they carry the ribs.

The **body** of a thoracic vertebra is very short compared with that of a cervical vertebra. The anterior end of the body is less convex, and the posterior cavity shallower, than in the region of the neck. Here, as in all the intercentral joints behind the axis, the bodies of adjacent bones are united by the intervertebral fibrocartilage. In the early members of the series there is a sharp ridge, the so-called **inferior spine,** on the middle of the lower aspect of the body, but this gradually becomes thicker as the vertebrae are followed backwards. At each side of the articular end of the body, before and behind, there is a little concave articular surface, termed the **demi-facet.** When adjacent vertebrae are in position the posterior of these facets on each side is opposed to the anterior facet of the next bone, and there is thus formed, with the aid of the intervertebral fibro-cartilaginous disc between the two bones, a cup-shaped cavity, or **costal facet,**[2] for articulation with the head of a rib. The vertebral **notches** are smaller than in the cervical region. The posterior pair are considerably deeper than the anterior, and in the bones at the end of the series they are frequently converted into foramina. The **vertebral foramen** is slightly depressed from above to below. The **articular processes** occupy the same position on the arch as in the neck, but they are much smaller than in that region. The **transverse processes** are small and single. Each carries on its lateral aspect

1 Occasionally the number is one more or fewer than eighteen.

2 Or capitular facet.

a smooth facet for articulation with the tubercle of the rib which corresponds numerically with the vertebra. The presence of this facet is characteristic of the thoracic vertebrae. The **spine** is of great size. Each is a flattened bar of bone the anterior border of which is thin and sharp, while the posterior is thick and grooved.

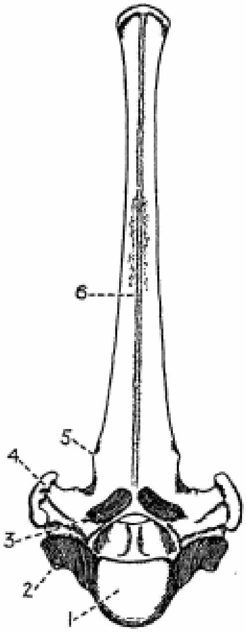


FIG. 17.—THIRD THORACIC VERTEBRA OF HORSE (ANTERIOR ASPECT)

1. Anterior extremity of body. 2. Anterior demi-facet. 3. Anterior articular process. 4. Transverse process. 5. Posterior articular process. 6. Spine.

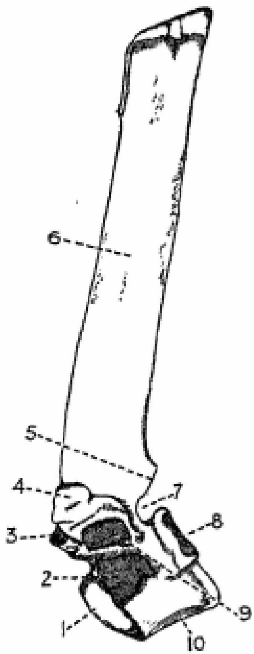


FIG. 18.—THIRD THORACIC VERTEBRA OF HORSE (LEFT LATERAL ASPECT)

1. Anterior extremity of body. 2. Anterior demi-facet. 3. Anterior articular process. 4. Transverse process. 5. Posterior articular process. 6. Spine. 7. Posterior vertebral notch. 8. Posterior demi-facet. 9. Facet on transverse process for tubercle of rib. 10. Inferior spine.

The foregoing description applies to the thoracic vertebrae as a series, but among themselves they vary considerably, particularly as regards the degree of development of some of their processes. Thus, it is observed that the facets for articulation with the heads of the ribs diminish in depth and extent from the first to the last vertebra. From the first bone to the ninth or tenth the articular processes diminish rapidly in size, and those of opposite sides approach each other on the arch. Behind the tenth vertebra the anterior articular processes tend to become concave from side to side, the posterior pair being correspondingly convex. The transverse processes diminish in extent from the first to the last bone. In the case of the last three or four bones, the anterior demi-facet is confluent with the facet for the tubercle of the rib. On examination of the thoracic series of vertebrae it is observed that in the anterior members of the series the transverse processes show a slight tendency to be divided into two parts. This becomes more and more pronounced until in the last four or five bones the division is complete, each transverse process consisting of a lateral portion bearing the facet for the tubercle of the rib, and a median portion, termed the **mammillary process,** which has come to surmount the anterior articular process. The spines diminish in length both forwards and backwards from the fourth, which is the longest. The second is a little broader than the first, and the succeeding spines diminish in

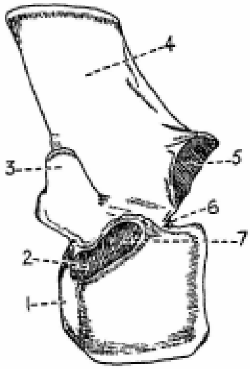


FIG. 19.—EIGHTEENTH THORACIC VERTEBRA OF HORSE (LEFT LATERAL ASPECT)

1. Anterior extremity of body. 2. Anterior demi-facet, confluent with facet for tubercle of rib. 3. Mammillary process. 4. Spine. 5. Posterior articular process. 6. Posterior vertebral notch. 7. Facet for tubercle of rib, confluent with anterior demi-facet.

breadth to about the ninth, from which point they increase in breadth to about the last. Their summits are sharp in the first and second, broad and tuberous from the third to about the tenth, while in the remainder they are compressed from side to side. These processes as far as the fifteenth have a backward inclination, which is most marked in the first four or five. The sixteenth lies vertically, and the last two are inclined slightly forwards.

The first thoracic vertebra has a decided resemblance to the last cervical vertebra. The articular and transverse processes and the notches are large as compared with those of succeeding bones. The spinous process is comparatively short (about three inches long), pointed at its summit, and slightly curved backwards.

The second thoracic vertebra has a spinous process six or seven inches long, and pointed at its summit.

The eighteenth thoracic vertebra is distinguished by the absence of the posterior demi-facets. Moreover this bone and a few others at the end of the series exhibit in all their parts, except their transverse processes, a decided resemblance to the lumbar vertebrae.

The Lumbar Vertebrae

This region usually comprises six bones, although in the ass, and occasionally in the horse, only five bones are present. Their **bodies** are intermediate in length between those of the cervical and thoracic regions. As in the thoracic region, the anterior end of the body is but slightly convex, and the concavity of the posterior end is correspondingly shallow. The posterior **vertebral notches** are larger

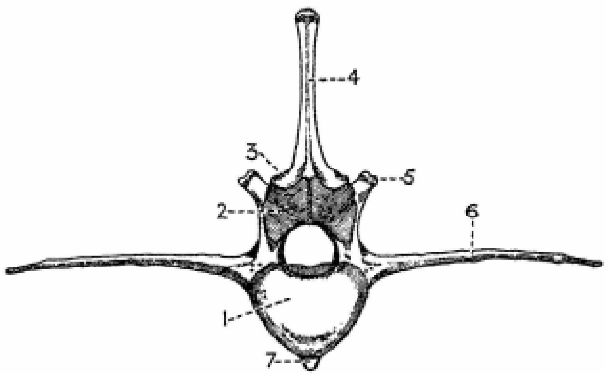


FIG. 20.—FIRST LUMBAR VERTEBRA OF HORSE (ANTERIOR ASPECT)
1. Anterior extremity of body. 2. Anterior articular process. 3. Posterior articular process. 4. Spine. 5. Mammillary process. 6. Transverse process. 7. Inferior spine.

than the anterior. The **vertebral foramen** is nearly circular. The anterior **articular processes** are concave from side to side, and directed medially. On its lateral aspect each bears an obtuse **mammillary process** lying in series with the corresponding process of the last thoracic vertebrae. The posterior pair of articular processes which lie close together project backwards from the posterior edge of the arch. For adaptation to the anterior pair they are convex in the transverse direction, and look almost directly outwards. The **transverse processes** form the most prominent feature in a lumbar vertebra. Each of these is a relatively enormous plate of bone, flattened from above to below, and projecting outwards nearly at right angles to the body. Each process is approximately horizontal in position, but it has a slight downward curve towards its free extremity. The large size of the transverse processes of the lumbar region is correlated with the great size and strength of the muscles of the loins, e.g. the longissimus dorsi and the psoas major muscles, which are attached to their upper and lower surfaces respectively. The **spinous process** is a broad flattened plate, about the same height as that of the last thoracic vertebra. Its summit forms a thick rough edge, and the whole process has a slight forward inclination.

With regard to the characteristics of individual lumbar vertebrae, it may be said that the vertical thickness of the body diminishes, while the breadth increases, from the first to the last bone. The ridge on the inferior aspect of the body which is present in the early members of the series, can scarcely be said to exist in the last three bones. The spinous processes diminish in size from the first to the last. The transverse processes are longest in the second and third, and shortest in the last. The process projects nearly at right angles to the body in the third, while the first two are inclined slightly backwards, and the last three more pronouncedly in the opposite direction. The thickness of the process is greatest in the last two bones, which are further distinguished by the presence of an articular facet on each border of the process. Such facets are found on the posterior borders of the processes of the fourth bone. By means of these facets additional joints are formed between the last three bones and between the last bone and the base of the sacrum. Between each facet and the corresponding extremity of the body there is left a notch, and when the vertebrae are articulated together a series of foramina is formed on each side. These foramina give passage to the inferior primary divisions of the spinal nerves.

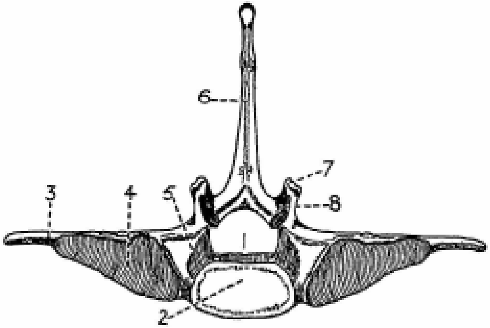


FIG. 21.—SIXTH LUMBAR VERTEBRA OF HORSE (POSTERIOR ASPECT)

1. Vertebral foramen. 2. Posterior extremity of body. 3. Transverse process. 4. Articular facet on transverse process. 5. Posterior vertebral notch. 6. Spine. 7. Mammillary process. 8. Posterior articular process.

The Sacrum

In the region of the croup in the adult animal the vertebrae, five in number, are fused together by ossification of the soft textures which united them together during foetal life. The single piece resulting from this fusion is termed the sacrum, and although it always continues to exhibit traces of its mode of formation, it is customary and convenient to describe it as a single bone. For purposes of description one may recognise in it a superior and an inferior surface, two lateral borders, a base and an apex.

The *superior surface,* broadest in front, shows along the middle line the **spines** of the five sacral vertebrae. These are more or less completely fused at their bases, and in old animals frequently at their summits also in the case of the last three segments. The summits of these processes are tuberous and generally bifid, except the first which is sharper. The first is not quite as tall as the second,

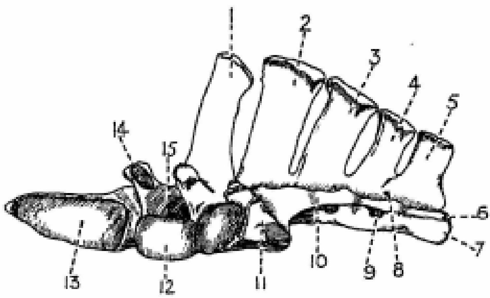


FIG. 22.—SACRUM OF HORSE (LEFT ANTERO-LATERAL VIEW)
1-5. Spines of sacral vertebrae. 6. Transverse process of fifth sacral vertebra. 7. Posterior extremity of body of fifth sacral vertebra. 8. Superior sacral foramen. 9. Inferior sacral foramen. 10. Lateral border. 11. Auricular facet. 12. Anterior extremity of body of first sacral vertebra. 13. Facet for articulation with transverse process of sixth lumbar vertebra. 14. Anterior articular process of first sacral vertebra. 15. Vertebral foramen of first sacral vertebra.

and the succeeding processes become successively shorter. At the bases of the fused spines on each side there are four foramina, the **superior sacral foramina,** through which pass the superior primary divisions of the sacral nerves from the vertebral canal.

The *inferior surface,* also broadest in front, is smooth and it forms the greater part of the roof of the pelvic cavity. It is slightly arched in the longitudinal direction, and it shows four faint transverse lines, indicating the lines of fusion of the five originally distinct sacral bodies. At the extremities of these lines are placed the **inferior sacral foramina,** four on each side. These diminish in size from the first to the last, and they transmit the inferior primary divisions of the sacral nerves. They lie in series with the foramina mentioned in connection with the lumbar vertebrae which transmit the inferior primary divisions of the lumbar nerves.

The *lateral borders.* Each of these bears towards its anterior end the so-called **auricular facet.** This constitutes a somewhat rough surface, bevelled so as to look upwards and laterally, for articulation with the iliac portion of the hip bone. Medially to the auricular facet a rough area serves for the attachment of the interosseous, or inferior, sacro-iliac ligament. Behind the auricular facet the lateral border is somewhat sharp, and here the sacro-sciatic and lateral sacro-iliac ligaments are attached.

The *base*, or anterior extremity, of the sacrum is in reality the anterior extremity of the first sacral vertebra. It shows centrally the entrance to the **vertebral foramen** of that vertebra, and on each side of the anterior border of its arch there is an **articular process**, similar in form to the anterior articular processes of the lumbar vertebrae.

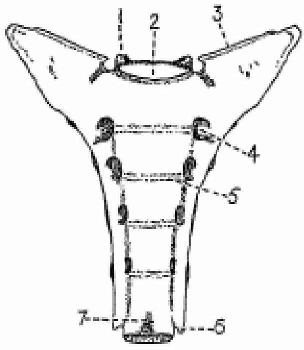


FIG. 23.—SACRUM OF HORSE (VIEWED FROM BELOW)

1. Anterior articular process of first sacral vertebra. 2. Anterior extremity of body of first sacral vertebra. 3. Facet for articulation with transverse process of sixth lumbar vertebra. 4. Inferior sacral foramen. 5. Line of fusion of originally distinct bodies of sacral vertebrae. 6. Transverse process of fifth sacral vertebra. 7. Posterior extremity of fifth sacral vertebra.

The border of the pedicle shows on each side the usual **notch.** Below the vertebral foramen lies the anterior end of the body of the first sacral vertebra, in the shape of a slightly convex articular surface, which is united to the posterior end of the body of the last lumbar vertebra by the usual intervertebral fibro-cartilage. On either side of this surface there is another facet of somewhat similar outline. These latter form synovial joints with like facets on the posterior borders of the last lumbar transverse processes. Between the central facet and these lateral facets there are vertebral notches lying in series with the inferior sacral foramina.

The *apex*, or posterior extremity, of the sacrum is formed by the posterior end of the last sacral segment. On it there is recognised the **vertebral foramen** of that bone, triangular in outline and much reduced in size. Above that there is seen the posterior border of the last **spine,** and below the vertebral foramen the nearly flat posterior end of the body of the last sacral vertebra which is movably united by the intervertebral disc to the first coccygeal bone. At each side of this articular surface there is a little backwardly projecting process representing the **transverse process** of the last sacral vertebra, but the arch is destitute of any articular processes.

The Coccygeal Vertebrae

This region comprises all the movable vertebrae behind the sacrum. The number of bones included within it is in most cases eighteen, but it is not rare to find one or two more or fewer than that number. The bones of the series steadily diminish in size from the first to the last.

The **first** in size and appearance has a close resemblance to the last sacral segment, to which in the middle-aged animal it is not infrequently united by ossification. It possesses a short **body** with flat or slightly convex articular extremities, which, through the medium of intervertebral discs, are movably united to the sacrum in front and the second bone behind. It possesses also a rudimentary arch, which with the body circumscribes a small triangular **vertebral foramen.** On the front of the arch are small projections representing the **anterior articular processes** or the **mammillary processes** which these carry laterally. At each side there is a small **transverse process,** and the arch is surmounted in the median plane by a rudimentary **spinous process.**

In the **second** and **third bones** the parts just enumerated as being present in the first are still recognisable, but in a less developed form.

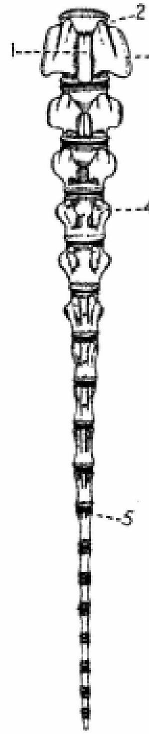


Fig. 24.—Coccygeal Vertebrae of Horse (viewed from above)

1-3. Spinous process, mammillary process and transverse process of first coccygeal vertebra. 4. Right half of arch of fourth coccygeal vertebra, failing to meet left half. 5. Intervertebral disc between tenth and eleventh coccygeal vertebrae.

In the **fourth bone** the **laminae** of the arch fail to meet in the median plane, and the vertebral foramen is therefore incomplete above.

In the succeeding bones the vertebral foramen is represented by a mere groove on the upper aspect of the body, while the processes become gradually reduced in size. In the last seven or eight bones the arch and processes are altogether suppressed, and only the bodies remain. Each of these is a little rod of bone, constricted in its middle like an hour-glass, and slightly rounded at its extremities. The last vertebra has the form of a short cone with the apex directed distally. Throughout the entire series the adjacent ends of these bodies are united by thin discs of intervertebral substance.

A number of the anterior coccygeal vertebrae carry at the anterior end of the under aspect of the body two small processes, between which the middle coccygeal vessels run.

THE VERTEBRAL COLUMN AS A WHOLE

In the articulated vertebral column the entire series of vertebral bodies forms a long flexible rod, which describes a succession of curves in the median plane of the body. Thus, the cervical region in the ordinary posture of the animal at rest is slightly arched, so as to be concave on its lower aspect. Towards the junction of the cervical and thoracic regions, however, the bony column is curved in the opposite direction, being concave above. The remainder of the thoracic region and the lumbar region are disposed in almost the same straight line. The sacrum, again, is slightly arched, forming on its under aspect a concavity which is continued by the bones of the coccygeal region when the tail hangs in its ordinary position.

The length of the vertebral bodies is greatest in the cervical region. The axis is the longest of all the vertebrae. Behind this the length gradually diminishes until the thoracic region is reached and here, behind the second or third of the series, the bodies of the vertebrae are very similar in length. In the lumbar region they become a little longer, but a gradual reduction in length occurs in the sacrum, and this diminution continues backwards in the coccygeal region from the first to the last bone. The so-called inferior spines attain their maximum size in the posterior members of the cervical group of vertebrae and in the first few thoracic vertebrae. Behind that they become less and less prominent.

The calibre of the vertebral canal is greatest of all in the atlas. Very much smaller in the three succeeding bones, it again increases considerably in the last three cervical and first two thoracic vertebrae. Behind that it again diminishes in size, until at the middle of the back the calibre of the canal is less than at any anterior point. In the region of the loins the calibre again increases as far as the last or second last bone, from which point it rapidly diminishes, until it loses its character of a complete canal about the fourth coccygeal bone. The ample capacity of the ring of the atlas permits free movement of the occipito-atlantal and atlanto-axial joints without danger of injury to the delicate spinal cord. The increased calibre of the canal at the junction of the neck and back and in the loins is correlated with the larger size of the cord, which in these regions shows the brachial and lumbar enlargements from which the nerves of the fore and hind limbs are derived respectively. The intervertebral joints, too, are more freely movable at these points.

On tracing the modification of size and form of the various processes throughout the column, it is observed that the articular processes attain their maximum size in the neck. In the thoracic region they are greatly reduced in size and hardly visible in the articulated spine. In the last thoracic bones, however, and in the loins, these processes become more conspicuous, owing to the presence of the mammillary process carried by the anterior pair on their lateral aspects.

The spines, except in the axis, are not of considerable size in the neck. In the thoracic region, however, they form the most prominent feature of the bones, and determine by their length the height of the withers. Throughout the lumbar region these processes still continue prominent, in the sacral region they become progressively smaller, and they finally disappear in the anterior part of the coccygeal region.

The transverse processes form strong rugged projections in the cervical region. In the thoracic vertebrae they are greatly reduced in size, but are specially distinguished by the articular facet, which each carries for the tubercle of a rib. In the loins the great size of these processes forms the main feature of the region. In the sacrum the separate transverse processes are not distinguishable. In the tail they are apparent but only in the anterior members of the series, and in an undeveloped form.

THE DEVELOPMENT OF THE VERTEBRAE

The vertebrae develop from the mesoderm of the various serial segments into which the embryo becomes divided. These segments, or **somites** as they are called, quite early in development show masses of specialised cells which grow medially and surround the **notochord,** the primitive membranous vertebral column, and the tissue of the central nervous system which lies above it. These masses are called **sclerotomes,** and they soon become differentiated into two parts, anterior and posterior, between which a cleft appears. The posterior portion, whose cells are more densely arranged than those of the anterior portion, sends in a process medially to unite with a corresponding process from the sclerotome of the opposite side and enclose the notochord. Another process extends dorsally and laterally to the spinal cord, while a third, known as the **costal process,** passes ventro-laterally. In some vertebrae these costal processes are united at their lower extremities below the notochord by a transverse bar of tissue, the **hypochordal bow.** In all vertebrae but the atlas this bow soon disappears as a separate structure.

In this way the plan of a typical vertebra is mapped out in membrane, the first process forming half of the body, the second half of the arch, and the third the transverse process and, in the case of the thoracic vertebrae, the rib. The vertebra is not, however, formed entirely from the posterior part of the sclerotome. The looser tissue of the anterior part of the sclerotome also grows medially towards the notochord and becomes united with the denser tissue of the posterior portion of the preceding sclerotome, the tissue which lay between the anterior and posterior portions of the sclerotome becoming converted into the **intervertebral fibro-cartilaginous disc.** Thus a vertebra is formed from two adjacent sclerotomes.

Centres of chondrification appear later in these membranous precursors of the vertebrae, and after the vertebra has thus been moulded in cartilage a number of centres of ossification appear in it.

In a typical vertebra ossification proceeds from three primary centres, one of which is for the greater part of the body, while each of the other two serves for one half of the arch and a small part of the body adjacent to the foot of the arch. Secondary centres appear in the cartilage at the anterior and posterior extremities of the body, forming thin discs of bone in these positions, and also at the extremities of the transverse processes. Where the spines are prominent, as in the thoracic and lumbar regions, the summits of the spines ossify as little epiphyses with separate centres.

The notochord, as previously mentioned, becomes enclosed in the bodies of the vertebrae and within these it finally disappears. That portion of the notochord, however, which lies in the region of the cleft separating the two parts of the sclerotome continues to develop to a greater degree than the portions lying in the region which will become the vertebral body, and it persists in the adult as the **pulpy nucleus** of the fibro-cartilaginous disc.

The development of the atlas and axis differs very materially from that which has been described as typical of the vertebrae in general. The **atlas** is formed from the posterior part of a sclerotome, its lateral masses and superior arch corresponding to the two halves of the arch of a typical vertebra. These masses of mesoderm become chondrified, and a single centre of ossification develops in each cartilage. The cartilage which completes the ring inferiorly, forming the inferior arch, shows two centres of ossification, one on each side, but these speedily coalesce. The inferior arch, however, is not homologous with the body of succeeding vertebrae but develops from the persistent hypochordal bow. An additional centre appears in the region of the wing. That portion of the sclerotome which would normally form the body of the atlas becomes detached and unites with the body of the **axis,** forming the **odontoid process.** This process ossifies from two centres, one representing the body and the other the posterior epiphysis of the atlas.

Between the vertebral arches the mesenchyme does not become converted into cartilage and bone, but persists as the membranous supraspinous and interspinous ligaments, and the ligamenta flava. The superior and inferior longitudinal ligaments similarly result from the mesenchyme lying above and below the vertebral bodies.

THE VERTEBRAL COLUMN OF THE OX

The ordinary number of vertebrae present in the spine of the ox is represented in the formula $\mathbf{C_7T_{13}L_6S_5C_{18-20}}$.

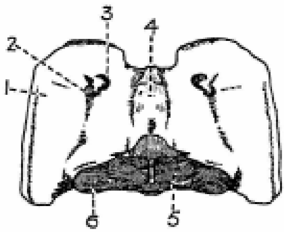


FIG. 25.—ATLAS OF OX (SUPERIOR ASPECT)

1. Wing. 2. Alar foramen. 3. Intervertebral foramen. 4. Superior tubercle. 5. Articular surface on inferior arch for odontoid process. 6. Articular surface on posterior border of lateral mass for anterior extremity of axis.

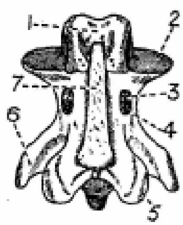


FIG. 26.—AXIS OF OX (SUPERIOR ASPECT)

1. Superior surface of odontoid process. 2. Articular surface at anterior extremity of body. 3. Intervertebral foramen. 4. Anterior opening of transverse foramen. 5. Posterior articular process. 6. Transverse process. 7. Spine.

Cervical Vertebrae.—The wings of the **atlas** lie in a more horizontal plane than in the horse. The transverse foramen is absent. As in the horse a short furrow unites the alar and intervertebral foramina, and from the middle of this furrow a third small foramen passes into the vertebral foramen. A fourth and smaller foramen perforates the wing a little behind the furrow, but this opening may be absent on one or both sides. The superior tubercle is more prominent than in the horse. The inferior tubercle, on the other hand, is scarcely so large. The posterior border of the lateral mass carries on its upper half a central and two lateral slight notches. The facets on this border for articulation with the axis are flatter than in the horse.

The body of the **axis** is relatively shorter than in the horse. The odontoid process is shorter, less pointed, and more spout-like on its upper aspect. The prominent collar of bone that underlies it is not notched mesially and the articular surface on each side of it is flatter. The spine is undivided and less massive than in the horse. The transverse processes are stronger.

The **third** to the **sixth vertebrae** have shorter bodies than in the horse. The so-called inferior spine is very similar to that of the horse. It is nearly absent in the sixth bone. Viewed from above, these bones are wider than in the horse, a continuous plate of bone uniting the anterior and posterior articular processes on the same side. The transverse process consists of an upper tuberculate division and a lower more plate-like part, the latter being very large in the sixth bone. The spine is a short thick rod, better developed than in the horse, and more inclined forwards. In the third vertebra the summit of the process is bifid. These processes increase in length from the third to the sixth bone.

The spine of the **seventh vertebra** is much larger than in the horse, having, in a moderate-sized animal, a height of from three to four inches. The body possesses no ridge on its inferior surface.

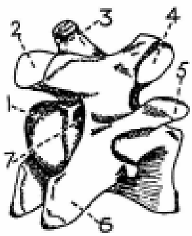


FIG. 27.—FOURTH CERVICAL VERTEBRA OF OX (LEFT ANTERO-LATERAL ASPECT)

1. Anterior extremity of body. 2. Anterior articular process. 3. Spine. 4. Posterior articular process. 5-6. Upper and lower divisions of transverse process. 7. Anterior opening of transverse foramen.

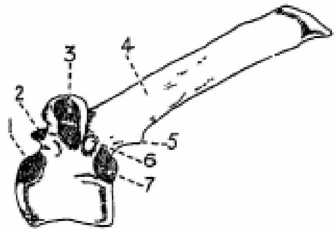


FIG. 28.—SEVENTH THORACIC VERTEBRA OF OX (LEFT LATERAL ASPECT)

1. Anterior demi-facet. 2. Anterior articular process. 3. Facet on transverse process for tubercle of rib. 4. Spine. 5. Posterior articular process. 6. Foramen representing posterior vertebral notch. 7. Posterior demi-facet.

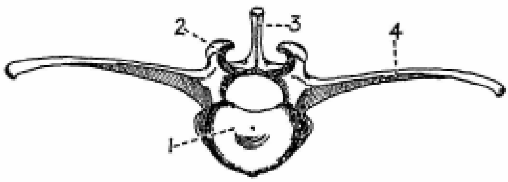


FIG. 29.—FIFTH LUMBAR VERTEBRA OF OX (ANTERIOR ASPECT)

1. Anterior extremity of body. 2. Anterior articular process. 3. Spine. 4. Transverse process.

Thoracic Vertebrae.—The bodies of these bones are longer than in the horse. The inferior ridge is even less developed than in the horse. The spinous processes are broader and their posterior borders are narrower. The first five spines are nearly equal in length and in breadth. Behind the fifth they diminish steadily in length to the last. With the exception of the last, they are all inclined backwards, the degree of inclination being very marked in the middle members of the series. Except in the last four or five bones, the articular facet of the transverse process is saddle-shaped, being convex in the vertical and concave in the horizontal direction. In nearly all of the thoracic vertebrae the intervertebral foramina are double, the posterior notch being represented by a complete foramen.

Lumbar Vertebrae.—The body is longer than in the horse and it is ridged inferiorly. The transverse processes are also longer and more slender. They do not form articulations among themselves, nor does the last articulate with the sacrum. The spines are broader but shorter than in the horse.

Sacrum.—The sacrum of the ox is more arched than that of the horse. The spines are shorter and completely fused together. The superior foramina are smaller, the inferior larger. There are no facets on the base of the bone for articulation with the last lumbar transverse processes. The lower face of the bone is traversed mesially by a longitudinal furrow for the middle sacral vessels.

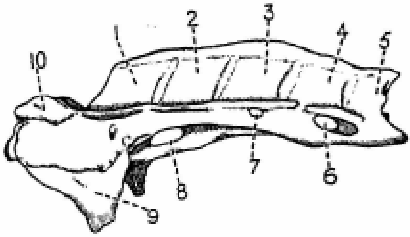


FIG. 30.—SACRUM OF OX (LEFT LATERAL VIEW)
1-5. Spines of sacral vertebrae. 6-7. Superior sacral foramina. 8. Inferior sacral foramen. 9. Auricular facet. 10. Anterior articular process of first sacral vertebra.

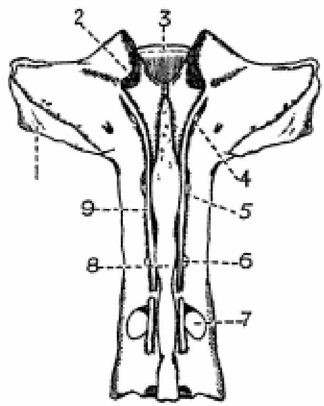


FIG. 31.—SACRUM OF OX (VIEWED FROM ABOVE)
1. Auricular facet. 2. Anterior articular process of first sacral vertebra. 3. Anterior extremity of body of first sacral vertebra. 4-7. Superior sacral foramina. 8. Spine of third sacral vertebra. 9. Ridge formed by fused articular processes.

Coccygeal Vertebrae.—The caudal vertebrae of the ox are proportionately larger than those of the horse, and their processes are better developed. A complete vertebral foramen is present in the first four or five bones, which also possess distinct though small anterior articular processes. In the first nine or ten bones distinct rudiments of the transverse processes are present. About as far as the twelfth vertebra two small processes are developed in front on the lower face of the body of each vertebra. The middle coccygeal vessels run between these processes.

THE VERTEBRAL COLUMN OF THE SHEEP

The spinal formula of the sheep may be stated as $C_7T_{13}L_6S_4C_{18}$. It is to be observed, however, that not rarely there are seven lumbar vertebrae, and that the number of coccygeal bones varies greatly with the breed. The extreme numbers of the latter are recorded as being three and twenty-four.

Cervical Vertebrae.—Except in respect of size, these bones resemble very closely those of the ox. In the **atlas** the eminences representing the superior and inferior tubercles are not so well developed. The superior arch is not so deeply notched on either its anterior or its posterior edge.

The spine of the **axis** is relatively not so high as in the ox, but the transverse processes are longer than in that animal.

In the **third** and **fourth bones** the transverse process is shaped more like that of the horse. In the third bone the spinous process is small, and throughout the series the so-called inferior spines are not so prominent as in the larger ruminant.

Thoracic Vertebrae.—These bones present the closest resemblance to the same bones of the ox. It may be remarked, however, that the borders of the spines are straighter, and that the posterior notches are only exceptionally converted into foramina.

Lumbar Vertebrae.—In all of these bones the transverse processes have a slight forward inclination. In other respects they are like those of the ox.

Sacrum.—The lower surface of this bone differs from that of the ox in being distinctly convex in the transverse direction, and in the absence of a median longitudinal furrow.

Coccygeal Vertebrae.—Except that they are devoid of processes on the lower faces of their bodies, these vertebrae are similar to those of the ox.

THE VERTEBRAL COLUMN OF THE PIG

The number of bones in the vertebral column of the pig is denoted in the formula $\mathbf{C}_7\mathbf{T}_{14}\mathbf{L}_6\text{or}_7\mathbf{S}_4\mathbf{C}_{20-23}$. In rare cases there may be as many as

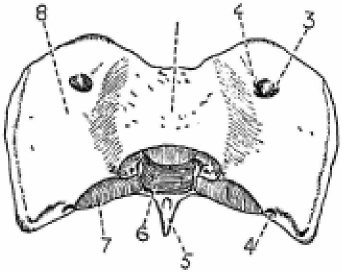


FIG. 32.—ATLAS OF PIG (SUPERIOR ASPECT)

1. Superior tubercle. 2. Intervertebral foramen. 3. Alar foramen. 4. Transverse foramen. 5. Inferior tubercle. 6. Articular surface on inferior arch for odontoid process. 7. Articular surface on posterior border of lateral mass for anterior extremity of axis. 8. Wing.

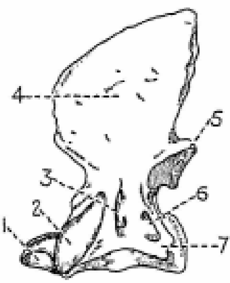


FIG. 33.—AXIS OF PIG (LEFT LATERAL ASPECT)

1. Odontoid process. 2. Articular surface at anterior extremity of body. 3. Intervertebral foramen. 4. Spine. 5. Posterior articular process. 6. Transverse foramen. 7. Transverse process.

seventeen thoracic vertebrae. In the domestic pig six is the most common number of lumbar bones. When seven are present the last of them is generally derived from the sacral region, which in that case possesses only three vertebrae.

Cervical Vertebrae.—The wings of the **atlas** project almost horizontally. The transverse foramen perforates the wing from its posterior border to its lower surface. The upper surface of the superior arch is very convex.

The odontoid process of the **axis** is short, conical and constricted at its base. The articular facets on either side of it are disjoined from it and distinctly convex in all directions. The transverse process is small and undivided, but there is a large transverse foramen. The spine is very high and undivided.

The bodies of the cervical vertebrae generally are relatively shorter in the pig than in any of the other domestic animals. Their extremities are also flatter, the anterior extremity being even slightly depressed. Only in the first one or two and the last of the series is there any suggestion of an inferior ridge. The laminae are very narrow from before to behind, and consequently a considerable interannular space is left in the articulated spine between adjacent arches. The articular processes are much more inclined than in the horse. A bar of bone perforated by a supernumerary foramen connects the anterior articular process to the upper division of the transverse process of the same side. The superadded foramen gives passage to the superior primary division of the spinal nerve. The spinous process is thicker and more prominent than in the horse, and it is inclined forwards. The transverse process consists of an upper short, tubercle-like division, and a lower plate-like part. The latter is directed downwards, and the right and left divisions, together with the lower surface of the body, give to the inferior aspect of the vertebra the form of a deep well-defined groove.

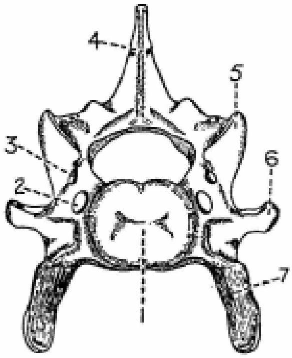


FIG. 34.—SIXTH CERVICAL VERTEBRA OF PIG (ANTERIOR ASPECT)

1. Anterior extremity of body. 2. Transverse foramen. 3. Supernumerary foramen. 4. Spine. 5. Anterior articular process. 6-7. Upper and lower divisions of transverse process.

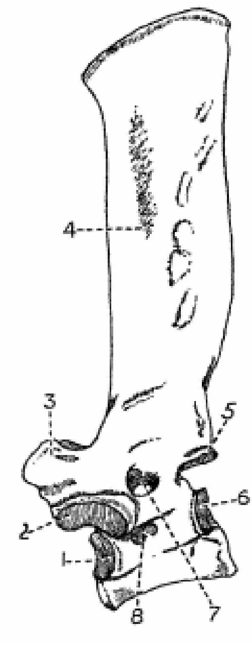


FIG. 35.—SECOND THORACIC VERTEBRA OF PIG (LEFT LATERAL ASPECT)

1. Anterior demi-facet. 2. Facet on transverse process for tubercle of rib. 3. Anterior articular process. 4. Spine. 5. Posterior articular process. 6. Posterior demi-facet. 7. Supernumerary foramen. 8. Foramen representing posterior vertebral notch.

In the **seventh vertebra** the spinous process is nearly as long as the immediately succeeding thoracic spines.

Thoracic Vertebrae.—The thoracic vertebrae of the pig have most resemblance to those of the ruminant. The extremities of the bodies are flatter than in the horse. In the last four bones the anterior demi-facet is confluent with the facet for the tubercle of the rib. Mammillary processes

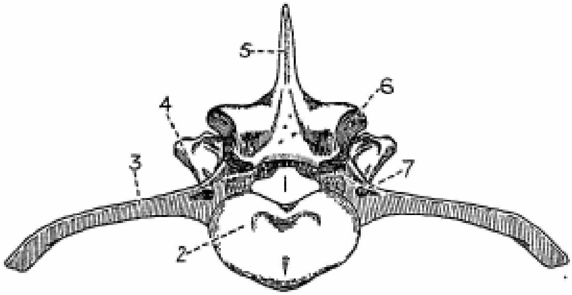


FIG. 36.—FIFTH LUMBAR VERTEBRA OF PIG (POSTERIOR ASPECT)
1. Vertebral foramen. 2. Posterior extremity of body. 3. Transverse process. 4. Mammillary process. 5. Spine. 6. Posterior articular process. 7. Supernumerary foramen in transverse process.

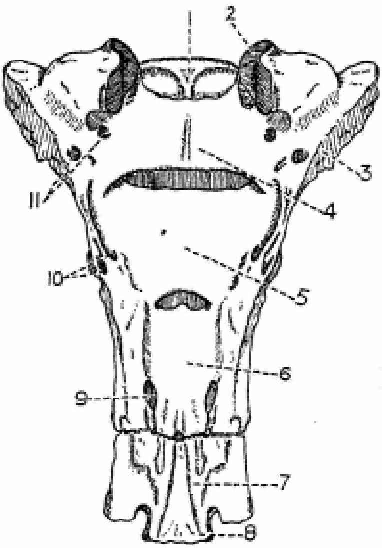


FIG. 37.—SACRUM OF PIG (VIEWED FROM ABOVE)
1. Anterior extremity of body of first sacral vertebra. 2. Anterior articular process of first sacral vertebra. 3. Auricular facet. 4-7. Arches of sacral vertebrae. 8. Posterior extremity of spine of fourth sacral vertebra. 9. Superior sacral foramen. 10-11. Double superior sacral foramina.

are present in all but the first two or three vertebrae, and **accessory processes** are carried by the posterior borders of the arch in the last few members of the series. A supernumerary foramen perforates the root of the transverse process, and the intervertebral foramina are usually double, as in the ox. The spines are relatively long and flat.

Lumbar Vertebrae.—These bones form no intertransverse joints. The transverse processes are perforated at the base by a supernumerary foramen. The intervertebral foramina in the anterior bones are sometimes double.

Sacrum.—The four vertebrae of this region remain distinct for a longer period than in the other domestic animals. Large interannular spaces are left between the adjacent arches. The auricular facets lie in a nearly vertical plane, and the spines are reduced to the condition of a slight crest.

Coccygeal Vertebrae.—The first four or five bones possess both anterior and posterior articular processes.

THE VERTEBRAL COLUMN OF THE DOG

The spinal formula of the dog is $\mathbf{C_7T_{13}L_7S_3C_{18-22}}$.

Cervical Vertebrae.—The **atlas** is narrow from before to behind. The superior arch presents no eminence in the position of the spine. The wings are prominent, nearly horizontal, and produced further backwards than in

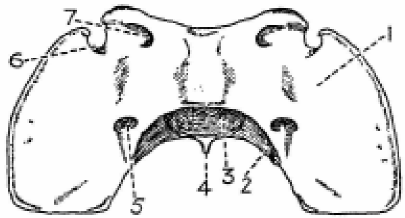


FIG. 38.—ATLAS OF DOG (SUPERIOR ASPECT)

1. Wing. 2. Articular surface on posterior border of lateral mass for anterior extremity of axis. 3. Articular surface on inferior arch for odontoid process. 4. Inferior tubercle. 5. Transverse foramen. 6. Notch representing alar foramen. 7. Intervertebral foramen.

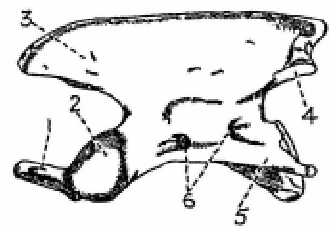


FIG. 39.—AXIS OF DOG (LEFT LATERAL ASPECT)

1. Odontoid process. 2. Articular surface at anterior extremity of body. 3. Spine. 4. Posterior articular process. 5. Transverse process. 6. Transverse foramen.

the other domesticated animals. The alar foramen is represented by a notch. The articular surfaces on the posterior aspect of the ring are concave.

The odontoid process of the **axis** is bluntly conical, and directed slightly upwards. It resembles most the same process of the pig, but it is longer and not constricted at its base. The facets on either side of it are distinctly convex in all directions, as in the pig. The spine is of great size, but undivided. Anteriorly it projects so far as to overhang the arch of the atlas. The anterior notch is never converted into a foramen. The transverse processes project farther backwards than in the horse.

Save in respect of size, the **third** to the **seventh** vertebrae resemble most closely the corresponding bones of the horse. The ends of the bodies, however, are flatter than in the horse, the spines are better developed, and the laminae are broader. The transverse measurement of the bones diminishes as they are traced backwards along the series.

Thoracic Vertebrae.—These have most resemblance to the same bones of the horse, but the spines are narrower and thicker on their posterior borders. The posterior demi-facet is absent on the last three bones.

Lumbar Vertebrae.—These bones are relatively large, and their processes are well-developed. The ends of the bodies are flatter than in the

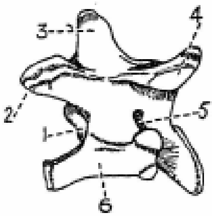


FIG. 40.—FIFTH CERVICAL VERTEBRA OF DOG (LEFT LATERAL ASPECT)
1. Anterior extremity of body. 2. Anterior articular process. 3. Spine. 4. Posterior articular process. 5. Transverse foramen. 6. Transverse process.

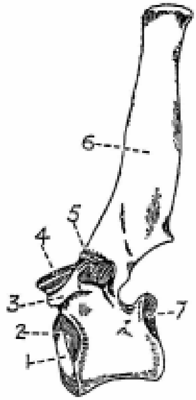


FIG. 41.—FOURTH THORACIC VERTEBRA OF DOG (LEFT LATERAL ASPECT)
1. Anterior extremity of body. 2. Anterior demi-facet. 3. Transverse process. 4. Anterior articular process. 5. Facet on transverse process for tubercle of rib. 6. Spine. 7. Posterior demi-facet.

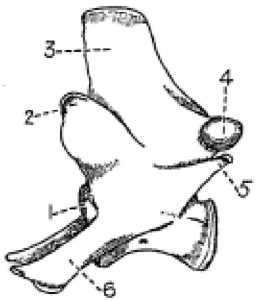


FIG. 42.—THIRD LUMBAR VERTEBRA OF DOG (LEFT LATERAL ASPECT)
1. Anterior extremity of body. 2. Mammillary process. 3. Spine. 4. Posterior articular process. 5. Accessory process. 6. Transverse process.

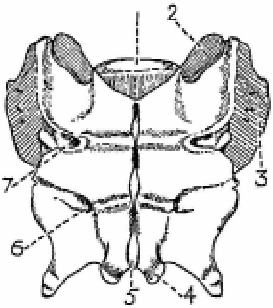


FIG. 43.—SACRUM OF DOG (VIEWED FROM ABOVE)
1. Anterior extremity of body of first sacral vertebra. 2. Anterior articular process of first sacral vertebra. 3. Auricular facet. 4. Posterior articular process of third sacral vertebra. 5. Spine of third sacral vertebra. 6-7. Superior sacral foramina.

horse. The anterior articular process carries laterally a distinct mammillary process, and a slender pointed accessory process projects backwards and upwards from the posterior border of the arch. The transverse processes are strong and inclined downwards and forwards. No intertransverse joints are formed.

Sacrum.—The sacrum of the dog is short, and the three vertebrae that compose it are early anchylosed. Its lower surface is very concave in the antero-posterior direction. The spines are short and fused together throughout their whole extent. The auricular facet lies in a more vertical plane than in the horse.

Coccygeal Vertebrae.—The anterior bones of this region in the dog are better developed than in the horse. The first three or four have all the parts of a typical vertebra distinctly developed, and their articular processes form synovial joints. Small V-shaped or Y-shaped bones, which have been termed **"chevron bones"**, lie below the third to the fifth or sixth intercentral joints. They form with the vertebrae a series of arches, the so-called **haemal arches,** for the middle coccygeal vessels.

THE VERTEBRAL COLUMN OF THE CAT

The cat has in each region of its spine the same number of vertebrae as the dog.

Cervical Vertebrae.—The inferior arch of the ring of the **atlas** is very narrow. The notch representing the alar foramen is deeper than in the dog, and the transverse foramen opens on the posterior border of the wing, as in the pig.

The odontoid process of the **axis** is longer and more slender than in the dog, and the spine is pointed at its posterior end.

The other cervical vertebrae closely resemble the same bones of the dog save that the seventh has no demi-facet for articulation with the first rib.

Thoracic Vertebrae.—These are very similar in form to those of the dog. The first has a facet large enough to receive the entire head of the first rib. The posterior demi-facet is absent in the last three bones.

Lumbar Vertebrae.—As in the dog, these bones are strong and rugged. Mammillary and accessory processes are well developed, and the transverse processes are much inclined downwards.

Sacrum.—This differs in no important respect from the same bone of the dog.

Coccygeal Vertebrae.—As in other species the number of coccygeal bones varies with the breed and with the individual. Most commonly they are about twenty, but only four are present in the Manx breed. In the first six or seven bones of this series rudiments of all the parts of a typical vertebra are present, and as far as the eighth a complete vertebral foramen is formed. From the second to about the tenth vertebra, small **"chevron bones"** are present.

CHAPTER III

THE SKELETON OF THE THORAX

THE skeleton of the thorax comprises, besides the thoracic vertebrae already described, the ribs, the costal cartilages and the sternum. Together these circumscribe a cavity that has the form of a cone compressed laterally. What may be termed the *roof* of this cavity is formed by the bodies of the thoracic vertebrae, its *floor* is formed by the sternum, and its *lateral walls* by the ribs and their cartilages. The *apex* of the cone is placed anteriorly, and is represented by an elliptical opening, bounded laterally by the first pair of ribs, and completed above by the body of the first thoracic vertebra. The *base* of the cone slopes obliquely downwards and forwards and is heart-shaped in outline. It is bounded superiorly by the body of the last thoracic vertebra, inferiorly by the most posterior segment of the sternum, and on each side by the last rib and the united cartilages of all the false ribs. In the living animal the base of the cavity is closed by the diaphragm; the apex is closed by the trachea, oesophagus, blood-vessels and other structures passing into or out of the chest; and the several intercostal spaces on each side are closed by the intercostal muscles.

THE RIBS AND STERNUM OF THE HORSE

The Ribs

The ribs of the horse number eighteen pairs, each vertebra of the thoracic region carrying a rib on either side. Each rib is an elongated, more or less curved, and highly elastic bone, articulated to the spine by its upper extremity, and prolonged at its lower extremity by a rod of cartilage termed a costal cartilage. The part of a rib where the curve is most acute is termed the **angle,** but this is not well marked in any of the ribs of the horse. For descriptive purposes there may be recognised in a rib two surfaces, two borders, and two extremities.

The *external surface* is convex in its length in all of the ribs. It is also convex in the transverse direction, but in the anterior half of the series this surface presents a shallow wide groove anteriorly. It shows, especially in the neighbourhood of the angle, some slight ridges for muscular attachment.

The *internal surface* is concave in its length, and flattened in the transverse direction. It is smoother than the external surface, and in the recent state it is lined by the pleura.

The *anterior border* is concave. In the anterior half of the series it is thin and sharp, but in the remainder of the ribs it is thick and rounded.

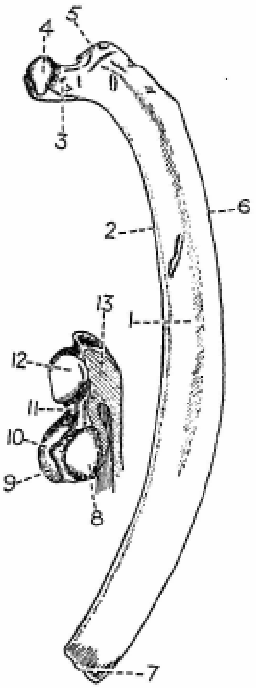


FIG. 44.—LEFT SIXTH RIB OF HORSE (EXTERNAL ASPECT, WITH VIEW OF UPPER EXTREMITY)

1. Shaft. 2. Anterior border. 3. Neck. 4. Head. 5. Tubercle. 6. Posterior border. 7. Lower extremity. 8-9. Anterior and posterior facets of head. 10. Groove dividing head. 11. Neck. 12. Tubercle. 13. Shaft.

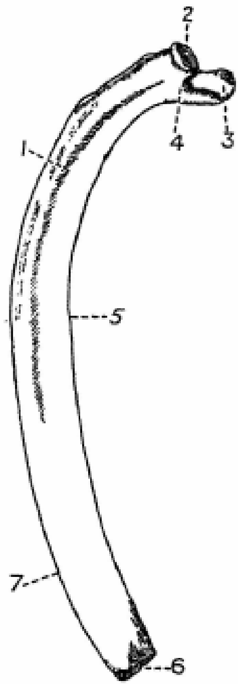


FIG. 45.—LEFT SIXTH RIB OF HORSE (INTERNAL ASPECT)

1. Shaft. 2. Tubercle. 3. Head. 4. Neck. 5. Anterior border. 6. Lower extremity. 7. Posterior border.

The *posterior border* is convex and thick. On its internal aspect it presents a groove which begins at its upper extremity and extends for a variable distance down the bone. The intercostal vessels and nerve descend in this groove. The borders of the ribs give attachment to the intercostal muscles which in the recent state fill up the intercostal spaces and complete the chest wall.

The *upper extremity* of each rib is compounded of the head, the neck, and the tubercle.

The **head** is a hemispherical articular process, divided (in all the ribs except the first) by a groove into an anterior and a posterior facet. It is received into one of the cavities formed by the costal facets of adjacent vertebrae and the intervening fibro-cartilage already described in connection with the bodies of the thoracic vertebrae. It thus articulates with the bodies of two thoracic vertebrae, except in the case of the first rib, the head of which articulates with the last cervical and first thoracic vertebrae. The groove which divides the head into two facets gives attachment to the intra-articular or conjugal ligament of the costo-central joint.

The **neck** of the rib is a constricted portion immediately below the head. It is roughened outwardly for ligamentous attachment.

The **tubercle** lies behind the head from which it is separated by the neck. It carries a nearly flat surface for articulation with the transverse process of the posterior one of these vertebrae. Outwardly the tubercle is roughened for muscular attachment.

The *lower extremity* is intimately united to its cartilage. It is roughened and often slightly expanded.

The Costal Cartilages

The ribs are prolonged inferiorly by the so-called costal cartilages. Each of these is a more or less rounded rod of hyaline cartilage, which, in the case of the eight anterior ribs, articulates by its distal end with the lateral surface of the sternum. These ribs are therefore termed **true** or **sternal ribs.** The remaining ten pairs of ribs are termed **false** or **asternal ribs,** since their cartilages do not articulate with the sternum. The cartilage of each of the false ribs is closely bound for nearly its entire length to its predecessor in the series, although sometimes one or more of the costal cartilages at the end of the series may project freely into the abdominal wall and be unconnected with the preceding cartilage. The ribs to which these cartilages belong are then termed **floating ribs.** In the young subject the costal cartilages are entirely composed of hyaline cartilage, but with advancing age they become more or less calcified by the deposition of lime salts.

Special Characters of the Ribs and Cartilages

The first rib is the shortest and the least curved. It has the largest head and tubercle, and the former is undivided. The external surface and anterior border of this rib carry some imprints for the attachment of the scalenus muscle. It is further distinguished by the presence of two smooth markings on its anterior border, the higher of these being the impress of the thoracic roots of the brachial plexus, while the lower marks the point at which the axillary vessels emerge from the chest.

In the case of the other ribs the head and tubercle diminish in size from the first to the last. In the last three or four ribs the

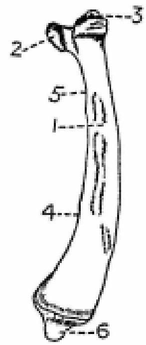


FIG. 46.—LEFT FIRST RIB OF HORSE (EXTERNAL ASPECT)
1. External surface of shaft, with imprints for attachment of scalenus. 2. Head. 3. Tubercle. 4. Groove for axillary vessels. 5. Groove for thoracic roots of brachial plexus. 6. Costal cartilage.

posterior articular facet of the head is confluent with the facet of the tubercle. The curvature of the ribs progressively increases from the first to the last. The length of the ribs diminishes in passing forwards and backwards from the ninth, which is the longest; and their breadth diminishes in the same way in passing forwards and backwards from the sixth. The ninth rib has the longest cartilage, and the first has the shortest. The cartilages of the true ribs are shorter and thicker than those of the false ribs, and their distal ends are blunt for articulation with the sternum, while the distal ends of the cartilages of the false ribs are pointed. The cartilage of the first rib differs from all the others in articulating in the median plane with its fellow of the opposite side as well as with the sternum.

The Sternum

The sternum, or breast bone as it is popularly called, is a mesially-placed segmented structure, forming the floor of the chest, and suspended from the thoracic vertebrae by means of the ribs. Although described as a single bone, in reality it comprises seven originally distinct osseous segments or **sternebrae** (the last two segments fuse at a very early stage of development), and throughout life a considerable portion of it retains its primitive cartilaginous structure. The sternum of the horse is distinctly canoe-shaped, and it may be described as possessing three surfaces, three borders, and two extremities.

The *superior surface* has the form of a very elongated isosceles triangle with the base behind. A fibrous cord, the median division of the internal sternal ligament, runs along its length in the middle line. The surface forms the floor of the thorax.

The *lateral surfaces*, right and left, are more extensive than the preceding. Each presents near its upper border a series of articular depressions, seven in number, for the cartilages of the sternal ribs from the second to the eighth. The first four of these depressions

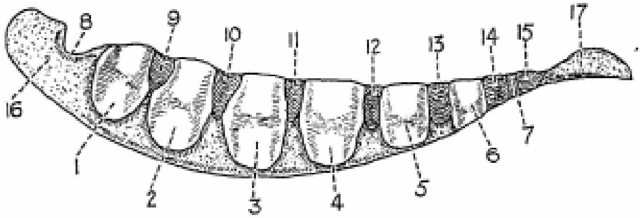


FIG. 47.—STERNUM OF HORSE (LEFT LATERAL VIEW)
1-7. Sternebrae. 8. Articular notch for first costal cartilages. 9-15. Articular cavities for second to eighth costal cartilages. 16. Presternal cartilage. 17. Xiphoid cartilage.

are vertically elongated, and separated by considerable intervals, but the remaining three are more circular in outline and lie nearer to one another. The lower extremities of the costal cartilages articulate each at the junction of two sternebrae, with the exception of the seventh and eighth cartilages which lie close together at the side of the fused sixth and seventh sternebrae. Beneath the line of these articular cavities each lateral face affords attachment to the deep pectoral muscles.

The *supero-lateral borders*, right and left, separate the superior and lateral surfaces. In the recent state each is traversed by a fibrous cord, the lateral division of the internal sternal ligament.

The *inferior border* is convex, narrow and blunt. It may be distinctly felt in the living animal and to it are attached the superficial pectoral muscles.

The *anterior extremity* of the sternum is entirely cartilaginous, forming a marked prominence termed the **presternal cartilage.** This process presents right and left faces, an inferior border continuous with the like parts of the body of the sternum, and an upper border with a wide semi-circular notch for articulation with the cartilages of the first pair of ribs. The presternal cartilage gives attachment to some of the muscles of the neck including the sternothyrohyoideus and the sternocephalicus, together with the anterior superficial pectoral muscle, and it can be felt in the living animal.

The *posterior extremity* is formed by the **xiphoid cartilage.** This is a thin, flexible piece of cartilage, irregularly circular in outline, concave on its upper aspect and convex on its lower. The diaphragm is attached across the upper surface of the cartilage close to its line of junction with the body of the sternum. This surface of the cartilage thus forms part of the floor of both the thorax and abdomen. The lower surface shows a ridge in the middle line to which the transversus abdominis muscle is attached.

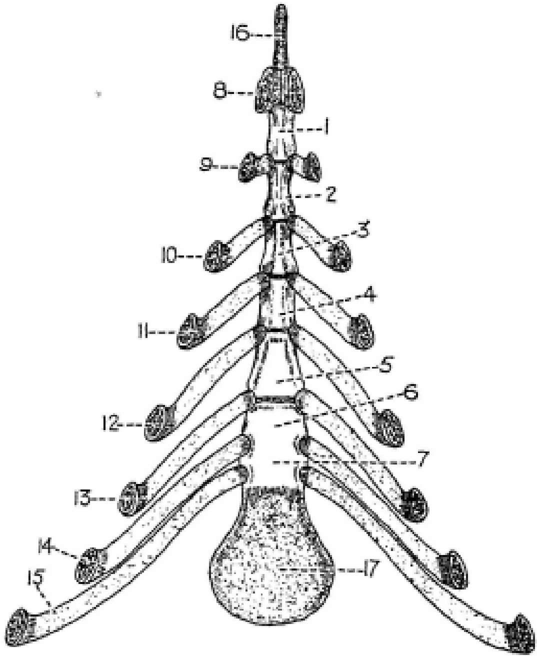


FIG. 48.—STERNUM OF HORSE (VIEWED FROM ABOVE)
1-7. Sternebrae. 8-15. First to eighth costal cartilages. 16. Presternal cartilage. 17. Xiphoid cartilage.

The first sternebra of the horse's sternum together with the presternal cartilage is the homologue of the **manubrium sterni** of human anatomy. The succeeding five pieces compose the **body,** while the last sternebra with its cartilaginous appendix forms the **xiphisternum.**

THE DEVELOPMENT OF THE RIBS AND STERNUM

The mesenchymal costal processes mentioned in connection with the development of the vertebrae give rise to the transverse processes and the **ribs.** During the cartilaginous stage of development that portion of the costal process which will become the rib severs its connection with the body of the vertebra, the intervening mesenchyme becoming converted into the ligaments of the costo-central joint. At this stage the rib is separated from the transverse process by a space, but this is later crossed by the development of the tubercle of the rib which forms a joint with the transverse process.

Each cartilage which is destined to become a rib shows three centres of ossification, one for the major part or body of the rib, another for the head, and another for the tubercle. Although the distal extremities of the ribs do not ossify in early life but persist as the so-called **costal cartilages,** it is usual to find an increasing deposition of bone in these cartilages as the animal gets older.

It should be noted that whilst ribs are fully developed only in connection with the thoracic vertebrae, the costal processes give rise to cartilaginous structures throughout the vertebral column. In the neck these do not develop to any great extent, being represented only by the lower part of the transverse processes in this region, but in the lumbar region they form the prominent plate-like transverse processes.

With regard to the development of the **sternum,** there appear in the ventral wall of the embryo two longitudinally running bars of cartilage which fuse with the lower extremities of the more anterior ribs. The two bars unite with one another in the middle line from before backwards to form a single plate of cartilage. In the horse in early life ossification commences in seven centres which will become the sternebrae. (In some species two lateral centres of ossification are found in some of the more posterior segments.) The osseous pieces developed from the last two centres speedily become indistinguishably fused, but the other pieces remain distinct for a long time or for life, and are separated by persistent cartilage. Beside the presternal and xiphoid cartilages, a considerable portion adjoining the inferior border remains cartilaginous and never becomes ossified.

THE RIBS AND STERNUM OF THE OX AND SHEEP

Ribs of the Ox.—The ox possesses thirteen pairs of ribs—eight true and five false. They are longer, broader and less curved than in the horse. The neck is longer, and the facet on the tubercle is slightly concave. The second to the tenth or eleventh ribs articulate with their respective cartilages in synovial joints.

Ribs of the Sheep.—These are very similar to the ribs of the larger ruminant.

Sternum of the Ox.—The sternum of the ox is compressed from above to below, presenting an upper and a lower surface. The former corresponds to the upper surface of the horse's sternum, the latter to the combined lateral surfaces of that bone. It comprises seven segments. The large

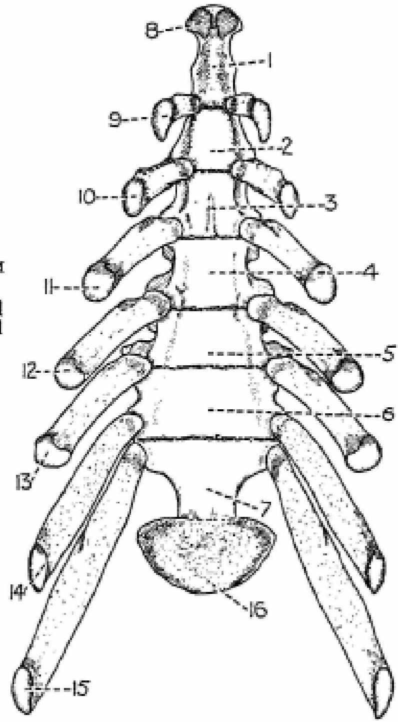


FIG. 49.—STERNUM OF OX (VIEWED FROM ABOVE)

1-7. Sternebrae. 8. Facet for first costal cartilage. 9-15. Second to eighth costal cartilages. 16. Xiphoid cartilage.

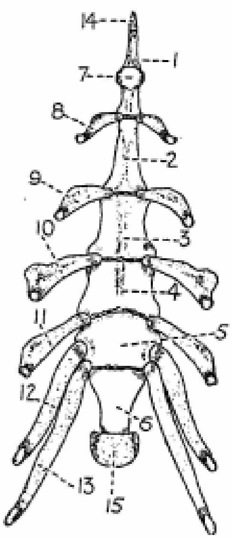


FIG. 50.—STERNUM OF PIG (VIEWED FROM ABOVE)

1-6. Sternebrae. 7. Facet for first costal cartilages. 8-13. Second to seventh costal cartilages. 14. Presternal cartilage. 15. Xiphoid cartilage.

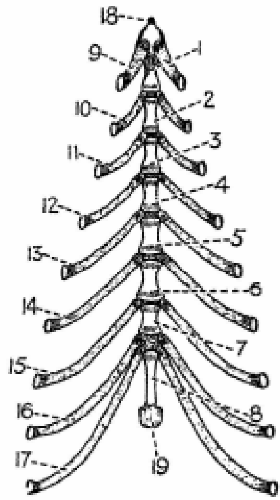


FIG. 51.—STERNUM OF DOG (VIEWED FROM ABOVE)

1-8. Sternebrae. 9-17. First to ninth costal cartilages. 18. Presternal cartilage. 19. Xiphoid cartilage.

manubrium has no presternal cartilage and it meets the second segment in a synovial joint. The xiphoid cartilage is smaller and more detached than in the horse. On each side of the sternum there are eight cavities for articulation with the cartilages of the sternal ribs.

Sternum of the Sheep.—This is similar to that of the ox, save that the first piece is not movably articulated to the second.

THE RIBS AND STERNUM OF THE PIG

Ribs.—The pig has in most cases fourteen pairs of ribs—seven true and seven false. Exceptionally there may be as many as seventeen pairs. They are somewhat similar to those of the ruminant, but are more curved. The second, third, fourth and fifth bones form movable joints with their cartilages.

Sternum.—The sternum of the pig comprises six pieces. It has most resemblance to that of the ruminant, but it is narrower, and the first segment carries a small presternal cartilage. As in the ox, the manubrium is movably articulated to the second piece. The xiphoid cartilage is small, and, owing to the length of the last sternebra, is well detached from the adjacent costal cartilages.

THE RIBS AND STERNUM OF THE DOG AND CAT

Ribs.—In the dog and cat the ribs number thirteen pairs, of which nine are sternal. They are narrower, relatively thicker, and more curved than in the other domestic animals. The last is a floating rib. Each of the last three bones articulates with but one vertebra corresponding to the more posterior of the two vertebrae of earlier joints, and the facet on the head is therefore undivided.

Sternum.—There are eight pieces in the sternum of these animals. Each sternebra is slightly compressed from side to side, and constricted in its middle. The uniting cartilage between the segments persists as such until late life. The presternal cartilage is reduced in size and the xiphoid cartilage is also small.

CHAPTER IV

THE SKULL

THE skull, which forms the skeleton of the head, may be said to consist of two portions—the cranium and the face. The **cranium** is that part of the skull which encloses the brain; the **face** contains the cavities of the mouth and nose, and with the cranium completes on each side the orbit, or cavity for the eye. A great many distinct bones enter into the formation of the skull, and, with the exception of the lower jaw, adjacent bones are united by closely applied surfaces or borders forming fibrous or cartilaginous joints. Moreover, it is only during early life that these joints are distinct, for with advancing age the soft uniting substance (cartilage or white fibrous tissue) itself becomes ossified. Hence, in animals beyond middle age, the limits of the various bones are almost entirely obliterated. For the study of the separate elements of the skull one should, therefore, take the head of a young animal. In the case of a foal it would be preferable were it not more than three months old. The skull of such a subject, when freed from the soft textures, can easily be resolved into its component bones. Some of the bones of the skull are median unpaired bones like the vertebrae, and others are double or paired like the ribs or the bones of the limbs.

The names of the **cranial bones** are as follows, the first four being regarded for the purpose of description as single and the others as paired bones: Occipital, Interparietal, Sphenoid, Ethmoid, Parietal, Frontal and Temporal.

The following are the names of the bones of the **face,** all of them except the last two being regarded as paired bones: Pterygoid, Palatine, Maxilla, Lacrimal, Malar, Nasal, Premaxilla, Superior Turbinate bone, Inferior Turbinate bone, Vomer, Mandible.

The before-mentioned bones constitute the skull proper, but to these are superadded the Hyoid bone, which comprises a number of separate pieces forming the skeleton of the tongue, and the auditory ossicles, three small bones situated in the tympanic cavity of the petrous division of the temporal bone.

THE BONES OF THE SKULL OF THE HORSE[1]

The Occipital Bone

This bone is placed at the extreme posterior part of the skull, and it is naturally considered first, since it furnishes the surfaces by which the skull is articulated to the anterior extremity of the vertebral column. It is made up of four parts—two lateral parts, a basilar part and a squamous part—grouped around a large central opening, the **foramen magnum.** This hole, which is comparable to a vertebral foramen, establishes a communication between the vertebral canal and the cranial cavity. The spinal cord here joins the brain.

The **lateral parts** lie on either side of the foramen magnum, meeting above to form the upper boundary of the foramen. Each carries a convex articular process, termed the **condyle,** which lies at the side of the foramen magnum. The condyle is received into one of the articular cavities on the front of the atlas. Laterally to the condyle, on each side, a strong curved process—the **paramastoid process**—projects backwards and downwards towards the middle line. The paramastoid processes show roughenings on their lateral aspects and at their free extremities for the attachment of muscles. Between the condyle and the root of the paramastoid process on each side a considerable hole, the **condylar foramen,** opens. Each lateral part meets its fellow in the middle line above the foramen magnum. Superiorly it articulates with the squamous part. Laterally it carries a large facet extending on to the root of the paramastoid process forming a joint with the petrous temporal bone. Inferiorly it joins the lateral border of the basilar part.

The **basilar part** is a thick rod of bone extending forwards from beneath the foramen magnum (its posterior extremity forms the lower boundary of the foramen) to articulate anteriorly by a truncated end with the body of the sphenoid. The outer surface of this part of the occipital bone is convex from side to side, and just at its point of junction with the sphenoid it carries two tubercles, one on either side the middle line, for the attachment of the inferior straight muscles of the head. The internal or cranial surface of the bone is slightly depressed, and the medulla oblongata and pons rest on it. The lateral borders are thin and sharp anteriorly and each forms the medial boundary of a very irregular opening termed the **foramen lacerum.** Posteriorly the borders meet the lateral parts of the occipital bone.

[1] Throughout the description of the bones of the skull, the head is assumed to be held with its long axis lying horizontally.

The **squamous part** is a thick, somewhat four-sided piece of bone lying above the foramen magnum (from which it is separated, however, by the medial portions of the lateral elements of the bone). Superiorly the outer surface of this part of the occipital bone is crossed by a prominent transverse and horizontal ridge which corresponds to the superior nuchal line of man but which owing to its greater development in the horse has been aptly termed the **nuchal crest.** The central horizontal portion of this crest forms the most posterior part of the skull and here the bone is extremely thick. Laterally it extends downwards and forwards on each side to be continued on the temporal bone as the **temporal crest.** On the squamous part of the occipital bone, just below the nuchal crest and in the middle line, a small laterally compressed process, the **external occipital protuberance,** serves for the attachment of the funicular part of the ligamentum nuchae. On either side of the protuberance is a roughened area into which the complexus is inserted. In front of the nuchal crest a small area of the outer surface faces directly upwards. This area shows in the middle line a ridge which is continued forwards on the interparietal and parietal bones and is known as the **parietal crest.** The internal surface shows a central and two lateral depressions which are the impresses of the corresponding lobes of the cerebellum. The circumferent border of the squamous part articulates with the interparietal and parietal bones antero-superiorly, with the squamous and petrous temporal bones laterally, and with the lateral parts of the occipital bone inferiorly.

The Parietal Bones

The parietal bones are placed on the superior aspect of the cranial cavity in front of the nuchal crest. Each has the form of a thin, slightly curved plate of bone possessing two surfaces and four borders.

The *superior* or *external surface* is convex, and for the greater part of its extent it enters into the formation of the **temporal fossa,** affording by its roughness attachment to the fibres of the temporal muscle. At the antero-medial angle a small, flat, triangular area of this surface is excluded from the temporal fossa by a curved ridge termed the **parietal crest.** The crest, which may be compared with the temporal line of man, becomes increasingly prominent with advancing age. It meets its fellow posteriorly in the median plane, where it is continued on to the interparietal and occipital bones, while anteriorly it is continuous with the posterior border of the supraorbital process of the frontal bone. Towards the lateral border a part of this surface is concealed in the articulated skull, being overlapped by the squamous temporal, with which it articulates by the dovetailing of numerous scaly processes.

The *inferior* or *internal surface* is concave, and it forms a considerable part of the roof or vault of the cranium, overlying the cerebral hemisphere. It is smooth and close-grained in texture, and

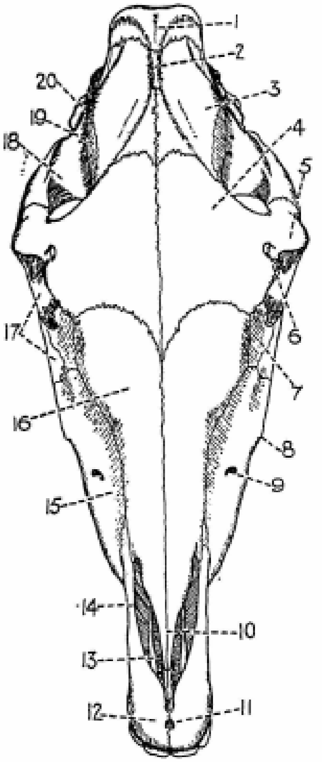


FIG. 52.—SKULL OF YOUNG HORSE (VIEWED FROM ABOVE, WITH MANDIBLE REMOVED)
1. Squamous part of occipital bone. 2. Interparietal bone. 3. Parietal bone. 4. Frontal bone. 5. Supraorbital process of frontal bone. 6. Supraorbital foramen. 7. Lacrimal bone. 8. Anterior extremity of zygomatic ridge. 9. Infraorbital foramen. 10. Nasal peak. 11. Incisive foramen. 12. Body of premaxilla. 13. Palatine process of premaxilla. 14. Nasal process of premaxilla. 15. Maxilla. 16. Nasal bone. 17. Malar bone. 18. Zygomatic process of squamous temporal bone. 19. Body of squamous temporal bone. 20. Triangular process of squamous temporal bone.

it presents two series of markings, viz. (1) a number of ramifying narrow grooves marking the course of the meningeal arteries, and (2) numerous shallow, pit-like or digital markings, which are impressions of the cerebral convolutions. In the recent state this surface is lined by the dura mater, which serves as an internal periosteum to the bone.

The *medial border*, which is thick and serrated in the whole of its extent, presents posteriorly a deep, square-cut notch for articulation with the interparietal. In front of this notch the medial border is opposed in the median line to the same border of the opposite bone, and in the adult skull the line of junction is raised outwardly into a prominent ridge which forms part of the parietal crest and which separates the right and left temporal fossae.

The *lateral border* is thin and sinuous. It articulates with the squamous temporal for nearly the whole of its extent, but the extreme part of it meets the wing of the posterior division of the sphenoid.

The *anterior border* has an internal bevel in its lateral half, and an external bevel in its medial half, and it articulates with the frontal bone.

The *posterior border* is articulated to the occipital and the squamous and petrous temporal bones. It presents a well-defined groove which enters into the formation of the **parieto-temporal canal.** This groove at first lies under cover of the posterior border and is open to the cranial cavity, but in passing laterally it crosses so as to lie on the outer aspect of the border. In the articulated skull the border now under consideration projects into the cranial cavity in front of its line of articulation with the occipital and temporal bones and gives attachment to a process of dura mater termed the tentorium cerebelli.

The Interparietal Bone

This bone is mesially placed on the superior aspect of the cranium, being wedged in between the parietal bones anteriorly and laterally, and the occipital bone behind. It presents two surfaces and four borders.

The *external surface* forms in the foal at birth a small four-sided flat area in front of the nuchal crest. In older animals it is crossed in the median line by the **parietal crest.**

The *internal* or *cranial surface* carries a three-sided process of bone which projects freely downwards and forwards into the cranial cavity. This process corresponds to the internal occipital protuberance of man, and its posterior face is turned towards the cerebellum while its lateral surfaces, right and left, are opposed to the cerebral hemispheres. Each of these lateral surfaces presents a vascular depression for the transverse venous sinus. The anterior border of the protuberance, which is continuous with the medial suture of the parietal bones, affords attachment to the falx cerebri. The lateral borders give attachment to the membranous tentorium cerebelli and because of this the protuberance has been termed the **osseous tentorium cerebelli.**

The *posterior border* of the interparietal is thick and dentated for articulation with the squamous portion of the occipital. The *lateral* and *anterior borders* are thinner, and more closely serrated for articulation with the parietals.

The Sphenoid Bone

This bone is placed at the base of the skull, its central portion being continuous behind with the basilar part of the occipital. In the foal at birth, and for some months afterwards, it is composed of two pieces, as distinct from each other as are any of the other bones of the skull. For convenience these divisions may be described separately, the posterior part, which lies next to the occipital, being termed the postsphenoid, and the anterior part the presphenoid.

The Postsphenoid Bone

This division of the sphenoid is composed of a central portion or body, two pairs of lateral projections or wings, and the pterygoid or subsphenoidal processes.

The **body** is a short cylinder of bone with square-cut or truncated *extremities,* the *posterior* of which is joined by a thin layer of cartilage to the basilar part of the occipital, while the *anterior* is united in the same way to the body of the presphenoid.[1] Its *external surface* is convex from side to side, and at the line of junction with the basilar part of the occipital lie two tubercles, one on each side, for the attachment of the inferior straight muscles of the head. The *superior* or *cranial surface* is flattened, with a faint depression in its anterior half. This depression is termed the **hypophyseal** or **pituitary fossa** since it lodges the hypophysis cerebri or pituitary body. The area around and including the fossa is termed the **sella turcica.** The *lateral borders* of the body of the bone have the wings attached to them.

The **wings**[2] project laterally and upwards on each side of the body. Each may be said to present two surfaces and four borders. The *inferior* or *outer surface* has attached to it anteriorly the pterygoid process. Medially, close to its junction with the body, it is crossed by a faint groove which leads anteriorly to the **pterygoid canal.** The *superior* or *cranial surface* of the wing is smooth, and lined by dura mater. It presents laterally a wide shallow depression for the piriform lobe of the cerebrum. Medially and parallel to this there is a deep well-defined groove for the maxillary division of the fifth cranial nerve. Laterally to this, between it and the depression for the piriform lobe, a narrow furrow marks the course of the fourth cranial nerve. Lastly, at the extreme medial part of this sur-

[1] In old animals the spheno-palatine sinuses may extend into the anterior part of the body.

[2] The greater wings of human anatomy.

face, close to its junction with the body, a faint longitudinal impression is left by the cavernous sinus.

The *medial border* of the wing is fused with the body. The *lateral border* is bevelled and scaly for articulation at its posterior corner with the parietal, and for the rest of its extent with the squamous temporal. The *posterior border* is free, forming the anterior boundary of the **foramen lacerum.** It presents three notches, viz. (1) a medial notch close to the body, for the internal carotid artery with its accompanying plexus of sympathetic nerves and surrounded by the inferior petrosal sinus; (2) a middle, for the mandibular division of the fifth cranial nerve; (3) a lateral, for the middle meningeal artery. The *anterior border* of the wing is articulated to the wing of the presphenoid. It presents the **foramen rotundum,** and by apposition with the presphenoid it forms the **foramen orbitale** and the **trochlear foramen.**[1]

The **pterygoid** or **subsphenoidal processes** project downwards and forwards from the lower and anterior aspect of the wings and body. At its base each is perforated by the **subsphenoidal** or **alar canal.** The **temporal foramen,** for the anterior deep temporal artery, opens from the canal behind the anterior border of the wing. The point and superior border of the process articulate with the palatine bone, and by the medial side of its base it contracts a small articulation with the pterygoid bone.

The Presphenoid Bone

This division of the sphenoid comprises a body and two lateral wings.

The **body** is a short rod, the *posterior extremity* of which is truncated for articulation with the body of the postsphenoid. The *anterior extremity* is excavated, and divided by a septum into two deep cavities, which form part of the right and left **spheno-palatine sinuses.** In old animals these sinuses may extend beyond the posterior extremity into the postsphenoid body. Superiorly, the septum is produced into a short projecting process, or **rostrum,** for articulation with the crista galli of the ethmoid. The *inferior* or *external surface* of the body is convex from side to side, porous, and concealed in its anterior half by articulation with the vomer. The lateral aspect of the body forms a small part of the medial wall of the orbit. Below this it is related to the palatine, and at the line of junction of these two areas lies a minute furrow leading to the

[1] The orbital and trochlear foramina represent the superior orbital fissure of human anatomy.

anterior opening of the pterygoid canal. The *superior* or *cranial surface* is smooth and nearly flat in its anterior two-thirds where it supports the cerebral hemispheres. In its posterior third it presents, at a lower level than the preceding, a smooth flat surface known as the **optic groove** on which lies the optic chiasma, and from either extremity of this a short passage, the **optic canal,** passes obliquely forwards and laterally to open externally near the junction of the body and the wing at the **optic foramen.**

The *lateral borders* of the body are joined to the wings.

The **wings.**[1] Each of these presents two surfaces and a circumferent border.

The *outer surface,* slightly convex, possesses an oblong part, which is smooth and free on the medial wall of the orbit; but in front of and behind this, forming three-fourths of the surface, the wing is rough and concealed by articulation with the orbital plate of the frontal bone. The *inner* or *cranial surface* is slightly concave, smooth, and furnished with some faint impressions left by the cerebral convolutions.

The *circumferent border* of the wing is articulated posteriorly to the wing of the postsphenoid, and it presents grooves, which complete the **foramen orbitale** and the **trochlear foramen.** Superiorly and laterally the border is convex and is received into a cleft of the frontal bone at the junction of the body and the orbital plate. Anteriorly the wing is also articulated to the cribriform plate of the ethmoid and orbital plate of the frontal, and it carries close to the body a notch, which, with a similar notch of the ethmoid and frontal, forms the **ethmoidal foramen.** The inferior or medial part of the border is fused with the body.

The Frontal Bones

These bones are placed on the upper aspect of the skull, on the limits of the cranium and face. Each comprises a main part or body, a reflected plate, an orbital plate and a supraorbital process.

The **body** presents for consideration two surfaces and four borders.

The *superior* or *external surface* of the body is smooth and subcutaneous. In the foal at birth it is distinctly convex, but in the adult animal it is nearly flat. The *inferior* or *internal surface* is divided into two parts by the reflected plate. The posterior or cranial part is smooth and it shows a number of markings left by the cerebral convolutions. The anterior part forms the superficial or external wall of the posterior part of the **frontal sinus.** It shows

[1] The lesser wings of human anatomy.

a number of bony septa which connect it to the underlying reflected plate.

The *medial border* is denticulated behind and plane in front, and for the whole of its extent it is articulated to the same border of the opposite bone. The *posterior border* is bevelled and scaly for articulation with the parietal. The *anterior border* has a wide outward bevel, and is scaly for articulation with the nasal bone medially and the lacrimal laterally. The *lateral border* carries the orbital plate and the supraorbital process.

The **reflected plate** is formed as a result of the separation of the two tables of compact tissue which constitute the bone. It is broadest posteriorly where it curves downwards and forwards in such a way that the frontal sinus extends posteriorly beyond and above the anterior limit of the cranial cavity. Its anterior part has the form of a narrow plate of bone overlying the posterior part of the nasal chamber. The reflected plate may be described as having two surfaces and two borders.

The *external surface* forms a large part of the floor of the frontal sinus. It presents an irregular appearance being most depressed about its centre. Bony plates run from this surface to the internal surface of the body. The *internal surface* is divided into two parts by a curved ridge. This projects freely downwards behind the upper part of the olfactory fossa meeting its fellow of the opposite side and the crista galli in the middle line. The posterior part of the surface bounds the cranial cavity, being continuous with the internal surface of the body and carrying impressions left by the cerebral convolutions. The smaller anterior part forms the upper boundary of the superior meatus of the nasal fossa. Laterally it is connected to the lateral mass and the cribriform plate of the ethmoid.

The *medial border* meets its fellow of the opposite side in the middle line of the skull. It is connected to the medial border of the body by a plate of bone which, joining the corresponding part of the opposite bone in a scaly articulation, forms a complete septum between the right and left frontal sinuses. The *lateral border* is joined posteriorly to the orbital plate, and anteriorly to the upper aspect of the lateral mass and the superior turbinate bone.

The **orbital plate** of the frontal passes downwards from the main portion of the bone at the medial side of the orbit. It possesses two surfaces and four borders.

The *external* or *orbital surface* is concave and smooth, and it forms the greater part of the medial wall of the orbit. Superiorly, close to the root of the supraorbital process, it shows a pit in the position of the fibrous loop through which the superior oblique muscle of the eyeball is reflected. This pit is scarcely perceptible in the young skull. The *internal surface* is divided into two portions by the lateral border of the reflected plate. The posterior and larger of these is opposed to the outer surface of the wing of the presphenoid. Superiorly and anteriorly it is limited by a deep semicircular cleft, the **incisura sphenoidalis,** into which the margin of the presphenoidal wing is received. The anterior portion is rough and

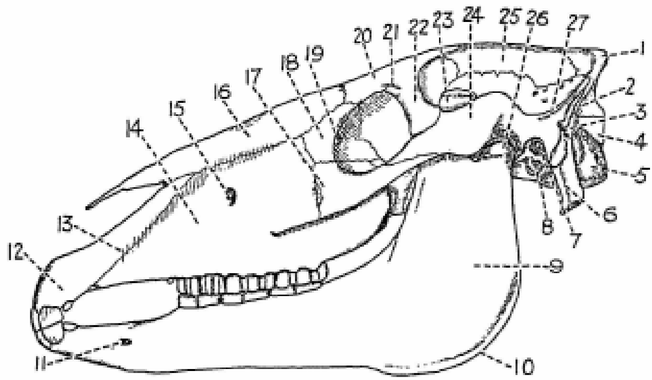


FIG. 53.—SKULL OF YOUNG HORSE (LATERAL VIEW)

1. Nuchal crest. 2. Squamous part of occipital bone. 3. Mastoid foramen. 4. Lateral part of occipital bone. 5. Occipital condyle. 6. Paramastoid process. 7. Auditory process of petrous temporal bone. 8. Styloid process of petrous temporal bone. 9. Mandible. 10. Angle of mandible. 11. Mental foramen. 12. Body of premaxilla. 13. Nasal process of premaxilla. 14. Maxilla. 15. Infraorbital foramen. 16. Nasal bone. 17. Malar bone. 18. Lacrimal bone. 19. Lacrimal fossa. 20. Frontal bone. 21. Supraorbital foramen. 22. Supraorbital process of frontal bone. 23. Coronoid process of mandible. 24. Zygomatic process of squamous temporal bone. 25. Parietal bone. 26. Condyle of mandible. 27. Temporal crest on triangular process of squamous temporal bone.

irregular. Superiorly it enters into the formation of the lateral wall of the frontal sinus, while inferiorly it is attached to the lateral mass of the ethmoid.

The *superior border* of the orbital plate unites it to the body of the bone. The *inferior border* is articulated to the presphenoid wing. It shows a deep oblong outcut occupied by that wing in the articulated skull, and in front of that a small notch which the wing and, more deeply, the cribriform plate of the ethmoid convert into a complete foramen, the **ethmoidal foramen.** The *posterior border* is thin, bevelled outwardly, and scaly for articulation with the squamous temporal. The *anterior border* is thin, convex, and articulated to the lacrimal, maxillary and palatine bones.

The **supraorbital process** [1] is a short rod of bone so named from its relation to the orbit. It stretches like a bridge between the frontal

[1] Also termed the zygomatic process.

bone and the zygomatic arch, and forms an imperfect separation between the orbital cavity and the temporal fossa. It presents two surfaces, two borders and two extremities.

The *upper surface* is smooth and convex. The *lower* or *orbital surface,* also smooth, is slightly depressed for the lacrimal gland.

The *posterior border* is concave in its length, and thick and rounded in the vertical direction. The *anterior border* is also concave in its length. It is sharper than the posterior border, and it forms the upper part of the orbital margin.

The *medial extremity* or root of the process is perforated close to the anterior border by the **supraorbital foramen.** At birth and for some months thereafter this foramen is represented by a notch. The *lateral extremity* is truncated for articulation with the zygomatic process of the squamous temporal.

The Temporal Bones

At birth the temporal bones of the horse are each composed of two distinct pieces, which are termed respectively the squamous and petrous portions.

The Squamous Temporal Bones

These bones form part of the lateral wall of the cranial cavity below the parietal. Each consists of a body to which are added two processes, the triangular process and the zygomatic process.

The **body** is an ovoid, slightly curved plate which may be described as possessing two surfaces and a circumferent border.

The *external surface* is convex and smooth, and for the most part it enters into the formation of the temporal fossa. In its posterior half the zygomatic process is attached to it. The *internal surface* is concave and smooth towards its centre, where it appears on the lateral cranial wall and is lined by the dura mater. Around this the internal surface is cut into numerous scaly processes for articulation with the parietal and frontal bones and the postsphenoidal wing.

The *circumferent border* is thin and scaly for articulation with these same bones, except at its posterior part where it is joined to the triangular process.

The **triangular process** springs from the posterior part of the circumferent border. It presents for description an internal and an external surface, three borders and three angles.

The *external surface* is crossed obliquely by a sharp ridge, the **temporal crest,** which continues the superior border of the zygomatic process to the nuchal crest, and marks here the limit of the temporal fossa. The *internal surface* is applied to the petrous temporal, and it is crossed just below the upper border by a groove, which the petrous temporal and parietal bones convert into a complete canal, the **parieto-temporal canal.**

The *inferior border* of the process is concave, forming a bay for the external auditory process of the petrous temporal. The *posterior border* presents a central notch which is converted into a foramen, the **mastoid foramen,** by apposition with the petrous temporal bone. By this foramen the posterior meningeal artery enters the parieto-temporal canal. The *superior border* is perforated by several small foramina communicating with the parieto-temporal canal.

The *anterior angle* of the process is that by which it is united to the body of the squamous temporal. The *postero-superior angle* touches the occipital bone at the nuchal crest. The *postero-inferior angle* abuts against the mastoid process.

The **zygomatic process.** This is a long curved process springing from the outer surface of the body and forming the lateral boundary of the temporal fossa. It passes at first laterally, and then, forming a bend, it passes forwards to join the posterior extremity of the malar bone. It may be described as possessing two surfaces, two borders and two extremities.

The *medial surface* is smooth and turned towards the temporal fossa. Its posterior part faces upwards, whilst its anterior part is directed medially. The *lateral surface* may also be divided into two parts. The posterior part has a small area directed laterally and posteriorly, but the greater part faces downwards. This area comprises three portions, viz. (1) a transversely elongated **glenoid cavity** or **articular fossa,** (2) in front of that a transversely elongated **condyle,** or **articular eminence,** and (3) behind the cavity a short nipple-like projection, the **postglenoid process.** The anterior aspect of this process is articular, forming as it were the posterior boundary of the glenoid cavity. The condyle of the mandible articulates with this surface through the medium of an articular fibro-cartilaginous disc. Immediately behind the postglenoid process the lower orifice of the parieto-temporal canal is found. The anterior part of the lateral surface is smooth and subcutaneous.

The *superior border* of the zygomatic process is convex and sharp, and is continuous behind with the temporal crest on the external surface of the triangular process. Immediately behind its anterior end it carries a rough surface for the abutment of the supraorbital process of the frontal bone. The *inferior border* forms a concavity facing medially.

The *posterior extremity* is fused to the outer surface of the bone. The *anterior extremity* is cut into an inferior bevel for articulation with the posterior extremity of the malar bone, and medially to this it contracts a small articulation with the maxilla.

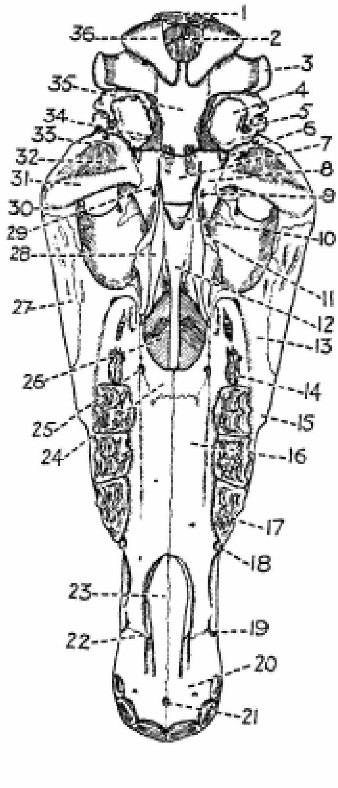


FIG. 54.—SKULL OF YOUNG HORSE (VIEWED FROM BELOW, WITH MANDIBLE REMOVED)

1. Nuchal crest. 2. Foramen magnum. 3. Paramastoid process. 4. Auditory bulla of petrous temporal bone. 5. Styloid process of petrous temporal bone. 6. Muscular process of petrous temporal bone. 7. Body of postsphenoid bone. 8. Wing of postsphenoid bone. 9. Posterior opening of subsphenoidal canal. 10. Body of presphenoid bone. 11. Pterygoid process of postsphenoid bone. 12. Vomer bone. 13. Maxilla. 14. Unerupted molar tooth. 15. Anterior extremity of zygomatic ridge. 16. Palatine process of maxilla. 17. First premolar tooth. 18. Additional premolar or wolf's tooth. 19. Position of alveolus for canine tooth. 20. Body of premaxilla. 21. Incisive foramen. 22. Palatine fissure. 23. Palatine process of premaxilla. 24. Horizontal part of palatine bone. 25. Anterior palatine foramen. 26. Pharyngeal opening of nasal fossa. 27. Malar bone. 28. Pterygoid bone. 29. Groove leading to pterygoid canal. 30. Zygomatic process of squamous temporal bone. 31-33. Condyle, glenoid cavity and postglenoid process of squamous temporal bone. 34. Foramen lacerum. 35. Basilar part of occipital bone. 36. Occipital condyle.

The Petrous Temporal Bones

These divisions of the temporal bones are so named from the stony hardness of their compact tissue. Each is situated on the postero-lateral aspect of the skull, and it has the form of a four-sided pyramid, the base of which is turned downwards and forwards.

The *anterior surface*, the smallest of the four, is articulated laterally to the posterior border of the parietal, but medially it is free, and directed towards the cerebral division of the cranial cavity. It forms much of the posterior boundary of the parieto-temporal canal.

The *posterior surface* is comparatively flat, and articulated to the occipital bone. It shows near its lower part a minute foramen by which the auricular branch of the tenth cranial or vagus nerve enters the facial canal which lies in the interior of the bone.

The *lateral surface* is concealed in the articulated skull, being overlapped by the triangular process of the squamous temporal. It is crossed by a groove for the posterior meningeal artery.

The *medial surface* is smooth and free, forming part of the boundary of the cerebellar division of the cranial cavity, and it presents some faint impressions. In its lower third it shows the **internal auditory meatus,** by which the seventh and eighth cranial nerves enter the bone. The floor of the meatus shows superiorly a foramen which is the beginning of the **facial canal,** through which passes the seventh cranial nerve. The rest of the floor is perforated by numerous minute openings for the filaments of the eighth cranial nerve. Behind the meatus, close to the postero-medial border, there is a narrow slit which leads to the **aqueduct of the cochlea,** and above that again is a larger slit which opens into the **aqueduct of the vestibule.**

These four surfaces are separated by four borders, of which two are anterior and two posterior.

The *antero-medial border* is sharp and slightly notched. It has been termed the **petrosal crest,** and the tentorium cerebelli is attached to it. The *antero-lateral border* is short, thick, and concealed by the triangular process of the squamous temporal. The *postero-medial border* is comparatively sharp. It sometimes shows at its lower part a small depression for the petrous ganglion of the ninth cranial nerve. The *postero-lateral border* projects freely on the exterior of the articulated skull between the squamous temporal and occipital bones, and forms a ridge, the **mastoid crest,** which is continuous above with the nuchal crest. Inferiorly the mastoid crest terminates in a blunt process, the **mastoid process,** which lies immediately in front of the root of the paramastoid process of the occipital. Both crest and process serve for muscular attachment. About its centre this border is notched for the posterior meningeal artery.

The *apex* of the bone is directed upwards and backwards, and is included between the occipital and squamous temporal bones.

The *base* is free in the articulated skull, and it forms the lateral boundary of the foramen lacerum. Beside several important foramina it carries the auditory process, the auditory bulla, the styloid process and the muscular process.

The **auditory process,** sometimes termed the **external auditory process,** since it bounds the outer opening of the external auditory meatus, is a short tube of bone which leads into the **tympanum** or

middle ear—an irregular cavity in the petrous temporal bone.[1] The annular cartilage at the root of the external ear surrounds this process, and the tympanic membrane is stretched across the internal opening of the meatus. The direction of the tube is upwards, outwards and backwards. In the foal at birth the process is very short and incomplete on its upper aspect.

The **styloid process,** formerly termed the **hyoid process,** lies below and medial to the auditory process. It derives its name from its homologue in man which has the form of a tapering spicule. In the horse it is a small plug-like rod of bone projecting downwards and forwards from a kind of sheath. It is united through the medium of a piece of cartilage to the styloid cornu of the hyoid bone.

The **auditory bulla** is placed immediately behind and medial to the styloid process. It is a large smooth boss with thin walls, its interior being honeycombed by air spaces in communication with the tympanum.

The **muscular process**[2] is a slender spicule of bone springing from the base anteriorly and medially to the styloid process, and projecting freely downwards and forwards. The tensor and levator palati muscles take origin from it.

The following openings or foramina occur on the base: (1) The **stylo-mastoid foramen.** This is of considerable size and is situated between the styloid process anteriorly and the mastoid process behind. It is the outward opening of the curved facial canal through which the seventh cranial nerve passes. The nerve obtains entrance to this canal at the bottom of the internal auditory meatus on the medial surface. (2) The **petro-tympanic fissure.** This opens above the styloid process and lateral to the root of the muscular process. It gives passage outwards to the chorda tympani nerve. (3) The orifice of the bony part of the **pharyngo-tympanic** (or **auditory) tube.** This is an irregular slit to the medial side of the root of the muscular process. The bony tube leads backwards into the tympanum, and from its outer opening the cartilaginous tube leads to the pharynx. (4) Medially to the orifice of the auditory tube a small foramen gives exit to the greater and lesser superficial petrosal nerves.

[1] Within the tympanum are found three small bones termed, from their resemblance to a hammer, an anvil and a stirrup, the **malleus, incus** and **stapes** respectively. They transmit the impulses created by the impinging of the sound waves on the tympanic membrane through the middle ear to the internal ear. For a description of these bones the reader is referred to works dealing with the sense organs of the domestic animals.

[2] Formerly termed the styloid process.

The Ethmoid Bone

This bone is situated in the median plane, and it comprises four parts, viz. a cribriform plate, a perpendicular plate and two lateral masses.

The **cribriform plate.** This is a sieve-like plate of bone placed horizontally as a partition between the cranial cavity and the nasal

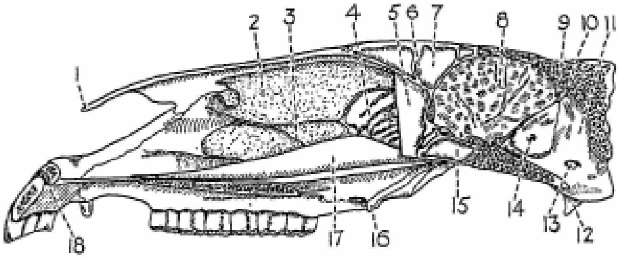


FIG. 55.—SAGITTAL SECTION OF SKULL OF ADULT HORSE
1. Nasal peak. 2. Superior turbinate bone. 3. Inferior turbinate bone. 4. Lateral mass of ethmoid bone. 5. Perpendicular plate of ethmoid bone (partly removed anteriorly). 6. Cribriform plate of ethmoid bone. 7. Septum separating frontal sinuses. 8. Cerebral compartment of cranium. 9. Projection formed by posterior border of parietal bone. 10. Parieto-temporal canal. 11. Cerebellar compartment of cranium. 12. Paramastoid process. 13. Condylar foramen. 14. Internal auditory meatus. 15. Septum separating spheno-palatine sinuses. 16. Hamulus of pterygoid bone. 17. Vomer bone. 18. Incisive foramen.

fossae. Its sieve-like character is due to numerous small perforations through which foramina the filaments of the first cranial or olfactory nerves pass to reach the nasal mucous membrane. It possesses an anterior and a posterior surface and a circumferent border.

The *posterior* or *cranial surface* is divided in the middle line by the posterior border of the perpendicular plate. Each half is slightly concave and porous in appearance, and it forms the anterior boundary of the **olfactory** or **ethmoidal fossa** in which the olfactory bulb is lodged. Besides the numerous small foramina for the olfactory nerves already mentioned, it shows at each side a larger foramen for the passage of the nasal branches of the ethmoidal artery and nerve, which last-mentioned enter the cranial cavity from the orbit by passing through the ethmoidal foramen situated at the lateral margin of the fossa.

The *anterior* or *nasal surface* is convex and concealed by the lateral masses which are attached to it.

The *circumferent border* of the cribriform plate is attached above to the frontal and below to the presphenoid bone. These two bones meet around its lateral aspect.

The **perpendicular plate** is placed in the median plane of the head, and two surfaces and four borders may be recognised in it.

The *surfaces*, right and left, are free, and covered in the recent state by nasal mucous membrane. They form part of the medial wall of the nasal fossae.

The *superior border* is articulated to the median suture of the frontal bones. The *inferior border* is received into the cleft of the vomer. The *posterior border* projects freely into the cranial cavity as a prominent crest—the **crista galli**—between the olfactory fossae. Superiorly the crista galli projects into the median suture of the frontal bones, and inferiorly it is articulated to the rostrum of the presphenoid. The *anterior border* of the perpendicular plate is irregular, and continuous in the recent state with the septal cartilage of the nose.

The **lateral masses** or **labyrinths.** Each of these is a conical mass, the base lying posteriorly, attached to the anterior surface of the cribriform plate, and almost entirely filling up the extreme posterior end of the nasal chamber. Each is composed of a number of small scrolls or convoluted shells of very fragile bone, arranged the one above the other. These are termed the **ethmo-turbinates,** and they increase in size from below to above, the most superior one being much larger than any of the others.

The *medial surface* of the lateral mass is plane and separated by a very narrow interval from the surface of the perpendicular plate. It shows the contours of the ethmo-turbinates, and the interspaces between them. The *lateral surface* is formed by a smooth thin layer of bone—the **lamina papyracea.**[1] It is convex and directed towards the frontal and maxillary sinuses, and to its internal surface the ethmo-turbinates are attached. It articulates with the reflected plate of the frontal and the superior turbinate above; the orbital plate of the frontal, the presphenoid and palatine laterally; and the palatine and vomer below.

The *base* is united to the cribriform plate, while the *apex*, formed by the anterior end of the largest ethmo-turbinate, is a free rounded projection.

In the recent state the ethmo-turbinates are invested by nasal mucous membrane. Air from the nasal cavity is admitted into the spaces or meatuses between the ethmo-turbinates by the openings on the medial surface of the lateral mass. The anterior end of the largest ethmo-turbinate encloses a cavity which communicates with the maxillary sinus.

[1] In the human subject and in some animals this appears on the medial wall of the orbit and is termed the orbital plate.

The Pterygoid Bones[1]

These are small, slightly twisted, strap-like bones, placed one on either side of the guttural opening of the nose. Each possesses two surfaces and two extremities.

The *medial surface* is smooth and covered by the mucous membrane of the pharynx.

The *lateral surface* is articulated to the palatine, vomer and sphenoid, and posteriorly, by contact with the last-named bone, it completes the **pterygoid canal.**

The *posterior extremity* of the bone is pointed, and wedged in between the body of the postsphenoid and the root of the pterygoid process.

The *anterior extremity* is free, slightly bent laterally and pulley-like on its antero-lateral aspect. This constitutes the **hamulus,** around which the tendon of the tensor palati muscle is reflected.

The Palatine Bones

The palatine bones lie one each side of the pharyngeal opening of the nose, their anterior extremities forming the extreme posterior part of the bony palate while their posterior ends appear on the medial wall of the orbit. They are very irregular in shape, each bone being twisted to form a horizontal and a perpendicular part.

The **horizontal part** is a flattened plate lying anteriorly which may be described as possessing two surfaces, two borders and two extremities.

The *superior surface* is smooth, and forms with its fellow of the opposite side a small part of the floor of the nasal chamber.

The *inferior surface,* also smooth, forms the most posterior part of the bony palate.

The *anterior border* is convex. It meets the posterior border of the palatine process of the maxilla.

The *posterior border* is concave, and to it is attached the fibrous aponeurosis of the soft palate. It is rough medially, and smooth laterally.

The *anterior extremity* is turned medialwards to meet the corresponding extremity of the opposite bone in the middle line. Superiorly the two bones form a ridge, the **nasal crest,** to which the vomer bone is united.

The *posterior extremity* is joined to the vertical part.

The **vertical part** of the palatine bone forms much the larger

[1] These bones are the homologues of the medial pterygoid plates of the greater wings of the sphenoid of man.

part of the bone, and it is situated posteriorly. It presents for description two surfaces, two borders and two extremities.

The *medial surface* may be divided into three areas: (1) a superior smooth and concave area which is covered by mucous membrane and which forms the lateral boundary of the pharyngeal opening of the nasal fossa; (2) a middle, narrow, elongated area, running downwards and forwards, which lies below and behind the preceding and which is for articulation with the pterygoid bone; (3) an inferior roughened area which shares in the formation of the **pterygoid crest** from which the medial pterygoid muscle takes origin.

The *lateral surface* also shows three distinct regions: (1) the most anterior and largest of these is roughened for articulation with the maxilla. It is traversed by a groove running downwards and forwards which the last-named bone converts into a complete canal, the **palatine canal;** (2) the middle area is smooth; superiorly it forms the medial wall of the **pterygo-palatine** fossa and the lower part of the orbit, while below it bounds the staphyline groove; (3) the most posterior part of this surface is depressed for the accommodation of the pterygoid process.

The *superior border* presents about its middle the round **spheno-palatine foramen.** In front of this the border is thin and denticulated for articulation with the ethmoid and the maxilla. Behind the foramen the two plates of bone separate so as to enclose a large cavity which enters into the formation of the spheno-palatine sinus. The medial lip of this cavity is articulated to the vomer, and the lateral lip to the presphenoid, frontal and maxillary bones. In some skulls it joins the lacrimal also.

The *inferior border* is rough in its posterior third, forming the pterygoid crest. This crest is most prominent at its extremities, the posterior of which rests laterally against the tip of the pterygoid process, while the anterior supports medially the pterygoid bone just above its hamulus. In its anterior two-thirds the inferior border is thick. Medially it forms the posterior edge of the bony palate, while laterally it joins the maxilla. In its middle third this border forms laterally, by apposition with the maxilla, a narrow groove—the **staphyline groove**—for the artery and nerve of that name.

The *anterior extremity* joins the horizontal portion of the bone.

The *posterior extremity* is wedged between the pterygoid process of the postsphenoid and the presphenoid body.

The Maxillae

With the exception of the mandible these are the largest bones of the skull. They are situated on the lateral aspects of the face.

and they carry the upper grinding teeth. For convenience of description each may be divided into a main portion, or body, and a palatine process.

The **body** possesses two surfaces, two borders and two extremities.

The *lateral* or *facial surface* is slightly concave in front and convex behind. A little above its centre it shows the **infraorbital foramen.** Towards its posterior and inferior part it is raised into a prominent ridge, the **zygomatic ridge**. The ridge is continued backwards by the inferior border of the malar bone, and it gives origin to the masseter muscle. Behind the ridge a rough area of the lateral surface is articulated to the malar bone.

The *medial* or *nasal surface* is markedly concave in the vertical direction, and it forms part of the lateral boundary of the nose. Near its upper border it is traversed antero-posteriorly by a groove for the naso-lacrimal duct. In the adult animal this groove is converted posteriorly into a complete canal, which is continuous with a similar canal on the medial surface of the lacrimal bone. A little below this groove a slight bony crest marks the line of attachment of the inferior turbinate bone. At the postero-superior part of this surface the bone is excavated into a large irregular cavity which forms part of the maxillary sinus. The palatine process is attached to this surface about the middle third of its length and close to its inferior border. Behind the posterior border of the process a rough scaly surface, traversed antero-posteriorly by a groove, serves for articulation with the palatine bone. The groove, by apposition with a like groove on the palatine bone, is converted into the **palatine canal.**

The *anterior border* of the body is convex, thin and scaly. It articulates in succession from in front backwards with the nasal process of the premaxilla, the nasal bone and the lacrimal bone.

The *inferior* or *alveolar border* is excavated in the adult animal by six large sockets, or alveoli, for the grinding (premolar and molar) teeth, and often by a small additional alveolus for a premolar tooth lying in front of the others.[1] In front of the most anterior alveolus this border becomes narrow, forming part of the interdental space. Behind the most posterior alveolus a rough mark, the **alveolar tuberosity,** serves for the attachment of the buccinator and depressor labii inferioris muscles.

The *anterior extremity* of the bone is pointed. It articulates with the premaxilla, and by apposition with that bone it forms an alveolus for the canine tooth.

The *posterior extremity* forms in the adult animal a great

[1] Commonly called the wolf's tooth.

rounded boss, the **maxillary tuberosity,** which is situated below the floor of the orbit, and into which the cavity of the maxillary sinus extends. At birth the tuberosity is but slightly developed, and within it lie the three unerupted upper molars. Immediately laterally to the tuberosity the posterior extremity carries a pointed process, the **zygomatic process,** which is articulated laterally to the malar, and by its posterior extremity to the zygomatic process of the squamous temporal. Medially the maxillary tuberosity is articulated to the palatine bone by apposition with which it forms the posterior orifice of the palatine canal. Superiorly it is isolated by a deep trench lying in front of the pterygo-palatine fossa which exhibits three foramina arranged in the form of a semi-circle. (1) The **posterior palatine foramen,** the lowest of the three is formed on the suture between the palatine bone and the tuberosity. It is the posterior orifice of the **palatine canal** whose anterior opening is found on the bony palate. (2) The **spheno-palatine foramen** is situated between the other two, and, as already described, it perforates the superior border of the palatine bone. (3) The **maxillary foramen** is formed entirely in the bone now under consideration. It is the posterior orifice of the **superior dental,** or **infraorbital, canal** which traverses the bone to open anteriorly at the infraorbital foramen. The thin plate of bone that bounds this trench above is articulated to the lacrimal, frontal and palatine bones.

The **palatine process** is a shelf of bone springing from the medial surface of the body, close to its alveolar border. It forms a large part of the bony palate, and it may be described as possessing two surfaces and four borders.

The *superior* or *nasal surface* forms part of the floor of the nose. It is a little rough, but in its anterior two-thirds, close to its medial border, it is traversed by a faint groove which marks the course of the vomero-nasal organ (of Jacobson).

The *inferior* or *palatine surface* is smooth and nearly flat. It forms part of the roof of the mouth, and it shows a number of small foramina for the passage of blood vessels. Close to its lateral border a longitudinal furrow, the **palatine groove,** descends along it. This furrow leads forwards from the anterior orifice of the palatine canal, and it marks the position of the palatine artery and nerve.

The *lateral border* of the palatine process is fused to the body. The *medial border* is dentated for articulation with the same border of the opposite process. The two bones form here a ridge, the **nasal crest,** on the nasal aspect of the suture which articulates with the lower border of the vomer bone. The *anterior border* slopes forwards and laterally. In its posterior part it articulates with the palatine process of the premaxilla (in old animals the bones are usually united here by ossification), while anteriorly it forms part of the lateral boundary of the palatine fissure. The *posterior border* is scaly and articulated to the palatine bone.

The Lacrimal Bones

These small bones are placed at the anterior part of the orbit, and each offers for description two surfaces and a circumferent border.

The *lateral surface* is sharply divided into a facial and an orbital portion by an edge which forms part of the orbital margin. The facial portion is irregularly pentagonal and slightly convex. Near the orbital margin it bears in the adult animal a small projection, the **lacrimal tubercle,** for attachment of the lacrimal tendon of the orbicularis oculi muscle. The orbital portion is concave, and irregularly triangular with the point near the depression in which lies the maxillary group of foramina. It forms a large part of the floor of the orbit, and anteriorly, close to the margin, it is deeply depressed to form the **lacrimal fossa,** from the bottom of which the osseous lacrimal canal begins. The fossa lodges the lacrimal sac, and the canal transmits the first part of the naso-lacrimal duct. Behind the lacrimal fossa a small pit marks the origin of the inferior oblique muscle of the eyeball.

The *medial surface* is concave, irregular, and crossed by an antero-posterior ridge that indicates the course of the bony canal already mentioned. The surface forms part of the lateral wall of the frontal and maxillary sinuses.

The *circumferent border* of the lacrimal bone is thin and scaly or denticulated. It articulates in its anterior portion with the maxilla, inferiorly with the malar and maxilla, superiorly with the nasal and the body of the frontal bone, and posteriorly with the orbital plate of the frontal. In some cases it articulates between the frontal bone and the maxilla on the medial wall of the orbit with the palatine bone.

The Malar Bones

The malar or zygomatic bones are placed immediately behind the lacrimals, and each meets the zygomatic process of the squamous temporal of its own side to complete the zygomatic arch. The bone may be described as possessing three surfaces, three borders, a base and an apex.

The *lateral* or *facial surface* is smooth, slightly convex, and, like the other surfaces, widest in front. It is crossed in its length just above the lower border by a roughened ridge, the **zygomatic ridge,** which is continued anteriorly on the maxilla, and posteriorly on the squamous temporal bone, and which affords origin to the masseter muscle. The *superior* or *orbital surface* is smooth, and distinctly concave in its length. It forms part of the floor and anterior wall of the orbit. The *medial surface* is excavated to form part of the lateral wall of the maxillary sinus. In young animals, however, the excavated area is small, and the greater part of the surface articulates with the maxilla.

The *supero-lateral border* is for the most part concave, and it forms part of the orbital margin. In front of the orbital margin the border articulates with the lacrimal bone, while behind it meets the zygomatic process of the squamous temporal. The *supero-medial border*, also concave, is thin and articulated to the zygomatic processes of the maxilla and of the squamous temporal bone. The *inferior border* is thick, nearly straight, and lies directly below and medial to the zygomatic ridge.

The *base* of the bone forms its most anterior point and it articulates with the maxilla.

The *apex* is thin, pointed and bevelled superiorly for articulation with the zygomatic process of the squamous temporal bone.

The Nasal Bones

The nasal bones are placed on the superior aspect of the face one on each side of the median plane. They are named from their relationship to the nasal cavity which they bound above. Each bone has the form of a thin plate, slightly curved in the transverse direction, with two surfaces, two borders, a base and an apex.

The *external* or *facial surface* is smooth and convex from side to side. It is nearly straight in its length, but in some subjects it is very distinctly convex in its lower third.

The *internal* or *nasal surface* is concave from side to side. For the most part it enters into the formation of the nasal fossa, but posteriorly it concurs in forming the frontal sinus. It is traversed lengthways by a thin ridge of bone placed nearer the lateral than the medial border. This ridge or crest marks the attachment of the superior turbinate bone. Posteriorly the ridge sends laterally a branch which forms the anterior boundary of the area belonging to the frontal sinus.

The *medial border* is straight and opposed to the same border of the opposite bone. In its anterior third it is plane, and for the rest of its extent it is scaly and denticulated.

The *lateral border* is sinuous in its outline. In its posterior two-thirds it is thin, scaly, and articulated to the maxilla and the nasal process of the premaxilla. About the junction of its anterior and its middle third it presents a rounded notch in front of which it is free and forms the edge of the **nasal peak.**

The *base* of the bone is convex, bevelled inwardly, and scaly for articulation with the frontal and lacrimal bones.

The *apex* lies beside the corresponding point of the opposite bone, with which it forms the free end of the nasal peak.

The Premaxillae

The premaxillary or incisive bones are situated at the anterior part of the face and carry the incisor teeth. Each bone comprises a lower thick part or body, a nasal process, and a palatine process.

The **body** presents three surfaces. The *anterior* or *labial surface,* is smooth, convex, and related to the upper lip. The *posterior* or *palatine surface* is smooth and slightly concave. It forms the extreme anterior part of the bony palate. The *medial* or *articular surface* is flat and articulated to the same surface of the opposite bone. It is traversed from above to below by a groove which, by apposition with a like groove on the opposite bone, forms a short passage termed the **incisive foramen.** The *inferior border,* which separates the palatine and labial surfaces, is thick anteriorly where it is excavated in the adult animal by three sockets or alveoli for the incisor teeth. Behind the lateral alveolus the border is smooth and rounded forming part of the interdental space.

The **nasal process** is the larger of the two processes and it has the form of an upward tapering prolongation of the body. It may be said to possess two surfaces, two borders and two extremities.

The *lateral* or *facial surface,* widest anteriorly, is smooth and rounded from above to below. The *medial* or *nasal surface* is nearly co-extensive with the preceding. It is also smooth and convex in the vertical direction, and it forms a narrow strip of the lateral boundary of the nose. The *superior border* is free, smooth, and thick. A wide angular gap, the **naso-maxillary notch,** separates it from the edge of the nasal peak. The *inferior border* is scaly for articulation with the maxilla. At its lowest point it forms by articulation with the latter bone the alveolus for the permanent canine tooth.[1] The *anterior extremity* of the nasal process is thick and joined to the body of the bone. The *posterior extremity* is pointed, and wedged in between the nasal bone above and the maxilla below.

The **palatine process** is shorter and more slender than the pre-

[1] When a temporary canine tooth is developed its socket belongs exclusively to the maxilla.

ceding, to the medial side of which it lies. It possesses two surfaces, two borders, and two extremities.

The *superior* or *nasal surface* forms part of the floor of the nasal chamber. It is slightly ridged lengthways. Medial to the ridge lies the septal cartilage of the nose, while laterally is a groove for the accommodation of the vomero-nasal organ. The *inferior* or *palatine surface* is flat and smooth, and it forms part of the bony palate. The *medial border* is straight and dentated for articulation with the same border of the palatine process of the opposite bone. The *lateral border* is convex posteriorly where it is joined to the palatine process of the maxilla. Anteriorly, however, a narrow interval, the **palatine fissure,** occurs between the two bones. The *anterior extremity* is fused to the body close to the median plane. The *posterior extremity* is included between the anterior end of the vomer and the palatine process of the maxilla.

The Vomer Bone

This bone is placed in the median plane of the head, forming part of the partition between the right and left nasal fossae. It is composed of two thin, elongated plates of bone, united, except towards the posterior extremity of the bone, to form a narrow deep channel directed upwards for the accommodation of the nasal septum. It may be described as possessing four surfaces, three borders, and two extremities.

The two *medial surfaces,* right and left, are smooth. Together they form the lateral boundaries of the channel previously mentioned and they are related to the perpendicular plate of the ethmoid behind and the septal cartilage in front.

The *lateral surfaces,* right and left, are for the greater part smooth and covered by the nasal mucous membrane. Posteriorly each shows an irregular curved line which articulates with the more medial of the two lips into which the superior border of the vertical part of the palatine divides, and in front of this with the lateral mass of the ethmoid. Above this line the surface forms part of the medial wall of the spheno-palatine sinus.

The *superior borders* of the two plates are thin, and each reaches its highest point in the posterior fourth of the bone.

The *inferior border* is common to both plates of the bone since it is here that they are united. It is narrow and smooth in its posterior half, and in the articulated skull it divides the guttural opening of the nose into a right and left half. In its anterior half the border is flattened and rough for articulation with the nasal crest of the maxillae and palatine bones.

The *posterior extremity* is flattened from above to below. It lies below the body of the presphenoid, being separated from that bone by an interval which is occupied in the recent state by the lowest and most posterior part of the septum nasi which usually remains cartilaginous. Posteriorly a wide notch is cut out of this extremity, and laterally to the notch the bone is articulated to the palatine and pterygoid bones.

The *anterior extremity* is pointed, and it extends as far as the posterior extremities of the palatine processes of the premaxillae with whose nasal aspects it articulates.

The Turbinate Bones

There are two of these bones on each side. In the articulated skull they are concealed within the nasal chamber, the extent of which they materially diminish. They are distinguished by the terms superior and inferior.

The Superior or Ethmoidal Turbinate Bones

Each of these bones, viewed as a whole, is irregularly conical, but it may be described as possessing two surfaces, two borders, and two extremities.

The *medial surface* is smooth, slightly convex, and separated by a narrow interval from the nasal septum. The *lateral surface* is attached along its upper limit to the crest already described in connection with the internal surface of the nasal bone.

The *superior border* is rounded transversely and separated from the nasal bone by a narrow interval, the **superior meatus** of the nose. The posterior border, also rounded, is separated by a similar interval, the **middle meatus,** from the inferior turbinate bone.

The *posterior extremity,* forming the base of the cone, is partly blended with the lateral mass of the ethmoid. The *anterior extremity,* or *apex,* reaches to near the angle of meeting of the nasal and premaxillary bones. In the recent state it is prolonged by two bars of cartilage to near the nostril.

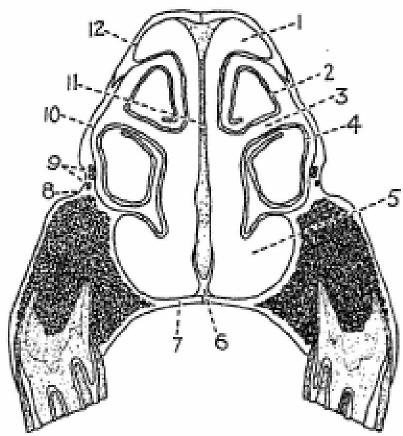
The superior turbinate bone is composed of a paper-like osseous curved plate, fixed supero-laterally to the before-mentioned ridge on the nasal bone. The plate circumscribes a cavity which is divided about its centre by a vertical transverse septum. In front of the septum the plate is rolled one and a half times on itself like a scroll. The first turn is made from the fixed edge downwards, as shown in Fig. 56. Behind the septum the bone completes the frontal sinus and its cavity is part of that sinus. In front of the septum the cavity of the bone opens directly into the nasal fossa. The bone is invested on both its surfaces by mucous membrane.

The Inferior or Maxillary Turbinate Bones

These bones resemble in most respects the preceding, but they are considerably smaller. The middle meatus separates each from the superior bone above, and a similar but larger interval, the **inferior meatus,** separates its lower border from the floor of the

FIG. 56.—TRANSVERSE SECTION OF SKULL OF ADULT HORSE (SECTION PASSING THROUGH SKULL AT LEVEL OF THIRD PREMOLAR TOOTH)

1. Superior meatus. 2. Superior turbinate bone. 3. Middle meatus. 4. Inferior turbinate bone. 5. Inferior meatus. 6. Vomer bone. 7. Palatine process of maxilla. 8. Depression anterior to infraorbital foramen. 9. Anterior continuations of superior dental canal. 10. Maxilla. 11. Septal cartilage. 12. Nasal bone.



nasal fossa. It is composed of a thin osseous plate attached by one edge to a crest on the maxilla, and, as in the case of the superior bone, its interior is partitioned by a transverse plate. The anterior portion is rolled upon itself scrollwise, the first turn being made from the fixed edge upwards or in a direction contrary to that of the superior bone. The posterior portion forms a thin wall for the anterior division of the maxillary sinus, the cavity within being part of that sinus. The anterior portion opens directly into the middle meatus of the nasal fossa.

The Mandible

Apart from the small bones (the auditory ossicles) found in the middle ear, the mandible or lower jaw is the only movably articulated bone of the skull. It comprises a body and a pair of rami or branches. It should be noted that the bone develops from two lateral halves which fuse some months after birth. For purposes of description, however, the bone is regarded as being unpaired.

The **body** is a single median piece from which the rami pass backwards on either side. It presents two surfaces and two borders.

The *superior* or *lingual surface* is smooth and slightly concave. In the recent state it is covered by mucous membrane, and the tip of the tongue rests upon it. The *inferior* or *labial surface* is comparatively smooth and convex. It is related to the lower lip. It shows a more or less distinct median mark indicating the line of fusion of the originally distinct right and left halves of the body.

The *anterior* or *alveolar border* is convex and is excavated by six close-set sockets or alveoli for the lower incisor teeth. Separated by a slight interval from the most lateral of these alveoli there is in the male another on each side for the canine tooth. These canine alveoli are small or absent in the mare. The *posterior border* is short and concave. It is continuous behind with the lower borders of the rami.

The **rami** diverge from one another like the limbs of the letter V, leaving between them a space termed the **mandibular space.** Each ramus is a somewhat elliptical plate, with a pronounced round bend a little behind its middle. The most curved part of the inferior border is termed the **angle** of the jaw. The part of each branch between the angle and the body is sometimes termed the **horizontal ramus,** and the part above the angle the **vertical ramus.** Each ramus may be said to present for description two surfaces, two borders and two extremities.

The *lateral surface* is widest at the angle, and it contracts towards either extremity. In front of the angle it is slightly convex and smooth, but in the region of the vertical ramus it carries a number of prominent rough lines for the attachment of the masseter muscle. Anteriorly, close to the body, it presents a large foramen, the **mental foramen,** which opens outwards from the mandibular canal.

The *medial surface* is co-extensive with the lateral. In front of the angle it is smooth and slightly depressed lengthways towards its middle. At its junction with the body, close to the inferior border, it presents a slight depression for the attachment of two muscles of the tongue, the geniohyoid and the genioglossus muscles. Sometimes a faint longitudinal line near the alveolar border marks the attachment of the mylohyoid muscle. Above the angle it is markedly concave and rough for the attachment of the medial pterygoid muscle. A little in front of its mid-point it shows the large **mandibular foramen.** This is the upper orifice of the **mandibular canal,** which descends through the ramus beneath the roots of the grinding teeth, and after opening outwards at the mental foramen is continued into the body under the canine and incisor teeth. At several points above the angle the vertical ramus is composed entirely of compact tissue, and is so thin as to be translucent.

The *superior* or *alveolar border* is excavated in front of the level of the angle by the alveoli, six in number in the adult, for the lower grinding teeth. In front of the most anterior of these alveoli this border forms a short interdental space. Above the angle it is thin and sharp, and immediately below the coronoid process of the upper extremity it is roughened for the attachment of the temporalis muscle.

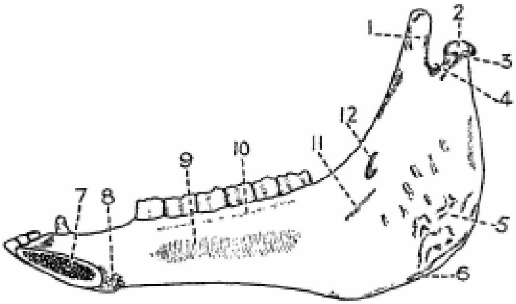


FIG. 57.—RIGHT HALF OF MANDIBLE OF ADULT HORSE (MEDIAL ASPECT. BODY OF MANDIBLE SECTIONED SAGITTALLY)

1. Coronoid process. 2. Condyle. 3. Depression for insertion of lateral pterygoid. 4. Mandibular notch. 5. Roughening for insertion of medial pterygoid. 6. Angle of mandible. 7. Sectioned body. 8. Depression for attachment of geniohyoid and genioglossus. 9. Depression on medial surface of ramus. 10. Line for attachment of mylohyoid. 11. Groove for mylohyoid nerve. 12. Mandibular foramen.

The *inferior border* is thick and rounded in front of the angle in the young subject, but in old animals it is much narrower and sharper. The middle third of this part is roughened medially for the insertion of the lower tendon of the digastricus muscle. The angle itself is broad and rough for muscular attachment, and immediately in front of it a smooth part indicates the point where the external maxillary, or facial, vessels and the duct of the parotid salivary gland turn round the bone. Behind and above the angle the bone again becomes much narrower and less rough.

The *anterior extremity* of the ramus is constricted and united to the body.

The *posterior extremity* carries the condyle and the coronoid process.

The **condyle,** the most posterior of the two, is a smooth transversely elongated process. It articulates with the squamous temporal through the medium of an interarticular fibro-cartilaginous disc. It is slightly convex from side to side, and markedly so from before to behind, and on the under side of its medial extremity it is rough and depressed for the insertion of the lateral pterygoid muscle. Immediately beneath the condyle is the **neck,** but in the horse this is not a marked constriction of the bone. In front the condyle is separated from the coronoid process by a deep rounded **mandibular** or **corono-condylar notch**.

The **coronoid process** surmounts the condyle by an inch and a half or two inches. It is flattened from side to side, rounded at its summit, and bent slightly backwards and laterally. In the articulated skull it projects into the temporal fossa, and it serves for the attachment of the temporalis muscle.

The Hyoid Bone

The so-called hyoid bone comprises a body, with its glossal process, and a number of paired osseous pieces grouped around it.

The **body** or **basihyoid** is a short transversely placed rod of bone. In the middle line the glossal process is solidly united with it in front. Each extremity carries superiorly a convex facet for articulation with the kerato-hyoid and it is fused with the thyroid cornu behind.

The **glossal process,** or **glossohyoid,** lies in the mid-line, and is united to the body by its posterior end, while its anterior end is pointed and free. The process is compressed from side to side, with a sharp upper and a blunt lower border. It is embedded in the root of the tongue, and it affords attachment to the mylohyoid, geniohyoid and great hyoglossus muscles.

The **thyroid cornua** or **thyrohyoids.**[1] Each of these is a slightly curved bar of bone, united by its anterior extremity to the body, and by its posterior extremity to the anterior cornu of the thyroid cartilage of the larynx.

In the adult animal the body, glossal process and thyroid cornua are united to form a single piece having some resemblance to a spur, the glossal process representing the spur proper and the combined body and thyroid cornua representing the fork for the heel.

The **keratohyoids.**[2] Each of these is a short rod of bone, which in the ordinary position of the head is directed obliquely upwards and forwards. Its lower extremity is furnished with a small cup-like facet for articulation with the body, while its upper extremity is blunt and united by intermediate cartilage to the lower end of the styloid cornu.

[1] The greater horns of human anatomy.
[2] The lesser horns of human anatomy.

The **styloid cornua** or **stylohyoids** are the largest pieces of the hyoid. Each is a long strap-shaped piece of bone, directed obliquely upwards and backwards from the keratohyoid to the base of the skull, and slightly curved in its length with the concavity laterally. When viewed in profile the bone has some resemblance to the human leg and foot, the latter part being represented by the upper extremity of the bone. It may be described as possessing two surfaces, two borders, and two extremities. The *lateral surface* is smooth and

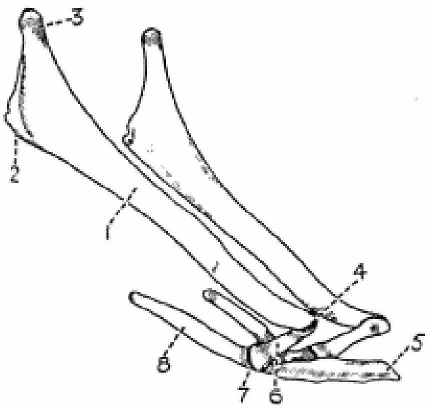


FIG. 58.—HYOID BONE OF HORSE (RIGHT ANTERO-LATERAL VIEW)
1. Styloid cornu. 2-3. Inferior angle and articular angle of upper extremity of styloid cornu. 4. Joint between styloid cornu and keratohyoid. 5. Glossal process. 6. Keratohyoid. 7. Joint between keratohyoid and body. 8. Thyroid cornu.

narrowest below. The *medial surface* is co-extensive with the lateral, and also smooth. The two *borders, anterior* and *posterior*, are thin and sharp. The *lower extremity* is narrow and united by cartilage to the keratohyoid. The *upper extremity* has, as already stated, an outline like the human foot. The toe-like point is united by a short rod of cartilage to the styloid process of the petrous temporal. The part representing the sole is separated from the paramastoid process of the occipital by a triangular interval which is filled up by the occipitostyloid muscle.[1] This sole-like border terminates inferiorly in a thickened " heel ", and both are roughened for muscular attachment.

The **epihyoids.** In the horse a pea-like nucleus of bone is usually interposed between the stylohyoid and the keratohyoid on each side, being embedded in the intermediate cartilage. It attains a much greater size in the other domestic quadrupeds.

[1] Also termed the jugulo-hyoid or occipito-hyoid muscle.

THE SKULL OF THE HORSE AS A WHOLE

The Cranium

The cranium is the cavity in which the brain is lodged. It is ovoid in form, and situated in the posterior part of the skull. Viewed as a whole it may be said to present a roof, a floor, lateral walls, and two extremities.

The *roof* of the cranium is formed by the squamous part of the occipital, the interparietal, the parietal and the frontal bones. The bones composing the roof are for the most part thin, but the squamous part of the occipital is thick and strong. At the anterior part of the cavity the frontal sinuses are extended upwards and backwards between the body of the frontal bone and its reflected plate which here forms the proper roof of the cavity, protection being thereby afforded to the underlying brain. The lateral parts of the roof correspond to the temporal fossae, and here again protection is afforded by the thick temporal muscles clothing the bones.

The *lateral walls* of the cranium are formed by the occipital, temporal, parietal, frontal and sphenoid bones. They pass without any line of demarcation into the roof and floor.

The *floor* is formed by the basilar part of the occipital and sphenoid bones. It is rugged and irregular, being perforated by foramina for the passage of cranial nerves and vessels. The bones of the cranial floor are thick as compared with the roof and walls; but notwithstanding this, a blow delivered over the roof may fracture the floor, where the bones are weakened by the numerous foramina that perforate them.

The *posterior extremity* of the cavity is pierced by the foramen magnum, which puts the cranium and the vertebral canal in free communication.

The *anterior extremity* is closed by the cribriform plate of the ethmoid, which serves as a partition between the cranium and the nasal fossae.

The cranium is partially subdivided even in the dry skull into three compartments, viz. a posterior or cerebellar, a middle or cerebral, and an anterior or olfactory compartment.

The **cerebellar compartment** underlies the vaulted squamous part of the occipital, its floor being formed by the basilar part of the same bone. It communicates posteriorly through the foramen magnum with the vertebral foramen of the atlas. Inferiorly the plane of separation between this and the cerebral compartment is indicated on the middle of the roof by the osseous tentorium cerebelli, and on each side by a bony ridge, formed by the parietal and petrous temporal bones. These bony projections indicate the attachments of the membranous tentorium cerebelli, which in the recent state effects a more complete separation between the cerebral and cerebellar compartments. The cerebellum is the largest of the divisions of the brain herein contained; but the medulla oblongata and pons are also lodged here, resting on the basilar part of the occipital bone.

The **cerebral compartment** greatly exceeds the other two in size. Its floor is formed by the sphenoid, and its roof and lateral walls by the parietal, frontal, and squamous temporal bones. Posteriorly it is separated in the manner previously indicated from the cerebellar compartment, and anteriorly the olfactory or ethmoidal fossae open freely off it. It is almost regularly ellipsoidal in form, and it is occupied by the cerebrum, whose convolutions leave their impress in the shape of shallow markings on the roof and walls of the cavity.

The **olfactory compartment** lies at the anterior extremity of the cranium, and it is divided by the crista galli into two well-defined oval pits, the **olfactory** or **ethmoidal fossae.** The anterior boundary of these pits is formed by the cribriform plate, and they accommodate the olfactory bulbs.

The Temporal Fossae

The temporal fossae, right and left, occupy the anterior and lateral aspects of the cranium. They are the cavities for the lodgment of the temporalis muscles, and their size varies very greatly in different species of animals, in correspondence with the degree of development of these muscles. In the horse, as in other herbivora, they are of relatively small capacity as compared with the great proportions that they attain in the dog and carnivorous animals in general.

Each fossa has the form of a wide and shallow spiral groove. In the backward direction it extends as far as the nuchal crest and here the right and left fossae approach the median plane, being separated only by the parietal crest.

The **parietal crest** is a slight bony ridge developed on the middle line of what was in the foal the flat smooth outer surface of the interparietal bone. Posteriorly it is prolonged to join the nuchal crest, and anteriorly it reaches the interparietal suture. As the temporal fossae descend they deviate from one another, and pass laterally to become continuous with the orbital cavities. Medially each fossa is limited anteriorly by the parietal crest as it curves laterally to join the posterior edge of the supraorbital process. Laterally it is bounded by the zygomatic process of the squamous temporal and by the temporal crest which leads backwards from that process to the nuchal crest. The bones that form the fossa are the occipital, parietal, interparietal, frontal, and squamous temporal. The surfaces of these bones are slightly roughened for the attachment of the temporalis muscle. In its lateral part the fossa presents a number of foramina communicating with the parieto-temporal canal.

The Orbits

The orbits, or sockets for the eyes, are situated on the lateral aspect of the skull, towards the junction of the cranium and the face. Each cavity is cone-shaped, the axis of the cavity being directed forwards, laterally and slightly upwards from its apex to its base. In the dry skull the bony boundaries of the orbit are deficient posteriorly, so that the cavity is there quite open laterally and continuous posteriorly with the temporal fossa. The apex of the orbit lies at the optic foramen. Its base is circumscribed by a circle of bone termed the **orbital margin.** The bones that enter into the formation of the margin are the lacrimal in front, the body of the frontal above, the supraorbital process of the frontal and the tip of the zygomatic process of the squamous temporal posteriorly, and the malar inferiorly. The bones that concur to form the walls of the orbit are those just mentioned, and in addition the palatine and sphenoid. The cavity of the orbit is much more perfectly circumscribed in the living animal in which a strong fibrous membrane, the ocular sheath, or the periorbita, completes it posteriorly, and isolates it from the temporal fossa. The interior of the orbit is for the most part smooth to permit the movements of the eyeball.

Superiorly, under the supraorbital process, a shallow pit marks the situation of the lacrimal gland. On the floor of the cavity the lacrimal bone presents the **lacrimal fossa** for the lodgment of the sac of the same name, and from the bottom of the fossa the bony tube for the naso-lacrimal duct begins. Immediately behind the lacrimal fossa a little pit marks the origin of the inferior oblique muscle of the eyeball. On the medial wall of the orbit, beneath the root of the supraorbital process, a slight depression of the orbital plate of the frontal marks the position of the fibrous loop for the play of the superior oblique muscle of the eyeball.

The Nasal Cavity

The cavity of the nose is divided by a vertical median partition into right and left halves, termed the **nasal fossae.** Each fossa is an elongated tubular passage, which for descriptive purposes may be said to present a roof, a floor, lateral walls and two extremities.

The *roof* or *superior wall* is formed by the nasal and frontal bones. The *floor* or *inferior wall* is formed by the palatine, maxillary, and premaxillary bones, the opposite aspect of these same bones forming the bony palate. The *medial wall* is very imperfect in the dry skull. It is formed in part by the vomer, and posteriorly by the perpendicular plate of the ethmoid; but in front of the anterior border of the plate the right and left fossae are not separated in the dried skeleton. In the recent state the perpendicular plate is continued forwards and the medial wall of the fossa is completed by the septal cartilage. The *lateral wall* is formed by the maxillary, the premaxillary, and nasal bones, and it is rendered very irregular by the superior and inferior turbinate bones which lie along it. These bones divide the nasal fossa into three narrow passages, termed respectively the superior, middle and inferior meatuses. The **superior meatus** lies above the superior turbinate bone, the **middle meatus** between the two turbinate bones, and the **inferior meatus,** the largest of the three, between the nasal floor and the inferior turbinate bone. The osseous tube for the naso-lacrimal duct opens into the middle meatus, and is continued forwards by a groove. At the posterior part of this same meatus a narrow interspace between the two turbinate bones leads into the maxillary sinus.

The *anterior extremity* of the nasal fossa is bounded by the nasal and premaxillary bones, and it opens into the outer air.

The *posterior extremity* is closed towards the cranial cavity by the cribriform plate of the ethmoid, and is further occluded by the lateral mass of the same bone. In front of and below the lateral mass the nasal fossa presents its guttural or pharyngeal opening. The right and left openings, or **posterior nares** as they are termed in opposition to the **anterior nares** or nostrils proper, are separated by the lower border of the vomer, while each is bounded laterally by the palatine and pterygoid bones.

The Paranasal Air Sinuses of the Skull

The paranasal sinuses of the skull are large air spaces developed on the limits of the cranium and the face, and communicating directly or indirectly with the nose. They affect considerably the contour of the head, and add to its volume without materially increasing its weight. In the recent state they are lined by a continuation of the mucous membrane of the nose. The sinuses number three pairs, viz. spheno-palatine, frontal and maxillary. They are imperfectly developed in the foal's head at birth and they continue to increase in size even after the period of adult life has been attained. The following description of them applies to the skull of a middle-aged subject.

The **spheno-palatine sinus** is the smallest of the three. It consists of a posterior or sphenoidal part, and an anterior or palatine part, which communicate with each other by a narrow aperture. The *sphenoidal part* consists of a variable number of loculi excavated in the body of the presphenoid, and separated from the opposite sinus by a bony plate lying in or near the median plane. The *palatine part* is bounded by the vomer, the palatine and the lateral mass of the ethmoid, and it opens superiorly into the medial compartment of the posterior part of the maxillary sinus.

The **frontal sinus** is the second in point of size. It is bounded by the frontal, nasal, lacrimal, lateral mass of the ethmoid, and superior turbinate bones. In the posterior direction it extends as far as a point lying a little behind the posterior border of the supraorbital process, so that it here lies above the anterior end of the cranial cavity. A medial plate forms a complete partition between the right and left sinuses. A thin bony septum extending between the lateral mass, the superior turbinate bone and the osseous tube for the naso-lacrimal duct separates the frontal from the maxillary sinus, but a large oval hole in this septum places the two sinuses in free communication.

The **maxillary sinus** is the largest of these cavities. It is divided into two parts, anterior and posterior,[1] by a thin bony septum which is usually complete. The septum is placed obliquely across the sinus and is very irregular in position. Its lateral border often meets the inner surface of the maxilla about an inch and a half in an average-sized animal, behind the anterior extremity of the zygomatic ridge. Its medial border joins the inferior turbinate bone.

The posterior part of the sinus is bounded by the maxilla, lacrimal, malar, ethmoid, and the two turbinate bones. It is imperfectly divided into a medial and lateral compartment by a bony ridge whose free upper edge corresponds to the superior dental canal. Over this edge the two compartments communicate freely with one another. The *medial compartment* extends backwards and medially to the orbit, and here the spheno-palatine sinus opens into it. Superiorly it communicates with the frontal sinus by the large aperture previously mentioned. Towards its anterior extremity it opens into the middle meatus of the nose by a narrow aperture between the two turbinate bones. The *lateral compartment* extends

[1] Formerly termed the inferior and superior maxillary sinuses respectively.

backwards below the orbit and into the maxillary tuberosity. Anteriorly the compartment is separated from the corresponding compartment of the anterior part of the sinus by the bony septum previously mentioned. The root of the most posterior molar tooth and in part that of the one next to it are seen in this compartment, invested by a thin layer of bone, but the relationship of the molar teeth to the sinus is dependent upon the position of the septum separating the two parts of the sinus.[1]

The *anterior part* of the maxillary sinus also comprises a lateral and a medial compartment. The *lateral compartment* is formed entirely in the maxilla. It lies in front of the corresponding compartment of the posterior part of the maxillary sinus from which, as before said, it is separated by a thin bony septum. The root of the fourth upper grinding tooth, and often also parts of the roots of the teeth on either side of that, project into it. The *medial compartment* is bounded by the maxilla and it also extends into the cavity of the posterior part of the inferior turbinate bone. It communicates laterally with the lateral compartment of the sinus above the ridge formed by the superior dental canal, and medially by a small opening, usually in common with that of the posterior part of the sinus, with the middle meatus of the nasal cavity. A horizontal line drawn about three-quarters of an inch in front of the anterior extremity of the zygomatic process of the maxilla would indicate, in an average-sized animal, the anterior limit of this part of the maxillary sinus.

The Foramina of the Skull

The **foramen magnum** is the largest foramen of the skull. It is nearly circular in outline, being compressed from above to below, and it is formed entirely in the occipital bone, whose condyles bound it on either side. It transmits the spinal cord with its meningeal envelopes, the spinal roots of the eleventh cranial nerves, the basilar artery, some veins which are part of the basilar plexus, and on each side fibres of the ligament of the odontoid process.

The **condylar foramen** is also a perforation of the occipital bone, its outer opening being found at the bottom of a deep fossa between the condyle and the root of the paramastoid process. It gives passage to the twelfth cranial nerve, a meningeal branch of the condylar artery, and the condylar root of the occipital vein.

The **foramen lacerum** is a large irregularly triangular gap in the floor of the cranium in the dry skull, bounded medially by the basilar part of the occipital, laterally by the base of the petrous temporal,

[1] Quite frequently the septum is found lying over the fourth cheek tooth.

and anteriorly by the wing of the postsphenoid. In the recent state it is in large measure closed by dense fibrous tissue or fibro-cartilage. At its posterior angle an opening known as the **jugular foramen**[1] is left for the exit of the ninth, tenth and eleventh cranial nerves, and for the entrance of a meningeal twig of the condylar artery. At the anterior edge of the gap now being considered three other foramina are left, these being bounded anteriorly by the notches previously described in connection with the wing of the postsphenoid, and posteriorly by the above-mentioned fibro-cartilage. The most medial of the three, the **carotid foramen,** gives passage to the internal carotid artery accompanied by the internal carotid plexus of the sympathetic system and surrounded by the inferior petrosal venous sinus. The nerve of the pterygoid canal also passes through the foramen. The middle foramen is the largest of the three. It is known as the **foramen ovale** and it gives passage to the mandibular division of the fifth cranial nerve. The most lateral of the three foramina, the **foramen spinosum,** lies just at the root of the elongated muscular process of the petrous temporal bone and it transmits the middle meningeal artery.

The **parieto-temporal canal** begins as a groove at the base of the osseous tentorium cerebelli of the interparietal bone. It is continued laterally on the parietal bone, being open towards the cavity of the cranium. Finally in its lateral third it becomes a complete canal between the petrous and squamous divisions of the temporal bone and the parietal bone, its outward orifice being found behind the postglenoid process. The transverse sinus of the dura mater passes along the entire length of the canal to issue at its outer opening. One or two veins communicating with the sinus pass through foramina situated near the anterior border of the triangular process of the squamous temporal bone. A vascular furrow on the lateral surface of the petrous temporal is converted into a canal by apposition with the triangular process of the squamous temporal, and through this the posterior meningeal artery runs into the parieto-temporal canal. The outer opening of this small canal is known as the **mastoid foramen.**

The **internal auditory meatus** is found on the medial surface of the petrous temporal, and by it the seventh and eighth cranial nerves enter the bone. The former is conducted through the bone by the curved **facial canal** to emerge again at the stylomastoid foramen. The eighth nerve is expended within the petrous temporal in supplying the labyrinth of the internal ear.

The **aqueduct of the cochlea** is a minute canal leading from the

[1] Formerly termed the foramen lacerum posterius.

scala tympani of the cochlea of the internal ear to open behind the internal auditory meatus. Above that again is the somewhat larger orifice of the **aqueduct of the vestibule** which transmits the endolymphatic duct of the membranous labyrinth.

The **stylo-mastoid foramen** opens between the mastoid process behind and the styloid process in front. As already stated it is the outward opening of the facial canal, and it gives passage to the seventh cranial nerve and the auricular branch of the tenth cranial nerve.

The **petro-tympanic fissure** has the form of a small foramen which lies laterally to the root of the muscular process of the petrous temporal. It gives exit to the chorda tympani nerve, a branch detached from the seventh nerve while in the facial canal.

The **external auditory meatus** is the outward opening of a short tube, the **external auditory process** of the petrous temporal, which in the articulated skull is situated between the postglenoid and triangular processes of the squamous temporal. In the dried skull it leads down into the tympanum or middle ear, but in the recent state the tympanic membrane is stretched across the inner end of the tube.

The bony part of the **pharyngo-tympanic tube** [1] opens on the base of the petrous temporal medially to the root of the muscular process. The tube admits air from the pharynx to the middle ear. The superficial petrosal nerves issue from the petrous temporal a little medially to the opening of the bony part of the pharyngo-tympanic tube, and the auricular branch of the vagus nerve enters the facial canal by a small foramen on the posterior surface of the same bone. The last-mentioned foramen cannot be seen in the articulated skull.

The **subsphenoidal** or **alar canal** perforates the root of the pterygoid or subsphenoidal process of the postsphenoid bone and gives passage to the internal maxillary artery. Its posterior orifice is plainly seen a little lateral from the body of the postsphenoid, but its anterior opening lies under concealment of the anterior border of the wing of the same bone.

The **pterygoid canal** is a fine canal for the transmission of the nerve of the same name. Its posterior orifice lies directly behind and medial to the posterior opening of the subsphenoidal canal, and its anterior orifice forms one of the group of orbital foramina. A groove leads to its posterior opening, and the canal itself is formed by the apposition of the sphenoid, pterygoid and, sometimes, the palatine bones.

At the back of the orbit a number of foramina are collected together to form what is sometimes termed the **orbital group of**

[1] Formerly known as the Eustachian tube.

foramina. They are eight in number, viz. the ethmoidal foramen, the optic foramen, the foramen orbitale, the foramen rotundum, the trochlear foramen, the anterior opening of the subsphenoidal canal, the anterior opening of the pterygoid canal, and the temporal foramen.

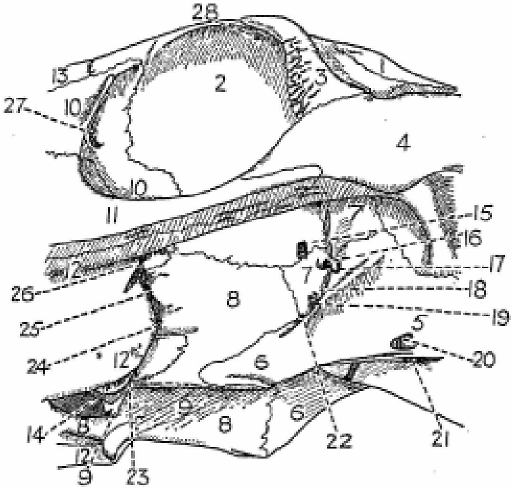


FIG. 59.—ORBITAL REGION OF SKULL OF YOUNG HORSE (LEFT VENTRO-LATERAL VIEW)

1. Parietal bone. 2. Orbital plate of frontal bone. 3. Supraorbital process of frontal bone. 4. Zygomatic process of squamous temporal bone. 5. Wing of postsphenoid bone. 6. Pterygoid process of post-sphenoid bone. 7. Wing of presphenoid bone. 8. Palatine bone. 9. Pterygoid bone. 10. Lacrimal bone. 11. Malar bone. 12. Maxilla. 13. Nasal bone. 14. Alveolar tuberosity of maxilla. 15. Ethmoidal foramen. 16. Optic foramen. 17. Temporal foramen. 18. Foramen orbitale. 19. Opening of foramen rotundum and subsphenoidal canal. 20. Posterior opening of subsphenoidal canal. 21. Groove leading to pterygoid canal. 22. Anterior opening of pterygoid canal. 23. Staphyline groove. 24. Posterior palatine foramen. 25. Spheno-palatine foramen. 26. Maxillary foramen. 27. Lacrimal fossa. 28. Supraorbital foramen.

The **ethmoidal foramen** is situated on the suture uniting the orbital plate of the frontal to the wing of the presphenoid, being formed by these bones in common. It is the most superior of the foramina of this group, and it transmits the ethmoidal artery and nerve into the cranium.

The **optic foramen** is formed entirely in the presphenoid bone, being the outer opening of the **optic canal** of that bone. It lies almost directly in the long axis of the orbit, opening a little behind and below the ethmoidal foramen. It is circular in form and it gives passage to the optic or second cranial nerve.

The **foramen orbitale** opens directly below the optic. It is formed between the postsphenoid and presphenoid, and it transmits the oculo-motor or third cranial nerve, the abducent or sixth cranial nerve, the ophthalmic division of the trigeminal or fifth cranial nerve, and the ophthalmic vein.

The **trochlear foramen** is the smallest of the group. It opens above and laterally to the foramen orbitale under concealment of the projecting anterior border of the postsphenoidal wing. It is formed between the postsphenoid and presphenoid, and it gives passage to the trochlear or fourth cranial nerve.

The **foramen rotundum** is formed in the postsphenoid and it opens immediately below the foramen orbitale. It transmits the maxillary division of the trigeminal nerve.

The **subsphenoidal canal** has its anterior orifice immediately below the foramen rotundum. In the complete skull the distinction between these two openings cannot be clearly seen, since they lie under concealment of the projecting border of the postsphenoidal wing.

The anterior orifice of the **pterygoid canal** is found in front of the thin septum of bone separating the foramen rotundum from the foramen orbitale. It is formed at the point of meeting of the subsphenoidal process of the postsphenoid with the lateral aspect of the body of the presphenoid and, sometimes, the upper border of the palatine bone, and it gives exit from the canal of the so-called nerve of the pterygoid canal.

The **temporal foramen** [1] opens on the outer surface of the postsphenoidal wing, and is separated from the other foramina of the group by the projecting anterior border of the wing. It is the outward opening of a short passage leading off from the subsphenoidal canal, and it transmits the anterior deep temporal artery, a branch detached from the internal maxillary artery.

The **supraorbital foramen** perforates the root of the supraorbital process of the frontal bone, and gives passage to the artery, vein and nerve of the same name.

The **lacrimal fossa** occupies nearly the whole of the orbital surface of the lacrimal bone, and from it the bony **lacrimal canal** leads forwards through the substance of the lacrimal bone to be continued for a short distance in the maxilla. The anterior opening of the canal is found on the nasal surface of the last-named bone, in the middle meatus of the nose, and it is continued forwards on the bone by a groove. The fossa lodges the lacrimal sac, and the tube gives passage to the naso-lacrimal duct.

The **olfactory foramina** include: (1) the numerous minute perforations of the cribriform plate of the ethmoid, giving passage to the

[1] Sometimes called the small alar foramen.

filaments of the olfactory or first cranial nerve, and (2) the single larger foramen at each side of the plate, which transmits the nasal branches of the ethmoidal artery and nerve into the nasal fossa.

The following three foramina, sometimes classed together as the **maxillary group of foramina,** are situated below the orbital floor, a short distance in front of the before-described orbital group.

(1) The **maxillary foramen** is the most superior of the three. It is formed entirely in the maxilla, but its outline cannot be very easily seen in the intact skull, since it lies in the depth of a deep trench, situated medially to the maxillary tuberosity. It transmits the superior dental or infraorbital artery, vein and nerve into the canal of the same name.

(2) The **spheno-palatine foramen** is placed between the other two. It is larger than the preceding, circular in outline, and pierces the superior border of the vertical part of the palatine bone. It opens into the nasal chamber and it transmits the spheno-palatine artery, vein and nerve.

(3) The **posterior palatine foramen** is formed in common by the palatine and maxillary bones, and it transmits the palatine artery and nerve into the palatine canal.

The **anterior palatine foramen** is found at the posterior part of the bony palate, on the suture uniting the palatine and maxillary bones. It gives passage to the palatine artery and nerve, and the palatine groove leads forwards from it along the palate.

The **palatine canal** is formed by the apposition of the palatine and maxillary bones. Its posterior orifice is the posterior palatine foramen of the maxillary group and its anterior opening is the foramen last described. It transmits the palatine artery and nerve.

The **infraorbital foramen** is found on the facial surface of the maxilla. It is the outward opening of a branch from the superior dental canal, and it gives exit to the infraorbital nerve and a slender artery of the same name.

The **superior dental** or **infraorbital canal** conveys the vessels and nerves for the teeth of the upper jaw. The maxillary foramen of the maxillary group of foramina is its posterior opening, and the superior dental artery and nerve here enter it, while the vein of the same name issues from it. The canal passes forwards in the maxilla above the roots of the grinding teeth, and, after giving off a branch to open outwards at the infraorbital foramen, it is continued into the premaxilla above the roots of the canine and incisor teeth.

The **incisive foramen** is in reality a short canal formed in the middle line by the apposition of the right and left premaxillary bones. Its lower opening is found at the anterior end of the bony palate, and it transmits to the upper lip the labial vessel resulting from the fusion of the palatine arteries of opposite sides.

The **palatine fissure** is a slit-like opening on each side of the bony palate, bounded medially by the palatine process of the pre-maxilla and laterally by the nasal process of the same bone and by the maxilla. In the recent state it is closed by fibro-cartilage into which the naso-palatine duct passes from the nasal fossa to end blindly above the palate.

The **mandibular foramen** is found on the medial surface of the lower jaw bone. It transmits the inferior dental or alveolar artery, vein and nerve into the canal of the same name.

The **mental foramen** is found on the lateral side of the ramus of the mandible close to its junction with the body. It is the outward opening of a branch from the mandibular canal, and it gives passage to the mental vessels and nerves.

The **mandibular canal** conveys the inferior dental, or alveolar, vessels and nerves for the supply of the teeth of the lower jaw. Beginning at the mandibular foramen, it descends through the ramus below the roots of the grinding teeth, and after opening outwards at the mental foramen, it is continued into the body of the bone to reach the canine and incisor teeth.

THE DEVELOPMENT OF THE SKULL

In the early stages of development the anterior extremity of the notochord and the precursor of the brain, which lies above and in front of it, are enclosed in a mass of the mesenchyme. Chondrification of the ventral portion of this mass occurs in the region which is destined to become the bodies of the occipital, sphenoid and ethmoid bones, and it extends dorsally on either side into the squamous part of the occipital and into the wings of the sphenoid bones. In this way there is formed the **chondrocranium.** Elsewhere with one exception the mesenchyme in the region of the cranium and the face becomes converted into a dense membranous sheet. The exception is in the region of the ear. Here the mesenchyme undergoes chondrification to form a mass of cartilage, known as the **periotic capsule,** which comes to lie at the side of the skull between the occipital and sphenoid bones. The posterior part of the occipital cartilage is formed of a group of four cartilaginous masses which it is believed represent the precursors of four originally separate vertebrae. These unite with one another and become incorporated in the occipital part of the chrondrocranium.

It will be noted that the chondrocranium forms only the ventral portions of the cranium together with the lower parts of its sides.

The mesenchyme bounding the upper parts of the sides and the roof of the cavity develops into fibrous tissue which does not become chondrified. Similar fibrous tissue occurs in the region of the face.

There are, however, further cartilaginous elements in the developing skull. These are derived from the mesenchyme which occupies the

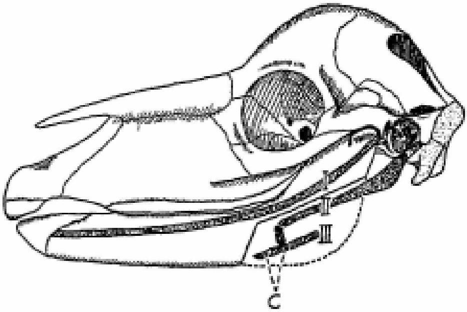


FIG. 60.—DIAGRAM OF SKULL OF FOETAL HORSE (LATERAL VIEW WITH PART OF MANDIBLE REMOVED. HEAVY STIPPLING:—STRUCTURES DERIVED FROM CARTILAGES OF BRANCHIAL ARCHES. LIGHT STIPPLING:—BONES OF SKULL DEVELOPED FROM CARTILAGE)

I, II, III. Structures derived from first, second and third branchial arches. C. Structures derived from cartilage uniting lower extremities of second and third arches.

branchial arches which lie between the branchial clefts. This tissue gives rise to a series of five pairs of cartilaginous bars the development of which differs very considerably the one from the other.

The first arch divides early into two processes, the maxillary and the mandibular processes. The **maxillary process,** which remains membranous, enters into the formation of the facial bones and will be referred to later. The **mandibular process** becomes chondrified forming a rod of cartilage known as **Meckel's cartilage.** The upper and posterior extremity of this cartilage comes to lie close to the periotic capsule already mentioned. Here it gives rise to the **malleus** and **incus,** two minute bones occurring in the cavity of the middle ear. Below this the cartilage extends forwards as far as the opening of the mouth to form in the early embryo a cartilaginous skeleton for the lower jaw. The second arch undergoes extensive chondrification. Its upper extremity, like that of the first arch, is situated near the periotic capsule, but its lower end reaches only to the root of the tongue. That portion attached to the periotic capsule will form the **stapes** (a third small bone in the tympanic cavity) and the **styloid process** of the petrous temporal bone, while the lower portion will develop into three segments of the hyoid bone, viz. the **stylohyoid,** the **epihyoid,** and the **keratohyoid.** The third, fourth and fifth arches are less well developed than their predecessors and cartilage appears only in their lower or anterior portions which are separated from the chondrocranium. The cartilage of the third arch develops into the **thyroid cornu** of the hyoid bone. The cartilages of the fourth and fifth arches unite in the formation of the thyroid cartilage of the larynx.

At a later stage ossification occurs in the cartilaginous masses forming the chondrocranium and in the cartilages of the branchial arches. A number of bones, however, do not undergo a cartilaginous stage in their development. These are the so-called membrane bones, and in them the mesenchyme becomes converted directly into bone. On the other hand some bones are composed of elements which have passed through both these stages of development. In other cases a cartilage may have developed to a certain stage and then been enclosed by a membrane bone.

The **occipital bone** is composed of four pieces, or elements, each of which develops from a separate centre of ossification in the cartilage and is separated from its adjacent element by a thin layer of cartilage. One of these elements, the **basi-occipital,** forms the basilar part of the bone. Two bound the foramen magnum laterally and superiorly. These are the so-called **ex-occipitals** and each is composed of a condyle, a paramastoid process and a connecting piece of bone which bounds the foramen magnum superiorly. The most inferior part of the condyle develops from the basi-occipital element. The fourth piece, the **supra-occipital,** forms the nuchal crest and that portion of the bone which lies immediately in front of and behind the crest.

In the sphenoid region a large number of centres of ossification appear in the two main cartilages for the postsphenoid and the presphenoid. In the case of the **postsphenoid** one centre (possibly originally two) appears in the body and one in each wing. The pterygoid process arises as an extension from the latter centre. The **presphenoid** develops from two centres, one in each wing.

Ossification in the **ethmoid bone** is later in beginning than in any of the surrounding bones, and at birth the horizontal and vertical plates are still quite cartilaginous while the lateral masses are then partly ossified. Each of the lateral masses ossifies from a single centre. A third centre appears in the cartilage in the middle line in the region of the crista galli and from this trabeculae pass across on either side to join the lateral masses, thus forming the cribriform plate. The anterior portion of the median cartilage forming the perpendicular plate never completely ossifies but persists as the cartilaginous septum nasi. In the membrane covering the lower and posterior part of the septum centres of ossification appear one on either side of the middle line. These centres unite below and form the **vomer bone** whose lateral plates enclose between them the perpendicular plate posteriorly and the septal cartilage of the nose anteriorly. The lateral masses of the ethmoid are at first just a mass of spongy bone, but as development proceeds the mucous membrane of the nasal chamber evaginates into the mass and the underlying bone becomes absorbed producing the so-called **ethmo-turbinates** and the meatuses which are characteristic of this part of the bone. It may be mentioned here that a similar process of protrusion of the mucous membrane with absorption of the underlying bone occurs in the more anterior part of the nose resulting in the formation of the **turbinate bones.** Each of these last-named bones, however, has its own centre of ossification in pre-existing cartilage. This process of extension of the mucous membrane with accompanying absorption of bone is also seen associated with the frontal, maxillary, sphenoid and adjacent bones. In these instances large cavities develop in the bones giving rise to the **paranasal sinuses.**

The periotic capsule reveals three or four centres of ossification which unite together to form the so-called petro-mastoid part of the **temporal bone.** This part comprises the mastoid crest and process and part of the adjacent bone, together with the petrous part proper which forms the densest part of the bone and is the most important in the sense that it contains the complicated internal ear or labyrinth. The tympanic part of the petrous temporal, which develops from a single centre, comprises the auditory bulla and the auditory and muscular processes. Unlike the petro-mastoid part the tympanic portion does not undergo chondrification but develops as a membrane bone. It is comparatively late in uniting with the rest of the bone, its outlines being quite distinct at birth. The styloid process arises from a separate centre of ossification in the cartilage of the second branchial arch. The squamous temporal resembles the tympanic portion of the temporal bone in that it develops as a membrane bone. It has one centre of ossification.

The remaining bones of the skull, which are concerned with the formation of the sides and roof of the cranium and the facial region, are formed from membrane. Centres of ossification appear in this membrane and in this way are formed the **parietal, frontal, nasal, lacrimal,** and **malar bones,** each with a single centre. The malar may, however, have an additional centre. The **interparietal bone,** although described as a single bone, is in reality a paired structure, developing from two lateral centres.

The **maxilla,** as has been mentioned earlier, is part of the skeleton of the first branchial arch. It develops from a single centre as a membrane bone. In the region of the free extremity of the maxillary process another centre appears to form the **premaxilla.** The **palatine bone** also arises in membrane from this arch, the bone having a single centre of ossification. Each **pterygoid bone** develops in membrane from the mesenchyme above the buccal cavity, but its hamulus is said to become chondrified before it is converted into bone.

The **mandible** develops in a somewhat more elaborate way than the majority of the bones of the skull. As previously mentioned, in the early embryo a rod of cartilage (**Meckel's cartilage**) is formed in the mesenchyme of the mandibular process of the first branchial arch. The upper or proximal part of the cartilage becomes incorporated with the periotic capsule to form the malleus and the incus, but the distal part forms a cartilaginous skeleton for the lower jaw. This cartilaginous skeleton, however, is only a temporary one, for soon a plate of membrane bone develops laterally to this portion of the cartilage, and extending forwards comes to enclose its anterior extremity where it will form the body of the bone. The original cartilage in this region of the mandible is considered to disappear and thus the bone is formed entirely from membrane. Ossification develops from one main centre in each half of the bone. At birth and for about two months afterwards the bone is composed of separate right and left halves united along a mesial suture or symphysis of the body.

Each of the main divisions of the **hyoid bone** has a separate centre of ossification in the preceding cartilage of the second and third arches. The body is formed in a cartilaginous plate uniting the anterior extremities of these cartilages. The bony glossal process develops as an extension of ossification from the body.

THE SKULL OF THE OX

Occipital Bone.—In the ox this bone is confined to the posterior part of the skull and is not at all visible when the head is viewed directly from above. As in the horse, it is primarily composed of four pieces, but the squamous part, even before birth, is united to the interparietal and parietal bones, whereas the basilar and lateral parts remain separable during the first few months of extra-uterine life. The basilar part is shorter but broader than in the horse. Its inferior surface is traversed mesially by a slight ridge, and furnished at its anterior extremity with two pronounced muscular eminences. Its cranial surface is more depressed than in the horse. The condyles have a well-defined edge dividing their articular surfaces into an upper and a lower facet. The paramastoid processes are shorter, wider at the base, and more curved medially at the tip than in the horse. Besides the usual foramen for the passage of the twelfth cranial, or hypoglossal, nerve there are other foramina piercing this part of the bone. Medially, i.e. within the cranial cavity, a large foramen, situated above and behind the condylar foramen, leads into a wide canal in the bone which passes upwards and forwards to open on the interior of the cranial cavity near the upper end of the parieto-temporal canal. This canal transmits a vein which places the transverse sinus and basilar plexus of veins in communication. One or two small foramina usually lead outwards from the canal into the condylar fossa. The squamous part shows on the middle of its outer face an obtuse eminence for the attachment of the funicular part of the ligamentum nuchae. On its cranial aspect it presents a central depression, and at each lateral angle a groove for the transverse venous sinus.

Interparietal Bone.—In the skull of the foetal calf this bone forms a separate element, which, as in the horse, results from the fusion of two lateral pieces. Before birth, however, it fuses with the squamous part of the

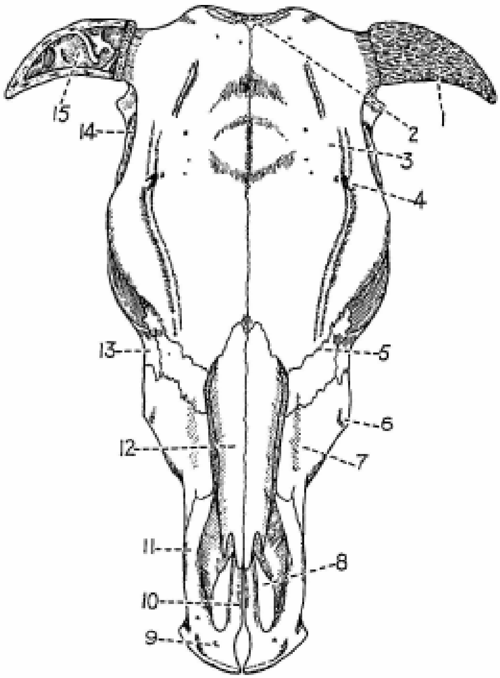


FIG. 61.—SKULL OF OX (VIEWED FROM ABOVE, WITH MANDIBLE REMOVED)

1. Horn process. 2. Central part of frontal eminence formed by parietal bones. 3. Frontal bone. 4. Supraorbital foramen. 5. Lacrimal bone. 6. Facial tuberosity. 7. Maxilla. 8. Palatine fissure. 9. Body of premaxilla. 10. Palatine process of premaxilla. 11. Nasal process of premaxilla. 12. Nasal bone. 13. Malar bone. 14. Zygomatic process of squamous temporal bone. 15. Horn process sectioned longitudinally to show its cavity.

occipital below and the two parietals above and on either side, the lines of junction being traceable for a longer period on the interior than on the exterior of the cranium. It differs notably from the same bone of the horse in that it does not carry any distinct osseous tentorium cerebelli on its cranial aspect.

Parietal Bones.—These bones differ altogether in form and position from the same bones of the horse. They are confined to the posterior and lateral aspects of the skull. The right and left bones fuse much more promptly than in the horse, and, as already stated, they are also early united with the interparietal and squamous part of the occipital bone. Each bone is bent to nearly a right angle, so as to present a medial part which unites with the same part of the opposite bone, and a lateral part which forms part of the medial wall of the temporal fossa. The medial parts of the united bones form a flat plate which lies behind a line joining the bases of the horn processes of the frontal bones, and whose outer surface looks directly backwards. A semicircular line crossing this part of the skull immediately above the area of attachment of the ligamentum nuchae indicates the suture between the inferior border of the parietal and the upper border of the occipital bone. This line may be regarded as representing the nuchal crest of the horse. Laterally it joins the parietal crest which separates the medial and lateral parts of the bone on the exterior of the skull. The lateral part of the parietal is slightly concave on its outer surface. It lies between the frontal and squamous temporal bones being largely overlapped by the latter in the articulated skull. The parietal bone of the ox forms only a very small part of the parieto-temporal canal, and in the adult animal its outer and inner tables become widely separated by an extension of the frontal air sinus.

Sphenoid Bone.—The body of the postsphenoid shares in the formation of the strong muscular eminences already mentioned in connection with the basilar part of the occipital bone. The hypophyseal fossa is deep, and posteriorly it is limited by a ragged projection corresponding to the posterior **clinoid processes** of the human subject. The wing of the postsphenoid is pierced behind and below its centre by a large foramen ovale for the passage of the mandibular division of the trigeminal nerve and the middle meningeal artery. This foramen takes the place of the middle and lateral notches of the posterior border of the wing in the horse. The most medial, or carotid, notch is absent, its place being taken by a much smaller outcut for the nerve of the pterygoid canal. The subsphenoidal processes are thin, laterally compressed plates, and the canal of the same name is absent. Laterally to the root of the last-named process, a small canal perforates the bone to open on the hypophyseal fossa. It gives passage to a small artery. A single large foramen takes the place of the trochlear foramen, foramen rotundum and foramen orbitale. The body of the presphenoid is, at most, but slightly excavated to form a sphenoidal[1] air sinus, and its wing takes no share in forming the ethmoidal foramen.

Frontal Bones.—The characteristic form of the skull of the ox is mainly due to the size and shape of these bones. They extend from the back of the skull to a little in front of the middle of its superior aspect, and the two bones together form the whole superior boundary of the cranium. At its postero-lateral angle each bone carries in most breeds of cattle a large projection termed the **horn process** or " horn core " for the support of the horn. These processes are conical in shape and slightly curved. Their length and the degree of their curvature vary in the different breeds. The external surface of the process has a rough and porous aspect and internally it is hollow, being excavated by a cavity in communication with the frontal sinus. Irregular bony septa subdivide the cavity into a variable number of intercommunicating spaces. In the so-called polled or hornless breeds, such as the Galloway and Aberdeen-Angus, the horn processes are absent. Between the horn processes a thick ridge runs across the posterior parts of the frontal bones. In the middle line this ridge is partly formed by the parietal bone and it has been termed the **frontal eminence.** The eminence is greatly developed in polled breeds. The supraorbital process is short and its lateral extremity articulates with the malar bone instead of with the

[1] The sinus receives this name in the ox since the palatine does not bound it.

zygomatic process of the squamous temporal as in the horse. The supraorbital foramen deserves to be called a canal. It is placed nearer the middle line of the head and its superior orifice, sometimes double, opens into a vascular furrow which is prolonged backwards towards the root of the horn process, and forwards to the anterior border of the bone. Anteriorly the united frontal bones form a notch for the nasal bones—a connection the

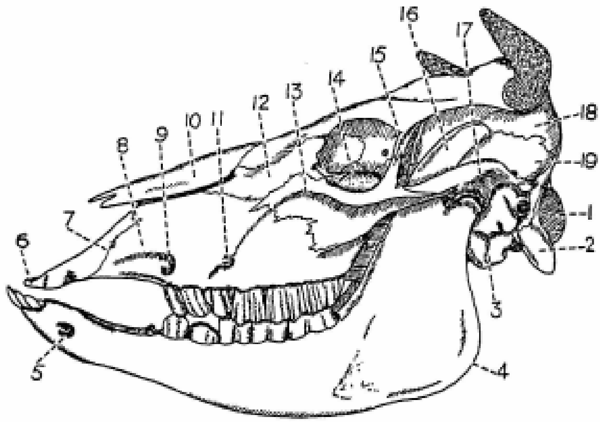


FIG. 62.—SKULL OF OX (LATERAL VIEW)

1. Occipital condyle. 2. Paramastoid process. 3. Auditory bulla of petrous temporal bone. 4. Angle of mandible. 5. Mental foramen. 6. Body of premaxilla. 7. Nasal process of premaxilla. 8. Maxilla. 9. Infraorbital foramen. 10. Nasal bone. 11. Facial tuberosity. 12. Lacrimal bone. 13. Malar bone. 14. Lacrimal protuberance. 15. Supraorbital process of frontal bone. 16. Coronoid process. 17. Zygomatic process of squamous temporal bone. 18. Lateral part of parietal bone. 19. Body of squamous temporal bone.

reverse of that found in the horse. The ethmoidal foramen is formed entirely in the frontal bone. The frontal sinus is of great size in the adult ox, reaching from near the level of the anterior margin of the orbit to the posterior extremity of the skull, and being prolonged into the horn process, the parietal and interparietal bones, and even into the occipital bone. The bone does not articulate with the palatine bone on the medial wall of the orbit.

Temporal Bones.—In the ox, as in all the domestic animals except the horse, the squamous and petrous parts of the temporal bone are speedily fused together. The zygomatic process articulates with the malar only, not with the frontal. The glenoid cavity is not so wide or deep as in the horse, but the condyle is more extensive. The postglenoid process is smaller. The zygoma bears immediately above the auditory process a blunt eminence that takes the place of the mastoid process of the petrous part in the horse. From this the temporal crest is continued upwards to join the parietal crest. The petrous part forms neither a mastoid crest nor a mastoid process. The tube of the auditory process is directed outwards and slightly downwards. The styloid process is concealed in a depression lying laterally to the auditory bulla. The bulla is more compressed from side to side than in the horse, and it approaches so close to the lateral border of the basilar part of the occipital bone as to render the foramen lacerum a much smaller opening than in the horse. The muscular process is longer and thicker. The parieto-temporal canal is formed largely between the squamous and petrous divisions of the temporal bone. Its internal orifice opens into the cranial cavity towards the point of articulation of the occipital, parietal and temporal bones. At its outer end there are three openings, viz. one on either side of the postglenoid process, and one in the temporal fossa.

Ethmoid Bone.—The perpendicular plate is large, and the most superior ethmo-turbinate, often termed the **great ethmo-turbinate,** is so voluminous that it might be regarded as a third (middle) turbinate bone.

Pterygoid Bones.—These are long, thin, and strap-like. The medial surface of each forms a large proportion of the lateral boundary of the pharyngeal opening of the nose. Superiorly it closes a vacuity between the subsphenoidal process and the palatine bone.

Palatine Bones.—These bones form about one-fourth of the bony palate. The palatine canal is formed entirely in the palatine bone, the anterior orifice of the canal, the anterior palatine foramen, being found towards the middle of the palatal surface of the bone. Behind this there are generally two or three small accessory palatine foramina leading out of the canal. The lateral border of the horizontal portion of the bone serves to complete the alveolus for the most posterior molar tooth. The spheno-palatine foramen is a very large elliptical opening. The vertical part of the bone is not excavated for the sphenoidal sinus, but the maxillary sinus is prolonged into its horizontal palatal part. In the ox this bone does not articulate with the frontal.

Lacrimal Bones.—The facial part of each of these bones is much larger than in the horse, and the lacrimal tubercle is absent. The lacrimal fossa is small and close to the orbital margin. This latter presents a deep notch in the region of the fossa and another at the fronto-lacrimal suture. On the floor of the orbit this bone forms a great **lacrimal protuberance** or **bulla** into which the maxillary sinus is prolonged. This part of the bone is thin and paper-like, and hence, unless great care be exercised, it is very apt to be destroyed, exposing the interior of the maxillary sinus.

Malar Bones.—These bones have more extensive facial surfaces than in the horse. The posterior extremity is bifurcate, the superior branch articulating with the supraorbital process of the frontal and the inferior branch with the zygomatic process of the squamous temporal.

Maxillae.—The maxillary bone is shorter than in the horse. The place of the zygomatic ridge on the bone is taken by a blunt eminence, the **facial tuberosity,** and by a rough curved line which extends from this tuberosity backwards and upwards to be continued on the facial surface of the malar. The infraorbital foramen is situated more anteriorly than in the horse, opening at the level of the first grinding tooth. The zygomatic process is small, and so also is the maxillary tuberosity. The palatine process is hollow, the maxillary sinus being prolonged into it. The maxilla takes no share in forming the palatine canal, and it forms much less of the bony palate than in the horse.

Nasal Bones.—These bones are both shorter and narrower than in the horse. Posteriorly the right and left bones form a triangular projection indenting the frontal bones. The anterior end of each bone is divided by a deep notch into a lateral and a medial process, the latter being the larger. The medial processes lie together, and give to the nasal peak of the ox a trifid character. The nasal bones articulate with the frontal by dentated sutures, but their other connections are by plane edges and hence a slight force serves to detach them in the dry skull.

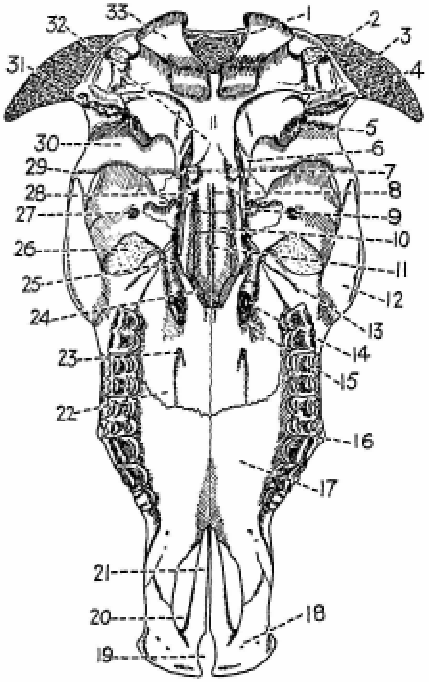


FIG. 63.—SKULL OF OX (VIEWED FROM BELOW, WITH MANDIBLE REMOVED)

1. Foramen magnum. 2. Paramastoid process. 3. Horn process. 4. Auditory process of petrous temporal bone. 5. Styloid process of petrous temporal bone. 6. Muscular process of petrous temporal bone. 7. Foramen ovale. 8. Body of postsphenoid bone. 9. Pterygoid process of postsphenoid bone. 10. Body of presphenoid bone. 11. Vomer bone. 12. Malar bone. 13. Maxilla. 14. Spheno-palatine foramen. 15. Posterior palatine foramen. 16. Facial tuberosity. 17. Palatine process of maxilla. 18. Body of premaxilla. 19. Interspace representing incisive foramen. 20. Palatine fissure. 21. Palatine process of premaxilla. 22. Horizontal part of palatine bone. 23. Anterior palatine foramen. 24. Pharyngeal opening of nasal fossa. 25. Hamulus of pterygoid bone. 26. Lacrimal protuberance. 27. Supraorbital foramen. 28. Pterygoid canal. 29. Zygomatic process of squamous temporal bone. 30. Glenoid cavity. 31. Opening of parieto-temporal canal. 32. Basilar part of occipital bone. 33. Occipital condyle.

Premaxillae.—The bodies of these bones are thin, compressed from above to below, and destitute of alveoli, the upper incisor and canine teeth being absent in the ox. There is no incisive foramen, an interspace, open anteriorly, intervening between the bodies of the right and left bones. The palatine fissure is a much wider opening than in the horse.

Vomer Bone.—In its posterior part the vomer is a slender plate lying within the depth of the guttural opening of the nose. In front of this it is free for a considerable distance, the bone being articulated to the anterior two-thirds of the maxilla only. Hence in the dried skull of the ox the nasal fossae are much more imperfectly separated than in the horse.

Turbinate Bones.—The superior bone is very much smaller than the inferior. It is thickest in its middle portion and pointed at both extremities. Its posterior part is included between the roof of the nose and the superior ethmo-turbinate. By its superior border it is attached to the nasal bone, and by its inferior border it is closely applied to the lacrimal and frontal bones. The cavity which it circumscribes communicates with the middle meatus of the nose and in the dried skull it opens also into the frontal sinus. The inferior turbinate bone is of large size. It is fixed to the maxilla by a lamella of its lateral face. Medially the lamella divides, its superior portion being rolled upwards, while its inferior portion is rolled in the opposite direction. The cavity of the bone above the before-mentioned lamella communicates with the middle meatus of the nose, and that below the lamella with the inferior meatus. The inferior turbinate bones are late in ossifying to the maxilla. Both turbinate bones are less fragile in texture than the same bones of the horse.

Mandible.—Except in very old animals the right and left halves of this bone are not ossified at the symphysis. The body of the bone carries eight close-set alveoli for the incisor teeth, and the alveolar border of each ramus is excavated by six other alveoli for the grinding teeth. The angle is thinner and less rounded than in the horse, and in front of it the lower border of the ramus is strongly convex. The condyle is saddle-shaped, being convex from before to behind and concave from side to side. The coronoid process is long, broad, and strongly bent backwards and laterally.

Hyoid Bone.—The glossal process is short and blunt. The thyrohyoids are not ossified to the body. The epihyoids rival the keratohyoids in size.

The Skull of the Ox as a Whole

The face is a little more bent upon the cranium than in the horse. The greatest difference, however, is found in connection with the anterior aspect of the cranium where in the ox there is much greater breadth and flatness of the skull between the level of the horn processes and the orbits. This is due mainly to the relatively great size of the frontal bones and to the enormous development of the frontal air sinuses. The wide separation thereby made between the outer and inner tables of the frontal and parietal bones masks the actual contour of the cranium in the ox. At the same time the temporal fossae are altogether displaced from the superior aspect of the skull and thrust downwards to its sides. This greater breadth of the skull affects also its inferior aspect at and behind the level of the glenoid cavity, the temporal bones and the basilar part of the occipital bone being proportionally wider than in the horse. The reduced size of the foramen lacerum and the presence of a large foramen ovale are other notable features of this region. The guttural opening of the nasal chamber is much more compressed laterally. The length of the bony palate is greater than in the horse, and its transverse measurement is also greater. A transverse line drawn through the posterior edge of the bony palate of the horse passes through the most posterior molar, but in the ox such a line lies half an inch or more behind that tooth.

THE SKULL OF THE SHEEP

Occipital Bone.—This bone in form and position differs less from the horse's occipital than does the same bone of the ox. It forms a transverse nuchal crest, which, as in the horse, lies at the most posterior part of the skull. The condyles, paramastoid processes and basilar part of the bone, on the other hand, resemble those of the ox, but the muscular eminences of the basilar part are situated more posteriorly and are further removed from the mesial plane. Another small eminence is found on either side immediately in front of the condyle. The condylar foramina resemble those of the ox. The frontal sinus is never prolonged into the occipital bone.

Interparietal Bone.—This is similar to that of the ox, save that the frontal sinus never invades it.

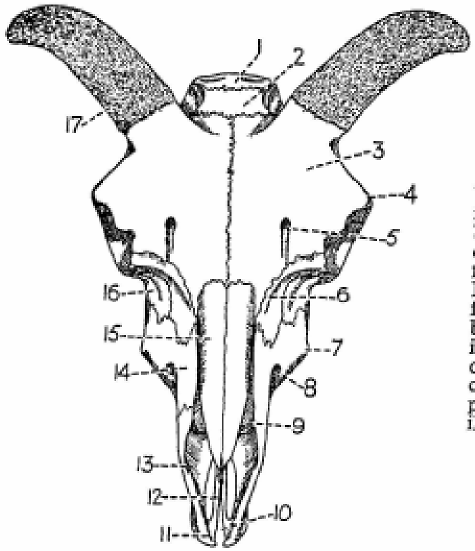


FIG. 64.—SKULL OF SHEEP (VIEWED FROM ABOVE, WITH MANDIBLE REMOVED)

1. Squamous part of occipital bone. 2. Fused parietal and interparietal bones. 3. Frontal bone. 4. Supraorbital process of frontal bone. 5. Supraorbital foramen. 6. Lacrimal bone. 7. Facial tuberosity. 8. Infraorbital foramen. 9. Superior turbinate bone. 10. Interspace representing incisive foramen. 11. Body of premaxilla. 12. Palatine process of premaxilla. 13. Nasal process of premaxilla. 14. Maxilla. 15. Nasal bone. 16. Malar bone. 17. Horn process.

Parietal Bones.—Each of these bones fuses early with its fellow of the opposite side and with the interparietal, but the united bones remain for a long time distinct from the squamous part of the occipital, the suture being evident in the young adult. The bone is bent in somewhat the same manner as in the ox, but the bend is not so abrupt. The medial part looks upwards and backwards and is therefore visible on the dorsal aspect of the skull as in the horse. The part that descends into the temporal fossa is slightly convex, whereas it is concave in the ox. The frontal sinus is never prolonged into the parietal and the bone participates in the formation of the parieto-temporal canal. The parietal of the sheep is actually thicker than the same bone of the horse—a protection to the brain that is obviously necessary in an animal whose head is employed as a weapon of offence.

Sphenoid Bone.—This bone is almost identical with that of the ox. The bony projection behind the pituitary fossa, representing the posterior clinoid processes, is even more prominent than in the ox. The sphenoidal sinus is very small or absent.

Frontal Bones.—These bones do not form the most posterior part of the skull as they do in the ox. Each bone is strongly convex at the level of the horn process, its posterior part facing upwards and backwards. The horn processes vary in shape, size and direction according to the breed, being in some slightly spiral. The frontal sinus is relatively smaller. The vascular furrow into which the supraorbital foramen opens does not extend behind the foramen. In the hornless breeds the bone shows a slightly roughened depression in place of the horn process.

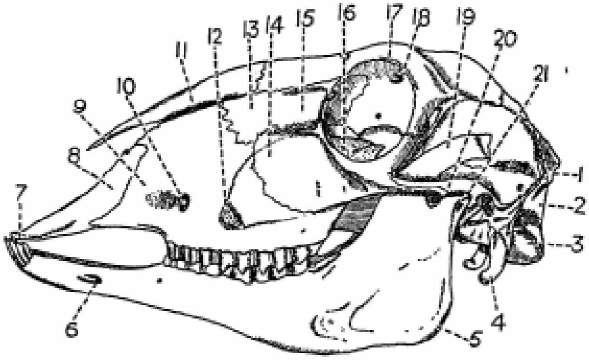


FIG. 65.—SKULL OF SHEEP (LATERAL VIEW)

1. Nuchal crest. 2. Squamous part of occipital bone. 3. Occipital condyle. 4. Paramastoid process. 5. Angle of mandible. 6. Mental foramen. 7. Body of premaxilla. 8. Nasal process of premaxilla. 9. Maxilla. 10. Infraorbital foramen. 11. Nasal bone. 12. Facial tuberosity. 13. Lacrimal bone. 14. Malar bone. 15. Fossa for infraorbital pouch. 16. Lacrimal protuberance. 17. Supraorbital process of frontal bone. 18. Supraorbital foramen. 19. Coronoid process. 20. Zygomatic process of squamous temporal bone. 21. Condyle.

Temporal Bones.—In these bones the fusion of the squamous and petrous portions is not so prompt as in the ox, and the tympanic part remains for a long time distinct from the petro-mastoid part. The auditory bulla is somewhat larger, less compressed, and more closely applied to the basilar part of the occipital bone than in the ox. The styloid process is larger and less concealed, and the curved plate of bone surrounding it does not extend as far laterally as the free extremity of the auditory process. In other respects the temporal bones of the sheep are similar to those of the ox.

Ethmoid Bone.—This is very similar to that of the ox.

Pterygoid Bones.—These bones are much broader superiorly than inferiorly where there is a slender backwardly projecting hamulus.

Palatine Bones.—Each of these bones resembles that of the ox in the considerable share that it takes in forming the bony palate. It differs, however, in that the palatine canal is not formed by it alone but in conjunction with the maxilla, the anterior palatine foramen opening on the suture, as in the horse. Furthermore, the sphenoidal sinus is rarely prolonged into its vertical part.

Lacrimal Bones.—In these bones the facial surface is depressed to form with the assistance of the malar a distinct fossa for the accommodation of the infraorbital, or lacrimal, pouch of the integument. In other respects the bones resemble the same bones of the ox.

Malar Bones.—The facial crest on these bones is more distinct in this animal than in the ox. The posterior extremity is bifurcate as in the ox.

Maxillae.—Save in assisting to form the palatine canal, the maxillary bone resembles that of the larger ruminant. A narrow cleft may isolate it from the nasal bone in the dry skull.

Nasal Bones.—The nasal bone of the sheep has only a very small area of articulation with the maxilla, a narrow interval in the dried skull

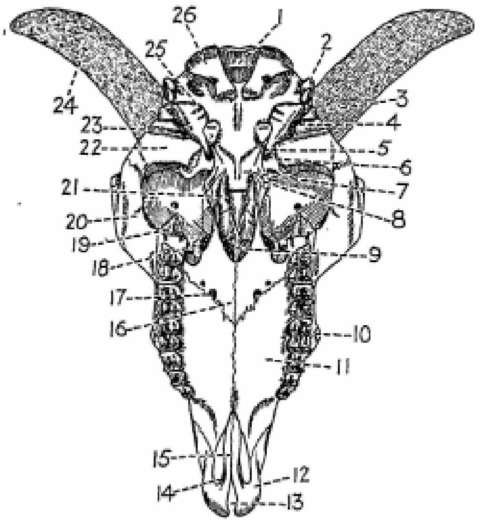


FIG. 66.—SKULL OF SHEEP (VIEWED FROM BELOW, WITH MANDIBLE REMOVED)

1. Foramen magnum. 2. Paramastoid process. 3. Auditory process of petrous temporal bone. 4. Styloid process of petrous temporal bone. 5. Muscular process of petrous temporal bone. 6. Foramen ovale. 7. Body of postsphenoid bone. 8. Pterygoid process of postsphenoid bone. 9. Vomer bone. 10. Facial tuberosity. 11. Palatine process of maxilla. 12. Body of premaxilla. 13. Interspace representing incisive foramen. 14. Palatine fissure. 15. Palatine process of premaxilla. 16. Horizontal part of palatine bone. 17. Anterior palatine foramen. 18. Spheno-palatine foramen. 19. Lacrimal protuberance. 20. Malar bone. 21. Pterygoid bone. 22. Glenoid cavity. 23. Postglenoid process. 24. Horn process. 25. Posterior part of foramen lacerum. 26. Occipital condyle.

separating the greater part of the adjacent borders of these bones. It does not articulate with the nasal process of the premaxilla. The anterior extremity of the bone is undivided, but the nasal peak is less acute than in the horse.

Premaxillae.—These bones closely resemble those of the ox. The palatine fissures are proportionally longer.

Vomer and Turbinate Bones.—Both these bones resemble the corresponding bones of the ox, but the superior turbinate bone is not united to the nasal.

Mandible.—This bone bears a close resemblance to the same bone of the ox, but the inferior border, from the body to the angle, is much less convex.

Hyoid Bone.—The epihyoids and the keratohyoids are of nearly equal size. The thyrohyoids are not anchylosed to the basihyoid, and the glossal process is short and blunt.

The Skull of the Sheep as a Whole

The sheep's skull resembles in most respects that of the larger ruminant. The smaller size of the frontal sinuses causes the posterior part of the skull to depart less from the form of the horse's cranium. Thus this region is formed by the occipital bone alone, and the medial parts of the parietal bones are visible when the head is viewed from above. The lateral position of the temporal fossae, the size and prominence of the orbits, and the large dimensions of the bony palate are points of resemblance between the skull of the sheep and that of the ox.

THE SKULL OF THE PIG

Occipital Bone.—This bone forms the highest point of the head, but only the anterior border of its squamous part, which constitutes a prominent nuchal crest, is visible when the skull is viewed directly from the front.

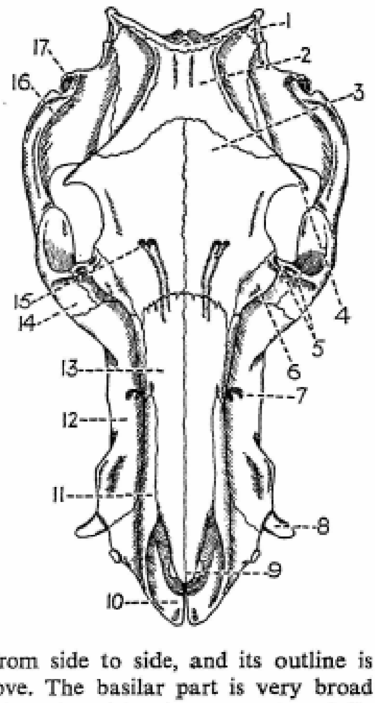


FIG. 67.—SKULL OF PIG (VIEWED FROM ABOVE, WITH MANDIBLE REMOVED)

1. Nuchal crest. 2. Fused parietal and interparietal bones. 3. Frontal bone. 4. Supraorbital process of frontal bone. 5. Osseous lacrimal canals. 6. Lacrimal bone. 7. Infraorbital foramen. 8. Canine tooth. 9. Nasal peak. 10. Body of premaxilla. 11. Nasal process of premaxilla. 12. Maxilla. 13. Nasal bone. 14. Malar bone. 15. Supraorbital foramen. 16. Zygomatic process of squamous temporal bone. 17. Auditory process of petrous temporal bone.

The foramen magnum is compressed from side to side, and its outline is somewhat triangular with the apex above. The basilar part is very broad posteriorly, but narrower where it joins the sphenoid. It is traversed mesially on its lower surface by a slight ridge. The paramastoid processes are of great length and they project nearly straight downwards. The condylar foramen is single, as in the horse, but further removed from the condyle, being placed close to the root of the paramastoid process. The squamous part of the bone unites with the parietals sooner than with the lateral parts. Its outer surface looks almost directly backwards, and on it two divergent ridges proceed from the foramen magnum to the extremities of the nuchal crest. It has no eminence for the ligamentum nuchae. The cranial surface shows close behind the line of junction with the parietals a furrow for the transverse sinus, but there is no osseous tentorium cerebelli. In the adult pig the frontal sinus is prolonged into the squamous part of the bone.

Interparietal Bone.—This element unites even before birth with the occipital bone.

Parietal Bones.—In position these bones agree with those of the horse, being situated on the dorsal aspect of the skull immediately in front of the nuchal crest. In shape, however, the bones resemble the parietals of the ruminant. The right and left bones are early united together, and the combined bones then present a flat medial plate which looks forwards and upwards, and two lateral slightly concave plates each of which, directed laterally, forms a large part of the medial wall of the temporal fossa. The medial plate is separated on each side from the lateral plate by a prominent parietal crest extending between the nuchal crest and the supraorbital process of the frontal bone. In the adult pig the outer and inner tables of the parietal are widely separated by a backward extension of the frontal sinus. No parieto-temporal canal is formed in the pig's skull.

Sphenoid Bone.—The hypophyseal fossa resembles that of ruminants, being limited behind by a large plate projecting forwards. The free corners of this process, the posterior clinoid processes, form prominent projections. The pterygoid processes are very strong, flattened from before to behind, and devoid of a canal. The foramen ovale, as in the horse, is represented by a notch on the posterior border of the wing of the postsphenoid, but it resembles that of the ox in giving passage to the middle meningeal artery in addition to the mandibular division of the trigeminal nerve. The orbital foramina are similar to those of the ox. The wing of the presphenoid articulates by suture with the frontal. In the adult pig the entire body of the sphenoid is excavated to bound the large sphenopalatine sinus.

Frontal Bones.—These bones are much smaller than in the ox, but larger than in the horse. In the wild pig the outer surface of each is nearly flat, but in the domesticated animal it is concave, the concavity being directed forwards and upwards, and being pronounced in some breeds. The supraorbital process is short, pointed, and unconnected to the zygomatic arch in the dry skull. The so-called supraorbital foramen is considerably removed from the root of that process and opens on the face almost level with the most anterior part of the margin of the orbit. As in the ox, this opening is nearer the mesial plane than in the horse, and a vascular groove descends from it to the nasal bone. The so-called ethmoidal foramen is formed entirely in the orbital plate of the frontal, which, as already mentioned, is articulated by suture with the wing of the presphenoid. The frontal bone of the pig articulates on the face with the maxilla between the nasal and lacrimal bones. The frontal sinus is very large and extends from this bone into the parietal, occipital, squamous temporal and nasal bones. It opens independently into the posterior part of the nasal fossa.

Temporal Bones.—The tympanic part of each petrous temporal fuses at an early age with the squamous temporal, but the petrous part proper, or periotic, remains for a long time distinct. The mastoid part is very rudimentary, and is not visible on the exterior of the articulated skull. It forms a small scale-like process on the medial surface of the squamous division. The auditory process is directed upwards and laterally. It is a much longer tube than in any of the other domesticated animals. A curved ridge runs downwards from the external auditory meatus to the auditory bulla. The auditory bulla is proportionately much larger than in the horse or ruminant, and it projects to a marked extent downwards below the root of the paramastoid process of the occipital. It approaches medially, although it rarely touches, the lateral border of the basilar part of the occipital bone, and the foramen lacerum is similar to that of the horse. The muscular process is represented by a slight prominence on the inferior aspect of the bulla. The styloid process is very slender and is concealed in the depth of

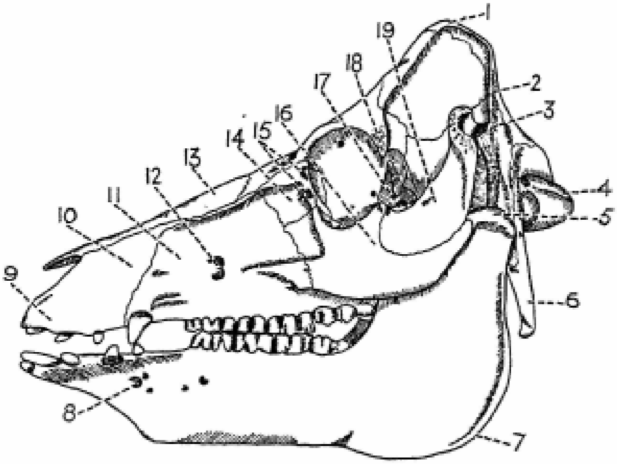


FIG. 68.—SKULL OF PIG (LATERAL VIEW)

1. Nuchal crest. 2. Squamous part of occipital bone. 3. Auditory process of petrous temporal bone. 4. Occipital condyle. 5. Condyle of mandible. 6. Paramastoid process. 7. Angle of mandible. 8. Mental foramen. 9. Body of premaxilla. 10. Nasal process of premaxilla. 11. Maxilla. 12. Infraorbital foramen. 13. Nasal bone. 14. Lacrimal bone. 15. Osseous lacrimal canals. 16. Malar bone. 17. Coronoid process. 18. Supraorbital process of frontal bone. 19. Zygomatic process of squamous temporal bone.

a depression immediately in front of the root of the paramastoid process of the occipital. Laterally to it, in this same depression, there is seen the stylo-mastoid foramen. The area for articulation with the mandible is extensive, being continued upwards for some distance on the posterior aspect of the zygomatic process. The postglenoid process is absent. The zygomatic process is very strong, and its anterior end rests in a deep notch of the malar bone. From the most prominent point of its superior border the sharp temporal crest passes to the medial side of the external auditory meatus, and is continued backwards and upwards to the nuchal crest forming the posterior limit of the temporal fossa.

Ethmoid Bone.—The cranial surface of the horizontal plate is directed forwards and slightly upwards, lying in nearly the same plane as the basicranial axis. The orbital plate, or lamina papyracea, which envelopes outwardly the lateral mass, is visible on the exterior of the skull, appearing between the frontal, palatine, maxillary and sphenoid bones immediately behind the maxillary group of foramina.

Pterygoid Bones.—Each of these bones has its long axis directed almost vertically. Its upper extremity is smaller than the lower extremity which carries a prominent hamulus.

Palatine Bones.—The palatine bones form more of the bony palate than in the horse though somewhat less than in the ruminant. Their palatal portions are triangular in outline with the apex anteriorly, and the anterior orifice of the palatine canal, the anterior palatine foramen, opens on the maxilla, the palatine taking no part in its formation. The pterygoid crest is a very massive projection situated at the side of the pharyngeal opening of the nose. Postero-medially to it lies the hamulus, and postero-laterally the prominent lower extremity of the pterygoid or subsphenoidal process. As in the ox the palatine does not articulate with the frontal.

Lacrimal Bones.—The facial surface of the lacrimal bone is larger than in the horse, though smaller than in the ox. It is crossed by a blunt ridge below which the bone is very depressed. There are two osseous lacrimal canals situated one above the other, the upper being on the orbital margin, and the lower situated on the facial surface. The orbital surface has a deep blind fossa marking the attachment of the inferior oblique muscle of the eyeball. A well-defined ridge, interrupted by a vascular furrow, traverses the orbital surface. The periorbital membrane, or ocular sheath, is attached to this ridge, and as much of the bone as lies laterally to the ridge is therefore excluded from the orbital cavity proper. The form of the facial surface of the lacrimal bone varies considerably in different breeds. In the wild pig and in some of the domestic breeds the lacrimo-frontal suture is much longer than the lacrimo-maxillary suture, but in other breeds the latter suture may equal or exceed the former suture in length. In the pig the lacrimal bone does not articulate with the nasal.

Malar Bones.—The facial part of each of these bones is small. The orbital surface, which is also of small extent, is smooth and groove-like. This surface is, strictly speaking, not orbital, for it is occupied by fat and vessels, and is excluded from the orbit proper by the before-mentioned attachment of the periorbital membrane to the orbital surface of the lacrimal. The zygomatic part is of great strength, and much more extensive than all the rest of the bone. Its posterior extremity is deeply notched above for the reception of the zygomatic process of the squamous temporal. It does not articulate with the supraorbital process of the frontal.

Maxillae.—These bones are of large size in the pig. The facial surface, which is concave, is perforated towards its centre by a large infraorbital foramen. The zygomatic ridge is short but strong, forming a buttress-like support for the malar. The alveolar border carries seven alveoli in the adult for the grinding teeth, the size of these alveoli increasing from before to behind. At the anterior extremity of this border a large complete alveolus is excavated for the canine tooth. In the adult male the facial side of this alveolus is raised into a ridge. The maxillary tuberosity is large in the young animal, being occupied by the developing last molar teeth. In the adult, after the eruption of these teeth, it subsides, the bone here forming a thin plate lying laterally to the vertical part of the palatine bone. The alveolar tuberosity has the form of a sharp ridge situated behind the last molar tooth. The zygomatic process is short but broad. The palatine process is of great length. In the adult animal it is often ridged transversely in its anterior half in correspondence with the palatine bars or ridges of the mucous membrane. The anterior palatine foramen opens on the posterior part of this palatine process, the palatine canal being formed entirely in

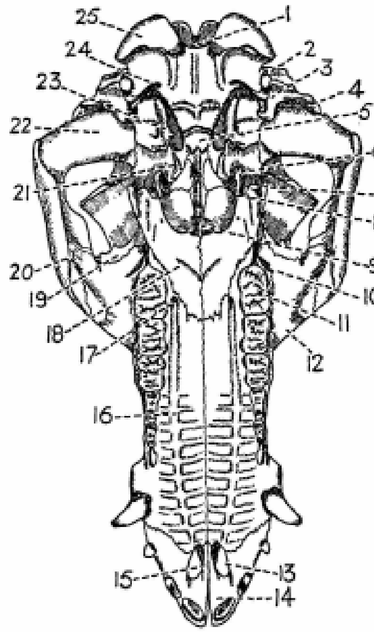


FIG. 69.—SKULL OF PIG (VIEWED FROM BELOW, WITH MANDIBLE REMOVED)

1. Foramen magnum. 2. Paramastoid process. 3. Styloid process of petrous temporal bone. 4. Auditory process of petrous temporal bone. 5. Body of postsphenoid bone. 6. Hamulus of pterygoid bone. 7. Lower extremity of pterygoid process of postsphenoid bone. 8. Pterygoid crest of palatine bone. 9. Vomer bone. 10. Maxillary group of foramina. 11. Third molar tooth. 12. Maxilla. 13. Palatine fissure. 14. Body of premaxilla. 15. Palatine process of premaxilla. 16. Palatine groove. 17. Anterior palatine foramen. 18. Horizontal part of palatine bone. 19. Lacrimal bone. 20. Malar bone. 21. Wing of postsphenoid bone. 22. Area for articulation with mandible. 23. Foramen lacerum. 24. Condylar foramen. 25. Occipital condyle.

this bone. A palatine groove, less distinct than in the horse, is continued forwards from the foramen. The maxillary sinus is small, and it does not extend into the palatine process. The spheno-palatine foramen is small, while the maxillary foramen and the superior dental canal are very large. In the pig this bone articulates with the frontal both in the lower part of the orbit and on the face.

Premaxillae.—In these bones the body and nasal process, especially the latter, are very strong in the pig. The body is excavated by three alveoli for the incisor teeth. Slight intervals separate these alveoli. The nasal process has a much longer articulation with the nasal bone than in the horse. The palatine process is shorter than in the horse. As in the ruminant a narrow interval separates the bodies of the right and left bones, and therefore no incisive foramen is formed. The palatine fissures are short but wide.

Nasal Bones.—Each of these bones is thicker and more solidly united to its fellow and to the surrounding bones than is the case in any of the other domestic animals. Its anterior extremity is undivided, and the nasal peak is similar to that of the horse, save that it is shorter and stronger. The vascular groove running forwards from the supraorbital foramen is continued for a short distance on the outer surface of this bone. The length and the degree of concavity of the outer surface of the nasal bones of the pig vary considerably with the breed, the bones being very short and concave in some breeds.

Vomer Bone.—This bone is of great length in the pig. Its posterior end is small, and the free part of its lower border, where it separates the posterior nares, lies more deeply and is sharper than in the horse. This border has a very extensive articulation with the bony palate, the anterior extremity of the bone reaching close to the body of the premaxilla.

Turbinate Bones.—The superior bone resembles that of the ruminant, but it is stronger, of greater length, and more firmly united to the nasal bone. It encloses a single undivided cavity which communicates by a narrow opening with the posterior part of the middle meatus, and near the same point with the frontal sinus. The inferior turbinate bone is larger than the superior. It bears a close resemblance to the same bone of the ruminant, but its texture is stronger.

Prenasal Bone, or **Os Rostri.**—This is a small osseous piece embedded in the snout, at the anterior end of the septal cartilage of the nose, to which it is movably united. Its purpose is to strengthen the snout as a digging organ. It is somewhat prismatic in form with the base placed superiorly.

Mandible.—The right and left halves of this bone soon become anchylosed at the median suture of the body as in the horse. The whole bone is relatively very large and strong. The alveoli for the seven cheek teeth cause a medial projection or bulging of the ramus. In addition to the main mental foramen, several smaller accessory foramina open behind it on the lateral surface of the ramus. Two or three small foramina are also present on the labial surface of the body. The coronoid process is small and almost on a level with the condyle. The latter is convex in both directions, and of almost equal extent in the antero-posterior and transverse directions.

Hyoid Bone.—The basihyoid is small, and the glossal process is represented by a mere median ridge. The thyrohyoids are anchylosed to the basihyoid. The keratohyoids are short and united to the body by cartilage. The epihyoids, and the stylohyoids exist for a long time as curved rods of cartilage which subsequently become converted into bone.

The Skull of the Pig as a Whole

The cranium forms a much greater proportion of the skull than in the horse, owing to the greater development of the frontal sinuses. As in the ox, the actual contour of the cranial cavity is masked by these sinuses. The capacity of the cranium is relatively less than that of the horse. No median parietal crest is formed in the pig, and the temporal fossae occupy only the lateral aspects of the cranium, the horizontal parts of the parietal bones forming a broad flat area between the fossae. The orbits are small, and the margin of each is incomplete laterally and below. In front of the orbits the transverse measurement of the face is less than in the horse, owing to the smaller size of the maxillary sinuses. The face, like the cranium, has a characteristic four-sided form, a tolerably abrupt edge marking the line of articulation of the nasal bone with the maxilla and premaxilla. The anterior openings of the nasal chamber are situated almost at the anterior extremity of the skull, and the nasal peak is short. The pharyngeal opening of the nasal chambers looks almost directly backwards. Its outline is more square than in the horse, and its bony boundaries are very strong. Lastly, the relatively enormous length of the bony palate is a very notable feature of the pig's skull. In the horse the bony palate measures somewhat less than one-half of the entire skull, whereas in the pig it forms two-thirds of the whole length. A transverse line drawn through the posterior edge of the hard palate falls some distance behind the most posterior molar tooth.

THE SKULL OF THE DOG

Occipital Bone.—In position this bone agrees closely with that of the horse. It forms a transverse nuchal crest, the centre of which is the most posterior point of the skull. Before birth its squamous part fuses with the interparietal element, which intrudes itself as a long narrow strip between the right and left parietal bones. The basilar part is short, broad, and furnished below with a faint median ridge. The auditory bulla of the temporal bone abuts upon each lateral border and between the two a short venous canal is formed. As a result of this abutment the vacuity corresponding to the foramen lacerum of the horse's skull is divided into an anterior opening, the carotid foramen (corresponding to the notch for the internal carotid artery in the sphenoid bone of the horse), and a posterior opening, the jugular foramen. The before-mentioned venous canal opens anteriorly into the cranial cavity and posteriorly into the jugular foramen. Behind its inner opening in the cranial cavity is a large foramen which leads into the venous condylar canal. The canal opens superiorly a little behind the cranial opening of the parieto-temporal canal, whilst inferiorly it joins the jugular foramen. The foramen magnum is very large and the condyles are wide apart. A large mastoid foramen lies above and in front of each. The paramastoid processes are shorter eminences than in any of the other domesticated animals.

Interparietal Bone.—As already stated this bone fuses before birth with the squamous part of the occipital. The osseous tentorium cerebelli is in the form of a large thin plate in the dog, and the parietal bones contribute largely to its formation. The right and left parieto-temporal canals unite in the substance of this process at its attached border. In the skulls of adult dogs of the larger breeds the outer surface of the interparietal bone is taken up almost entirely in forming a strong median parietal crest, the sides of which give attachment to the temporal muscles. In young dogs, however, and throughout life in the smaller breeds, the crest is very poorly developed.

Parietal Bones.—In position these bones correspond exactly with those of the horse. They are also similar in shape although relatively more extensive. In adult animals of the larger breeds the external surface of each bone is almost entirely taken up in forming the temporal fossa. Mesially it forms a strong parietal crest which materially increases the extent of these fossae, and affords attachment to the powerful temporal muscles. In the smaller breeds, however, and in the young animals of all breeds, each parietal bone is traversed by a curved ridge which limits the temporal fossa and cuts off medially a smooth area of variable breadth that takes no share in forming the fossa. This ridge is in fact the parietal crest.

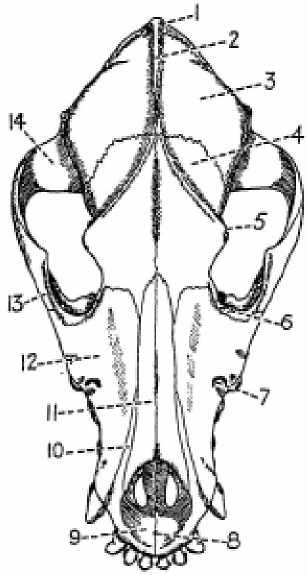


FIG. 70.—SKULL OF DOG (VIEWED FROM ABOVE, WITH MANDIBLE REMOVED)

1. Centre of nuchal crest. 2. Interparietal bone. 3. Parietal bone. 4. Frontal bone. 5. Supraorbital process of frontal bone. 6. Lacrimal bone. 7. Infraorbital foramen. 8. Incisive foramen. 9. Body of premaxilla. 10. Nasal process of premaxilla. 11. Nasal bone. 12. Maxilla. 13. Malar bone. 14. Zygomatic process of squamous temporal bone.

Sphenoid Bone.—The wings of the postsphenoid are much larger than those of the presphenoid. The hypophyseal fossa is deeper than in the horse, and is limited in front and behind by clinoid processes. A subsphenoidal or alar canal is present, as in the horse, and the foramen rotundum opens into it instead of appearing independently in the orbit. The trochlear foramen is unrepresented in the dog, since the nerve of that name emerges from the cranium through the large foramen orbitale. A foramen ovale is present as in the ox. There is no spheno-palatine sinus in the dog.

Frontal Bones.—The supraorbital process is even smaller than in the pig. It has the form of a short blunt tubercle which does not reach the zygoma, and the orbital margin is therefore incomplete supero-laterally. The supraorbital foramen is absent. The ethmoidal foramen is formed entirely in the frontal bone. The frontal sinus is of considerable extent in the larger breeds, but it is rudimentary in the smaller. As in the pig, the frontal bone articulates with the maxilla on the face. In the larger breeds a considerable part of the outer surface of this bone enters into the formation of the temporal fossa, the temporal and the facial parts being separated by a prominent ridge which is a forward continuation of the parietal crest and which ends anteriorly by joining the supraorbital process. In young animals, and in the small breeds at any age, this line is faint, and the temporal part of the bone is small.

Temporal Bones.—The separate parts of the temporal bone soon become anchylosed together. The zygomatic process forms a wide lateral bend, leaving a capacious temporal fossa. It has a long articulation with the malar, but the supraorbital process of the frontal and the zygomatic process of the maxilla do not reach it. There is an extensive glenoid cavity and a large postglenoid process, but the condyle or articular eminence is absent. The mastoid portion of the bone is small. The auditory process is very short,

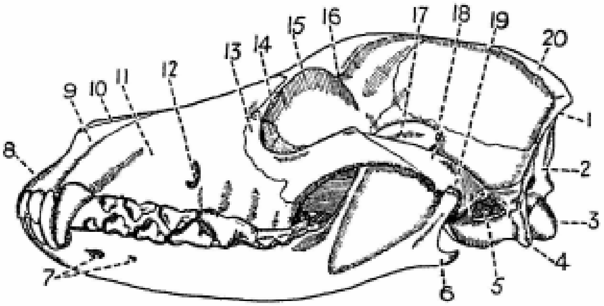


FIG. 71.—SKULL OF DOG (LATERAL VIEW)

1. Nuchal crest. 2. Squamous part of occipital bone. 3. Occipital condyle. 4. Paramastoid process. 5. External auditory meatus. 6. Process at angle of mandible. 7. Mental foramina. 8. Body of premaxilla. 9. Nasal process of premaxilla. 10. Nasal bone. 11. Maxilla. 12. Infraorbital foramen. 13. Malar bone. 14. Lacrimal bone. 15. Frontal bone. 16. Supraorbital process of frontal bone. 17. Coronoid process. 18. Zygomatic process of squamous temporal bone. 19. Condyle. 20. Interparietal bone.

and the external auditory meatus is large and directed outwards and slightly upwards. The auditory bulla is of great size. It abuts closely against the basilar part of the occipital, a venous canal, as already mentioned, being formed between them. Immediately lateral to this venous passage a second canal, the **carotid canal,** perforates the medial aspect of the bulla. Posteriorly this canal begins at the jugular foramen and anteriorly it ends at the carotid foramen. The internal carotid artery passes through this canal. The muscular process is rudimentary. The styloid process is also very small, and concealed in the depth of a deep depression in front of and above the area of articulation between the auditory bulla and the paramastoid process of the occipital. The stylo-mastoid foramen opens in front of the root of the paramastoid process in this same depression. The medial surface of the petrous temporal shows above the internal auditory meatus a larger blind depression for the flocculus, a lobe of the cerebellum. The antero-medial border of the petrous part forms a sharp and prominent petrosal crest for the attachment of the tentorium cerebelli. Near its lower end this border is perforated by a large foramen through which the trigeminal nerve passes forwards.

Ethmoid Bone.—This bone is large in the dog. The ethmoidal fossae are very deep, and but slightly separated from each other, for the crista galli is not prominent. The ethmoturbinates of the lateral masses are large and numerous.

Pterygoid Bones.—In the dog these bones are quadrangular in outline, being shorter but broader than in the horse. The postero-inferior angle carries a small backwardly projecting hamulus.

Palatine Bones.—Both the palatine and the orbital parts of these bones are larger than in the horse. The former furnish nearly a third of the length of the bony palate. As in the horse, the anterior palatine foramen opens on the suture between the palatine and the maxilla, but sometimes the palatine canal itself is formed entirely in the first of these bones. Two or three accessory palatine foramina perforate the bone behind the main foramen. No spheno-palatine sinus is developed in the dog.

Lacrimal Bones.—Each of these bones is almost entirely orbital, little more than its anterior border entering into the formation of the face. The maxilla cuts it off from articulation with the nasal bone, but, on the other hand, it articulates constantly with the palatine on the medial wall of the orbit.

Malar Bones.—In these bones the facial part is very small, but the zygomatic part is greatly developed. The posterior extremity has a long superior bevel for articulation with the zygomatic process of the squamous temporal. The orbital border of the process carries a small tubercle which in the recent state is connected by the orbital ligament to the supraorbital process of the frontal bone.

Maxillae.—These bones form a much larger proportion of the face than in the horse, the posterior extremity of each being developed at the expense of the malar and lacrimal bones. The small size of the latter bone allows the maxilla to articulate with the frontal. There is a large centrally placed infraorbital foramen, but the zygomatic ridge is absent. The alveolar border carries alveoli for the six cheek teeth, and at its anterior end it forms with the aid of the premaxilla a large socket for the canine tooth. The palatine process forms much less of the bony palate than in the horse. The anterior palatine foramen opens on the suture between this bone and the palatine, but the canal itself is sometimes formed entirely in the palatine. The palatine groove is faint, and the maxillary sinus is very small. The alveolar tuberosity is represented by a small sharp ridge behind the last molar tooth.

Nasal Bones.—These bones are very small in the dog. In most breeds the posterior ends are narrower than the anterior, but sometimes this relationship is reversed. The outer surface of each bone is more or less concave in its length, the concavity being most marked in the smaller breeds. The anterior extremity exhibits a rounded notch, and the nasal peak is therefore absent.

Premaxillae.—The bodies of these bones are strong. Each is excavated by three alveoli for the incisor teeth, and with the aid of the maxilla it forms the socket for the canine tooth. The palatine process is shorter but stronger than in the horse, and on their nasal aspects the right and left processes form a groove for the septal cartilage of the nose. The nasal process intrudes itself between the maxilla and the nasal bone for a much longer distance than in the horse. The palatine fissures are short but wide, and the incisive foramen is very small or altogether absent.

Vomer Bone.—The posterior extremity of this bone is narrow and deeply notched. The posterior part of its inferior border lies more in the depth of the pharyngeal orifice of the nose, which is therefore less distinctly divided than in the horse.

Turbinate Bones.—The turbinate bones are generally more richly convoluted than in the horse. The anterior part of the superior bone, however, forms a simple curved plate overhanging the inferior bone. The posterior part of this superior bone is not distinctly separated from the lateral mass

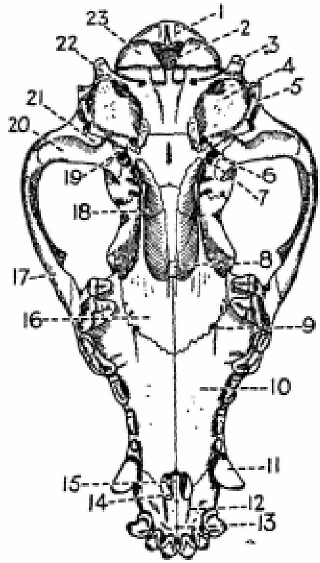


FIG. 72.—SKULL OF DOG (VIEWED FROM BELOW, WITH MANDIBLE REMOVED)

1. Squamous part of occipital bone. 2. Foramen magnum. 3. Paramastoid process. 4. Auditory bulla of petrous temporal bone. 5. Auditory process of petrous temporal bone. 6. Foramen ovale. 7. Posterior opening of subsphenoidal canal. 8. Vomer bone. 9. Anterior palatine foramen. 10. Palatine process of maxilla. 11. Canine tooth. 12. Body of premaxilla. 13. Incisive foramen. 14. Palatine fissure. 15. Palatine process of premaxilla. 16. Horizontal part of palatine bone. 17. Malar bone. 18. Pterygoid bone. 19. Wing of postsphenoid bone. 20. Glenoid cavity. 21. Postglenoid process. 22. Jugular foramen. 23. Occipital condyle.

of the ethmoid. The inferior bone is attached to the medial surface of the maxilla by a main lamina which, passing medially, divides as in the ox into two secondary lamellae. These are rolled in opposite directions and carry a number of tertiary lamellae. The bones take no part in forming the frontal or maxillary sinuses.

Mandible.—Except in old animals the right and left halves of this bone do not become anchylosed. The axis of the bone from the coronoid process to the anterior extremity of the body forms only a slightly curved line. At its junction with the body the ramus is stronger than in the horse, and laterally it carries two or three mental foramina. In the position of the angle, which would otherwise be indistinct, there is a strong backwardly directed process for the attachment of the masseter and medial pterygoid muscles. Above and in front of this the lateral face of the ramus is deeply depressed for the attachment of the masseter. The condyle is elongated transversely, convex from before to behind, and slopes downwards and towards the middle line. The coronoid process is a relatively enormous plate of bone, standing much higher than the condyle, and rivalling the ramus in breadth. The mandibular notch is not well marked. The alveolar border of the ramus carries alveoli for the seven cheek teeth, and each half of the body is excavated by four other alveoli for the canine tooth and the three incisors. There is a short interdental space between the canine and the first cheek tooth.

Hyoid Bone.—The basihyoid is elongated transversely and rod-like. The glossal process is absent, and the thyrohyoids are not anchylosed with the body. The epihyoids are nearly equal in size to the stylohyoids, and much larger than the keratohyoids.

The Skull of the Dog as a Whole

Contrary to what is the case in the horse, the cranial part of the skull rivals or exceeds the facial part in size. The reduction in the size of the facial part is most marked in the smaller breeds. The temporal fossae are vastly more developed than in the horse, a feature which is characteristic of the

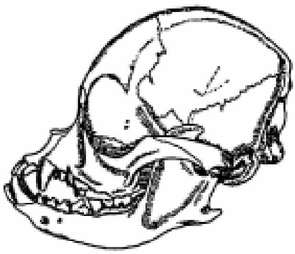


FIG. 73.—SKULL OF DOG OF SMALL, SHORT-NOSED BREED (LATERAL VIEW)

carnivorous skull. As already mentioned the right and left fossae in the larger breeds approach the middle line dorsally, being separated only by the parietal crest posteriorly. To increase further the capacity of these fossae, the zygomatic processes of the squamous temporals take a much wider sweep laterally than in the horse. In the bull-dog and related breeds the transverse measurement from one process to another stands in relation to the long axis of the entire skull as 2 to 3, whereas it is almost as 2 to 5 in the horse. As in the pig the orbital cavity in the dry skull communicates freely with the temporal fossa, the orbital margin, owing to the slight development of the supraorbital process of the frontal, being incomplete postero-laterally. The axis of the orbit has more of a forward and less of a lateral direction than in the herbivorous orders. The frontal region is relatively smaller, owing to the small size of the frontal sinuses. Similarly, the lateral aspect of the face is more depressed on account of the slighter development of the maxillary sinuses. The breadth of the bony palate, more especially in the bull-dog and smaller breeds, is relatively greater than in the horse. A transverse line drawn through the posterior margin of the bony palate falls a little behind the most posterior molar tooth. The posterior nares look almost directly backwards, and they are more compressed from above to below than in the horse. The anterior openings of the nasal cavity on the other hand, are more circular in outline than in the horse, and they are placed nearly at the anterior extremity of the skull.

THE SKULL OF THE CAT

The skull of the cat is somewhat similar in form to the skull of a small dog, and the individual bones resemble fairly closely the same bones of the dog. It is therefore unnecessary to consider each bone individually.

As compared with the horse or the ruminant, the cat exhibits a great reduction in the size of the facial part of the skull. Thus, in the skull of the horse, the distance between the nuchal crest and the most anterior point

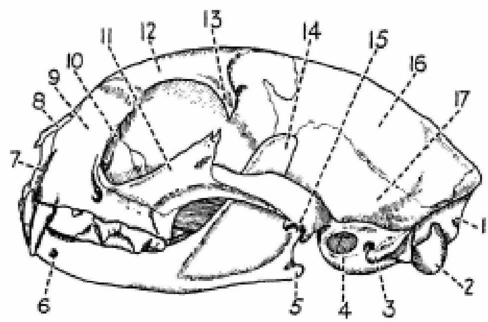


FIG. 74.—SKULL OF CAT (LATERAL VIEW)

1. Squamous part of occipital bone. 2. Occipital condyle. 3. Paramastoid process. 4. External auditory meatus. 5. Process at angle of mandible. 6. Mental foramen. 7. Nasal process of premaxilla. 8. Nasal bone. 9. Maxilla. 10. Lacrimal bone. 11. Malar bone. 12. Frontal bone. 13. Supraorbital process of frontal bone. 14. Coronoid process. 15. Condyle. 16. Parietal bone. 17. Body of squamous temporal bone.

of the frontal bone is almost equal to the distance between the latter point and the anterior extremity of the premaxilla, whereas in the cat the ratio of the first of these measurements to the second is as 3 is to 1. The dorsal aspect of the cat's skull forms an almost regular curve, the nasal bone having a slight upward convexity continuous with that of the frontal. The temporal fossa, as in other carnivorous animals, is large. The orbital margin is incomplete postero-laterally, but the supraorbital process is better developed than in the dog. The orbit is relatively much larger than in any of the other domestic animals, and, as in the dog, its axis is directed well forwards. The cranial cavity is relatively capacious, and it has a large osseous tentorium cerebelli which belongs to the parietal bones. The auditory bullae are still larger than in the dog. The bony palate is of small size, and its length is equalled by its transverse measurement at its posterior part. Less than one-third of its median suture belongs to the maxillary bones. The ramus of the lower jaw is only slightly curved and is shorter than in the dog. As in the latter animal, the coronoid process is of great size, and the angle carries a muscular process.

CHAPTER V

THE SKELETON OF THE FORE LIMB

IN the fore limb of a horse or other quadruped we recognise four regions or segments, viz. (1) the shoulder, (2) the arm or brachium, (3) the forearm or antebrachium, and (4) the fore foot or manus.

The skeleton of the shoulder of the horse is formed by a single bone—the **scapula.** In man, the cat, and some other animals, a second bone—the **clavicle**—is present. The skeleton of the arm is invariably formed by a single bone—the **humerus.** The forearm, on the other hand, includes two bones—the **radius** and the **ulna.** The manus has a much more complex skeleton than any of the other segments of the limb. It comprises three sets of bones, viz. (1) a group of short bones termed the **carpus,** (2) a number of approximately parallel long bones, termed the **metacarpus,** and (3) the **phalanges,** or skeleton of the digit.

THE BONES OF THE FORE LIMB OF THE HORSE

The Scapula

The scapula, or shoulder blade, belongs to the class of flat bones. It occupies a movable position on the antero-lateral part of the thorax, and in the horse and other animals destitute of a clavicle it is connected to the axial skeleton by muscles only. The entire bone is somewhat triangular in outline, and its long axis is directed obliquely downwards and forwards. It may be described as possessing two surfaces, three borders, and three angles.

The *lateral surface,* widest above, is traversed lengthways by a prominent ridge of bone known as the **spine.** This ridge attains its greatest height and prominence a little above its middle, where it carries a rough **tubercle** for the attachment of the trapezius muscle. Above the tubercle the spine gradually subsides in extending to the upper border of the bone. Below the tubercle the ridge has a blunt rough edge, and it terminates a few inches above the lower angle of the bone. This gradual subsidence of the spine is a notable feature of the scapula of the horse, for in many animals a larger or smaller process, known as the **acromion,** prolongs the spine at its lower extremity.

The spine partitions this surface into two unequal divisions, which, from their being slightly hollowed out, are known as fossae. The division in front of the spine is termed the supraspinous fossa, while that behind it is the infraspinous fossa. The area of the first of these is about half that of the other. The **supraspinous fossa** is comparatively smooth, and occupied by the supraspinatus muscle. Just below the lower end of the spine it shows some faint transverse

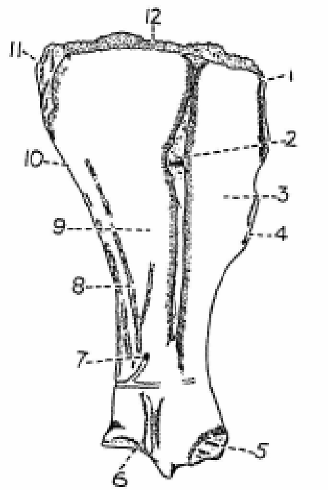


FIG. 75.—RIGHT SCAPULA OF HORSE (LATERAL ASPECT)

1. Anterior angle. 2. Tubercle of spine. 3. Supraspinous fossa. 4. Coracoid border. 5. Coracoid process. 6. Glenoid cavity. 7. Nutrient foramen. 8. Ridges for attachment of teres minor. 9. Infraspinous fossa. 10. Glenoid border. 11. Posterior angle. 12. Vertebral border.

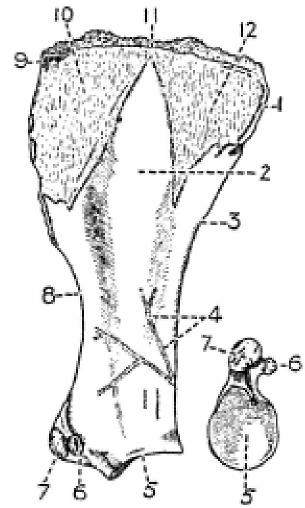


FIG. 76.—RIGHT SCAPULA OF HORSE (MEDIAL ASPECT, WITH VIEW OF INFERIOR EXTREMITY)

1. Posterior angle. 2. Subscapular fossa. 3. Glenoid border. 4. Impressions for branches of subscapular vessels. 5. Glenoid cavity. 6. Coracoid process proper. 7. Coracoid process. 8. Coracoid border. 9. Anterior angle. 10. Rough area for levator scapulae and serratus magnus. 11. Vertebral border. 12. Rough area for serratus magnus.

grooves, which are the impresses left by blood-vessels. The **infraspinous fossa** is also for the most part smooth. It shows, however, some vascular impressions, and near the posterior border and towards its lower end some slight muscular ridges. The **nutrient foramen** of the scapula is found in the inferior third of this fossa, about opposite the lower end of the spine. The infraspinous fossa lodges the infraspinatus and teres minor muscles, the rough lines previously mentioned marking the attachment of the last-named muscle.

The *medial surface* of the scapula is similar to the lateral in extent and outline. Its lower two-thirds is taken up entirely in forming the shallow **subscapular fossa,** which lodges the subscapularis muscle. At its upper end this fossa extends with a tapering point to near the upper border of the bone. In front of this prolongation of the fossa there is an extensive rough area, on which the levator scapulae and serratus magnus muscles are inserted, and behind the prolongation there is another somewhat similar area for the attachment of the last-named muscle. The subscapular fossa shows in its lower half a number of branching vascular impressions, which mark the course of branches of the subscapular vessels.

The *anterior border* of the bone is also appropriately termed the *coracoid border,* since it is terminated inferiorly by the coracoid process. In its upper half this border is convex, blunt and rough, but in its lower half it is thin, smooth and concave.

The *posterior border,* also called the *glenoid border* because it conducts at its lower end to the glenoid cavity, is slightly concave. At its extreme upper part it is thick and tuberous, in its middle third it is thin and slightly grooved, whilst in its lower third it is again thick and slightly roughened. The large head of the triceps brachii takes origin from this border.

The *superior* or *vertebral border* carries the **scapular cartilage of prolongation.** This is a thin flexible plate of cartilage representing a persistent or unossified part of the foetal cartilaginous scapula. The cartilage is smooth and convex on its upper free edge, and posteriorly it forms a rounded projection which extends beyond the line of the posterior border of the scapula. The medial surface of the cartilage gives attachment to the rhomboideus muscle.

The *anterior* or *cervical angle,* which separates the upper and anterior borders, is comparatively thin.

The *posterior angle* is that which separates the superior from the posterior border. It is thick and tuberous, and from it arise the deltoid and teres major muscles.

The remaining angle is the *inferior* or *articular angle.* It carries the glenoid cavity and the coracoid process. The **glenoid cavity** is a shallow, oval, articular depression, which meets the head of the humerus in the shoulder joint. A little beyond the rim of the cavity the capsular ligament of the joint is attached. Antero-medially the cavity shows a deep notch which accommodates part of the synovial membrane of the joint, and at the diagonally opposite point the rim carries laterally a small blunt tubercle from which some of the fibres of the teres minor arise. A very faint constriction, or **neck,** encircles the bone immediately above the glenoid cavity. The **coracoid process** lies at the anterior part of the lower angle of the scapula and has the form of an obtuse rough eminence with a projecting tubercle, the **coracoid process proper,** on its medial aspect. This latter is probably the homologue of the coracoid bone of the fowl and lower vertebrates. The coraco-brachialis takes origin from this projection, and the remainder of the process gives origin to the biceps brachii muscle. A broad well-defined groove separates the coracoid process from the glenoid cavity on the medial aspect of the bone.

The Humerus

The humerus, which belongs to the class of long bones, occupies an oblique position in the limb, its long axis being directed downwards and backwards between the shoulder and elbow joints. It possesses a shaft and two extremities.

The *shaft* may be described as possessing four surfaces.

The *anterior surface* is widest above, and narrowest towards its lower end. It is for the most part smooth and covered by the biceps brachii muscle, but in its middle and lower thirds it carries some rough lines medially marking the attachment of the coraco-brachialis muscle.

The *medial surface* is rounded from side to side, and blended with the anterior and posterior surfaces. About the junction of its upper and its middle third it bears a rough, slightly projecting area for the attachment of the tendons of the latissimus dorsi and teres major muscles, and hence sometimes termed the **teres tuberosity.** Lower down, in the inferior third of this surface, is the **nutrient foramen** of the bone.

The *posterior surface* is smooth, convex in the cross direction, and blended with the medial and lateral surfaces.

The *lateral surface* is largely occupied by the **spiral groove.** At its upper end this groove encroaches on the posterior surface, and, after a spiral course downwards and forwards, it terminates towards the front of the lower end of the shaft. It lodges the brachialis muscle. From the anterior surface the groove is separated by a ridge which extends upwards from a little above the coronoid fossa. This ridge affords insertion to the brachio cephalicus[1] and the anterior superficial pectoral muscles. At its most prominent point, a little above the middle of the shaft, it carries a massive projection which gives attachment to the deltoid muscle, and which is therefore termed the **deltoid tuberosity.** Immediately above this tuberosity, and almost blended with it, is a nodule for the insertion of the teres minor muscle. From this nodule a curved line, limiting here the spiral groove, and giving origin to the lateral head of the triceps brachii muscle, extends upwards and backwards towards the articular head.

[1] Or mastoido-humeralis.

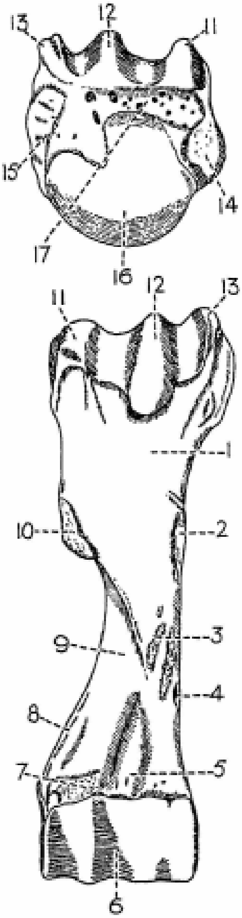


FIG. 77.—RIGHT HUMERUS OF HORSE (ANTERIOR ASPECT, WITH VIEW OF SUPERIOR EXTREMITY)

1. Anterior surface of shaft. 2. Teres tuberosity. 3. Rough lines for attachment of coraco-brachialis. 4. Nutrient foramen. 5. Coronoid fossa. 6. Lower articular surface. 7. Pit for origin of extensor carpi radialis and extensor pedis. 8. Area on lateral epicondyle for origin of extensor carpi radialis. 9. Spiral groove. 10. Deltoid tuberosity. 11. Summit of lateral tuberosity. 12. Ridge dividing bicipital groove. 13. Anterior division of medial tuberosity. 14. Convexity of lateral tuberosity. 15. Posterior division of medial tuberosity. 16. Head. 17. Area between bicipital groove and head perforated by foramina.

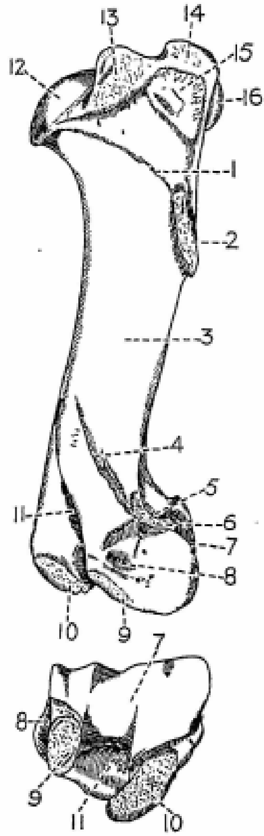


FIG. 78.—RIGHT HUMERUS OF HORSE (LATERAL ASPECT, WITH VIEW OF INFERIOR EXTREMITY)

1. Curved line for origin of lateral head of triceps brachii. 2. Deltoid tuberosity. 3. Spiral groove. 4. Area on lateral epicondyle for origin of extensor carpi radialis. 5 Coronoid fossa. 6. Pit for origin of extensor carpi radialis and extensor pedis. 7. Lower articular surface. 8. Pit for attachment of lateral collateral ligament of elbow joint. 9. Area for origin of flexor carpi lateralis. 10. Area for origin of flexor carpi radialis, flexor carpi ulnaris and flexors of digit. 11. Olecranon fossa. 12. Head. 13-14. Convexity and summit of lateral tuberosity. 15. Area for insertion of superficial tendon of infraspinatus. 16. Ridge dividing bicipital groove.

The *superior extremity* of the humerus is compounded of the head, the lateral and medial tuberosities, and the bicipital groove.

The **head** is an extensive, slightly convex, nearly circular articular surface, which forms the posterior part of the upper extremity. It is opposed to the glenoid cavity of the scapula in the shoulder joint, and it is surrounded by a well-defined edge. Beneath the head posteriorly there is a constriction and this portion of the bone is referred to as the **neck.**

The **lateral** or **greater tuberosity** is a massive process placed at the antero-lateral part of the upper extremity. It is composed of two divisions, termed respectively the summit and the convexity. The **summit** lies anteriorly. It forms the lateral boundary of the bicipital groove, and gives attachment to the lateral tendon of the supraspinatus muscle. The **convexity,** which lies immediately lateral to the articular head, gives attachment on its deep face to the deep tendon of the infraspinatus muscle. Its lateral surface is smooth and covered by fibro-cartilage for the play over it of the superficial tendon of the infraspinatus muscle. This latter tendon obtains insertion into a rough oval mark between the summit and the deltoid tuberosity.

The **medial** or **lesser tuberosity** is placed opposite to the lateral. It comprises an anterior and a posterior division. The anterior division forms the medial boundary of the bicipital groove, and it gives attachment at its highest point to the medial tendon of the supraspinatus, while on its medial aspect the posterior deep pectoral muscle is inserted into it. The posterior division lies to the medial side of the articular head, and gives insertion to the tendon of the subscapularis muscle.

The **bicipital groove** is so named because the upper tendon of the biceps brachii muscle plays over it. It is placed at the front of the upper extremity of the humerus, between the medial and lateral tuberosities. A prominent ridge divides it into two channels, the more lateral of which is slightly the larger, and the entire surface is covered by cartilage to facilitate the play of the biceps brachii tendon. Behind the bicipital groove and in front of the articular head there is an area of bone showing a number of foramina for the passage of vessels belonging to the spongy tissue of the bone.

The *lower extremity* of the humerus carries two condyles united together to form a pulley-like, or trochlear, surface for articulating with the bones of the forearm, together with two epicondyles, and two pits, the olecranon and coronoid fossae.

The **medial condyle,** separated from the lateral by an obtuse articular ridge passing from front to back, is traversed immediately medial to this ridge by a sagittal groove. The groove begins in front at the upper limit of the articular surface, and after turning around the lower aspect of the surface gains the olecranon fossa at the back of the bone. The greater part of this surface articulates with the radius, but its posterior prolongation towards the olecranon fossa articulates with the ulna. The **lateral condyle,** much the smaller, is faintly grooved like a pulley. It articulates with the radius.

The epicondyles have the form of thick ridges lying behind and above the condyles. The **medial epicondyle** shows an extensive rough area inferiorly for the origin of the flexor carpi radialis,[1] flexor carpi ulnaris [2] and the flexors of the digit. It carries medially a small tubercle for the attachment of the medial collateral ligament of the elbow joint. The **lateral epicondyle** has a sharp anterior edge which forms here the lateral boundary of the spiral groove, and gives origin to the extensor carpi radialis.[3] At its lowest point the lateral epicondyle shows a rough area, similar to but rather smaller than that of the medial epicondyle, for the origin of the flexor carpi lateralis.[4] Laterally the epicondyle carries a deep pit for the attachment of the lateral collateral ligament of the elbow joint.

The **coronoid fossa** is a well-marked pit situated on the anterior aspect of the lower extremity, immediately above the articular surface. The fossa receives the coronoid process of the radius in extreme flexion of the elbow joint. Laterally to this fossa there is a smaller rough pit which affords a common origin to the extensor carpi radialis and extensor pedis [5] muscles.

The **olecranon fossa** is much deeper than the coronoid fossa. It lies at the back of the lower extremity of the bone, being bounded by the two epicondyles. The olecranon fossa receives the beak of the olecranon of the ulna during complete extension of the elbow joint.

The Radius

In the adult horse the bones of the forearm, the radius and the ulna, are rigidly united by ossification of the ligamentous fibres which bind them together in the young animal, and they thus form what would popularly be regarded as a single bone. The radius, which is much the larger of the two, is a long bone, slightly curved in its length, and extending in a nearly vertical direction from the elbow joint above to the carpus below. It possesses a shaft and two extremities.

[1] Or flexor metacarpi internus.
[2] Or flexor metacarpi medius.
[3] Or extensor metacarpi magnus.
[4] Or flexor metacarpi externus, or ulnaris lateralis.
[5] Or extensor digitorum communis.

The *shaft* of the radius, which is slightly curved in its length, with the convexity forwards, is flattened from before to behind, so as to present an anterior and a posterior surface separated on either side by rounded ill-defined borders.

The *anterior surface,* slightly convex in its length and markedly so in the cross direction, is for the most part smooth and covered by the extensor muscles of the carpus and digit.

The *posterior surface,* slightly concave in its length, is nearly flat from side to side. In its lower third and towards the medial border there is a rough elevation for the attachment of the supracarpal check band of the superficial flexor muscle of the digit. Above this, and extending upwards near the lateral border, there is an elongated triangular area with the point below. To this area the ulna is united by short ligamentous fibres in the young animal, which undergo ossification in the adult. Superiorly, a few inches below the upper end of the bone, this area is limited by a smooth transverse depression forming the anterior boundary of the **radio-ulnar interosseous space,** through which the interosseous vessels of the forearm are transmitted. The **nutrient foramen** of the bone is placed at the lower limit of this smooth surface. Above the interosseous space the posterior surface is rough and irregular in its lateral half. Here the radius and ulna are united by interposed ligamentous fibres which only in the very old animal become ossified.

The *medial border* is thick, and for the greater part it lies subcutaneously. A few inches below the upper extremity it shows a rough imprint for the attachment of the long superficial division of the medial collateral ligament of the elbow joint. Immediately above this a smooth groove passes horizontally across the border. The groove accommodates the brachialis tendon of insertion which becomes attached to a roughened area near the posterior surface.

The *lateral border* is rather more roughened than the medial. It is covered by the lateral extensor muscle of the digit.[1]

The *upper extremity* of the radius carries an articular surface that is like the mould or impression of the lower articular surface of the humerus. A well-defined edge encircles the articular surface, and at the middle of its anterior half it carries a slight projection, the **coronoid process.** Behind the main articular surface, and looking backwards there are two small facets which form synovial joints with like facets on the ulna. At either extremity of its transverse axis the upper end of the radius is prominent and rough for ligamentous and muscular attachment. Towards the medial side of the anterior surface at this extremity there is a rough round eminence, the **bicipital tuberosity,** into which the biceps brachii muscle is inserted.

[1] Or extensor suffraginis muscle.

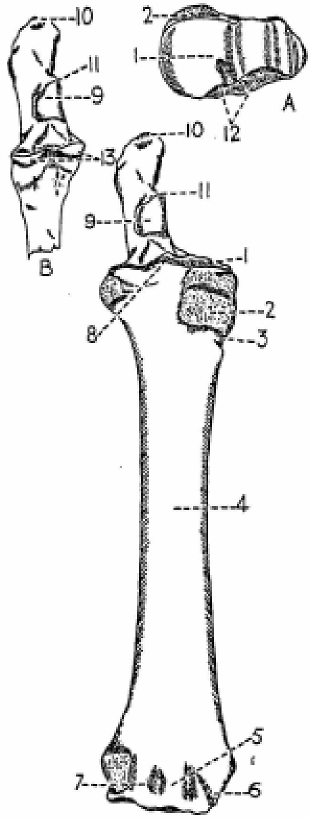


FIG. 79.—RIGHT RADIUS AND ULNA OF HORSE (ANTERIOR VIEW, WITH A. VIEW OF SUPERIOR EXTREMITY OF RADIUS, AND B. VIEW OF SUPERIOR EXTREMITY OF ULNA)

1. Upper articular surface of radius. 2. Bicipital tuberosity. 3. Groove for accommodation of brachialis tendon. 4. Anterior surface of shaft of radius. 5. Groove for tendon of extensor carpi radialis. 6. Groove for tendon of extensor carpi obliquus. 7. Groove for tendon of extensor pedis. 8. Coronoid process. 9. Trochlear notch. 10. Summit of olecranon. 11. Beak of olecranon. 12. Facets for articulation with ulna. 13. Facets for articulation with radius.

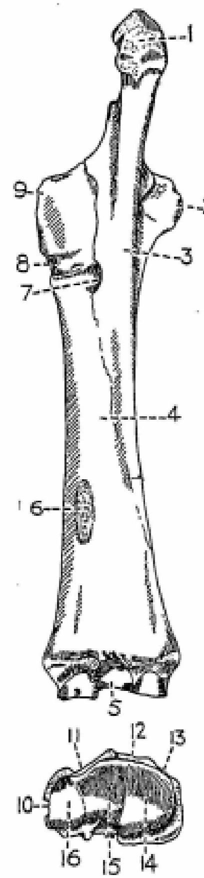


FIG. 80.—RIGHT RADIUS AND ULNA OF HORSE (POSTERIOR VIEW, WITH VIEW OF INFERIOR EXTREMITY OF RADIUS)

1. Summit of olecranon. 2. Roughening for ligamentous attachment. 3. Posterior border of shaft of ulna. 4. Posterior surface of shaft of radius. 5. Lower articular surface of radius. 6. Roughening for supracarpal check band of superficial flexor of digit. 7. Radio-ulnar interosseous space. 8. Groove for accommodation of brachialis tendon. 9. Roughening for ligamentous attachment. 10. Groove for tendon of lateral digital extensor. 11. Groove for tendon of extensor pedis. 12. Groove for tendon of extensor carpi radialis. 13. Groove for extensor carpi obliquus. 14. Area for articulation with scaphoid. 15. Area for articulation with lunate. 16. Area for articulation with cuneiform and accessory.

The *lower extremity* is furnished with an articular surface compounded of several facets for articulation with the upper row of carpal bones. At either extremity of its transverse diameter it carries a prominent rough tuberosity for ligamentous attachment. The lateral tuberosity has a vertical groove for the tendon of the lateral digital extensor muscle. On the anterior aspect of the bone, immediately above the articular surface, there are three distinct grooves. The medial groove is the smallest, and it is directed obliquely downwards and medially. It lodges the tendon of the extensor carpi obliquus.[1] The middle groove is wide, and vertical in its direction, and it gives passage to the tendon of the extensor carpi radialis. The lateral groove resembles in size and direction the middle one, and it lodges the tendon of the extensor pedis. At the back of the lower extremity, immediately above the articular surface, the bone shows a depressed area overhung by a rough ridge for ligamentous attachment.

The Ulna

One of the most remarkable features of the skeleton of the horse is the relatively small size of the ulna. In the human subject, for example, and in many other animals, the ulna is the larger of the two bones of the forearm, extending from the point of the elbow to the wrist or carpus. In man, moreover, the radius and ulna remain movable upon one another throughout life. In the horse, on the other hand, the ulna is a comparatively diminutive bone, rigidly fixed in adult life to the upper half of the radius. The ulna of the horse is in reality a long bone whose development has been arrested. It may be described as possessing a shaft and two extremities.

The *shaft* is a three-sided piece of bone, tapering towards its lowest point.

The *anterior surface* of the shaft is opposed to the lateral part of the posterior surface of the radius. It presents, a little below its upper end, a smooth portion forming the posterior boundary of the **radio-ulnar interosseous space** where a **nutrient foramen** leading to the small medullary cavity can usually be found. Above and below the space this surface is rough, and united to the radius by ligament. As already stated, however, the ligamentous fibres below the interosseous space are invariably ossified in the adult, but it is only in late life that ossification invades the fibres uniting the bones above the space.

The *medial* and *lateral surfaces* are smooth and related to the

[1] Or abductor pollicis longus.

fleshy mass of the flexor muscles of the digit. The medial surface is the more extensive of the two.

The *medial* and *lateral borders* are sharp and well-defined. The *posterior border* is smooth, rounded from side to side and slightly concave in its length.

The *upper extremity* is made up of the olecranon and the trochlear notch.

The **olecranon** is a massive piece of bone, surpassing in weight all the rest of the ulna. It presents a lateral convex and a medial concave surface, a thick, round and nearly straight posterior border, and an anterior border which is concave and sharper. The latter border terminates below in a projecting **beak** which overhangs the trochlear notch, and which during extreme extension of the elbow joint passes into the olecranon fossa of the humerus. The **summit** of the olecranon forms the point of the elbow. It has the form of a rough tuberosity, and it gives insertion to the triceps brachii muscle.

The **trochlear notch** is a semicircular outcut situated below the anterior border of the olecranon, and above the anterior surface of the body. It is for the most part smooth for articulation with the lower extremity of the humerus. Immediately below the notch, and placed at the upper limit of the anterior surface of the body, there are two small facets which form synovial joints with similar facets already described on the radius.

The *inferior extremity* of the ulna reaches to the lower third of the radius where it terminates by a sharp point or by a minute nodular enlargement, but the lateral tuberosity situated at the lower extremity of the radius, which ossifies from a separate centre, should be regarded as the lower end of the ulna.

The Carpus

The bones of the carpus together constitute the first segment of the manus. In the horse they are at the most eight in number, but in the majority of cases only seven are present. They are arranged in two rows or tiers, and all of them belong to the class of short bones. The names and relative positions of the bones in each row are shown below, the left side of the page corresponding to the medial side of the limb:

Upper row—**scaphoid** (radial carpal bone), **lunate** (intermediate carpal bone), **cuneiform** (ulnar carpal bone) and **accessory** (pisiform).

Lower row—**trapezium, trapezoid, magnum** and **unciform.** These bones are sometimes referred to as the first, second, third and fourth carpal bones, respectively. The bone which is inconstantly present is the trapezium, the most medial bone of the lower row.

The Scaphoid[1]

Also termed the **radial carpal bone,** this is the largest bone of the upper row, and it is also the most regularly six-sided of all the bones of the carpus. The *superior surface* of the bone is smooth

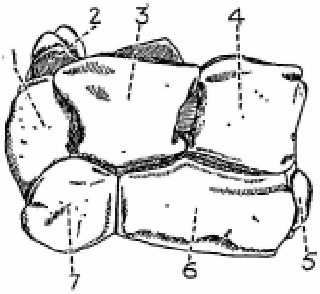


FIG. 81.—RIGHT CARPUS OF HORSE (ANTERIOR VIEW)
1. Cuneiform. 2. Accessory. 3. Lunate. 4. Scaphoid. 5. Trapezoid. 6. Magnum. 7. Unciform.

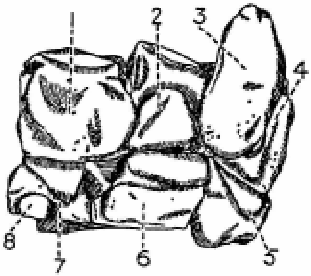


FIG. 82.—RIGHT CARPUS OF HORSE (POSTERIOR VIEW)
1. Scaphoid. 2. Lunate. 3. Accessory. 4. Cuneiform. 5. Unciform. 6. Magnum. 7. Trapezoid. 8. Trapezium.

and articular and it responds entirely to the radius, being convex in front and concave behind. The *inferior surface,* recognised by its smoothness as being also entirely articular, is convex in its anterior half, and cupped in its posterior half. It responds to the magnum and trapezoid. The *lateral surface* presents anteriorly two articular facets for the lunate. For the remainder of its extent it is non-articular, and irregularly excavated for the attachment of an inter-osseous ligament. The remaining three surfaces, *anterior, medial* and *posterior,* are non-articular.

The scaphoid articulates with four bones, viz. the radius, lunate, trapezoid, and magnum.

The Lunate

This bone is also known as the **intermediate carpal bone,** and in point of size it is the second bone of the upper row. It may be recognised by its wedge shape. Its *superior surface* is smooth and carries a convex area in front and a concavity behind, both of which articulate with a corresponding area at the lower end of the radius.

[1] Formerly called the navicular bone in human anatomy.

The *inferior surface*, also smooth and articular, is slightly convex in front and concave behind. It articulates with the magnum and unciform. The *medial* and *lateral surfaces* present two facets each, the remainder of these surfaces being depressed and rough for the attachment of interosseous ligaments. The facets on the medial surface respond to similar facets on the scaphoid, while those on the lateral surface play the same part with regard to the cuneiform. The *anterior surface*, which is slightly convex, rough and non-articular, forms the base of the wedge. The *posterior surface*, which represents the apex of the wedge, is rounded and non-articular.

The lunate articulates with five bones, viz. the radius, scaphoid, cuneiform, magnum, and unciform.

The Cuneiform [1]

This, the smallest bone of the upper row, is also known as the **ulnar carpal bone.** It may be distinguished from all the other bones of the carpus by the shallow cup-like shape of its *superior surface*, which is smooth for articulation with the radius. The *inferior surface*, entirely articular, lies obliquely and responds to the unciform. The *medial surface* possesses two facets for articulation with the lunate. The *anterior* and *lateral surfaces* are blended. They are rough and non-articular. The *posterior surface* is almost entirely articular, being in the shape of a vertically elongated, slightly concave facet for articulation with the accessory bone.

The cuneiform articulates with four bones, viz. the radius, lunate, unciform, and accessory.

The Accessory [2]

This bone is distinctly flattened and four-sided in shape, and by that character it can be easily distinguished from the other bones of the carpus. Functionally it differs from the other members of the upper row in that it is not a weight-bearing bone. Projecting backwards from the lateral aspect of the carpus it affords increased leverage to the flexor carpi ulnaris and flexor carpi lateralis, and may therefore be regarded as a sesamoid bone to the tendons of these muscles. The bone may be described as possessing two surfaces and four borders. The *medial surface* is concave, and it forms part of the lateral boundary of the carpal canal—the tubular passage through which the tendons of the flexors of the digits pass at the back of the knee. The *lateral surface* is slightly convex. It is crossed

[1] The triquetrum of human anatomy.
[2] The pisiform of human anatomy.

obliquely downwards and forwards by a furrow which lodges a tendon of the flexor carpi lateralis. The *anterior border* of the bone carries two facets, the lower of which is convex and oval for articulation with the cuneiform, while the upper, which is concave and circular, responds to the lower extremity of the radius. The *superior* and *posterior borders* are blended and roughened for the attachment

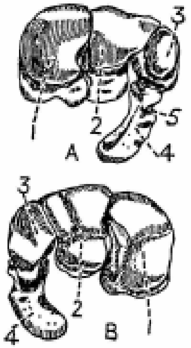


FIG. 83.—ARTICULAR SURFACES OF BONES OF UPPER ROW OF RIGHT CARPUS OF HORSE (A. VIEWED FROM ABOVE. B. VIEWED FROM BELOW)

1. Scaphoid. 2. Lunate. 3. Cuneiform. 4. Accessory. 5. Furrow for tendon of flexor carpi lateralis.

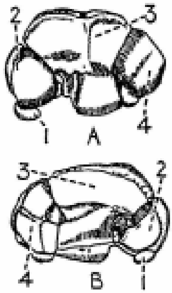


FIG. 84.—ARTICULAR SURFACES OF BONES OF LOWER ROW OF RIGHT CARPUS OF HORSE (A. VIEWED FROM ABOVE. B. VIEWED FROM BELOW)

1. Trapezium. 2. Trapezoid. 3. Magnum. 4. Unciform.

of the previously mentioned tendons of the flexors of the carpus. The *inferior border,* also rough, gives attachment to strong ligaments binding the bone to the unciform and the lateral small metacarpal bone.

The accessory bone articulates with two bones, viz. the radius and the cuneiform.

The Trapezium

When present this bone, which is also termed the **first carpal bone,** is of small dimensions, and lies at the back of the trapezoid. It is rounded in form, and occasionally double the size of the common pea, though generally it is much smaller. It may articulate with the back of the trapezoid, or the upper extremity of the adjacent metacarpal bones, but usually it is completely enclosed in the lower part of the medial ligament of the carpus.

The Trapezoid

When the trapezium is absent, this bone, which is also known as the **second carpal bone,** is the smallest of the bones of the lower row. It more approaches the hemispherical in shape than any of the other bones of the carpus. The *superior surface* of the bone is convex, smooth and articular, and it is prolonged so as to encroach upon the medial surface. It articulates with the scaphoid. The *inferior surface,* also articular, is compounded of two facets, the anterior and larger of which is for the medial small metacarpal bone, while the other articulates with the large metacarpal. The *lateral surface* carries two or three facets for articulation with the magnum, and for the rest of its extent it is rough for the attachment of an interosseous ligament. The *anterior* and *medial surfaces* are blended so as to form one continuous convex surface. The *posterior surface* is encroached upon above by the superior articular surface. Below this it is roughened and depressed, but when the trapezium is present it may bear a small facet for articulation with that bone.

The trapezoid articulates with four or five bones, viz. the scaphoid, trapezium (inconstantly), magnum, large metacarpal and medial small metacarpal.

The Magnum [1]

Sometimes termed the **third carpal bone,** this bone greatly exceeds in size any of the other bones of the lower row. The scaphoid exceeds it in weight, but the magnum is readily distinguished from that bone by its greater breadth. Its *superior surface* is compounded of two articular facets separated by a slight ridge. The medial facet articulates with the scaphoid, the lateral with the lunate. The *inferior surface* is also entirely articular, and, with the exception of a small bevelled facet antero-medially, it is entirely taken up in articulating with the large metacarpal bone. The small bevelled facet is for the medial small metacarpal bone. The *medial surface* carries two or three small facets for the trapezoid, and for the rest of its extent it is depressed and rough for the attachment of an interosseous ligament. The *lateral surface* is similar to the preceding, but is less extensive. It bears two facets for the unciform. The *anterior surface* is extensive, convex and non-articular. The *posterior surface,* also non-articular, is narrow and rounded.

The magnum articulates with six bones, viz. the scaphoid, lunate, trapezoid, unciform, large metacarpal and medial small metacarpal.

The Unciform [2]

The unciform, or **fourth carpal bone,** is not unlike the trapezoid in general form. It may, however, be distinguished from that bone

[1] The capitate of human anatomy. [2] The hamate of human anatomy.

(of the opposite limb) by its greater size, and by the roughened convexity of the nodule[1] on its posterior surface. Its *superior surface* is smooth, convex and prolonged laterally so as to encroach on the lateral surface. It articulates with the lunate and cuneiform bones. The *inferior surface* is compounded of two bevelled facets

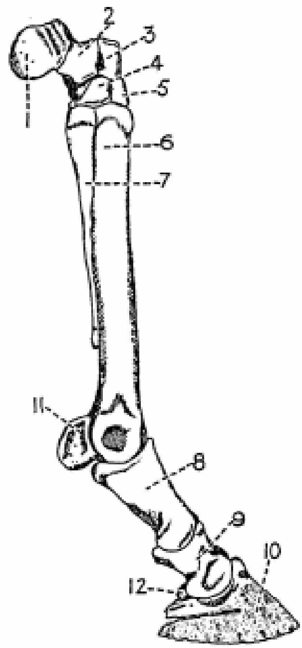


FIG. 85.—RIGHT MANUS OF HORSE (LATERAL VIEW)

1. Accessory. 2. Cuneiform. 3. Lunate. 4. Unciform. 5. Magnum. 6. Large metacarpal bone. 7. Lateral small metacarpal bone. 8. First phalanx. 9. Second phalanx. 10. Third phalanx. 11. Metacarpo-phalangeal sesamoid bone. 12. Navicular bone.

separated by a slight ridge. The more medial of these articulates with the large metacarpal, while the other responds to the lateral small metacarpal. The *medial surface* carries two facets for the magnum, the intervening area affording attachment to an interosseous ligament. The *anterior surface* is slightly convex and non-articular. The *lateral surface* is of small extent, being encroached upon above by the superior articular surface. Below this it is continuous with the anterior surface. The *posterior surface* forms an obtuse nodular process, smooth and articular medially and below, but roughened laterally for ligamentous attachment.

The unciform articulates with five bones, viz. the lunate, cuneiform, magnum, large metacarpal and lateral small metacarpal bones.

[1] The nodule is regarded by some as the homologue of the fifth carpal bone present in some species.

The Metacarpus

The second segment of the manus is the metacarpus, the skeleton of which comprises the metacarpal bones. In this region it is convenient to include also the metacarpo-phalangeal sesamoid bones, small bones situated, as their name implies, at the junction of the metacarpus with the digital region. In the typical mammalian manus five metacarpal bones are present, one for each digit, as is the case with the human hand or the fore foot of the dog, and named from the most medial to the most lateral, the first, second, third, fourth and fifth metacarpal bones. The metacarpus of the horse, however, exhibits a marked departure from the typical plan. Two of the five metacarpal bones, the first and the fifth, with their digits are entirely suppressed. Of the remaining three, only one, the third is present in a fully developed condition and carries a digit, the second and fourth being small slender bones, unprovided with digits, and placed one on each side of the main bone. The last mentioned bone is termed the **large metacarpal bone,** the two vestigial bones being known as the **lateral** and **medial small metacarpal bones.**

The Large Metacarpal Bone

This, the **third metacarpal bone,** is a long bone, and it occupies a nearly vertical position between the carpus above and the fetlock joint below. Like other long bones it possesses a shaft and two extremities.

The *shaft* is slender having regard to the great weight that it has to support, but in compensation for this it is largely composed of compact tissue. It is semicylindrical in shape, and may be described as possessing two surfaces and two borders.

The *anterior surface* is convex and smoothly rounded from side to side.

The *posterior surface* is comparatively flat, and with the small metacarpal bones on either side it forms a shallow wide channel for the superior sesamoidean ligament of the fetlock joint. This channel is for the most part smooth, but close to its upper end it is slightly roughened for the attachment of the before-mentioned ligament. Towards the junction of its upper and middle thirds it shows the **nutrient foramen** of the bone. On either side, beginning a little above the middle of the bone and extending upwards to the superior extremity, there is a narrow rough surface to which the small metacarpal bone is articulated.

The *borders, medial* and *lateral,* are smooth, slightly concave in the vertical direction, and rounded from side to side.

The *upper extremity* carries an articular surface for the lower row of carpal bones. About three-fourths of this surface is for the

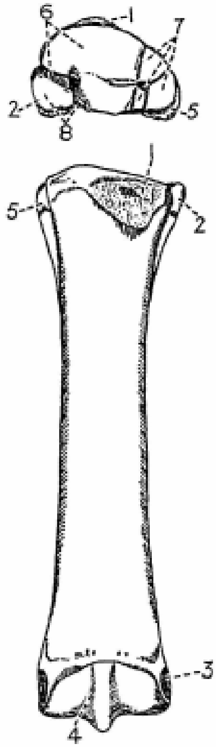


Fig. 86.—Right Metacarpal Bones of Horse (anterior view, with view of superior extremities)

1. Area for insertion of extensor carpi radialis tendon. 2. Upper extremity of medial small metacarpal bone. 3. Depression for ligamentous attachment. 4. Lower articular surface of large metacarpal bone. 5. Upper extremity of lateral small metacarpal bone. 6. Facets for magnum. 7. Facets for unciform. 8. Facets for trapezoid.

magnum, and one-fourth, in the form of two sloping facets situated laterally, one in front and one behind, articulates with the unciform. The facet for the trapezoid, which is small and sometimes absent altogether, is situated at the postero-medial part of the area for the magnum. At each side of the posterior aspect of the upper extremity, there are two small facets which form synovial joints with the heads of the small metacarpal bones. On the antero-medial aspect of this extremity, a rough projecting surface serves for the insertion of the extensor carpi radialis tendon.

The *lower extremity* carries an articular surface for the first phalanx and the metacarpo-phalangeal sesamoid bones. An antero-posterior ridge traverses this surface from front to back, and divides it into two pulley-like areas of which the more medial is slightly the larger. The sesamoid bones articulate with the extreme posterior part of this surface, and the first phalanx with the remainder. At either extremity of its transverse diameter, this end of the bone presents a depression for ligamentous attachment.

The Small Metacarpal Bones[1]

These bones, which represent the **second** and **fourth metacarpal bones** of pentadactyl species, are in reality rudimentary long bones.

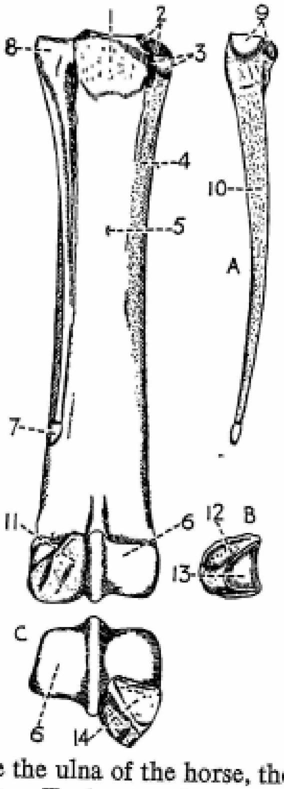


FIG. 87.—RIGHT METACARPAL BONES AND METACARPO-PHALANGEAL SESAMOID BONES OF HORSE (POSTERIOR VIEW, WITH A. ANTERIOR ASPECT OF LATERAL SMALL METACARPAL BONE, B. ANTERO-LATERAL ASPECT OF LATERAL METACARPO-PHALANGEAL SESAMOID BONE, AND C. VIEW OF INFERIOR EXTREMITY OF LARGE METACARPAL BONE AND BASE OF MEDIAL METACARPO-PHALANGEAL SESAMOID BONE)

1. Roughening for attachment of superior sesamoidean ligament. 2. Facets for unciform. 3. Facets for upper extremity of lateral small metacarpal bone. 4. Rough surface for attachment of lateral small metacarpal bone. 5. Nutrient foramen. 6. Lower articular surface of large metacarpal bone. 7. Lower extremity of medial small metacarpal bone. 8. Upper extremity of medial small metacarpal bone. 9. Facets on upper extremity of lateral small metacarpal bone for large metacarpal bone. 10. Roughening on anterior surface of lateral small metacarpal bone for attachment to large metacarpal bone. 11. Posterior surface of medial metacarpo-phalangeal sesamoid bone. 12-13. Abaxial and anterior surfaces of lateral metacarpo-phalangeal sesamoid bone. 14. Base of medial metacarpo-phalangeal sesamoid bone.

Like the ulna of the horse, they possess only a very small medullary cavity. Each may be described as possessing a shaft and two extremities.

The *shaft* is a three-sided slender rod of bone, tapering to its lower extremity. It is slightly curved in its length, with the concavity of the curve directed abaxially.

The *anterior surface* is comparatively flat and rough, except towards its lower part. The greater part of this surface is opposed to the back of the large metacarpal bone, and united to it by an

[1] Commonly known as "splint bones".

interosseous ligament. In animals beyond middle age, however, this ligament is often wholly or in part ossified. For an inch or two above its lower end this surface is free, and separated by a narrow interval from the back of the large bone.

The *abaxial surface* is smooth and slightly rounded from side to side.

The *axial surface* is the narrowest of the three. It helps to form the channel for the superior sesamoidean ligament of the fetlock joint with whose edge it is in contact.

The *upper extremity*, or **head**,[1] of each bone is relatively massive. Superiorly it carries an articular surface composed of a single facet in the case of the lateral, or fourth, bone, and compounded of two facets in the case of the medial, or second, bone. By this surface the lateral bone articulates with the unciform, and the medial with the trapezoid and magnum. On its anterior aspect the head bears two small facets which meet and form synovial joints with similar surfaces already described on the back of the upper end of the large metacarpal bone. On its abaxial aspect the head is rough for tendinous and ligamentous attachment.

The *lower extremity* forms a small nodular process referred to by the layman as the " button of the splint bone ". This normally stands out a little from the back of the large metacarpal, and may easily be felt in the living animal in the lower third of the metacarpus as a slightly flexible process.

The two small bones may be distinguished the one from the other by the following characteristics: the medial bone is generally the larger of the two, both in volume and in length; the articular surface of the proximal end is formed by a single facet in the case of the lateral bone, but it is compounded of two facets in the case of the medial bone. It should be noted, too, that whilst the head of the lateral bone has always two facets for articulation with the large metacarpal, the medial bone has sometimes only one such facet.

The Metacarpo-Phalangeal Sesamoid Bones

These small bones, often termed the **proximal sesamoid bones** in contradistinction to the distal sesamoid bone which lies at the second interphalangeal joint, are placed behind the lower extremity of the large metacarpal bone. There are two in each limb, and they are developed in that position for the purpose of affording increased leverage to the flexor muscles of the digit. They belong to the class of short bones, and each has the form of a three-sided pyramid.

[1] Note that in human anatomy the head is the distal extremity of a metacarpal bone.

The *anterior surface* is smooth and articular. It is concave in the vertical and convex in the transverse direction, and it articulates with one half of the posterior part of the lower articular surface of the large metacarpal bone.

The *posterior* or *axial surface*, slightly convex in both directions, is comparatively smooth. In the recent state this surface is covered by a layer of fibro-cartilage, and with the corresponding surface of the opposite sesamoid bone it forms a pulley-like groove for the gliding of the tendon of the deep flexor digit.

The *abaxial surface* is depressed for the attachment of most of the fibres of the superior sesamoidean ligament. It is the narrowest of the three surfaces.

The *apex* of the pyramid is directed upwards, and the *base* downwards, the latter affording attachment to the inferior sesamoidean ligaments.

The Digit

The digital region is the terminal segment of the manus. In its most complete degree of development the mammalian manus comprises five digits, as is exemplified in the thumb and four fingers of the human hand. As in the case of the metacarpal bones, these five digits are distinguished by the numerals one to five, the most medial digit being the first, and the most lateral the fifth. Another set of designations is also applied to the digits, the first being called the pollex, the second the index, the third the digitus medius, the fourth the digitus annularis, and the fifth the digitus minimus.

The horse possesses but one digit—the medius—corresponding to the middle finger of the human hand. The skeleton of this digit comprises three main bones, termed the phalanges, and a small sesamoid bone, commonly called the navicular bone.

The First Phalanx [1]

This bone belongs to the class of long bones, and it occupies an oblique position in the limb, being directed downwards and forwards from the fetlock or metacarpo-phalangeal joint above to the pastern or first interphalangeal joint below. The degree of inclination varies very considerably in different horses. When the slope is excessive, undue strain is thrown upon the tendons and ligaments at the back of the limb; and when, on the other hand, the bone is nearly upright, almost the entire weight of the animal is thrown upon the bones of the digit. The first phalanx has a four-sided shaft and two extremities.

[1] Formerly termed the os suffraginis.

The *anterior surface* of the shaft is comparatively smooth, and slightly rounded from side to side. Near the upper extremity it may show a rough area for the attachment of the tendon of the lateral digital extensor muscle.

The *medial* and *lateral surfaces,* also rounded, pass insensibly on either side into the anterior surface. Sometimes each exhibits

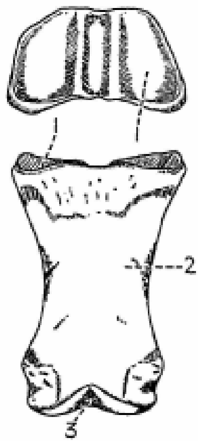


FIG. 88.—RIGHT FIRST PHALANX OF HORSE (ANTERIOR ASPECT, WITH VIEW OF SUPERIOR EXTREMITY)

1. Lateral articular cavity of upper extremity. 2. Anterior surface of shaft. 3. Groove dividing lower articular surface.

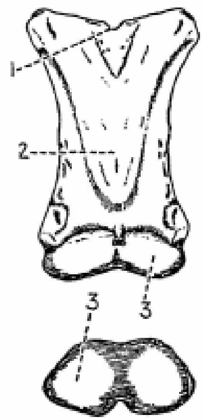


FIG. 89.—RIGHT FIRST PHALANX OF HORSE (POSTERIOR ASPECT, WITH VIEW OF INFERIOR EXTREMITY)

1. Posterior part of groove dividing upper extremity. 2. V-shaped area on posterior surface of shaft. 3. Lateral division of lower articular surface.

about its centre a vascular impression left by the perpendicular artery of the pastern.[1]

The *posterior surface* is flattened, and in its upper two-thirds it carries a V-shaped area, which marks the attachment of the middle division of the inferior sesamoidean ligament.

The *medial* and *lateral borders* (which separate the posterior from the medial and lateral surfaces) are rough in their lower halves for ligamentous attachment.

The *upper extremity* of the bone carries an articular surface that is like the mould or impress of the lower extremity of the large metacarpal bone with which it articulates. It shows a deep antero-posterior groove, and on each side of the groove a shallow articular cavity, the medial being slightly more extensive than the lateral. The entire articular surface is somewhat four-sided in outline, and its posterior corners are supported by buttress-like tubercles of bone, which at the same time serve for the attachment of ligaments.

[1] Or artery of the first phalanx.

The *lower extremity* carries an articular surface to meet the second phalanx in the first interphalangeal joint. A shallow ill-defined groove traverses this surface from front to back, and divides it into two slightly convex areas, the medial of which is somewhat larger than the lateral. At either side of the lower extremity of the bone there is a shallow oblique groove surmounted by a tubercle, these serving for ligamentous attachment.

The Second Phalanx[1]

In the horse this bone does not possess a medullary cavity, and it is therefore classed with the short bones. The bone is placed

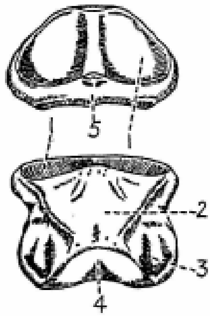


FIG. 90.—RIGHT SECOND PHALANX OF HORSE (ANTERIOR ASPECT, WITH VIEW OF SUPERIOR SURFACE)

1. Lateral articular cavity of upper surface. 2. Anterior surface. 3. Pit for ligamentous attachment. 4. Groove dividing lower surface. 5. Smooth area for attachment of fibro-cartilage.

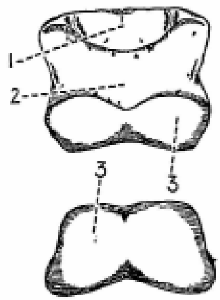


FIG. 91.—RIGHT SECOND PHALANX OF HORSE (POSTERIOR ASPECT, WITH VIEW OF INFERIOR SURFACE)

1. Smooth area for attachment of fibro-cartilage. 2. Posterior surface. 3. Lateral division of lower surface.

obliquely in the digit, its inclination corresponding with that of the first phalanx. It may be described as possessing six surfaces.

The *anterior surface* is slightly depressed, and widest in its transverse diameter. It is blended with the medial and lateral surfaces and the inferior articular surface extends on to it below.

The *posterior surface*, more extensive than the anterior, carries at its extreme upper part a transversely elongated projecting smooth area, which in the recent state is covered with fibro-cartilage for the passage of the tendon of the deep flexor of the digit. The two divisions of the tendon of insertion of the superficial flexor of the digit are attached at the extremities of this area. Inferiorly the posterior surface is encroached upon by the articular inferior surface. The remainder of this surface is comparatively smooth, and it

[1] In the horse this bone receives the additional name of the os coronae.

presents a number of foramina for the passage of blood-vessels for the spongy tissue in the interior of the bone.

The *medial* and *lateral surfaces* are rough and perforated by foramina, and at its lower part each carries a distinct pit for ligamentous attachment.

The *upper surface* is articular, and moulded on the lower extremity of the first phalanx. It presents two shallow cavities separated by an antero-posterior ridge, the medial cavity being slightly more extensive than the lateral.

The *lower surface* is also articular, meeting the third phalanx and the navicular bone in the terminal joint of the limb. This surface resembles in form the lower extremity of the first phalanx, but is rather more extensive in the antero-posterior direction.

The Third Phalanx[1]

This bone is included entirely in the hoof to which it bears some resemblance in shape. Its compact tissue is denser than that of any of the other bones of the skeleton with the exception of the petrous division of the temporal bone. It belongs to the class of short bones, and for purposes of description there may be recognised in it five surfaces, three borders and two lateral angles.

The *anterior, medial* and *lateral surfaces* form one continuous area which has been termed the *laminal surface,* since in the recent state it is clothed by the sensitive laminae which unite it to the horny laminae of the wall of the hoof. This surface slopes downwards and responds to the deep surface of the wall of the hoof. It is convex from side to side, and nearly straight from above to below. It is dotted over by numerous foramina of various sizes, the largest of which form a semi-circle in the region of the lower limit of the surface. In the vertical direction the surface is most extensive towards its centre, and it tapers gradually towards the angles of the bone. Like the other surfaces it is nearly symmetrical on either side of the axial plane of the digit, but the slope is steeper medially than laterally. On either side of this surface, running horizontally forwards from each angle, there is a groove, termed by some the **dorsal groove,**[2] which terminates anteriorly in one of the larger foramina.

The *inferior surface* looks slightly backwards as well as downwards, and it is divided by a curved line—the **semilunar crest**—into an anterior and a posterior part. The anterior or sole area is

[1] In the horse this bone is also known as the os pedis. It was previously termed the coffin bone.

[2] Formerly termed the preplantar groove.

crescentic in outline and slightly vaulted. It is comparatively smooth, more close-grained in texture than the laminal surface, and it responds to the upper surface of the horny sole. The posterior or tendinous division of this surface shows on each side a considerable foramen—the **volar foramen**—to which the **volar groove** conducts from the angle of the bone. The volar foramina transmit the termina-

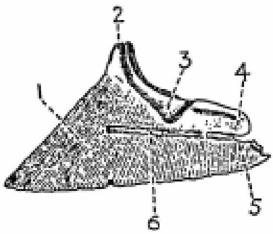


FIG. 92.—RIGHT THIRD PHALANX OF HORSE (MEDIAL ASPECT)

1. Laminal surface. 2. Pyramidal process. 3. Pit for attachment of anterior collateral ligament of second interphalangeal joint. 4-5. Upper and lower divisions of medial angle. 6. Dorsal groove.

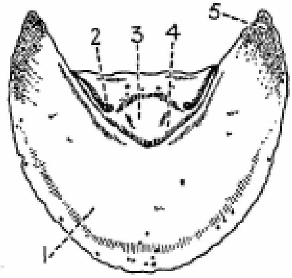


FIG. 93.—RIGHT THIRD PHALANX OF HORSE (INFERIOR ASPECT)

1. Sole area. 2. Volar foramen. 3. Tendinous area. 4. Semilunar crest. 5. Lateral angle.

tions of the medial and lateral digital arteries into the **semilunar sinus,** an excavation towards the centre of the bone in which the two arteries meet and anastomose. Between the volar foramina and the semilunar crest this surface is rough, and to the rough area and the crest itself the tendon of the deep flexor muscle of the digit is attached.

The *superior* or *articular surface* is for the most part moulded on the lower articular surface of the second phalanx. It presents two shallow cavities separated by an ill-defined antero-posterior ridge, the medial cavity being a little more extensive than the lateral. The extreme posterior part of this surface has the form of a transversely elongated nearly flat facet for articulation with the navicular bone.

The *antero-superior border* separates the articular and laminal surfaces. At its mid-point it carries an obtuse eminence—the **pyramidal process**—for the insertion of the tendon of the extensor pedis muscle. Behind this on either side there is a pit for the attachment of the anterior collateral ligament of the second interphalangeal joint.

The *postero-superior border* is nearly straight, and it forms the posterior limit of the articular surface.

The *inferior border* is the most extensive of the three. It is sharp, convex, and slightly notched, and it separates the laminal and inferior surfaces. The lateral half of this border is more convex than the medial.

The *medial* and *lateral angles* of the bone are also termed the **wings.** Each is a backwardly directed process, divided into an upper and a lower division by a notch through which passes the dorsal artery of the third phalanx to reach the dorsal groove on the laminal surface. In the old animal the notch is generally converted into a foramen. The wings serve for the support of the **collateral cartilages**[1] **of the foot.** These are curved plates of cartilage, largely of the

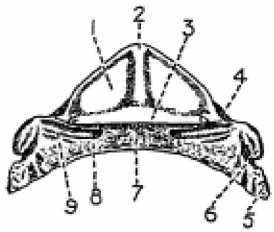


FIG. 94.—RIGHT THIRD PHALANX OF HORSE (POSTERIOR ASPECT)

1. Medial division of articular surface. 2. Pyramidal process. 3. Facet for navicular bone. 4. Pit for anterior collateral ligament of second interphalangeal joint. 5-6. Divisions of lateral angle. 7. Tendinous division of inferior surface. 8. Volar foramen. 9. Volar groove.

hyaline variety, possessing two surfaces, a superficial or abaxial, and a deep or axial surface, and a circumferent border. The *superficial surface* is convex. Superiorly it is subcutaneous, but below it is covered by the coronary and laminal portions of the corium of the foot. The *deep* or *axial surface* is correspondingly concave and is related to the digital cushion. The *circumferent border* is continuous anteriorly with the anterior collateral ligament of the second interphalangeal joint, and below with the angle of the third phalanx. Superiorly it is thin and it can be felt in the living animal projecting immediately above the upper border of the hoof. The posterior part of the border lies near its fellow of the opposite side behind the digital cushion at the heel. In the old animal the wings are increased in size by ossification of the adjacent collateral cartilages.

The Navicular Bone[2]

This bone, sometimes known as the **distal sesamoid bone,** is a small shuttle-shaped bone placed behind the articulation between the second and third phalanges. It is elongated transversely, and it possesses two surfaces, two borders, and two extremities.

The *anterior* or *articular surface* of the bone, which may be recognised by its smoothness, is directed upwards and forwards to articulate with the posterior part of the lower articular surface of

[1] Formerly called the lateral cartilages.

[2] It should be noted that in human anatomy the scaphoid, or central tarsal bone, is also termed the navicular bone.

the second phalanx. For adaptation to that surface it is convex in its middle and concave on either side, the medial concavity being slightly larger than the lateral.

The *posterior* or *tendinous surface* resembles the preceding in form, but it is broader and less smooth. It is directed downwards and backwards, and in the recent state it is covered by fibro-cartilage for the passage of the tendon of the deep flexor muscle of the digit.

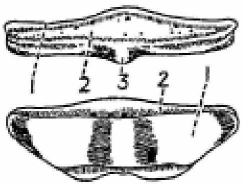


FIG. 95.—RIGHT NAVICULAR BONE OF HORSE (ANTERIOR ASPECT, WITH VIEW OF SUPERIOR BORDER)

1. Medial division of articular surface. 2. Groove on upper border. 3. Ridge on posterior surface.

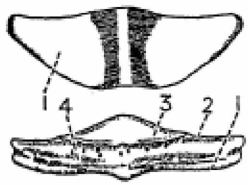


FIG. 96.—RIGHT NAVICULAR BONE OF HORSE (POSTERIOR ASPECT, WITH VIEW OF INFERIOR BORDER)

1. Posterior surface. 2. Medial division of articular surface. 3. Facet for third phalanx. 4. Grooved area for interosseous ligament of second interphalangeal joint.

The *upper border* is thick and grooved in its middle, but thinner towards its extremities where it gives attachment to fibres of the posterior collateral ligament of the second interphalangeal joint.

The *lower border* is composed of two portions, viz. an anterior articular portion, in the form of a transversely elongated flat facet for articulation with the third phalanx, and a posterior grooved portion, perforated by numerous foramina, which affords attachment to the interosseous, or phalango-sesamoidean, ligament of the second interphalangeal joint.

The *extremities* of the bone are pointed.

THE DEVELOPMENT OF THE BONES OF THE FORE LIMB

The bones of the fore limb are derived from the specialised diffused form of the mesoderm, termed the mesenchyme. This shows in the region of the limb bud of the embryo a condensation which forms a solid core for the limb bud. Later the core becomes converted into cartilaginous masses, and in these masses there appear a number of centres of ossification which result eventually in the formation of the several bones of the limb.

The **scapula** develops from a single plate of cartilage with a main centre of ossification for the greater part of the bone including the spine. A second centre belongs to the coracoid process (which in the fowl and lower vertebrates is a separate bone), and a third centre appears in the glenoid cavity. The tubercle of the spine also has its own centre of ossification. Ossification in the region of the superior border is a slow and prolonged process in most domestic animals, for even in the old subject a considerable portion of the cartilage persists. Although the scapula is classed as a flat bone, it is common to find in aged animals a small medullary cavity in the constricted region above the inferior angle.

The **humerus,** like other long bones, has three main centres of ossification, viz. a central one for the shaft, or diaphysis as it is sometimes called, and epiphyseal centres at each extremity. At the upper extremity, however, an additional centre appears for the lateral tuberosity, and another centre occurs in the region of the medial epicondyle. A further centre can be detected in the developing deltoid tuberosity.

The **radius** and **ulna,** which are typical long bones, each have the usual three centres of ossification, viz. one for the shaft, and one for each extremity. In the horse, however, the lower epiphysis of the ulna unites before birth with the lower extremity of the radius, the line of union remaining apparent in the adult on the articular surface. It may be connected above to the diaphysis of the ulna by a delicate rod of bone, but this connection often remains as a fibrous cord. The upper or proximal epiphysis of the ulna forms only the tip of the olecranon, the greater part of this process being developed from the centre for the body.

Each of the bones of the **carpus** ossifies from a single centre, although one or two additional subsidiary centres may appear in the early embryo. These, however, soon fuse with one or other of the main centres.

A typical **metacarpal bone** has the usual three centres of ossification found in a long bone. Modifications, however, occur in the different species. In the horse only three metacarpal bones occur, these corresponding to the second, third and fourth bones of the manus of the dog or man. The large (third) metacarpal bone is a long bone with the three usual centres of ossification, although the centre for the upper extremity fuses with that for the shaft before birth. The small (second and fourth) bones are also long bones, but their development has become arrested, particularly in the distal parts of their shafts. Usually only two centres of ossification can be detected in these bones, one for the shaft and one for the upper extremity, but occasionally it is possible to trace a third centre at the distal extremity.

Both the first and the second **phalanges** have three centres of ossification. The lower epiphysis of each, however, is consolidated in embryonic life with that for the shaft. The third phalanx possesses two centres which fuse before birth. One is responsible for that part of the bone around the articular surface, whilst the second is responsible for the distal part of the bone bounded by the laminal and inferior surfaces. A single centre develops in each proximal or **metacarpo-phalangeal sesamoid bone,** and also in the distal sesamoid or **navicular bone.**

THE BONES OF THE FORE LIMB OF THE OX

Scapula.—The vertebral border is longer than in the horse. The spine is placed nearer the anterior or coracoid border, the area of the supraspinous fossa being about one-third that of the infraspinous fossa. At its lower end

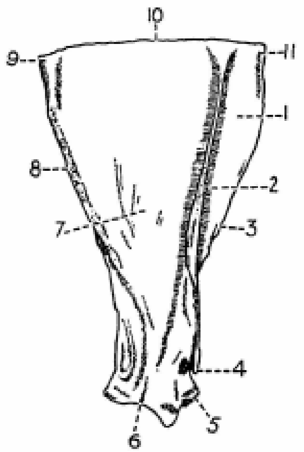


FIG. 97.—RIGHT SCAPULA OF OX (LATERAL ASPECT)
1. Supraspinous fossa. 2. Spine. 3. Coracoid border. 4. Acromion. 5. Coracoid process. 6. Glenoid cavity. 7. Infraspinous fossa. 8. Glenoid border. 9. Posterior angle. 10. Vertebral border. 11. Anterior angle.

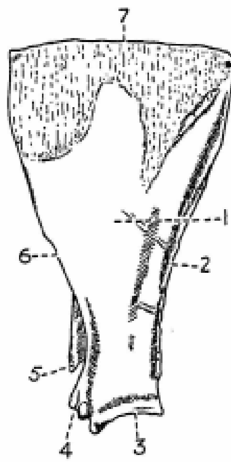


FIG. 98.—RIGHT SCAPULA OF OX (MEDIAL ASPECT)
1. Subscapular fossa. 2. Glenoid border. 3. Glenoid cavity. 4. Coracoid process. 5. Acromion. 6. Coracoid border. 7. Vertebral border.

the spine is produced into a short but distinct acromion. The subscapular fossa is shallow and ill-defined at its upper end. The coracoid process is small and lies close to the glenoid cavity, which is larger and more circular than in the horse.

Humerus.—The spiral groove is shallower than in the horse, and the deltoid and teres tuberosities are smaller. The nutrient foramen is generally found on the posterior surface. The articular head is larger than in the horse, and the neck, though still indistinct, is better developed. The bicipital groove is undivided, and the summit of the lateral tuberosity is produced

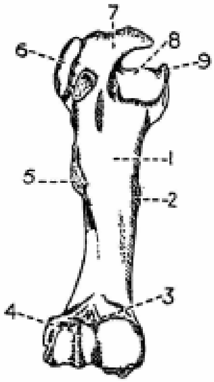


FIG. 99.—RIGHT HUMERUS OF OX (ANTERIOR ASPECT)

1. Anterior surface of shaft. 2. Teres tuberosity. 3. Coronoid fossa. 4. Antero-posterior ridge of lower articular surface. 5. Deltoid tuberosity. 6. Convexity of lateral tuberosity. 7. Summit of lateral tuberosity. 8. Bicipital groove. 9. Anterior division of medial tuberosity.

FIG. 100.—RIGHT HUMERUS OF OX (LATERAL ASPECT)

1. Deltoid tuberosity. 2. Spiral groove. 3. Coronoid fossa. 4. Lower articular surface. 5. Olecranon fossa. 6. Head. 7. Convexity of lateral tuberosity. 8. Summit of lateral tuberosity.

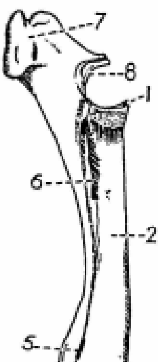


FIG. 101.—RIGHT RADIUS AND ULNA OF OX (LATERAL VIEW)

1. Upper articular surface of radius. 2. Shaft of radius. 3. Lower articular surface of radius. 4. Lower extremity of ulna. 5. Inferior radio-ulnar interosseous space. 6. Superior radio-ulnar interosseous space. 7. Olecranon of ulna. 8. Trochlear notch of ulna.

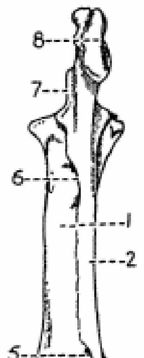


FIG. 102.—RIGHT RADIUS AND ULNA OF OX (POSTERIOR VIEW)

1. Posterior surface of shaft of radius. 2. Shaft of ulna. 3. Lower extremity of ulna. 4. Lower articular surface of radius. 5. Inferior radio-ulnar interosseous space. 6. Superior radio-ulnar interosseous space. 7. Trochlear notch of ulna. 8. Olecranon of ulna.

medially so as to form half an arch over the groove. The olecranon and coronoid fossae are deep, and the antero-posterior ridge of the lower articular surface is more prominent than in the horse.

Radius.—This bone is proportionally shorter but broader than in the horse. The bicipital tuberosity is smaller, and the grooves at the lower end of the bone for the extensor tendons are indistinct. The upper articular surface has a deep antero-posterior groove.

Ulna.—This bone is much better developed than in the horse. It has a massive olecranon, and its shaft is as long as that of the radius, reaching to the carpus. Between the opposed bones a passage is left in the position of the radio-ulnar interosseous space of the horse, and a smaller passage exists a few inches above the carpus. A groove along the lateral side of the line of union connects the upper and lower passages. In the adult animal the two bones of the forearm are solidly anchylosed throughout the entire length of their surfaces of contact, save at their upper ends, where, as in the horse, they respond by two small synovial facets.

Carpus.—Six bones are present in the carpus of the ox—four in the upper row and two in the lower. The upper row comprises the same bones as are present in the horse. The scaphoid is proportionally smaller, and the lunate larger. These two bones articulate with the radius, while the cuneiform articulates with both the bones of the forearm. The accessory bone is much smaller than in the horse, devoid of a groove on its lateral surface, and articulated to the cuneiform only. In the lower row the trapezium is unrepresented. The more medial and larger of the two bones present in this row represents the combined trapezoid and magnum. The unciform is larger than in the horse.

Metacarpus.—In the adult ox this region comprises two bones, viz. a large and a lateral small metacarpal bone. The **large metacarpal** presents some resemblance to the same bone of the horse. It represents the combined third and fourth metacarpals of the human hand, and in foetal life the two bones are distinct and separate. Its shaft is traversed on both its anterior and its posterior surfaces by a vertical furrow, and at either extremity of these furrows a canal transmits vessels through the thickness of the shaft. The medullary canal of the bone is divided lengthways by a bony septum whose edges correspond to the before-mentioned furrows. The furrows and the septum indicate the lines of fusion of the originally separate bones. The lower extremity is divided by an antero-posterior cleft, each of the divisions having a likeness to the lower articular surface of the same bone of the horse. The medial division is slightly larger than the lateral.

The **small metacarpal bone** of the ox has the form of a very short rod, and is articulated to the large bone in the same position as the lateral small metacarpal bone of the horse. Its head responds to the main bone by a small synovial facet, but it does not as a rule contract any articulation with the unciform. The bone represents the fifth metacarpal bone of the human hand.

The ox possesses four **metacarpo-phalangeal sesamoid bones** in each fore limb. The bones are arranged in pairs, the lateral and the medial pair lying behind and articulating with the lateral and medial division of the lower extremity of the large metacarpal bone respectively. The bones of each pair are not alike in general form, for whilst the abaxial bones may be said to resemble the sesamoid bones of the horse, the axial pair are more six-sided and show an extensive posterior surface instead of a border. Each of the bones articulates with the upper extremity of the first phalanx by means of a small facet on its base, and the bones of each pair also articulate together.

Digits.—The ox possesses four digits corresponding to those of the human hand without the thumb. Only two of these, representing the third and

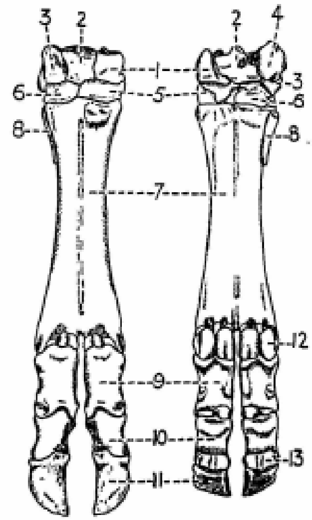


FIG. 103.—RIGHT MANUS OF OX (ANTERIOR VIEW)

FIG. 104.—RIGHT MANUS OF OX (POSTERIOR VIEW)

1. Scaphoid. 2. Lunate. 3. Cuneiform. 4. Accessory. 5. Combined trapezoid and magnum. 6. Unciform. 7. Large metacarpal bone. 8. Lateral small metacarpal bone. 9. First phalanx. 10. Second phalanx. 11. Third phalanx. 12. Metacarpo-phalangeal sesamoid bone. 13. Distal sesamoid bone.

(The smaller digits are not represented.)

fourth, are weight-bearing digits; the other two are very much reduced in size, and are placed behind the fetlock joint. The latter pair correspond to the second and fifth digits of the human hand. Each of the two main digits includes the same bones as are present in the single digit of the horse, but each of the smaller digits contains only two bones, which represent rudimentary second and third phalanges. The following are the characters of the bones of the main digits, each bone of the medial digit being slightly larger than the corresponding bone of the lateral digit.

The **first phalanx** bears some resemblance to one-half of the same bone of the horse, divided vertically. Its abaxial aspect is convex and smooth, while the opposite surface is flattened and roughened posteriorly for ligamentous attachment. Both its extremities are divided by an antero-posterior groove, the abaxial division being the larger of the two. Superiorly it articulates with the lower end of the large metacarpal bone, and with the corresponding metacarpo-phalangeal sesamoid bones.

The **second phalanx** is little more than half the length of the first, which it otherwise resembles. A small medullary canal is present in its centre. Its upper articular surface is divided unequally by an antero-posterior ridge.

The **third phalanx** has a close resemblance to one-half of the third phalanx of the horse. Its laminal surface is rough, porous and perforated by about a dozen foramina of considerable size. The largest of these is close to the posterior angle. The axial surface is flattened. The sole surface is only slightly concave, and it is perforated by two or three considerable foramina. No distinct semilunar crest is present, but a narrow area looking backwards between the articular and sole surfaces represents the tendinous

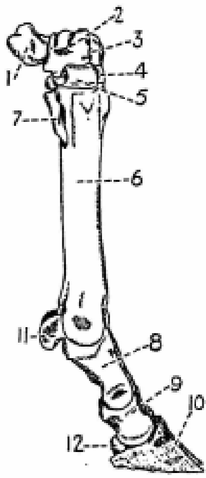


FIG. 105.—RIGHT MANUS OF OX (LATERAL VIEW)

1. Accessory. 2. Cuneiform. 3. Lunate. 4. Combined trapezoid and magnum. 5. Unciform. 6. Large metacarpal bone. 7. Lateral small metacarpal bone. 8. First phalanx. 9. Second phalanx. 10. Third phalanx. 11. Metacarpo-phalangeal sesamoid bone. 12. Distal sesamoid bone.

(*The smaller digits are not represented.*)

surface of the horse's bone. The articular surface presents posteriorly a small nearly flat facet for the distal sesamoid bone, and for the rest of its extent it is moulded on the lower end of the second phalanx. The pyramidal process is small, and the pits present on either side of it in the horse are not represented in the ox. Near its summit it is perforated by a foramen, and a much larger opening, taking the place of the volar foramen of the horse, is found on its axial aspect. These foramina conduct to a large vascular space in the interior of the bone. The wing of the horse's bone is represented by a short blunt process which is sometimes divided by a minute notch into an upper and a lower part as in the horse.

Each digit possesses a **distal sesamoid bone** which is proportionally shorter and broader than the corresponding bone of the horse.

THE BONES OF THE FORE LIMB OF THE SHEEP

Scapula.—This bone is proportionally broader at its upper part than in the ox. On the other hand the neck is more distinctly marked. The acromion is slightly smaller. In all other respects the bone bears the closest resemblance to the scapula of the ox.

Humerus.—The spiral groove is scarcely so deep as in the ox. The deltoid and teres tuberosities are smaller, and the former is higher up on the shaft.

The lateral tuberosity is less prominent, especially in its posterior half. The coronoid fossa is shallower.

Radius and Ulna.—Except in point of size, these bones are almost identical with those of the ox. The ulna is rather more slender, and the superior radio-ulnar interosseous space is larger. The union of the two bones is less intimate, the fibres of the interosseous ligaments above the space persisting as in the horse.

Manus.—The bones of this region correspond almost exactly with those of the larger ruminant, but the small metacarpal bone is even less developed, and the two posterior digits, i.e. the second and the fifth, are generally devoid of phalanges.

THE BONES OF THE FORE LIMB OF THE PIG

Scapula.—This bone is proportionally broad. The anterior or coracoid border is markedly convex in its upper three-fourths. The spine is placed

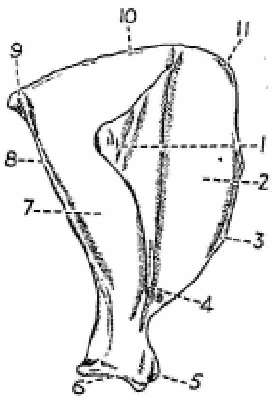


FIG. 106.—RIGHT SCAPULA OF PIG (LATERAL ASPECT)

1. Spine. 2. Supraspinous fossa. 3. Coracoid border. 4. Nodule representing acromion. 5. Coracoid process. 6. Glenoid cavity. 7. Infraspinous fossa. 8. Glenoid border. 9. Posterior angle. 10. Vertebral border. 11. Anterior angle.

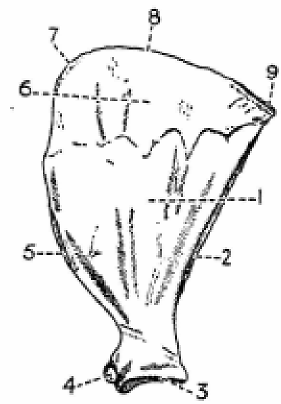


FIG. 107.—RIGHT SCAPULA OF PIG (MEDIAL ASPECT)

1. Subscapular fossa. 2. Glenoid border. 3. Glenoid cavity. 4. Coracoid process. 5. Coracoid border. 6. Rough area for levator scapulae and serratus magnus. 7. Anterior angle. 8. Vertebral border. 9. Posterior angle.

somewhat nearer the middle of the bone than in the horse, and it has the form of a triangular plate, the summit of which curves backwards over the infraspinous fossa. About two inches above the glenoid cavity the spine terminates in a minute nodule which represents an acromion. The coracoid process is small and closely applied to the glenoid cavity which is deeper than in the horse. Above the articular angle there is a well-marked constriction or neck.

Humerus.—This bone is distinctly curved in its length so that its lateral profile resembles an italic *f* without the crossbar. The spiral groove is shallower than in the horse. The deltoid tuberosity is small, and the teres tuberosity is represented by a rough non-projecting mark. As in the ox, the nutrient foramen is generally on the posterior surface. The articular head

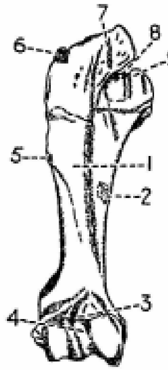


FIG. 108.—RIGHT HUMERUS OF PIG (ANTERIOR ASPECT)

1. Anterior surface of shaft. 2. Teres tuberosity. 3. Coronoid fossa. 4. Lower articular surface. 5. Deltoid tuberosity. 6. Convexity of lateral tuberosity. 7. Summit of lateral tuberosity. 8. Bicipital groove. 9. Medial tuberosity.

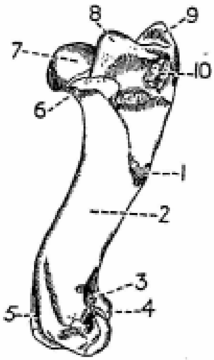


FIG. 109.—RIGHT HUMERUS OF PIG (LATERAL ASPECT)

1. Deltoid tuberosity. 2. Spiral groove. 3. Coronoid fossa. 4. Lower articular surface. 5. Olecranon fossa. 6. Neck. 7. Head. 8. Convexity of lateral tuberosity. 9. Summit of lateral tuberosity. 10. Area for attachment of infraspinatus.

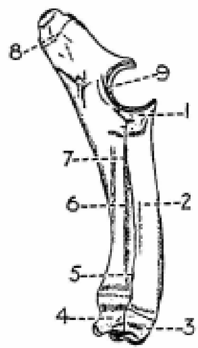


FIG. 110.—RIGHT RADIUS AND ULNA OF PIG (LATERAL VIEW)

1. Upper extremity of radius. 2. Shaft of radius. 3. Lower extremity of radius. 4. Lower extremity of ulna. 5. Inferior radio-ulnar interosseous space. 6. Shaft of ulna. 7. Superior radio-ulnar interosseous space. 8. Olecranon of ulna. 9. Trochlear notch of ulna.

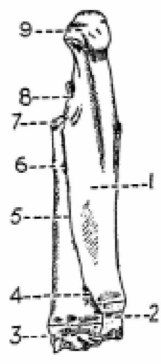


FIG. 111.—RIGHT RADIUS AND ULNA OF PIG (POSTERIOR VIEW)

1. Medial surface of shaft of ulna. 2. Lower extremity of ulna. 3. Lower extremity of radius. 4. Inferior radio-ulnar interosseous space. 5. Posterior surface of radius. 6. Superior radio-ulnar interosseous space. 7. Upper extremity of radius. 8. Trochlear notch of ulna. 9. Olecranon of ulna.

is very convex and beneath it there is a well-marked neck. The bicipital groove is undivided. The summit of the lateral tuberosity is very prominent and produced medially over the bicipital groove, which it thus almost converts into a complete foramen.

Radius.—This bone is relatively short, but thick. In the articulated skeleton the greater part of its posterior surface is concealed by the ulna. The bicipital tuberosity is less distinct than in the horse.

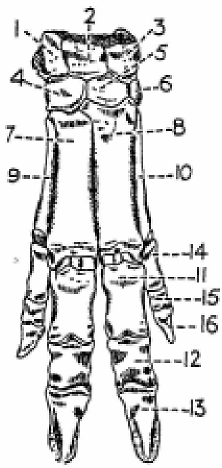


FIG. 112.—RIGHT MANUS OF PIG (ANTERIOR VIEW)
1. Cuneiform. 2. Lunate. 3. Scaphoid. 4. Unciform. 5. Magnum. 6. Trapezoid. 7-8. Axial metacarpal bones. 9-10. Abaxial metacarpal bones. 11-13. First, second and third phalanges of axial digit. 14-16. First, second and third phalanges of abaxial digit.

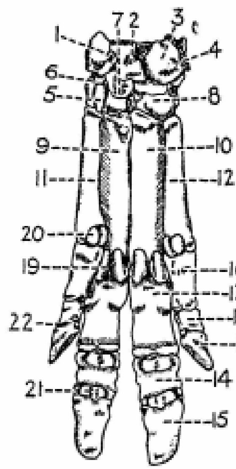


FIG. 113.—RIGHT MANUS OF PIG (POSTERIOR VIEW)
1. Scaphoid. 2. Lunate. 3. Accessory. 4. Cuneiform. 5. Trapezium. 6. Trapezoid. 7. Magnum. 8. Unciform. 9-10. Axial metacarpal bones. 11-12. Abaxial metacarpal bones. 13-15. First, second and third phalanges of axial digit. 16-18. First, second and third phalanges of abaxial digit. 19-20. Metacarpo-phalangeal sesamoid bones. 21-22. Distal sesamoid bones.

Ulna.—The ulna of the pig is a well-developed long bone, exceeding the radius in volume. It has a massive olecranon and its lower end reaches to the carpus, where it articulates with the cuneiform and accessory bones. The shaft of the bone presents lateral, medial and anterior surfaces, the last being closely applied to the back of the radius, to which it is united by an interosseous ligament. There is a radio-ulnar interosseous space in the same position as in the horse, and often a smaller space is situated near the lower extremities of the bones.

Carpus.—Eight bones are present in the carpus of the pig—four in each row. The lunate is larger than the scaphoid. These two bones articulate with the radius, the cuneiform articulates with both bones of the forearm, and the accessory with the ulna. The trapezium is constantly present in the form of a small conical bone articulated to the back of the trapezoid. The latter bone responds inferiorly to the two most medial metacarpals (the second and third), the magnum to the medial large metacarpal, and the unciform to the two most lateral metacarpals (the fourth and fifth).

Metacarpus.—The pig possesses four metacarpal bones, corresponding with the second to the fifth bones of the human hand. The axial or central two of these (the third and fourth) are large and of nearly equal size, while the other two (the second and fifth), disposed one on either side of the larger pair, are considerably smaller. Two small **sesamoid bones** articulate with the lower end of each metacarpal bone and with the adjacent upper extremity of the first phalanx.

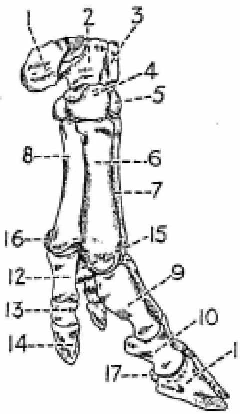


FIG. 114.—RIGHT MANUS OF PIG (LATERAL VIEW) 1. Accessory. 2. Cuneiform. 3. Lunate. 4. Unciform. 5. Magnum. 6-7. Axial metacarpal bones. 8. Abaxial metacarpal bone. 9-11. First, second and third phalanges of axial digit. 12-14. First, second and third phalanges of abaxial digit. 15-16. Metacarpo-phalangeal sesamoid bones. 17. Distal sesamoid bone.

Digits.—Each of the four metacarpals of the pig carries a digit. The axial or central pair are large and of approximately equal size. The abaxial, or medial and lateral, digits are also about equal to each other in size, but considerably smaller than the axial pair, and in ordinary circumstances they do not reach the ground. Each of the digits possesses the usual **phalanges** and a **distal sesamoid bone** all of which resemble very closely the corresponding bones of the ox. These four digits of the pig correspond to the four fingers of man's hand, but the thumb is altogether absent in this animal.

THE BONES OF THE FORE LIMB OF THE DOG

Clavicle.—The collar bone of man is represented in the dog by a minute bone embedded in the brachiocephalicus muscle in front of the shoulder joint. Sometimes it is absent.

Scapula.—The vertebral border carries a very small cartilage of prolongation. As in the pig, the coracoid border is very convex in its upper three-fourths. The spine is near the middle of the lateral surface, and the two fossae are therefore of nearly equal size. It has no very distinct tubercle, but at its lower end it is produced into a short acromion. The subscapular fossa is shallow, and extended upwards to the vertebral border. The coracoid process is small, and closely applied to the glenoid cavity. At the lower end of the posterior border, immediately above the glenoid cavity, there is a distinct tubercle for the attachment of fibres of the long head of the triceps brachii muscle.

Humerus.—This bone is relatively long in the dog, and it resembles the pig's humerus in being curved like an italic *f*. The spiral groove is very much

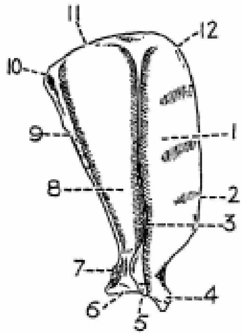


FIG. 115.—RIGHT SCAPULA OF DOG (LATERAL ASPECT)

1. Supraspinous fossa. 2. Coracoid border. 3. Spine. 4. Coracoid process. 5. Acromion. 6. Glenoid cavity. 7. Tubercle for long head of triceps brachii. 8. Infraspinous fossa. 9. Glenoid border. 10. Posterior angle. 11. Vertebral border. 12. Anterior angle.

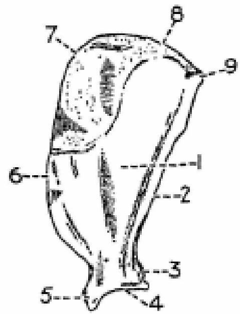


FIG. 116.—RIGHT SCAPULA OF DOG (MEDIAL ASPECT)

1. Subscapular fossa. 2. Glenoid border. 3. Tubercle for long head of triceps brachii. 4. Glenoid cavity. 5. Coracoid process. 6. Coracoid border. 7. Anterior angle. 8. Vertebral border. 9. Posterior angle.

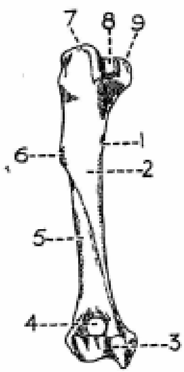


FIG. 117.—RIGHT HUMERUS OF DOG (ANTERIOR ASPECT)

1. Teres tuberosity. 2. Anterior surface of shaft. 3. Lower articular surface. 4. Foramen connecting coronoid and olecranon fossae. 5. Spiral groove. 6. Deltoid tuberosity. 7. Lateral tuberosity. 8. Bicipital groove. 9. Medial tuberosity.

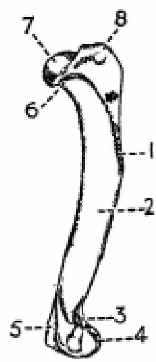


FIG. 118.—RIGHT HUMERUS OF DOG (LATERAL ASPECT)

1. Deltoid tuberosity. 2. Spiral groove. 3. Foramen connecting coronoid and olecranon fossae. 4. Lower articular surface. 5. Olecranon fossa. 6. Neck. 7. Head. 8. Lateral tuberosity.

shallower than in the horse. The deltoid tuberosity is small and a rough mark represents the teres tuberosity. The nutrient foramen is on the posterior surface. The articular head is more convex than in the horse, and the neck is better developed. The bicipital groove is undivided. The lateral tuberosity is small, and not distinctly divided into a summit and a convexity. The lateral condyle of the lower articular surface is only faintly grooved, and the coronoid and olecranon fossae usually communicate in the dried bone by a large foramen.

Radius.—The bones of the forearm are relatively long in the dog. The radius is much flattened from before to behind. The coronoid process is prominent, and the posterior edge of the upper extremity forms a convex articular surface for the ulna. The lower end of the bone has three tendinous grooves, similar to those found on the front of the lower extremity of the horse's radius.

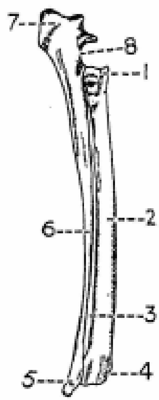


FIG. 119.—RIGHT RADIUS AND ULNA OF DOG (LATERAL VIEW)

1. Upper extremity of radius. 2. Shaft of radius. 3. Radio-ulnar interosseous space. 4. Lower extremity of radius. 5. Lower extremity of ulna. 6. Shaft of ulna. 7. Olecranon of ulna. 8. Trochlear notch of ulna.

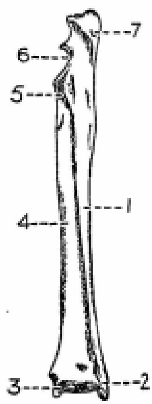


FIG. 120.—RIGHT RADIUS AND ULNA OF DOG (POSTERIOR VIEW)

1. Shaft of ulna. 2. Lower extremity of ulna. 3. Lower extremity of radius. 4. Posterior surface of shaft of radius. 5. Upper extremity of radius. 6. Trochlear notch of ulna. 7. Olecranon of ulna.

Ulna.—As in the pig, this is a well-developed though somewhat slender long bone. Beneath the trochlear notch it is articulated rather to the medial side of the head of the radius. A narrow interosseous space separates the shafts of the two bones. The lower end of the ulna articulates with the cuneiform and accessory bones. The summit of the olecranon has a pulley-like groove.

Carpus.—Seven bones are present in the carpus of the dog—three in the upper row and four in the lower. The reduction in the number of bones commonly present in the upper row is due to the fusion of the scaphoid and lunate to form a single large bone. This bone articulates with the radius, the cuneiform articulates with both bones of the forearm, and the accessory with the ulna. The accessory has the shape of a short rod constricted in its middle. The cuneiform is remarkable in that it descends to the lateral side of the unciform to contract an articulation with the most lateral metacarpal bone. In the lower row the trapezium is invariably present articulating with the first and second metacarpals. The trapezoid articulates with the second metacarpal; the magnum, which is smaller than

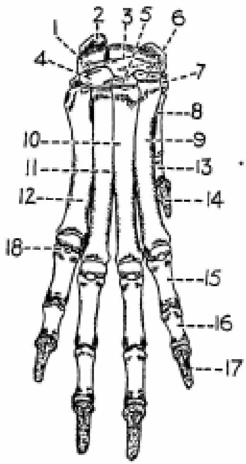


FIG. 121.—RIGHT MANUS OF DOG (ANTERIOR VIEW)

1. Cuneiform. 2. Accessory. 3. Fused scaphoid and lunate. 4. Unciform. 5. Magnum. 6. Trapezoid. 7. Trapezium. 8-12. First to fifth metacarpal bones. 13. Fused first and second phalanges of first digit. 14. Third phalanx of first digit. 15-17. First, second and third phalanges of second digit. 18. Anterior sesamoid bone.

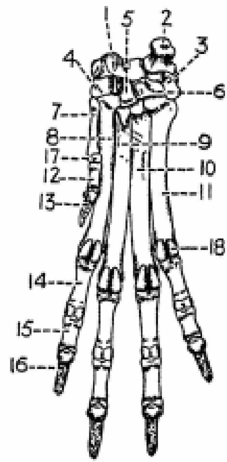


FIG. 122.—RIGHT MANUS OF DOG (POSTERIOR VIEW)

1. Fused scaphoid and lunate. 2. Accessory. 3. Cuneiform. 4. Trapezium. 5. Magnum. 6. Unciform. 7-11. First to fifth metacarpal bones. 12. Fused first and second phalanges of first digit. 13. Third phalanx of first digit. 14-16. First, second and third phalanges of second digit. 17. Single metacarpo-phalangeal sesamoid bone of first digit. 18. Metacarpo-phalangeal sesamoid bone of fifth digit.

the unciform, articulates with the third metacarpal and slightly with the fourth also; while the unciform articulates with the fourth and fifth metacarpals. On the medial side of the dog's carpus a small shot-like sesamoid bone is usually articulated to the scapho-lunate bone.

Metacarpus.—Five bones are present in the metacarpus of the dog. The first or most medial of these is much the shortest, and the third and fourth are the longest. The second is only slightly shorter than the third and fourth, and a little longer than the fifth, which is the thickest bone of the five. Superiorly the five bones articulate among themselves by diarthrodial facets, and in passing downwards they diverge slightly. The first bone has a pulley-like lower end, but the other bones have inferiorly a convex articular surface divided in its posterior half by a slight central ridge. Each metacarpal carries two small **sesamoids** in the usual position on the flexor aspect of the metacarpo-phalangeal joint.[1] Each of the bones carries a small facet for articulation with a like facet on the upper extremity of the first phalanx. In addition small **anterior sesamoid bones** are often found on the extensor aspects of the joints. Each is little larger than a pin head, and lies embedded between the extensor tendon and the capsule of the joint.

Digits.—In the manus of the dog there are five digits, corresponding to those of the human hand. The most medial of these, which is the homologue of the human thumb, possesses only two phalanges, one probably representing the fused first and second phalanges, the other undoubtedly the third phalanx of the other digits. In walking this digit does not come into con-

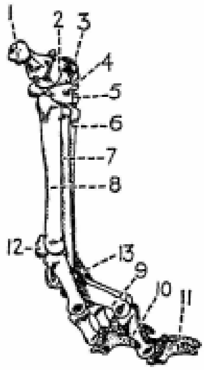


FIG. 123.—RIGHT MANUS OF DOG (LATERAL VIEW)
1. Accessory. 2. Cuneiform. 3. Fused scaphoid and lunate. 4. Unciform. 5. Magnum. 6-8. Third, fourth and fifth metacarpal bones. 9-11. First, second and third phalanges of fourth digit. 12. Metacarpo-phalangeal sesamoid bone. 13. Anterior sesamoid bone.

tact with the ground. Of the other four digits the central pair, the third and fourth, are a little longer than the one on either side. Each of the four weight-bearing digits possesses three phalanges. The **first** and **second phalanges** are diminutive long bones. The **third phalanx** is a small hook-like bone with a projecting collar[2] encircling its base and forming the outer boundary of a groove which accommodates the proximal border of the horny claw. A projection on the under aspect of the base of this phalanx affords insertion to the tendon of the deep flexor muscle of the digits. A fibro-cartilaginous mass takes the place of a distal sesamoid bone.

As compared with the other regions of the limb, the manus of the dog is very short.

THE BONES OF THE FORE LIMB OF THE CAT

Clavicle.—Although it is still rudimentary, this bone is better developed in the cat than in any of the other ordinary domestic animals. It has the form of a slender rod whose extremities are connected by soft parts only to the acromion of the scapula and the manubrium sterni.

Scapula.—This bone resembles the scapula of the dog, but the cervical

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[1] In the case of the first metacarpal bone there is often only one sesamoid bone in this situation.

[2] Sometimes termed the ungual crest.

angle is more rounded, the acromion is larger, extending below the level of the glenoid cavity, and the coracoid process is relatively long and

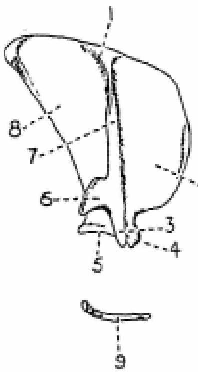


FIG. 124.—RIGHT SCAPULA (LATERAL ASPECT) AND CLAVICLE OF CAT

1. Vertebral border. 2. Supraspinous fossa. 3. Acromion. 4. Coracoid process. 5. Glenoid cavity. 6. Metacromion. 7. Spine. 8. Infraspinous fossa. 9. Anterior surface of clavicle.

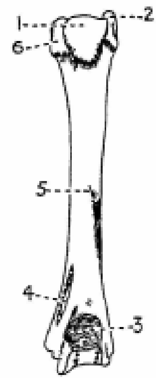


FIG. 125.—RIGHT HUMERUS OF CAT (POSTERIOR ASPECT)

1. Head. 2. Lateral tuberosity. 3. Olecranon fossa. 4. Supracondylar foramen. 5. Posterior surface of shaft. 6. Medial tuberosity.

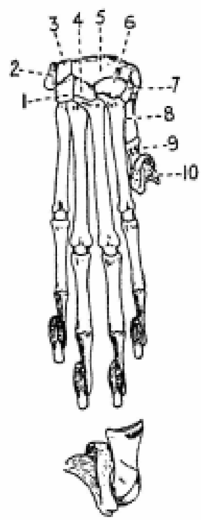


FIG. 126.—RIGHT MANUS (ANTERIOR VIEW) AND SECOND AND THIRD PHALANGES (MEDIAL VIEW) OF CAT

1. Unciform. 2. Accessory. 3. Cuneiform. 4. Magnum. 5. Fused scaphoid and lunate. 6. Trapezoid. 7. Trapezium. 8. First metacarpal bone. 9. Fused first and second phalanges of first digit. 10. Third phalanx of first digit.

hook-like. Immediately above the acromion the spine gives off a backwardly projecting **metacromion**, only a rudiment of which is present in the scapula of the dog.

Humerus.—As compared with the corresponding bone in the dog, this bone in the cat is relatively longer. The medial tuberosity is poorly developed. The olecranon and coronoid fossae do not communicate. A little above the medial condyle the bone is pierced by a **supracondylar foramen** through which the median nerve and brachial artery with a small satellite vein pass.

Radius and Ulna.—These bones present a close resemblance to the corresponding bones of the dog, but they are proportionally longer and more slender.

Manus.—Seven bones are present in the **carpus,** the scaphoid and lunate, as in other carnivora, being fused. The accessory bone articulates with the unciform as well as with the cuneiform. In the **metacarpal** and **digital regions** the same bones are present as in the dog. In the case of all the digits, except the most medial, or pollex, the terminal phalanx is ordinarily retracted, so as to lie laterally to the second phalanx. To permit this retraction of the terminal phalanx with its claw, the second phalanx presents a hollow on its lateral aspect.

CHAPTER VI

THE SKELETON OF THE HIND LIMB

THE hind limb, like the fore, comprises four regions, viz. (1) the hip or haunch, (2) the thigh, (3) the leg, and (4) the hind foot or pes. The skeleton of the hip is formed by the **hip bone;** the thigh contains a large main bone, the **femur,** and a sesamoid bone termed the **patella;** the leg contains two bones, the **tibia** and the **fibula;** and the pes has three sets of bones in its skeleton, the **tarsus,** the **metatarsus,** and the **phalanges.**

THE BONES OF THE HIND LIMB OF THE HORSE

The Hip Bone [1]

This is a large irregularly shaped bone which, with its fellow of the opposite side, enters into the formation of the walls of the cavity of the pelvis. The two bones united together are therefore sometimes referred to as the single **pelvic bone.** In foetal life each hip bone is composed of three distinct segments which meet together to form a large articular cavity called the **acetabulum** or **cotyloid cavity** at the hip joint. These three segments are termed respectively the **ilium,** the **pubis,** and the **ischium.** Although in adult life the lines of junction of these originally distinct elements become obliterated, it is convenient to describe each element separately.

The Ilium

This is the largest of the three divisions of the hip bone. It is irregular in shape, being expanded and flattened antero-superiorly, and narrow and prismatic in its posterior and lower part. The latter portion is sometimes termed the *shaft* of the ilium. The bone may be described as possessing three surfaces, three borders and two extremities.

The *gluteal surface* faces laterally, upwards and backwards. It is wide and concave above, narrow and convex below. Its expanded portion is comparatively smooth and is covered by the middle gluteus muscle, while the narrow inferior third of the surface

[1] Or os coxae.

presents some rough lines and markings for the origin of the deep gluteus.

The *iliac surface* is directed forwards. Like the other surfaces it is widest above, and it is covered by the iliacus muscle. About

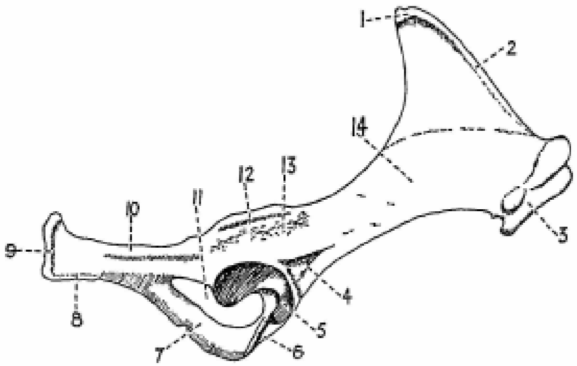


FIG. 127.—RIGHT HIP BONE OF HORSE (LATERAL VIEW)

1. Sacral tuberosity. 2. Crest of ilium. 3. Coxal tuberosity. 4. Pit for lateral head of rectus femoris. 5. Cotyloid cavity. 6. Subpubic groove. 7. Inferior surface of pubis. 8. Inferior ischial spine. 9. Ischial tuberosity. 10. Lateral border of ischium. 11. Obturator foramen. 12. Superior ischial spine. 13. Markings for origin of deep gluteus. 14. Gluteal surface of ilium.

the junction of its middle and lower thirds it shows a large **nutrient foramen,** and at the same place, running obliquely across the shaft, are smooth impressions left by the iliaco-femoral[1] vessels. In the upper third of this surface smaller and fainter impressions are left by the ilio-lumbar vessels.

The *sacral* or *pelvic surface* is directed medially towards the cavity of the pelvis. In its upper third it carries an irregular **auricular facet,** which forms a joint with a like facet on the sacrum. Below this facet the surface is for the most part smooth and faintly grooved longitudinally at its lower part for the obturator vessels and nerve. Above the auricular facet the bone is rough for muscular and ligamentous attachment.

The *cotyloid border* of the bone conducts inferiorly to the cotyloid cavity, and it separates the gluteal and iliac surfaces. It is concave in its length, narrow above and thick below.

The *ischial border* separates the gluteal and sacral surfaces. It is markedly concave, and for the most part thin and sharp. In its lower and posterior part, above the cotyloid cavity, it is elevated and roughened laterally, forming part of the **superior ischial spine,**

[1] Or lateral circumflex femoral.

to which the sacro-sciatic ligament is attached. About its middle this border forms the anterior boundary of the **greater sciatic foramen.**

The *pubic border* is so named because it conducts inferiorly to the pubic bone. At the upper part of the ilium this border is altogether effaced, the iliac and pelvic surfaces being there blended. In its lower third it is known as the **ilio-pectineal line,** the most prominent point of which is roughened for the insertion of the psoas minor muscle, and which is therefore termed the **psoas tubercle.**

The *superior extremity* of the ilium has the form of an extensive **crest** which terminates at either extremity in a prominent angle of bone. The medial angle, or **sacral tuberosity,**[1] is acute, and it forms a rough projection of bone which surmounts the first sacral spine and is the highest point of the skeleton in the region of the croup. The lateral angle, or **coxal tuberosity,**[2] is formed by a massive piece of bone composed of four eminences arranged in pairs, two above and two below. This angle forms a more or less conspicuous surface prominence in the living animal. The crest as well as the before-mentioned angles are rough for muscular attachment.

The *inferior extremity* of the ilium meets the pubis and ischium in the cotyloid cavity. On its anterior aspect, immediately above the cavity, there are two pits, one on each side of the termination of the cotyloid border of the bone. These give origin to the medial and lateral heads of the rectus femoris muscle.

The Pubis

This is the smallest of the three divisions of the hip bone. It is placed at the anterior part of the floor of the pelvic cavity, and it possesses two surfaces, three borders and three angles.

The *superior surface* is smooth and concave in the mare, convex in the young subject and the stallion. It is largely covered by the obturator internus muscle, and above this lies the urinary bladder.

The *inferior surface* is for the greater part convex and roughened for the attachment of the obturator externus muscle. It is crossed anteriorly by a groove, the so-called **subpubic groove,**[3] which extends laterally into the cotyloid cavity. The lateral part of the groove lodges the accessory ligament of the hip joint. In front of it here lies a roughened tuberosity, the **ilio-pectineal eminence,** from which fibres of the pectineus muscle take origin. Medially the groove accommodates a tributary of the deep femoral vein.

[1] Or angle of the croup.
[2] Or angle of the haunch.
[3] Formerly termed the pubio-femoral groove.

The *anterior border* forms part of the inlet or brim of the pelvis, and to it is attached the prepubic tendon of the abdominal muscles. It is thin in its medial half, but laterally, where it emerges with the ilio-pectineal eminence, it is thick and tuberous. Still more laterally the border leads upwards to the ilio-pectineal line.

The *medial border* is opposed to the corresponding border of the opposite bone, forming the **pubic symphysis.**

The *lateral border* is concave, and it forms the anterior and medial boundaries of the obturator foramen.

The *antero-lateral angle* meets the ilium and ischium in the cotyloid cavity.

The *antero-medial angle* is opposed to the corresponding angle of the opposite bone at the anterior end of the symphysis.

The *posterior angle* joins the antero-medial angle of the ischium.

The Ischium

This bone forms the posterior part of the floor of the pelvis. It is flattened and four-sided, exhibiting two surfaces, four borders and four angles.

The *superior surface* is smooth and slightly concave. It is covered by the obturator internus muscle.

The *inferior surface* is nearly flat, and it carries roughenings for the origin of the adductor muscles of the thigh.

The *anterior border* forms the lateral and posterior boundary of the obturator foramen.

The *medial border* is opposed to the opposite bone along the **ischial symphysis.**

The *posterior border* is thick and rough. It slopes inwards towards the corresponding border of the opposite bone, forming with it the **ischial arch,** which constitutes the inferior boundary of the pelvic outlet.

The *lateral border* forms the lower boundary of the **lesser sciatic foramen,** and it is for the most part thick, smooth, and rounded for the passage of the tendon of the obturator internus muscle. At its anterior end it is elevated, sharp, and roughened laterally, forming part of the **superior ischial spine.**

The *antero-medial angle* meets the pubis.

The *antero-lateral angle* joins the ilium and the pubis in the cotyloid cavity.

The *postero-medial angle* is opposed to the corresponding angle of the opposite side in the centre of the ischial arch.

The *postero-lateral angle* forms a thick rough process, the **ischial tuberosity,** which may be felt in the living animal covered by muscle at the point of the buttock. On its lower aspect the tuberosity carries a prominent ridge, the **inferior ischial spine.** From the tuberosity the semitendinosus, the semimembranosus and the biceps femoris muscles take origin.

The Cotyloid Cavity

The cotyloid cavity, or **acetabulum,** is a deep hemispherical articular cavity formed on the lateral aspect of the hip bone by the

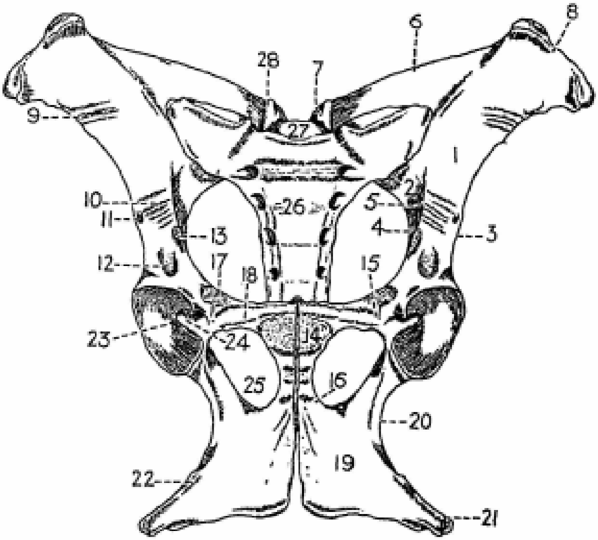


FIG. 128.—PELVIC BONE AND SACRUM OF HORSE (VIEWED FROM BELOW) 1. Iliac surface of ilium. 2. Sacral surface of ilium. 3. Cotyloid border of ilium. 4. Ischial border of ilium. 5. Pubic border of ilium. 6. Crest of ilium. 7. Sacral tuberosity. 8. Coxal tuberosity. 9. Grooves for ilio-lumbar vessels. 10. Grooves for iliaco-femoral vessels. 11. Nutrient foramen. 12. Pit for medial head of rectus femoris. 13. Psoas tubercle. 14. Inferior surface of pubis. 15. Antero-lateral angle of pubis. 16. Posterior angle of pubis. 17. Ilio-pectineal eminence. 18. Subpubic groove. 19. Inferior surface of ischium. 20. Lateral border of ischium. 21. Ischial tuberosity. 22. Inferior ischial spine. 23. Cotyloid cavity. 24. Acetabular fossa. 25. Obturator foramen. 26. Inferior surface of sacrum. 27. Anterior extremity of first sacral vertebra. 28. Anterior articular process of first sacral vertebra.

meeting of its three constituent pieces. The cavity, which in the recent state is deepened by the attachment around its rim of a ring of fibro-cartilage termed the **labrum acetabulare,** receives the articular head of the femur in the hip joint. The rim presents a wide interruption or **acetabular notch** medially. By this notch the accessory ligament of the hip joint enters the cavity. For the most part the cavity is smooth and articular, but from the notch of its rim a triangular, rough, non-articular part extends laterally to near its centre. This non-articular depression is called the **acetabular fossa.** It serves for the accommodation of the accessory ligament and it also gives attachment to the round ligament of the joint.

The Obturator Foramen

This is a large opening on the floor of the pelvis, circumscribed by the ischial and pubic bones. It is oval in shape with the long axis directed forwards and outwards. A thin fibrous stratum, the obturator membrane, stretches across the foramen leaving anteriorly a passage through which the obturator vessels and nerve pass to reach the thigh.

The Pelvis

The cavity of the pelvis is the most posterior of the three great visceral cavities of the body. In the living subject it has the form of a short tube, directly continuous in front with the abdominal cavity. In the skeleton the boundaries of the pelvis are imperfectly indicated by the hip bones, the sacrum and the first three coccygeal bones. The great vacuity which is present on each side between the lateral border of the sacrum and the hip bone is filled up in the recent state by the sacro-sciatic ligament. The plane of communication between the pelvis and the abdomen is termed the brim or inlet of the pelvis, and the posterior opening of the cavity is termed its outlet. The **inlet** is a complete bony ring, circumscribed by the base of the sacrum above, by the anterior margins of the pubic bones below, and by the ilio-pectineal lines on each side. The inlet is nearly circular in outline, and it looks downwards and forwards. The margin of the outlet of the pelvis is not so well defined as that of the inlet. It is indicated in the skeleton by the third coccygeal vertebra above and by the posterior borders of the ischial bones below. In the recent state it is completed laterally by the hinder edge of the sacro-sciatic ligament, which stretches on each side between the coccygeal bones above and the ischial tuberosity below. The **outlet** is considerably smaller than the inlet, and in shape it is ovoid with the broad end below. The plane of the outlet is directed backwards and upwards, being nearly parallel to the plane of the inlet.

Differences between the Male and Female Pelvis.—Considerable differences are exhibited between the pelvis of the horse and that of the mare, these differences depending upon the fact that in the parturient mare the foetus has to traverse the pelvic cavity.

Speaking generally it may be said that the breadth and capacity of the pelvis are much greater in the mare than in the horse. The shaft of the ilium is longer and more slender in the mare than in the horse, and the concavity of the ischial border in the region of the greater sciatic foramen is not so marked. The floor of the pelvis in the region of the pubis is depressed in the mare whereas it is convex in the horse. In the region of the ischia the floor is flatter in the female, the two bones meeting in the middle line at a more open angle. The ischial arch is wider and more open in the mare, and the obturator foramina are larger and more circular. It should be noted that the pelvis of a male which was castrated in early life comes to resemble that of a female in many respects.

The Femur

The femur is the most massive bone in the body. It is a long bone and it occupies an oblique position in the limb, stretching downwards and forwards between the hip and stifle joints. Like other long bones, it possesses a shaft and two extremities.

The *anterior, medial* and *lateral surfaces* of the *shaft* are blended so as to form one continuous smooth surface which is almost straight from above to below, convex in the transverse direction, and clothed by the quadriceps femoris muscle.

The *posterior surface* is extensive, widest above, and flattened. It is crossed obliquely in its lower third by a smooth impression, running downwards and towards the lateral border, which marks the course of the femoral blood vessels. Immediately above this there is a four-sided rough area into which the adductor muscles of the thigh are inserted. Above this again, towards the medial border, an oblique rough line or ridge serves for the attachment of the quadratus femoris muscle. At the same level, but towards the opposite side, and situated partly on the back of the third trochanter, there is a rough circular area to which part of the biceps femoris muscle is attached.

The *medial border,* or, rather, the border which separates the posterior surface from the medial surface, carries the **lesser trochanter** in its upper third. This has the form of a thick rough projection, and it serves for the insertion of the iliacus and psoas major muscles. The **nutrient foramen** of the bone is found about the middle of this border, and near the same point the pectineus is inserted into a rough impression. Still lower, immediately below the groove for the femoral vessels, this border carries the **medial supracondylar crest,** from which the medial head of the gastrocnemius muscle arises.

The *lateral border* carries, at nearly the same level as the lesser trochanter, a strong forwardly curved projection termed the **third trochanter.** The superficial gluteus is inserted into the rough free

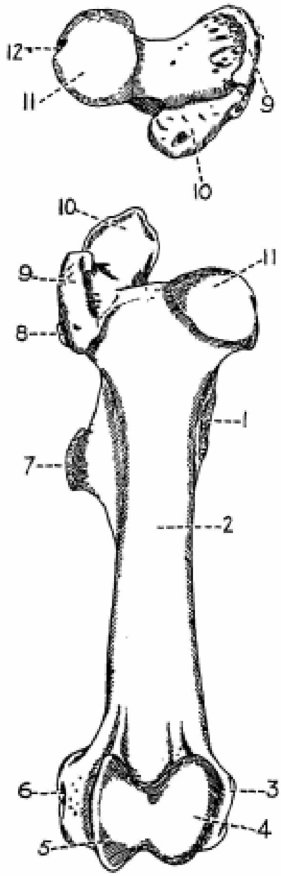


FIG. 129.—RIGHT FEMUR OF HORSE (ANTERIOR ASPECT, WITH VIEW OF SUPERIOR EXTREMITY)

1. Lesser trochanter. 2. Anterior surface of shaft. 3. Medial condyle. 4. Medial lip of trochlea. 5. Lateral lip of trochlea. 6. Lateral condyle. 7. Third trochanter. 8. Line for insertion of middle gluteus. 9. Convexity of greater trochanter. 10. Summit of greater trochanter. 11. Head. 12. Fovea.

edge of this process. At the lower part of this border, opposite to the medial supracondylar crest, there is a deep rough pit—the **supracondylar fossa.** The superficial digital flexor muscle arises from the bottom of the fossa, and from its rough lateral lip, which is termed the **lateral supracondylar crest,** the lateral head of the gastrocnemius takes origin.

The *upper extremity* of the femur is made up of the articular head and the greater trochanter.

The **head** is a hemispherical articular process, which is received into the cotyloid cavity of the hip bone. A deep non-articular triangular depression, or **fovea,** extends from near the centre to the medial border of the head and gives attachment to the round and accessory ligaments of the hip joint. A distinct line marking the attachment of the capsular ligament encircles the head, and beneath it the bone is slightly constricted forming the **neck.**

The **greater trochanter** lies laterally to the head, and it consists of two parts, viz. a summit, and a convexity. The **summit,** which is

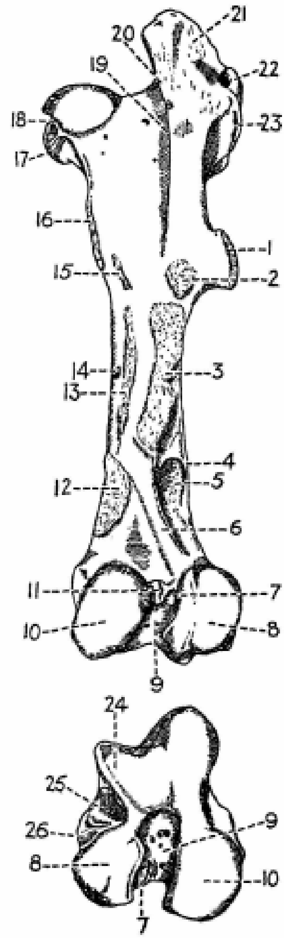


FIG. 130.—RIGHT FEMUR OF HORSE (POSTERIOR ASPECT, WITH VIEW OF INFERIOR EXTREMITY)

1. Third trochanter. 2. Area for attachment of biceps femoris. 3. Area for insertion of adductors. 4. Lateral supracondylar crest. 5. Supracondylar fossa. 6. Groove for femoral vessels. 7. Pit for anterior cruciate ligament. 8. Lateral condyle. 9. Intercondylar groove. 10. Medial condyle. 11. Pit for ligamentous slip of lateral semilunar cartilage. 12. Medial supracondylar crest. 13. Area for insertion of pectineus. 14. Nutrient foramen. 15. Line for attachment of quadratus femoris. 16. Lesser trochanter. 17. Head. 18. Fovea. 19. Trochanteric fossa. 20. Trochanteric crest. 21. Summit of greater trochanter. 22. Convexity of greater trochanter. 23. Line for insertion of middle gluteus. 24. Lateral lip of trochlea. 25. Pit for common tendon of extensor pedis and superficial division of flexor tarsi. 26. Pit for origin of popliteus.

placed posteriorly, gives attachment to one of the tendons of the middle gluteus. In a medium-sized animal it surmounts the head by about two inches, and from it a prominent ridge, the **trochanteric crest,** descends to near the third trochanter. To the crest is attached the piriformis muscle. Immediately medial to the crest lies the

trochanteric fossa, a deep depression which receives the tendons of insertion of the obturator internus and externus and the gemelli muscles. The **convexity** lies in front of the summit, from which it is separated by a notch. In the recent state the convexity gives attachment deeply to the deep gluteus, while its superficial or lateral surface is covered by fibro-cartilage for the passage of a tendon of the middle gluteus which obtains insertion into a rough oblique line below. Between the head and the greater trochanter is an area of bone perforated by numerous foramina for the passage of vessels belonging to the spongy tissue of the bone.

The *lower extremity* of the femur is made up of the trochlea in front and the condyles behind.

The **trochlea** is a pulley-like groove for articulation with the patella and its medial fibro-cartilaginous extension. The groove is nearly vertical in direction, and its medial lip or ridge is much more prominent than its lateral lip. Laterally to the extreme lower end of the lateral lip, between it and the lateral condyle, there is a well-marked pit for the common tendon of the extensor pedis [1] and the superficial division of the flexor tarsi [2] muscles.

The **condyles,** medial and lateral, are separated by a deep **intercondylar groove,** which lodges the spine of the tibia and the cruciate ligaments of the stifle joint. Each condyle is a convex, ovoid articular process, for articulation with the upper extremity of the tibia. There is a marked want of adaptation between the articular surfaces of the femoral condyles and the corresponding condyles of the tibia, but in the complete joint this is compensated for by the interposition of the semilunar cartilages. On its superficial, or abaxial, aspect the medial condyle carries a small eminence for the attachment of the medial collateral ligament of the stifle joint. The lateral condyle bears laterally two small pits, the upper of which marks the attachment of the lateral collateral ligament, while the lower serves for the origin of the popliteus muscle. At the posterior part of the intercondylar groove, close to the medial condyle, there is a pit for the attachment of one of the ligaments of the lateral semilunar cartilage; and opposite to this, close to the lateral condyle, there is a larger pit for the attachment of the anterior cruciate ligament.

The Patella

This is a short bone articulating with the trochlea of the femur. Corresponding with the knee-cap of the human subject, it is a

[1] Or extensor digitorum longus. [2] Or peroneus tertius.

typical sesamoid bone, its function being to give increased lever power to the quadriceps femoris muscle. It presents for consideration three surfaces and two extremities.

The *anterior surface* is the most extensive of the three. It is convex in all directions and rough for the attachment of the quadriceps femoris muscle and the lateral and middle anterior patellar ligaments.

The *posterior surface* is entirely articular, and may be recognised by its smoothness. A broad ridge divides it into two areas,

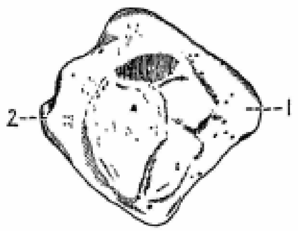


FIG. 131.—RIGHT PATELLA OF HORSE (ANTERIOR ASPECT)
1. Medial angle. 2. Lateral angle.

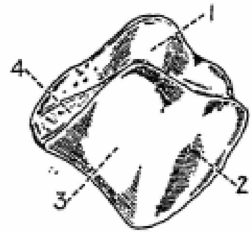


FIG. 132.—RIGHT PATELLA OF HORSE (POSTERIOR ASPECT)
1. Superior surface. 2. Lateral groove of posterior surface. 3. Medial groove of posterior surface. 4. Area for attachment of fibro-cartilage.

both of which are grooved in the vertical direction. The central ridge slides in the groove of the femoral trochlea, and the areas on either side of this are adapted, though not very accurately, to the lips of the trochlea. The medial area is much more extensive than the lateral, in correspondence with the larger size of the medial lip of the trochlea.

The *superior surface* is the smallest of the three. It is concave from before to behind, and slightly convex from side to side.

The two *angles* are lateral and medial. The lateral is the more rounded, the medial being sharper and having attached to it a **fibro-cartilaginous extension** whose posterior surface, continuous with that of the patella, is smooth for articulation with the medial lip of the femoral trochlea.

The Tibia

The tibia is a long bone, and in size it greatly exceeds the fibula, the other bone of the leg. It occupies an oblique position in the limb, extending downwards and backwards between the stifle and hock joints. It possesses a three-sided shaft and two extremities.

The *lateral surface* of the *shaft* is widest above, and slightly spiral in its direction. At its upper part it faces almost directly laterally, but it gradually inclines towards the front of the bone, until at its lower end it faces directly forwards. It is concave above, convex in its middle, and nearly flat at its lower end. In the whole of its extent it is smooth and clothed by the deep division of the flexor tarsi [1] muscle.

The *medial surface* is wide above and narrow below. In its upper fourth it is rough for the attachment of the gracilis muscle, but for the remainder of its extent it is smooth and subcutaneous in position.

The *posterior surface* is flattened in the transverse direction. Below the upper extremity lies a triangular area whose apex extends downwards to a point about the middle of the length of the shaft of the bone and near the medial border. This area, which shows a few ridges running obliquely across it, accommodates the popliteus muscle. Laterally to this lies another somewhat triangular area the apex of which lies just below the lateral condyle. This area is crossed by a number of roughened lines whose direction is more vertical and it affords origin to fibres of the deep digital flexor, which muscle lies on the smooth lower third of this surface. Between the previously described triangular areas is found the **nutrient foramen.**

The foregoing surfaces are separated by the anterior, lateral and medial borders.

The *anterior border* is very sharp and prominent in its upper third, constituting the tibial **crest.** The crest gives attachment along its length to the biceps femoris muscle, while medially, near its lower end, a rough area indicates the point of insertion of the semi-tendinosus muscle. Below the crest the anterior border has the form of a roughened line which lies subcutaneously, corresponding to the "shin" of the human leg.

The *lateral border,* which is concave in its length, is separated from the fibula by an interosseous space which is bridged across by the tibio-fibular interosseous fibrous membrane. The anterior tibial vessels pass through the upper part of the space, and leave there a smooth impression on the lateral border of the bone.

The *medial border* is almost straight in its length. It carries in its upper third a prominent tubercle for the attachment of fibres of the popliteus muscle.

The *upper extremity* is massive, and is compounded of a tuberosity and two condyles.

The **tuberosity** is a non-articular process, continuous inferiorly with the crest. It presents a vertical groove for the accommodation of the middle of the three anterior ligaments of the patella, which

[1] Or tibialis anterior.

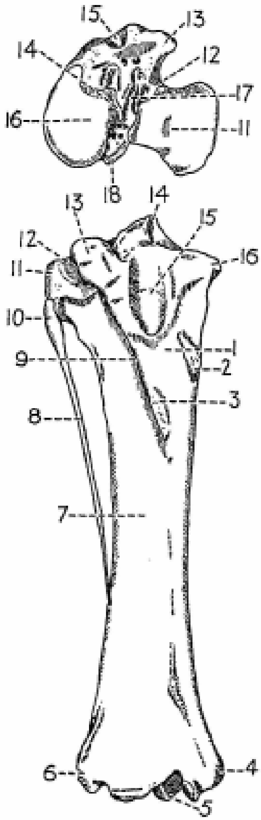


FIG. 133.—RIGHT TIBIA AND FIBULA OF HORSE (ANTERIOR VIEW, WITH VIEW OF SUPERIOR EXTREMITY OF TIBIA)

1. Medial surface of shaft of tibia. 2. Area for attachment of gracilis. 3. Area for insertion of semitendinosus. 4. Medial malleolus of tibia. 5. Inferior articular surface of tibia. 6. Lateral malleolus of tibia. 7. Lateral surface of shaft of tibia. 8. Shaft of fibula. 9. Tibial crest. 10. Superior extremity of fibula. 11. Lateral condyle of tibia. 12. Notch for common tendon of extensor pedis and superficial division of flexor tarsi. 13. Tuberosity of tibia. 14. Tibial spine. 15. Groove for middle anterior patellar ligament. 16. Medial condyle of tibia. 17. Pit for attachment of anterior cruciate ligament. 18. Tubercle for attachment of posterior cruciate ligament.

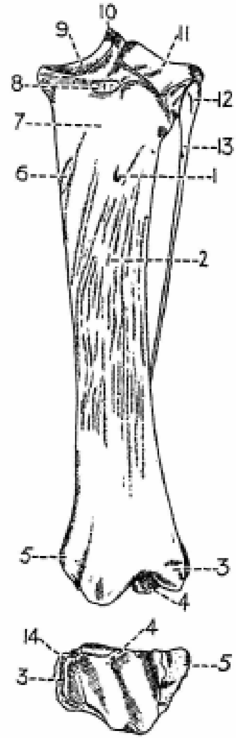


FIG. 134.—RIGHT TIBIA AND FIBULA OF HORSE (POSTERIOR VIEW, WITH VIEW OF INFERIOR EXTREMITY OF TIBIA)

1. Nutrient foramen of tibia. 2. Lines for origin of deep digital flexor. 3. Lateral malleolus of tibia. 4. Inferior articular surface of tibia. 5. Medial malleolus of tibia. 6. Tubercle for attachment of popliteus. 7. Area for accommodation of popliteus. 8. Tubercle for attachment of posterior cruciate ligament. 9. Medial condyle of tibia. 10. Tibial spine. 11. Lateral condyle of tibia. 12. Superior extremity of fibula. 13. Shaft of fibula. 14. Line of fusion of originally distinct lateral malleolus with inferior extremity of tibia.

ligament is attached to an oval mark at the lower end of the groove. The medial and lateral anterior patellar ligaments are attached to the tuberosity on either side of the groove. Laterally to the tuberosity, and between it and the lateral condyle, a deep notch is left for the passage of the common tendon of origin of the superficial division of the flexor tarsi and the extensor pedis muscles.

The **lateral condyle** carries superiorly a saddle-shaped articular surface upon which lies the semilunar cartilage which adapts the surface for the better accommodation of the lateral femoral condyle. Laterally this condyle presents a narrow facet for articulation with the head of the fibula.

The **medial condyle** carries superiorly a slightly undulated articular surface which, with the semilunar cartilage, responds to the medial condyle of the femur, and which is prolonged on the medial surface of the tibial spine. On its posterior aspect the medial condyle bears a small tubercle for the attachment of the posterior cruciate ligament.

Situated near the centre of the upper extremity is a peak-like process of bone known as the **spine** of the tibia. On its medial aspect the spine is smooth, and continuous with the articular surface of the medial condyle. It presents laterally a pit for the attachment of the anterior cruciate ligament.

Between the lateral and medial condyles, and between these and the tuberosity, the bone is rough and perforated by numerous foramina for the passage of blood-vessels belonging to the spongy tissue.

The *lower extremity* of the tibia carries an articular surface for the talus, on either side of which lie two prominences called the malleoli. The more lateral of these is in fact the lower extremity of the fibula detached from that bone and now regarded as forming part of the tibia.

The *articular surface* is composed of two deep grooves separated by an articular ridge and bounded on either side by the axial surfaces of the two malleoli. The grooves are disposed obliquely forwards and laterally. The lateral usually shows a line indicating where the originally distinct lower extremity of the fibula has fused with the adjacent part of the tibia.

The **lateral malleolus** is roughened on its lateral aspect for the attachment of the lateral collateral ligament of the hock joint. Running vertically over this surface is a groove for the passage of the tendon of the lateral digital extensor muscle.[1] On its deep, or axial, surface the malleolus is smooth and articular.

[1] Or peroneus muscle.

The **medial malleolus** is more rounded and prominent than the lateral malleolus. Its rough superficial face gives attachment to the medial collateral ligament of the hock joint while its axial surface is smooth and articular.

The Fibula

In the horse there is a marked disparity between the bones of the leg, the fibula being very small and slender. In size and shape it is not unlike the small metacarpal bones, and like these it is to be regarded as a rudimentary long bone, its medullary cavity being undeveloped and its lower extremity having become united to the lower extremity of the tibia where it forms the lateral malleolus. It possesses a shaft and two extremities.

The *shaft* is a styliform rod of bone, tapering to its lowest point. For a short distance at its lower end it is closely applied to the lateral border of the tibia, but for the remainder of its extent it is separated from the tibia so as to leave between the two bones an elongated space across which stretches the interosseous membrane.

The *upper extremity*, or **head,** is the thickest part of the bone. It presents two surfaces and two borders.

The *medial surface* is flat and generally rough, but it shows superiorly a narrow facet for articulation with a like facet on the lateral condyle of the tibia.

The *lateral surface* is slightly convex and it is roughened for the attachment of the lateral collateral ligament of the femoro-tibial joint.

The *anterior* and *posterior borders* are blunt, the latter being the thicker of the two.

The *inferior extremity* forms a sharp point which reaches to the lower third of the tibia and is continued by a fibrous cord to the lateral malleolus.

The Tarsus

The tarsus comprises six short bones, named as follows: **talus, calcaneum, scaphoid, cuboid, large cuneiform** and **small cuneiform.** These bones may be said to form two rows comparable to those of the carpus, the upper row comprising the talus and calcaneum, and the lower the cuboid and the two cuneiforms, while the scaphoid is interposed between the two rows medially.

The Talus [1]

This bone is also called the **tibial tarsal bone.** It is of very irregular shape, but it may be described as possessing six surfaces.

The *superior* and *anterior surfaces* are blended to form an articular surface, or **trochlea,** for the lower extremity of the tibia. The trochlea consists of a deep groove bounded on either side by two rounded ridges, and it winds with a spiral twist downwards, forwards and laterally so as to make nearly half a turn around the bone.

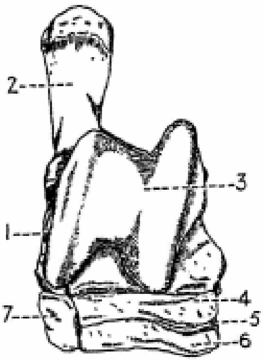


FIG. 135.—RIGHT TARSUS OF HORSE (ANTERIOR VIEW)

1. Calcaneum. 2. Tuber calcanei. 3. Talus. 4. Scaphoid. 5. Small cuneiform. 6. Large cuneiform. 7. Cuboid.

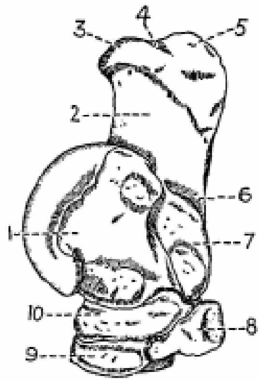


FIG. 136.—RIGHT TARSUS OF HORSE (MEDIAL VIEW)

1. Talus. 2. Tuber calcanei. 3. Area on which tendon of gastrocnemius rests in extreme flexion of tarsal joint. 4. Area for insertion of gastrocnemius. 5. Area for play of tendon of superficial flexor of digit. 6. Groove for tendon of deep flexor of digit. 7. Sustentaculum tali. 8. Small cuneiform. 9. Large cuneiform. 10. Scaphoid.

The *inferior surface* is almost entirely articular, and it is slightly convex from before to behind. It articulates laterally with the cuboid by a small oblique facet and for the remainder of its extent with the scaphoid. A non-articular groove for the attachment of an interosseous ligament begins about the centre of this surface and runs to its lateral margin.

The *posterior surface* is rugged and irregular. It carries three, or sometimes four, facets for articulation with the calcaneum, and intervening rough areas for ligamentous attachment.

The *medial surface* carries two tuberosities. The superior, smaller one, gives attachment to fibres of the medial collateral liga-

[1] Formerly known as the astragalus.

ment of the hock joint, while the more prominent lower tuberosity serves for the attachment of the talo-metatarsal ligament.

The *lateral surface* shows a shallow pit for the attachment of fibres of the lateral collateral ligament of the hock joint.

The talus articulates with four bones, viz. the tibia, calcaneum, scaphoid and cuboid.

The Calcaneum [1]

The calcaneum, sometimes termed the **fibular tarsal bone,** is also of very irregular shape. It may, however, be described as consisting of a body, and two processes, the tuber calcanei and the sustentaculum tali.

The **body** is placed inferiorly and it presents six surfaces.

The *anterior surface* is irregular and is moulded on the lateral part of the posterior surface of the talus. It is provided with three facets, one facing medially, one inferiorly and one forwards, all for articulation with the talus. Between these facets the bone is rough for ligamentous attachment.

The *superior surface* is joined to the tuber calcanei.

The *lateral surface* is continuous above with the corresponding surface of the tuber whilst below it is roughened for ligamentous attachment.

The *medial surface* bears posteriorly the sustentaculum tali. Below and in front of the sustentaculum it is irregular and depressed for ligamentous attachment, except at its lowest point where there is a semicircular facet for articulation with the talus.

The *inferior surface* carries an elongated facet, sometimes divided into two parts, for articulation with the cuboid.

The *posterior surface* is roughened and is continuous with the posterior border of the tuber.

The **tuber calcanei** is a massive projection which corresponds to the heel of the human subject. The process is flattened from side to side, presenting a *lateral surface* which is nearly plane, and a *medial surface* which is less extensive, and concave, forming the lateral boundary of the groove along which the tendon of the deep flexor of the digit passes behind the hock joint.

The *anterior border* of the tuber is short, rounded, and slightly concave in its length.

The *posterior border* is longer, thicker and nearly straight, and in the recent state the calcaneo-metatarsal ligament is attached to it.

The *upper extremity* of the tuber forms the so-called **point of the hock.** It is slightly expanded and shows posteriorly a smooth,

[1] Formerly known as the os calcis.

convex area over which the tendon of the superficial flexor of the digit plays. In front of this lies a depressed mark for the insertion of the gastrocnemius tendon, while still more anteriorly the bone shows a small convex area on which this tendon rests during extreme flexion of the hock joint. On either side of the summit are roughened markings to which are attached the tendons of the biceps femoris and semitendinosus together with slips from the tendon of the superficial flexor of the digit.

The *lower extremity* is joined to the body.

The **sustentaculum tali** is much smaller than the tuber and it projects medially from the body. It carries an oblique facet on its lower and anterior aspect for articulation with a similar facet on the posterior surface of the talus, while posteriorly it shows a broad smooth groove over which plays the tendon of the deep flexor of the digit. It is joined laterally to the body of the bone, whilst its medial extremity is free and roughened for the attachment of fibres of the medial collateral ligament of the hock joint.

The calcaneum articulates with two bones, viz. the talus and cuboid.

The Scaphoid

This bone, also called the **central tarsal bone,** is flattened in shape, having two surfaces and four borders.

The *upper surface* is slightly concave from before to behind and is smooth for articulation with the talus.[1] It possesses a non-articular groove which begins about the centre and is directed to the lateral border.

The *lower surface* is slightly convex, and for the most part smooth. It articulates with the small cuneiform by a narrow convex facet at its postero-medial corner, and for the remainder of its extent by two facets (sometimes continuous with one another laterally) with the large cuneiform. A non-articular groove runs between the last-mentioned facets of this surface, affording attachment to an interosseous ligament.

The *anterior* and *medial borders,* which are not distinctly separated, are convex and rough.

The *posterior border* is notched and irregular.

The *lateral border* is concave and provided with two facets, one in front and one behind, for articulation with the cuboid.

The scaphoid articulates with four bones, viz. the talus, cuboid, and the two cuneiform bones.

[1] There is often a small facet posteriorly for articulation with the lower surface of the sustentaculum tali.

The Large Cuneiform[1]

This bone, also termed the **third tarsal bone,** is somewhat similar in shape to the scaphoid, but it is more triangular in outline, and smaller. It presents two surfaces and three borders.

The *upper surface* is slightly concave and is divided into two unequal facets by a transverse non-articular groove. (Occasionally the facets are continuous with one another laterally.) The surface articulates with the scaphoid.

The *lower surface* is very slightly convex. It presents a non-articular groove which usually runs quite across the surface, dividing it into a larger anterior and a smaller posterior facet for articulation with the large metatarsal bone. Occasionally these facets are continuous medially. A small additional facet may be present postero-medially for the medial small metatarsal bone.

The *anterior border*, forming the base of the triangle, is convex, rough, and non-articular.

The *lateral border* is concave, and furnished with two facets, one in front and one behind, for articulation with the cuboid.

The *medial border,* slightly more concave than the lateral, has one facet for articulation with the small cuneiform bone.

The large cuneiform usually articulates with four bones, viz. the scaphoid, small cuneiform, cuboid, and large metatarsal bone. It may also articulate with the medial small metatarsal bone.

The Small Cuneiform

This is much the smallest of the bones of the tarsus. It is formed by the fusion of two embryonic elements corresponding to the medial and intermediate cuneiforms, or **first** and **second tarsal bones,** of the pig and dog. Occasionally the two bones remain distinct. The bone is very irregular in shape, but it may be described as possessing two surfaces, two borders, a base and an apex.

The *medial surface* faces medially and backwards. It is narrow anteriorly and rough for ligamentous attachment. Behind this it becomes wider, and it shows a smooth area over which the cunean tendon of the deep division of the flexor tarsi muscle plays to become inserted into a roughened area posteriorly.

The *lateral surface* is irregular and bears a backwardly projecting nodule.

The *superior border* carries a narrow, concave facet for articulation with the scaphoid.

[1] Also known as the lateral cuneiform.

The *inferior border* bears a small flat facet anteriorly for articulation with the large metatarsal, and immediately behind this a larger concave facet [1] for the medial small metatarsal bone.

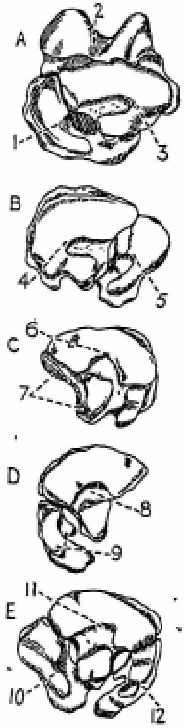


FIG. 137.—ARTICULAR SURFACES OF BONES OF RIGHT TARSUS OF HORSE (A. INFERIOR VIEW OF CALCANEUM AND TALUS. B. SUPERIOR VIEW OF SCAPHOID AND CUBOID. C. INFERIOR VIEW OF SCAPHOID. D. SUPERIOR VIEW OF SMALL CUNEIFORM AND LARGE CUNEIFORM. E. INFERIOR VIEW OF CUBOID, LARGE CUNEIFORM AND SMALL CUNEIFORM)
1. Inferior surface of calcaneum. 2. Anterior surface of talus. 3. Inferior surface of talus. 4. Superior surface of scaphoid. 5. Superior surface of cuboid. 6. Inferior surface of scaphoid. 7. Facets for cuboid on lateral border of scaphoid. 8. Superior surface of large cuneiform. 9. Superior surface of small cuneiform. 10. Inferior surface of cuboid. 11. Inferior surface of large cuneiform. 12. Inferior surface of small cuneiform.

The *base* is rounded, non-articular, and produced inferiorly into a nodular projection.

The *apex*, placed in front, carries a small facet antero-laterally for articulation with the large cuneiform.

The small cuneiform articulates with four bones, viz. the scaphoid, large cuneiform, large metatarsal and medial small metatarsal bone.

The Cuboid

Also known as the **fourth tarsal bone,** the cuboid has the most regular shape of all the tarsal bones. It is a six-sided bone, in shape not unlike a brick.

The *superior surface* is slightly convex and smooth for articulation with the talus medially and the calcaneum laterally.

[1] This is often represented by two facets.

The *inferior surface* carries two facets, the larger lateral facet articulating with the lateral small metatarsal bone, while the smaller facet, situated antero-medially, articulates with the large metatarsal bone. Occasionally the posterior portion of the lateral facet is cut off from the broad anterior portion by a non-articular depression, and it has a small area of contact with the large metatarsal bone medially.

The *medial surface* is articulated to the scaphoid and large cuneiform by four facets, two for each bone, one in front and one behind, in each case. The remainder of the surface is rough and non-articular, and it is provided with an antero-posterior groove, which in the articulated tarsus forms, with the opposed scaphoid and large cuneiform bones, a canal for the passage of the perforating tarsal artery and an accompanying vein.

The *lateral, anterior* and *posterior surfaces* are rough and non-articular.

The cuboid articulates with six bones, viz. the talus, calcaneum, scaphoid, large cuneiform, large metatarsal and lateral small metatarsal bones.

The Metatarsus

In its most complete form the mammalian metatarsus contains five bones, corresponding to the five bones of the metacarpus. Such is the case, for example, in the human foot. In the horse, however, the most lateral and medial bones are entirely suppressed, and of the remaining three only the central one is fully developed and carries a digit, the other two being slender and bearing no digits. These three bones are named respectively the **large metatarsal,** and the **lateral** and **medial small metatarsal bones.**

The Large Metatarsal Bone

This bone, which represents the **third metatarsal bone** of a pentadactyl species, is a long bone, and it extends in a nearly vertical direction between the hock and fetlock joints. In form it closely resembles the large metacarpal, but it is easily distinguished from that bone by its greater length, and the more regularly cylindrical character of its shaft. The shaft is narrowest in its middle, and slightly expanded at its extremities, and, although nearly circular in transverse section, it may, for purposes of description, be said to present four surfaces.

The *anterior surface* is convex and smooth, and it passes insensibly on either side into the lateral and medial surfaces, which are also smooth and rounded from side to side.

The *lateral surface* shows a faint groove which begins at its upper end and crosses it very obliquely downwards and backwards to reach the line of apposition of this bone with the lateral small metatarsal, disappearing about the middle of the large bone. This groove marks the course of the large, or lateral dorsal, metatarsal artery.

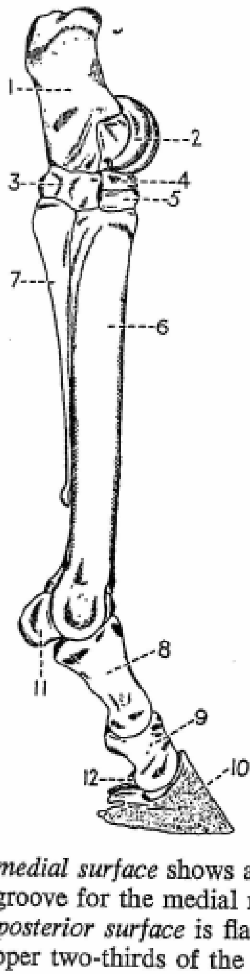


FIG. 138.—RIGHT PES OF HORSE (LATERAL VIEW)

1. Calcaneum. 2. Talus. 3. Cuboid. 4. Scaphoid. 5. Large cuneiform. 6. Large metatarsal bone. 7. Lateral small metatarsal bone. 8. First phalanx. 9. Second phalanx. 10. Third phalanx. 11. Metatarso-phalangeal sesamoid bone. 12. Navicular bone.

The *medial surface* shows at its upper end a shorter and fainter oblique groove for the medial metatarsal vein.

The *posterior surface* is flattened. At each side of this surface, in the upper two-thirds of the bone, there is a narrow rough area, slightly widening as it ascends, for the attachment of the interosseous ligament uniting this bone to the corresponding small metatarsal bone. Between these areas the bone is smooth, forming with the small metatarsal bones a channel for the suspensory ligament of the fetlock joint. The lower third of this surface is smooth. The

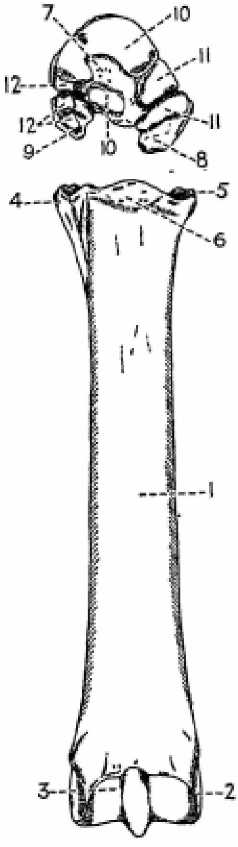


FIG. 139.—RIGHT METATARSAL BONES OF HORSE (ANTERIOR VIEW, WITH VIEW OF SUPERIOR EXTREMITY)

1. Anterior surface of shaft of large metatarsal bone. 2. Medial depression at inferior extremity of large metatarsal bone. 3. Lower articular surface of large metatarsal bone. 4. Upper extremity of lateral small metatarsal bone. 5. Upper extremity of medial small metatarsal bone. 6. Area for insertion of flexor tarsi. 7. Upper extremity of large metatarsal bone. 8. Upper extremity of lateral small metatarsal bone. 9. Upper extremity of medial small metatarsal bone. 10. Facets for large cuneiform. 11. Facets for cuboid. 12. Facets for small cuneiform.

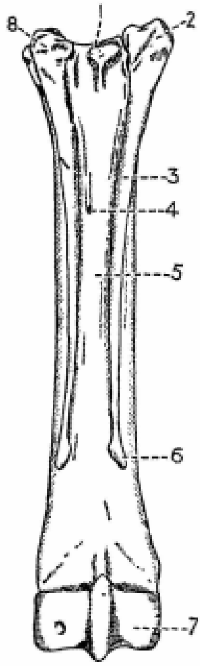


FIG. 140.—RIGHT METATARSAL BONES OF HORSE (POSTERIOR VIEW)

1. Upper extremity of large metatarsal bone. 2. Upper extremity of lateral small metatarsal bone. 3. Shaft of lateral small metatarsal bone. 4. Nutrient foramen of large metatarsal bone. 5. Posterior surface of shaft of large metatarsal bone. 6. Lower extremity of lateral small metatarsal bone. 7. Lower articular surface of large metatarsal bone. 8. Upper extremity of medial small metatarsal bone.

nutrient foramen of the bone lies on this surface about the junction of its upper and middle thirds.

The *upper extremity* presents an articular surface for the lower tarsal bones. Laterally this surface shows a small facet for the cuboid. Occasionally a second, smaller, facet for the cuboid lies posteriorly, separated from the anterior facet by a non-articular groove which extends medially towards the middle of the surface. At its postero-medial corner the surface carries a very small facet for the small cuneiform bone. The remaining part of this surface articulates with the large cuneiform bone, the area being usually divided into unequal anterior and posterior parts by a non-articular depression. On the posterior aspect of the upper extremity there are four small facets in pairs, two on each side, these being for articulation with the heads of the small metatarsal bones. On the front of this extremity, but more medially than laterally, a rough semi-circular ridge serves for the insertion of the flexor tarsi muscle.

The *lower extremity* differs from the corresponding area of the large metacarpal bone only in being larger, both in its transverse and its antero-posterior diameter. It articulates with the first phalanx and the proximal sesamoid bones.

The Small Metatarsal Bones

These bones, which may also be termed the **second** and the **fourth metatarsal bones,** closely resemble the corresponding bones of the fore limb. They are, however, longer, and their upper extremities are more massive. The lateral (fourth) bone is the larger of the two, particularly in respect of its head, which is provided with two facets in front for the large metatarsal bone, and one or two above for the cuboid. The head of the medial (second) bone has similarly two facets in front for the large metatarsal bone and one or two above for the small cuneiform bone. Sometimes a third facet occurs here for the large cuneiform bone.

The Metatarso-Phalangeal Sesamoid Bones

In the hind limb these bones are slightly smaller than the corresponding bones of the fore limb.

The Digit

The typical mammalian pes possesses five digits or toes, as is exemplified in the human foot. The toes are distinguished by the numerals one to five, the most medial toe, or **hallux,** which corresponds to the thumb, being the first. The horse, however, possesses but one hind digit or toe, viz. the homologue of man's middle toe. The bones of this digit are the same in number and names as those of the fore digit already described, and their resemblance to the latter is so close as to make a detailed description of them unnecessary.

The **first phalanx** is shorter, wider above, and narrower below than the corresponding bone of the fore limb. The **second phalanx** is longer and has a shorter transverse diameter. The **third phalanx,** when viewed from its inferior aspect, is more pointed at the toe, and the inferior surface is more concave or vaulted. The **navicular,** or **distal sesamoid, bone** is shorter and narrower.

THE DEVELOPMENT OF THE BONES OF THE HIND LIMB

The bones of the hind limb are formed, as in the case of the fore limb, from a mass of mesenchyme extending into the hind limb bud. Areas of chondrification develop later, and in these certain centres of ossification appear which will result in the formation of the bony skeleton.

The **hip bone** develops from an oval plate of cartilage situated laterally to the vertebral column in the sacral region. At first the long axis of this plate lies at right angles to that of the vertebrae, but as the embryo grows the direction of the plate changes, so that its long axis becomes directed downwards and backwards, its antero-superior extremity, however, retaining its connection with the first few sacral vertebrae. Three main centres of ossification appear in the cartilage, one anteriorly for the shaft of the ilium, and two posteriorly for the pubis and ischium. Two secondary centres develop later, one in the crest of the ilium and the other in the ischial tuberosity, while a third appears in the acetabulum, and this unites the three segments of the bone together. The obturator foramen occurs as a result of the failure of the medial part of the posterior end of the original dorsal element to become chondrified, the mesenchyme undergoing no further stage of development than a fibrous membrane which persists as the obturator membrane.

The **femur,** like other long bones, ossifies from three main centres, one for the shaft and one for either extremity. To these a fourth centre is added for the greater trochanter, and a fifth for the third trochanter.

The **patella** results from the ossification of a single cartilaginous mass which develops in the tendons of insertion of the quadriceps femoris muscle. It may be compared with the accessory bone of the carpus developed in the tendon of the ulnaris lateralis (or lateral flexor of the carpus) although, of course, the two bones are not homologous.

The **tibia** possesses the three main centres of ossification common to long bones and also one subsidiary centre for the tuberosity at the upper extremity. In the horse the tibia shows a further centre which is for the lateral malleolus. In reality, however, this malleolus represents the distal end of the fibula, which, although detached from the bony shaft of the fibula at birth, unites with the tibia some time later, the line of union of the two bones being evident on their articular surfaces even in old animals. Typically the **fibula** arises from three main centres, one for the shaft and one for each extremity, but this number is reduced according to the degree of development which the bone exhibits in the various species.

In the embryo the cartilaginous **tarsal** elements are arranged in two rows with an intervening central cartilage. From the upper row the talus and calcaneum develop. The former probably arises from two centres which fuse early, while the latter also develops from two centres, one for the main mass of the bone and one for the summit of the tuber. This portion of the calcaneum remains unossified to the body for more than a year after birth. The distal row possesses four cartilages. These give rise to the cuneiform bones and the cuboid. In the horse the small cuneiform bone represents the two most medial elements which have fused before birth. Occasionally the fusion of the pieces resulting from these two centres does not take place, and the horse then possesses three distinct and separate cuneiform bones as in man or the dog. In the ox and sheep the large cuneiform results from the fusion of the intermediate and lateral elements, and the small cuneiform represents the medial element. The central cartilage of the embryo ossifies from a single centre into the scaphoid bone.

The development of the remaining bones of the hind limb generally resembles that of the corresponding bones of the fore limb.

THE BONES OF THE HIND LIMB OF THE OX

Hip Bone.—The gluteal surface of the ilium shows a faint longitudinal ridge in its lower part. The coxal tuberosity is compounded of three eminences, the ischial border of the bone is more concave, and the superior ischial spine is more elevated. A groove is present on the under surface of the pubic bone, but, unlike the subpubic groove of the horse, it does not extend into the cotyloid cavity. The gap in the rim of this cavity is much smaller than in the horse, and the rim is cut anteriorly by a small notch or a complete foramen. The ischial tuberosity has the form of a large trifid process, and a strong curved muscular ridge is carried by the inferior surface of the ischium. The obturator foramina are very large. The pubic and ischial bones of opposite sides join at a more acute angle than in the horse, and the pelvic floor is thus more basin-like. In the adult animal a strong bony ridge is

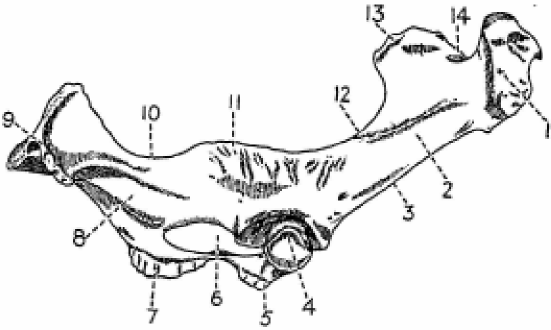


FIG. 141.—RIGHT HIP BONE OF OX (LATERAL VIEW)
1. Coxal tuberosity. 2. Gluteal surface of ilium. 3. Cotyloid border of ilium. 4. Cotyloid cavity. 5. Ridge on inferior aspect of pubic symphysis. 6. Obturator foramen. 7. Ridge on inferior aspect of ischial symphysis. 8. Inferior surface of ischium. 9. Ischial tuberosity. 10. Lateral border of ischium. 11. Superior ischial spine. 12. Ischial border of ilium. 13. Sacral tuberosity. 14. Crest of ilium.

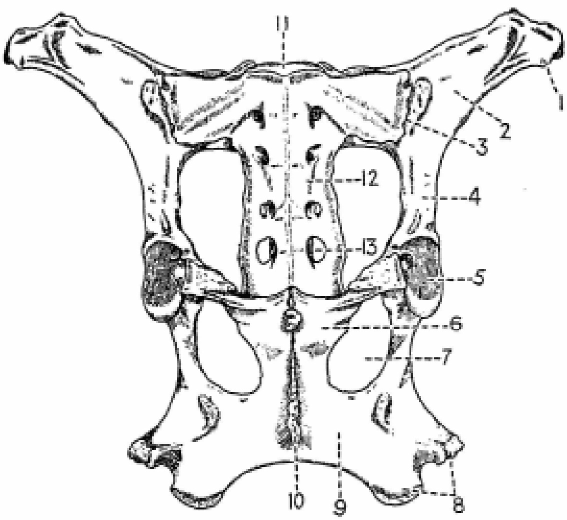


FIG. 142.—PELVIC BONE AND SACRUM OF OX (VIEWED FROM BELOW)
1. Coxal tuberosity. 2. Iliac surface of ilium. 3. Sacro-iliac joint. 4. Shaft of ilium. 5. Cotyloid cavity. 6. Inferior surface of pubis. 7. Obturator foramen. 8. Ischial tuberosity. 9. Inferior surface of ischium. 10. Ridge on inferior aspect of ischio-pubic symphysis. 11. Anterior extremity of first sacral vertebra. 12. Inferior surface of sacrum. 13. Inferior sacral foramen.

developed on the under aspect of the ischio-pubic symphysis. Each half of this ridge has a separate centre of ossification.

Femur.—The shaft is less massive, the posterior surface is narrower than in the horse, and the third trochanter is absent. The lesser trochanter is

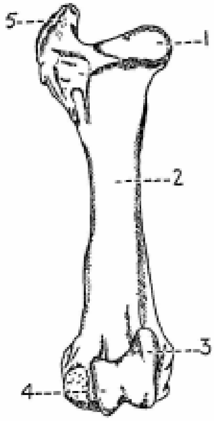


FIG. 143.—RIGHT FEMUR OF OX (ANTERIOR ASPECT)

1. Head. 2. Anterior surface of shaft. 3. Medial lip of trochlea. 4. Lateral lip of trochlea. 5. Greater trochanter.

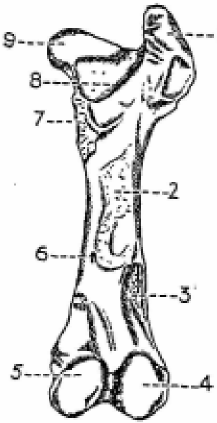


FIG. 144.—RIGHT FEMUR OF OX (POSTERIOR ASPECT)

1. Greater trochanter. 2. Area for insertion of adductors. 3. Supracondylar fossa. 4. Lateral condyle. 5. Medial condyle. 6. Nutrient foramen. 7. Lesser trochanter. 8. Trochanteric fossa. 9. Head.

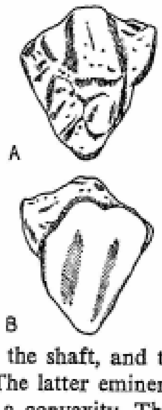


FIG. 145.—RIGHT PATELLA OF OX (A. ANTERIOR ASPECT. B. POSTERIOR ASPECT)

higher upon the shaft, and the trochanteric crest connects it to the greater trochanter. The latter eminence is very massive, but it is not divided into a summit and a convexity. The head is smaller and more spherical, and the neck is better marked. The fovea for the attachment of the round ligament is shallow and almost centrally placed on the head. The supracondylar fossa is much shallower than in the horse. As in the latter animal the medial lip of the femoral trochlea is much more prominent than the lateral lip.

Patella.—This bone is narrower and more pointed below than in the horse.

Tibia.—In the ox this bone is proportionally shorter than in the horse, and the muscular ridges on the posterior surface are fewer in number, but they extend further upwards. The tuberosity of the upper extremity is devoid of a groove. The lateral condyle carries no facet for the head of the fibula. The notch between the lateral condyle and the tuberosity is much narrower than in the horse. The grooves of the lower articular surface have an antero-posterior direction and the lateral malleolus is altogether separate from this bone.

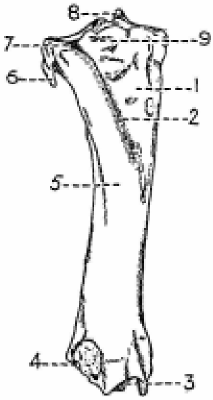


FIG. 146.—RIGHT TIBIA OF OX, WITH SUPERIOR EXTREMITY OF FIBULA (ANTERIOR VIEW)

1. Medial surface of shaft of tibia. 2. Tibial crest. 3. Inferior articular surface of tibia. 4. Area for articulation with lateral malleolus. 5. Lateral surface of shaft of tibia. 6. Superior extremity of fibula. 7. Notch for common tendon of extensor digitorum longus and peroneus tertius. 8. Tibial spine. 9. Tuberosity of tibia.

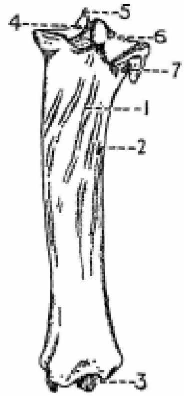


FIG. 147.—RIGHT TIBIA OF OX, WITH SUPERIOR EXTREMITY OF FIBULA (POSTERIOR VIEW)

1. Lines for origin of deep digital flexor. 2. Nutrient foramen of tibia. 3. Inferior articular surface of tibia. 4. Medial condyle of tibia. 5. Tibial spine. 6. Lateral condyle of tibia. 7. Superior extremity of fibula.

FIG. 148.—RIGHT LATERAL MALLEOLUS OF OX (A. LATERAL ASPECT. B. MEDIAL ASPECT)

1. Superior articular surface for tibia. 2. Inferior articular surface for calcaneum. 3. Medial articular surface for talus.

Fibula.—This bone is even more rudimentary than in the horse. In the young adult its shaft and upper extremity are represented by a fibrous cord extending between the lateral condyle of the upper end of the tibia and the lateral malleolus. The latter process is ossified as a separate bone, articulating with the talus, calcaneum and tibia. In the middle-aged subject the upper extremity of the fibula is also generally ossified, but anchylosed to the tibia.

Tarsus.—Only five bones are present in the tarsus of the ox, viz. the talus, calcaneum, two cuneiforms and a bone representing the combined scaphoid and cuboid bones of the horse. The pulley-like surface by which the talus is articulated to the tibia is vertically grooved. The lower surface of the talus is in the form of a trochlea for articulation with the scapho-cuboid. The tuber calcanei is longer and more slender than in the horse, and its upper extremity is grooved for the passage of the tendon of the superficial digital flexor. The scapho-cuboid bone extends completely across the

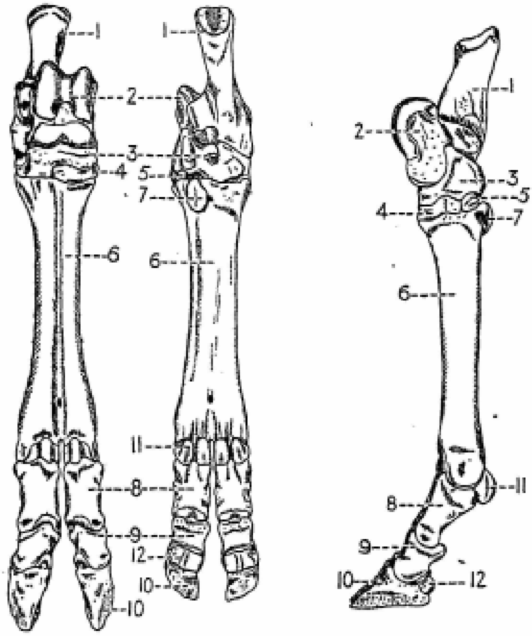


FIG. 149.—RIGHT PES OF OX (ANTERIOR VIEW)

FIG. 150.—RIGHT PES OF OX (POSTERIOR VIEW)

FIG. 151.—RIGHT PES OF OX (MEDIAL VIEW)

1. Calcaneum. 2. Talus. 3. Scapho-cuboid. 4. Large cuneiform. 5. Small cuneiform. 6. Large metatarsal bone. 7. Small metatarsal bone. 8. First phalanx. 9. Second phalanx. 10. Third phalanx. 11. Metatarso-phalangeal sesamoid bone. 12. Distal sesamoid bone.

(The smaller digits are not represented).

tarsus, and it contracts articulation with all the other bones. Of the two cuneiform bones the larger and more lateral represents the fused lateral and intermediate cuneiforms of the typical mammalian tarsus, while the smaller bone corresponds to the medial cuneiform bone of such a tarsus. The large bone is flattened from above to below, the small bone is round.

Metatarsus.—The ox possesses a large metatarsal bone representing the combined third and fourth metatarsal bones of the human foot, and a small flattened bone, somewhat four-sided in outline, placed like a sesamoid bone at the back of the upper end of the large bone and medially. This rudimentary bone may possibly represent the second metatarsal bone. The large bone is somewhat similar to the corresponding bone of the fore extremity, but it is longer and its shaft is distinctly four-sided. A vascular canal extends through the bone from the upper extremity to open below on the upper part of the posterior surface. In the foetus the third and fourth metatarsal bones are distinct and separate, and in the adult animal indications of their former independence are seen in mesial furrows on the anterior and posterior surfaces of the shaft and a longitudinal septum of the medullary cavity. Towards the lower extremity these grooves are connected by a canal running through the substance of the bone.

Digits.—The digital region of the hind limb presents the closest correspondence with the same segments of the fore extremity.

THE BONES OF THE HIND LIMB OF THE SHEEP

Hip Bone.—The gluteal surface of the ilium has a longitudinal ridge as in the ox. The long axes of the ilium and ischium form a nearly straight line. The crest is longer and more convex than in the larger ruminant, the coxal tuberosity is less massive and the superior ischial spine is less elevated. Anchylosis of the symphysis is late in occurring. In other respects the bone resembles that of the ox.

Femur.—The greater trochanter is on a level with the head, the supracondylar fossa is very shallow, the crests of the same name are scarcely observable, and the lips of the trochlea are of nearly equal prominence.

Tibia.—The tibia is relatively longer than in the ox and its shaft is more rounded.

Fibula.—This bone is represented by a small projection on the lateral condyle of the tibia and by the lateral malleolus. No shaft is developed.

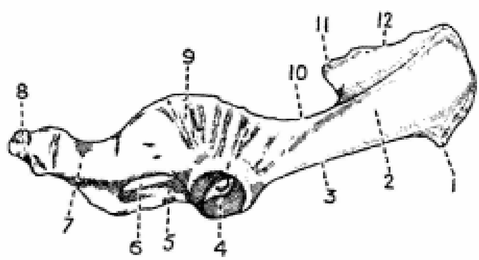
Pes.—The skeleton of this region is similar to that of the large ruminant, but the rudimentary digits are either destitute of a skeleton or possess only a single ossicle.

THE BONES OF THE HIND LIMB OF THE PIG

Hip Bone.—The gluteal surface of the ilium is traversed by a ridge extending between the crest and the superior ischial spine, and on either side

FIG. 152.—RIGHT HIP BONE OF PIG (LATERAL VIEW)

1. Coxal tuberosity. 2. Gluteal surface of ilium. 3. Cotyloid border of ilium. 4. Cotyloid cavity. 5. Inferior surface of pubis. 6. Obturator foramen. 7. Inferior surface of ischium. 8. Ischial tuberosity. 9. Superior ischial spine. 10. Ischial border of ilium. 11. Sacral tuberosity. 12. Crest of ilium.



of this ridge the surface is distinctly concave. The crest is long and markedly convex, and the coxal tuberosity is undivided. The superior ischial spine is elevated and provided laterally with prominent muscular ridges. The long axis of the ilium is almost in the same straight line as that of the ischium.

The inferior ischial spine has the form of a rounded tubercle. The sub-pubic groove is absent. The cotyloid cavity is very similar to that of the ruminant, but it is proportionally deeper. Anchylosis does not usually take place at the ischio-pubic symphysis.

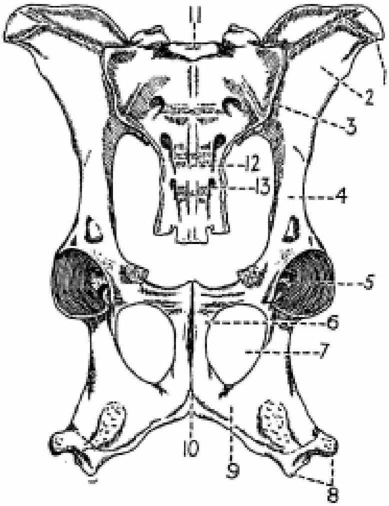


FIG. 153.—PELVIC BONE AND SACRUM OF PIG (VIEWED FROM BELOW)

1. Coxal tuberosity. 2. Iliac surface of ilium. 3. Sacro-iliac joint. 4. Shaft of ilium. 5. Cotyloid cavity. 6. Inferior surface of pubis. 7. Obturator foramen. 8. Ischial tuberosity. 9. Inferior surface of ischium. 10. Ischio-pubic symphysis. 11. Anterior extremity of sacrum. 12. Inferior surface of sacrum. 13. Inferior sacral foramen.

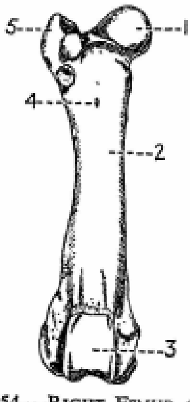


FIG. 154.—RIGHT FEMUR OF PIG (ANTERIOR ASPECT)

1. Head. 2. Anterior surface of shaft. 3. Trochlea. 4. Nutrient foramen. 5. Greater trochanter.

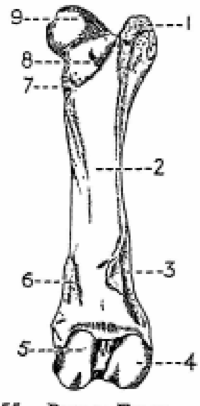


FIG. 155.—RIGHT FEMUR OF PIG (POSTERIOR ASPECT)

1. Greater trochanter. 2. Posterior surface of shaft. 3. Supracondylar fossa. 4. Lateral condyle. 5. Medial condyle. 6. Medial supracondylar crest. 7. Lesser trochanter, 8. Trochanteric fossa. 9. Head.

Femur.—The femur of the pig is proportionally longer than in the horse. The shaft is very similar to that of the ruminant, the third trochanter being absent, and the posterior surface narrower than in the horse. The lesser trochanter is near the upper end of the bone. The greater trochanter is undivided, and its highest point is almost on a level with the head. The latter is more spherical than in the horse and its fovea is small. The neck is very much better marked than in the horse or the ruminants. The trochanteric

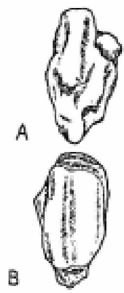


FIG. 156.—RIGHT PATELLA OF PIG (A. ANTERIOR ASPECT. B. POSTERIOR ASPECT)

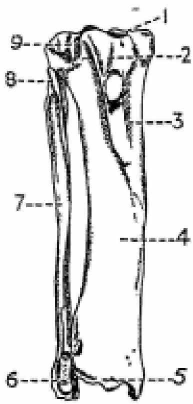


FIG. 157.—RIGHT TIBIA AND FIBULA OF PIG (ANTERIOR VIEW)

1. Medial condyle of tibia. 2. Tuberosity of tibia. 3. Medial surface of shaft of tibia. 4. Lateral surface of shaft of tibia. 5. Inferior extremity of tibia. 6. Inferior extremity of fibula. 7. Shaft of fibula. 8. Superior extremity of fibula. 9. Notch for common tendon of extensor digitorum longus and peroneus tertius.

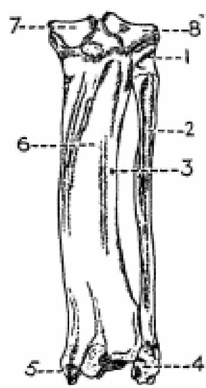


FIG. 158.—RIGHT TIBIA AND FIBULA OF PIG (POSTERIOR VIEW)

1. Superior extremity of fibula. 2. Shaft of fibula. 3. Nutrient foramen of tibia. 4. Inferior extremity of fibula. 5. Inferior extremity of tibia. 6. Posterior surface of shaft of tibia. 7. Medial condyle of tibia. 8. Lateral condyle of tibia.

crest is oblique. The supracondylar fossa is shallow, and the medial supracondylar crest is poorly developed. The lips of the femoral trochlea are of nearly equal prominence.

Patella.—This bone is longer and narrower than in the horse.

Tibia.—This bone is very similar to the tibia of the ruminant. Its posterior surface is almost smooth. The tuberosity at the upper extremity has a shallow vertical furrow, and the articular grooves of the lower extremity are antero-posterior in direction.

Fibula.—The fibula of the pig is completely ossified throughout its whole extent. Its upper extremity, or head, articulates with the lateral condyle of the tibia in the same manner as in the horse. Its lower extremity, the lateral malleolus, is movably articulated to the talus and to the lateral

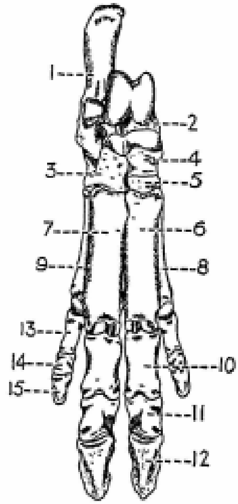


FIG. 159.—RIGHT PES OF PIG (ANTERIOR VIEW)

1. Calcaneum. 2. Talus. 3. Cuboid. 4. Scaphoid. 5. Lateral cuneiform. 6-7. Axial metatarsal bones. 8-9. Abaxial metatarsal bones. 10-12. First, second and third phalanges of axial digit. 13-15. First, second and third phalanges of abaxial digit.

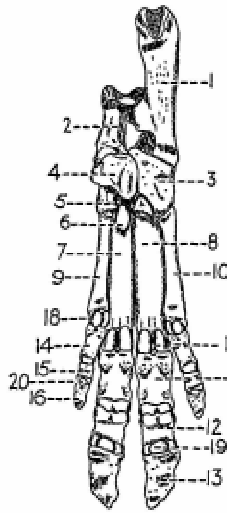


FIG. 160.—RIGHT PES OF PIG (POSTERIOR VIEW)

1. Calcaneum. 2. Talus. 3. Cuboid. 4. Scaphoid. 5. Medial cuneiform. 6. Subtarsal sesamoid bone. 7-8. Axial metatarsal bones. 9-10. Abaxial metatarsal bones. 11-13. First, second and third phalanges of axial digit. 14-16. First, second and third phalanges of abaxial digit. 17-18. Metatarso-phalangeal sesamoid bones. 19-20. Distal sesamoid bones.

aspect of the lower end of the tibia. The shaft of the bone is thin, and markedly concave in the upper half of its lateral surface, and it has a sharp anterior and a thicker posterior border. Between the opposed shafts of the leg bones a wide interosseous space is left.

Tarsus.—Seven bones are present in the tarsus of the pig, viz. the talus, calcaneum, scaphoid, cuboid and three cuneiform bones. The talus and calcaneum are very similar to the corresponding bones of the ox. The lower articular surface of the talus has the form of a double trochlea for articulation with the scaphoid and cuboid. The cuboid is relatively large, and it articulates with the two most lateral metatarsal bones. The three cuneiforms are distinguished as lateral, intermediate and medial. The first of these is much the largest, and it articulates with the more medial, i.e. the third, of the two large metatarsal bones. The intermediate cuneiform, which is much the smallest of the three, articulates with the two most medial metatarsals. The medial cuneiform also articulates with the two most medial metatarsal bones.

Metatarsus.—The pig possesses four metatarsal bones, resembling very

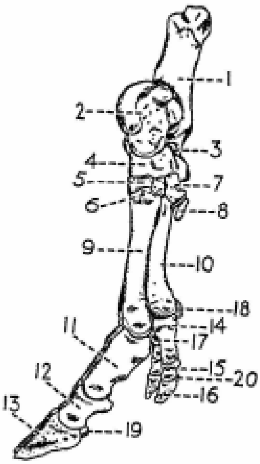


FIG. 161.—RIGHT PES OF PIG (MEDIAL VIEW)

1. Calcaneum. 2. Talus. 3. Cuboid. 4. Scaphoid. 5. Lateral cuneiform. 6. Intermediate cuneiform. 7. Medial cuneiform. 8. Subtarsal sesamoid bone. 9. Axial metatarsal bone. 10. Abaxial metatarsal bone. 11-13. First, second and third phalanges of axial digit. 14-16. First, second and third phalanges of abaxial digit. 17-18. Metatarso-phalangeal sesamoid bones. 19-20. Distal sesamoid bones.

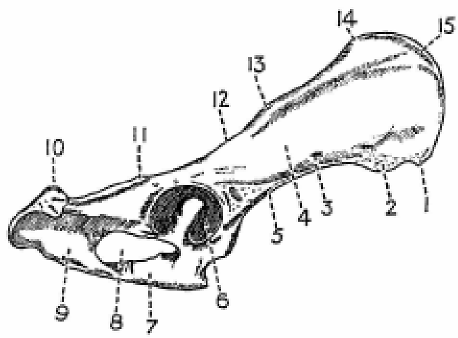


FIG. 162.—RIGHT HIP BONE OF DOG (LATERAL VIEW)

1-2. Anterior and posterior divisions of coxal tuberosity. 3. Nutrient foramen. 4. Gluteal surface of ilium. 5. Cotyloid border of ilium. 6. Cotyloid cavity. 7. Inferior surface of pubis. 8. Obturator foramen. 9. Inferior surface of ischium. 10. Ischial tuberosity. 11. Superior ischial spine. 12. Ischial border of ilium. 13-14. Posterior and anterior divisions of sacral tuberosity. 15. Crest of ilium.

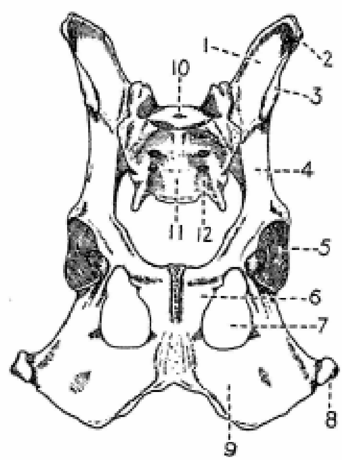


FIG. 163.—PELVIC BONE AND SACRUM OF DOG (VIEWED FROM BELOW)

1. Iliac surface of ilium. 2-3. Anterior and posterior divisions of coxal tuberosity. 4. Shaft of ilium. 5. Cotyloid cavity. 6. Inferior surface of pubis. 7. Obturator foramen. 8. Ischial tuberosity. 9. Inferior surface of ischium. 10. Anterior extremity of sacrum. 11. Inferior surface of sacrum. 12. Inferior sacral foramen.

closely the corresponding bones of the fore extremity. The axial pair, i.e. the third and fourth bones, are about equal in size, and much larger than the other two. The latter, the second and fifth, are placed one behind each of the larger pair. A sesamoid bone articulated behind the upper end of the medial large metatarsal bone is sometimes regarded as a rudiment of the metatarsal bone of the first digit.

Digits.—Four digits are present in the foot of the pig. These are homologous with the second, third, fourth and fifth toes of the human foot, but the great toe, the first, is entirely suppressed in the pig. All the bones of this region present the closest resemblance to the corresponding bones of the fore limb.

THE BONES OF THE HIND LIMB OF THE DOG

Hip Bone.—The gluteal surface of the ilium is deeply depressed. The crest is very convex, and the sacral tuberosity is represented by a ridge

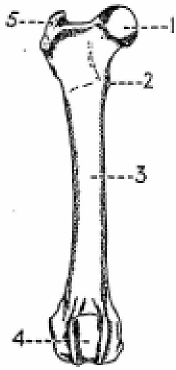


FIG. 164.—RIGHT FEMUR OF DOG (ANTERIOR ASPECT)

1. Head. 2. Lesser trochanter. 3. Anterior surface of shaft. 4. Trochlea. 5. Greater trochanter.

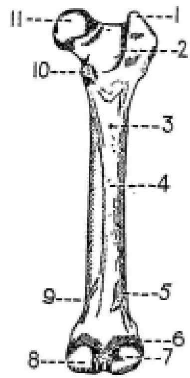


FIG. 165.—RIGHT FEMUR OF DOG (POSTERIOR ASPECT)

1. Greater trochanter. 2. Trochanteric fossa. 3. Nutrient foramen. 4. Posterior surface of shaft. 5. Lateral supracondylar crest. 6. Facet for fabella. 7. Lateral condyle. 8. Medial condyle. 9. Medial supracondylar crest. 10. Lesser trochanter. 11. Head.

carrying two widely separated prominences.[1] The coxal tuberosity similarly carries an upper and a lower eminence.[2] The superior ischial spine is less elevated than in the larger animals. The ilium and ischium join at a more open angle than in the horse. The subpubic groove is absent. The ischial tuberosity is undivided. The cotyloid cavity is deep. The ischial arch is of

[1] The posterior superior and posterior inferior iliac spines of human anatomy.

[2] The anterior superior and anterior inferior iliac spines of human anatomy.

small extent. The transverse diameter of the pelvis is much greater behind than in front. Anchylosis at the ischio-pubic symphysis is later in occurring than in the horse.

Femur.—This bone is proportionally of much greater length than in the larger domestic animals, and its shaft is more curved. The posterior

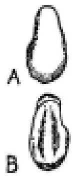


FIG. 166.—RIGHT PATELLA OF DOG (A. ANTERIOR ASPECT. B. POSTERIOR ASPECT)

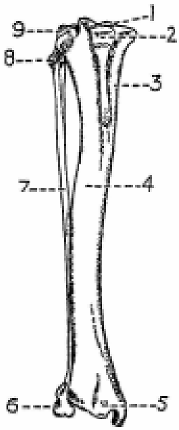


FIG. 167.—RIGHT TIBIA AND FIBULA OF DOG (ANTERIOR VIEW)

1. Medial condyle of tibia. 2. Tuberosity of tibia. 3. Medial surface of shaft of tibia. 4. Lateral surface of shaft of tibia. 5. Inferior extremity of tibia. 6. Inferior extremity of fibula. 7. Shaft of fibula. 8. Superior extremity of fibula. 9. Notch for tendon of extensor digitorum longus.

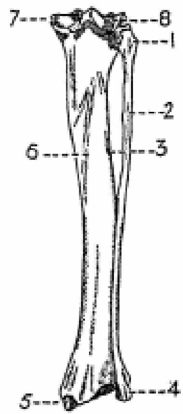


FIG. 168.—RIGHT TIBIA AND FIBULA OF DOG (POSTERIOR VIEW)

1. Superior extremity of fibula. 2. Shaft of fibula. 3. Nutrient foramen of tibia. 4. Inferior extremity of fibula. 5. Inferior extremity of tibia. 6. Posterior surface of shaft of tibia. 7. Medial condyle of tibia. 8. Lateral condyle of tibia.

surface is largely occupied by a roughened area, corresponding to the linea aspera of man, which affords attachment to the adductor femoris muscle and, on either side of this, the lateral and medial vasti muscles. The third trochanter is absent. The greater trochanter is small, undivided, and on a lower level than the head. The latter is more spherical than in the horse, its fovea is shallow, and the neck is well marked. The medial and lateral supracondylar crests are indistinct and the supracondylar fossa is absent. The lips of the trochlea are of equal height. On the posterior aspect of the lower extremity, immediately above each condyle, there is a circular flat facet for the **fabella.** Each fabella is a bony nodule, rather smaller than a pea, playing the part of a sesamoid to the corresponding tendon of origin of the gastrocnemius muscle.

Patella.—This bone is vertically elongated and narrower above than below.

Tibia.—The leg bones of the dog are very long. The lower part of the shaft of the tibia is more rounded than in the horse. The tuberosity of the upper end has no furrow, and the lateral malleolus does not form part of the lower extremity. The articular furrows of the latter are antero-posterior in direction.

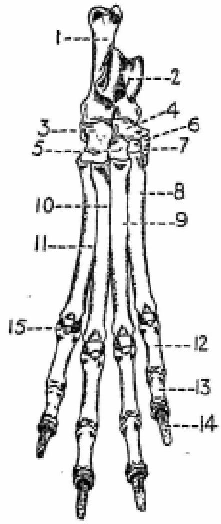


FIG. 169.—RIGHT PES OF DOG (ANTERIOR VIEW)

1. Calcaneum. 2. Talus. 3. Cuboid. 4. Scaphoid. 5. Lateral cuneiform. 6. Intermediate cuneiform. 7. Medial cuneiform. 8-11. Second to fifth metatarsal bones. 12-14. First, second and third phalanges of second digit. 15. Anterior sesamoid bone.

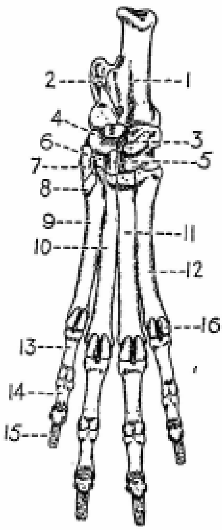


FIG. 170.—RIGHT PES OF DOG (POSTERIOR VIEW)

1. Calcaneum. 2. Talus. 3. Cuboid. 4. Scaphoid. 5. Lateral cuneiform. 6. Intermediate cuneiform. 7. Medial cuneiform. 8-12. First to fifth metatarsal bones. 13-15. First, second and third phalanges of second digit. 16. Metatarso-phalangeal sesamoid bone.

Fibula.—The fibula of the dog is long and slender. Its upper extremity is articulated to the tibia in the usual position, and its lower extremity furnishes the lateral malleolus, articulating with the tibia and talus. A wide interosseous space separates the shafts of the two bones in their upper half, but in the lower half of the leg the shafts are closely united by short interosseous fibres.

Tarsus.—Like the pig, the dog possesses seven tarsal bones. The upper end of the tuber calcanei is grooved. The lower articular surface of the talus is convex and is received into a cup-like cavity of the scaphoid. The cuboid is proportionally larger than in the horse, and it articulates with the two most lateral, i.e. the fourth and fifth, metatarsal bones. Of the three cuneiforms, the lateral is the largest and the intermediate the smallest. The medial bone articulates with the two most medial, i.e. the first and second, metatarsal bones, the intermediate with the second metatarsal, and the lateral with the second and third metatarsal bones.

Metatarsus.—The dog possesses five metatarsal bones corresponding to those of the human foot. The first, the most medial, of these is usually

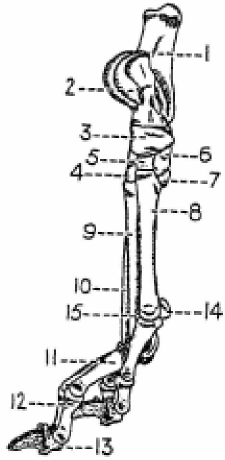


FIG. 171.—RIGHT PES OF DOG (MEDIAL VIEW)
1. Calcaneum. 2. Talus. 3. Scaphoid. 4. Lateral cuneiform. 5. Intermediate cuneiform. 6. Medial cuneiform. 7-10. First to fourth metatarsal bones. 11-13. First, second and third phalanges of third digit. 14. Metatarso-phalangeal sesamoid bone. 15. Anterior sesamoid bone.

in the form of a conical nodule but may show a greater degree of development when a first digit is present. The other four are well-developed long bones. The third and fourth are nearly equal in length, and somewhat longer than the second and fifth. In form and connections these four bones are very similar to the corresponding metacarpal bones.

Digits.—Four well-developed digits are constantly present in the hind foot of the dog. These correspond to the four lateral toes of the human foot. Each of them comprises bones almost identical in size and form with the corresponding bones of the anterior digits. The first (most medial) toe of the dog varies very greatly in its development. It may be absent, or represented by a single small bone connected by ligament to its metatarsal. In its maximum degree of development it possesses three perfect phalanges, resembling in form, but being one half smaller than, the phalanges of the other toes.

THE BONES OF THE HIND LIMB OF THE CAT

Hip Bone.—The shaft of the ilium is flatter and broader than in any of the other domestic animals, being almost of the same breadth and thickness throughout its length. The gluteal surface is depressed as in the dog and the iliac surface is almost suppressed. The auricular facet is near the middle of the length of the sacral surface. The superior ischial spine is slightly developed and the ischial arch is broad. The ischial tuberosity is rounded and devoid of a spine on its lower aspect. The obturator foramen is of great size, and anchylosis takes place only in rare cases at the ischio-pubic symphysis.

Femur.—The shaft is long, rounded, and devoid of a third trochanter. The head is nearly globular and set on to the shaft at almost a right angle. The neck is well marked. The markings for the attachment of muscles on

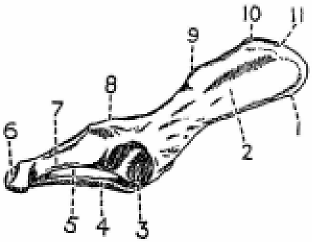


Fig. 172.—Right Hip Bone of Cat (lateral view)

1. Coxal tuberosity. 2. Gluteal surface of ilium. 3. Cotyloid cavity. 4. Inferior surface of pubis. 5. Obturator foramen. 6. Ischial tuberosity. 7. Inferior surface of ischium. 8. Superior ischial spine. 9-10. Posterior and anterior divisions of sacral tuberosity. 11. Crest of ilium.

the shaft, e.g. the supracondylar fossa and crests, are ill-defined. The lesser trochanter, however, is prominent. The trochlea is wide, and its lips are equal in prominence. Behind the lower extremity, and slightly removed from the condyles, two small pits serve for articulation with the fabellae.

Tibia and **Fibula.**—The leg bones of the cat are long. In the relative size of the two bones with regard to one another, and in their mode of union, they resemble closely the same bones of the dog. The lower extremity of the fibula is larger than the upper.

Pes.—The tarsus comprises seven bones very similar to those of the dog. There are four well-developed metatarsal bones and digits, but the first (most medial) is very rudimentary, and the corresponding digit is absent.

CHAPTER VII

THE SKELETON OF THE DOMESTIC FOWL

THE osseous tissue of the domestic fowl is, as in most birds, for the most part dense and close grained, and it is characterised chemically by the presence in it of a large proportion of calcium phosphate. Notwithstanding this the entire skeleton is light as compared with that of the mammal, owing to the fact that many of the bones in the adult bird contain air instead of marrow. The air, which is derived from the large air sacs in communication with the lungs, reaches the interior of the bones through openings known as **pneumatic foramina.**

THE VERTEBRAL COLUMN

The number of vertebrae in the spine of the common domestic fowl may be represented by the following formula: $\mathbf{C_{13-14}, T_7, L\text{-}S_{14}, C_{6-7}}$.

Cervical Vertebrae.—The cervical region is always long, curved, and freely movable in birds, and in the common fowl its skeleton is formed of thirteen or fourteen bones. The **atlas** is small and ring-like, and the **axis,** as in mammals, possesses an odontoid process. This process articulates with the single condyle of the occipital bone. In the succeeding bones the ends of the bodies are saddle-shaped, the anterior extremity being convex in the vertical and concave in the horizontal direction, while the posterior extremity has the converse configuration. In a number of the posterior bones the transverse process is prolonged downwards and backwards by a slender rod which has a special centre of ossification and is to be regarded as a **cervical rib** whose development has been arrested.

Thoracic Vertebrae.—In the fowl these vertebrae are seven in number. In the adult fowl the second to the fifth bones are generally anchylosed into a solid mass, and the seventh vertebra is also fused with the succeeding lumbar vertebrae.

Lumbo-Sacral Vertebrae.—The spine of the bird in the lumbar and sacral regions is composed of a group of anchylosed vertebrae to which the term **sacrum** is commonly applied. This portion of the spine includes not only the fourteen lumbo-sacral vertebrae, but in addition there are fused with it anteriorly and posteriorly the last thoracic and the first coccygeal vertebrae respectively. The composite sacrum is anchylosed for its entire length to the ilium on either side. The spines are well developed in the first three or four bones of the series but behind this they disappear entirely.

Coccygeal Vertebrae.—There are six or seven coccygeal bones in the spine of the common fowl. The first of these is ossified to the sacrum. The last, which is much larger than any of the others, is termed the **pygostyle.** In reality it is formed by the fusion of several coccygeal vertebrae. The bone is roughly pyramidal in shape with the apex projecting in an upward and backward direction at the end of the vertebral column. It serves as a support for the tail feathers and the coccygeal gland.

THE RIBS AND STERNUM

The Ribs.—The common fowl possesses seven pairs of ribs. Each of the ribs with the exception of the first and second comprises an upper segment, or **vertebral rib,** corresponding to the osseous rib of the mammal, and a lower segment, or **sternal rib,** homologous with the mammalian costal cartilage. The first and second ribs, and usually the last rib, do not articulate with the sternum. Each rib, with the exception of the first and last, carries near its upper end a short **uncinate process.** This passes backwards and upwards over the succeeding rib to which it is connected by ligament.

The Sternum.—The sternum differs from the corresponding structure of the domestic mammals in that in the adult it is formed entirely of bone. It results from the fusion of five pieces which have separate centres of ossification in the chick. The central of these forms the main part, or **body,** of the bone. Its superior surface is concave, and pierced by foramina which permit air to enter the interior from the adjacent air sac. The inferior surface is encroached upon by the lower borders of two processes which project in the middle line from the anterior and posterior borders. The anterior process is termed the **rostrum,** or **manubrium.** It is short and pierced by a foramen on each side of which, on the anterior border of the body, lies an elongated facet for articulation with the coracoid bone. The posterior process, which is called the **metasternum,** is very long, being in fact more extensive than the body itself. It carries inferiorly a thin plate of bone known as the **keel,** or **sternal crest.** This plate, deep in front and narrow behind, affords attachment to the well-developed pectoral muscles of the fowl. United to each lateral border of the body are two bony projections, one in front, the antero-lateral process, and one behind, the postero-

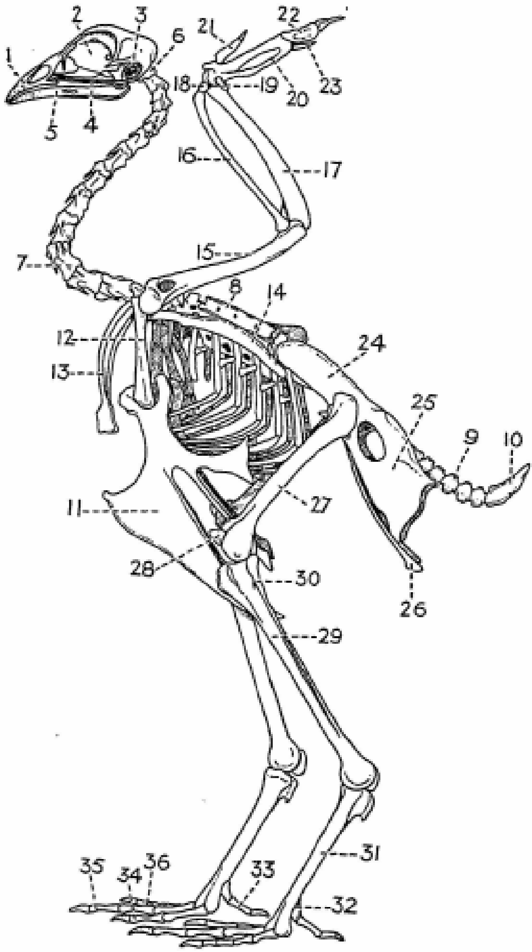


FIG. 173.—SKELETON OF DOMESTIC FOWL (LATERAL VIEW)
1. Premaxilla. 2. Cavity of orbit. 3. Cavity of tympanum. 4. Malar bone. 5. Mandible. 6. Atlas. 7. Tenth cervical vertebra. 8. Anchylosed thoracic vertebrae. 9. Fourth coccygeal vertebra. 10. Pygostyle. 11. Sternum. 12. Coracoid. 13. Clavicle. 14. Scapula. 15. Humerus. 16. Radius. 17. Ulna. 18. Radial carpal bone. 19. Ulnar carpal bone. 20. Third metacarpal bone. 21-23. First, second and third digits of wing. 24. Ilium. 25. Ischium. 26. Pubis. 27. Femur. 28. Patella. 29. Tibio-tarsus. 30. Fibula. 31. Tarso-metatarsus. 32. First metatarsal bone. 33-36. First, second, third and fourth digits of hind limb.

lateral process, each having its own centre of ossification. The **antero-lateral process** projects upwards and forwards behind the coracoid bone. The **postero-lateral process** is short and soon divides into two parts. The lateral and more anterior division covers the last two or three ribs and is broad and plate-like. The medial and more posterior division, longer and more rod-like, projects backwards parallel to the lateral border of the metasternum. Both these divisions have thin expanded extremities, and in the recent state the deep notches between them and between the posterior division and the metasternum are closed by tough membrane.[1] Between the antero-lateral and the postero-lateral process the lateral border of the body shows four depressions for articulation with the third, fourth, fifth and sixth ribs. Occasionally the last rib also meets the sternum.

THE SKULL

The cranium of the fowl is composed of the same elements as are present in the mammalian cranium save that there is no interparietal. The sutures uniting the various bones disappear much more promptly than in the mammal, the limits of the separate elements of the cranium being largely indistinguishable even when the young bird leaves the shell.

The **occipital bone** has only one condyle which articulates with both the atlas and the axis. The bony part of the auditory tube of the **petrous temporal bone** is peculiar in that it runs transversely across the base of the skull between the sphenoid and the temporal bones to open a little laterally to the middle line. The **sphenoid bone** is largely concealed by a broad plate, the **basitemporal bone.** The perpendicular plate of the **ethmoid** forms a large **interorbital septum** which, however, is perforated posteriorly so as to put the two orbits in communication at the point where the optic nerves emerge from the cranium into the orbits.

The bones of the face are greatly modified as compared with the same bones of the mammalian skull. The **premaxillary bones** are very large, and form the chief support of the upper division of the beak. Each has an elongated nasal process which extends backwards with its fellow between the nasal bones as far as the frontal bone.

[1] The antero-lateral process has been termed the costal process, and the same term has been applied to the lateral division of the postero-lateral process. The lateral and medial divisions of the postero-lateral process and the metasternum were formerly referred to as the outer, inner and middle xiphoid processes respectively.

The palatine process is a slender plate separated from its fellow by a median cleft. The **nasal bones** together with the premaxillae circumscribe the anterior nares which are placed near the base of the beak. Posteriorly they are united to the frontal bones. The articulations of the nasal processes of the premaxillae and the nasal bones with the frontals connect the beak to the cranium, but owing to the

FIG. 174.—SKULL OF DOMESTIC FOWL (LATERAL VIEW)

1. Occipital bone. 2. Cavity of tympanum. 3. Quadrate bone. 4. Pterygoid bone. 5. Malar bone. 6. Mandible. 7. Maxilla. 8. Premaxilla. 9. Nasal bone. 10. Lacrimal bone. 11. Palatine bone. 12. Frontal bone. 13. Squamous temporal bone (zygomatic process). 14. Parietal bone. 15. Perpendicular plate of ethmoid bone forming interorbital septum.

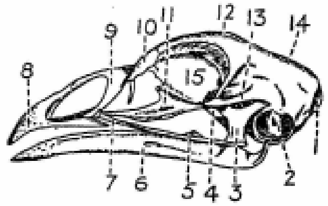
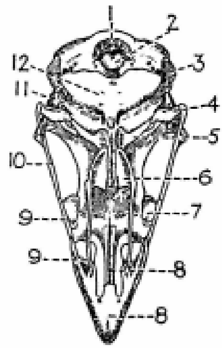


FIG. 175.—SKULL OF DOMESTIC FOWL (VIEWED FROM BELOW)

1. Foramen magnum. 2. Occipital condyle. 3. Cavity of tympanum. 4. Inferior extremity of quadrate bone. 5. Pterygoid bone. 6. Palatine bone. 7. Lacrimal bone. 8. Premaxilla. 9. Maxilla. 10. Malar bone. 11. Orifice of bony part of pharyngo-tympanic tube. 12. Basi-temporal bone.



slender character of these unions the upper jaw is permitted an appreciable degree of movement on the cranium. The **maxillae** are small and slender. Each is united to the premaxilla and nasal in front and to the malar behind. The **malar bone**[1] has the form of a slender rod united to the maxilla by its anterior end, while its posterior extremity articulates medially with the quadrate bone. The **palatine bones** bound the posterior nares on each side. Anteriorly they articulate with the maxillae and premaxillae, and posteriorly they meet the pterygoids. Each **pterygoid bone** articulates by its medial end with the basi-sphenoid, the joint being a movable one, while its opposite end articulates with the quadrate bone. Each half of the **mandible** results from the fusion of five pieces and the two halves are joined together anteriorly to form a pointed body. The posterior extremity of each ramus carries two curved processes, one projecting backwards and upwards, the other medially and upwards.

[1] This bone results from the fusion of two separate elements known as the quadrato-jugal and the jugal.

The **quadrate bone** (the homologue of the malleus of the mammalian tympanum) articulates postero-superiorly with the sphenoid and temporal bones in a diarthrodial joint. Antero-superiorly it meets the pterygoid, whilst inferiorly it articulates with the mandible and the malar bone.

The **hyoid bone** possesses a slender body elongated in the sagittal direction and carrying anteriorly a process resembling a spear head in shape. This is known as the glossal process. Posteriorly a rod-like **uro-hyal** projects backwards. From the point where the uro-hyal meets the body two long cornua project backwards and upwards on either side. Each cornu is composed of two bony segments united by cartilage to one another. Its posterior extremity is attached by muscle to the back of the skull.

THE BONES OF THE WING

The pattern of the skeleton of the wing of the domestic fowl corresponds in general with that of the fore limb of the mammal. Whilst, however, the clavicle and the bones of the arm and forearm are well developed, the skeleton of the manus is considerably modified and most of the bones of this region are reduced in their development.

Scapula.—This is a long narrow bone, rod-like towards the articular angle, but thin and plate-like elsewhere. No spine is developed.

Coracoid.—The coracoid bone is the homologue of the coracoid process of the mammalian scapula. It is a thick strong bone with its long axis inclined towards the vertical direction. Its upper extremity articulates with the scapula, the clavicle and the humerus, while the broader inferior extremity forms a diarthrodial joint with the anterior border of the sternum. The glenoid cavity is formed in common by the coracoid and scapula.

Clavicle.—In the fowl the right and left clavicles fuse with a median interclavicle to form a V-shaped bone known as the **furcula.** The angle of union carries a laterally compressed process, the **hypocleidium,** which is united by ligament to the sternum. The upper extremity of each clavicle meets the corresponding scapula and coracoid medially to the shoulder joint, forming a passage, the **foramen triosseum,** through which plays the tendon of the supracoracoid or smaller pectoral muscle.

Humerus.—The humerus of the fowl is a well-developed long bone. The articular head is compressed from side to side and is articulated to the scapula and coracoid.

Radius and **Ulna.**—When the wing is at rest, these bones lie almost parallel to the humerus. The radius has the form of a slender rod with expanded extremities. The ulna is a more massive bone, curved in its length. The olecranon is not prominent.

Carpus.—The carpus comprises only two free bones, one radial and one ulnar, which represent the upper row of bones in the mammalian carpus. Centres for the lower row of bones are apparent during development in cartilage, but these unite early with the metacarpal elements.

Metacarpus.—The metacarpus includes three bones corresponding to the metacarpals of the thumb and the two adjacent fingers of the human hand. The first, i.e. the most medial, of these has the form of a small nodule projecting from the upper extremity of the second bone to which it is united. The second and third bones are united at their extremities, a narrow interval separating their shafts. The second bone is considerably larger than the third. It carries a little below its upper extremity a flattened triangular plate which projects backwards over the lateral aspect of the third bone. The third bone is slender and curved in its length.

Digits.—Corresponding to the three metacarpals, the terminal segment of the limb possesses three digits, the pollex, index and medius, or first, second and third, respectively. The first digit has two phalanges. The first of these has the form of an elongated pyramid to the apex of which is articulated the second phalanx. This is a small bone terminating distally in a sharp point. The second digit also has two phalanges. The first phalanx carries a thin plate of bone on its lateral or ulnar aspect, and the second phalanx terminates in a sharp point. The third digit shows only one short phalanx, pyramidal in shape, which is closely attached to the lateral border of the first phalanx of the second digit.

THE BONES OF THE HIND LIMB

Hip Bone.—The **ilium** is elongated from before to behind and anchylosed for the whole of its length with the anterior part of the so-called sacrum and with the last thoracic vertebra. The **ischium** lies laterally to the posterior part of the sacrum to which it is fused. Behind the acetabulum a large oval greater sciatic foramen lies between the adjacent borders of the two bones. From the acetabulum the **pubic bone** passes backwards and downwards as a long slender rod, with its free extremity curving medially. A small oval obturator foramen lies below the acetabulum, bounded by the ischium above and the pubis below. The floor of the fowl's pelvis is completed by membrane, there being no pubic or ischial symphysis. In the dried bone the cotyloid cavity is pierced by a large foramen, but in the recent state this is occupied by membrane.

Femur.—This bone in its general form resembles the same bone of the mammal. The articular area on the head of the bone extends laterally on to the greater trochanter. Its distal end articulates with the fibula as well as with the tibia and patella.

Patella.—This bone is relatively large and transversely elongated.

Tibio-Tarsus.—This is the main bone of the leg. Its distal end, which carries a pulley-like articular surface, is distinct in the embryo and is the homologue of the mammalian talus and calcaneum.

Fibula.—This is an elongated slender bone which, in relative size and mode of union with the tibia, is not unlike the same bone of the horse.

Tarso-Metatarsus.—This succeeds the tibio-tarsus, there being in the fowl's skeleton no free tarsal bones. The tarso-metatarsal bone is a long bone resulting from the fusion of three metatarsal bones, viz. the second, third and fourth. Its proximal end is completed by a separate ossification representing the distal bones of the mammalian tarsus. In the male a conical bony core for the horny spur, or **calcar,** is united to the medial side of the metatarsus about the junction of its middle and lower thirds. The first or most medial metatarsal bone is rudimentary. It is attached to the lower third of the tarso-metatarsus by ligament, and it projects downwards and backwards from the postero-medial aspect of that bone.

Digits.—The ordinary number of digits present in the foot of the fowl is four (in the Dorking and some other breeds five). All the phalanges except the most distal in each digit are rod-like bones having expanded extremities, the proximal extremity being always larger than the distal extremity. The terminal phalanx is claw-like and pointed at its free extremity. The four digits are homologous with those of the human foot minus the little toe. The most medial digit is directed backwards and medialwards, while the other three radiate in an anterior direction. The first, the most medial, has two phalanges, the second has three, the third four, and the fourth five.

SECTION II

ARTHROLOGY

CHAPTER I

GENERAL CONSIDERATIONS REGARDING THE JOINTS

THE study of joints is termed **Arthrology.** In Anatomy the word joint, or articulation, is applied to the union of any two of the constituent pieces (bone or cartilage) of the skeleton, whether or not this union is a movable one. The term **Syndesmology** is used almost synonymously with arthrology, although, strictly speaking, that science embraces only a study of the ligaments which in almost every joint pass between the bones and bind them together.

THE CLASSIFICATION OF JOINTS

Joints may be arranged in three main groups, (1) Fibrous joints, (2) Cartilaginous joints, and (3) Synovial joints.

Fibrous Joints

In this group the opposed surfaces or borders of the bones are closely united by a relatively thin layer of interposed white fibrous tissue. Consequently, in this class, movement at the joint is inappreciable or altogether absent. The term **synarthrosis** is used to describe this absence of movement at such a joint. The great majority of the fibrous joints are found in connection with the skull. In these joints the borders of the bones concerned meet one another along a line or **suture,** and they are adapted to each other by a series of interlocking processes, the line of union in the intact joint having thus some resemblance to a seam. If these processes are fine, pointed and regular, like the teeth of a saw, e.g. the interfrontal suture, the joint is termed a **serrate suture.** If the processes are larger, broader at their free ends, and less regular, e.g. the interparietal joint, the suture is described as **dentate.** Where the interlocking processes are thin, bevelled and scale-like, e.g. the joint between the squamous temporal and the parietal bones, the joint is described as a **squamous suture.** A **flat suture,** or a **harmonious suture,** is one in which the opposed borders are almost plane, as in the internasal joint. The term **schindylesis** is used to describe cases in which the border of one bone is received into a fissure or cleft of another. An example of this is seen in the joint between the presphenoidal wing and the groove formed by the frontal bone. The movement which occurs between two bones united by an interosseous membrane or ligament, e.g. the shafts of the radius and ulna as distinct from their extremities, is regarded as taking place at a fibrous joint, and to this variety the term **syndesmosis** is applied. It may be observed here that the soft tissue of fibrous joints is merely the remnant of the original material in which ossification took place, and with advancing age even this remnant may disappear by ossification. This process is known as **synostosis.**

Cartilaginous Joints

Here the bones contributing to the formation of the joint are united by cartilage, and the extent of movement permitted, which is very limited, depends largely on the amount of this connecting material. In some cases this cartilage is a persistence of the original embryonic mass, and is of the hyaline variety. Examples of this type of joint are (*a*) the articulation between the basilar part of the occipital and the body of the postsphenoid (where movement is absent); [1] and (*b*) the joint between the petrous temporal bone and the styloid cornu of the hyoid bone (where movement is appreciable).[2]

In other cases there is a chondrification of what was originally a membranous plate between separate masses of cartilage, and the result is a mass of fibro-cartilage separating two plates of hyaline cartilage attached to the adjacent bones. Such is the type of joint between the vertebral bodies.

Synovial Joints

This group of joints, also known as **Diarthrodial Joints,** is the largest and most important of the three great classes. Functionally these joints are distinguished by their greater freedom of movement, and structurally by the possession of a synovial membrane. The articular surfaces are here covered by a layer of hyaline cartilage, and the bones are maintained in apposition (but not united as in the two preceding classes) by ligaments passing from bone to bone around the joint. In each synovial joint there is thus formed a potential if not an actual cavity, bounded at either extremity by the cartilage-covered articular surfaces, and completed elsewhere by the delicate synovial membrane which secretes the synovia or joint oil.

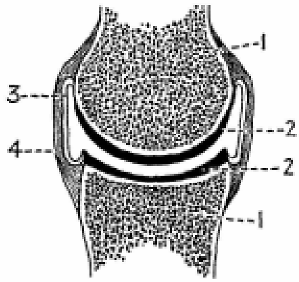
[1] Formerly termed synchondrosis. [2] Formerly termed amphiarthrosis.

The **articular cartilage** forms a layer, variable in thickness, over every bony surface entering into the formation of a synovial joint. It is of the hyaline variety, bluish-white in colour, and insensitive. It is nourished by blood from the underlying bone or the synovial membrane at the periphery of the articular surface, or by the synovia in contact with its free surface. In the joints of adult animals the articular cartilage possesses a calcified layer connecting it to the bone.

Ligaments exert a binding or restraining action on joints. Most of them pass like inextensible bands between the bones composing

FIG. 176.—DIAGRAM OF VERTICAL SECTION OF SYNOVIAL JOINT

1. Sectioned bone. 2. Articular cartilage. 3. Cellular (secretory) layer of synovial membrane. 4. Fibrous layer of synovial membrane (capsular ligament).



the joint, maintaining the articular surfaces in more or less close apposition, and thus materially strengthening the articulation. In keeping with this function they are generally cord-like in shape, and in many cases they exert an important action in limiting or restraining the movement of the joint in some particular direction. In most cases the ligaments are composed of white fibrous tissue, but some, such as the great ligamentum nuchae, are composed of yellow elastic tissue.

The **synovial membrane** is the structure by which the synovia is secreted. It has a groundwork of vascular fibrous connective tissue lined inwardly by a more or less complete layer of flattened cells resembling an endothelium. The outer fibrous layer is often so well developed that it is regarded as a separate entity when it is termed a **capsular ligament.** The membrane takes the form of a thin bag or sac extending between the bones to which it is attached a variable distance away from the margin of their articular surfaces. It completely surrounds the joint cavity which it encloses as a capsule. In some cases the outer layer is thinner and less complete, and in a considerable number of joints it is so thin that the cellular layer obtains its chief support from the deep surfaces of the retaining ligaments or the adjacent muscles. At the margin of the articular surface the synovial membrane blends by a transition stage with the articular cartilage. In the same region the membrane often shows a number of fringe-like or villous processes projecting into the joint cavity. These so-called **synovial fringes** serve to distribute the synovia over the margin of the cartilages. Immediately external to the synovial membrane there is frequently a considerable amount of fat, which serves as a sort of packing and protecting material, and in its semi-fluid state does not interfere with the movements of the joint. **Synovia** is the glairy, straw-coloured fluid which plays the part of a lubricant to the articular surfaces. Although somewhat oily in appearance, it contains only traces of fat, its glairy character being due to mucin and albumin.

Although the term "**joint cavity**" has more than once been used in the foregoing description, it ought to be observed that there is not normally any actual cavity in a joint, in the sense of a space empty or occupied by air. Apart altogether from the binding action of the ligaments, atmospheric pressure plays an important part in maintaining the articular surfaces in apposition, and is of itself sufficient to prevent any great separation of the bones even under strong traction. When, during the movements of a joint, the articular surfaces are partly separated, and there is a tendency to the formation of a gap between them, atmospheric pressure drives in the soft structures in the neighbourhood and thus prevents the formation of a vacuum. In certain diseased states there is a hyper-secretion of fluid from the internal surface of the synovial membrane, and the joint may then come to possess a considerable cavity occupied by this fluid.

The Classification of Synovial Joints

Synovial joints are subdivided, according to the form of the articular surfaces and the movements permitted, into the following four classes:

Plane Joint.—This variety of joint, also known as an *arthrosis*, is one with nearly flat articular surfaces, the movement between which is of a gliding character. The small joints formed between the bones in the same row of the carpus are of this nature.

Hinge Joint.—A hinge joint, or *ginglymus*, is one in which, either from the form of the articular surfaces or the restraining action of the ligaments, movement is limited to flexion and extension. The elbow joint and the true hock joint are examples.

Ball-and-Socket Joint.—As its name implies this is a type of joint in which one of the articular surfaces has the form of a rounded head or ball, while the other is concave and more or less exactly moulded on the former. It is also termed an *enarthrosis*. The hip and the shoulder joints form good examples of this class.

Pivot Joint.—This kind of articulation is one in which one of the bones furnishes a pivot around which the other bone rotates. It is commonly termed a *trochoid* joint. The joint between the atlas and the axis is of this nature.

The Movements of Synovial Joints

For the sake of precision the various movements executed in synovial joints are defined as follows:

(1) **Gliding.**—This term indicates a simple sliding movement of one articular surface upon another. The slight movement permitted between the individual bones of the tarsus of the horse furnishes an example of this type of movement.

(2) **Angular Movements.**—These occur in the joints of the limbs, and are such as vary the size of the angle formed by the meeting of the two bones. If the effect of this movement is to diminish the size of the angle, the movement is termed **flexion,** if to increase it, **extension.** In the case of those joints where the normal position of the bones is markedly angular, e.g. the fetlock joint of the horse, it is customary to speak of *dorsal flexion*[1] and *volar* (or *plantar*) *flexion.* If the angular movement carries the distal bone of the joint away from the median plane of the body, it is termed **abduction,** and where it has the opposite effect, **adduction.** These latter movements are seen in ball-and-socket joints.

(3) **Circumduction.**—In this variety of movement the shaft of the distal bone of the joint describes the surface of a cone, or, to put it in other words, the distal end of the same bone describes a circle. Examples are seen in the shoulder and hip joints.

(4) **Rotation.**—This term is applied to the movement in which a bone, without change of place, turns around an axis passing through itself, or in which it revolves around a pivot furnished by the other bone of the joint. It occurs at the atlanto-axial joint.

THE DEVELOPMENT OF JOINTS

As has been stated earlier, during the first stages in the development of the embryo, that part of the mesenchyme which is destined to become the skeleton undergoes a process of condensation. This is seen in the head, along the mid-dorsal line of the body, and in the limb buds. In these regions there exists a continuous core of the denser mesenchyme in which the individual bones of the skull, the vertebral column and the limbs, respectively, will ultimately appear,

[1] Sometimes known as over-extension.

first in membrane then in bone tissue, with, in many cases, an intervening stage of chondrification. The mesenchyme which lies between the areas which will become the bones is converted into white fibrous tissue or cartilage, and in this way the bones will be united at a fibrous or a cartilaginous joint respectively.

In the case of a synovial joint, however, a special thickening, known as the **primitive joint plate,** appears in the mesenchyme connecting the areas which are the precursors of the bones. A cavity appears in this joint plate as a result of degeneration occurring in its centre, and in this way the joint cavity is formed. The mesenchyme surrounding the cavity develops into the synovial membrane and the capsular ligament.

Occasionally, e.g. in the mandibular joint, a double cavity may appear in the mesenchyme, the intervening septum between the cavities then developing into a fibro-cartilaginous disc. It should be noted that the so-called intra-articular ligaments, e.g. the cruciate ligaments of the stifle joint, were formed originally outside the synovial membrane. During development they approached the synovial membrane which they pushed before them as they passed into the centre of the joint cavity. Thus whilst they traverse the joint cavity they are in fact extra-capsular, for, being surrounded by the synovial membrane, they are excluded from the cavity by that membrane.

Chapter II

THE JOINTS OF THE AXIAL SKELETON

THE JOINTS OF THE AXIAL SKELETON OF THE HORSE

The Joints of the Vertebral Column

THE intervertebral joints and ligaments from the axis to the sacrum are so closely alike that one description will suffice for the series. With the exception of the atlas, every vertebra in front of the sacrum forms three joints with the succeeding bone. The first of these is a cartilaginous articulation between the vertebral bodies, the posterior end of each body being firmly united to the anterior end of the next by a disc of fibro-cartilage. Above this joint, two synovial joints, one on each side, are formed between the posterior aspect of each arch and the anterior aspect of the next. The articular surfaces for these are carried by the articular processes. Lastly, supernumerary joints are formed between the last three lumbar transverse processes, and between the last processes and the sacrum. These joints are also of a synovial character, but in old animals they are frequently anchylosed. For convenience of description, the various ligaments that connect the vertebrae may be divided into (1) those that consolidate the vertebral bodies, and (2) those that connect contiguous arches, including the ligaments that connect the different processes.

The Joints of the Vertebral Bodies

The joints between the vertebral bodies are consolidated by the intervertebral discs, and by the superior and inferior longitudinal ligaments.

The **intervertebral discs.** Each disc is a thin plate of fibro-cartilage interposed between the concave posterior end of one body and the convex anterior end of the next. It is therefore convex on its anterior surface and concave on the other. The discs are not of uniform thickness, those in the thoracic region being thinner than those of the neck or loins. Moreover, they are not uniform in texture, the outer part of each being considerably denser than its centre. The peripheral part of each disc, which is known as the **annulus fibrosus,** is composed of concentric laminae of fibro-cartilage, alternating with laminae of fibrous tissue. In each layer the fibres pass obliquely between the two bones, and in successive layers the direction of the fibres is reversed. This part of the disc is dense and tough, and it forms an exceedingly strong bond of union between the bodies. Towards its centre the disc becomes pulpy, soft, and

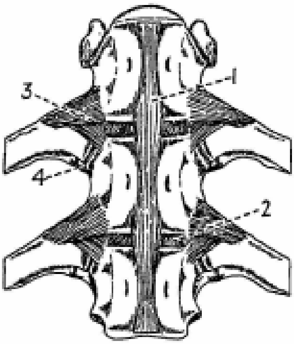


FIG. 177.—INTERVERTEBRAL AND COSTO-CENTRAL JOINTS OF HORSE (7TH, 8TH AND 9TH THORACIC VERTEBRAE AND UPPER EXTREMITIES OF ASSOCIATED RIBS, VIEWED FROM BELOW)

1. Inferior longitudinal ligament. 2. Intervertebral disc. 3. Radiate ligament. 4. Posterior costo-transverse ligament.

elastic. This portion is called the **nucleus pulposus,** and its presence permits of greater freedom of movement between the two vertebrae. The nucleus pulposus is derived from the notochord of the embryo. In the thoracic region the discs concur in forming the cavities for the reception of the heads of the ribs. It is interesting to note that in the human subject these discs are actually thicker than in the horse, man's erect posture exposing his spine to greater risk of concussion, and requiring, to counteract this, the interposition of a thicker elastic cushion between the adjacent bones.

The **superior longitudinal ligament.** This is a riband-like, white, fibrous ligament extending along the floor of the vertebral canal from the sacrum to the axis, and intimately adherent to the bodies of the vertebrae and to the intervertebral discs, or (in the thoracic region) to the intra-articular ligaments of the ribs. The edges of the ligament are scalloped, its breadth being greatest where it passes over an intervertebral disc, and least at the centre of the vertebra.

The **inferior longitudinal ligament** is a thin stratum of white fibres covering the inferior aspect of the vertebral bodies from the sacrum as far forwards as the sixth thoracic vertebra.

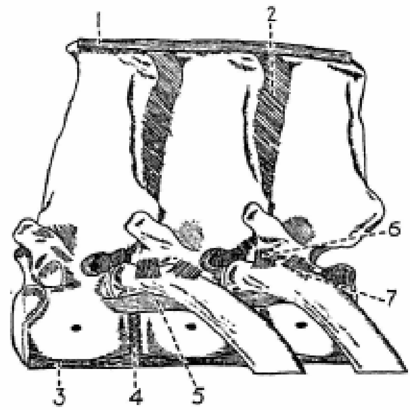
The Joints of the Vertebral Arches

The ligaments connecting the adjacent arches and the vertebral processes are the ligamenta flava, the capsular ligaments of the articular processes, the interspinous ligaments and the supraspinous ligament, the last being in the cervical region so peculiarly modified that it receives a special name—the ligamentum nuchae. In the lumbar region there are, in addition, capsular ligaments of the intertransverse joints, and intertransverse ligaments.

The **ligamenta flava** connect the edges of adjacent arches. They serve to complete the vertebral canal, being composed of fibres that pass from the posterior edge of one arch to the anterior edge of the next. They are composed of white fibrous tissue in the thoracic and lumbar regions, but of yellow elastic tissue in the neck.

FIG. 178.—INTERVERTEBRAL, COSTO-CENTRAL AND COSTO-TRANSVERSE JOINTS OF HORSE (LEFT LATERAL VIEW OF 14TH, 15TH and 16TH THORACIC VERTEBRAE AND UPPER EXTREMITIES OF ASSOCIATED RIBS)

1. Supraspinous ligament. 2. Interspinous ligament. 3. Inferior longitudinal ligament. 4. Intervertebral disc. 5. Radiate ligament. 6. Anterior costo-transverse ligament. 7. Posterior costo-transverse ligament.



The **capsular ligaments** of the joints of the articular processes are membranous sacs whose edges are attached around the articular surfaces. Each supports by its inner face the synovial membrane. In the region of the neck they are loose and composed of yellow elastic tissue, but elsewhere they are tight and are made of white fibrous tissue.

The **interspinous ligaments.** In the thoracic and lumbar regions these ligaments fill up the interspaces of the vertebral spines. The ligament of each space is composed of two distinct strata of white fibres, a right and a left. The fibres are directed obliquely downwards and backwards, being attached at either end to the borders of the spines. This oblique attachment of the fibres permits the separation of the spines during flexion of the vertebral column. In the cervical region each interspinous ligament is composed of two narrow strips of yellow elastic tissue, attached at either end to a vertebral spine.

The **supraspinous ligament.** This is a dense cord of white fibrous tissue extending along the tips of the vertebral spines from the sacrum to the region of the fourth thoracic vertebra where it becomes directly, yet without any definite line of demarcation, continuous with the funicular portion of the ligamentum nuchae. Besides forming a strong bond of union between the vertebral spines that it covers, it affords attachment to several muscles of the back and loins.

The **ligamentum nuchae.** This takes the place of the preceding ligament in the neck. It is composed of two divisions—a funicular and a lamellar part.

The **funicular** part has the form of two cords running side by side from the level of the summit of about the fourth thoracic spine (where the ligament is continuous with the last described ligament)

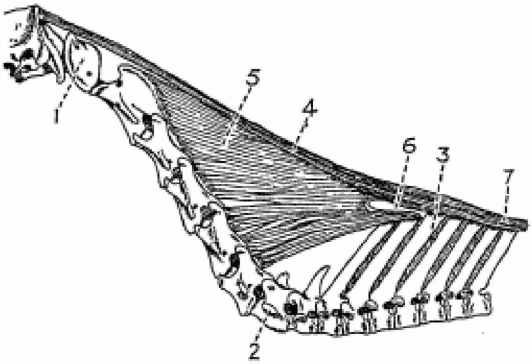


FIG. 179.—LIGAMENTUM NUCHAE OF HORSE (LATERAL VIEW)

1. Atlas. 2. Seventh cervical vertebra. 3. Fourth thoracic vertebra. 4. Funicular part of ligamentum nuchae. 5. Lamellar part of ligamentum nuchae. 6. Space occupied by supraspinous bursa. 7. Supraspinous ligament.

to the skull where they are attached to the external occipital protuberance. The cords are composed of yellow elastic tissue, and when the ligament is relaxed they are slightly curved with the concavity upwards. Above the ligament, in the middle line of the neck, there is usually developed a considerable amount of yellow elastic tissue mixed with fat.

The **lamellar** part is composed of a double (right and left) sheet of yellow elastic fibres attached superiorly to the spines of the second and third thoracic vertebrae and to the under aspect of the funicular part, and extending obliquely downwards and forwards to become attached in bundles to the spines of the last six cervical vertebrae. The right and left layers are connected by loose areolar tissue. In the anterior two-thirds of the ligament the lamellae form a complete septum in the median plane of the neck, but in its posterior part the fibres form an open meshed network. The bundles of attachment to the last one or two cervical spines are very thin and may even be absent.

This enormous mass of yellow elastic tissue affords great assistance to the muscles of the neck in supporting the head, and in restoring it to position when it has been lowered. In addition the funicular part forms a line of attachment for some of the cervical muscles.

Two or three **synovial bursae** are associated with the funicular part of the ligament. One, the atlantal bursa, lies beneath the ligament at the level of the atlas, another, the supraspinous bursa, is situated in the loose fatty tissue between the ligament and the summits of the spines of the second and third thoracic vertebrae. A third bursa, the axial bursa, is occasionally found between the ligament and the spine of the axis.

The **capsular ligaments** of the intertransverse joints are peculiar to the Equidae in which they occur in the joints between the transverse processes of the last three lumbar vertebrae and that between the last lumbar transverse process and the base of the sacrum. They are composed of white fibrous tissue and they support the synovial membrane. The ligament is thickest below the joint.

The **intertransverse ligaments** are thin fibrous sheets connecting the adjacent edges of the transverse processes in the lumbar region.

The Occipito-Atlantal Joint

This is a double articulation, comprising on each side a synovial joint between the occipital condyle and its receiving cavity on the front of the atlas. Associated with the joint are four ligaments, a superior, an inferior, and two lateral ligaments.

The **superior ligament** extends in the form of a membrane from the occipital bone above the foramen magnum and the condyles on either side to the superior arch of the atlas. The ligament is in close contact with the underlying synovial membranes and, on either side, with the lateral ligaments. It is thickened by elastic fibres which cross each other in the middle line.

The **inferior ligament** extends in a manner similar to that of the superior ligament between the inferior arch of the atlas and the occipital bone below the foramen magnum and the condyles.

Each of the **lateral ligaments** consists of a strong bundle of short fibres extending from the wing of the atlas to the paramastoid process.

Each **synovial membrane** is supported outwardly by the occipito-atlantal ligaments and inwardly by the dura mater and the occipital prolongation of the odontoid ligament. Occasionally the cavities of the two membranes communicate below.

The Atlanto-Axial Joint

This joint, formed between the atlas and the axis, possesses four ligaments.

The **odontoid ligament** is situated on the floor of the vertebral canal. It has the form of a short flat band, narrowest behind, where it is fixed to the upper surface of the odontoid process, and widening out in front to be attached to the upper surface of the inferior arch of the atlas. On each side a thin bundle is continued forwards to become attached to the occipital bone within the foramen magnum.

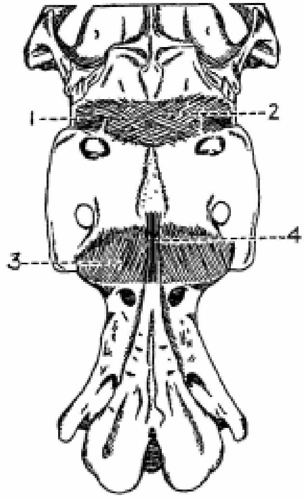


FIG. 180.—OCCIPITO-ATLANTAL AND ATLANTO-AXIAL JOINTS OF HORSE (VIEWED FROM ABOVE)

1. Lateral occipito-atlantal ligament. 2. Crossed fibres thickening superior occipito-atlantal ligament. 3. Inter-annular atlanto-axial ligament. 4. Inter-spinous atlanto-axial ligament.

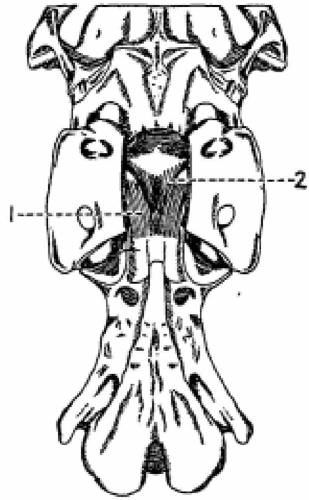


FIG. 181.—OCCIPITO-ATLANTAL AND ATLANTO-AXIAL JOINTS OF HORSE (VIEWED FROM ABOVE, WITH SUPERIOR ARCH OF ATLAS REMOVED)

1. Odontoid ligament. 2. Bundle of odontoid ligament continuing to be attached to occipital bone.

The **interannular ligament** is a membranous sheet extending between the posterior borders of the superior arch and lateral masses of the atlas and the anterior border of the arch of the axis. It completes the vertebral canal between the two bones as the ligamenta flava do in the case of the succeeding joints.

The **interspinous ligament** consists of two parallel bands of yellow elastic fibres running between the upper aspect of the superior arch of the atlas and the spine of the axis.

The **inferior ligament** is a thin white fibrous band fixed in front to the inferior tubercle of the atlas and behind to the median ridge on the inferior surface of the axis.

The single **synovial membrane** for this joint obtains support from the odontoid ligament superiorly, the lower portions of the interannular ligaments on either side, and the inferior ligament below.

The Joints of the Sacrum and Coccyx

The five sacral vertebrae are firmly united to one another by ossification of the intervertebral discs at an early age. The joints between the ill-developed articular processes also become anchylosed. In old horses the first coccygeal vertebra often becomes firmly united to the last sacral vertebra by ossification, but behind this the vertebrae are free to move, being united by small intervertebral discs which, for adaptation to the form of the bones, are slightly concave on both their surfaces. No synovial joints occur in the coccygeal region. The supraspinous and the superior and inferior longitudinal ligaments of the lumbar region are continued back on the sacrum, and these same ligaments are further prolonged on the coccygeal bones, for which they form a kind of fibrous sheath.

Movements in the Region of the Spine

The amount of movement possible in the different regions of the spinal column is variable. The skull moves upon the anterior extremity of the spine at the occipito-atlantal joint, but here, apart from a very little lateral movement, only flexion and extension (nodding) movements of the head are executed. It is at the atlanto-axial joint that the rotatory or side to side movements of the head take place. In these movements the axis remains fixed, its odontoid process serving as a pivot around which the atlas, carrying with it the head, rotates. Behind the axis flexion and extension (movements in a vertical plane) and lateral inclination are executed with freedom in the cervical region, especially in its posterior part. In the lumbar region these movements are much more restricted, owing to the greater size and firmer union of the last lumbar transverse processes with each other and with the sacrum. In the thoracic region movement is even more hampered than in the loins, the ribs being the chief obstacle to lateral bending, and the size and firm connection of the vertebral spines preventing freedom of flexion and extension. Further, the thinness of the intervertebral discs in this region is opposed to free movement. Rotation and circumduction are freely executed in the neck, but in the back, these movements are inappreciable, and in the loins they are prevented by the form of the articular processes. The sacral vertebrae, and in old subjects the first coccygeal vertebra, are firmly united by anchylosis, and, of course, no movement is permissible in this region. The tail, however, possesses a greater range of movement than is found in any other region of the spine, this being due to the suppression of the arches and processes, and to the form of the diminutive bodies which are convex at either end.

THE JOINTS OF THE RIBS AND STERNUM

In connection with the ribs five series of joints are formed, viz. (1) the costo-central joints between the vertebral bodies and the heads of the ribs, (2) the costo-transverse joints between the tubercles of the ribs and the transverse processes of the thoracic vertebrae, (3) the costo-chondral joints between the ribs and their prolonging cartilages, (4) the chondro-sternal joints between the cartilages of the first eight ribs on each side and the sternum, and (5) the inter-chondral joints between the adjacent cartilages of the false ribs. Finally in this group of articulations there fall to be described the joints between the adjacent sternebrae which are known as the intersternal joints.

The Costo-Central Joints

In these joints the head of the rib is received into a shallow cup formed by two adjacent vertebral bodies and the disc that unites them. Each joint possesses three ligaments, viz. the capsular, the radiate and the intra-articular ligaments.

The **capsular ligament** surrounds the whole joint, connecting the margin of the head of the rib with the periphery of the articular cavity formed by the adjacent thoracic vertebrae and the intervening fibro-cartilaginous disc.

The **radiate ligament** lies beneath the joint. Its fibres are attached on the one hand to the rib just below its articular head, and they spread out as they pass medially to be attached to the sides of the bodies of the two vertebrae and the intermediate disc. The more anterior fibres form much the stronger bundle.

The **intra-articular** or **conjugal ligament** is fixed to the groove dividing the head of the rib into two facets. It passes medially across the floor of the vertebral canal, being united to the upper border of the intervertebral disc, and covered by the superior longitudinal ligament. On the median plane of the body it becomes continuous with the corresponding ligament of the opposite rib, detaching a few fibres forward to end on the body of the more anterior vertebra entering into the formation of the joint. It is poorly developed in the case of the first rib, where it runs from the upper aspect of the head to the body of the first thoracic vertebra below the notch.

The early costo-central joints have only one **synovial membrane,** but the remaining joints of the series possess two small synovial membranes, separated from each other by the intra-articular ligament.

The Costo-Transverse Joints

These are the joints formed between the costal tubercles and the vertebral transverse processes. Each possesses two ligaments—an anterior and a posterior.

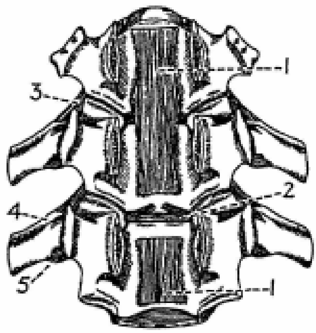


FIG. 182.—INTERVERTEBRAL, COSTO-CENTRAL AND COSTO-TRANSVERSE JOINTS OF HORSE (2ND, 3RD AND 4TH THORACIC VERTEBRAE AND UPPER EXTREMITIES OF ASSOCIATED RIBS, VIEWED FROM ABOVE, WITH VERTEBRAL ARCHES PARTLY REMOVED AND SUPERIOR LONGITUDINAL LIGAMENT PARTLY CUT AWAY)

1. Superior longitudinal ligament. 2. Intra-articular ligament. 3. Radiate ligament. 4. Anterior costo-transverse ligament. 5. Posterior costo-transverse ligament.

The **anterior costo-transverse ligament** [1] lies in front of the joint and connects the neck of the rib to the lateral aspect of the pedicle, i.e. between the facet for the head and that for the tubercle of the rib.

The **posterior costo-transverse ligament** is a smaller bundle of fibres which stretches across the supero-posterior aspect of the joint, being attached medially to the transverse process and laterally to the rib just below its tubercle.

The last two or three costo-transverse joints do not possess a special **synovial membrane,** the posterior costo-central sac being prolonged to supply them, but each of the other joints of the series has its own proper synovial membrane.

The Costo-Chondral Joints

These are a form of cartilaginous joint, the roughened and slightly excavated lower end of the rib receiving, and being directly united to, the proximal extremity of the costal cartilage. The continuity of the periosteum of the rib with the perichondrium of the cartilage helps to consolidate the union.

[1] Sometimes called the ligament of the neck of the rib.

The Chondro-Sternal Joints

These are the synovial joints formed between the sternum and the cartilages of the first eight ribs. Each joint possesses a synovial membrane and a **capsular ligament.** This ligament is thicker above and below than laterally, and the thickenings are sometimes designated the **superior** and **inferior chondro-sternal ligaments.** The fibres of the superior ligaments radiate as they pass medially to blend with the internal sternal ligament. The first costal cartilage differs from the others in that it is articulated medially with its fellow of the opposite side, and forms with it a common chondro-sternal joint, there being a single synovial membrane for the whole.

The Interchondral Joints

The cartilage of the first false rib, i.e. the ninth, is firmly united by fibrous tissue to the cartilage of the last true rib, and it is further bound to the lower face of the xiphoid cartilage by a small band, the **chondro-xiphoid ligament.** The tip of each succeeding cartilage is united by elastic fibres to the posterior surface of the cartilage in front of it.

The Intersternal Joints

In the adult horse the last two or three osseous segments, or sternebrae, are generally fused together, and the remainder are rigidly united by thin persisting portions of the primitive cartilage from which the sternum was developed. The upper surface of the sternum is traversed along its length by an **internal sternal ligament.** This consists towards the anterior part of the sternum of a strong band of white fibres which divides about the second chondro-sternal joint into three divisions. The median division continues backward along the middle line as far as the xiphoid cartilage, whilst the lateral divisions diverge as they pass back above the chondro-sternal joints to end near the eighth costal cartilage.

Movements of the Ribs

The costal movements are of great importance in respiration. During the act of inspiration each rib is rotated laterally and forwards as if it were hinged on an axis passing through its head and the sternal end of its cartilage. There is thus a simultaneous rotation in the costo-central and chondro-sternal joints, the effect being to move the mid-point of each rib laterally and forwards from the corresponding point of the opposite rib. In this way the transverse diameter of the chest, measured between any two opposite ribs, is lengthened, and the thoracic capacity is thereby greatly increased. During the act of expiration each rib returns to its original position by moving in the opposite direction. In each of these respiratory movements the tubercle of the rib glides on the facet of the transverse process, moving in a circle whose centre is the costo-central joint. The movement is precisely of the same nature in the whole series of ribs, but it is not of the same extent, the range of motion increasing from the first rib to the last. The anterior, or true, ribs are hampered in their movements by the overlying fore limb, and by the nature of their connection with the sternum. Besides, being but slightly arched, their rotation has little effect in removing their mid-point from the median plane of the chest. On the other hand, the false ribs are not under cover of the shoulder, their lower extremities have greater play, and, being much curved, their rotation has a powerful effect in widening the chest.

THE JOINTS OF THE SKULL

The Fibrous and Cartilaginous Joints of the Skull

All the intrinsic joints of the skull, with the exception of that between the lower jaw and the squamous temporal bone, are of the fibrous or the cartilaginous variety. At birth and for a short time afterwards all of these joints are distinct, but in an old skull the entire series of bones (with the before-mentioned exception) are united by anchylosis, that is to say, the process of ossification eventually converts the last remnant of intervening cartilage or connective tissue into bone. In the case of the cranium the sutures of the interparietal bone are the first to become obliterated, and in succession all the other cranial joints are similarly effaced, until by the sixth year the brain cavity is a rigid bony case.[1] By the tenth year the facial sutures are similarly obliterated, save that the greater part of the internasal joint persists throughout life as a flat or harmonious suture.

The purpose of the fibrous and cartilaginous joints of the skull is not to permit of movement between the adjacent bones, as is the case with the other joints of the skeleton, but to make provision for the growth of the bones, and for the necessary expansion of the various cavities of the head, in keeping with the growth of their contained organs. In the case of the cranium, for example, as long

[1] Even in old age the petrous temporal does not fuse completely with the surrounding bones.

as the suture between the opposite parietal and frontal bones persists, growth takes place in the intervening fibrous tissue. At the same time the process of ossification is advancing into this newly formed tissue at the margins of the bones, which thus grow in breadth. The interparietal and interfrontal sutures thus make provision for the expansion of the cranial cavity in the transverse direction. Similarly, the sutures that lie on the lateral aspect of the cranium, between the parietal and frontal bones superiorly, and the temporal and sphenoid bones below, provide for its expansion in the vertical direction. But provision has to be made for growth of the cranial cavity in length also, and that is found in the various transverse sutures, such as those that connect the occipital to the bones in front, and those between the parietal and frontal bones. By the time the animal has reached the age of six years the brain has attained its full growth, and the last of the sutures disappears. In a precisely similar way the facial sutures provide for the expansion of the paranasal air sinuses and the cavities of the orbits, nose and mouth.

After what has already been said, a detailed description of the various fibrous and cartilaginous joints of the skull is not necessary. It only remains to be added that, while in most cases the separate articulations are named simply from the bones that enter into their formation, such as temporo-sphenoidal, fronto-nasal, internasal, etc., a few receive special designations, borrowed from human anatomy. Thus the interparietal is also termed the *sagittal* suture; the fronto-parietal the *coronal* suture; and the occipito-parietal the *lambdoid* suture.

The Mandibular Joint

This is the only synovial joint formed in connection with the bones of the skull. On each side the joint is formed between the condyle of the mandible and the articular surface of the squamous temporal bone. The joint possesses an articular fibro-cartilaginous disc and three ligaments.

The **articular disc** is a layer of fibro-cartilage interposed between the articular surfaces. Superiorly it is adapted to the articular surface of the squamous temporal bone and is concavo-convex. Inferiorly it presents a concavity for the condyle of the mandible. The disc extends completely across the joint, its rim being adherent to the inner surface of the capsular ligament. There are thus in reality two distinct joints with separate **synovial membranes,** one between the disc and the temporal bone, and another between the disc and the mandibular condyle.

The **capsular ligament** envelopes the joint, being attached around the temporal articular surface above, and around the mandibular condyle below. As already stated the rim of the articular disc is united to the inner surface of the ligament.

The **posterior ligament** is a yellow elastic band, fixed by one extremity to the postglenoid process, and by the other to the posterior border of the mandible beneath the condyle.

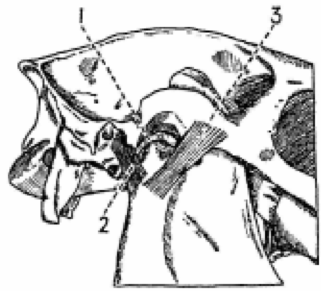


FIG. 183.—RIGHT MANDIBULAR JOINT OF HORSE (LATERAL VIEW, WITH CAPSULAR LIGAMENT REMOVED)
1. Articular disc. 2. Posterior ligament. 3. Lateral ligament.

The **lateral ligament** is a short white band of fibres scarcely distinct from the capsular ligament. It is fixed superiorly to the lateral surface of the zygoma, and inferiorly to the lateral aspect of the lower jaw below the condyle.

Movements.—In the shut mouth the condyle of the lower jaw underlies the glenoid cavity of the squamous temporal bone from which it is separated by the articular disc. In opening the mouth the lower jaw is depressed by rotation of the condyles around a horizontal axis passing through both joints (right and left). At the same time that this movement is executed between the condyles and the lower surfaces of the discs these latter are themselves carried forwards by gliding on the temporal articular surfaces, until, when the mouth is fully open, the condyles of the lower jaw underlie the same processes of the temporal bones. By an inverse movement the mouth is shut. When the above-mentioned sliding movement between the discs and the temporal surfaces is executed without depression of the lower jaw, the latter is protracted until the lower incisors come to lie altogether in front of the upper. When this movement is executed forwards on one side and backwards on the other the mandible is carried across the upper jaw and a grinding action is communicated to the molar teeth.

The Joints of the Hyoid Bone

In connection with the hyoid bone four joints are formed on each side, viz. the basi-cornual joint between the body and the kerato-hyoid, the intercornual joint between the kerato-hyoid and the stylo-hyoid, the temporo-hyoideal joint between the stylo-hyoid and the petrous temporal bone, and the thyro-hyoideal joint between the thyro-hyoid and the thyroid cartilage of the larynx.

Basi-Cornual Joint

This is formed between the shallow articular cup carried by the lower end of the kerato-hyoid and the convex articular facet of the body. The connection is a synovial one, the joint being provided with a small capsule.

Intercornual Joint

This is a cartilaginous union, the adjacent extremities of the stylo-hyoid and the kerato-hyoid being united by intermediate cartilage in which there is usually embedded a pea-like nucleus of bone—the epihyoid.

Temporo-Hyoideal Joint

Like the preceding this is a cartilaginous articulation, the toe-like part of the upper end of the stylo-hyoid being united to the styloid process of the petrous temporal bone through the medium of a cylinder of fibro-cartilage about half an inch in length.

Thyro-Hyoideal Joint

This is a variety of diathrosis, the short rod of cartilage attached to the posterior extremity of the thyro-hyoid being united to the anterior cornu of the thyroid cartilage of the larynx by white fibrous tissue which has the form of a capsule enclosing a small synovial membrane.

Movements of the Hyoid Bone

The movements executed in these joints are largely of the nature of flexion and extension, the hyoid bone, carrying with it the root of the tongue, moving backwards and forwards. In addition the larynx may be drawn forwards towards the root of the tongue, and the shafts of the kerato-hyoids may move laterally or medially at the basi-cornual joints. These movements are brought into play during the act of swallowing. Of the four joints, the intercornual articulation possesses the least, and the temporo-hyoideal and thyro-hyoideal articulations the greatest range of movement.

THE COMPARATIVE ANATOMY OF THE JOINTS OF THE AXIAL SKELETON

The Joints of the Vertebral Column

Intertransverse Joints.—These joints do not occur in the domesticated animals other than the Equidae.

Interspinous Ligaments.—In the **ox** these ligaments are composed of elastic fibres even as far backwards as the lumbar region. In the **cat** the ligaments are largely replaced by interspinous muscles throughout the neck, back and loins. In the **dog** similar muscles are found replacing these ligaments in the neck.

Ligamentum Nuchae.—The degree of development of this ligament varies greatly in different species of animals, depending both on the weight of the head, and on the length of the neck.

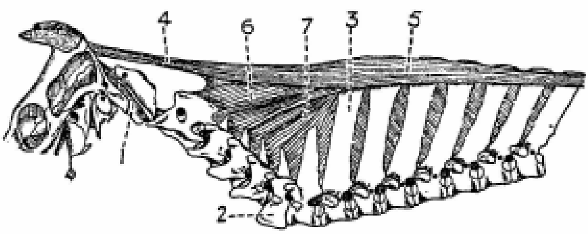


FIG. 184.—LIGAMENTUM NUCHAE OF OX (LATERAL VIEW)
1. Atlas. 2. Sixth cervical vertebra. 3. First thoracic vertebra. 4. Funicular part of ligamentum nuchae. 5. Funicular part of ligamentum nuchae overlapping summits of thoracic spines. 6-7. Anterior and posterior portions of lamellar part of ligamentum nuchae.

In the **ox** it is even better developed than in the horse, the head in the former species being relatively heavier, although the neck is shorter. In the ox the funicular part resembles that of the horse except that in the neighbourhood of the withers it overlaps the early thoracic spines laterally, and it continues some distance behind this even into the lumbar region. The lamellar portion may be described as consisting of two parts, anterior and posterior. The anterior portion is very dense. It arises from the funicular part and is inserted into the spines of the second, third and fourth cervical vertebrae. The posterior portion is more open. It takes origin from the anterior border of the first thoracic spine and from the funicular part, and ends on the spines of the last three cervical vertebrae.

In the **dog** the ligament is rudimentary, having the form of a slender elastic cord extending between the axis and the spine of the first thoracic vertebra.

In the **pig** and **cat** the ligament is still more rudimentary, being represented merely by a thin superficial fibrous raphe, and a few strands of elastic tissue in the median plane of the neck.

Occipito-Atlantal Joint.—In the **pig, dog** and **cat** there is only one synovial membrane for this articulation, and in the **carnivora** it communicates with the atlanto-axial capsule.

Atlanto-Axial Joint.—In the **pig, dog** and **cat** the odontoid ligament has a right and a left division, known as **alar ligaments,** which are attached anteriorly to the occipital bone within the condyles. The atlas is provided with a **transverse ligament,** which, stretching from one lateral mass to the other within the ring, passes above the odontoid process and retains it in position. A small synovial bursa is developed between the ligament and the process.

The Joints of the Ribs and Sternum

Costo-Chondral Joints.—In the **ruminant,** all the ribs, except the first and the last one or two, meet their cartilages at a synovial joint provided with strong capsular fibres. In the **pig** similar joints are formed between the second, third, fourth and fifth (sometimes sixth) ribs and their cartilages.

Chondro-Sternal Joints.—In contrast to what is found in the horse, the first pair of joints remain distinct from one another in the **ruminants, pig** and **carnivora.**

Intersternal Joints.—In the **ox** (not the sheep) and **pig,** the first segment of the sternum, or manubrium, is articulated to the second by a synovial joint. The joint is enclosed by strong capsular fibres, and slight lateral movement is permitted.

The Joints of the Skull

These joints generally resemble the corresponding joints already described in connection with the skull of the horse. There is, however, no posterior ligament in the **mandibular joint** in the animals now under consideration. In the **ox** the various movements permitted are even more free than in the horse. In the **pig** lateral movements are restricted, but antero-posterior movements (protraction and retraction) are very free. In the **dog** it may be said that practically the only movements executed are elevation and depression. In this animal too, the articular fibro-cartilaginous disc is very thin.

Chapter III

THE JOINTS OF THE FORE LIMB

THE JOINTS OF THE FORE LIMB OF THE HORSE

The Shoulder Joint

THIS important joint is formed between the glenoid cavity of the scapula and the articular head of the humerus. Notwithstanding its great size it possesses only one ligament, viz. a capsular ligament.

The **capsular ligament** is a typical ligament of its class, having the form of a double-mouthed sac, one mouth being attached around the glenoid cavity, a little outwardly to the rim, and the other similarly a little beyond the periphery of the head of the humerus. The ligament is for the most part thin, loose and membranous, but it is strengthened anteriorly by two bundles of elastic fibres which start from behind the coracoid process and diverge to become attached to the medial and lateral tuberosities. A large pad of fat is interposed in front of the joint between the ligament and the tendon of the biceps; and posteriorly the small scapulo-humeral, or capsularis, muscle passes vertically over the ligament on which some of its fibres seem to end. Inwardly the ligament is lined by the **synovial membrane.**

It is to be remarked that, although this joint is not provided with any retaining ligaments, it is seldom dislocated. This is explained in part by the considerable extent of the humeral articular surface, and partly by the numerous and powerful muscles that become attached around the joint and to some extent play the part of ligaments. As in other joints, too, atmospheric pressure tends to keep the bones in contact.

Movements.—The shoulder joint is a typical enarthrosis, possessing considerable freedom of movement, and admitting of flexion, extension, abduction, adduction, circumduction and rotation. The greatest range of movement is in the antero-posterior direction (flexion and extension). In the horse, as compared with the human subject, the movement of abduction is greatly restricted by the much lower attachment of the pectoral muscles which in a manner bind the arm and forearm to the chest wall. It is important to notice in this connection the absence of any joint between the scapula and the trunk skeleton, such as is afforded by the intermediation of the clavicle in man. Nevertheless, the muscular attachments of the scapula permit it to move freely on the wall of the chest. When a horse raises its fore limb from the ground, as a preparation for carrying it forwards, the scapula moves on the thorax, its articular angle being carried upwards and forwards, thus making room for

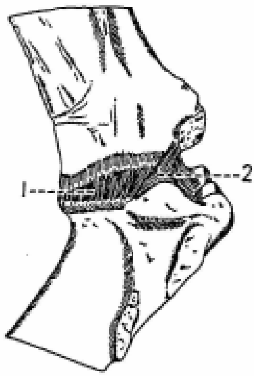


FIG. 185.—RIGHT SHOULDER JOINT OF HORSE (LATERAL VIEW)
1. Capsular ligament. 2. Anterior thickening of ligament running to lateral tuberosity.

the extension of the shoulder joint, while its posterior angle in the same degree is carried downwards and backwards. When the extended limb is brought into contact with the ground, and receives the weight of the body, a gliding movement in the opposite direction restores the scapula to its original obliquity. In the ordinary standing posture the average inclination of the scapula to the horizontal is 60°, and that of the humerus 50° to 55°, the value of the scapulo-humeral angle posteriorly being 110° to 115°.

The Elbow Joint

This is the joint formed between the distal end of the humerus on the one hand, and the upper articular surface of the radius together with the trochlear notch of the olecranon on the other. It possesses three ligaments, two collateral ligaments (medial and lateral), and an anterior ligament.

The **medial ligament** is composed of white fibres fixed above to a small eminence on the medial aspect of the medial epicondyle at the lower end of the humerus. Inferiorly its most superficial and longest fibres are attached to the medial border of the radius a little below the level of the bicipital tuberosity, while its deeper fibres, more or less distinct from the preceding, are attached to the medial tuberosity at the upper extremity of the radius. At their lower attachment these latter fibres are fused behind with the medial arciform ligament and in front with the anterior ligament and the biceps tendon.

The **lateral ligament** is shorter and stronger than the preceding. It is fixed superiorly to a depression on the lateral aspect of the lateral epicondyle at the distal end of the humerus and inferiorly to the lateral tuberosity at the upper end of the radius.

The **anterior ligament** is membranous and irregularly four-sided. It is placed on the anterior aspect of the joint, being attached to the humerus above, to the radius below, and to the medial and lateral collateral ligaments on each side. Its posterior face is lined by the synovial membrane of the joint.

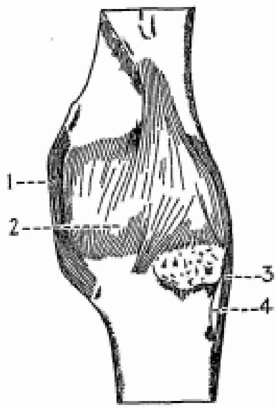


FIG. 186.— RIGHT ELBOW JOINT OF HORSE (ANTERIOR VIEW)

1. Lateral collateral ligament. 2. Anterior ligament. 3. Superficial fibres of medial collateral ligament. 4. Space accommodating brachialis tendon of insertion.

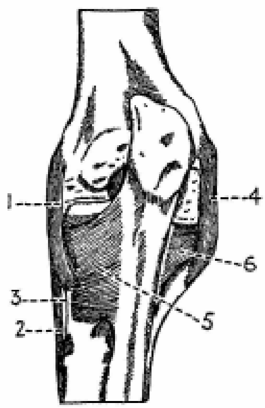


FIG. 187.—RIGHT ELBOW JOINT OF HORSE (POSTERIOR VIEW)

1-2. Deep and superficial fibres of medial collateral ligament. 3. Space accommodating brachialis tendon of insertion. 4. Lateral collateral ligament. 5-6. Medial and lateral arciform ligaments.

Behind the collateral ligaments the **synovial membrane** lines the tendons of the flexor muscles of the carpus and the superficial and deep flexors of the digit, and a pouch of it ascends into the olecranon fossa, where a pad of fat separates it from the anconeus muscle.

Movements.—The elbow joint is a typical ginglymus, the only movements being flexion and extension. Other movements are prevented by the form of the articular surfaces and by the strong collateral ligaments. In flexion the bones of the forearm do not move in the plane of the humerus, but deviate a little laterally. Extension cannot be carried so far as to bring the arm and forearm bones into the same straight line, the movement being arrested by the tension of the collateral ligaments, and by the passage of the beak of the olecranon into the fossa of the same name. In the ordinary standing posture the humero-radial angle anteriorly measures 140° to 145°, the humerus having an inclination to the horizontal of 50° to 55°, and the radius being approximately vertical.

The Radio-Ulnar Joint

In adult life the bones of the forearm are anchylosed together by synostosis from the radio-ulnar interosseous space downwards. Above the space their opposed surfaces remain distinct until advanced age, and at the upper limit of their contact two small convex facets on the ulna respond to two concave facets on the posterior surface of the radius. The bones are united by three ligaments, an interosseous ligament and two arciform ligaments.

The **interosseous ligament** is composed of short, strong, white fibres occupying the narrow interspace between the two bones above the radio-ulnar space. In the foal the bones are similarly united below the space, but, as already stated, this part of the ligament soon disappears by ossification, and in very old subjects the upper portion is also more or less completely converted into bone.

The **medial** and **lateral arciform,** or **transverse ligaments** are composed of glistening white fibres passing transversely on each side from the border of the ulna above the radio-ulnar space to the back of the radius, and blending in part with the collateral ligaments of the elbow joint.

The upper joints are of the synovial variety, the **synovial membranes** being dependent pouches of the elbow joint membrane.

Movements.—The movements permitted between the radius and ulna in the horse are quite inappreciable, notwithstanding that the bones respond at the upper limit of their contact by two small diarthrodial facets. The suppression of movement between the bones of the forearm is one of the most striking peculiarities of the horse's limb. In man the bones move freely upon one another, permitting the palm of the hand to be turned either downwards or backwards with the thumb directed towards the side of the body as in pronation, or alternately upwards or forwards with the thumb directed away from the side of the body which is the position of supination. In the horse the manus is fixed in the condition of pronation.

The Carpal Joint

This joint, commonly known as the **knee joint** in the horse, is a composite articulation comprising three main joints, viz. (1) the radio-carpal joint between the distal end of the radius and the proximal row of carpal bones; (2) the intercarpal joint, between the two rows of carpal bones; and (3) the carpo-metacarpal joint between the distal row of the carpus and the proximal ends of the metacarpal bones. But besides these we have in each tier of the carpus the subsidiary joints between the adjacent bones. The numerous ligaments may be grouped together according as they belong specially to one or other of these articulations. Four ligaments, however, are common in the sense that they serve to consolidate each of the three main articulations of the carpus. They are situated in front, at the back and on either side of the joint, and are known as the anterior, posterior, lateral collateral and medial collateral ligaments respectively. The two last-named are usually termed the lateral and medial carpal ligaments.

The Common Carpal Ligaments

The **anterior carpal ligament** is a membranous four-sided structure, fixed superiorly to the radius and inferiorly to the large metacarpal bone, while on either side it blends with the collateral ligaments. Its deep face is partly adherent to the carpal bones or their anterior ligaments, and partly it is lined by synovial membrane. The tendons of the extensor pedis muscle and of the extensor muscles of the carpus play over its superficial face where they are provided with synovial sheaths.

The **posterior carpal ligament** is much stronger than the preceding. Placed on the posterior aspect of the carpus, it is fixed to the radius above and to the large metacarpal bone below. Its medial border blends with the medial carpal ligament. Its anterior face is closely attached to the carpal bones over which it passes, and posteriorly it presents a smooth face covered by the synovial sheath of the carpal canal to facilitate the gliding of the tendons of the superficial and deep flexor muscles of the digit. Inferiorly this ligament appears to be directly continued to form the so-called **sub-carpal check ligament** which reinforces the tendon of the deep flexor muscle of the digit below the carpus.

The **lateral carpal ligament** is fixed superiorly to the lateral tuberosity of the distal end of the radius. Its longest and most superficial fibres reach the head of the lateral small metacarpal bone, while its deeper strands end on the cuneiform and unciform bones. Anteriorly it is confounded with the anterior ligament, and inferiorly it covers and blends with the most lateral intercarpal ligament. It is perforated by a thecal canal for the tendon of the lateral digital extensor.

The **medial carpal ligament** is attached superiorly to the medial tuberosity of the radius, and inferiorly to the upper extremities of the large and medial small metacarpal bones, furnishing slips as it passes over the carpus to the scaphoid, magnum and trapezoid bones. It blends in front and behind with the anterior and posterior carpal ligaments.

The Radio-Carpal Ligaments

There are three of these. The strongest is a thick cord that stretches obliquely downwards and medially between the radius and the scaphoid, on the posterior aspect of the carpus. The second is a very slender ligament which is fixed to the radius beneath the preceding, and passes downwards to be attached to the lunate bone and to the interosseous ligament between the cuneiform and accessory bones. The third is situated on the lateral aspect of the joint. It runs from the radius beneath the attachment of the lateral carpal ligament to end on the lateral aspect of the accessory bone just in front of the groove for the tendon of the lateral flexor of the carpus.

The Intercarpal Ligaments

These ligaments fall into three groups, viz. (1) the ligaments uniting the bones of the upper row of the carpus, (2) the ligaments uniting the bones of the lower row, and (3) the ligaments connecting the two rows of bones.

(1) The **ligaments of the upper row.** There are six of these. Three are described as anterior ligaments and three as interosseous ligaments.

The anterior ligaments are flat short bands of white fibres passing transversely between the adjacent bones. The one connecting the scaphoid and lunate, and that between the latter bone and the cuneiform are strictly speaking anterior, and are covered by the anterior carpal ligament; but the third ligament which connects the accessory to the cuneiform is placed on the lateral aspect of the carpus.

The three interosseous ligaments are composed of short fibres connecting the contiguous surfaces of the bones. The ligament passing between the accessory and cuneiform bones is less distinctly interosseous than the other two, being placed on the posterior aspect of the carpus, under cover of the posterior carpal ligament. Its fibres are also attached to the lunate bone.

(2) The **ligaments of the lower row.** The three constant bones of this tier are connected by two anterior and two interosseous ligaments, similarly disposed to those of the upper row.

(3) The **ligaments connecting the two rows of bones.** These are

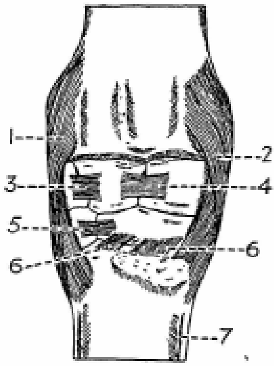


FIG. 188.—RIGHT CARPAL JOINT OF HORSE (ANTERIOR VIEW, WITH ANTERIOR CARPAL LIGAMENT REMOVED)

1. Lateral carpal ligament. 2. Medial carpal ligament. 3. Anterior ligament of upper row of carpal bones (connecting lunate and cuneiform). 4. Anterior ligament of upper row of carpal bones (connecting scaphoid and lunate). 5. Anterior ligament of lower row of carpal bones (connecting magnum and unciform). 6. Anterior carpo-metacarpal ligaments (connecting magnum and large metacarpal bone). 7. Interosseous ligament uniting large and small metacarpal bones.

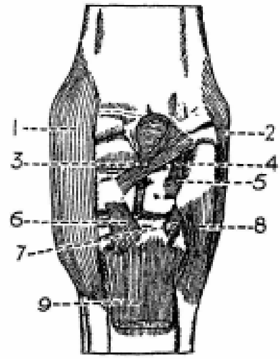
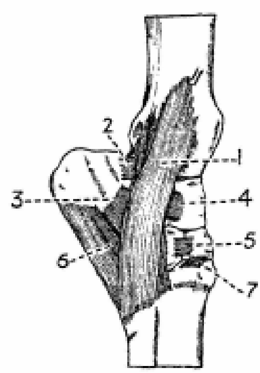


FIG. 189.—RIGHT CARPAL JOINT OF HORSE (POSTERO-MEDIAL VIEW, WITH POSTERIOR CARPAL LIGAMENT REMOVED)

1. Medial carpal ligament. 2. Lateral carpal ligament. 3. Radio-carpal ligament (connecting radius and scaphoid). 4. Radio-carpal ligament (connecting radius to lunate and interosseous ligament between cuneiform and accessory). 5. Interosseous ligament of upper row of carpal bones (connecting accessory to cuneiform and lunate). 6. Intercarpal ligament connecting upper and lower rows of carpal bones (connecting scaphoid to magnum and trapezoid). 7. Intercarpal ligament connecting upper and lower rows of carpal bones (connecting cuneiform to magnum and unciform). 8. Intercarpal ligament connecting upper and lower rows of carpal bones (connecting accessory to unciform and lateral small metacarpal bone). 9. Superior sesamoidean ligament.

FIG. 190.—RIGHT CARPAL JOINT OF HORSE (LATERAL VIEW, WITH ANTERIOR CARPAL LIGAMENT REMOVED)

1. Lateral carpal ligament. 2. Radio-carpal ligament (connecting radius and accessory). 3. Anterior ligament of upper row of carpal bones (connecting accessory and cuneiform). 4. Anterior ligament of upper row of carpal bones (connecting lunate and cuneiform). 5. Anterior ligament of lower row of carpal bones (connecting magnum and unciform). 6. Intercarpal ligament connecting upper and lower rows of carpal bones (connecting accessory to unciform and lateral small metacarpal bone). 7. Anterior carpo-metacarpal ligament (connecting magnum and large metacarpal bone).



three in number. Two are situated on the posterior aspect of the carpus. Of these one connects the scaphoid to the magnum and trapezoid, and the other joins the cuneiform to the magnum and unciform. The third ligament, the strongest of the three, is situated on the lateral aspect of the joint, its fibres being fixed superiorly to the accessory, and inferiorly to the unciform and the head of the lateral small metacarpal bone.

The Carpo-Metacarpal Ligaments

These are four in number, two anterior and two interosseous. Of the anterior ligaments, the first is composed of two short separate slips connecting the magnum to the large metacarpal bone, and the second passes between the unciform and the head of the lateral small metacarpal bone. The medial interosseous ligament is confounded superiorly with the interosseous ligament between the trapezoid and magnum. Inferiorly it is attached to the interstice between the large metacarpal and the head of the medial small metacarpal bone. The lateral interosseous ligament passes in like manner from the interosseous ligament between the magnum and unciform to the interstice between the large metacarpal and the lateral small metacarpal bone.

Synovial Membranes of the Carpus.—There are three carpal synovial membranes, corresponding to the three main joints. The radio-carpal synovial membrane facilitates the movements between the radius and the bones of the upper row, and descends between the latter bones as far as their interosseous ligaments. The intercarpal synovial membrane similarly belongs to the articulation between the two tiers, but it is also insinuated above and below between the bones of the same row as far as their interosseous ligaments. Between the magnum and the unciform this membrane communicates with the next. The carpo-metacarpal synovial membrane belongs specially to the articulation between the lower row and the metacarpus. At the same time it ascends between the bones of the lower row as far as their interosseous ligaments, and dips down to supply the joints between the large metacarpal bone and the heads of the small metacarpal bones.

Movements.—The radio-carpal and the intercarpal articulations are ginglymus joints, and when flexion and extension are executed at the carpus both of these joints participate in the movement. In the ordinary standing posture the long axis of the carpus and metacarpus is in a straight line with the axis of the forearm, that is to say, it is approximately vertical. When the carpus is flexed the distal part of the limb is carried freely backwards, a gap being formed in front between the radius and the upper row, and between the two rows. Provision is made for this in the disposition of the ligaments, the special ligaments of these joints being placed behind and on either side, so as to present no obstacle to the necessary separation of the bones in front. With the same object the anterior carpal ligament is loose in the extended carpus. During extension, movement is arrested as soon as the metacarpus is brought into line with the forearm. Further movement in this direction is prevented by the strong posterior carpal ligament, and by the special radio-carpal and those intercarpal ligaments which connect the two rows of carpal bones, all of which are for the most part placed behind these joints. Owing to the slight obliquity of the radio-carpal and intercarpal joints, the metacarpus and digit during flexion deviate a little laterally from the plane of the forearm bones. In the extended carpus movements of abduction and adduction are impossible owing to the tension of the strong collateral ligaments, but when the joint is flexed these ligaments are relaxed, and very slight abduction and adduction movements are possible.

The carpo-metacarpal joint is of the nature of a plane joint or arthrosis, the motion being of a gliding character and very restricted. It does not participate to any appreciable degree in the movement of flexion, which is resisted by the anterior and interosseous ligaments special to this joint.

Lastly it remains to be said that the small gliding joints formed between adjacent bones in each row of the carpus, although not contributing to the main movements executed at the knee, are nevertheless of great importance, for they tend to distribute pressure in the joint, and thus obviate the ill effects which would have been likely to result from concussion had each row been a single osseous piece.

The Intermetacarpal Joints

Each small metacarpal bone is united throughout the greater part of its length to the side of the posterior surface of the large metacarpal bone by a syndesmosis. The union is effected by means of an **interosseous ligament,** composed of short fibres passing between the opposed bony surfaces. In animals above middle age this ligament is very frequently ossified by synostosis, and the small bones are then inseparably connected to the main bone of the metacarpus. The proximal extremities of the small metacarpal bones form small synovial joints with the large metacarpal bone.

Each joint is lubricated by a process of the carpo-metacarpal

synovial membrane, and it does not possess any ligaments peculiar to itself. For an inch or two above its lower extremity the small bone normally stands out a little from the back of the large metacarpal bone, and the loose interosseous fibres there persist and permit on pressure some slight movement of the terminal part of the bone.

Movements.—Apart from the passive movement previously mentioned at the lower extremities of the small bones, the only movement permitted between the large and small metacarpal bones is a very slight gliding of the synovial facets at their upper extremities.

The Metacarpo-Phalangeal Joint

The bones that enter into the formation of this articulation, which is commonly known as the **fetlock joint,** are the large metacarpal bone, the first phalanx, and the proximal sesamoid bones. The two sesamoid bones, firmly connected together, are fixed to the back of the joint, increasing the articular surface of the first phalanx, and adapting it more accurately to the distal end of the large metacarpal bone. The ligaments connected with the joint may therefore be naturally divided into: (1) the sesamoidean ligaments, which are more directly associated with the sesamoid bones, and (2) the common ligaments, which are chiefly concerned in uniting the large metacarpal bone to the first phalanx.

The Sesamoidean Ligaments

The ligaments of the first group are: an intersesamoidean ligament, a pair of collateral sesamoidean ligaments, a superior sesamoidean ligament, and three inferior sesamoidean ligaments.

The **intersesamoidean ligament** closely unites the two sesamoid bones together. It extends above the apices of the bones, forming a thick fibro-cartilaginous mass which in front supports the joint capsule and, behind, concurs with the posterior surfaces of the sesamoids in forming the pulley-like groove for the deep digital flexor tendon.

The **collateral sesamoidean ligaments,** lateral and medial, are composed of transverse fibres uniting each sesamoid to the corresponding side of the lower extremity of the large metacarpal bone and the upper end of the first phalanx.

The **superior sesamoidean** or **suspensory ligament.** This ligament, while largely composed of white fibrous tissue, invariably contains some bundles of striped muscular fibres. It is, in fact, the homologue of one of the palmar interosseous muscles of the paw of the dog. The main part of the ligament has the form of a strong riband lodged in the channel formed by the three metacarpal bones. Superiorly the fibres of this riband have a double origin, (1) from the lower row of carpal bones, and (2) from a roughened marking

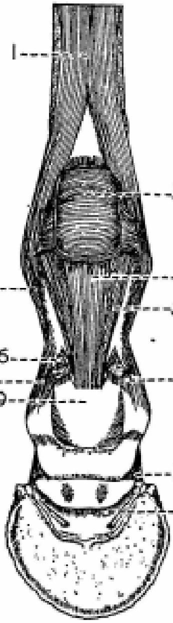


FIG. 191.—RIGHT METACARPO-PHALANGEAL, FIRST INTERPHALANGEAL AND SECOND INTERPHALANGEAL JOINTS OF HORSE (POSTERIOR VIEW)

1. Superior sesamoidean ligament. 2. Continuation of superior sesamoidean ligament which joins extensor pedis tendon. 3. Intersesamoidean ligament. 4. Superficial inferior sesamoidean ligament. 5. Middle inferior sesamoidean ligament. 6-7. Axial and abaxial posterior ligaments of first interphalangeal joint. 8. Superficial digital flexor tendon (cut). 9. Complementary fibro-cartilage. 10. Posterior collateral ligament of second interphalangeal joint. 11. Interosseous ligament of second interphalangeal joint.

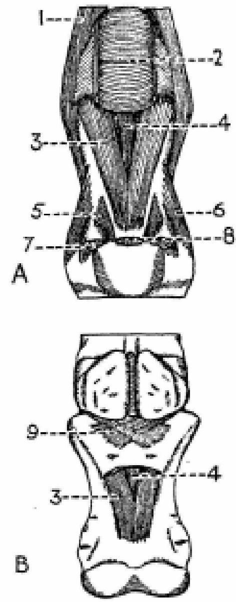


FIG. 192. — INFERIOR SESAMOIDEAN LIGAMENTS OF HORSE. A. RIGHT METACARPO-PHALANGEAL AND FIRST INTERPHALANGEAL JOINTS (POSTERIOR VIEW, WITH SUPERFICIAL INFERIOR SESAMOIDEAN LIGAMENT REMOVED). B. RIGHT METACARPO-PHALANGEAL JOINT (POSTERIOR VIEW, WITH SUPERFICIAL INFERIOR SESAMOIDEAN AND INTERSESAMOIDEAN LIGAMENTS REMOVED)

1. Superior sesamoidean ligament. 2. Intersesamoidean ligament. 3. Middle inferior sesamoidean ligament (oblique bundle). 4. Middle inferior sesamoidean ligament (central bundle). 5-6. Axial and abaxial posterior ligament of first interphalangeal joint. 7. Superficial digital flexor tendon (cut). 8. Superficial inferior sesamoidean ligament (cut). 9. Deep inferior sesamoidean ligament.

at the back of the upper end of the large metacarpal bone. A few inches above the sesamoids the ligament bifurcates, the branches diverging to gain the abaxial aspects of the sesamoid bones. Here a considerable part of each branch terminates, the remainder being continued as a narrow flat band which crosses obliquely downwards and forwards to gain the anterior aspect of the first phalanx where it joins the extensor pedis tendon. The tendon thus reinforced ultimately becomes inserted on the pyramidal process of the third phalanx.

The **inferior sesamoidean ligaments** are arranged in three layers, viz. superficial, middle and deep. The superficial, or straight, ligament is riband-like, and slightly broader above than below. Superiorly it is attached to the bases of the sesamoids, and inferiorly to the complementary fibro-cartilage of the second phalanx. The middle, or oblique, ligaments take the form of two bundles attached above to the bases of the sesamoid bones and below to the converging lines on the posterior surface of the first phalanx. A slender central bundle is often found running vertically between the before-described oblique bundles, being fixed superiorly to the bases of the sesamoids and inferiorly to the posterior surface of the first phalanx near the apex of the roughened V-shaped area. The deep or **cruciate ligament** consists of a few short fibres disposed like the letter X and fixed on the one hand to the bases of the sesamoids and on the other to the posterior surface of the first phalanx near its upper limit.

The Common Ligaments

The second group of ligaments of this joint comprises two collateral ligaments and an anterior ligament.

The lateral and medial **collateral ligaments** consist each of (1) a superficial fasciculus, whose fibres pass vertically from the lateral or medial extremity at the lower end of the large metacarpal bone to the corresponding aspect of the upper end of the first phalanx, and (2) a deep fasciculus of oblique fibres fixed beneath the preceding to the pit at the side of the lower end of the large metacarpal bone and radiating to be attached to the abaxial aspect of the sesamoid and the upper extremity of the first phalanx.

The **anterior ligament** is a membranous four-sided structure which encloses the joint in front of the collateral ligaments, and whose deep face serves for the support of the synovial membrane. It is fixed to the large metacarpal bone above, to the first phalanx below, and to the collateral ligaments on each side. The extensor pedis tendon plays over its anterior face, a small synovial bursa being interposed.

The Synovial Membrane of the Metacarpo-Phalangeal Joint.—This is supported in front by the anterior ligament, and on either side by the collateral ligaments. Posteriorly it is supported under the sesamoid bones by the deep inferior sesamoidean ligament, but above these bones it is unsupported, and hence when distended it first shows itself here, in front of the branches of the suspensory ligament.

Movements.—The only movements executed in the fetlock joint are flexion and extension. In an animal with well-formed or moderately oblique pasterns, the axis of the digit in the ordinary standing posture slopes downwards and forwards forming an angle posteriorly of about 60° (about 65° in the case of the hind limb) with the horizontal. The metacarpus being approximately vertical, there is thus formed in front of the fetlock joint an angle of about 150°. The first effect of volar flexion is to obliterate this angle by bringing the metacarpus and digit into the same straight line, and when carried further a progressively diminishing angle is formed behind the joint. This backward movement is very free, but it is finally arrested by the obstacle that the sesamoids and the adjacent soft structures offer to the complete closing of the angle. The movement of extension is freely permitted until the normal anterior angle of 150° is formed, but further movement in that direction is strongly resisted by the superior sesamoidean ligament. That ligament, indeed, may be described as a powerful brace or stay to prevent over-extension of the fetlock joint. In the extended joint abduction and adduction are prevented by tension of the collateral ligaments, but when the joint is fully flexed slight lateral movements can be effected by manipulation.

The First Interphalangeal Joint

This joint, commonly known as the **pastern joint,** is formed between the distal end of the first and the proximal end of the second phalanx. The lower articular surface is extended by a complementary fibro-cartilage, and the joint possesses two pairs of posterior ligaments and two collateral ligaments.

The **complementary fibro-cartilage.** This is a broad plate of fibrocartilage projecting upwards from the flattened area below the posterior border of the upper articular surface of the second phalanx to which it is attached. Anteriorly it supports the joint capsule, whilst posteriorly it forms part of the anterior boundary of the synovial sesamoidean sheath through which the tendon of the deep digital flexor muscle passes. The terminal insertions of the superficial flexor tendon blend with the cartilage at its extremities, and at its mid-point the superficial division of the inferior sesamoidean ligament is attached to it.

The **posterior ligaments** are four in number, two on each side. The abaxial pair run from the postero-lateral aspect of the first phalanx about the middle of the length of the bone to the complementary fibro-cartilage abaxially to the insertion of the superficial digital flexor tendon. The axial pair are shorter. They are attached above to the posterior surface of the first phalanx on either side of and a little above the lowest attachment of the middle inferior sesamoidean ligament, and they end on the complementary cartilage one on either side of the superficial inferior sesamoidean ligament.

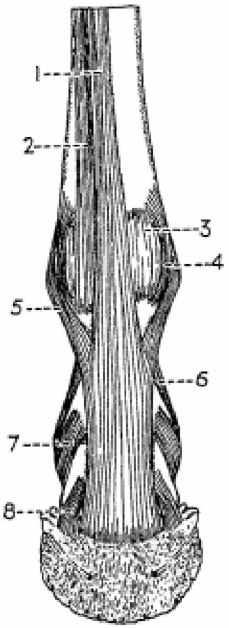


FIG. 193.—RIGHT METACARPO-PHALANGEAL, FIRST INTERPHALANGEAL AND SECOND INTERPHALANGEAL JOINTS OF HORSE (ANTERIOR VIEW)

1. Extensor pedis tendon. 2. Lateral digital extensor tendon. 3. Anterior ligament of metacarpo-phalangeal joint. 4. Collateral ligament of metacarpo-phalangeal joint. 5. Continuation of superior sesamoidean ligament joining extensor pedis tendon. 6. Abaxial posterior ligament of first interphalangeal joint. 7. Collateral ligament of first interphalangeal joint. 8. Anterior collateral ligament of second interphalangeal joint.

The **collateral ligaments** (medial and lateral) are fixed superiorly to the sides of the lower end of the first phalanx, and inferiorly to the sides of the upper extremity of the second phalanx. Some of the anterior fibres of each ligament are prolonged downwards and backwards to form part of the posterior collateral ligament of the next joint.

Synovial Membrane.—This is supported in front by the extensor pedis tendon, which here plays the part of an anterior ligament. On each side it is supported by the collateral ligaments, and posteriorly it lines the complementary fibro-cartilage and is prolonged upwards as a pouch behind the lower extremity of the first phalanx.

Movements.—The only movements executed at this joint are flexion and extension. In the limb at rest the second phalanx has almost the same inclination as the first. The backward movement of the second phalanx (flexion) is freely permitted, but it is impossible to carry the movement of extension much beyond the point at which the first and second phalanges are in the same straight line, this movement (over-extension) being resisted by the posterior ligaments attached to the complementary cartilage and by the superficial inferior sesamoidean ligament.

The Second Interphalangeal Joint[1]

This joint has three bones entering into its formation, viz. the second and third phalanges and the distal sesamoid, or navicular,

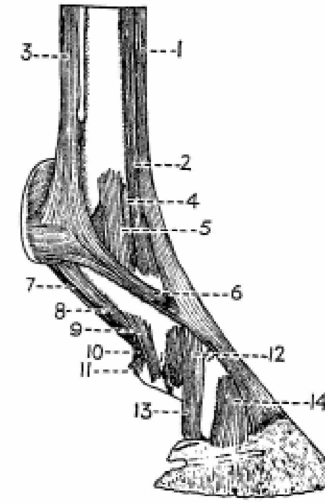


FIG. 194.—RIGHT METACARPO-PHALANGEAL, FIRST INTERPHALANGEAL AND SECOND INTERPHALANGEAL JOINTS OF HORSE (LATERAL VIEW)
1. Extensor pedis tendon. 2. Lateral digital extensor tendon. 3. Superior sesamoidean ligament. 4. Anterior ligament of metacarpo-phalangeal joint. 5. Collateral ligament of metacarpo-phalangeal joint. 6. Continuation of superior sesamoidean ligament joining extensor pedis tendon. 7. Superficial inferior sesamoidean ligament. 8. Middle inferior sesamoidean ligament. 9. Abaxial posterior ligament of first interphalangeal joint. 10. Axial posterior ligament of first interphalangeal joint. 11. Superficial digital flexor tendon (cut). 12. Collateral ligament of first interphalangeal joint. 13. Posterior collateral ligament of second interphalangeal joint. 14. Anterior collateral ligament of second interphalangeal joint.

bone. The distal sesamoid bone is in a manner complementary to the terminal phalanx, these two together furnishing the lower articular surface. For this purpose they are firmly united by an interosseous ligament, and they are then connected to the first and second phalanges by two pairs of ligaments, the anterior and posterior collateral ligaments.

The **interosseous ligament**[2] is composed of short fibres passing from the lower border of the navicular bone to the tendinous surface of the third phalanx behind its articular surface.

The **anterior collateral ligaments.** Each of these, medial and lateral, passes from a depression at the side of the second phalanx to be attached to the excavation at the side of the pyramidal process of the third phalanx.

[1] Formerly called the coffin joint.
[2] Sometimes termed the phalango-sesamoidean ligament.

The **posterior collateral ligaments.**[1] In part each of these ligaments appears to be a continuation of the anterior fibres of the collateral ligament of the first interphalangeal joint, and the remainder of its fibres are attached above to the side of the second phalanx. After an oblique course downwards and backwards, each ligament ends on the lateral extremity and adjacent part of the upper border of the distal sesamoid bone. From the extremity of the latter bone some fibres pass to be attached to the wing of the third phalanx and the axial surface of the collateral cartilage.

Synovial Membrane.—This is supported in front by the expanded tendon of the extensor pedis muscle and on either side by the anterior and posterior collateral ligaments. A protrusion of the membrane passes between the anterior and posterior collateral ligaments, lying in close relation to the deep face of the collateral cartilage. Another protrusion passes upwards posteriorly between the navicular bone and the posterior surface of the second phalanx, whilst a fourth passes downwards to lubricate the joint between the navicular bone and the third phalanx.

Movements.—The only movements permitted in this joint are flexion and extension, the extent of these movements being somewhat less than in the preceding articulation.

THE COMPARATIVE ANATOMY OF THE JOINTS OF THE FORE LIMB

Shoulder Joint.—In the **pig, dog** and **cat** the rim of the glenoid cavity is encircled by a ring of fibro-cartilage known as the **labrum glenoidale.** In these animals the synovial membrane of the joint is in communication with that which favours the play of the biceps tendon in the bicipital groove.

Elbow Joint.—In the **ox** this joint differs but little from that of the horse. It may be remarked, however, that the union between the two bones of the forearm is even more intimate than in the horse, the interosseous fibres being normally ossified in adult life throughout the length of the bones.

In the **pig** the radius and ulna are rigidly united by interosseous fibres which are so short and strong as to prevent any appreciable movement between the two bones.

In the **dog** and **cat** the radius and ulna are articulated together by a synovial joint at either extremity, and between these two points they are separated by a narrow interspace occupied by an interosseous ligament or membrane. The proximal joint possesses an **annular ligament** which passes transversely in front of the upper extremity of the radius from the region of the attachment of the lateral ligament to the tendons of the biceps and brachialis muscles at their insertion medially. The head of the radius is thus

[1] Sometimes termed the collateral sesamoidean ligaments.

closely maintained in contact with the articular surface of the ulna, but it is allowed to rotate freely within the ring bounded by the ulnar articular surface behind and the annular ligament in front. In the ordinary position of the paw, that is when its palmar or flexor aspect looks backwards or downwards, the radio-ulnar joint is said to be in a condition of pronation. In man, the opposite position, that is when the anterior or dorsal surface faces forwards or upwards, is termed supination. In the dog, however, the joint permits only of partial supination as is seen when the animal holds anything between its fore paws. To bring about this latter position the radial head rotates within the annular ligament, while the distal end of the bone, carrying with it the paw, is rotated slightly laterally around the lower end of the ulna.

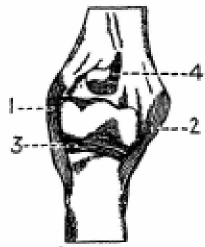


FIG. 195.—RIGHT ELBOW JOINT OF DOG (ANTERIOR VIEW, WITH ANTERIOR LIGAMENT REMOVED)
1. Lateral collateral ligament. 2. Medial collateral ligament. 3. Annular ligament. 4. Olecranon of ulna.

Carpal Joints.—There are, of course, manifold minor differences exhibited by the carpal ligaments in the different domestic animals, in correspondence with the variations of the bones forming the joints. The general plan, however, is similar in all. As regards movements, it may be observed that abduction and adduction are much more free in the **carnivora** than in the other domestic animals.

Intermetacarpal Joints.—In the **ox** the rudimentary fifth metacarpal is articulated to the main bone in the position of the horse's lateral small metacarpal bone, a pouch of the carpo-metacarpal synovial membrane supplying the joint. The small bone is more movable than the corresponding bone of the horse, and it seldom or never becomes anchylosed to the main bone. Moreover it contracts no articulation with the carpus.

In the **pig** and in the **carnivora** small synovial joints are formed between the proximal ends of the adjacent metacarpal bones, permitting, in the latter animals especially, distinct movement. The bones are connected at these extremities by interosseous fibres, and by anterior (or dorsal) and posterior (or volar) ligaments.

Metacarpo-Phalangeal Joints.—There are two metacarpo-phalangeal articulations in the **ruminant,** one for each digit. Their synovial membranes, however, are in communication posteriorly. Besides an intersesamoidean ligament between the two sesamoids of the same digit there is an additional ligament between the two medial or axial sesamoids of the two digits. The superior sesamoidean or suspensory ligament shows a marked difference from that of the horse. As has already been stated, this ligament in the horse invariably contains some muscular fibres, and ought to be regarded as a modified interosseous muscle. In the case of the ox the true nature of the ligament is much more evident, the muscular tissue, in the young subject especially, being so abundant that the structure might with equal propriety be described as a muscle. Occupying the same position as in the horse, the ligament divides about the middle of the metacarpus into an anterior and a posterior portion. The posterior division is a flat broad band which bifurcates, each branch uniting with the adjacent division of the tendon of

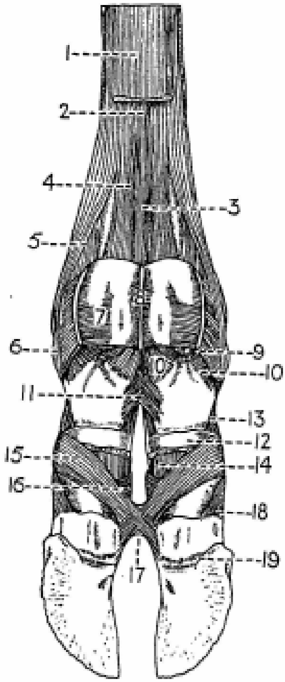


FIG. 196.—RIGHT METACARPO-PHALANGEAL, FIRST INTERPHALANGEAL AND SECOND INTERPHALANGEAL JOINTS OF OX (POSTERIOR VIEW, WITH POSTERIOR DIVISION OF SUPERIOR SESAMOIDEAN LIGAMENT CUT)

1. Posterior division of superior sesamoidean ligament (cut). 2. Anterior division of superior sesamoidean ligament. 3. Axial band from anterior division of superior sesamoidean ligament. 4-5. Subdivisions of abaxial band from anterior division of superior sesamoidean ligament which join metacarpo-phalangeal sesamoid bones. 6. Continuation of anterior division of superior sesamoidean ligament joining proper digital extensor tendon. 7. Intersesamoidean ligament of medial digit. 8. Axial intersesamoidean ligament (forming septum between sesamoidean synovial sheaths). 9. Crossed inferior sesamoidean ligaments. 10. Collateral inferior sesamoidean ligaments. 11. Superior interdigital ligament. 12. Complementary fibro-cartilage of second phalanx. 13. Posterior ligament of first interphalangeal joint. 14. Superficial digital flexor tendon (cut). 15. Origin of inferior interdigital ligament. 16. Fibres of inferior interdigital ligament ending on axial surface of second phalanx. 17. Crossed fibres of inferior interdigital ligament. 18. Posterior collateral ligament of second interphalangeal joint. 19. Interosseous ligament of second interphalangeal joint.

the superficial flexor muscle of the digits behind the fetlock joint to form a ring for the passage of the corresponding division of the deep flexor tendon. The anterior division, which is much the stronger, resolves itself into three bands. Of these, the two abaxial bands each divide into two slips one for each sesamoid bone. Each of the bands passing to the two abaxial sesamoids detaches an oblique slip to join the proper extensor tendon of the digit after the manner of the horse's ligament. The remaining band of the anterior division is much more slender and less muscular than the preceding. It passes into the cleft at the lower extremity of the large metacarpal bone, and running downwards and forwards between the first phalanges it divides into two divisions each of which joins the proper extensor tendon of its own digit. There are four inferior sesamoidean ligaments in each digit. Two of these connect the lower extremities of the sesamoid bones to the back of the upper extremity of the corresponding first phalanx. The other two are intercrossed like the deep ligament of the horse. There is a strong **superior interdigital ligament** composed of intercrossed fibres connecting the opposed surfaces of the first phalanges of the two digits. This ligament is absent in the **sheep.** The remaining ligaments of this joint closely resemble the same ligaments of the horse, but it may be mentioned that the axial collateral ligaments arise together from the cleft at the lower extremity of the large metacarpal bone and, separating, each becomes attached below to the axial aspect of the upper extremity of the first phalanx.

In the **pig** and the **carnivora** each metacarpo-phalangeal articulation has its own proper ligaments which in a general way resemble those of the ruminant. The inferior sesamoidean ligament is composed merely of two intercrossed bundles. In the dog the anterior ligament has a small nucleus of bone in it which plays the part of a sesamoid bone to the corresponding tendon of the common extensor of the digit. The place of the suspensory ligament is taken by distinct interosseous muscles.

Interphalangeal Joints.—In the **ox** the complementary cartilage of the second phalanx has only two slips attaching it to the first phalanx. In addition to the two collateral ligaments, anterior and posterior, found in the horse the terminal joint of the limb is provided with an anterior elastic ligament. In both **ox** and **sheep** a strong band of fibres passes downwards from each after-claw or rudimentary digit to end on the third phalanx.

In the **carnivora** the last interphalangeal joint is provided with two elastic ligaments which act as retractors of the claw. These ligaments, which are much stronger in the dog than in the cat, are attached by their proximal ends to the anterior aspect of the second phalanx, and by their opposite ends to the front of the terminal phalanx, above the root of the claw.

The **inferior interdigital ligament** in the **ox** consists of two bands of fibres which intercross in the interdigital space. Each runs from the upper extremity of the abaxial surface of the second phalanx of one of the digits to the axial extremity of the navicular bone of the other digit. Some of the fibres end on the second phalanx and navicular bone of the digit from which the ligament takes origin. In the early part of its course each ligament lies superficially to the tendon of the deep flexor of the digit. In the **sheep** the ligament is represented by a band of fibres connecting the opposed ends of the navicular bones and the axial surfaces of the second and third phalanges of the two digits.

CHAPTER IV

THE JOINTS OF THE HIND LIMB

THE JOINTS OF THE HIND LIMB OF THE HORSE

The Sacro-Iliac Joint

THIS is the joint formed between the auricular facet of the sacrum and the corresponding articular surface of the ilium. Only one ligament, the inferior sacro-iliac, passes in close relation to the joint, but it is convenient to describe here four other ligaments which are associated with the pelvic girdle. These are the sacro-sciatic ligament, the superior and lateral sacro-iliac ligaments, and the ilio-lumbar ligament.

The **inferior sacro-iliac ligament** is composed of short, strong, white fibres that pass between the sacrum and the ilium in close relation to the articular surfaces. It comprises an upper or anterior, and a lower or posterior, portion, the former being much the stronger of the two. This ligament is the chief bond of connection between the spine and the hip bone.

The **sacro-sciatic ligament.** This large membranous ligament, which represents the combined sacro-spinous and sacro-tuberous ligaments of man, forms the greater part of the lateral boundary of the pelvis. It is irregularly four-sided in form. Its upper border is fixed to the lateral border of the sacrum (where some of its fibres are continuous with fibres of the lateral sacro-iliac ligament) and behind this to the transverse processes of the first one or two coccygeal bones. Its lower border is attached to the superior ischial spine and to the ischial tuberosity, and between these points it forms the upper boundary of the lesser sciatic foramen. The anterior border is short and forms the posterior boundary of the greater sciatic foramen. The posterior border, much more extensive than the anterior, is thin, ill-defined, and united to the coccygeal origin of the semimembranosus muscle. The lateral surface of the ligament is largely covered by the middle gluteus and biceps femoris muscles. It is crossed by the sciatic and gluteal nerves. Its medial surface is related to some of the pelvic viscera and is lined anteriorly by the peritoneum. The **greater sciatic foramen** is an elliptical opening in the lateral wall of the pelvis, limited by this ligament behind, and by the ischial border of the ilium in front. It gives passage to the gluteal and sciatic nerves and the anterior gluteal vessels. The **lesser sciatic foramen** is a second opening in the pelvic wall, bounded by the sacro-sciatic ligament above and the ischial bone below. It transmits the tendon of the obturator internus and the nerve to this muscle, together with a vein connecting the internal pudic and obturator veins.

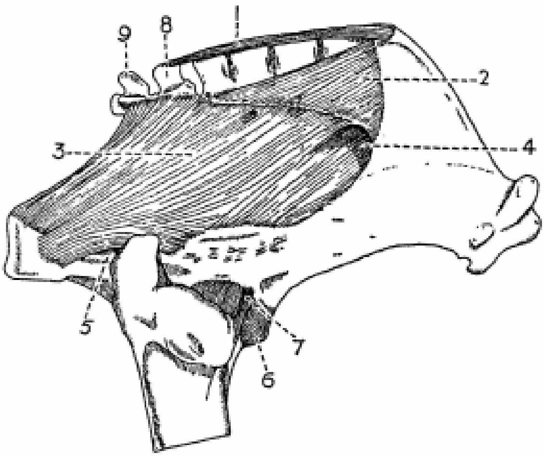


FIG. 197.—LIGAMENTS OF PELVIC GIRDLE AND RIGHT HIP JOINT OF HORSE (LATERAL VIEW)

1. Superior sacro-iliac ligament. 2. Lateral sacro-iliac ligament. 3. Sacro-sciatic ligament. 4. Greater sciatic foramen. 5. Lesser sciatic foramen. 6. Capsular ligament of hip joint. 7. Ilio-femoral ligament. 8-9. First and second coccygeal vertebrae.

The **superior sacro-iliac ligament** [1] has the form of a cord passing obliquely between the medial angle or sacral tuberosity of the ilium and the summits of the sacral spines.

The **lateral sacro-iliac ligament** [2] is membranous and triangular. Its anterior border is fixed to the upper part of the ischial border of the ilium. Its lower border is attached to the lateral border of the sacrum, where some of its fibres continue into the sacro-sciatic ligament. The posterior, or upper, border is ill-defined being continuous with the fascia investing the coccygeal muscles.

The **ilio-lumbar ligament** is a thin triangular sheet which is attached to the iliac surface of the ilium above the level of the auricular facet, from which region its fibres radiate to become attached anteriorly to the transverse processes of the last few lumbar vertebrae.

[1] Formerly termed the superior ilio-sacral ligament.
[2] Formerly termed the inferior ilio-sacral ligament.

Movements.—The sacro-iliac joint possesses a rudimentary **synovial membrane.** It is, however, a joint in which only very restricted movement is permitted, as is indicated by the nature of the articular surfaces, only small portions of which show the smooth and polished character commonly found in synovial joints. But if it is a comparatively immobile joint, it is at the same time a remarkably strong one, its stability being secured mainly by the inferior sacro-iliac ligament.

The Ischio-Pubic Symphysis

The right and left hip or coxal bones meet together along the median plane of the body, and in the foal the medial border of each ischial and pubic bone is united to its fellow of the opposite side by a thin stratum of fibro-cartilage. The union is further strengthened by transverse fibres passing across the symphysis above and below. In adult animals the symphysis is in great part obliterated by anchylosis, ossification invading in the first place the inter-pubic part of the fibro-cartilage, and gradually extending backwards between the ischia. No appreciable movement is permitted at the symphysis.

The Obturator Membrane

Although unconnected with any pelvic articulation, the obturator membrane may conveniently be noticed here. It is a thin stratum of fibrous tissue which extends across the foramen of the same name, leaving anteriorly a passage for the obturator vessels and nerve in their descent to the thigh.

The Hip Joint

The hip or **coxo-femoral joint** is formed between the head of the femur and the acetabulum of the hip bone. Fixed to the margin of the acetabulum is a ring of fibro-cartilage, the **labrum acetabulare,**[1] which serves to deepen the cavity. Medially the labrum bridges across the gap in the rim of the cavity which it thus converts into a foramen for the passage of the accessory ligament. This part of the labrum is sometimes termed the **transverse ligament.**

The joint possesses three main ligaments, viz. round, accessory, and capsular.

The **round ligament** (ligamentum teres) is a short strong cord, fixed superiorly to the acetabular fossa and inferiorly to the fovea on the head of the femur.

[1] Formerly termed the cotyloid ligament.

The **accessory ligament** [1] is peculiar to the Equidae. It derives its fibres from the prepubic tendon of the abdominal muscles, and the fibres pass obliquely backwards and laterally towards the acetabulum. Each ligament enters this cavity by passing through the

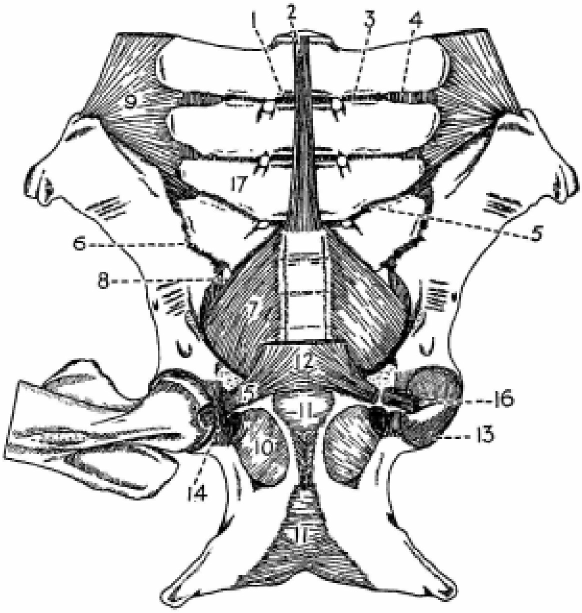


FIG. 198. LIGAMENTS OF PELVIC GIRDLE, SACRO-ILIAC JOINTS AND HIP JOINTS OF HORSE (VIEWED FROM BELOW, WITH CAPSULAR LIGAMENTS OF HIP JOINTS REMOVED, AND FEMUR REMOVED FROM LEFT HIP JOINT BY CUTTING ACCESSORY AND ROUND LIGAMENTS)

1. Intervertebral disc. 2. Inferior longitudinal ligament. 3. Capsular ligament of lumbar intertransverse joint. 4. Lumbar intertransverse ligament. 5. Capsular ligament of lumbosacral intertransverse joint. 6. Inferior sacro-iliac ligament. 7. Sacro-sciatic ligament. 8. Greater sciatic foramen. 9. Iliolumbar ligament. 10. Obturator membrane. 11. Transverse fibres of ischio-pubic symphysis. 12. Prepubic tendon. 13. Labrum acetabulare. 14. Transverse ligament. 15. Accessory ligament. 16. Round ligament. 17. Sixth lumbar vertebra.

notch in its rim, over the so-called transverse ligament, and it terminates in the fovea of the head of the femur just behind the point of attachment of the round ligament. Before it enters the joint it lies in the subpubic groove on the lower surface of the pubic bone where it perforates the origin of the pectineus muscle.

The **capsular ligament** has the form of a double-mouthed sac, attached on the one hand to the rim of the acetabulum and to the

[1] Formerly termed the pubio-femoral ligament.

labrum acetabulare, and on the other hand to the line that circumscribes the head of the femur. The sac is thinnest on the medial and posterior aspects of the joint, and thickest in front, where it is strengthened by an oblique band of fibres, the **ilio-femoral ligament.** The deep surface of the ligament is everywhere lined by the synovial membrane.

The Synovial Membrane.—This is capacious, and apart from lining the deep face of the capsular ligament, invests the accessory and round ligaments in the interior of the joint.

Movements.—The hip joint is a typical ball-and-socket joint, and in the horse it possesses a greater range of movement than any other articulation of the limbs. When the horse stands squarely on its four limbs, the ilio-femoral angle measures from 110° to 115°, the inclination of the femur to the horizontal being about 80°, and that of the ilium from 30° to 35°. In flexion the femur is carried forwards, this movement being executed with great freedom. In extension the femur moves back to its original inclination, and it may even be carried so far as to efface the normal anterior angle and form a new angle behind the joint. Abduction is considerably restricted in the horse by the tension exerted by the round and accessory ligaments.

The Stifle Joint

The stifle joint corresponds to the knee of the human subject. The bones that enter into its formation are the femur, the tibia and the patella. In reality it comprises two articulations, viz. (1) that between the patella with its fibro-cartilage and the femoral trochlea, and (2) that between the femoral condyles and the tibia.

The Femoro-Patellar Joint

This joint possesses a capsular ligament and two collateral ligaments. Three other ligaments, the anterior patellar ligaments, unite the patella to the tibia and may conveniently be considered in this description.

The **capsular ligament** is loose and membranous. It is attached around the margins of the articular surfaces.

The **collateral femoro-patellar ligaments,** lateral and medial, are flat bands scarcely distinct from the capsular ligament. The lateral ligament runs from the lateral angle of the patella to the femur just above the lateral condyle, while the medial passes from the fibro-cartilaginous extension of the patella to the femur just above its medial condyle.

The **anterior patellar ligaments**[1] are distinguished as lateral, middle and medial. The lateral and middle ligaments are attached superiorly to the anterior surface of the patella, the medial to the fibro-cartilaginous extension on the medial aspect of that bone. All three ligaments are inserted inferiorly into the tuberosity of the tibia, the middle ligament into the lower part of the vertical groove of that process, and the other two into its most prominent part on either side of the groove. The middle ligament, embedded in a pad of fat, lies on a deeper plane than the other two, and immediately above its lower attachment a small synovial bursa favours its gliding in the vertical groove of the tibial tuberosity. These ligaments serve as tendons of insertion to the quadriceps femoris muscle, transmitting its action to the tibia.

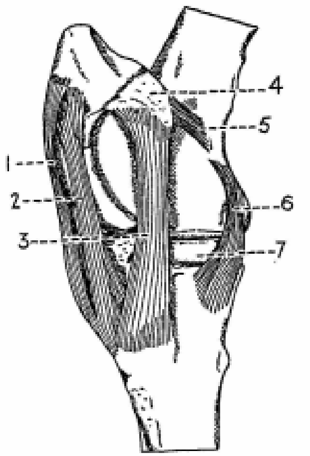


FIG. 199.—RIGHT STIFLE JOINT OF HORSE (ANTERO-MEDIAL VIEW, WITH CAPSULAR LIGAMENT OF FEMORO-PATELLAR JOINT REMOVED)

1. Lateral anterior patellar ligament. 2. Middle anterior patellar ligament. 3. Medial anterior patellar ligament. 4. Medial fibro-cartilaginous extension of patella. 5. Medial collateral femoro-patellar ligament. 6. Medial collateral femoro-tibial ligament. 7. Medial semilunar cartilage.

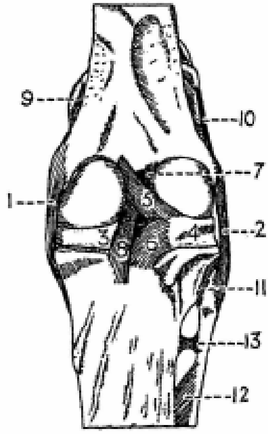


FIG. 200.—RIGHT STIFLE JOINT OF HORSE (POSTERIOR VIEW, WITH POSTERIOR LIGAMENT REMOVED)

1. Medial collateral femoro-tibial ligament. 2. Lateral collateral femoro-tibial ligament. 3. Medial semilunar cartilage. 4. Lateral semilunar cartilage. 5-6. Posterior ligamentous slips of lateral semilunar cartilage. 7. Origin of anterior cruciate ligament. 8. Posterior cruciate ligament. 9-10. Medial and lateral collateral femoro-patellar ligaments. 11. Peripheral fibres of tibio-fibular synovial joint. 12. Interosseous membrane of tibio-fibular joint. 13. Crossed fibres of interosseous membrane of tibio-fibular joint.

The Synovial Membrane.—This lines the deep face of the capsular ligament, and when the joint capsule is distended it forms an upward protrusion between the femur and the quadriceps femoris

[1] Formerly termed the straight patellar ligaments.

muscle. Inferiorly it is in contact with the capsules of the femoro-tibial joint, and it generally communicates with them by one or two small openings.

The Femoro-Tibial Joint

This joint, formed between the femoral and tibial condyles with the interposition of two semilunar cartilages, possesses two collateral ligaments, two cruciate ligaments and a posterior ligament.

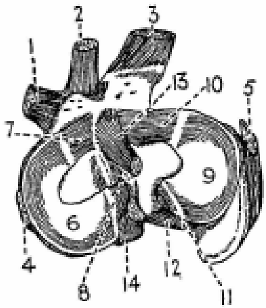


FIG. 201.—SUPERIOR EXTREMITY OF RIGHT TIBIA OF HORSE (FEMUR AND PATELLA REMOVED BY CUTTING COLLATERAL FEMORO-TIBIAL, ANTERIOR PATELLAR AND CRUCIATE LIGAMENTS AND LIGAMENTOUS SLIP OF LATERAL SEMILUNAR CARTILAGE. CAPSULAR LIGAMENT OF FEMORO-PATELLAR JOINT AND POSTERIOR LIGAMENT OF FEMORO-TIBIAL JOINT HAVE BEEN REMOVED) 1-3. Medial, middle and lateral anterior patellar ligaments (cut). 4-5. Medial and lateral collateral femoro-tibial ligaments (cut). 6. Medial semilunar cartilage. 7-8. Anterior and posterior ligamentous slips of medial semilunar cartilage. 9. Lateral semilunar cartilage. 10-12. Anterior and posterior ligamentous slips of lateral semilunar cartilage (upper posterior ligamentous slip has been cut.) 13. Anterior cruciate ligament (cut). 14. Posterior cruciate ligament (cut).

The **semilunar cartilages** are two crescentic or sickle-shaped pieces of fibro-cartilage interposed between the condyles of the femur and those of the tibia. The convex margin of each is turned outwards and is much thicker than the concave border which is so thin as to be translucent. The lower surface of each is flattened to rest on the tibia, while the upper surface is hollowed to embrace the femoral condyle. The cartilages are maintained in position by ligamentous slips [1] as follows:—the anterior extremity or horn of the medial semilunar cartilage is fixed into an excavation in front of the tibial spine, while its posterior extremity is similarly fixed behind the spine. The lateral semilunar cartilage is fixed by its anterior extremity in front of the spine, while its posterior extremity is bifid, having an upper slip inserted into a depression at the posterior part of the intercondylar groove near the medial condyle, and a lower which is attached to the lateral tibial condyle just below the rim of its articular surface posteriorly.

The **collateral femoro-tibial ligaments** are strong fibrous cords placed one on each side of the joint. The lateral ligament is fixed above to the higher of the two pits on the lateral condyle of the femur, covering the origin of the popliteus muscle from the lower

[1] Formerly termed the coronary ligaments.

pit. It descends over the lateral condyle of the tibia, a synovial bursa being interposed, and is attached below to the upper extremity of the fibula. The medial ligament is longer and more slender than the preceding. It is fixed above to the small tubercle on the medial condyle of the femur, plays over the edge of the articular surface of the tibial condyle and becomes attached to the condyle immediately below.

The **cruciate ligaments** are lodged in the intercondylar notch. They take the form of two strong fibrous cords crossing each other like the limbs of the letter X. They are distinguished as anterior and posterior from the relative positions of their attachments to the tibia. The **anterior,** the more lateral of the two, is attached superiorly to the axial aspect of the lateral condyle of the femur where it bounds the intercondylar groove. Its fibres, which have a slightly spiral arrangement, extend downwards and forwards to be inserted into the lateral aspect of the tibial spine. The **posterior** ligament is longer than the anterior, and is fixed superiorly to the axial aspect of the medial condyle. It extends downwards and backwards to be fixed to a special tubercle on the back of the tibia, behind the medial condyle.

The **posterior ligament** is membranous in character, and it serves to close in the joint on its posterior aspect and to give support there to its synovial membranes. It is attached superiorly across the back of the femur above its condyles; below it is attached to the tibia just below the margins of the articular surfaces of the condyles, and on either side it is partly adherent to the collateral ligaments. Its deep face is adherent to the interarticular cartilages and to the posterior cruciate ligament, and is lined elsewhere by synovial membrane.

Synovial Membranes.—The femoro-tibial articulation is in reality a double joint, one for each femoral condyle and the opposed tibial surface, and each of these joints possesses a synovial membrane. The two membranes are separated from one another by the cruciate ligaments, while behind and at the sides they line the posterior and collateral ligaments. In front they are in contact with the synovial capsule of the femoro-patellar joint, and they are separated from the anterior patellar ligaments by a pad of fat. As already stated, they generally communicate with the femoro-patellar membrane. The joint cavities are partially subdivided by the semilunar cartilages, and the lateral synovial membrane invests the tendon of origin of the popliteus and the common tendon of the superficial division of the flexor tarsi and the extensor pedis muscles.

Movements at the Stifle Joint.—The femoro-tibial articulation is of a ginglymous nature, its movements being almost confined to flexion and extension. When a horse stands squarely, the articular angle (behind the joint) measures from 145° to 150°, the femur sloping downwards and forwards at an angle of 80° with the horizontal, and the tibia having an opposite inclination of 65° to 70°. In progression the joint is first flexed to clear the foot of the ground, this action coinciding with flexion of the hip joint. When the thigh has been raised and carried sufficiently forwards by this flexion of the hip, extension of the stifle comes into play, and carries the distal part of the limb forwards. The act of flexion is very free, since, with the exception of the posterior cruciate ligament, all the femoro-tibial ligaments are relaxed by that movement. Extension cannot be carried so far as to bring the thigh and leg bones into the same straight line, the movement being arrested by tension of the collateral and anterior cruciate ligaments. In this position of the joint these same ligaments completely prevent any side to side or rotatory movements of the tibia, but such movements can be executed to a slight extent when the joint is flexed. During extension the semilunar cartilages are moved forward, being, as it were, squeezed out of place, and during flexion they return to their original position.

In the ordinary standing posture of the horse at rest, the patella and its fibro-cartilaginous extension lie on the medial lip of the trochlea, and the joint is fixed in this position. Moreover, there are in the region of the leg two strong fibrous cords, the superficial division of the flexor tarsi and the superficial flexor of the digit, which are attached to the femur above and the tarsus and metatarsus below, and prevent the movement of the hock and the joints below without the simultaneous movement of the stifle joint. Thus the fixing of the stifle joint results in the fixing of the succeeding joints, and enables a horse to stand for long periods with little muscular effort.

The movements of the patella on the femoral trochlea take place simultaneously with the flexion and extension movements between the femur and the tibia. The patella ascends on the trochlea when the quadriceps femoris muscle contracts—an action which necessarily entails the extension of the leg, since the anterior patellar ligaments are attached below to the tibia. For the same reason, when the stifle joint is flexed the patella is made to descend again on the trochlea. These movements of the patella are a combination of gliding with coaptation, that is to say, while the bone moves up or down as a whole on the femoral trochlea, successive areas of their articular surfaces come into contact with one another.

The Tibio-Fibular Joint

The head of the fibula is articulated to the lateral aspect of the lateral condyle of the tibia, forming an obscure synovial joint. Short, strong peripheral fibres pass between the two bones, and bind them very closely together. Below this point the bones have a fibrous union, an **interosseous membrane** of white fibrous tissue connecting them together, and filling up the tibio-fibular interosseous space. The membrane is perforated superiorly by the anterior tibial vessels, and just above the aperture for their transmission the fibres of the membrane are disposed in opposite directions, like the limbs of the letter X. Below this, where the slender body of the fibula comes into contact with the lateral border of the tibia, the bones are united by short interosseous fibres; and from the pointed lower end of the bone a round cord of fibres is continued to the lateral malleolus of the tibia. In reality this cord represents an unossified part of the shaft of the fibula, and, as already stated, the lateral malleolus is the lower epiphysis of the same bone.

Movements.—No appreciable movements are executed between the tibia and the fibula of the horse. In keeping with this, the articular surface of the head of the fibula, and the facet of the tibia to which it is opposed, lack the smooth polished character of synovial surfaces in general.

The Tarsal Joint

This joint, which is familiarly known as the **hock joint,** is, like the knee, not a simple joint, but a complex series of joints to which appertain a great many distinct ligaments. The simplest and most systematic order of study for these ligaments is to consider them according as they are associated particularly with one or other of the following joints, viz. (1) the tibio-tarsal joint, (2) the intertarsal joints, and (3) the tarso-metatarsal joints.

The Ligaments of the Tibio-Tarsal Joint

The following four ligaments, viz. anterior, posterior, and two collateral (lateral and medial), are tibio-tarsal, that is to say, they belong specially to the joint formed between the tibia and the tarsus, or, to speak more precisely, between the tibia and the talus.

The **anterior ligament** is a membranous ligament, roughly four-sided in outline designed to enclose the tibio-taloid joint in front, and give support by its deep face to the synovial membrane. It is fixed above to the tibia, and below to the talus, scaphoid and large cuneiform, blending in part with the talo-metatarsal ligament. On either side it blends with the collateral ligaments. The anterior or superficial face of the ligament is related to the anterior tibial vessels and to the tendons of the flexor tarsi and extensor pedis muscles. These tendons afford it support except at its supero-medial part, where, consequently, it is bulged out as a " bog-spavin " when there is an excess of synovia in the joint.

The **posterior ligament** is somewhat similar in form and purpose to the preceding, completing the tibio-taloid joint posteriorly. It is fixed to the tibia above, to the collateral ligaments at the sides, and to the talus below where it is continuous with the posterior tarso-metatarsal ligament. Its anterior face is lined by the synovial membrane of the joint, while its posterior surface is overspread by the synovial membrane of the tarsal canal through which the tendon of the deep flexor of the digit plays at the back of the hock. The ligament presents a fibro-cartilaginous thickening above the sustentaculum tali which, with the posterior surface of the sustentaculum, forms a smooth surface over which the deep flexor tendon plays. This tendon affords support to the ligament, and resists to some extent its backward distension, but where there is a great excess of fluid in the joint the ligament yields, and is pushed out on either side of the tendon above the before-mentioned fibro-cartilaginous thickening.

The **lateral collateral ligament** consists of a superficial and a deep fasciculus, which are intercrossed. The superficial division, which is much the larger of the two, is fixed superiorly to the posterior part of the lateral malleolus, and inferiorly its fibres end on the talus, calcaneum, cuboid, large metatarsal and lateral small metatarsal bones. It is perforated by a thecal canal for the passage of the lateral digital extensor tendon. The deep bundle of fibres extends downwards and backwards from its point of attachment to the forepart of the lateral malleolus, and it ends by distinct slips on the talus and the calcaneum.

The **medial collateral ligament** comprises three sets of fibres which may be distinguished as superficial, middle and deep. The superficial division, the largest of the three, is fixed superiorly to the medial malleolus from which point its fibres descend over the medial aspect of the tarsus, ending on the talus, scaphoid, large and small cuneiforms, and large and medial small metatarsal bones. The middle division is attached superiorly beneath the preceding ligament to the anterior part of the medial malleolus, and inferiorly it ends on the sustentaculum tali of the calcaneum and the talus itself. The deep division is a slender bundle of fibres stretching between the anterior part of the medial malleolus and the talus under cover of the middle fasciculus.

The Ligaments of the Intertarsal Joints

The individual bones of the tarsus are united together by the following ligaments, viz. the talo-calcanean, the cuboido-scaphoid,

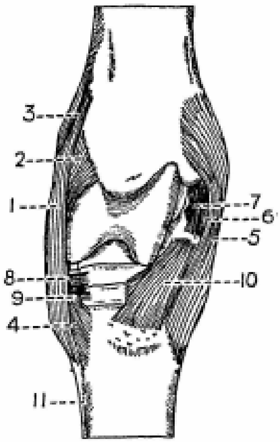


FIG. 202.—RIGHT TARSAL JOINT OF HORSE (ANTERIOR VIEW, WITH ANTERIOR TIBIO-TARSAL LIGAMENT REMOVED)

1-2. Superficial and deep divisions of lateral collateral ligament. 3-4. Superior and inferior extremities of thecal canal for passage of lateral digital extensor tendon. 5-7. Superficial, middle and deep divisions of medial collateral ligament. 8. Anterior cuboido-scaphoid ligament. 9. Anterior cuboido-cunean ligament. 10. Talo-metatarsal ligament. 11. Interosseous ligament uniting large and small metatarsal bones.

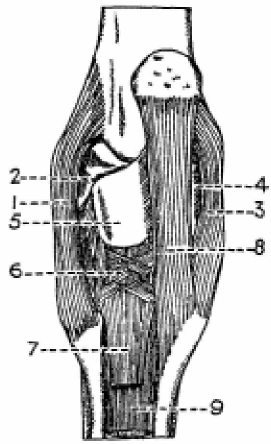


FIG. 203.—RIGHT TARSAL JOINT OF HORSE (POSTERIOR VIEW, WITH POSTERIOR TIBIO-TARSAL LIGAMENT REMOVED)

1. Superficial division of medial collateral ligament. 2. Attachment of middle division of medial collateral ligament to talus. 3-4. Superficial and deep divisions of lateral collateral ligament. 5. Sustentaculum tali. 6. Posterior tarso-metatarsal ligament. 7. Subtarsal check ligament. 8. Calcaneo-metatarsal ligament. 9. Superior sesamoidean ligament.

the cuboido-cunean, the scaphoido-cunean, the intercunean and the talo-scaphoid ligaments. It should be noted, however, that the ligaments of the tibio-tarsal and tarso-metatarsal joints also help to bind the individual bones of the hock to one another.

The **talo-calcanean ligaments,** as the name expresses, unite the talus and the calcaneum. They are four in number, a superior, two collateral, and an interosseous. The superior, or posterior, ligament is composed of short fibres connecting the bones above their surfaces of contact, the collateral ligaments pass between them on each side, while the interosseous ligament is buried between the two bones, being implanted into the rough areas between their articular facets.

The **cuboido-scaphoid ligaments** are two, an anterior and an interosseous. The anterior ligament is of small size and passes between the cuboid and the scaphoid above the entrance to the vascular canal by which the perforating tarsal vessels pass through the hock. The interosseous ligament connects the opposed surfaces of the two bones, forming, as it were, the roof of the same canal.

The **cuboido-cunean ligaments** are also two, an anterior and an interosseous. The anterior ligament passes between the two bones on the anterior aspect of the hock, below the entrance to the above-mentioned vascular canal. The interosseous ligament unites the bones where they are opposed to one another in the interior of the hock.

The **scaphoido-cunean ligament** is interosseous. It unites the scaphoid to the large cuneiform, its short fibres being inserted into the non-articular or excavated parts on the opposed surfaces of the two bones.

The **intercunean ligament** is also interosseous in position, and, as its name expresses, it unites the large and small cuneiform bones.

The **talo-scaphoid ligament** is an interosseous ligament completely concealed while the bones are in position. It is composed of short fibres closely uniting the lower surface of the talus to the upper surface of the scaphoid, being attached to the non-articular depressions of these surfaces.

The Ligaments of the Tarso-Metatarsal Joints

The ligaments belonging to this group unite the bones of the tarsus to the metatarsal bones, but, as has been previously mentioned, they also assist in binding some of the individual bones of the tarsus together. They consist of the calcaneo-metatarsal, the talo-metatarsal and the posterior tarso-metatarsal ligaments.

The **calcaneo-metatarsal ligament**[1] is a strong band of fibres situated at the back of the hock, being attached to the posterior border of the tuber calcanei, the cuboid, and the head of the lateral small metatarsal bone.

The **talo-metatarsal ligament**[2] is situated on the antero-medial aspect of the tarsus. Its fibres are attached superiorly to the medial surface of the talus from which they radiate downwards and forwards to end on the scaphoid, the large cuneiform, the large metatarsal and the medial small metatarsal bones.

The **posterior tarso-metatarsal ligament** is placed behind the

[1] Also termed the plantar tarsal ligament.
[2] Also termed the dorsal tarsal ligament.

tarsus. It forms a thick layer of fibrous tissue, closely adherent to the tarsal bones and to the heads of the metatarsal bones. Its medial border blends with the medial collateral ligament of the

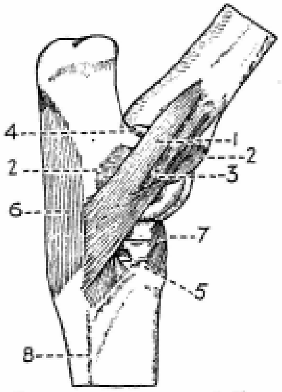


FIG. 204.—RIGHT TARSAL JOINT OF HORSE (LATERAL VIEW, WITH ANTERIOR AND POSTERIOR TIBIO-TARSAL LIGAMENTS REMOVED)

1-2. Superficial and deep divisions of lateral collateral ligament. 3. Thecal canal for passage of lateral digital extensor tendon. 4. Superior talo-calcanean ligament. 5. Anterior cuboido-cunean ligament. 6. Calcaneo-metatarsal ligament. 7. Talo-metatarsal ligament. 8. Interosseous ligament uniting large and small metatarsal bones.

tibio-tarsal joint, and its lateral with the calcaneo-metatarsal ligament. The anterior face of the ligament, where not adherent to the bones, is lined by synovial membrane, and its posterior face is overspread by the synovial membrane of the tarsal canal. Inferiorly it is prolonged as a slender band of fibres, termed the **subtarsal check ligament,** which joins the tendon of the deep flexor of the digit in the upper third of the metatarsus.

Synovial Membranes of the Tarsus.—There are four synovial capsules in the tarsus. (1) The tibio-tarsal is the largest and most important. It lubricates the joint between the tibia and the talus, being supported by the anterior, posterior and collateral ligaments of that articulation. It sends a prolongation to supply the upper two talo-calcanean facets, and it communicates with the next capsule. (2) An intertarsal synovial membrane lubricates the joint formed between the calcaneum and talus, as representing the upper row of tarsal bones, and the cuboid and scaphoid as representing the lower. It is prolonged above to supply the two lower talo-calcanean facets, and below to lubricate the anterior cuboido-scaphoid articulation. (3) A second intertarsal membrane lubricates the joint between the scaphoid and the large cuneiform, and sends prolongations to the posterior articulations between the cuboid and these two bones. (4) The tarso-metatarsal synovial membrane belongs specially to the articulation between the cuboid and cuneiform bones above and the metatarsal bones below. It also supplies the articulations between the large and small metatarsal bones, the articulation between the two cuneiforms, and the anterior articulation between the cuboid and the large cuneiform.

Movements.—The only important joint in the tarsus, as regards the range of its movement, is the tibio-taloid articulation, sometimes termed the **true hock joint.** It is a typical ginglymus, the only movements permitted being flexion and extension. When the horse stands squarely on its four legs, the tibio-tarsal angle measures from 155° to 160°, the inclination of the tibia being 65° to 70°, and the tarsus and metatarsus being approximately vertical. During flexion the pes

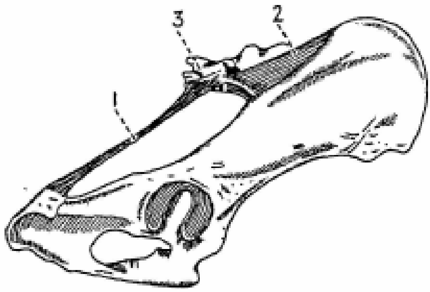


FIG. 205. — LIGAMENTS OF PELVIC GIRDLE OF DOG (LATERAL VIEW)
1. Sacro-sciatic ligament. 2. Lateral sacro-iliac ligament. 3. First coccygeal vertebra.

is carried forwards, and, owing to the oblique character of the pulley of the talus, the metatarsal bones do not move in the plane of the tibia, but deviate a little laterally. This movement is very free, and may be carried so far as to close the normal articular angle. The movement of extension cannot be carried so far as to obliterate this angle by bringing the leg and metatarsus into line, this being prevented by tension of the collateral ligaments. These same ligaments, coupled with the form of the articular surfaces, effectually prevent side to side or rotatory movements in the joint. As has been stated earlier, flexion or extension of the hock joint can only occur if there is a corresponding movement in the stifle joint.

The movements permitted in the other tarsal articulations are of a very restricted character, consisting merely in a slight gliding movement between the opposed surfaces. As in the knee, these small joints play an important role in distributing and equalising pressure in the joint.

The Intermetatarsal, Metatarso-Phalangeal and Interphalangeal Joints

It is unnecessary to describe the remaining joints of the hind limb, these resembling in the closest manner the corresponding joints of the anterior member.

THE COMPARATIVE ANATOMY OF THE JOINTS OF THE HIND LIMB

Sacro-Iliac Joint.—In all the domestic animals the ligaments of this joint resemble generally those described in connection with the corresponding joint of the horse, except that in the **dog** and **cat** the sacro-sciatic ligament has the form of a fibrous cord. Attached above to the lateral border of the sacrum near its posterior extremity and to the transverse process of the first coccygeal vertebra, its fibres pass downwards and backwards to end on the ischial tuberosity. The ligament is the homologue of the sacro-tuberous ligament of the human subject.

Hip Joint.—As already stated the accessory ligament is not present in any of the domestic species save the horse and the ass. The round ligament is poorly developed in all these species. Because of these modifications a greater range to the movement of abduction is permitted, as is exemplified by the ease with which the ox can kick in the lateral direction.

Stifle Joint.—In the **sheep, pig** and **carnivora** there is only one anterior patellar ligament, and there is a single synovial membrane for the femoro-patellar and femoro-tibial articulations. In the **dog** the two semilunar cartilages are connected anteriorly, and the articulations between the femoral condyles and the fabellae are supplied by the common synovial membrane of the joint.

Tibio-Fibular Joints.—These joints are absent in the **ruminants.** In the **pig** and the **carnivora** the leg bones are articulated by a synovial joint at either extremity, while their shafts are united by an interosseous membrane.

Tarsal Joints.—Of all the domestic animals the horse is the one in which the movements at the tarsus are most restricted. This applies more particularly to the secondary articulations of the tarsus, such as the talo-calcanean and talo-scaphoid joints, in which, in the other species, the facets are less flat, and therefore more favourable for movement.

मोडे सामग्री

16/5/81

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(The main references are indicated in heavy type)