1. Veterinary Anatomy - An Introduction

Definition and Divisions

Anatomy is the branch of biological science, which deals with the form and structure of the body and its parts. The various parts of the body must work together in near-perfect harmony to maintain the life and well-being of an animal. The term anatomy strictly means *cutting open* or *dissociating the parts of the body*.

Branches of Anatomy

Gross anatomy / Macroscopic anatomy

Topographical /Regional Anatomy

All the structures, present in the each regions or parts of the body are studied in the order, in which they should present themselves, in the course of dissection. For example, the anatomy of the neck region would include all the muscles, bones, organs, blood vessels and nerves present in the neck.

Systematic Anatomy

The branch of anatomy deals with the different systems in the animal body are studied one after another. E.g. Skeletal system, muscular system etc.

Osteology (Bones)

Arthrology (Joints)

Myology (Muscles)

Splanchnology(Visceral organs)

Angiology (Cardio-vascular system)

Neurology (Nervous system)

Aesthesiology (Sense organs)

Histology and Cytology / Microscopic Anatomy

Developmental Anatomy / Embryology

The anatomy can also be classified as

Special Anatomy which concerns with one species.

Comparative anatomy compares with the other species.

Directional Terms

Certain directional terms are used in anatomy for description of the various organs or parts of the body with regard to their position, direction etc. It is assumed that the animal is in the ordinary standing position.

Cranial and *caudal* refers to the ends of the animal as it stands on four legs. *Cranial, cephalic* or *anterior* means direction towards the head. *Caudal* or *posterior* means direction towards the tail.

Rostral is a special term used only to describe positions or directions on the head especially towards the tip of the nose.

Dorsal and *ventral* refer to "up and down" directions with the animal in a standing position.

Dorsal or *superior* means towards the back (top surface) of a standing animal and *ventral* or *inferior* means towards the belly (bottom) of a standing animal.

Medial and *lateral* refers to positions relative to the median plane. *Medial* means towards the median plane (toward the center line of the body) and *lateral* means away from the median plane.

Deep and *superficial* refer to the position of the body parts relative to the center or surface of the body. *Deep* means towards the center of the body or body part. (Internal is sometimes used in place of deep). *Superficial* means towards the surface of the body. (External is sometimes used in place of superficial).

Proximal and *distal* are used to describe positions only on extremities, such as leg, ear and tail, relative to the body. *Proximal* means towards the body and *distal* means away from the body.

With respect to distal parts of limbs, the anterior and posterior faces are referred as *dorsal* and *volar* respectively in the case of the pectoral limb and *dorsal* and *plantar* in the pelvic limb. The *medial* and *lateral* aspects are referred as radial and ulnar respectively in the case of the pectoral limb and *tibial* and *fibular* in the pelvic limb. The terms *axial* and *abaxial* are used to denote the structures lying towards or away from the central axis of the limb.

There are three anatomical planes of reference. Each plane is an imaginary "slice" through the body.

Median or sagittal plane: A plane that runs down the centre of the body lengthwise and divides it into equal left and right halves. It is also known as midsagittal plane. Plane parallel to the sagittal plane but not on the median line is called Parasagittal plane.

Transverse plane: A plane across the body that divides it into cranial (head-end) and caudal (tail-end), those are not necessarily equal.

Dorsal or Horizontal plane: A plane at right angles to the sagittal and transverse planes. It divides the body into dorsal and ventral parts that are not necessarily equal

2. Introduction to Osteology

Introduction

Osteology is the study of bones, the hardest structure in the body excepting teeth. Bones support and protect the tissues of the body and form the framework or skeleton of the body. They also act as levers to which muscle or their tendons are

attached and serve as parts of loco-motor apparatus. It serves as a storehouse for calcium in the body. In addition, the bone marrow found inside the bones forms one of the important sources of blood corpuscles.

The skeleton is generally classified as

Exo-skeleton

Endo-skeleton

Exo-skeleton

Exo - skeleton found on the surface of the body. It is characteristic of invertebrates. In higher vertebrates, it is represented by nails on the digits, horns, hooves, etc., seen in some of the mammals.

Endo-skeleton

Endo-skeleton found embedded in soft tissues within the body. It forms the supporting framework consists of two parts:

Axial skeleton: Consisting of the skull, the vertebral column, ribs and sternum.

Appendicular skeleton: Consisting of the bones in the pectoral (forelimb) and pelvic (hind limb) limbs.

In addition to this arrangement of bones, small bones occur in the tissues of an organ or other structures, which do not form a part of the regular skeleton. These small bones are called *Heterotropic bones* and occur only in particular sites in particular species of animals only.

The typical examples are

os cordis. in the heart of cattle

os penis, in the penis of the dog, also in bats, rodents and some primates

os rostri, in the snout of pigs

os phrenic, in the diaphragm in camels. (The term *splanchnic or visceral bone* is also used to refer to these heterotropic bones).

Bones

Bone is a hard structure, appears yellowish-white in color in a fresh dead bone. While in the living animal, it appears bluish pink. It is hard and rigid in macerated and prepared bones, but in the living animals, the rigidity is combined with a certain degree of flexibility also. They function to move, support, and protect the various organs of the body, produce red and white blood cells and store minerals.

Composition of Bone

The bone is composed of *organic* and *inorganic matters*. Roughly it contains 30% organic and 70% inorganic matter and this proportion varies with the bones in different parts of the body. The proportion varies with the age and there is high percentage of organic matter In growing animals,which is slowly replaced by inorganic matter.

Organic matter

It is present in the bone are bone cells, collagen fibres and matrix or the intercellular substance.

Inorganic matter

The organic matter chiefly consists of the fibrous protein - collagen and ossein and chondroitin sulphate.

The organic part contributes to the flexibility.

It consists mostly of calcium phosphate (about 85%), and small amounts of calcium carbonate (10%), magnesium phosphate, sodium carbonate and sodium chloride.

The inorganic salts are responsible for the rigidity and hardness of bone.

Structure of Bone

Microscopic structure

The bone is one of the varieties of connective tissue, consisting of *bone cells* or *osteocytes*, parallel rows of *fine collagen fibres*, which are embedded in the *amorphous ground substance*.

The ground substance or matrix is impregnated with regularly arranged crystals of calcium salts.

The deposition of the mineral matter renders the intercellular substance hard and impermeable, forming thin plates or lamellae.

Macroscopical/Gross structure

The gross structure of the bone shows differences in the arrangement of these bony lamellae, forming either *compact or cancellated bone*.

Compact bone

It is dense, white and hard and forms the outer shell of a bone. It is found aggregated in portions where there is greatest strain on the bone is exerted.

Bone is arranged in the form of concentric system called the *Haversian system or Osteone*.

Cancellated or Spongy bone

It is made up of delicate plates, which intercross each other forming a meshwork with spaces containing marrow.

Cancellated bone is found in the epiphyses of long bones and is always covered by a layer of compact bone.

Haversian systems are absent.

Classification of Bones

Bones are classified based on their general shape and function as long bones, flat bones, short bones and irregular bones.

Long bones

Have an elongated cylindrical part, the *shaft* or *diaphysis* and *two expanded extremities* or *epiphysis*.

The shaft encloses the medullary cavity, which in life is occupied by yellow marrow.

The wall consists of dense compact bone of considerable thickness in the middle part of the shaft but becoming thinner towards the extremities. Inside of the compact bone, there is a thin layer of spongy bone lining the *medullary cavity*.

Each epiphysis consists of spongy bone covered by a thin layer of compact bone.

The spaces in the cancellated bone of the epiphyses are occupied by red marrow.

Long bones are found in the limbs and act as pillars for support and as levers. E.g. humerus, femur.

Some long bones do not develop completely and their medullary cavity is very small or even absent which are called as *aborted long bones*. E.g. ulna of horse.

Some bones though long they do not have a medullary cavity and are sometimes referred to as *elongated bones*. E.g. Ribs.

Flat bones

They are expanded in two directions. They are plate like, affording large surface area for the attachment of muscles and protection of subjacent structures.

The flat bones are made up of varying thickness of spongy bone between two layers of compact bone E.g. scapula, flat bones of skull like frontal, parietal.

The flat bones of the cranial vault are composed of an outer layer of ordinary compact bone or lamina externa and an inner layer of very dense compact bone, lamina interna or tabula vitrea and between these is a variable amount of spongy bone called *diploe*.

Short bones

They present similar dimensions in length, breadth and thickness. They are made up of a thin layer of compact bone outside and spongy bone inside.

The *medullary cavity is absent*. This arrangement helps to diffuse concussion. E.g. carpals, tarsals.

Sesamoid bones

They are short bones, which do not bear the weight of the body and they are developed in the capsules of joints or in tendons.

They alter the direction of tendons and also give leverage to the tendons of muscles. E.g. patella.

Irregular bones

They are irregular in shape and are usually placed on the median line. They resemble short bones in structure. E.g. vertebrae.

Pneumatic bones

These bones contain *air spaces* within the compact substance instead of spongy bone and marrow. These cavities/spaces are lined by mucous membrane and are termed as *sinuses*. They communicate indirectly with the external air.

In mammals, some flat bones of the skull (frontal, maxilla, palatine, etc.) enclose sinuses and communicate directly or indirectly with nasal cavity.

In the fowl, many of the bones are pneumatic (vertebrae, sternum, humerus and femur) and these receive air through the medium of air sacs.

Coverings of Bone

Periosteum

It is the membrane, which invests the outer surface of the bone except its articular areas where it is covered by articular cartilage.

The periosteum consists of *an outer protective fibrous layer* and *an inner cellular osteogenic layer*.

Endosteum

It is a thin membrane lining the medullary cavity and larger haversian canals.

It ia also called as medullary membrane.

Bone Marrow

There are two kinds of marrow - *red and yellow*.

Red marrow

It occupies the interstices of spongy bone everywhere and medullary cavity of long bones at birth. After birth, the red marrow is gradually replaced by yellow marrow.

Red marrow is an important blood forming substance and contains precursors of erythrocytes, granular leukocytes of the blood, giant cells, which give rise to platelets and a few fat cells.

In the adult, red marrow is present only in the vertebrae, sternum, ribs, skull bones and epiphyses of long bones.

Yellow marrow

It consists of ordinary adipose tissue especially in the medullary cavity of long bones and short bones. Yellow marrow fills the spaces of the spongy bone in short bones (carpals and tarsals) and medullary cavity of long bones.

Development of Bone

In the embryonic life, the future elements of the skeleton are derived from the mesenchyme, which is derived from the mesoderm.

Ossification is the process of development of bone from the mesenchyme.

The formation of bone during the fetal stage of development occurs by two processes called Intramembranous and Endochondral ossification.

Intramembranous ossification

The flat bones of the skull are developed by ossification in a membranous layer formed by the condensation of mesenchymal tissue. Hence, this process is being termed as intramembranous methods of ossification. The bones developed by this method are termed as membranous bones.

The steps in intramembranous ossification are

1. Development of ossification centre
2. Calcification
3. Formation of trabeculae
4. Development of periosteum

At a point (centres of ossification), osteoblasts are differentiated from mesenchymal cells. A meshwork of collagen fibres produced by the osteoblasts appears between the cells. It becomes vascularised by capillary network. The osteoblasts produce other organic intercellular substances like mucoprotein, glycoprotein, mucopolysaccharides etc. This organic non-calcified matrix is known as *osteoid*. Now the matrix is calcified by the osteoblasts. Few osteoblasts become entrapped by the surrounding matrix and are transformed into osteocytes. Simultaneously, other osteoblasts proliferate by division and are arranged in radiating manner from the centre. Thus trabeculae are formed between the cells. The trabeculae join each other to form cancellous bone. The osteoblasts surrounding the bony spicules deposit more bones to the free ends and sides and thus calcification is spread and the bone becomes compact. The periosteum is developed from the condensation of the mesenchyme.

Intra cartilagenous ossification /endochondral method of ossification

The bones of appendicular skeleton, vertebral column, ribs etc, are developed by intracartilagenous or endochondral method of ossification . In this method, a cartilage model of future bone is formed at first and then it is replaced by bone. Bones developed by this method are termed as *cartilaginous bones*. The process of ossification does not take place simultaneously all over the cartilaginous or membranous representative of a future bone. It begins at one or more points known as centres of ossification, from which it extends until the central soft tissue is replaced by bone. In a long bone, there is a primary centre of ossification for the diaphysis and secondary centres appear for the epiphysis. Additional centres may appear in some bones for the various processes present in the bone. The number of centres is different for the various bones in the body, but the number for each bone is constant in a particular species.

This process occurs in stages.

Stage-I

At the beginning, a cartilage model is formed by the condensation of the mesenchymal tissue. Perichondrium appears around the cartilage. The cartilage cells (chondroblasts) at the mid section of the model proliferate by mitosis and are arranged in rows towards the ends. They mature and hypertrophied. The hypertropic cells produce alkaline phosphatase and precipitate calcium salt at the matrix. The surrounding calcification cause death of the cartilage cells and thereby form spaces-the primary areolae . This zone is known as *primary ossification centre*. At the same time osteoblasts appear at the inner layer of perichondrium and form subperiosteal collarbone around the primary ossification centre.

Stage-II

At this stage the collar bone is eroded by the increased activity of the subperiosteal steoclasts and peroisteal buds containing osteoblasts, osteoclasts and blood vessels enter into the primary ossification centre. The osteoclasts absorb the irregular calcified mass and form secondary large areolae . These secondary areolae lead to the formation of marrow cavity, which subsequently becomes filled up by the bone marrow.

Stage-III

It is known as stage of true bone formation. Here the osteoblasts appear and lay down lamellated bone. Subsequently a number of longitudinal grooves proliferate and enclose a small blood vessel, which already developed along the periosteum and convert the grooves into tunnels. The lining osteoblasts of the tunnel convert the tunnel into Haversian system by proliferation and differentiation into osteocytes.

The whole process is repeated again and again and the ossification extends longitudinally. Simultaneously new bones are formed under the periosteum by appositional method. Secondary ossification centres appears at the ends of the cartilagenous model at birth. This zone is called epiphysis. Ossification occurs in the similar way in both directions.

Growth of Bones

Flat bones of the skull increase in size by continued marginal ossification from connective tissue at the site of later sutures.

Both cartilage and membranous bones grow in thickness through further deposition of matrix at their outer surfaces.

At the ends of a long bone a layer of cartilage does not ossify and remains as articular cartilage throughout life.

In growth phase, a portion of the cartilagenous model remains as epiphyseal cartilage cartilage between the epiphysis and diaphysis.

The epiphyseal cartilage helps in longitudinal growth of the bone and is replaced totally by bone when the growth is complete. Therefore the length of the bone increases with the growth of the epiphyseal cartilage. But with the advancement of the age, the growth of this metaphyseal cartilage slows down and the calcification becomes more rapid. So the whole epiphyseal cartilages become ossified and growth in length ceases.

The width increases by the deposition of subperiosteal membrane bone.

Factors influencing the development and growth of bones

They are include calcium phosphorous, vitamin D, vitamin C, alkaline phosphatase, parathyroid hormone, growth hormone of pituitary, thyroid hormone and vitamin A.

Terminology

The surface of the bones presents a number of features in the form of prominences, depressions, perforations etc. These may be articular (forming joints with corresponding articular areas of another bone) or non-articular furnishing attachment to muscles, tendons and ligaments.

Some of the terms used to designate the features of bones are as below:

Bone feature	Definition
Process	A general term for prominence.
Tubercle	A small blunt projection which, if more developed is called a tuberosity while a trochanter is the largest of these.
Spine	A pointed proection.
Crest	A sharp ridge.
Head	A rounded articular enlargement at the end of a bone; it may be joined to the shaft by the neck.
Condyle	A somewhat cylindrical articular eminence while an epicondyle is the non-articular projection in connection with it.
Protuberance, prominence, eminence, torus	A varieties of bony projections.
Trochlea	A pulley -lie articular area.
Glenoid cavity	A shallow cup-like articular depression
Cotyloid cavity	A deep cut like articular depression.
Line	A faint elongated elevation whereas a crest is an elongated elevation.

Facet	A flat articular surface.
Foramen	A perforation for the transmission of vessels, nerves etc.
Sinus	An air cavity within the bone lined by mucous membrane and communicates with the exterior.
Hiatus	A depression leading to two or more foramina. The terms fossa, fovea and sulcus denote various forms of depressions.
Cleft	A fissure in a bone.
Lamina	A thin plate of a bone.
Cornu or hamulus	A curved horn like process.
Canal	A bony tunnel (foramen of some length).
Meatus	A narrow passage.
Articular process	A projection that contacts an adjacent bone.
Articulation	The region where adjacent bones contact each other—a joint.
Canal	A long, tunnel-like foramen, usually a passage for notable nerves or blood vessels.
Eminence	A relatively small projection or bump.
Suture	Articulation between cranial bones.
Labyrinth	A cavity within a bone.
Malleolus	One of two specific protuberances of bones in the ankle.
Mamus	An arm-like branch off the body of a bone.

Several terms are used to refer to specific features of long bones

Bone feature	Definition
Diaphysis	The long, relatively straight main body of a long bone; region of primary ossification. Also known as the *shaft*.
Epiphysis	The end regions of a long bone; regions of secondary ossification
Epiphyseal plate	Also known as the *growth plate* or *physis*. In a long bone it is a thin disc of hyaline cartilage that is positioned transversely between the epiphysis and metaphysis. In the long bones of humans, the epiphyseal plate disappears by twenty years of age.
Head	The proximal articular end of the bone.
metaphysis	The region of a long bone lying between the epiphysis and diaphysis.
Neck	The region of bone between the head and the shaft.

Blood and Nerve supply of Bone

Arteries

The bones are highly vascular.

The bone is supplied with blood externally on the surface and internally on the lining of the medullary cavity.

The surface arteries ramify over the periosteum and large blood vessels gain entrance through the nutrient foramen and branches widely along the course and on the endosteal lining of the bone. Thus there is a network of blood vessels over the entire bone.

Veins

They accompany the arteries ans mostly recurrent in nature.

Nerves

They accompany the blood vesels. The periosteal branches are senosry.

Lymph vessels

They run in company with blood vessels of the marrow,forming a network under the periosteum.

Number of Skeletal Segments

The number of bony segments are varies with the species.

Some of the bones are laid down in the embryonic life, either fuse or disappear in adult life. So the young and adult animal of the same species will not have the same number of bones.

The number of bones in the skeleton are given below

	Skull (Including hyoid and mandible)	Vertebral column (approx)	Ribs and Sternum	Fore limb	Hind limb	Visceral bone	Total (approx)
Ox	32	51	26+1+0	24 x 2	24 x 2	2 os cordis	208
Horse	32	51	36+1+0	20 x 2	20 x 2	-	200
Dog	32	51	26+1+2	44 x 2	45 x 2	1 os penis	291
Pig	30	52	28-30+1+0	40 x 2	40 x 2	1 os rostri	274
Rabbit	34	46	24-26+1+0	31 x 2	29 x 2	-	229
Fowl	40	41	14+1+1+2	13 x 2 (coracoid)	21 x 2	2 os opticus	169

3. Appendicular Skeleton - Scapula and Humerus

Appendicular Skeleton

The appendicular skeleton consists of bones, which form the framework of the pectoral or forelimbs and the pelvic or hind limbs, including the elements, which serve to anchor or attach the limbs to the trunk of body, referred to as the pectoral and pelvic girdles respectively.

The arrangement of the bones in the girdles and the rest of the regions of the limb are similar in the pectoral and pelvic limbs.

The bones present in each species of animal represent modifications from a common pattern as part of evolutionary changes the species or group has undergone.

The general designations for the different parts of the limbs and bones present in each are given below.

Pectoral limb

Pectoral girdle and shoulder region: Scapula, Coracoid and Clavicle.

Arm: Humerus

Forearm: Radius and Ulna

Manus: Consisting of

Carpus: A number of small bones called carpals arranged in the domestic mammals in two rows.

Metacarpus: Typically consisting of five bones designated only by numbers 1 to 5, but showing considerable modifications in different animals.

Digits: These form the terminal parts of the limbs and usually correspond to the number of the fully developed metacarpals. These are also designated by numbers 1 to 5. Each digit is composed of a number of bones arranged serially called the phalanges. The number of phalanges may vary (from 1 to 5) within the species and also in different digits of the same species.

Pelvic limb

Pelvic girdle and hip region: Ilium, ischium, and pubis,

Thigh: Femur

Leg: Tibia & fibula

Pes: Consisting of

Tarsus (3 rows)

Metatarsus : similar to the forelimb

Digits

Bones of the pectoral limb

Pectoral girdle and shoulder region : Scapula, Coracoid and Clavicle.

Arm : Humerus

Forearm : Radius and Ulna

Manus : Consisting of

Carpus: A number of small bones called carpals arranged in the domestic mammals in two rows.

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Modifications in different animals

It should be noted that in all animals, there are considerable modifications in the number present and the extent of development of the various bones as compared with the typical pattern. Significant modifications are noted in the domestic animals to be studied (i.e. *ox, sheep, goat, horse, pig, dog, rabbit* and fowl). They are

The absence of a typical pectoral girdle and only scapula being well developed in all the mammals, (all three bones are present in the fowl).

Ulna is being reduced and fused to radius in ox and horse.

Extensive modifications in the bones of the manus, (i.e.) *carpus, metacarpus* and *digits*, with two well developed digits in the ox, sheep, goat, pig and only one in the horse but five (first reduced) in the dog and three in the fowl.

For specific bones present in each species, refer details given in the descriptions of corresponding regions.

Scapula

Ox

It is flat, triangular bone, situated on the antero-lateral aspect of the thorax and directed obliquely downward and forward. The clavicle is absent. It is connected to the axial skeleton only by muscles.

It has *two surfaces, three borders and three angles* .

The *lateral surface* or the *dorsum* is wide above and narrow below.It is traversed by the *scapular spine*, which divides the lateral surface into an cranial supraspinous fossa and the caudal infraspinous fossa, the former being the smaller. The free edge of the spine is in great part subcutaneous, somewhat rough and tuberous in the middle for the attachment of *trapezius* and is prolonged downward to form the *acromion process* for the *deltoideus muscle*. The supraspinous fossa lodges the *supraspinatus muscle*. The infraspinous fossa is occupied by the *infraspinatus* and the muscular ridges at its lower part are for the origin of *teres minor*. The *costal* or *ventral surface* presents a shallow depression called *subscapular fossa* , which lodges the *subscapularis*. The upper third of this surface presents cranially a triangular rough area for the *serratus cervicis* and posteriorly a rough line for the *serratus thoracis*.

The *cranial border* is thin, convex above and concave below. The *caudal border* is thick, presents the nutrient foramen in the lower third and is rough for *deltoideus*, *teres major* and *long head of triceps muscles*. The *vertebral border* is

thick, pitted and carries in life the scapular cartilage, the unossified part of the fetal scapula. The *medial face* of the cartilage gives attachment to the *rhomboideus*.

The *cranial* or *cervical angle* is thin. The *caudal* or *dorsal angle* is thick. The *ventral* or *glenoid angle* carries the glenoid cavity and cranial to it the *tuber scapulae*.The former meets the head of the humerus to form the shoulder joint. The rim of the cavity presents the *glenoid notch* on the craniolateral aspect. The tuber scapula is for the *biceps brachii* and presents the coracoid process on its medial aspect for the *coraco brachialis*.

Horse

The acromion process is absent.

The subscapular fossa is deeper and partly separates two triangular rough areas in the upper third.

The glenoid notch is on the antero-medial aspect of the rim.

On its postero-lateral aspect the rim presents a tubercle for *teres minor*.

The tuber scapula is larger and placed further away from the glenoid cavity.

Pig

Scapula of the pig is very wide.

The scapular spine is triangular and is very wide in its middle, which curves backward over the infraspinous fossa and bears large tuberosity.

Acromion process is rudimentary.

The cranial border is slightly convex, thick and rough in its middle.

The caudal border is wide and slightly concave.

The vertebral border is convex and the scapular cartilage is not so extensive as in horse and ox.

The cranial angle is thin and bent medially. The caudal angle is thick and is at right angle.

The glenoid notch is absent.

The tuber scapula is above the antero-medial part of the glenoid cavity.

No distinct coracoid process and it unite with the rest of the bone at about one year.

Dog

The Clavicle, when present, is a small cartilaginous or bony plate embedded in the *brachiocephalicus* muscle, in front of the shoulder joint and does not articulate with the rest of the skeleton.

In the Scapula, the spine is placed in the middle of the dorsum and increases in height from above downward, to the level of the glenoid cavity where it terminates in the acromion process.

The vertebral border is convex and the scapular cartilage is in the form of a thin band.

The glenoid cavity extends to the inferior face of the tuber scapula.

The coracoid process is absent.

Fowl

It has a clavicle, coracoid, and the scapula.

The *clavicle* is a thin, bent rod directed downward and backward. The flat dorsal end rests against the scapula and the coracoid to form the *foramen triosseum* . The clavicles of two sides unite ventrally to form a flattened plate called *Hypocleidium,* which is attached to the rostrum of the sternum by a ligament. The two combined clavicles form the *furcula* and are also called *"wish bone"*.

The *coracoid* is rod like, directed backward, downward and inward. The upper extremity is prolonged into a hook-like process medially. It presents a small articular surface -the glenoid cavity for articulation with humerus. Below this, there is another area for articulation with scapula. The lower extremity articulates with the sternum.

The scapula is a narrow saber-shaped bone placed parallel to the vertebral column. The anterior end presents a depression laterally which forms part of the glenoid cavity for the reception of the head of the humerus and a projection cranially -the acromion process, which meets the clavicle and coracoid to form the foramen triosseum. the posterior end lies at the level of the sixth rib.

Humerus

Ox

It is a long bone placed obliquely downward and backward between the shoulder joint above and the elbow joint below.

It has a *shaft* and *two extremities*.

Shaft:

It has a twisted appearance and has *four surfaces*.

The anterior face is triangular, wide and smooth above, narrow and rough below.

The posterior face blends with the medial and lateral faces. It presents the nutrient foramen about the middle.

The medial face is nearly straight in its length. Just above its middle it presents the teres tubercle for latissimus dorsi and teres major.

The lateral face is spirally curved and forming the *musculo-spiral groove*, which contains the brachialis muscle. The groove is continuous with the posterior face above and winds around towards the front. Lateral surface is separated from the anterior by a distinct border the crest of humerus,

which bears above its middle the deltoid tuberosity. The crest is for the insertion of brachio-cephalicus and superficial pectoral and the deltoid tuberosity for the deltoideus muscle. A curved line extends upward from the deltoid tuberosity and is for the lateral head of triceps. At the upper part of the curved line is a nodule for the teres minor.

Proximal extremity:

It consists of a *head, neck, two tuberosities* and the *intertuberal or bicipital groove*.

The head presents a circular articular surface, which articulates with the glenoid cavity of the scapula to form the shoulder joint.

The lateral tuberosity consists of two parts - an *anterior summit* arching medially and a *posterior convexity*. The former over-hangs the bicipital groove and gives attachment to the lateral tendon of the infraspinatus. The convexity gives attachment medially to the medial tendon of the infraspinatus.

The medial tuberosity is smaller and consists of *anterior* and *posterior parts*. The anterior part forms the medial boundary of the intertuberal groove and gives attachment to the medial tendon of supraspinatus and to the deep pectoral. The posterior part is for the subscapularis.

The intertuberal groove is bounded by the anterior divisions of the two tuberosities and in life, is covered by a fibro cartilage for the play of the tendon of origin of biceps brachii.

Distal extremity:

It has an oblique surface, which is divided by a ridge into two condyles, the medial being the larger. The medial condyle is crossed by a groove, which extends into the olecranon fossa and articulates with the semilunar notch of the ulna.

This extremity presents anteriorly above the articular area, the *coronoid fossa,* which receives the coronoid process of the radius in extreme flexion of the elbow joint.

Behind and above the condyles are two thick ridges, the epicondyles. The medial epicondyle is more prominent and furnishes origin to flexor muscles of the carpus and digits and bears a tubercle for the attachment of medial ligament of the elbow joint. The margins of the olecranon fossa are for the origin of the anconeus. The lateral epicondyle bears laterally the condyloid crest in the form of a raised ridge, which gives origin to extensor carpi radialis. Between these two epicondyles is the deep olecranon fossa, which receives the anconeus process of ulna during extreme extension. The distal extremity also presents a rough depression

laterally and a tubercle medially for the collateral ligaments of the elbow joint.

Horse

The deltoid tuberosity is more prominent.

The bicipital groove is divided by intermediate ridge.

The summit of lateral tuberosity does not arch inward.

The coronoid and the olecranon fossa are shallower.

Pig

It has the appearance of italic letter '*f*' minus the cross bar.

The shaft is laterally compressed and flat on the medial side.

The musculo-spiral groove is shallow and the deltoid tuberosity is small and there is a larger rounded eminence midway between it and the lateral tuberosity.

Teres tubercle is absent.

The condyles are of equal size.

The coronoid fossa is prominent.

The olecranon fossa is narrow and deep.

Occasionally the suprtrochlear foramen is found.

Dog

The musculospiral groove is shallow.

The deltoid tuberosity is in the form of a low ridge.

The lateral tuberosity is undivided.

The coronoid and the olecranon fossa communicate with each other through the supratrochlear foramen through which no soft structure passes.

Fowl

The bone is directed parallel to thoracic vertebrae when the wing is at rest.

The proximal extremity presents on the medial aspect, an opening leading into the air cavity in its shaft.

Radius

Ox

The radius is the larger and shorter of the two bones of the forearm.

It is a long bone placed obliquely downward between the elbow joint above and the carpal joint below.

It consists of a *shaft* and *two extremities*.

Shaft

It is flattened from before backwards.

It has *two surfaces* and *two borders*.

The *dorsal face* is convex in its length, smooth and covered by the extensors of the carpus and digits.

The *volar face* is concave in its length. It presents along its lateral border a narrow rough area where it is attached with the ulna by interosseous ligament. This rough area is interrupted above and below by two smooth areas which forms the proximal and distal *ra*dio-ulnar arches. These two arches are connected laterally by the *radio-ulnar groove* which is for the passage of the interosseous vessels.

The *medial border* is for the most part subcutaneous presents proximally, a rough area for the brachialis and the medial ligament of the elbow.

The *lateral border* is rounded in its proximal third, wide and flat below and is limited by the radio-ulnar groove. This border gives attachment to the lateral digital extensor and the extensor carpi obliquus.

Proximal extremity

It presents an articular area, which is divided by a sagittal groove into two divisions, the medial being the larger.

It articulates with the distal extremity of the humerus and is surrounded by a rim, which carries the *coronoid process* about the middle of the anterior surface. The coronoid process is received into the coronoid fossa of the humerus during the extreme flexion of the elbow.

Posteriorly just below the articular surface are two facets for articulation with the like facets of the ulna and between these and the proximal interosseous space is a quadrilateral rough area to which the ulna is attached.

The medial aspect of the anterior face presents a *radial tuberosity* into which the biceps brachii is inserted. The *lateral tuberosity* is more prominent and gives attachment to the lateral extensor of the digit.

Distal extremity

It is wide.

It presents three oblique facets for the carpal bones viz., radial, intermediate and ulnar carpals from within outward.

The facet for the ulnar carpal is partly furnished by the ulna.

On the medial and lateral aspects are rough elevations for the collateral ligaments of the carpus.

Horse

Close to the medial border of the volar face, below the middle is a rough elevation for the radial check ligament.

The lateral border presents only one smooth area to form the proximal radio-ulnar arch.

The radial tuberosity is more prominent.

The facets of the distal extremity are less oblique.

The lateral face articulates with the ulnar carpal below and with the accessory carpal behind.

Pig

It is short, thick and curved posteriorly.

Dog

The radius and ulna are relatively long and articulate with each other at their extremities enclosing a narrow interosseous space and permit a certain degree of movement.

The proximal extremity of radius is small and bears a concave surface for articulation with the humerus above and a convex marginal area posteriorly for the ulna.

The distal extremity is wide and its medial border projects downward forming the styloid process of radius. Laterally there is a concave facet for the ulna.

Fowl

The bones of forearm are nearly parallel to humerus.

Of the two bones the radius is slender while the ulna is thicker and longer.

They articulate at their ends and enclose a wide interosseous space.

The proximal extremity of the radius presents a concave articular area while the distal extremity is flattened from side to side and articulates with the radial carpal.

Ulna

Ox

It is a long bone and longer than the radius.

It situated on the posterolateral aspect of the radius.

It is fused with the radius in the adult, except at the two inter-osseous spaces above and below.

Shaft

It is complete, *three sided* and strongly curved.

Its proximal part contains the medullary cavity, which extends somewhat into the proximal end.

The *dorsal face* is rough except at two places where it is smooth and is applied to the volar aspect of the radius.

The *medial face* is wide.

The *lateral face* presents the radio-ulnar groove between it and the radius.

Proximal extremity

It forms the major part of the bone and is made up of the *semilunar notch* and the *olecranon process*.

The *olacranon process* is quadrilateral in shape directed upward and backward. The medial surface is concave and smooth while the lateral is convex and rough above. The anterior border bear on its middle a pointed projection the *anconeus process* that is for *anconeus* and during extreme extension of the elbow joint it passes into the olecranon fossa of the humerus. The posterior border is thick and concave. The summit of the olecranon process forms the *point of the elbow* and gives attachment to *triceps*.

The *semilunar notch* is placed below the anconeus process and articulates with the posterior part of the medial division of the articular area of the humerus. Below the notch are two facets for articulation with the like facets on the posterior face of the proximal extremity of the radius.

Distal extremity

It is fused with the radius.

It projects below the level of the radius forming the styloid process of ulna, which furnishes a part of the facet for the ulnar carpal.

Horse

It is shorter, reaching only the distal third of the radius. It forms only the proximal radio-ulnar arch.

There is no articulation with the ulnar carpal.

Pig

The proximal extremity is large and the olecranon process is prominent.

The distal extremity is small and tapers to a blunt point.

Dog

It is well developed and crosses the volar face of the radius medio-laterally closing a narrow interosseous space.

The olecranon is grooved and shows three prominences of which the posterior one is large and rounded.

Below the semilunar notch is concave surface for the radius.

The styloid process articulates dorso-medially with radius and low with ulnar and the accessory carpals.

Fowl

It is larger and thicker than the radius.

It is curved in its length.

The proximal extremity has two concave articular areas.

The olecranon process is short.

The distal extremity is expanded and presents a trochlea and articulates with radial and ulnar carpal bones.

Carpals

The carpals are arranged in the following pattern in domestic animals.

Ox

The carpus consists of six bones arranged in two rows *-four in the proximal and two in the distal rows*. They are short bones arranged as noted below.

	Medial		Lateral	
Proximal row	Radial carpal	Intermediate carpal	Ulnar carpal	Accessory carpal
Distal row	Fused second and third carpal		Fourth carpal	

Radial carpal (scaphoid)

It is the largest bone of the upper row.

The *proximal surface* is convexo-concave from before backward and articulates with the radius.

The *distal surface* articulates with the fused second and third carpal.

The *lateral face* bears facets for the intermediate carpal.

The *dorsal, medial* and *volar faces* are continuous and rough.

Intermediate carpal (lunar)

It is wedge-shaped.

The *dorsal face* is rough and forms the base.

The *apex* is posterior, is prolonged medially.

The *proximal face* is convexo- concave from before backward and articulates with the radius.

The *distal face* is divided by a sagittal ridge into two facets for the second and third and the fourth carpals.

The *medial face* has facets for the radial carpal.

The *lateral face* articulates with the ulnar carpal.

Ulnar carpal (cuneiform)

It is very irregular.

The *proximal face* is oblique directed backward and downward, encroaches on the distal face and articulates with the fourth carpal.

The *medial face* has facets for the intermediate carpal.

The *dorsal face* is rough and convex

The *volar face* has a facet for the accessory carpal.

Accessory carpal (pisiform)

It is short, thick and rounded.

It is a sesamoid bone situated behind the ulnar carpal.

The *proximal face* is narrow and rough for *flexor ulnaris* and *ulnaris lateralis*.

The *distal face* is broad and rough.

The *dorsal face* has facet for the ulnar carpal.

Fused second and third carpal (os magnum)

It is the largest of the carpals the medial one of the two bones of the distal row.

The *proximal face* has two facets, medial larger for the radial carpal and the lateral smaller for the intermediate carpal.

The *distal face* articulates with the large metacarpal.

The *lateral face* has facets for the fourth carpal.

The *medial* and *dorsal faces* are continuous rough and convex.

Fourth carpal (unciform)

The *proximal face* has two facets for the intermediate and the ulnar carpals.

The *distal face* articulates with the large metacarpal.

The medi*al face* has facets for the fused second and third carpal.

The *dorsal* and the *lateral faces* are continuous and rough.

Horse

5. Has *seven or eight bones*. They are:

Radial carpal: Resembles that of the ox.

Intermediate carpal: The lateral angle of its proximal face is more pointed.

Ulnar carpal: The smallest bone of the proximal row. The proximal face articulates only with the radius.

Accessory carpal: It is discoid. The *medial face* is concave and the lateral is convex and rough. A smooth groove for the long tendon of *ulnaris lateralis* crosses its anterior part obliquely downward and slightly forward. The anterior border has two facets -the upper concave for the radius and the lower convex for the ulnar carpal.

First carpal (trapezium): It is inconstant; when present it is situated behind the second.

Second carpal (trapezoid): It is the smallest bone of the distal row. The proximal face has a convex facet for the radial carpal. The distal face is flat and articulates with the medial small and large metacarpals. The lateral face has two facets for the third carpal. The dorsal and the medial faces are continuous and rough.

Third carpal (os magnum): It is the largest carpal. It is irregularly triangular with the base anterior. The proximal face articulates with the radial and the Intermediate carpals and distal with the large and medial small metacarpals. The

medial border is more concave than the lateral. *Fourth carpal (unciform)* - It the proximal face is convex and articular and encroaches on the lateral face. The distal face articulates with the large and the lateral small metacarpals. The medial face has two facets for the third carpal.

Pig

It has *eight bones* – four in each row.

	Medial		Lateral	
Proximal row	Radial carpal	Intermediate carpal	Ulnar carpal	Accessory carpal
Distal row	First carpa l	Second carpal	Third carpal	Fourth carpal

The bones of the proximal row resembles that of an ox with the exception that accessory carpal is similar to that of horse but has no lateral groove. The first carpal is small, elongated from before backward, rounded and articulates in front with the second carpal.

Dog

It has *seven bones* -Three in the proximal and four in the distal row. The radial and the intermediate are fused.

	Medial		Lateral	
Proximal row	Radial - Intermediate carpal		Ulnar carpal	Accessory carpal
Distal row	First carpal	Second carpal	Third carpal	Fourth carpal

	Medial		Lateral		
Proximal row	Radial carpal	Intermediate carpal	Ulnar carpal	Accessory carpal	
Distal row	First car pal	Second carpal	Central carpal	Third carpal	Fourth carpal

Fowl

There are only two free bones in the adult.

The radial carpal is quadrilateral while the ulnar carpal is forked.

The bones of the lower row fuse with those of the carpus during the development forming the *carpometacarpal bone*.

	Medial		Lateral	
Proximal row	Radial carpal	Intermediate carpal	Ulnar carpal	Accessory carpal
Distal row	First carpal	Second carpal	Third carpal	Fourth carpal

Metacarpals

Ox

The metacarpus consists of a *large metacarpal(fifth). (fused third and fourth)* , which carries the digit and a *lateral small metacarpal*

Large Metacarpal

It is a bone placed vertically between the carpus above and fetlock below. It results from the fusion of third and fourth metacarpals.It consists of a shaft and two extremities.

Shaft

It is semi-cylindrical and as *two surfaces* and *two borders* .

The *dorsal surface* is convex transversely and is marked by a vertical vascular groove at either end (usually at the distal end) of which is a foramen, which traverses the thickness of the shaft.

The *volar surface* is flat from side to side and presents a shallow vertical groove, which communicates with the anterior groove through the foramina described above. This surface is in contact with the superior sesamoidean ligament.

The borders are *medial* and *lateral* and rounded. The latter, at its upper part has the lateral small metacarpal attached to it posteriorly.

Proximal extremity

It has two facets separated by a ridge in front and a notch behind.

The medial facet is larger and corresponds to the second and third carpal and lateral to the fourth carpal. At the dorsal aspect of this extremity is the metacarpal tuberosity for the *extensor carpi radialis*. At the postero-medial aspect is a tubercle for the attachment of *extensor carpi obliquus*. The lateral aspect of the volar face bears a small facet for the lateral small metacarpal.

Distal extremity

It is divided into two parts by a sagittal cleft.

Each part is made of two condyles separated by a sagittal ridge for articulation with the first phalanx below and two sesamoids behind.

The medial condyle is slightly larger than the lateral.

The abaxial aspects of each division are depressed for ligamentous attachment.

Lateral Small Metacarpal(Fifth Metacarpal)

It is an aborted long bone and is an inch and a half long.

The bone is attached to the postero-lateral aspect of the proximal extremity of the large metacarpal.

The proximal extremity is rounded and bears a small facet on the anterior face for the large metacarpal.

The distal extremity is pointed.

Horse

The metacarpus consists of *one large metacarpal* (third) *two small metacarpals or splints* (second and fourth).

Large metacarapal

The vascular grooves on the dorsal and volar faces are absent.

The volar face is roughened on either side in its proximal two thirds for attachment of the splints with which it forms a wide groove for the lodgment of suspensory ligament.

It articulates with the second, third and fourth carpals above and by means of small facets on either side, with the proximal extremities of the splints.

The distal extremity of the large metacarpal resembles one of the parts of the distal extremity of large metacarpal of the ox.

The medial condyle of the articular area for the first phalanx is slightly larger than that of the lateral.

Small metacarpals

The shaft of each is three sided.

The dorsal face is rough for attachment to the large metacarpal.

The proximal extremity is relatively massive and has one or two facets dorso-laterally for the large metacarpal.

The medial bone bears two facets above for the second and the third carpals while the lateral presents one facet for the fourth.

The distal extremity is in the form of a small nodule and usually forms the '*button*' of the splint.

Pig

Has four bones.

The first is absent.

Third and fourth metacarpals are large and carry the chief digits.

The second and fifth are much smaller and bear the accessory digits.

Dog

Has five bones.

The first is the shortest.

The third and the fourth are longest.

The second is longer than the fifth.

The lie close together above but diverges distally.

The proximal ends articulate with each other and the first four with the corresponding carpals.

The fifth also articulates with the fourth carpal.

Fowl

The metacarpus includes three bony elements, which fuse together with the lower row of carpal bones to form a single bone, **carpo-metacarpus**.

The first i.e. most medial is in the form of a 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; narrow interval separates their shafts.

Digits

Ox

It has two digits -the third and fourth are fully developed and have *three phalanges* and *three sesamoids* each.

The second and the fifth are vestiges and are known as accessory digits or dew claws.

These are placed behind the fetlock. Each accessory digit contains one or two small phalanges, which do not articulate with the rest of the skeleton

Horse

There is only one digit - the third and it consists of three phalanges and three sesamoids.

Pig

Two chief digits (the third and fourth) consist of three phalanges each.

There are two accessory digits and the numbers of phalanges in each are similar to that of the chief digits.

Dog

There are five digits.

The third and the fourth digits are the longest.

The firstdigit has two phalanges and does not come in contact with the ground.

The rest have three phalanges each.

Fowl

There are three digits.

The first and the second digits have two phalanges each.

The third digit has one phalanx.

Sesamoids are absent.

Phalanges

Ox

First phalanx / os suffraginis

It is a long bone placed obliquely downward and forward between the large metacarpal above and the second phalanx below.

The *shaft* is four sided.

The *dorsal face* is convex and blends with the abaxial.

The *volar face* is flat and presents two tubercles, one on either side about the middle of its borders for ligamentous attachment.

The *axial face* is flat.

The *proximal extremity* is larger than the distal. Its articular surface is divided by a sagittal groove into two areas (the abaxial being the larger and higher), which respond to the distal end of the large metacarpal and behind these are two facets for the proximal sesamoids. On the volar aspect are two tubercles for ligamentous attachment.

The *distal extremity* is smaller. Its articular surface is divided by a sagittal groove into two condyles (abaxial being the larger) which respond to the proximal extremity of the second phalanx.

Second phalanx /os coronae

It is a long bone placed obliquely downward and forward between the first and third phalanges. The distal half of each is included within the hoof.

The *shaft* is three sided.

The volar face is encroached on by the distal articular surface.

The *abaxial face* is rough while the *axial face* is flat.

The *proximal extremity* is made up of two glenoid cavities, the abaxial of which is the larger. The volar aspect presents two tubercles for the attachment of the *superficial flexor tendon*.

The *distal extremity* is smaller and is divided by sagittal groove into two condyles, the abaxial being the larger. It articulates with the superior face of the third phalanx below and the distal sesamoid behind.

Third phalanx / os pedis

It is a short bone entirely enclosed in the hoof.

It presents *four surfaces* and an *angle*.

The *superior face* is articular and presents two areas for the distal extremity of the second phalanx and a small facet along the volar border for the distal sesamoid.

The *inferior face* or *solar surface* is nearly flat, wide in the middle and narrowest in front. It is in contact with the sensitive sole in life.

The *interdigital surface* is smooth and grooved below and rough and porous above. It presents a large foramen near the extensor process, the *volar foramen*.

The *laminar surface* slopes from above downward and becomes steep posteriorly. Distally it is traversed by the preplantar groove with several foramina; the most posterior of these is the largest. The surface is covered by the sensitive lamina in life. At the extreme upper part of the dorsal border is the *extensor process* for the *common digital extensor*. The volar border is thick for the attachment of the deep flexor of the digit. The angle is a blunt process at the extreme posterior part of the laminar surface.

Horse

Each phalanx appears like the combined corresponding phalanges of the ox.

First phalanx, the volar face presents a "V" shaped area beginning from the proximal tuberosities and converging distally, which furnishes attachment to the distal sesamoidean ligament. The proximal face is articular and is divided by a sagittal groove into two concave areas, the medical being the larger. The lateral face bear tubercles.

Second phalanx is a short bone being more wide than long.

Third phalanx has *three surfaces*, *three borders* and *two angles*. The *superior articular surface* is adapted to the distal extremity of the second phalanx and distal sesamoid. The *volar face* is divided by the semilunar crest into a larger concave *solar surface* and smaller *semilunar flexor surface*. The latter presents a central prominent area on either side of which is the volar foramen, which leads into semilunar canal within the bone. The crest and the prominent area furnish attachment to the deep flexor tendon. The *antero-superior* or *coronary border* bears about its middle the extensor process or the pyramidal process for the common extensor tendon. The *postero-superior border* is nearly straight and forms the posterior limit of the superior articular surface. The *distal border* is irregularly notched with a wider notch in front. The *angles* or *wings* project backward and are divided into upper and lower parts by a notch or a foramen. The proximal border of the angle carries the cartilage of the third phalanx.

Pig

Each digit has three phalanges.

The phalanges of third and fourth are well developed.

The phalanges of second and fifth digit are small and generally donot reach the ground.

There are two proximal and distal sesamoid bones in each digit.

Dog

The first digit has two phalanges and the other digits have three phalanges each.

The first phalanges of the chief digits have four sided shafts and the second phalanges about two thirds of the length of the first phalanges and their distal extremities are wider and flatter than those of the first.

The third phalanges correspond to the shape of the claws.

The proximal face or base responds to the second phalanx.

It is encircled by a collar of bone with which it forms a groove into which the proximal border of the claw is received.

Fowl

The first and second digits have two phalanges each.

The third has only one phalanx.

Proximal Sesamoids

Ox

The proximal sesamoids are a pair for each digit.

They are situated behind the distal extremity of the large metacarpal and afford increased leverage to the flexors of the digits.

Each bone has the form of a three-sided pyramid with the *base* below and the *apex* above. The **base** presents a facet for the first phalanx. The **dorsal surface** articulates with the distal extremity of the large metacarpal on its volar aspect.

Each sesamoid also presents a facet for articulation with a similar facet of its fellow. The abaxial and axial sesamoids of each digit articulate with each other. The opposing faces of the axial sesamoids are covered in life by fibrocartilage and form a groove for the gliding of the *deep flexor tendon* of the digit.

Horse

There is only one digit (third) and hence one pair of proximal sesamoids.

Each is much larger and distinctly pyramidal in shape.

It articulates only with the large metacarpal but neither with the first phalanx nor with its fellow. The abaxial surface is concave.

Pig

Similar to that of an ox.

Dog

Nine proximal sesamoids are present; one for the first digit and two for each for the other digits.

Besides, there is a dorsal sesamoid in the capsule of each metacarpo-phalangeal joint.

Fowl

The sesamoids are absent.

Distal sesamoid

Ox

The distal sesamoid is otherwise called as *os navicularis*.

It is placed behind the second inter-phalangeal articulation. It presents *two surfaces, two borders* and *two extremities* .

The *dorsal face* is articular, faces upward and forward and presents two facets for the second phalanx.

The *volar* or *flexor surface* is broader and in life is covered by fibro-cartilage for the play of the deep flexor tendon.

The *proximal border* is grooved for ligamentous attachment.

The *distal border* bears a small facet about its middle for the os pedis. The extremities are rounded.

Horse

The distal sesamoid is shuttle shaped and longer, with narrow extremities.

Pig

One distal sesamoid for each chief digit.

Absent in accessory digits.

Dog

The distal sesamoids are cartilaginous.

Fowl

They are absent.

7. Appendicular Skeleton - Os coxae

Bones of the Pelvic Limb

The general designations for the different parts of the pelvic limb and bones present given below.

Pelvic girdle and hip region : I*lium, ischium, and pubis*

Thigh : *Femur*

Leg : *Tibia & fibula*

Pes : Consisting of

Tarsus: A number of small bones called tarsals arranged in the domestic mammals in three rows.

Metatarsus: Typically consisting of five bones designated only by numbers 1 to 5, but showing considerable modifications in different animals.

Digits: These form the terminal parts of the limbs and usually correspond to the number of the fully developed metacarpals. These are also designated by numbers 1 to 5. Each digit is composed of a number of bones arranged

serially called the phalanges. The number of phalanges may vary (from 1 to 5) within the species and also in different digits of the same species.

Os Coxae

Ox

The *os coxae* or *hip bone* consists of three flat bones, ilium, ischium and pubis, which fuse together to form the *acetabulum*.

The ilium extends from the acetabulum upwards forming the lateral wall of the pelvic cavity.

The pubis and ischium extend medially and backward respectively and their medial borders fuse with those of the opposite side to form the *pelvic / ischio-pubic symphysis*.

The pubis and ischium form the anterior and posterior parts respectively of the floor of the bony pelvis and enclose between them on each side, a large *obturator foramen*.

Ilium

The *ilium* is the largest of the three parts.

It is irregularly triangular being wide above narrow and prismatic at the middle and slightly expanded below.

It presents *two surfaces, three borders and three angles*.

The *lateral* or *gluteal surface* is directed dorso-laterally and backward. The inferior third of this surface presents rough lines for the origin of the *gluteus profundus*. This surface is traversed by the gluteal line running nearly parallel to the cotyloid edge from a little below the tuber coxae to become continuous with the ischiatic spine. This surface serves for the origin of the *gluteus medius*.

The *medial* or *pelvic surface* presents a rough triangular medial part-the *sacral surface* and a smooth quadrilateral part -the *iliac surface*. The former presents an irregular facet, the articular surface for the sacrum. The iliac surface is directed forward and is covered by *iliacus*. The *ilio-pectineal* line, which separates these two surfaces, begins below the articular surface and joins the anterior border of the pubis and forms the lateral boundary of the pelvic inlet. It bears about the middle the *psoas tubercle* for the *psoas minor*.

The *cotyloid border* leads to the acetabulum, little above and infront of which are two depressions (the lateral one is faint) for the origin of the *rectus femoris*.

The *ischiatic border* is concave and forms the *greater isciatic notch*. The notch forms the greater ischiatic foramen which is covered by the sacro-sciatic ligament in life and serves for the passage of gluteal nerves and anterior gluteal vessels. In its lower part, it is convex, rough and is continuous with the ischiatic spine, which

gives attachment to the sacro-sciatic ligament at its free edge and to the *gluteus profundus* on its lateral aspect.

The *dorsal border* or *the crest* of the ilium is concave thick and rough for the attachment of the muscles of the loin.

The *medial angle* or *tuber sacrale* is separated from its fellow and forms with it and the sacrale spines, the *point of the croup*.

The *lateral angle* or *tuber coxae* is large and prominent, wide in the middle and smaller at either end and serves for the attachment of the iliacus, *obliquus abdominis internus, tensor fasciae latae, gluteus medius* etc.

The *inferior* or *acetabular angle* is thick and meets the other two parts at the acetabulum.

Ishium

The *ischium* is smaller than ilium.

It is irregularly quadrilateral and placed behind the ilium and the pubis.

It has *two surfaces* and *four borders*.

The *dorsal pelvic surface* is slightly concave transversely and forms the posterior part of the pelvic floor.

The *ventral surface* presents about its middle a rough ridge for the *biceps femoris*. It is roughened for the origin of the *adductor* muscles of the thigh. The anterior border is concave and forms the posterior boundary of the obturator foramen.

The *posterior border* slopes forward and downward and meets the same borders of its fellow to form the ischial arch, which constitutes the inferior boundary of the pelvic outlet.

The *medial border* with its fellow form the *ischiatic symphysis*, presents ventrally a ridge which gives attachment to the suspensory ligament of the penis in the male and that of the udder in the female.

The *lateral border* is concave and forms the *lesser isciatic notch* and is continuous with the ischiatic spine. The notch forms the lower boundary of the *lesser sciatic foramen* bordered above by the sacro-sciatic ligament (in life), which is for the passage of the posterior gluteal vessels.

The *antero-lateral angle* joins the ilium and the pubis at the acetabulum.

The *postero lateral angle-tuber ischii* is a trifid process and serves for the origin of the *biceps femoris, semitendinosus and semimembranosus*.

Pubis

The *pubis* is the smallest of the three parts.

It is irregularly triangular and has *two surfaces* and *three borders*.

The *dorsal* or *pelvic surface* forms the anterior part of the pelvic floor and the urinary bladder rests on it in life.

The *ventral surface* is rough for muscular attachment.

The *anterior border* is thick. Laterally it bears the ilio-pectineal eminence and curves for the attachment of the prepubic tendon.

The *posterior border* forms the anterior margin of the obturator foramen.

The *medial border* meets the same border of its fellow at the pubic symphysis. The *acetabular angle* joins the ilium and the ischium at the acetabulum.

The medial borders of the pubis and the ischium meet the corresponding borders of their fellows to form the *pelvic symphysis / Ischio-pubic symphysis* and the pelvic floor is basin like.

Acetabulum

Acetabulum is a cotyloid cavity formed on the ventro-lateral aspect of the os coxae by the meeting of its three components.

It consists of an *articular* and a *non-articular part*.

The former is nearly circular and articulates with the head of the femur. The rim of the cavity presents on its postero-medial spect the *acetabular notch*, which transmits the round ligament of the hip joint.

The non-articular part, the *acetabular fossa* is situated in the depth of the acetabulum.

Another small notch may be seen antero-medially, though sometimes it is replaced by a foramen or is absent.

Obturator foramen

The *obturator foramen* is a large, elliptical opening on the floor of the pelvis and is circumscribed by the ischium and the pubis.

It is covered in life by the obturator muscles.

Pelvic cavity

The *pelvic cavity* is the smallest and the most posterior of the three visceral cavities of the body.

The bony pelvis composed of the os coxae laterally and ventrally. The sacrum and the first three coccygeal vertebrae dorsally. The lateral vacuities are closed up by the sciatic ligaments in life.

The pelvic inlet is bounded by the terminal line or brim which is composed of the base of the sacrum dorsally, ilio-pectineal lines laterally and the anterior borders of pubis ventrally.

The *pelvic outlet* is much smaller and is very incomplete in the skeleton. The third coccygeal vertebra bound it dorsally and ventrally by the ischial arch and the sacro-sciatic ligament and *semimembranosus* muscle completes it laterally.

Sexual differences

The ischial arch is wider and the outlet is larger in the female than in the male.

The conjugate (vertical) and transverse diameters are greater in the female so that the cavity is roomier.

The pubis and the ischium of the opposite sides meet at a more open angle in the female than in the male.

Horse

The gluteal line is very faint.

The tuber coxae is large and compounded four tuberosities arranged in pairs.

The pelvic surface of the ischium is less concave and meets its fellow at a more open angle.

The ischial arch is wide and shallow.

The ridge on the inferior face of the ischium is absent.

The symphyseal ridge is also absent.

The tuber ischii is not trifid and its lower border forms the ventral ischiatic spine.

The ventral face of the pubis crossed near the anterior border by the pubic groove which leads to the acetabular notch which transmits the pubo-femoral or the accessory and round ligaments of the hip to femur.

The acetabular notch is on the medial part of the rim.

Pig

Os coxae is long and narrow.

The ilium and ischium are almost in line with each other.

The gluteal surface is divided into two fossa by a ridge which is continuous with the greater ischiatic spine behind.

The iliac crest forms the highest point of the bone.

There is a crest or tubercle on the ventral surface of the ischium.

The ilio-pectineal line is prominent and the psoas tubercle is well marked.

Pelvic inlet is elliptical in outline.

Dog

The ilium is nearly in a vertical plane.

The gluteal surface is concave.

The crest of the ilium is strongly convex.

The ischium has a twisted appearance.

The lesser ischiatic notch is absent.

The acetabulum is deep.

The symphyseal part of pubis is thick and fuses late with the opposite bone.

Fowl

The *ilium* is elongated and extends over the entire length of the hipbone. It is firmly fused to the transverse processes of the lumbo-sacral mass. The pelvic face is concave for the lodgment of kidney. The lateral border is free in its anterior half but is fused with the ischium behind.

The *ischium* is smaller and lies below and lateral to the posterior part of the ilium is triangular. The sciatic foramen is formed by the adjacent borders of the ischium and ilium behind the acetabulum. The ventral border forms the obturator foramen with the pubis.

The *pubis* is a long and slender rod running along the ventral border of the ischium. The anterior end has a muscular process.

The *acetabulum* is large and perforated and presents at its supero-posterior part process - *anti-trochanter* for articulation with the great trochanter of the femur.

Femur

Ox

The femur, the most massive of the long bones, extends obliquely downward and forward between the hip and the stifle joints. It consists of a *shaft* and *two extremities*.

Shaft

The *shaft* posses four surfaces**.**

The *anterior, medial* and *lateral surfaces* are continuous, convex from side to side and are covered in life by the *quadriceps femoris*.

The *posterior face* is narrow in the middle where it is rough for the *adductor*. Below this is an oblique vascular impression running downward and outward marking the course of the femoral vessels.

The medial border of posterior surface presents in its upper third the *trochanter minor*, which is for *quadratus femoris* and *ilio-psoas*. Extending from this trochanter obliquely and joining the *trochanter major* is *trochanteric ridge,* which forms the postero-lateral boundary of the *trochanteric fossa,* ridge is for the *gluteus medius* and fossa for *gemellus, obturator externus* and *obturator internus*.

The distal third of this border carries above the medial condyle the *medial supra condyloid crest* for the medial head of the *gastrocnemius*. The rest of this border below the trochanter minor is for the *pectineus*.

The *lateral border* presents in its distal third the *supracondyloid fossa,* which is bounded laterally by the lateral *supra-condyloid crest*. The fossa for the *superficial flexor of the digit* and the crest for the lateral head of the *gastrocnemius*.

Proximal extremity

It composed of the *head* and the *trochanter major*.

The *head* is medial and articulates with the acetabulum. The small non-articular sulcus, *fovea capitis,* on the middle of the head is for the round ligament of the hip joint.

The *trochanter major* or *greater trochanter* is massive and is for the *gluteus medius*. The *lateral face* is convex. Below its base are two rough tubercles -the upper one for the *middle gluteus* and the lower one for the *deep gluteus*.

Distal extremity

The *distal extremity* is large and comprises of *trochlea* in front and *two condyle*s *behind.*

The *trochlea* articulates with patella. The medial ridge of the trochlea is more prominent.

The *condyles* are separated by the intercondyloid fossa and articulate with the condyles of the tibia through the medium of the *interarticular cartilages or menisci.*

The *medial condyle* presents an eminence on its medial aspect for the medial ligament.

The *lateral condyle* presents two depressions on its lateral aspect, the upper one for the lateral ligament of the stifle and the lower one for the *popliteus*.

Between the lateral condyle and the lateral ridge of the trochlea is, the *extensor fossa* for the *complex* muscle.

The inter-condyloid fossa lodges the spine of the tibia. Its anterior part is for the posterior crucial ligament. At its posterior part close to the medial condyle is a depression for the coronary ligament of the lateral meniscus and close to the lateral condyle is another depression for the anterior cruciate ligament.

Horse

It is more massive.

The posterior face bears in its proximal third a rough eminence for the *biceps femoris*.

The trochanter minor is in the form of a rough ridge.

The lateral border bears the *trochanter tertius* in its proximal third for the *superficial gluteus*.

The supracondyloid fossa and the lateral supra condyloid crest is better developed.

The trochanteric ridge is vertical and extends from the proximal third to the great trochanter.

The great trochanter is made up of a convexity a summit and a crest.

The crest is below and lateral to the convexity

Pig

The shaft is wide and relatively massive.

A ridge extends from the trochanter major to the lateral supracondyloid crest and there is no supracondyloid fossa.

The third trochanter is absent.

Dog

The shaft is proportionately large and strongly curved with the convexity forward.

The supra condyloid fossa is absent.

The trochanteric fossa is rounded and deep.

The ridges of the trochlea are sagittal and equal.

The inter condyloid fossa is wide.

On the posterior aspect of the distal extremity immediately above each condyle is a small facet for a sesamoid-the *fabella*.

The *fabellae* are two small rounded sesamoid bones, located one each on the condyles of the femur on the posterior aspect.

They are developed in the tendons of origin of the *gastrocnemius* muscle.

Fowl

The head is prominent but smaller than the acetabulum and the articular surface extends on the trochanter and articulates with the acetabulum and the facet on its rim.

The lateral condyle presents on its lateral aspect a groove for the head of fibula.

Patella

Ox

It is a large sesamoid bone placed on and articulating with the trochlea of the femur.

It gives increased leverage to the extensors of leg. It is irregularly triangular and presents *two surfaces, two borders*, a *base* and an *apex*.

The *anterior surface* is convex and rough.

The *posterior* or *articular surface* is divided by a vertical ridge into two concave areas of which the medial is larger.

The two borders converge to the *apex* below.

The *lateral border* is convex.

The *medial border* is concave, forms an angle at the base and gives attachment to the fibro-cartilage of the patella.

The *base* faces upward and is irregular and narrow.

Sheep and Goat

It is relatively longer and narrower than that of ox.

Horse

The base is wide and large.

Pig

It is very much compressed transversely and presents 3 surfaces.

Dog

It is long and narrow.

Fowl

It is wide and thin.

Tibia

Ox

The tibia is a long bone placed obliquely downward and backward between the stifle and the hock joints. It consists of a *shaft* and *two extremities*.

Shaft

The shaft is three sided above and becomes smaller and flattened below.

It has *three surfaces* and *three borders*.

The *lateral surface* is wide above and inclines gradually to the front of the bone distally. It is covered by the tibialis anterior.

The *medial face* is subcutaneous, broad above and is slightly convex and rough for the medial ligament of the stifle, sartorius, gracilis and semimembranosus.

The *posterior face* is flat. The upper fourth of this surface has a triangular area marked by the popliteal line for the popliteus. The rest of this surface is marked by rough lines for the deep flexor.

The *anterior border* is prominent in its upper third forming the tibial crest. It presents on its medial aspect a rough prominence for the semitendinosus. The rest of its extent is rounded and indistinct.

The *lateral border* is concave and has the fibrous part of fibula applied against it in life.

The *medial border* is thick and rounded in its upper fourth for the popliteus.

Proximal extremity

The proximal extremity is large and is made up of *two condyles*, a *tuberosity* and a *spine*.

The *tuberosity* is anterior; it is continuous distally with the tibial crest and is for the straight ligaments of the patella. Between the tuberosity and the lateral condyle is the sulcus muscularis for the passage of the tendon of origin of the complex muscle.

The condyles are *medial* and *lateral*. Each presents a saddle shaped articular surface above for the corresponding condyle of the femur and the meniscus. The condyles

are separated behind the popliteal notch on the medial aspect of which is a tubercle for the posterior cruciate ligament. The *lateral condyle* has the rudimentary fibula fused with it on its lateral aspect and serves for the attachment of the lateral ligament of the stifle.

The *tibial spine* is placed between the condyles whose articular surfaces are continued on the spine. It is bifid at the summit. Before and behind the spine are the depressions for ligaments.

Distal extremity

The distal extremity is smaller than the proximal.

The *articular surface* presents two deep sagittal grooves.

The *malleoli* are bony prominences on the outer marigins of the sagittal grooves.The *medial* is smaller and fused with the distal extremity of the tibia. The medial groove is bounded on the medial aspect by the medial malleolus (which is fused to the tibia). The latter is rough medially for ligamentous attachments and articulates laterally. Its anterior part is prolonged downward to end in a blunt point. The lateral groove is separated by a sharp ridge from an outer area, which is for the *lateral malleolus*. The latter completes the lateral groove.

Horse

The medial border presents at its upper part a small tubercle for the popliteus.

The popliteal line is prominent.

The anterior tuberosity is grooved vertically.

Below the lateral margin of the lateral condyle is a facet for the fibula.

The grooves on the distal extremity are oblique.

The lateral malleolus is fused to the tibia.

Pig

The shaft is slightly curve.

Tibial tuberosity is grooved in front and a narrow sulcus separates it from the lateral condyle.

Proximal part of the tibial crest is very prominent.

Dog

The shaft forms a double curve, the proximal part is convex medially and the distal part convex laterally.

The tibial crest is prominent.

The facet for the fibula is on the postero-lateral aspect of the lateral condyle.

The distal extremity presents laterally a facet for fibula.

Fowl

The tibia fuses below with the upper row of tarsal bones and hence called tibio-tarsus.

The tibio tarsus is the longest bone in the body.

The proximal extremity is large and irregular.

The distal extremity comprises of a trochlea behind and two condyles in front, representing the fused bones of the upper row of the tarsus.

Fibula

Ox

The fibula is rudimentary.

The *head* is fused to the tibia and is continued below by a small shaft.

The *distal extremity* or *lateral-malleolus* is connected to the shaft in life by a fibrous cord. It is quadrilateral in outline and compressed from side.The *proximal articular face* is concave in front and convex behind. It articulates with the lateral facet of the distal extremity of tibia. The *distal face* has a concave facet for the fibular tarsal.The *medial face* presents a curved groove, which responds to the lateral ridge of the tibial tarsal. The *lateral face* is rough and irregular.

Horse

It is better developed and placed along the lateral border of the tibia.

The shaft is a slender rod, extends down to about the middle of the tibia with which it forms the tibio-fibular arch.

The proximal extremity is large and flattened from side to side.

The medial face has a facet for the lateral condyle of the tibia.

The lateral face is slightly convex and rough.

The anterior and posterior edges are blunt and rounded, the posterior being the thicker.

The distal extremity -the lateral malleolus is fused to the tibia.

Pig

It extends the entire length of the tibia.

Dog

It is nearly as long as tibia.

It is slender, somewhat twisted and enlarged at either end.

The proximal extremity presents a facet on the medial aspect for the tibia.

The distal extremity articulates with the tibia and the tibial tarsal medially and bears two tubercles laterally, the proximal being anterior.

Fowl

It is thin rod shaped bone.

It is thick above and tapers to a point below reaching the lower third of tibia.

The head is massive and articulates with the lateral condyle of the tibia and a presents a facet on its medial aspect for the lateral condyle of the femur.

Tarsals

Ox

The tarsus is composed of five short bones arranged in below:

	Medial	Lateral
Proximal row	Tibial tarsal	Fibular tarsal
Central row	Fused Central and 4th tarsal	
Distal row	First tarsal	Fused second & third tarsal

Tibial tarsal (astragalus)

It has **six surfaces**.

The **proximal** and the **dorsal face** continuous and form a trochlea with vertical ridges for the tibia and the lateral malleolus.

Distal face articulates with the fused central and 4th tarsal.

The **plantar face** responds to fibular tarsal. A narrow elongated area on the medial aspect of the lower part of this face for the planter prolongation of the fused central and 4th tarsal.

The **lateral face** is more depressed and shows two facets for the fibular tarsal.

Fibular tarsal (os calcis)

It is the largest tarsal, is placed behind and lateral to tibial tarsal.

It has **body** and **medial process** -the sustentaculum tali.

The **lateral face** of the body is flat and rough while the **medial face** presents two facets for the tibial tarsal.

The process the **sustentaculum tali**-projects medially and presents a facet dorsally for tibial tarsal. The body is prolonged above to form the tuber calcis.

Fused central and fourth tarsal (scapho-cuboid)

The **proximal face** presents two concave areas for the tibial tarsal, a projection postero-medially for the narrow medial facet on the distal face of the tibial tarsal and a narrow facet on its lateral aspect for fibular tarsal.

The **distal face** is uneven. The medial half is higher in level and presents a large facet in front for second and third tarsal and a small facet behind for the first tarsal. The lateral half presents two facets separated by a transverse groove and articulates with the large metatarsal bone.

First tarsal (cuneiform parvum)

It is a small round piece of bone situated at the postero-medial aspect of the tarsus.

The proximal face articulates with the fused central and 4th tarsal.

The distal face with the large metatarsal and the dorsal face with the fused second and third tarsal.

Fused 2nd and 3rd tarsal (cuneiform magnum)

It is placed beneath the fused central and 4th tarsal on its medial aspect.

The proximal face is concavo-convex from before backward and articulates with the fused central and 4th tarsal.

The distal face articulates with the large metatarsal.

The plantar face has a facet for the first tarsal.

The dorsal and medial faces are continuous, convex and rough.

Horse

It has six bones.

In the *tibial tarsal*,the ridges of the trochlea curve obliquely downward and outward. The lateral face has no facets for the fibular tarsal.

The *fibular tarsal* is short and thick. It does not articulate with the lateral malleolus. The medial process is larger.

The *central tarsal (scaphoid)* is not fused to the fourth tarsal (cuboid). It is flat and irregularly quadrilateral. The proximal face is concave and articulates with the tibial tarsal. The distal face is convex and articulates with the third tarsal and the fused 1st and 2nd tarsal. The dorsal and the medial borders are continuous and rough. The lateral border is oblique and has two faces for the cuboid.

The *fused 1st and 2nd tarsal (cuneiform parvum)* is irregular in shape. The medial face is convex. The lateral face is concave. The proximal face is concave and has two facets for the central tarsal. The distal face articulates with the large and the medial small metatarsals. The plantar end is prolonged downward into a nodular projection.

The *third tarsal (cuneiform magnum)* is triangular in outline. The proximal face is concave and articulates with central tarsal. The distal face is convex and is for the large metatarsal. The medial border has no facet for the fused 1st and 2nd tarsal and the lateral has two facets for the fourth tarsal.

The *fourth tarsal (cuboid)* has six surfaces. It is not fused to the central tarsal. The proximal face is convex transversely and is for the fibular tarsal and the tibial tarsal. The distal face presents two facets separated by a sagittal ridge for the lateral small metatarsal bones. The medial face has facets for the central and the third tarsal. The dorsal, lateral and the plantar surfaces are convex and rough.

	Medial	Lateral	
Proximal row	Tibial tarsal	Fibular tarsal	
Central row	Central tarsal		
Distal row	Fused 1st and 2nd tarsal	3rd tarsal	4th tarsal

Pig - It has seven bones

	Medial	Lateral		
Proximal row	Tibial tarsal	Fibular tarsal		
Central row	Central tarsal			
Distal row	First	Second	Third	Fourth tarsals

Dog - It has seven bones

	Medial	Lateral		
Proximal row	Tibial tarsal	Fibular tarsal		
Central row	Central tarsal			
Distal row	First	Second	Third	Fourth tarsals

Fowl

The tarsus is absent as such in the adult.

In the proximal row the embryonic elements fuse with the tibia and in the distal row with the metatarsus.

Metatarsals

Ox

The metatarsus has two bones -the *large* (*third and fourth*) and the medial *small* (second) *metatarsal bones*.

Large metatarsal bone (third and fourth)

It resembles the large metacarpal except for the following differences

The bone is longer than metacarpal.

The shaft is four sided.

The dorsal metatarsal groove is deeper.

The *plantar face* presents a shallow groove. Commencing at the upper part of the groove is a vascular tunnel passing obliquely upward and forward through the proximal extremity to open on the articular face of the extremity behind and between the facets.

The *proximal extremity* presents a flattened facet laterally for the fused central and 4th tarsal and a large facet on the medial aspect for the fused 2nd and third tarsal behind which is another small facet for the first tarsal. At its postero medial aspect, this extremity presents a facet for the small metatarsal bone.

The dorso-medial aspect presents a tuberosity for the attachment of the tendon of the *peroneus tertius*.

The *distal extremity* resembles that of the large metacarpal.

Medial small metatarsal

The *medial small metatarsal* is disc shaped piece of bone situated at postero-medial aspect of the proximal extremity of the large metatarsal bone.

It presents small facet on its dorsal face for the large metatarsal. The rest of the bone is rough.

Horse

It has three metatarsal -one *large (third*) and *two small* (*second and fourth)* medial and lateral metatarsals.

The large metatarsal resembles the large metacarpal.

The vertical groove presents in the ox are absent.\

The proximal extremity presents facets for the third tarsal, the fourth tarsal and sometimes the second tarsal. The shaft is cylindrical.

The *small metatarsals,* each has two small facets in front for the large metatarsal.

The *lateral (fourth) metatarsal* is relatively massive, especially in its upper part.

The proximal extremity is large and outstanding and bears one facet above for the fourth tarsal.

The *medial bone (second metatarsal)* is much more slender than the lateral especially in its proximal part, which bears two facets above for the first the second tarsal and sometimes one for the third tarsal.

Pig

Four in number and resembles that of the metacarpal of the forelimb.

The second and fifth are placed more towards the plantar aspect of the large bones.

Dog

Five metatarsals are present.

The first is small and the other four are well developed and resemble the metacarpals.

Fowl

The *tarso-metatarsus* is a single bone formed by the fusion of the distal row the tarsals with the second, third and fourth metatarsals.

The proximal extremity presents two glenoid cavities for the distal end of the tibio-tarsus.

The shaft is two-sided.

The first metatarsal is attached by ligament to the postero-medial border of the large metatarsus. In the male, a conical projection arises from the medial aspect of the body of the metatarsus and serves as a core for the *horny spur* or *calcar*.

The distal extremity divides into three processes.

Each process is in the form of an articular convexity. The medial one is the shortest and articulates with the second digit.

The middle one is the longest and articulates with the third-digit.

The lateral one articulates with the fourth digit.

Digits

Ox

Resemble those of the forelimb very closely.

Horse

Compared with corresponding phalanges of the pectoral limb, the first phalanx is a little short, wider above and narrower below; the second is slightly longer and narrower, the third is narrower, the angle of inclination of the dorsal surface a little greater. The planter surface is more concave and the angles are less prominent and closer together.

The proximal sesamoids are smaller and the distal shorter and narrower.

Pig

Each chief digit comprises of three phalanges.

Dog

Of the five digits the first is often absent.

The other four digits constantly present and resemble those of the forelimb.

Fowl

Four digits are usually present and the firth digit is absent.The number of phalanges in each digit is one more than the serial number of the digit.

The phalanges of each digit diverge and enclose the inter-digital spaces.

10. *Axial Skeleton* - ***Vertebral column in general, cervical, thoracic and lumbar vertebrae***

Introduction

It consists of the skull, the vertebral column, ribs and sternum.

Vertebral Column

Certain vertebrae remain free throughout life and are termed *movable* or *true vertebrae* and certain others get used together with the adjacent ones and are termed *fixed or false vertebrae*.

The column as a whole may be divided for description into five regions - *cervical, thoracic, lumbar, sacral* and *coccygeal* accordingly as they form the skeleton of the *neck, back, loins, croup* and *tail* respectively.

The number of bones in each region except the last is fairly constant in each species so that their number can be expressed as a formula called the vertebral formula.

The vertebral formula in domestic animals is given below.

	Cervical vertebrae	Thoracic vertebrae	Lumbar vertebrae	Sacral vertebrae	Coccygeal vertebrae
Ox	C-7	T-13	L-6	S-5	Cy-18-20
Sheep	C-7	T-13	L-6-7	S-4	Cy-16-18
Horse	C-7	T-18	L-6	S-4	Cy-15-21
Pig	C-7	T-14-15	L-6-7	S-4	Cy-20-23
Dog	C-7	T-13	L-3	S-3	Cy-20-23
Rabbit	C-7	T-12	L-4	S-4	Cy-16
Fowl	C-13-14	T-7	LS-14	-	Cy-7

Vertebrae

All the bones of the column which are constructed on the same general plan are termed *typical vertebrae*.Those that deviate from the general plan are atypical vertebra.

The typical vertebrae presents a *body, an arch and processes*.

Body

It is the fundamental part of the vertebra around which the other parts are grouped.

It is in the form of a solid rod.

The anterior end is convex and the posterior end is correspondingly concave.

The anterior end of one vertebra meets the posterior end of the preceding vertebra and between them is interposed a disc of fibrocartilage -the **intervertebral disc**.

The dorsal surface of the body is flat and forms the floor of the vertebral foramen while the ventral face presents centrally the ventral spinous process for muscular and ligamentous attachments.

Neural arch

The neural arch is situated on the superior face of the body and it forms with the body, a bony ring - the *vertebral foramen*.

The entire series of these rings constitutes a canal called the spinal or *vertebral canal* for the lodgment of the spinal cord.

Each half of the arch is made up of a vertical pedicle and a horizontal lamina.

The anterior and posterior edges of the pedicles exhibit notches - the *vertebral notches* which when adjacent vertebrae are in position circumscribe the intervertebral foramina for the passage of vessels and spinal nerves.

Processes

The processes of the vertebra are variable in size, development and shape in the different regions. They are:

Articular or Oblique Processes: These are four in number two of which are placed on the anterior and two on the posterior edge arch. These present articular area, which face upward in the anterior and downward in the posterior processes. The anterior processes of one vertebra are overlapped by and articulate with the posterior processes of vertebra in front and form synovial joints. The non-articular area serves for muscular and ligamentous attachments.

Transverse Processes: They are two in number for each vertebra, one on either side spring from the lateral aspect of the body or the lower part of the arch. These vary in size and shape in the different regions.

Spinous Processes (neural or superior spines): They are single, projecting from the middle of the dorsal part of the neural arch. They vary greatly in size, form and direction in different vertebrae.

Ventral spinous processes: These are also single and are situated on the ventral aspect of the bodies of the vertebrae.

Mamillary processes: are those situated between the transverse and anterior articular processes or on the latter. *e.g*. lumbar vertebrae.

Accessory processes: are situated between the transverse and posterior articular processes. *e.g*. lumbar vertebrae of dog.

Cervical Vertebrae

The cervical vertebrae form the skeleton of the neck. In the ox, horse and dog there are 7 cervical vertebrae.

In all the animals including the fowl, the first and second cervical vertebrae named *atlas* and *axis* respectively and are *atypical vertebrae* .

In the ox, horse and dog, the third, fourth and fifth cervical vertebrae are similar while the sixth and seventh, present some special features. The transverse process consists of two parts in the 3rd to the 6th vertebra, which in the 7th is undivided.

In the fowl there are 14 cervical vertebrae. The third to 14th shows some special features when compared with the cervical vertebrae of mammals.

Thoracic Vertebrae

Ox

They are 13 in number and the characteristic features of these vertebrae are the great development of neural spines, the presence of capitular facets on the body and tubercular facets on the transverse processes for articulation with the ribs.

The bodies are shorter. On the sides of the articular ends of the body both before and behind are concave articular facets -the costal or capitular facets which with those of the adjacent vertebrae and the intervertebral disc form capitular or costal cavities for articulation with the heads of ribs. The anterior notches of the pedicle are shallower and the posterior ones are converted into foramina in the posterior series.

The articular processes are small.The anterior ones are represented by small oval facets on the anterior part of the arch except in the first one where they surmount the transverse processes. The posterior ones spring from the base of the spinous process.

The transverse processes though prominent do not always articulate with ribs.

The spinous process is very long and of enormous size, which is characteristic of the vertebrae of this region. Each is a flattened plate, which serves for the attachment of the spinal muscles and ligaments.

Special Features

The anterior vertebrae in the series bear rounded mammillary processes.

The spine of the first is very long and is usually pointed. The spines of the next two are the longest and behind these they gradually diminish in height. The backward slope, which is at first, slight and then increase to the tenth. The last dorsal has a vertical spine.

The tubercular facets gradually decrease in size from before backwards.

The last dorsal has no posterior capitular facets.

Horse

They are 18 in number.

The bodies are shorter.

The spine of the first is shorter and curved backward.

The spinous processes increase in length to the third and fourth, then gradually diminish to the fifteenth beyond which they are about the same in height.

The backward inclination of the superior spine is most pronounced in the second, the sixteenth is vertical and those of the last two are directed slightly forwards.

The last four or five show a distinct mammillary process.

Pig

The bodies are relatively long and constricted in the middle.

The ventral spine is absent.

Mamillary process is present except in the first two.

The last transverse process is lumbar in character.

Small accessory process occurs in the posterior part of the region.

Dog

The bodies are wider and compressed dorso-ventrally.

The transverse processes in the posterior of the series bear mamillary processes and in the last three accessory processes also.

The posterior facets on the bodies for the heads of the ribs are absent on the last two or three, so that the head of each of the last three ribs articulates with only one corresponding centrum.

Fowl

They are seven in number.

The first and the sixth are free, second to the fifth are fused into one piece. The seventh is fused to the lumbo-sacral segment.

Each vertebra presents a complete capitular cavity for the corresponding rib.

The superior and inferior spines are well developed and are fused from the second to the fourth.

The transverse processes are plate like and present tubercular facets, at their free ends. Thin plates of bone fill the gaps between the transverse processes.

Lumbar Vertebrae

Ox

The lumbar vertebrae are six in number and are characterized by greatly *elongated transverse processes* and *strongly curved articular processes*.

Body

The body is constricted in the middle, expanded at the extremities and much compressed from above downwards.

The anterior extremity is less convex and the posterior less concave.

The arches of the first three are about equal in size and similar to the last dorsal but behind, they gradually increase in breadth and height.

The posterior notches are much deeper.

The intervertebral foramina are often double in the anterior and are very-large further back.

Processes

The articular processes are large.

They are placed a little further apart and are strongly curved.

The anterior articular processes are concave, directed medially and show the mammillary processes on their lateral aspect.

The posterior articular processes are convex, directed outwards and project from the arch at the base of the superior spine.

The transverse processes are elongated plates flattened from above downwards and project outwards at right angles to the body.

The processes are all directed forwards. They are shortest in the first and the length gradually increases to the fifth and in the sixth they are shorter than those of the fifth. The inter-transverse spaces on either side are filled up by the inter transversales lumborum muscles in life.

The spines are broad flattened plates, resemble the last thoracic and are of the same height as the last dorsal. That of the last is the narrowest of all.

The ventral spines are rudimentary and afford attachment to the ventral longitudinal ligament.

Horse

They are six in number.

The bodies are shorter.

The first three have a distinct ventral spine, which subsides thereafter.

The transverse process increases in length from the first to third or fourth and then diminishes. The first one or two slightly curve backwards and the last two or three curve forward and the third is at right angles.

The posterior border of the transverse processes of the fifth at its medial part has an oval concave facet, which articulates with a convex facet on the anterior border of the sixth transverse process. Sometimes the fifth has small facet for the fourth also.

The sixth transverse processes are thick at the base and thin and narrow elsewhere and curve forwards. It articulates by a large concave facet on its posterior border with corresponding facet of the sacrum.

Pig

Six or seven in number.

The bodies are longer and bear a ventral crest.

The arches are deeply notched and are separated by an increasing space dorsally.

The mamillary process project outward and backward.

Transverse processes will not articulate with each other or with sacrum.

The posterior edge of the root of the transverse process is marked by a notch in the anterior series and a foramen in the posterior part.

The dorsal spines are broad and incline forward except the last, which is narrow and vertical.

Dog

They are seven in number.

Their bodies increase in width from first to last.

The transverse processes are plate-like and are directed forward and downward. They do not form any joints with each other or with sacrum as in the horse.

Accessory and mamillary processes are present.

Spinous processes incline a little forward.

Fowl

The lumbar and sacrum are fused and called as lumbosacrals.

They are fourteen in number and these with the seventh dorsal and the first coccygeal-altogether 16 -are fused into one mass called synsacrum. This forms a rhomboid mass included between the two pelvic bones.

The spines form a crest in the anterior third but absent posteriorly.

The transverse ridges on the ventral face indicate the positions of the transverse processes. The extremities of all the transverse processes fuse with the medial border of the ilium.

Sacrum

Ox

The sacrum is formed by the fusion of five sacral vertebrae. It is triangular in form and is wedged in between the ilia with which it articulates on each side. Its long axis is strongly curved and it presents two surfaces, two borders, a base and an apex.

The dorsal surface is widest in front and shows along its median line a crest -the median sacral crest, which is formed by the fusion of spinous processes of the five sacral vertebrae. The summit of this crest is rough and tuberous. On either side of this crest is another crest -the lateral sacral crest, which results from the fusion of articular processes. The dorsal surface shows four dorsal sacral foramina for the passage of the dorsal primary branches of the sacral spinal nerves.

The ventral surface is arched and forms the roof of the pelvis. This surface is marked centrally by a faint longitudinal groove for the middle sacral artery and also by four transverse lines, which indicate the lines of fusion of the bodies of the sacral vertebrae. There are four large ventral sacral foramina at the ends of the transverse lines on either side for the ventral primary branches of the sacral spinal nerves.

The lateral borders are thin, concave and serve for the attachment of the sacro-sciatic ligament.

The base or anterior extremity of the sacrum is infact the anterior end of the first sacral vertebrae. It shows centrally the body of the first sacral segment, which is wide flattened from above downwards and is elongated transversely. It articulates with the posterior end of the body of the sixth lumbar vertebra and the ventral margin projects slightly forming the promontory. The edge of the pedicles shows the usual anterior notches, which with the posterior notches of the last lumbar from the intervertebral foramina for the sixth lumbar spinal nerves. The anterior part of the sacral (vertebral) canal is triangular with its angles rounded off. Traced backward, its size diminishes and the posterior opening is small and triangular. On either side of the arch and above the notches are the anterior articular processes, which are very large and widely separated.

The lateral parts of the base are the alae or wings. Each wing is quadrilateral compressed plate directed downwards and forwards. The anterior face is extensive, concave from side to side and non-articular. The posterior face is rough and in its lower part there is a triangular area -the articular surface for articulation with the ilium.

The apex or posterior extremity of the sacrum is the posterior end of the fifth sacral vertebra. Centrally, it presents a small triangular neural ring and the posterior notches. Above these is the posterior extremity of the median sacral crest. Placed below the neural ring is the centrum of the last sacral segment, which is flat.

Horse

The sacrum presents five separate dorsal spines, the bases of which are fused in old animals.

On either side of the bases of the spines is a groove in which are the four dorsal foramina.

The ventral surface is not so deeply arched as in the ox.

The wings are prismatic with pointed ends. Each has a large oval convex facet in front, which articulates, with the facet on the posterior border of the transverse process of the last lumbar vertebra.

Pig

Usually four vertebra.

Fuse in the later part of the life.

The spines are little developed.

The anterior articular processes are very large.

Dog

It is formed by three segments and is short wide and quadrangular

The articular processes are vestigial and are represented on the side of the median crest as a pair of tubercles and lateral to these are the two dorsal sacral foramina.

The pelvic face is deeply concave and presents two ventral sacral foramina.

Wings are prismatic and very high. Their lateral faces are extensive, face almost directly inward and bear an auricular surface on the lower part.

Promontory is distinct.

The transverse processes of the last segment project backward and may articulate or fuse with those of the first coccygeal

Spinal canal is compressed dorso-ventrally.

Fowl

The lumbar and sacrum are fused and called as l umbosacrals.

They are fourteen in number and these with the seventh dorsal and the first coccygeal -altogether 16 -are fused into one mass called synsacrum. This forms a rhomboid mass included between the two pelvic bones.

The spines form a crest in the anterior third but absent posteriorly.

The transverse ridges on the ventral face indicate the positions of the transverse processes. The extremities of all the transverse processes fuse with the medial border of the ilium.

Coccygeal Vertebrae

Ox

The coccygeal vertebrae vary considerably in number from 18 to 20.

These gradually diminish in size from the first to the last.

The first five or six are typical vertebrae but beyond the sixth the processes and the arches get gradually suppressed so that the posterior ones are made up of bodies only.

The transverse processes are relatively large.

The ventral surface presents a pair of processes -the *haemal processes* and between these is a groove – the *sulcus vasculosus* for the middle coccygeal artery.

The articular processes do not carry facets.

The arch disappears from the sixth backwards and the rudiments of the transverse processes disappear after the 9th or 10th.

Horse

15-21 in number, An average is 18.

The laminae fail to meet dorsally after the fourth so that the neural arch is incomplete.

Pig

It is characterized by the presence of functional articular processes on the first four or five beyond which these become non-articular and smaller.

The arches of the first four or five are complete.

Fusion of the first coccygeal vertebra with the sacrum is not uncommon.

Dog

20 to 23 in number.

Neural rings are present in the first six.

The first three or four have articular processes which form joints.

Haemal arches or *chevron bones* in the form of a V or Y occur ventrally at the inter-central junctions of the third, fourth and fifth usually.

Fowl

They are seven in number. The first one is fused, with the lumbo-sacrals.The last is a three-sided pyramid called *pygostyle,* which results from the fusion of three or four vertebrae in the embryo and forms a foundation for the feathers of the tail and coccygeal glands. Its apex projects upward and backward

The intermediate ones are typical vertebrae.

The transverse processes of these are well developed and the spines are bifurcated.

Vertebral Column As a Whole

Curve

The curve of the column is slight and concave above in the cervical region whereas in the dorsal and lumbar regions the curve is gently concave below and in the sacral region it is strongly convex above.

The curvature varies in the coccygeal region.

Vertebral (Neural) canal

The caliber is greatest in the atlas.

It is reduced in the axis but becomes wider at the cervico-dorsal junction. From here it is once again reduced to about the terminal part of the dorsal region.

It increases again in the lumbar region to about the middle of the sacrum. It thereafter diminishes and disappears altogether by about the fifth or sixth coccygeal.

Processes

The *articular processes* are best developed in the cervical region. They are smaller in the dorsal region but again become larger and strongly curved in the lumbar region.

The *spines* are best developed in the dorsal region. In the lumbar and sacral regions they are shorter but plate like. In the cervical region, they are shorter.

The *ventral spines* are best developed in the cervical region.

The *transverse processes* are large and plate like in the lumbar, thick and short in the dorsal but larger in the cervical region.

Ribs

Ox

The ribs are elongated curved bones, which form the skeleton of the lateral thoracic walls.

They are arranged serially in pairs, which correspond in number to the thoracic vertebrae. Thus there are thirteen pairs of ribs.

Each rib articulates dorsally with two vertebrae and is continued ventrally by a costal cartilage. Those that articulate with the sternum by means of their cartilage, (eight pairs) are termed sternal ribs; the remainder is asternal ribs.

Ribs at the end of the series with free ventral ends not attached to adjacent cartilage are floating ribs.The intervals between ribs are intercostal spaces.

A typical rib is an elongated, flat curved plate. It presents a shaft and two extremities.

Shaft

The shaft is most curved at its upper part while its lower part is twisted and inclines inwards.

The lateral surface is convex and is marked by a wide groove in its anterior part.The point at which a rib most curved is termed the angle and here it presents a rough area for the attachment of the longissimus dorsi muscle.

The medial surface is smooth, concave and presents at its posterior part a distinct groove -the costal groove which turns downwards and disappears about the middle of the bone and lodges the intercostal vein.

The borders serve for the attachment of the intercostal muscles.

Upper extremity

The upper vertebral extremity is made up of a head, neck and a tubercle.

The head presents an articular area which is composed of two convex facets -anterior and posterior, separated by a non-articular groove. The facets articulate with the capitular facets of two adjacent dorsal vertebrae and the intervertebral fibrocartilage between them and the groove serves for the attachment of the round conjugal ligament.

The neck joints the head to the shaft and is roughened above and in front for ligamentous attachment.

The tubercle is situated above and behind the head at the junction of the head and neck. Dorsally it presents a transversely placed concave facet for articulation with a tubercular facet of the posterior vertebra of the two with which the head articulates.

The tubercular facet is small, flat or absent in the last two or three ribs.

Lower extremity

The lower sternal extremity is smooth and articulate with its costal cartilage.

The ventral ends of the second to the tenth or eleventh inclusive form diarthrodial joint (movable) with their cartilages.

Special Features

The first rib is the shortest and least curved.The sternal end widens very greatly.The lateral surface and the anterior border present a rough area about their middle for the scalenus ventralis. At the lower part of anterior border is a smooth impression left by the dorsal roots of the brachial plexus.The groove on the lateral surface and the costal groove are absent.The head is divided by an oblique ridge into the two facets. The tubercle is larger than that of any other rib.

The eighth, ninth and tenth ribs are the longest and widest. Both in front and behind these, the length and breadth diminish gradually. The first costal cartilage is the shortest.

The costal cartilages are rods of hyaline cartilage and form diarthrodial joints with ribs (from) -2nd to tenth or eleventh). Those of sternal ribs articulate with the sternum by sternal cartilages. Those of asternal ribs overlap and are attached to each other by elastic tissue to form the costal arch. Except in the case of the first the cartilage does not continue the rib but forms with the later an angle, which is open in front and increases from the second to the last.

Horse

There are 18 pairs of ribs. 8 sternal and 10 asternal, they are shorter, narrower, thicker, regular and more curved.

The neck is shorter.

The length increases upto the 10th and then diminishes.

The anterior borders of the ribs from the 2nd to 8th are sharp and from 9th to 18th rounded and thick.

The lower ends of ribs are s lightly enlarged and roughened at the junction with the costal cartilage.

In regard to dorso-ventral direction, the first rib inclines a little forward the second is about vertical and others slope backwards in increasing degree.

The two first costal cartilage articulate with each other and with sternum.

The upper ends of cartilages form synarthrodial joints (immovable) with ribs.

Pig

There are 14 or 15 pairs of ribs. Of which 7 are sternal and seven or eight are asternal.

They are strongly curved with a distinct angle.

The backward slope of the posterior rib is slight.

The first rib is prismatic, has a large sternal end and a very short cartilage.

The tubercle fuses with the head on the last five or six.

The second to fifth form diarthrodial joints with their cartilages, which are wide and plate-like.

The 15 th rib when present, may be fully developed and its cartilage enter into the formation of the costal arch.

But in most cases it is floating and in some cases it is only about an inch in length.

Dog

There are 13 pairs of ribs. 9 sternal and 4 asternal.

They are strongly curved narrow and thick.

The last rib is usually floating.

The heads of the last two or three ribs articulate with only one vertebra.

The costal cartilages are long and curve ventrally and forward. The length and curvature of the first pair are striking special features.

Fowl

There are 7 pairs of ribs.

Each rib is made up of an upper vertebral rib and a lower sternal rib.

The first, second and sometimes seventh do not have sternal ribs: These are floating.

The head of a rib articulates with the capitular cavity of a single dorsal vertebra.

Except the first and seventh, the posterior border of each vertebral rib presents an uncinate process directed backward to overlap the succeeding rib.

Sternal ribs are homologues of mammalian costal cartilage.

Ribs

Ox

The ribs are elongated curved bones, which form the skeleton of the lateral thoracic walls.

They are arranged serially in pairs, which correspond in number to the thoracic vertebrae. Thus there are thirteen pairs of ribs.

Each rib articulates dorsally with two vertebrae and is continued ventrally by a costal cartilage. Those that articulate with the sternum by means of their cartilage, (eight pairs) are termed sternal ribs; the remainder is asternal ribs.

Ribs at the end of the series with free ventral ends not attached to adjacent cartilage are floating ribs.The intervals between ribs are intercostal spaces.

A typical rib is an elongated, flat curved plate. It presents a shaft and two extremities.

Shaft

The shaft is most curved at its upper part while its lower part is twisted and inclines inwards.

The lateral surface is convex and is marked by a wide groove in its anterior part.The point at which a rib most curved is termed the angle and here it presents a rough area for the attachment of the longissimus dorsi muscle.

The medial surface is smooth, concave and presents at its posterior part a distinct groove -the costal groove which turns downwards and disappears about the middle of the bone and lodges the intercostal vein.

The borders serve for the attachment of the intercostal muscles.

Upper extremity

The upper vertebral extremity is made up of a head, neck and a tubercle.

The head presents an articular area which is composed of two convex facets -anterior and posterior, separated by a non-articular groove. The facets articulate with the capitular facets of two adjacent dorsal vertebrae and the intervertebral fibrocartilage between them and the groove serves for the attachment of the round conjugal ligament.

The neck joints the head to the shaft and is roughened above and in front for ligamentous attachment.

The tubercle is situated above and behind the head at the junction of the head and neck. Dorsally it presents a transversely placed concave facet for articulation with a tubercular facet of the posterior vertebra of the two with which the head articulates.

The tubercular facet is small, flat or absent in the last two or three ribs.

Lower extremity

The lower sternal extremity is smooth and articulate with its costal cartilage.

The ventral ends of the second to the tenth or eleventh inclusive form diarthrodial joint (movable) with their cartilages.

Special Features

The first rib is the shortest and least curved.The sternal end widens very greatly.The lateral surface and the anterior border present a rough area about their middle for the scalenus ventralis. At the lower part of anterior border is a smooth impression left by the dorsal roots of the brachial plexus.The groove on the lateral surface and the costal groove are absent.The head is divided by an oblique ridge into the two facets. The tubercle is larger than that of any other rib.

The eighth, ninth and tenth ribs are the longest and widest. Both in front and behind these, the length and breadth diminish gradually. The first costal cartilage is the shortest.

The costal cartilages are rods of hyaline cartilage and form diarthrodial joints with ribs (from) -2nd to tenth or eleventh). Those of sternal ribs articulate with the sternum by sternal cartilages. Those of asternal ribs overlap and are attached to each other by elastic tissue to form the costal arch. Except in the case of the first the cartilage does not continue the rib but forms with the later an angle, which is open in front and increases from the second to the last.

Horse

There are 18 pairs of ribs. 8 sternal and 10 asternal, they are shorter, narrower, thicker, regular and more curved.

The neck is shorter.

The length increases upto the 10th and then diminishes.

The anterior borders of the ribs from the 2nd to 8th are sharp and from 9th to 18th rounded and thick.

The lower ends of ribs are s lightly enlarged and roughened at the junction with the costal cartilage.

In regard to dorso-ventral direction, the first rib inclines a little forward the second is about vertical and others slope backwards in increasing degree.

The two first costal cartilage articulate with each other and with sternum.

The upper ends of cartilages form synarthrodial joints (immovable) with ribs.

Pig

There are 14 or 15 pairs of ribs. Of which 7 are sternal and seven or eight are asternal.

They are strongly curved with a distinct angle.

The backward slope of the posterior rib is slight.

The first rib is prismatic, has a large sternal end and a very short cartilage.

The tubercle fuses with the head on the last five or six.

The second to fifth form diarthrodial joints with their cartilages, which are wide and plate-like.

The 15 th rib when present, may be fully developed and its cartilage enter into the formation of the costal arch.

But in most cases it is floating and in some cases it is only about an inch in length.

Dog

There are 13 pairs of ribs. 9 sternal and 4 asternal.

They are strongly curved narrow and thick.

The last rib is usually floating.

The heads of the last two or three ribs articulate with only one vertebra.

The costal cartilages are long and curve ventrally and forward. The length and curvature of the first pair are striking special features.

Fowl

There are 7 pairs of ribs.

Each rib is made up of an upper vertebral rib and a lower sternal rib.

The first, second and sometimes seventh do not have sternal ribs: These are floating.

The head of a rib articulates with the capitular cavity of a single dorsal vertebra.

Except the first and seventh, the posterior border of each vertebral rib presents an uncinate process directed backward to overlap the succeeding rib.

Sternal ribs are homologues of mammalian costal cartilage.

Sternum or Breast Bone

Ox

The sternum is a medially placed-segmented bone, forming the floor of the thorax. It is made up of the seven bony segments,sternebrae and is elongated from before backwards. The segments are connected by intervening cartilages. It is compressed laterally till about its middle and thereafter it is flattened from above downwards. It is directed obliquely downwards and backwards.

It presents two surfaces, two borders and two extremities.

The dorsal face is narrow in front but becomes gradually wider behind. This face gives attachment to the internal ligament in the middle and transverses thoracis muscle laterally. It forms the floor of the thorax.

The ventral face is extensive and is strongly convex in front but more or less concave behind the second sternebrae. The surface affords attachments to the pectoral muscles and the recti abdominis muscles. The two surfaces are marked by transverse lines indicating the lines of fusion of the sternebrae.

The lateral borders are thick in front but become thinner gradually behind.

Each border presents eight articular cavities for articulation with the ventral extremities of the first eight costal cartilages.The first of these is on the anterior part of the dorso-lateral aspect of the first sternebrae. Excepting the first and the last two, the other cavities are between the sternebrae. The facets for the seventh and eighth costal cartilages often become confluent.

The anterior extremity is the anterior end of the first sternebrae, which forms the manubrium sterni or presternum.The posterior end of this segment articulates with the anterior end of the second sternebrae to form a diarthrodial joint.The anterior extremity furnishes attachment to the sternocephalicus and sternothyro-hyoideus muscle.

The posterior extremity or metasternum is formed by the xiphoid cartilage, which is thin, flexible and nearly circular. Between the pre and metasternum is the body or mesosternum.

The diaphragm is attached across the upper concave face of xiphoid cartilage close to its junction with the last sternebrae.The part of the cartilage behind the line of attachment of the diaphragm forms the floor of the abdomen.The ventral face furnishes attachment to the transverse abdominis and linea alba.

Horse

It is composed of seven sternebrae.

It is canoe or boat shaped and presents three surfaces, three borders and two extremities.

The superior surface is narrow and triangular.

The two lateral surfaces are convex above, slightly concave below and present costal cavities on their upper parts.

The dorsolateral borders separate the dorsal and lateral surfaces.

The inferior border is the keel.

The anterior extremity presents a laterally compressed cariniform cartilage, which presents a deep notch superiorly for articulation with the two first costal cartilages

The first sternebrae is fused with the second

The manubrium is made up of the cariniform cartilage and the first sternebrae.

Pig

The sternum consists of six segments and resembles that of Ox in general.

The first segment is long and bears a blunt pointed cartilage at its anterior end, its posterior end forms a diarthrodial joint with the body.

The last segment has a long, narrow part, which bears the xiphoid cartilage.

Dog

The sternum is composed of eight sternebrae - all fused.

Each sternebrae slightly compressed from side and constricted in its middle

The anterior end bears a small presternal cartilage.

The xiphoid cartilage is narrow.

Fowl

The sternum differs from the corresponding structure of domestic mammals since it is formed entirely of bone in the adult. It results from the fusion of five pieces, which have separate centres of ossification in the chick.

The central wide part forms the body of the bone. In front of this is the anterior process -the rostrum or manubrium and behind is the posterior process or metasternum.

The dorsal surface of the body is concave and pierced by foramina, which permit air to enter the interior from the adjacent air sac. The ventral surface is encroached upon by the lower borders of anterior and posterior processes.

The anterior process or rostrum is short and on either side of its root is an elongated facet for articulation with the coracoid bone.

The posterior process or metasternum is very long being in fact more extensive than the body itself. It carries ventrally, a thin plate of bone called the keel or sternal crest, which affords attachment to the pectoral muscles.

The keel is broad in front and fades out posteriorly. United to each lateral border of the body are the antero-lateral or costal process in front and the postero lateral process behind. The costal process projects upwards and forward. The postero-lateral process is short and divides into a medial and lateral xiphoid processes. The lateral division is broad, plate-like and covers the l ast two or three ribs. The medial division is longer and projects backward parallel to the lateral border of the metasternum. The deep notches between them and between the posterior division and metasternum are closed in life by tough membrane. Between the antero-lateral and 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.

Thorax

Ox

The thoracic cavity is the anterior of the three visceral cavities.

It is compressed laterally and is narrow in front and wide behind.

The *roof* is formed by the bodies of the dorsal vertebrae.

The *lateral walls* are formed by the ribs and their cartilages.

The *base* slopes obliquely downwards and forwards and is bounded superiorly by the last dorsal, inferiorly by the last sternebra and laterally by the last ribs and their cartilages.

The *thoracic inlet* is oval and limited above by the first dorsal vertebra below by the first sternebra, and laterally by the two first ribs. In life, the inlet is closed by a number of structures, which enter and leave the thorax while the base is closed by the diaphragm.

The intercostal muscles fill up the intercostal spaces between the ribs.

Horse

It is very much compressed laterally.

It is longer than in ox.

Pig

Relatively wide.

Dog

It is barrel-shaped.

Fowl

The thoracic cavity is continuous with abdomial cavity and relatively wide.

Skull

▲ The bones of the skull are divided into cranial and facial groups. The former enter into the formation of the cranium,which lodges the brain and the essential organs of hearing while the latter form the boundaries of the oral and nasal cavities and also support the pharynx, larynx and tongue. The two sets together form the orbits. Some of the bones are also forming sinuses and they are called as paranasal sinuses.

▲The *cranial bones* are parietal, interparietal, occipital, sphenoid, ethmoid, temporal and frontal. Of these, occipital, sphenoid, ethmoid are unpaired.

▲The *Facial bones* are nasal, premaxilla, maxilla, palatine, pterygoid, lacrimal, malar, turbinates, vomer, mandible and hyoid.

▲Most of the bones of the skull are flat bones developed in membrane. Those of the cranial base may be classified as irregular and are developed in cartilage. Occipital, sphenoid, ethmoid, petro-mastoid parts of temporal and turbinates develop in cartilage. Others develop in membrane.

▲ *Wormian* or *Sutural bones* are small irregular bones situated in the sutures of the cranial bones. They are developed after birth in the cranial, cranio-facial and facial sutures. Their number and position varies with the species of animals and even in the breeds of the same species.

▲ Cranial wormian bones are rare. When seen, they are at the junction of the petrous-temporal with the occipital bone. The wormian bones of the cranio-facial and facial sutures are more frequent. They are more particularly met with in the bovine species in the fronto-nasal, internasal, lacrymo-nasal, zygomatico-maxillary, orbital and maxillo-nasal incisive sutures.

▲ Skull of the pig and skull of the rabbit are described separately for the convenience.

Cranial Bones

The *cranial bones* form the **cranial cavity.** which lodges the brain with its meninges,vessels and essential organ of hearing. They are named as follows:

Parietal

Interparietal

Occipital

Sphenoid

Ethmoid

Temporal

Frontal

Of these, occipital, sphenoid, ethmoid are unpaired.

Facial Bones

The face is more extensive than the cranium in most of the domnestic animals.Sone of thses bones involved in the formation of nasal cavity. The facial bones are named as following:

Nasal

Maxilla

Premaxila

Palatine

Pterigoid

Lacrimal

Malar

Turbinate

Vomer

Mandible

Hyoid

The last three are single, the others are paired.

Facial Bones

Sinuses of the Skull (Paranasal Sinuses)

Ox

The sinuses are air cavities in bones, which are lined by mucous membrane in the fresh state. They communicate with the nasal cavity directly or indirectly and hence are termed *diverticula of the nasal cavity*. The sinuses are *frontal, maxillary, palatine* and *sphenoid*.

Frontal sinus

It is the largest of all the sinuses and is excavated in the frontal, parietal, interparietal and supraoccipital.

It extends from the posterior wall of the cranium down to the level of the anterior margins of the orbit and laterally to the frontal crests and supra-orbital process; medially it is separated from its fellow by an imperforate bony septum.

The cavity is divided into small spaces by partial septa.

This sinus communicates with the middle meatus by narrow apertures at the ethmoidal meatuses.

In the macerated skull, its communication with the cavity of the dorsal turbinate and the lacrimal part of the maxillary sinus is closed in life by the mucous membrane.

Maxillary sinus

It is formed in the body of maxilla.

It extends forward to the level of the facial tuberosity and upward to a line joining the infra-orbital foramen to the upper margin of the orbit.

It extends behind into the maxillary protuberance and the lacrimal bulla to a point nearly opposite to the bifurcating of the zygomatic process of the malar.

It also extends upward and backward through a large opening into a cavity formed by the lacrimal frontal ethmoid and the roots of the last 3 or 4 check teeth project into the sinus covered by a plate of bone.

It communicates with the palatine sinus over the infra-orbital canal. Above this it communicates with the middle nasal meatus.

Palatine sinus

It is formed in the palatine processes of maxilla, and horizontal part of palatine bones.

It is separated from its fellow by a bony septum.

It extends from posterior border of the palatine to about an inch in front of the level of the first cheek tooth.

It communicates with the maxillary sinus laterally and is separated from the ventral meatus medially by mucous membrane in life.

The palatine canal passes obliquely through the posterior part of the sinus.

Sphenoidal sinus

It is excavated in the body of the presphenoid and extends into the orbital wing.

It is smallest of the four sinuses and communicates with the ventral ethmoidal meatuses.

Horse

The sinuses are *maxillary, frontal, spheno-palatine and ethmoidal.*

Maxillary sinus

It is the largest and is formed by the maxilla, lacrimal malar, posterior turbinate and lateral masses of ethmoid.

It extends from the level of the supraorbital process behind to the level of a line joining the infraorbital foramen and the facial crest.

Its dorsal boundary is a line drawn from the infraorbital foramen backward parallel to the facial crest.

The ventral wall or floor is the alveolar part of the maxilla. It is divided into anterior and posterior part by an oblique septum directed inward, backward and upward from about two inches behind the anterior end of the facial crest.

The posterior end of the ventral turbinate forms the upper part of the septum.

The *anterior compartment (inferior maxillary sinus)* is partially divided by the infra-orbital canal into lateral and medial parts. The former is formed entirely in the maxillary bone and the root of the fourth cheek tooth and parts of third and fifth cheek teeth project into it, covered by a plate of bone. The medial or turbinate part communicates with the outer compartment and with the middle meatus.

The *posterior compartment (superior maxillary sinus)* is also divided into two parts by the infraorbital canal over which it freely communicates with spheno-palatine sinus. Dorsally it communicates with the frontal sinus through a large oval, *fronto-maxillary* opening. In front of this covered by a plate of bone is a narrow *naso-maxillary* opening by which the sinus opens into the posterior part of the middle meatus.

Frontal or Fronto-turbinate sinus

It is formed in the frontal, lacrimal, ethmoid and dorsal turbinate bone. It consists of *frontal* and *turbinate parts*.

The *frontal part* extends forward to the anterior margins of the orbits, backwards to the temporal condyles and outwards into the roots of the supra-orbital processes.

A median septum is present as in the ox.

The *turbinate part* is situated in the posterior part of the dorsal turbinate bone, roofed in by the nasal and lacrimal bones.

It extends forward to a transverse plane about half way between the anterior margin of the orbit and the infra orbital foramen.

It is in free communication behind with the frontal part over the lateral mass of ethmoid.

It is separated form the nasal cavity by a thin turbinate plate.

Spheno-palatine sinus

It is formed in the body of presphenoid and vertical part of the palatine bone.

It communicates with the medial part of the posterior compartment of the maxillary sinus.

Ethmoid sinus

It is the largest cavity in the ethmo-turbinate.

It communicates with the maxillary sinus.

Dog

The frontal sinus is confined to the frontal bone and opens into the ethmoidal meatuses.

The maxillary sinus is small and communicates with the nasal cavity, very freely.

There are no sphenoidal or palatine sinuses.

Fowl

There are no sinuses in the skull.

Mandible or Lower jaw Bone

Ox

It is a single bone. It is the largest bone of the face and is made up of two halves, which do not fuse completely so that a mandibular symphysis is present. It has a body and two rami.

Body

The lingual surface of the body is covered in life by mucous membrane and tip of the tongue rests on it.

The mental surface is related to the lower lip.

The symphyseal surfaces are rough and irregular.

The alveolar border presents alveoli for the lower incisor teeth.

Two rami

The two rami diverge backward from the body and enclose the mandibular space.

Each ramus is bent to form a horizontal part and a vertical part. The most prominent part of the curve is the angle.

The lateral surface is widest at the angle and narrow at either end. It is smooth and convex in the horizontal part and is nearly flat in the vertical part. A rough elevation near the angle and the rough line are for the insertion of the masseter muscle. It presents a fossa at its junction with the body. Placed in this fossa is the mental foramen-the external opening of the mandibular (inferior dental) canal. A small incisor canal continues the mandibular canal into the body of the mandible.

The medial surface of the horizontal part gives attachment to the mylo-hyoid muscle. An its junction with the body is a fossa for the genio-hoyid and

genio glossus muscle. On the vertical part, this surface presents rough lines inferiorly for the medial pterygoid. Placed about the middle of this surface is the mandibular foramen the posterior opening of the mandibular canal. From the foramen, a groove leads forward and downward-the lingual groove for the lingual nerve.

The dorsal or alveolar border of the ramus presents the inter-alveolar space in front and six alveoli for the lower cheek teeth behind. In the vertical part it serves for the attachment of muscles.

The ventral border of the horizontal part is convex, and presents a smooth impression in its posterior part left by the facial vessels and parotid duct. It is concave and thin in the vertical part.

The anterior extremity of each ramus joins the body. The posterior or articular extremity presents a coronoid process in front separated by the mandibular notch through which passes the masseteric nerve. The coronoid process is long, curves backward into the temporal fossa and is for the temporalis.

The condyle is elongated transversely, placed about two inches below the summit of the coronoid process and articulates with the condyle of the squamous temporal through the medium of an interarticular cartilage. The condyle projects inwards for the lateral pterygoid.

Horse

The two halves of the mandible fuse completely.

The alveolar border of the body presents six alveoli for the lower incisors and two for the canines.

The lingual groove is absent.

The antero-medal part of the condyle presents a depression.

The fovea pterygoidea is for the lateral pterygoid muscle.

Coronoid process is less prominent.

The rami diverge less than in ox.

Dog

The two halves do not fuse.

The alveolar border of the body presents six alveoli for the incisors and two for canines.

The horizontal part of ramus carries seven alveoli for the lower cheek teeth.

The interalveolar space is very short or even absent.

There are two or three mental foramina on either side.

The vertical part is relatively small.

The lateral face of the vertical part presents a deep masseteric fossa.

The posterior border bears an angular process at the level of the mandibular foramen.

This is the equivalent of the angle of other animals. The condyle is placed very low.

The coronoid process is extensive and is bent slightly outwards and backward.

Fowl

It is a single bone and each half is made up of five pieces in the embryo.

The two halves fuse anteriorly. Posteriorly its articular part carries an articular area for the lower end of the quadrate bone. Behind this, the ventral border is carried upward and backward by a process.

The quadrate bone articulates with the articular part of mandible below, above it articulates with the temporal, in front of the tympanic cavity, laterally with the quadrato jugal bone; medially with the pterygoid bone. It is irregularly four sided. Its anterio-medial angle projects into the orbit as a muscular process. The quadrate is the homologue of the mammalian incus (one of the middle ear ossicles). Its presence and the great mobility of the bone of the face permit extensive opening of the mouth. (See for details-under mandibular articulations in arthrology).

Hyoid Bone

Ox

It is situated between the vertical parts of the rami of the mandible and extends obliquely downward and forward from the temporal above to the root of the tongue below. It consists of a *body*, a *lingual (glossal) process* and *four pairs of cornua (stylohyoid, epihyoid, keratohyoid and thyrohyoid).*

The *body* or *basi-hyoid* is short rod of bone placed transversely. The anterior border, in its middle, carries the short blunt *glossal process*, which is embedded in the root of the tongue.

The body is attached to the *thyroid cornua* of the thyro-hyoid by bars of cartilage on the postero -lateral aspects.

The thyroid cornua extend backward and upward from the body and are attached to the anterior cornua of the thyroid cartilage of the larynx.

The *ketato-hyoids (small cornua)* are directed upward and forward and articulate by the lower ends by concave facets with the cartilage uniting the body and thyroid cornua. Their upper ends are attached to the of lower ends of the *middle cornua* or *epihyoids* by short bars of cartilage.

The epihyoid is a small curved rod attached to the small cornua below and the *great cornu* or *stylo-hyoid* above which is largest piece.

The great cornu is directed upward and backward. Its lower end is attached to the upper end of the epihyoid. Its upper end resembles a human foot and has a heel-like part the *muscular angle* for muscular attachment and a toe-like part-the *articular angle,* which is connected by a short rod of cartilage to the hyoid process of the petrous temporal.

Horse

The lingual process (glosso-hyoid) is longer with its free end pointed.

The thyro-hyoid are fused with the body.

The body of thro-hyoids and glosso-hyoid are fused and resemble spur or fork.

The epihyoid is fused with the lower end of the stylo-hyoid.

Dog

The glosso-hyoid is absent.

The epihyoid is longer than the stylo-hyoid.

The stylo-hyoid is bent and twisted.

The thyro-hyoid is permanently attached to the body by cartilage.

Fowl

It is composed of seven bony segments-three median and two lateral processes.

The anterior median segment is the *entoglossal* and is embedded in the tongue.

It articulates behind with the second or basi-hyoid.

The *basi-hyoid (body)* is connected behind to the third segment of uro-hyoid at its middle and to the lateral processes by a bar of cartilage at either end.

The *uro-hyoid* is partly bony and partly cartilaginous.

Each *lateral process* consists of an anterior *basi-branchial* and a posterior *cerato-branchial* connected by cartilage. The lateral processes extend posteriorly upwards and towards the occipital bone.

Arthrology

The study about joints is termed arthrology or *syndesmology*. A *joint* or *articulations* are the structures, where two or more bones of the skeleton meet one another by certain determined areas of their surface named *articular areas* with the help of certain binding materials.

In immovable joints, the adjacent margins of the bones in contact, being separated merely by a thin layer of fibrous membrane called the sutural *ligament* eg. joints in the skull. In certain regions at the base of the skull this fibrous membrane is replaced by a layer of cartilage.

Where slight movement combined with great strength is required, the osseous surfaces are united by tough and elastic *fibrocartilages* E.g. joints in the vertebral bodies.

In freely movable joints, the surfaces are completely separated and the bones forming the joints are expanded for greater convenience of mutual connection are covered by *cartilage* and enveloped by *capsules* of fibrous tissue. The cells lining the interior of the fibrous capsule form an imperfect membrane—the *synovial membrane*—which secretes a lubricating fluid. The joints are strengthened by strong fibrous bands called *ligaments*, which extend between the bones forming the joint.

Bone

Bone constitutes the fundamental element of all the joints.

In the long bones, the extremities are the parts which form the articulations.They are generally enlargedand consist of spongy cancellous tissue with a thin coating of compact substance.

In the flat bones, the articulations usually take place at the edges.

In the short bones at various parts of their surfaces.

The layer of compact bone which forms the joint surface where the articular cartilage is attached is called the *articular surface*. It differs from ordinary bone tissue in that it contains no Haversian canals, and its lacunæ are larger and have no canaliculi. The vessels of the cancellous tissue as they approach the articular surface, turn back in loops, and do not perforate it. This layer is consequently denser and firmer than ordinary bone, and is evidently designed to form an unyielding support for the articular cartilage.

Cartilage

Cartilage is a non-vascular structure which is found in various parts of the body in adult life chiefly in the joints, in the parietes of the thorax, and in various tubes, such as the trachea and bronchi, nose, and ears, which require to be kept permanently open.

In the early period of fetus, the greater part of the skeleton is cartilaginous and are replaced by bone.

Cartilage is divided according to its structure into *hyaline cartilage, white fibrocartilage*, and *yellow* or *elastic fibrocartilage*.

Hyaline Cartilage

Hyaline cartilage consists of a gristly mass of a firm consistence, but of considerable elasticity and pearly bluish color. Except where it coats the articular ends of bones, it is covered externally by a fibrous membrane, the *perichondrium*.

It contains no nerves.

Microscopically it consist of cells of a rounded or bluntly angular form, lying in groups of two or more in a granular or almost homogeneous matrix.

Articular cartilage, costal cartilage, and *temporary cartilage* are all of the hyaline variety. They present differences in the size, shape, and arrangement of their cells.

White Fibrocartilage

White fibrocartilage consists of a mixture of white fibrous tissue and cartilaginous tissue in various proportions; to the former of these constituents it owes its flexibility and toughness, and to the latter its elasticity.

When examined under the microscope it is found to be made up of fibrous connective tissue arranged in bundles, with cartilage cells between the bundles; the cells to a certain extent resemble tendon cells, but may be distinguished from them by being surrounded by a concentrically striated area of cartilage matrix and by being less flattened.

Ligaments

Ligaments are composed mainly of bundles of white fibrous tissue placed parallel closely interlaced with one another and present a white, shining, silvery appearance.

They are pliant and flexible to allow perfect freedom of movement, but strong, tough, and inextensible to yield readily to applied force.

Some ligaments consist entirely of *yellow elastic tissue*, as the ligamenta flava which connect together the laminæ of adjacent vertebræ. In these cases the elasticity of the ligament is intended to act as a substitute for muscular power.

Capsules

Articular Capsules

The articular capsules form complete envelopes for the freely movable joints. Each capsule consists of two strata—an *external* (stratum fibrosum) composed of white fibrous tissue, and an *internal* (stratum synoviale) which is a secreting layer and is usually described separately as the synovial membrane.

Fibrous capsules

It is attached to the whole circumference of the articular end of each bone entering into the joint, and thus entirely surrounds the articulation

Synovial membrane

It invests the inner surface of the fibrous capsule and is reflected over any tendons passing through the joint cavity

It is composed of a thin, delicate, connective tissue with branched connective-tissue corpuscles.

Its secretion is thick, viscid, and glairy, like the white of an egg, and is hence termed synovia.

They consist of connective tissue covered with endothelium and contain fat cells in variable quantities with isolated cartilage cells.

Synovial sheath

They serve to facilitate the gliding of tendons in fibroosseous canals.

Each sheath is arranged in the form of an elongated closed sac, one layer of which adheres to the wall of the canal and the other is reflected upon the surface of the enclosed tendon.

These sheaths are chiefly found surrounding the tendons of the Flexor and Extensor muscles of the fingers and toes as they pass through fibroosseous canals in or near the limb.

Synovial bursae

They are interposed between surfaces which glide upon each other.

They consist of closed sacs containing a minute quantity of clear viscid fluid.

Development of Joints

The mesoderm from which the different parts of the skeleton are formed shows at first no differentiation into masses corresponding with the individual bones. Thus continuous cores of mesoderm form the axes of the limb-buds and a continuous column of mesoderm the future vertebral column.

The *first indications of the bones and joints are circumscribed condensations of the mesoderm* and these condensed parts become chondrified and finally ossified to form the bones of the skeleton.

The intervening non-condensed portions consist at first of undifferentiated mesoderm, which may develop in one of three directions. It may be converted into fibrous tissue as in the case of the skull bones, a synarthrodial joint being the result or it may become partly cartilaginous, in which case an amphiarthrodial joint is formed. Again, it may become looser in texture and a cavity ultimately appear in its midst; the cells lining the sides of this cavity form a synovial membrane and thus a diarthrodial joint is developed.

The tissue surrounding the original mesodermal core forms fibrous sheaths for the developing bones, *i. e.,* periosteum and perichondrium, which are continued between the ends of the bones over the synovial membrane as the capsules of the

joints. These capsules are not of uniform thickness, so that in them may be recognized especially strengthened bands which are described as ligaments.

This, however, is not the only method of formation of ligaments. In some cases by modification of, or derivations from, the tendons surrounding the joint, additional ligamentous bands are provided to further strengthen the articulations.

In several of the movable joints the mesoderm which originally existed between the ends of the bones does not become completely absorbed—a portion of it persists and forms an articular disk. These disks may be intimately associated in their development with the muscles surrounding the joint, *e. g.,* the menisci of the knee-joint, or with cartilaginous elements, representatives of skeletal structures, which are vestigial in human anatomy, *e. g.,* the articular disk of the sternoclavicular joint.

Classification of Joints

Joints are classified *anatomically* according to their *mode of development*, the *nature of uniting medium* and the *form of joint surfaces*.

They can also classified *physiologically* base on the *amount* and *kind of movements* permitted or the absence of movement in them.

These joints are classified *developmentally* as

Fibrous joints

Cartilaginous joints

Synovial joints

Based on the *nature of uniting medium* and the *movements permitted*, they are classified as

Synarthroses (includes fibrous and primary cartilagenous joints)

Amphiarthroses (secondary cartilaginous joints)

Diarthroses (synovial joints)

Movements of Synovial Joints

Movements are determined chiefly by the form, extent of joint surfaces and the arrangements of ligaments. They are classified as

Translation or *Gliding:* one bone moves or glides over another in the same plane (carpals and tarsals).

Angular: During these movements, the angles between the two adjoining bones change. The angular movement as follows;

Flexion –The motion that diminishes the angle between the bones forming the joint.

Extension-The angle increase or the segment straightens (elbow).

Adduction-Inward movement of one segment from the central axis.

Abduction- Outward movement of one segment from the central axis.

The terms *depression, elevation* also refer to angular movements in a vertical place (temporo-mandibular joint).

Circumduction - The distal end of the bones forming the joint describes a circle or segment of one (hip point).

Rotation: One bone rotates around the longitudinal axis of another (atlanto-axial).

Pronation and *Supination* refer to the position and movement of forearm and manus. In supination the volar (palmar in men) face of the manus is turned forward (or upward) and in pronation, it faces backwards (downwards).

Articulations of the Skull

Most of the bones of the skull are united by *sutures*. A few are united by *cartilage* (synchondrosis) and one (temporomandibular) joint is a *synovial joint*.

The *sutures* have been named according to the bones involved in their formation. E.g. interparietal suture, interfrontal suture, frontoparietal suture, temporoparietal suture etc.

The principal *synchondroses* are between (1) basioccipital and post sphenoid (2) post sphenoid and presphenoid (3) parts of occipital. Most of these joints ossify in life.

A *symphysis* occurs between the two halves of the ventral ends of the mandible at the median plane. This symphysis does not ossify even in adult life.

The only movable articulations are the temporo-mandibular and hyoidean articulations.

Articulations of the Vertebral Column

The bones of the vertebral column are serially articulated by their bodies and by the neural processes.

Most of the joints are articulated by some common or common variety of ligaments and therefore called as *common vertebral articulations*.

There are few joints in the vertebral column, which are not articulated by common ligaments, are called as *special vertebral articulations*.

The *common vertebral articulations* are of two kinds:

Intercentral, those formed between the bodies of the vertebrae

Interneural, those formed between articular processes of adjacent vertebrae.

Associated with these joints are ligaments, some of which extend the whole length of vertebral column-the *common ligaments* and some are restricted to a single joint-the *special ligaments*.

The *special vertebral articulations* are the *occipito-atlantoaxial* and the *coccygeal articulations*.

Common Vertebral Articulations

The bones of the vertebral column are serially articulated by their bodies and by the neural processes. Most of the joints are articulated by some common or common variety of ligaments and therefore called as *common vertebral articulations***.**

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Intercentral articulations

Ox

These are *amphiarthroses* formed the bodies of adjacent vertebrae.

Ligaments

Inter-vertebral discs-Each of these is made up of fibro cartilage and is interposed between the bodies to which it is intimately attached. These discs are thinnest in the dorsal, thicker in the cervical and lumbar and thickest in the coccygeal region. Each consists of a peripheral fibrous (**annulus fibrosus**) and a soft central pulpy substance (nucleus pulposus). There are joint cavities in the cervical intercentral joints, in those between the last cervical and first thoracic and between last lumber and first sacral joints.

The ventral longitudinal ligament: It lies along the ventral faces of the bodies of vertebrae and the intervertebral discs to which it is firmly attached. It is strongest in the lumbar region where it is blended with the crura of the diaphragm. It begins from about the seventh dorsal as a thin band, becomes gradually thicker and wider behind and terminates on the pelvic face of the sacrum. In the anterior dorsal (in front of seventh dorsal) and the cervical regions, it is replaced by the *longus colli* muscle.

The dorsal longitudinal ligament: It is a ribbon like white fibrous band extending from the sacrum to the axis along the floor of the spinal canal intimately attached to the superior faces of the intervertebral dics. In each vertebra, it is narrow in the middle and wider at the extremities.

Interneural articulations

These are *diarthroses* formed between the articular processes. The articular surfaces are extensive flat and oval in the cervical region; small and flat in the thoracic

region, while in the lumbar region the anterior ones are concave and the posterior convex. They are *arthrodia* in the neck and back and *trochoid* in the lumbar region.

Ligament

Capsular ligament surrounds the joint.

Ligamenta flava connects neural arches of the adjacent vertebrae.

Interspinous between the spines of the contiguous vertebrae.

Intertransverse-between the adjacent of the transverse processes in the lumbar region.

The *supraspinous ligament* is an elastic ligament extending from the sacrum to the occipital bone consists of a *dorso- lumbar* and a *cervical part*.

The dorso-lumbar part starts from the sacral spines where it is blended with the dorsal sacroiliac ligament and is attached all along its course to the summits and the first dorsal is continued by the cervical part.

The *cervical part* or *ligamentum nuchae* consists of right and left parts, which are continuous with the dorso-lumbar parts. Each division of the cervical part is made up of *dorsal funicular portion* and a *ventral lamellar portion*.

The *funicular parts* of the two sides run forwards and are inserted to the external occipital protuberance.

The *lamellar parts* is thick is made up of anterior and posterior divisions. The *anterior division* is paired (right &left), its fibres proceed from the funicular part and becomes inserted to the neural spine of second, third and fourth cervical vertebrae.

The *posterior division* is single and its fibres arise from the first dorsal and are inserted to the neural spines of the fifth, sixth and seventh cervical vertebrae. The ligamentum nuchae assists the extensors of the head and neck.

Motion

Dorsal, ventral and lateral flexion and rotation.

The range of movement in a single joint is small, but the sum of the movements is considerable.

The movements are free in the cervical and coccygeal regions whereas movement is restricted in the thoracic and lumbar regions.

Horse

The dorso-lumbar part of supraspinous ligament is made up of white fibrous tissue. The ligamentum nuchae is less developed. The lamellar parts are undivided and are inserted to the neural spines of the second to the sixth cervical.

Intertransverse articulations are present in the lumbar region. These are peculiar to equidae. These are *arthrodia* between the transverse processes of the sixth and wing of sacrum and also between the transverse processes of the sixth and the fifth. It may also be present between those of the fourth and fifth. There is a tight joint capsule reinforced ventrally by fibrous tissue.

Dog

The ligamentum nuchae is narrow fibrous band and interspinous muscles replace interspinous ligaments.

Special Vertebral Articulations

There are few joints in the vertebral column, which are not articulated by common ligaments, are called as *special vertebral articulations*.

The *special vertebral articulations* are

Occipito -atlantal articulation

Atlanto -axial articulation

Sacral and coccygeal articulations

Thoracic Articulations

The thoracic articulations may be divided as

Extrinsic articulations

Costo-vertebral articulations between the ribs and vertebrae.

Intrinsic articulations

Costo-chondral articulations between the ribs and costal cartilages.

Chondro-sternal articulations between the costal cartilages and sternum.

Sternal articulations between the segment of sternum articulations.

Joints of the Forelimb

The joints of the forelimb are as follows

Shoulder joint between the scapula and humerus.

Elbow joint between humerus and radius and ulna.

Carpal joint formed by the union of carpals bones with radius and ulna.

Intermetacarpal articulation between the metacarpal bones.

Fetlock joint between the metacarpal, first phalanx with proximal sesamoids.

The interphalangeal articulations are

Pastern joint formed between the first and second phalanges

Coffin joint formed between the second and third phalanges and the distal sesamoid.

Shoulder Joint

Ox

(Click for image of Shoulder joint anterior view, posterior view and medial view)

It is an *enarthrosis* formed between the glenoid cavity of the scapula and the head of the humerus.

Ligaments

Capsular ligament is the only ligament, which is loose and is protected by the several muscles of the shoulder around the joint.

The position of the joints not fixed because both the bones can move.

Motion

Polyaxial. Extension and flexion are best marked. Adduction and abduction and circumduction are also present.

Horse

No difference.

Dog

The rim of the glenoid cavity is raised by a marginal cartilage.

Elbow/Cubital joint

This is a composite joint consisting of

Humero-radio-unlar articulation

Radio-ulnar articulation.

Humero-radio-unlar articulation

Ox

It is a *ginglymus* formed between the distal extremity of humerus and the proximal ends of radius and ulna. The articular surfaces are the condyles of the humerus and concavities on the proximal extremity of radius and the semilunar notch of the ulna.

Ligaments

Capsular ligament forms a pouch over the olecranon fossa

Medial and *Lateral collateral ligaments* attached above on the respective faces of the distal extremity of the humerus and the medial and lateral tuberosities of the upper extremity to the radius.

The medial ligament consists of a *superficial part* attached to the medial border of the radius below the radial tuberosity and a *deep part* attached to the medial tuberosity.

Motion

Extension and flexion.

Horse

No difference.

Dog

The capsule is strengthened by two bands.

One is in front, which is oblique and arising in front of the lateral condyle of humerus above the joint surface joins the terminal part of biceps and brachialis below:

The other is on the postero medial aspect from the medial side of olecranon fossa (or the lateral aspect of medial epicondyle) to the ulna just above the anconeus process and the lateral ligaments are attached below to the radius and ulna.

Radio-ulnar articulation

Ox

It is a *diarthrosis* and an *amphiarthrosis* formed between the radius and ulna.

The *diarthrosis* is formed between the facets on the ulna and corresponding facets of the radius.

Ligaments

Capsular ligament-continuous with that of the humero-radio articulation.

The *amphiarthrosis* is formed between the shafts of the radius and ulna. One above the proximal radio ulnar arch, second between the two radio ulnar arches and the third below the distal radio ulnar arch.

Ligaments

Three interosseous ligaments, which ossify in the adult.

In addition, there are *two arciform ligaments*, lateral and medial which are attached to lateral aspect of the olecranon process of the ulna.

Motion

Is inappreciable, the forearm being fixed in the position of pronation.

Horse

There is only one inter-osseous ligament.

Two bones above the proximal ulnar arch are not ossified till late in life.

Dog

The joints between the radius and ulna at either end are *trochoid*. The proximal joint has in addition to the capsular ligament, an *annular ligament* that arises from the lateral condyle of the humerus and joins the terminal part of the brachialis and the biceps brachii.

The distal joint has a tight capsular ligament.

The shafts are united by interosseous ligaments.

Motion

Limited supination is possible with the lateral rotation of the radius carrying the paw with it.

Knee joint

Ox

It is composite joint consisting of

Radio-ulnar-carpal articulations

Carpal articulations

Proximal carpal articulations

Intercarpal articulations

Distal carpal articulations

Carpo-metacarpal articulations.

The joint as a whole is having *common ligaments* and *special ligaments*.

Common ligaments

Capsular ligament is a loose sac. Its anterior part is called *dorsal carpal ligament*, which covers the joint in front and is adherent to the extensor tendons passing over it. The posterior part is called as *volar carpal ligament* covers the joint behind and its posterior face forms the anterior wall of the carpal sheath.

Lateral and *Medial carpal ligaments* which arise from the distal extremity of the radius and ulna, pass down adherent to the carpal bones and are attached to the upper extremity of the large metacarpal below on the lateral and medial aspects of the joint.

The *carpal sheath* or *canal* is formed by the volar capsular ligament in front and by the volar annular ligament behind, which extends from the posterior border of accessory carpal to the medial aspect, blending with the medial ligament of the carpus. The canal is lined by synovial membrane and serves for the passage of tendons of *flexor perforans*, deep division of *flexor perforatus*, median nerve, ulnar artery and vein.

Special ligaments

There are large number of special ligaments connecting the various bones of the carpal joint.

Radia-ulnar carpal articulation

It is *diarthrosis* between the lower extremity of the radius, styloid process of ulna and upper row carpal bones. The radius articulates with all the three bones and the ulna articulate with ulnar carpal only.

Ligaments

One oblique and *three posterior ligaments*.

Oblique ligament connects the radius and ulnar carpal obliquely on the dorsal aspect.

The three posterior ligaments connects the (1) radius and radial carpal (2) radius and intermediate carpal (3) ulnar and accessory carpal on the volar aspect.

Carpal articulations

Proximal carpal articulations

They are also *diarthroses* and between the bones of upper row.

Ligaments

There are *three anterior, two posterior* and *three interosseous ligaments*.

The *three anterior ligaments* are connecting viz., (1) radial carpal to intermediate carpal (2) intermediate to ulnar carpal (3) ulnar carpal to accessory carpal on the dorsal aspect.

The *posterioe ligaments connects* the (1) Intermediate to ulnar metacarpal (2) Ulnar carpal to accessory carpal on the volar aspect.

Interosseous ligaments that connect adjacent bones.

Inter-carpal articulations

They are *arthroid* and between the bones of proximal row and distal row.

Ligaments

There are *two oblique* and *three posterior ligaments*.

The *two oblique ligaments* are connecting on the dorsal aspect viz.,(1)obliquely radial carpal and fourth carpal (2) ulnar carpal and fourth carpal fibres also extend below to the large and small connect metacarpal bones.

*The three posterior ligaments are connecting o*n the volar aspect (1) radial carpal to fused second and third carpal. (2) ulnar carpal to fourth carpal (3) accessory carpal to fourth carpal.

Distal carpal articulations

They are *arthroid* between the fused second and third carpal and fourth carpal.

Ligaments

A ligament connectssecond and third carpal to fourth carpal on dorsal aspect

An interosseous ligament.

Carpo-metacarpal articulation

They are formed between the distal row of carpal bones and proximal extremity of the metacarpal bone.

Ligaments

There are *two anterior, two posterior* and *two interosseous ligaments*. However, these short ligaments are sometime weak or inconstant in number.

The *anterior ligaments* connects (1) second and third carpal to on large metacarpal (2) fourth carpal to large metacarpal on the dorsal aspect.

The posterior ligaments connects . (1) ulnar carpal to large metacarpal (postero lateral) (2) second and third carpal to large metacarpal (3) fourth carpal to large metacarpal on the volar aspect.

An *interosseous ligament* connects second and third carpal to large metacarpal. Two anterior and posterior ligaments hold the accessory carpal.

Synovial membranes

There are three large and one small synovial membrane.

Motion

Extension and flexion and to a small extent abduction and circumduction in the radio-ulnar carpal.

In the other joints motion is inappreciable.

Horse

There is minor difference due to the increased number of the carpal bones.

There are two other important ligaments peculiar to the horse called superior and inferior check ligaments.

The *superior check ligament (supracarpal)* arises from the dorsal part of the medial border of the radius and is inserted to the tendon of the superficial flexor of the digit above the carpus.

The *inferior check ligament (subcarpal)* is a continuation of the volar capsular ligament of the carpus. It joins the tendon of the deep flexor of the digit about midway down the metacarpus. The check ligaments assist the flexor tendons after severe exertion to keep them tight and prevent flexion.

Dog

There are differences due to variation in the number of bones of the carpus.

Inter Metacarpal Joint

Ox

It is a diarthrosis and an amphiarthrosis formed between the large and small metacarpal bones, the former between the facets of their proximal extremities and the latter between their shafts.

Common Ligaments

Dorsal capsular ligament of the carpus.

Lateral ligament of the carpus

Ligament connecting ulnar carpal and fourth carpal and large metacarpal and small metacarpal.

Special Ligaments

Intermetacarpal ligament

An interosseous ligament connecting the shafts of the bones.

Motion

Slight vertical gliding.

Horse

Each small metacarpal is united through its length to the postero lateral face of the large metacarpal by syndesmosis.

There is an interosseous ligament.

The proximal extremities of each small metacarpal from synovial joints with the large metacarpal.

Dog

Interosseous ligaments connect the various metacarpal bones.

The proximal ends of second to fifth bone from synovial joints.

The proximal ends of bones are connected on their dorsal aspect by the feeble bands.

Fetlock Joint or Metacarpo-Phalangeal Articulation

Ox

There are two such joints for each limb. Each is a *ginglymus* formed between the distal extremity of the large metacarpal, the proximal extremity of the first phalanx below and the proximal sesamoids behind.

Ligaments

The joint has a *capsular, collateral* and *sesamoidean ligaments*.

The *capsular ligaments* enclose the joints and adherent to the extensor tendons passing over the metacarpal.

The *collateral ligaments* are in the form of *axial* and *abaxial ligaments*.

The *abaxial ligaments* extend from the lateral aspects of the distal extremity of the large metacarpal to the abaxial sesamoids and the proximal extremity of the first phalanx below.

The *axial ligaments* arise common from the cleft of the large metacarpal bone and each spreads out on the cleft of the large metacarpal bone. It then spreads out and attached to the proximal part of the interdigital space of

the first phalanx, where its fibres blend with the superior interdigital ligament.

The sesamoidean ligaments are *superior, inferior, collateral* and *inter sesamoidean*.

The *superior sesamoidean* or *suspensory ligament* (musculus interossei) arises from the volar face of the distal row of carpal bones and the proximal extremity of the large metacarpal descends on the volar face of the latter and divides about its middle into two branches-*anterior* and *posterior*.

The *posterior branch* soon bifurcates at the distal end of the large metacarpus and each unites with one the divisions of the tendon of the *superficial flexor of the digit* behind the fetlock to form a ring for the passage of the tendon of the *deep flexor of the digit*.

The *anterior branch* divides into six branches, which are in three pairs-*abaxial, middle* and *axial*.

The *abaxial* and *middle* slips are attached to the abaxial and axial sesamoids of each digit. The slips passing to the abaxial sesamoids detaches a slip which passes downwards the and forwards on the abaxial face of each digit to join the extensor tendon of the respective digit on the dorsal aspect.

The *two axial slips* pass into the cleft of the large metacarpal bone enter the inter-digital space and here join the same extensor tendons.

The suspensory ligament prevents extensive dorsal flexion of the fetlock joint and its slips prevent excessive volar flexion. In the young, the superior sesamoidean ligament is muscular while in the adult it becomes fibrous.

The *inter-sesamoidean ligaments* are three for each limb has three such ligament placed between four sesamoids.

The *collateral sesamoidean ligaments* extend between the corresponding faces of abaxial sesamoids to the proximal extremity of the first phalanx and the lateral aspects of the large metacarpal.

The *inferior sesamoidean* are *two straight* and *two oblique*.

The *straight ones* are vertical, connecting the bases of the sesamoids to the upper end of the first phalanx.

The *oblique ligaments* are placed deeper, also extended from the base of the sesamoids, they cross and get attached to joint the first phalanx.

Motion

Extension and flexion.

Horse

There is only one metacarpo phalangeal joint for each limb and hence there are only *two collateral* and *one inter-sesamoidean ligament* for the whole joint.

The *inferior sesamoidean ligament* is made up of three parts-*superficial, middle and deep*.

The superficial or straight (Y-shaped) connects bases of two sesamoids to the first phalanx.

The *middle* one connects the sesamoids to the 'V' shaped area on the volar face of the second phalanx.

The *deep or cruciate* (X-shaped) ligament connects the base of each sesamoid to the phalanx. The *suspensory ligament* passes in the channel between the large and small metacarpal bones and divides above the fetlock into two branches. Each of these is attached to the superior and lateral faces of each sesamoid and then passes obliquely forward and downward to the dorsal face of the first phalanx and joins the tendon of the extensor pedis to form broad ligament.

Dog

There are five metacarpo-phalangeal joints in the dog.

Each joint has its own capsule and indistinct collateral ligaments.

A small dorsal sesamoid bone occurs in the anterior of each capsule over which the corresponding extensor tendon plays.

The *cruciate inferior sesamoidean* ligaments are present on the volar aspect.

The suspensory ligament is placed by interosseous muscles.

Pastern Joint

Ox

The proximal interphalangeal articulations are two for each limb. Each is *ginglymus* formed between the first and second phalanges. It has a glenoid fibro cartilage behind, kept in position by ligament and confounded with the tendon of the superficial flexor.

Ligaments

The capsular ligament

Abaxial collateral ligament extends from axial face of distal extremity of first phalanx to abaxial face of proximal extremity of second phalanx

Axial collateral ligaments extend from the axial face of distal extremity of first phalanx to the interdigital or axial face of the proximal extremity of the second phalanx. Fibres also extend downwards to be attached to the interdigital face of third phalanx.

Volar abaxial and *volar axial ligaments* which extends from the first phalanx to the proximal extremity of the second phalanx on the corresponding aspects.

Proximal or *superior inter digital ligament* is a strong ligament of intercrossing fibres connects the axial faces of the shafts of the first phalanges in each limb.

A strong band of fibres unite the rudimentary digits of the second phalanx.

The *distal* or *inferior inter-digital ligament* (cruciate) consists of two strong bands attached above to the lateral tubercles at the proximal extremity of the second phalanx of each digit cross each other in the inter-digital spaces, behind and are inserted to the navicular bone of the other digit and axial face of the second phalanx and the navicular bone of the same digit to some extent.

The two *inter-digital ligaments* prevent excessive abduction of the digits.

Motion - Extension and flexion.

Horse

There is only one such joint in each limb.

Inter-digital ligaments crossing the volar face of the first phalanges restrict apart of the digits.

The 2nd & 3rd; 3rd & 4th; 4th & 5th are connected.

Dog

It has the glenoid cartilage which is united on its posterior surface to the tendon of the superficial digital flexor and is kept attached to the first phalanx.

It has one capsular ligament and two lateral ligaments.

Coffin Joint

Ox

The distal interphalangeal articulations are two for each limb. Each is a *ginglymus* formed between the second and third phalanges and the distal sesamoid.

Ligaments

Capsular ligament

Anterior elastic ligament which is attached above to the distal ends of the first phalanx crosses the dorsal face of the second phalanx and is inserted to the extensor process of the third phalanx.

The abaxial and axial collateral ligaments.

The *abaxial collateral ligament* is closely adherent to the proper digital extensor tendon.

The *axial collateral ligament* extends from the distal extremity of first phalanx receives fibres from the second phalanx and is attached to the interdigital surface of the third phalanx.

Volar collateral or *Collateral sesamoidean ligaments*. The *volar abaxial ligament* arises from the distal extremity of the first phalanx receives fibres from the second phalanx and are attached to the *volar axial ligament* extends from the lower end of the phalanx to the interdigital face of the third phalanx.

The *superior navicular ligament* is formed by fibres from the two volar collateral and is attached to the upper border of the navicular bone.

The *inferior navicular ligament* or *phalango-sesamoidean ligament* extends from the distal border of the navicular to the flexor surface of the os pedis.

Horse

There is only one joint for each limb.

The dorsal elastic ligament is absent.

In addition, it has three ligaments attaching the lateral cartilages to the phalanges.

Lateral cartilages of the third phalanx are rhomboid plates of hyaline cartilage.

The anterior end of each is attached to the distal extremity of the second phalanx by a short strong band.

The lower border is thick and is attached by another band to the angle of third phalanx.

The posterior end curves axially towards its fellow.

Dog

Each joint has a capsular and two lateral ligaments.

An elastic ligament attached above to the distal end of the second phalanx and below to the collar at the base of third phalanx aids in retracting the claw.

Joints of the Hindlimb

The joints of the hindlimb are as follows

Sacro-iliac joint between the articular surfaces of the ilium and sacrum.

Pelvic symphysis formed between the pubis and ischium of the two sides.

Hip joint between the acetabulum of os coxae and the head of the femur.

Stifle joint between the femur,tibia and patella.

Tibio-fibular joint between the tibia and fibula

Hock joint formed by the union of tarsal bones with tibia.

Fetlock joint between the metatarsal, first phalanx with proximal sesamoid.

The *interphalangeal articulations* are

Pastern joint formed between the first and second phalanges.

Coffin joint formed between the second and third phalanges and the distal sesamoid.

Sacro-illiac Joint

Ox

It is *diarthrosis* between the articular surfaces of the ilium and sacrum.

Ligaments

Capsular ligaments

Dorsal sacro-iliac ligaments –connects the dorsum of the sacral spines to the tuber sacrale. In t he spinal attachment it blends with supraspinous ligament.

Lateral sacro-iliac ligament is a thick, irregularly quadrilateral sheet, placed above the sacro-sciatic ligament and below the dorsal sacro-iliac ligament. It is attached anteriorly to the tuber sacrale and the medial border of the ilium above the greater sciatic foramen and ventrally to the lateral border of the sacrum. Its lateral surface is in contact with the *middle gluteus* and *biceps femoris* and *superficial gluteus* muscle. Its deep face is related to *dorsal* and *lateral coccygeal* muscles.

Ilio -lumbar ligament attaches the ilium to the transverse process of the lumbar vertebrae.

Sacro-sciatic ligament is a vast membranous expansion situated in the pelvis between the sacrum and the os coxae.

It is irregularly quadrilateral in shape and forms the lateral wall of the pelvis.

Its dorsal border is attached to the lateral surface of the sacrum and the first two or three coccygeal bones attaches it.

Its inferior is attached to ischiatic spine and tuber ischii.

It forms between these two attachments and the bones two foramina the greater and lesser sacro-sciatic foramina for the passage of structures out of the pelvic cavity.

Its posterior border forms the lateral boundary of the pelvic outlet.

The lateral face of this ligament is covered by the *gluteus medius* and *biceps femoris*, which derive part of their origin from it.

The posterior part of the medial face gives origin to the *retractor ani*.

Motion

Is appreciable in this joint.

Horse

The sacro-sciatic ligament is broader.

The greater sciatic foramen transmits the posterior gluteal vessels and nerves and the lesser sciatic foramen transmits the tendon of the obturator internus and is pyriform.

Dog

The sacro-sciatic ligament is a narrow thin band, which extends from the part of the lateral margin of the sacrum to the tuber ischii.

Pelvic Symphysis

Ox

It is *amphiarthrosis* formed between the pubis and ischia of the two sides.

The intervening cartilage gets ossified with increasing age.

The obturator foramen is covered in life by the obturator membrane called *obturator ligament*, leaving a space in front for the passage of the tendon of the obturator internus muscle and the obturator nerve.

Horse & Dog

No difference.

Hip Joint

Ox

The coxo-femoral articulation is an *enarthrosis* formed between the acetabulum of os coxae and the head of the femur.

Ligaments

Capsular ligament.

Cotyloid ligament is a marginal cartilage, which deepens the acetabulum.

That part of cotyloid ligament stretches across the cotyloid notch converting it into a foramen for the passage of structures and out of the joint is the transverse *acetabular ligament*.

Round ligament is attached to the lateral lip of acetabular notch and to the fovea capitis, on the head of femur.

Motion

Gliding, circumduction, adduction and abduction are possible, extension and flexion are most marked.

Horse

The cotyloid ligament is narrower.

There is an additional ligament, the *accessory* or *pubic femoral ligament* which arises from the prepubic tendon, passes outwards and upwards and then backwards lodged in the pubic groove, the acetabular notch and is inserted to the fovea capitis behind the round ligament. This ligament is peculiar to solipeds and it prevents abduction and limits side-kicking. The absence of the ligament in

ruminants permits free abduction and this is the reason why ruminants can kick side ways, this movement being known as *'cow kick'*.

Dog

Resembles that of the Ox.

Stiffle Joint

The stifle joint is composite joint composed of

Femoro-patellar articulation

Femoro-tibial articulation

Femoro-Patellar joint

Ox

The femoro-patellar joint is *gliding joint* where the patella glides over the trochlea of the femur.

Ligaments

The *capsular ligament* is loose. It forms a pouch under the insertion of the quadriceps muscle.

The *medial* and *lateral ligaments* which arise from corresponding faces of the condyles of the femur to the lateral and medial angles of the patella.

The *straight ligaments of the patella* are *lateral, middle* and *medial*, which extend from the patella and its fibrocartilage to the anterior tuberosity of the tibia.

Bursae of the patellar ligaments are two. One is interposed between the middle ligament and the upper part of the trochlea; a smaller one occurs between the upper part of the same ligament and the apex of the patella.The second is interposed between the lateral patellar ligament and the lateral condyle of the femur.

Motion

The patella moves up and down the trochlea of femur.

Horse

No difference.

Dog

There is only one straight ligament.

Femoro-Tibial joint

Ox

The femoro-tibial joint is a *ginglymus* formed between the condyles of the femur and those of the tibia.

Ligaments

The joint has a *capsular ligament*, t*wo inter-articular cartilages* called *menisci*, *two collateral ligaments*, *two crucial ligaments* and a *posterior ligament*.

The *capsular ligament* is attached to the margins of articular surfaces of femur and tibia and also to the convex borders of the menisci and to the cruciate ligaments. There are two synovial sacs, partially divided by the menisci into upper and lower compartments. The two synovial sacs communicate with each other and the medial sac also communicates with femoro patellar joint.

The *menisci (inter-articular cartilages)* are *medial* and *lateral*.

They are 'C' shaped plates of fibro-cartilage interposed between the condyles of the femur and tibia.

The lateral borders are thick and convex while their medial borders are thin and concave.

The proximal faces are hollowed out for the condyles of the femur and the distal faces are flattened for the condyles of the tibia. These cartilages bring about congruence of the articular surfaces and are kept in position by ligaments called *coronary ligaments*.

The *lateral meniscus* has three coronary ligaments one anterior and two posterior, of which one is superior attached to a depression on the medial aspect of inter-condyloid fossa of femur and other inferior attached to the tibia, lateral to the popliteal notch.

The *medial meniscus* has two coronary ligaments one anterior and one posterior. These are attached to the depression in front and behind the tibial spine.

The *collateral ligaments* arise from the corresponding condyles of the femur. The lateral ligament is attached to the fibula and the medial is to the medial condyle of the tibia.

The *posterior ligaments* are membranous, enclose the joint behind.

The *cruciate ligaments* are anterior and posterior. The *anterior* arises from the tibial spine, extends upwards and backwards and ends on the lateral part to the inter-condyloid fossa of femur. The *posterior* is attached below the tubercle medial to the popliteal notch, directed upwards and forwards and is attached to the anterior part of the inter-condyloid fossa of femur.

Motion

Extension and flexion.

Horse & Dog

No difference.

Tibio-Fibular Joint

Ox

The bony fibula is replaced by a ligament for most of its extent and thus the proper tibio-fibular articulation is absent.

The upper end of the fibula fuses with the lateral tuberosity of the tibia.

The lower end ossifies as a separate piece of bone and forms a diarthrosis with the lower end of the tibia.

Motion

Inappreciable as two bones are closely united by strong short fibres.

Horse

It forms a *diarthrosis* and an *amphiarthrosis*.

The former is between the head of the fibula and the lateral condyle of the tibia.

It has a tight capsular ligament.

The amphiarthrosis is between the shafts of the bones and has an interosseous ligament.

Dog

Diarthrodial joints are formed between the bones at either ends, the shafts are united by interosseous ligaments.

Hock Joint

Ox

This is a composite joint consisting of

Tibio tarsal articulation

Proximal tarsal articulations

Inter tarsal articulations

Distal tarsal articulations

Tarso-metatarsal articulations.

The tibio tarsal articulation is a *ginglymus*. The rest are *arthrodia*. The joint has *common ligaments* and *special ligaments*.

Common ligaments

Capsular ligament may be divided into two parts-*anterior* and *posterior*.

The *anterior capsular ligament* is membranous and encloses and tibio-tarsal joint in front.

The *posterior capsular ligament* is also membranous and is attached to the tibial tarsal above, metatarsal below and blends with the lateral ligaments.

The *lateral* and *medial collateral* ligaments extending from the distal end of the tibia above, attached to the tarsal bones and the large metatarsal bone below.

Posterior ligament (calcaneo-metatarsal ligament) is on the postero-lateral aspect from the posterior border of tuber calcis passes down and is attached to the central and fourth tarsal and to the large metatarsal below.

Dorsal oblique ligament is a narrow band placed at the antero-internal aspect of the joint. It extends from the medial side of the tibial tarsal, passed obliquely downwards and attaches on the fused central, fourth tarsal and the large metatarsal bones.

Tarso- metatarsal ligament is on the plantar aspect of the joint. It is blended in front with plantar oblique capsular ligament and is adherent to all the tarsal bones. It also blends medially with the medial (collateral) ligament and laterally with planter tarsal ligament. Its plantar face is lines by synovial membrane and forms anterior wall of the tarsal sheath.

Besides these ligaments, there are certain *annular ligament* which serve to bind the tendons of the muscles.

On the dorsal aspect, there are two-*proximal* and *distal*.

The *proximal annular ligament* is large and thick running across from medial to lateral malleolus. It binds fascia down the tendons of complex muscle.

The *distal annular ligament* is thin, arises from fibular tarsal runs obliquely downwards inward is attached to the large metatarsal.

The *plantar* or *posterior annular ligament* extends from the fibular tarsal and plantar ligament to the medial collateral ligament. This from the posterior wall of the tarsal sheath.

The *tarsal sheath* is formed in front by the tarso-metatarsal ligament (blended with plantar capsular ligament) and behind by the plantar annular ligament. The posterior and anterior faces respectively of these ligaments are lined by synovial membrane and this sheath for the tendon of the *deep flexor,* plantar arteries and nerves.

Special Ligaments

Tibio-tarsal articulations

It is a ginglymus, between lower extremity of tibia and tibial and fibular tarsal bones. The common ligament of the hock joint serves to bind the tibia and tibial tarsal.

Proximal tarsal articulation

Between tibial tarsal and fibular tarsal bones.

Ligaments

one extends from the supero-posterior margin of the trochlea of tibial tarsal to fibular tarsal

From sustentaculum tali to adjacent part of tibial tarsal on the medial aspect

A lateral band from trochlear process of fibular tarsal to lateral ridge of the trochlea of tibial tarsus.

An interosseous ligament.

Proximal inter-tarsal articulation

Between tibial and fibular tarsals above and central & fourth tarsal below.

Ligaments

Interosseous between tibial and centrals

Interosseous between fibular and central tarsals.

Distal inter-tarsal articulation

Between central & fourth tarsal above fused second and third tarsal and first tarsal below.

Ligaments

From central tarsal to fused second and third tarsal on the dorsal aspect.

Interosseous ligaments connecting fused central and fourth tarsal to fused second and third tarsal and to large metatarsal.

Distal tarsal articulation

Between fused second and third tarsal and first tarsal

Interosseous ligament between fused second and third tarsal and first tarsal.

Tarsal metatarsal articulation

Between central and fourth tarsal, second and third tarsal bones above and large metatarsal bone below.

On the dorsal aspect extending obliquely from medial aspect of tibial tarsal, down to large metatarsal. Synovial membranes are four in member.

Motion

Extension and flexion in the tibio-tarsal and gliding in other joints.

Horse

Minor differences due to the variation in number of bones.

Check ligaments are ill developed.

The supra tarsal ligament is vestigial and is represented by deep tarsal fascia, attached to both sides of tendo-achilles.

The sub tarsal ligament is the prolongation of the tarso-metatarsal ligament, which joins the deep flexor tendon.

Dog

Differences are present due to variation in the number of bones.

Fetlock Joint

Ox

There are two such joints for each limb. Each is a *ginglymus* formed between the distal extremity of the large metacarpal, the proximal extremity of the first phalanx below and the proximal sesamoids behind.

Ligaments

The joint has a *capsular, collateral* and *sesamoidean ligaments*.

The *capsular ligaments* enclose the joints and adherent to the extensor tendons passing over the metatarsal.

The *collateral ligaments* are in the form of *axial* and *abaxial ligaments*.

The *abaxial ligaments* extend from the lateral aspects of the distal extremity of the large metatarsal to the abaxial sesamoids and the proximal extremity of the first phalanx below.

The *axial ligaments* arise common from the cleft of the large metatarsal bone and each spreads out on the cleft of the large metatarsal bone. It then spreads out and attached to the proximal part of the interdigital space of the first phalanx, where its fibres blend with the superior interdigital ligament.

The sesamoidean ligaments are *superior, inferior, collateral* and *inter* sesamoidean.

The *superior sesamoidean* or *suspensory ligament* (musculus interossei) arises from the volar face of the distal row of tarsal bones and the proximal extremity of the large metatarsal descends on the volar face of the latter and divides about its middle into two branches-*anterior* and *posterior*.

The *posterior branch* soon bifurcates at the distal end of the large metatarsus and each unites with one the divisions of the tendon of the *superficial flexor of the digit* behind the fetlock to form a ring for the passage of the tendon of the *deep flexor of the digit*.

The *anterior branch* divides into six branches, which are in three pairs-*abaxial, middle* and *axial*.

The abaxial and *middle* slips are attached to the abaxial and axial sesamoids of each digit. The slips passing to the abaxial sesamoids detaches a slip which passes downwards

the and forwards on the abaxial face of each digit to join the extensor tendon of the respective digit on the dorsal aspect.

The *two axial slips* pass into the cleft of the large metatarsal bone enter the inter-digital space and here join the same extensor tendons.

The suspensory ligament prevents extensive dorsal flexion of the fetlock joint and its slips prevent excessive volar flexion. In the young, the superior sesamoidean ligament is muscular while in the adult it becomes fibrous.

The *inter-sesamoidean ligaments* are three for each limb has three such ligament placed between four sesamoids.

The *collateral sesamoidean ligaments* extend between the corresponding faces of abaxial sesamoids to the proximal extremity of the first phalanx and the lateral aspects of the large metatarsal.

The *inferior sesamoidean* are *two straight* and *two oblique*.

The *straight ones* are vertical, connecting the bases of the sesamoids to the upper end of the first phalanx.

The *oblique ligaments* are placed deeper, also extended from the base of the sesamoids, they cross and get attached to joint the first phalanx.

Motion

Extension and flexion.

Horse

There is only one metatarso phalangeal joint for each limb and hence there are only *two collateral* and *one inter-sesamoidean ligament* for the whole joint.

The *inferior sesamoidean ligament* is made up of three parts-*superficial, middle and deep*.

The superficial or straight (Y-shaped) connects bases of two sesamoids to the first phalanx.

The *middle* one connects the sesamoids to the 'V' shaped area on the volar face of the second phalanx.

The *deep or cruciate* (X-shaped) ligament connects the base of each sesamoid to the phalanx. The *suspensory ligament* passes in the channel between the large and small metatarsal bones and divides above the fetlock into two branches. Each of these is attached to the superior and lateral faces of each sesamoid and then passes obliquely forward and downward to the

dorsal face of the first phalanx and joins the tendon of the extensor pedis to form broad ligament.

Dog

There are five metatarso-phalangeal joints in the dog.

Each joint has its own capsule and indistinct collateral ligaments.

A small dorsal sesamoid bone occurs in the anterior of each capsule over which the corresponding extensor tendon plays.

The *cruciate inferior sesamoidean* ligaments are present on the volar aspect.

The suspensory ligament is placed by interosseous muscles.

Pastern Joint

Ox

The proximal interphalangeal articulations are two for each limb. Each is *ginglymus* formed between the first and second phalanges.It has a glenoid fibro cartilage behind, kept in position by ligament and confounded with the tendon of the superficial flexor.

Ligaments

The capsular ligament

Abaxial collateral ligament extends from axial face of distal extremity of first phalanx to abaxial face of proximal extremity of second phalanx

Axial collateral ligaments extend from the axial face of distal extremity of first phalanx to the interdigital or axial face of the proximal extremity of the second phalanx. Fibres also extend downwards to be attached to the interdigital face of third phalanx.

Volar abaxial and *volar axial ligaments* which extends from the first phalanx to the proximal extremity of the second phalanx on the corresponding aspects.

Proximal or *superior inter digital ligament* is a strong ligament of intercrossing fibres connects the axial faces of the shafts of the first phalanges in each limb.

A strong band of fibres unite the rudimentary digits of the second phalanx.

The *distal* or *inferior inter-digital ligament* (cruciate) consists of two strong bands attached above to the lateral tubercles at the proximal extremity of the second phalanx of each digit cross each other in the inter-digital spaces, behind and are inserted to the navicular bone of the other digit and axial face of the second phalanx and the navicular bone of the same digit to some extent.

The two *inter-digital ligaments* prevent excessive abduction of the digits.

Motion

Extension and flexion.

Horse

There is only one such joint in each limb.

Inter-digital ligaments crossing the volar face of the first phalanges restrict apart of the digits.

The 2nd & 3rd; 3rd & 4th; 4th & 5th are connected.

Dog

It has the glenoid cartilage which is united on its posterior surface to the tendon of the superficial digital flexor and is kept attached to the first phalanx.

It has one capsular ligament and two lateral ligaments.

Coffin Joint

Ox

The distal interphalangeal articulations are two for each limb. Each is a ginglymus formed between the second and third phalanges and the distal sesamoid.

Ligaments

Capsular ligament

Anterior elastic ligament which is attached above to the distal ends of the first phalanx crosses the dorsal face of the second phalanx and is inserted to the extensor process of the third phalanx.

The abaxial and axial collateral ligaments.

The *abaxial collateral ligament* is closely adherent to the proper digital extensor tendon.

The axial collateral ligament extends from the distal extremity of first phalanx receives fibres from the second phalanx and is attached to the interdigital surface of the third phalanx.

Volar collateral or *Collateral sesamoidean ligaments*. The *volar abaxial ligament* arises from the distal extremity of the first phalanx receives fibres from the second phalanx and are attached to the *volar axial ligament* extends from the lower end of the phalanx to the interdigital face of the third phalanx.

The *superior navicular ligament* is formed by fibres from the two volar collateral and is attached to the upper border of the navicular bone.

The *inferior navicular ligament* or *phalango-sesamoidean ligament* extends from the distal border of the navicular to the flexor surface of the os pedis.

Horse

There is only one joint for each limb.

The dorsal elastic ligament is absent.

In addition, it has three ligaments attaching the lateral cartilages to the phalanges.

Lateral cartilages of the third phalanx are rhomboid plates of hyaline cartilage.

The anterior end of each is attached to the distal extremity of the second phalanx by a short strong band.

The lower border is thick and is attached by another band to the angle of third phalanx.

The posterior end curves axially towards its fellow.

Dog

Each joint has a capsular and two lateral ligaments.

An elastic ligament attached above to the distal end of the second phalanx and below to the collar at the base of third phalanx aids in retracting the claw.

Biomechanics

Introduction

It deals with force and accelerations acting on living animals.

The Mammalian body is governed by laws of statics and dynamics (biodynamics).

Biostatics deals with forces and their equilibrium acting upon animals and their organs in state of rest or in motion.

Biodynamics of locomotor system as well as many disorders of lacomotor system have a mechanical basis.

So it is essential to have basic knowledge of mechanical processes in animal

Locomotion is movement of an organism from one place to another.

Muscles bones and joints are three Chief components of locomotion which work on principles of levers.

Muscles are Motor of biological engines and tendons are cord like structures of muscles which transmit, channelize and distribute the energy of muscles.

The centre of gravity of the animals body lies behind xiphoid about the level of 9th intercostals space.

The position of the centre of gravity is not constant for it shift backward when the head is lifted, when the abdominal organs are distended or when the tails is extended.

In contrast it shift forwards when the head and neck are lowered or if the abdominal organs are empty.

It lies nearer the front foot than the back once because of the weight of the head and neck.

Hence it is easier to knock a standing animal of balance by pushing forwards or sideways than pushing backwards.

The fore limb carry more weight than the hind limbs since the centre of gravity lies nearer to fore limb.

Biomechanics of the Trunk

The body of animal excluding head and limbs is trunk.

The Trunk is constructed like a bow and string or arched bridge/suspension bridge and the front and back limbs act as only pillars of the bridge.

The bridge is made up of bones, joints ligaments, muscles and their tendons.

The bridge of trunk is not a rigid construction.

It is rigid in thoracic region where it I formed by the sernum, their ribs, intercostals muscles while in the abdominal regions it is formed by linea alba and the four abdominal muscles with their aponeurosis.

Here it is tensile and contractile.

Ribs being vertically placed reinforce the cranial part f the bridge construction.

Bow

The Bow is arched and formed by thoracic and lumber vertebrae, intervertebral discs, pelvis, associated muscles and ligaments.

It has top boom (strong cable) formed by neural arches and spinous processes of vertebrae, ligaments (supraspinous and interspinous) and muscles of then back and bottom boom formed by vertebral bodies and interveretebral discs.

Bow is elastic due to intervertebral discs, interspinous and supraspinous ligaments.

Bow is rather flat in ungulates while it is dorsally convex in guinea pigs and rabbits.

The camivores take up intermediate position.

String

The two ends of bow are linked by the sternum, linea alba and abdominal muscles particularly rectus abdominis.

This string stretches the bow.

It has dorsal string made up of epaxial muscles (eg. Longissimus dorsi) which straightens the bow and ventral string made up of a) Hypaxial muscles i.e ventral to vertebrae (eg., Longus colli in cranial Thoracic and Cervical regions, psoas major and minor in caudal thoracic, lumbar and sacral regions) form interrupted ventral string – this flexes bow and stabilizes bow with epaxial muscles. B)

Abdominal muscles form – uninterrupted ventral string (Oblique, transverse and rectus muscles particularly recti muscles).

This uninterrupted ventral string is indirectly attached to bow by interposition of thoracic skeleton cranially and pelvic bones caudally.

The ventral uninterrupted string flex the bow in throacolumbar region eg. Back of sitting cat, leaping and galloping.

The string bears weight of the organs supported by he ribs, transverse and oblique abdominal muscles and their aponeurosis.

The part of the weight of the viscera rests directly on ventral abdominal wall (Ventral String) and tends to arch the bow but elasticity of the bow and active contractions of the extensor muscles of the extensor muscles of the back oppose arching of bow by string.

The other part of organ weight is transferred to axis of body (bow) through ribs and abdominal muscles which stretches the bow that is resisted by string.

The string is fixed not only to the two ends of the bridge but is attached all along the bow.

The bow and string can alter the form by muscular action and participate in the movements of the body as a whole.

The possibility of overextension in the lumbar region where rib protection is not there is prevented by ventral longitudinal ligament and articular processes which are well developed.

When bow is arched dorsally by contraction of the abdominal muscles and sublumbar muscles – tendons and muscles of the tope boom are stretched and the spinous processes separate while pressure on bottom boom is increased and the vertebral bodies are squeezed together excessively.

Excessive arching in this direction is countered by the discs, supraspinous ligament and longissimus muscles.

The function of the bridge.

The function of the cantilever in animal body is to counter and thus balance the centrifugal thrust which develops in the bottom boom when the animal is moving.

They also help maintaining equilibrium.

The front cantilever is represented by the head and neck and caudal cantilever is represented by sacrum and tail.

By raising and lowering the front cantilever the centre of gravity of the body can be altered thereby shifting the overall balance.

In animals with long neck and heavy heads like horses and cattle the weight is carried mainly passively by the elastic ligamentum nuchae.

A type of cantilever is placed both infront and behind the bow of the bridge.

Biomechanics of the Limb

The hind end of the bridge of trunk is suspended by the hip joint on the supporting columns of the hind limbs.

The front end of the bridge is suspended like a sling between two forelimbs by synsarcosis of the shoulder girdle particularly by serratus ventralis.

The limbs are not solid columns but are angled levers.

The joints are anchored by ligaments muscles and their tendons.

The forelimbs carry more weight than do the hind limbs and take up the weight propelled on to them form behind.

That is why there is greater muscular mass in the hind limbs.

The forelimb from hip joint down may be related to the advantage.

The Pelvic girdle represents hind end of the bridge bow and is apart of the trunk construction.

It is firmly anchored in the direction of the thrust (i.e obliquely forwards and upwards) to the vertebral column.

The jointed columns (limbs) are able to carry load because all the joints are prevented from buckling by their ability to be locked.

Biomechanics of the Forelimb

Bear more weight than hind limbs but have less musculature.

The thoracic part of the serratus ventralis which is an important suspensory structure is heavily permeated by tendons and covered by a strong tendinous sheet.

The large amount of areolar tissue between the distal part of the scapula and thorax permits the gliding movements as freely as if there was a well lubricated joint.

The scapular cartilage acts as a shock absorber when scapula glides over chest.

The joints of forelimb are supported by strong collateral ligaments which prevent the joints from knuckling medially or laterally while shoulder joint is supported by strong muscles and their tendons all around.

The biceps brachi and lacertus fibrosus prevents the shoulder joint from buckling.

By virtue of the connection between the lacertus and tendon of extensor carpi radialis the stress is transmitted onto the proximal extremity of the large metacarpal.

This has steady effect on the carpal joint.

Shift in centre of gravity cannot be avoided even when the animal is standing.

So the elbow joint must be prevented from buckling forwards.

This is prevented by triceps brachii and superficial and deep digital flexors and are heavily permeated by tendons.

Stability of elbow joint is provided by medial and lateral collateral ligaments and long transverse axis of humeral condyles.

The carpal joint is protected against hyperextension by suspensory ligament and superficial and deep digital flexors.

The structure which locks the fetlock joint is the stay apparatus which include

Suspensory ligament

Oblique and straight seasamoidean ligaments. When the weight I placed on the limb the fetlock joint is overextended.

This causes stay apparatus to be stretched and the sesamoid bones contained within it to become wedged against the trochlea of large metacarpal locking the fetlock.

Flexors help in this process.

The attachment of superficial flexor tendon to second Phalanx protects against over extension of fetlock.

The reinforcing bands running from the suspensory ligament to extensor tendons combat the tendency for pastern and coffin joints to flex when the flexor tendon is weighted.

Distal seasamoid acts is similar manner to part of suspensory apparatus of the fetlock.

Cattle, horse, Pig, Sheep, goat and camel are ungluligrades since they walk on 3rd phalanx though a medium of hoof where as carnivores are digitgrades where entire digit rests on ground while humans are plantigrades who walk on pes.

Biomechanics of the Hindlimb

Bear less body weight and are more accurately angled than the forelimbs.

The pelvis is firmly attached to the trunk.

The practically immobile sacroiliac joint may be considered as an adaptation for propulsion and weight bearing.

The hind end of the bridge rests on the head of the femur though acetabulum.

Stability to stifle joint is provided by expanded joint surface strong collateral ligaments and extensor action of Quadriceps Via Patellar ligaments.

Fixation of fetlock, pastern and Coffin joints is achieved in essentially similar fashion to that in the forelimb.

Stay Apparatus of limbs in Horse

The stay apparatus of limbs includes suspensory apparatus of fetlock joint as well as those structures aiding in supporting the limbs while horse stands.

It supports limb particularly fetlock, diminishes concussion and prevents excessive extension of fetlock, pastern and coffin joints.

It includes muscles tendons and ligaments.

The ability of the horse to stand while he sleeps is due to stay apparatus.

The ability to stand for weeks or days at a time needs an additional mechanism.

This is best developed in forelimbs as these limbs bear more weight than the hind limb.

As a whole the muscle in horse are more permeated with tendinous tissue while in other species they are more muscular so later fatigue faster when standing.

Structures forming Stay Apparatus in Forelimb

Serratus ventralis, Tendon of Biceps brachii, Tendon of Triceps, Lacertus Fibrosus, Extensor Carpiradialis, Carpi radialis, Common digital extensor, Radial/Superior check ligament, Subcarpal/Inferior check ligament, Superficial digital flexor tendon, Deep digital flexor tendon, Suspensory ligament (interirsseous muscle), Collateral ligaments of fetlock, intersesamoidean and Collateral sesasmoidean ligaments and distal sesamodean ligaments.

Much of the weight of the trunk is supported between ther forelimbs by a string like arrangement of the two Serratus Ventralis muscles.

The weight is transferred to the scapula and then to other bones of Forelimb.

At rest shoulder joint is fixed in a relatively flexed position, the elbow is an extended position both being has a long superficial tendon lacertus fibrosus which attaches to the tendon of extensor carpiradialis and aid it to keep the carpus extended.

The superficial and deep digital flexor are given supporting ligaments above and below the carpus respectively and relieve tension on the muscle bellies and help in fixing the carpal joint.

These tow check ligaments assist flexor tendons after severe exertion to keep them tight and prevent flexion.

Rather than casing entire body weight to fall on the digital flexor muscles latter are aided by two check ligaments.

Radial or superior check ligaments, morphologically radial head of superficial flexor from distal part of radius to tendon of latter muscle.

Subcarpal or inferior check ligament is continuation of strong volar ligament to deep flecor tendon.

Without these, dorsal flexion of fetlock could be counteracted only by contraction of flexor muscles.

The two bands of suspensory ligament to common digital extensor tendon and branches to seasmoids transfer forces to metacarpal and carpal bones to which upper part of suspensory ligament is attached.

Structures forming Stay Apparatus in Hindlimb

Tensor fascia latae, Gastrocnemius, Peroneus tertius, Long digital extensor, Superficial digital flexor deep digital flexor, superior check ligament, substarsal (inferior) check ligament, Suspensory ligament, Collateral ligaments of fetlock, Intersesamoidean ligament and distal sesamoidean ligaments.

The abduction of limb is limited by accessory or pubiofemoral ligament.

A peculiarity is that stifle and hock are extended / flexed simultaneously.

Subtarsal check ligament is less developed than in forelimb or even absent.

Superior check ligament is absent being rendered non – essential by tendinous nature of the superficial flexor.

The trochlear ridges of tibial tarsal are oblique so lower part of limb moves laterially when hock is flexed.

This trochlear obliquity which is found only in equidae is apparently related to caudal extent of rib cage.