Nabanka Chanda

PRIMARY

VETERINARY ANATOMY

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1975 Robert Getty revised and improved the 4th edition of Sisson and Grossman's Anatomy of Domestic animals with the help of many distinguished veterinary anatomists throughout the world including some Indian contributors like N G Ghosal and B S Nanda.

1977 Nickel R. Schummer A and Seiferle wrote a text book on the anatomy of domestic animals in German language which was later translated by W O Sac. This is also an elaborate publication like Getty edition of Sisson and grossman's Anatomy of Domestic animals.

1981 Dellman H D and Brown E M. published the book "Text book of Veterinary Histology".

1986 Mariappa D. prepared a text on Anatomy and histology of Indian Elephant.

1986 Lahunta A and Habel RE wrote the "Applied Veterinary Anatomy"

1991 Dyce K M, Sack W O and Wensing C S G. wrote the book "Anatomica Veterinaria"

1992 Smallwood JE. Published "A guided form of Veterinary Anatomy"

1994 Pandit R V. a noted veterinary anatomist from Nagpur documented osteology of Indian liger.

1994 Kanan C V prepared a students dissection guide on the Anatomy of the bovine ,edited by U B Sing, who is the author of a book-let on histological technic.

1995 Ghosh R K wrote a text book "Primary Veterinary Anatomy" in a concise form which has been improved and elaborated in subsequent editions.

1997 Sing H and Roy K S prepared an " Atlas of Buffalo Anatmy".

1998 Ramkrishna V and Gadre K M. published "A systemic histology of domestic animals".

2002 Ghosh R K Published a book-let on Veterinary Embryology.

2013 Ghosh R K revised and improved the veterinary embryology book-let, added the histology portion and published a text book "Essentials of Veterinary Histology and Embryology".

2013 Rao C S has written a book "Fundamentals of Veterinary developmental Anatomy".

Beside the above mentioned publications many more publications might have been produced throughout the globe in different years.

Many important research articles in Veterinary Anatomy which have been published in various reputed and international journals have not been reported in this presentation.

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1 INTRODUCTION

Anatomy deals with the study of biological structures. **Veterinary Anatomy** is concerned with the structure and forms of the organs and tissues of principal domestic animals and birds. Generally this subject is studied on comparative basis. However, the biological structures may be studied in different forms. In Gross anatomy the structures are studied after dissection, with the help of naked eye only. **Histology** or **Microscopic anatomy** deals with the study of finer details of the structures of various tissues and of different organs. The process of differentiation, growth and development of an organ or structure comes under **Embryology** or **Developmental anatomy**.

When this science of structures and forms of various organ systems of a body are studied in close correlation with the Physiology, makes the foundation of the whole of Medicine and life science.

There are many ways by which Gross anatomy can be studied. Some of the important methods are as follows :

1. **Systemic Anatomy**—Here the structures of particular organ system are studied serially without going to the details of the surrounding structures.

2. **Topographic Anatomy or Surface Anatomy**—In this method the principal structures or organs of any part of the body are described in relation to a definite and limited area of the surface.

3. **Surgical Anatomy**—This is an applied part of the subject where the structures of some specific sites are studied for application in surgical practice.

4. **Radiological Anatomy**—Here the structures of the body are studied with the help of X-ray. Ultrasonography or MRI may be useful for studying anatomy of any animal in any desired plane. C.T. scan is also another similar device for studying this subject in normal and altered physiological condition.

5. **Comparative Anatomy**—In this method, analogous structures of different species of animals are studied on comparative basis.

Besides these, a variety of other methods are used to study the subject, *e.g.*, Zoological Anatomy, Philosophical Anatomy, *etc.*

Broadly there are three divisions of Antomy :

1. Histology or microscopic Anatomy.
2. Embryology or the developmental Anatomy.
3. Gross or naked eye Anatomy.

In this book only the systemic gross anatomy of principal domestic animals and birds are presented on comparative basis keeping cow as the model animal of study.

DESCRIPTIVE ANATOMICAL TERMS

A number of scientific words or terms most of which come from Latin or Greek are used to indicate precisely the position and direction of different parts of the body, such as :

Anterior = Front; ***Lateral or external*** = Away from median plane; ***Posterior*** = Back; ***Medial or internal*** = Close to median plane; ***Superior*** = Above; ***Superficial*** = Close to surface; ***Inferior*** = Below; ***Deep*** = Beneath superficial; ***Proximal*** = Upper or superior; ***Distal*** = Inferior or lower; ***Cranial*** = Towards the head end; ***Caudal*** = Towards tail end, ***Rostral*** = Towards the nose; ***Palmar*** = The surface of the fore limb that contacts the ground in standing condition; ***Planter*** = The contact surface of the hind limb in standing condition; ***Axial*** = Towards central line of the body or any body part; ***Abaxial*** = Away from axis.

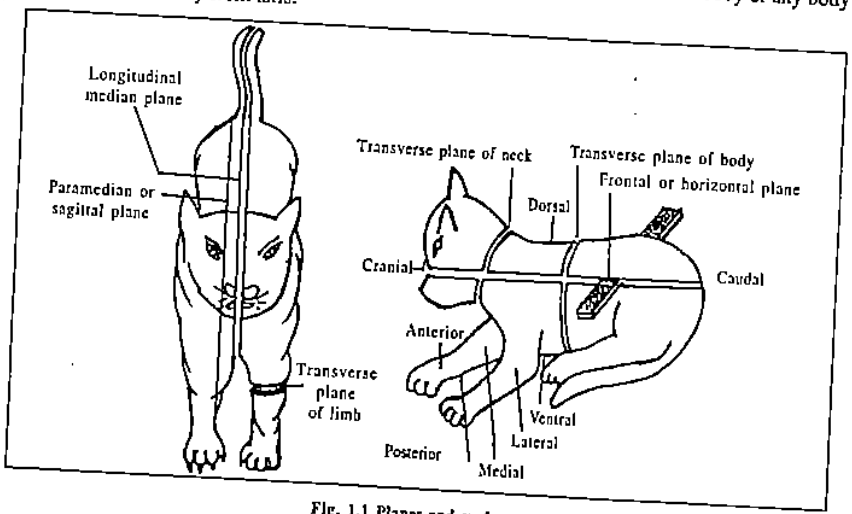


Fig. 1.1 Planes and surfaces.

Planes of Body

Longitudinal median plane—This plane divides the body into almost two equal halves. ***Sagittal*** or ***Paramedian plane***—Any plane which is parallel to the median plane is sagittal plane. ***Coronal plane***—Any plane which is at right angle to the sagittal plane is a coronal plane. ***Transverse planes*** are the cross sectional planes. ***Frontal plane*** or ***Horizontal plane***—This plane cuts the long axis of the body of an animal horizontally. This is perpendicular to the sagittal planes and transverse planes of the body.

DIVISIONS OF GROSS ANATOMY

According to the study of different organ system the gross anatomy may be divided into the following chapters :

Osteology = Study of bones; **Arthrology** = Study of joints; **Myology** = Study of muscles; **Splanchnology** = Study of the visceral organs of different systems; **Angiology** = Study of the heart and vessels; **Neurology** = Study of the organs of nervous systems; **Aesthesiology** = Study of the organs of special senses.

2 OSTEOLOGY

Osteology deals with the components of skeleton. Bones are the principal components of a skeleton. Beside the formation of skeleton, bones act as levers for muscles, protect certain viscera (skull), manufacture blood cells and also act as reservior of mineral salts.

Skeleton can be defined as a hard framework of the body which supports soft structures. This is composed of bones, cartilages and ligaments. The skeleton is responsible for the maintenance of the shape, flexibility as well as locomotion of the body. For the purpose of description the skeleton is divided into two parts, *Axial* and *Appendicular*. The axial skeleton comprises of the bones of skull, vertebral column, ribs and sternum. The appendicular skeleton is made up of the bones of the limbs. The skeletons of typical vertebrates are bilaterally symmetrical.

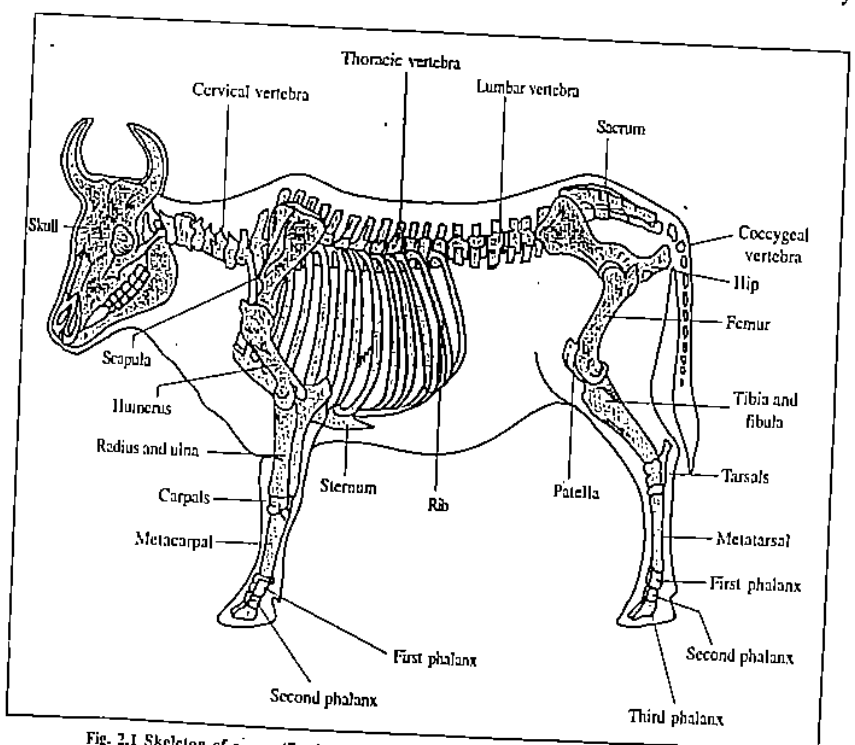


Fig. 2.1 Skeleton of a cow (For better understanding limbs of only one side has been shown).

Function of skeleton

1. It gives protection to the vital organs in the thorax, pelvis and skull.
2. It provides attachments to the muscles.
3. It is a basic structure for movement.
4. It accommodates blood forming tissue—marrow.
5. It is a store house of salts and minarals for future utilisation.
6. Since the components of skeleton have their growth and death, it is a dynamic and living structure.

Classification of bones

According to the naked eye appearance with regard to their shape, size and structure the bones have been classified into several catagories as follows :

(i) **Long bones**—These are the long hollow cylindrical type of bones, found in the limbs. These are weight bearing bones and act as levers. A long bone has a body or shaft and two expanded ends. The shaft consists of a tube of compact bone and contains a large medullary cavity which is filled with bone marrow. These bones ossify in cartilage. *e.g.*, **Femur, Humerus.**

Modified long bones—Some bones, like clavicle in dogs, rabbit and fowl do not possess meduallary cavity and therefore considered as modified long bones. **Miniature long bones** — These are long bones but small in size, e.g., **metacarpals** of dogs.

(ii) **Short bones**—These are small pieces of partially smooth surfaced bones mainly found in the joints and help in their mobility. Most of these bones present six surfaces. They are mainly composed of spongy substance with a thin layer of cortical compact bone, *e.g.*, **carpal bones.**

(iii) **Flat bones**—They are flat irregular bony plates designed for enclosing cavities which contain important organs of the body. Flat bones are composed of two plates of compact bone with intervening spongy bone. The intervening spongy tissue in the bones of cranial vault is known as **dipole** *e.g.*, **scapula, some cranial bones of skull.**

(iv) **Irregular bones**—These are also small bones with rough and irregular surfaces generally found in the midline of the skeleton. Their so many projections help in the attachment of various muscles. They are composed of spongy substance with thin covering of compact substance, *e.g.*, **vertebra.**

(v) **Pneumatic bones**—Some long bones of birds have cavities inside their bodies which accommodate air sacs through pneumatic foramen in living condition, *e.g.*, **Humerus** of fowl. In mammals bones situated close to the nasal cavity which contain air-filled cavities are also considered as pneumatic bones, e.g., Frontal bone, maxilla and ethmoid.

(vi) **Sesamoid bones**—These are small seasame (seed) like bones develop within tendon and ossify after birth. These bones have no Haversian system and no periosteum. They work as pully to avoid friction, *e.g.*, patella.

(vii) **Visceral bones**—These are found in the viscera of some animals and birds, *e.g.*, os penis in dog; os cordis in ruminents; os opticus in some fowl; os rostrale in pig; os phrenic in camel, *etc.*

Composition of bone

Bone is a mineralised connective tissue and the composition varies greatly with the age and site. It provides rigidity as well as elasticity to the body and therefore, composed of (a) *inorganic mineral salts* and (b) *Organic matters.* The approximate ratio between the two substances is 1 : 2. The Organic matter includes membranes, cells, cartilages, vessels, nerves, fluids and marrow.

In mature bone nearly 1/5th of the weight in water. Mineral salt form 60% to 70% and organic materials 30% to 40% of the dry weight of bone.

Although variable, the bones of ox possess the bone salts in following percentage :

Calcium Phosphate	—	86%
Calcium Carbonate	—	5.8%
Magnesium Phosphate	—	3%
Sodium Carbonate and Sodium fluoride, *etc.*	—	5.2%

CARTILAGE

Cartilages are nonvascular pliable strong structures form supporting framework of articulating surfaces of bones, foetal skeleton and certain organs of the body. This is a semihard connective tissue which has a high tensile strength, rigidity, elasticity and resistance to compressive force. Although its vascularity is very low, it possesses the capacity for growth. Cartilages are composed of a semihard matrix of sulphated glycosaminoglycans embedded with collagenous or elastic collagenous fibres and cartilage cells—the chondrocytes. There are three types of cartilages available in the body. They are **Hyaline-cartilage, Elastic-cartilage** and **Fibro-cartilage.** Hyaline cartilages are found in the articular surfaces of bones and possess perichondrium and fine collagen fibres. The hyaline cartilages appear smooth and glassy because the fibers are very fine and surrounded by glycosaminoglycans. Fibrocartilages have no perichondrium. They have small chondrocytes and thick collagen fibers. Intervertebral discs are formed by fibrocartilages. Elastic cartilages are found in epiglottis and external ear. They are composed of both collagen and coarse elastic fibers. They also possess perichondrium.

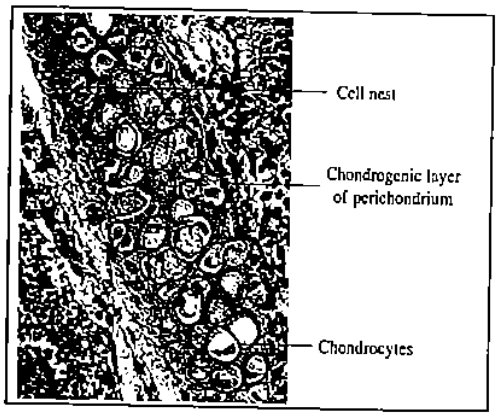


Fig. 2.2 Hyaline Cartilage.

The matrix and fibers are secreted by the chondroblasts during growth stage and the cells become entrapped by their own secretions. Now the chondroblasts are converted into chondrocytes. These newly formed chondrocytes undergo division and in each lacuna several chondrocytes are found. There are known as cell nests.

STRUCTURE OF BONES

Bone is a living tissue and is not a static material. It has its growth and death. It is provided with vessels and nerves. Bones are composed of two types of substances—*compact* and *spongy*. The distribution of the compact and spongy substances vary from bone to bone. In a long bone there remains a large elongated cavity within the body known as marrow cavity. The cavity remains filled up by bone marrow. In spongy bones there are plenty of small spaces which also remain occupied by the bone marrow.

A young long bone presents the following parts :

a) Diaphysis
b) Epiphysis
c) Metaphysis

The *Diaphysis* is the part of the bone ossified from primary ossification center and form the shaft (body) of the bone.

The *Epiphysis* is ossified from the secondary ossification outer and generally forms the ends of the bone. Epiphysis may be of 3 types : a) ***Pressure epiphysis*** – It transmits the body weight. Heads of femur and humerus and condyles of femur and tibia are the examples. b) ***Traction epiphysis*** – It is formed by the pull of muscle. Examples – trochanters of femur, tubercles of humerus. c) ***Atavistic epiphysis*** – When an individual bone is attached secondarily on a host bone like a parasite to derive nutrition, is called atavistic epiphysis. Example – coracoid process of scapula.

The *Metaphysis* is the end of diaphysis that faces towards the epiphysal cartilage and helps in the growth in length of the bone.

The outer surface of a bone is covered by a membrane except where it is covered by a cartilage. This membrane is known as periosteum. A thin membrane also invests the medullary cavity is known as endosteum. The cartilage which covers the articular surface of a bone is known as articular cartilage.

Compact bone—This is a dense and hard substance situated at the external aspect of the bone and surrounds spongy substance. In the long bones the compact substance is thin at the ends and very thick at the body. It comprises of a bony tissue arranged in a definite pattern, known as **Haversian system or osteons**. Numerous very narrow canals pass through the compact substance along the length of the bone are known as **Haversian canals**. These canals carry blood vessels and nerves. Around these canals bone matrix is present in the form of several concentric lamellae. In between the lamellae there are minute spaces known as **lacunae** which give accommodation to the bone cells—the osteocytes. Very minute canals radiate from these lacunae to accommodate the processes of bone cells. These are called **canaliculi**. All these structures, *i.e.*, the Haversian canal, the lamellae, lacunae and canaliculi constitute the Haversian system (Fig. 2.4 and 2.7). In between Haversian systems the triangular areas are filled up by irregular bony deposits called **interstitial lamellae**. The Haversian canals communicate with the marrow cavity and with surface of the bones by some transverse canals which are not surrounded by bony lamella. These transverse canals are known as **Volkmann's canals**. These canals also communicate with the spaces of spongy bone. The Haversion system runs longitudinally along the shaft of long bones. Average diameter of this system is about 150 microns.

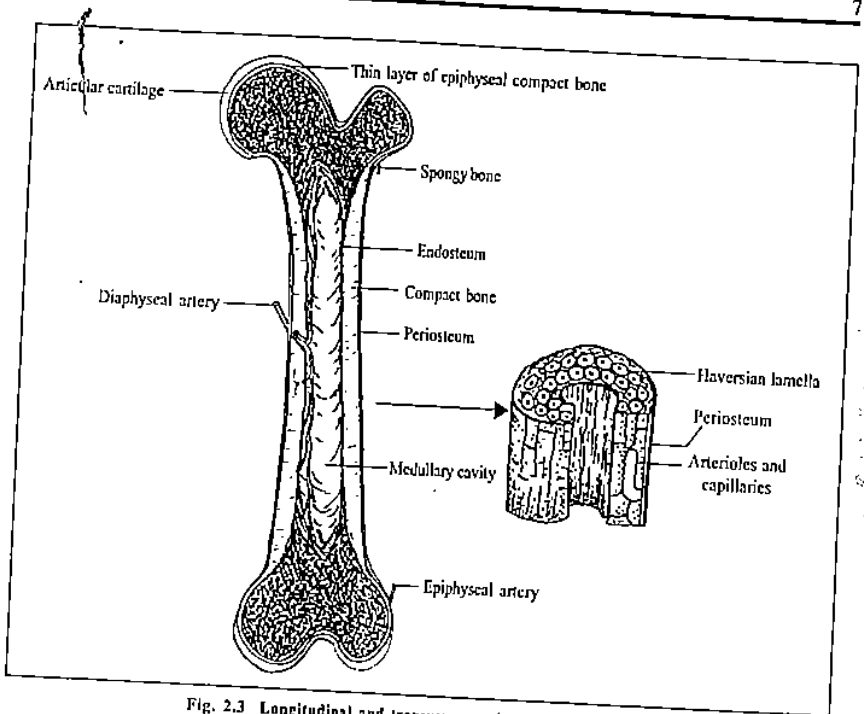


Fig. 2.3 **Longitudinal and transverse sections of a long bone.**

Circumferential lamellae or primary osteons

These lamellae encircle outer and inner surface of the long bone. These lamellae are not arranged as per the Haversion system but are held together by perforating fibers. Circumferential lamellae are formed by deposition of layers of new bone under osteogenic layer of periosteum and thereby the shaft of the bone grows in width. This process in known as **Appositional growth**.

Formation of Haversian system (Fig. 2.5)

When thick bony lamellae are deposited at the outer surface of a growing long bone, the nutrition of bone tissue suffers. Therefore a number of longitudinal grooves appear on the outer surface under the periosteum and each groove accommodates a blood vessel along the floor. The grooves become converted to tunnels by further deposition of bones at the ridges. Therefore each tunnel contains a blood vessel and becomes lined by osteoblasts. These osteoblasts continue deposition of bone salts in a concenteric manner arround the tunnels and lamellae are formed. Subsequent proliferation of osteoblasts and their differentiation into osteocytes lead to the formation of Haversian system.

Spongy bone—The spongy bone is also known as cancellous bone. A large number of very small boney plates (trabeculae) unite irregularly enclosing small marrow spaces between them

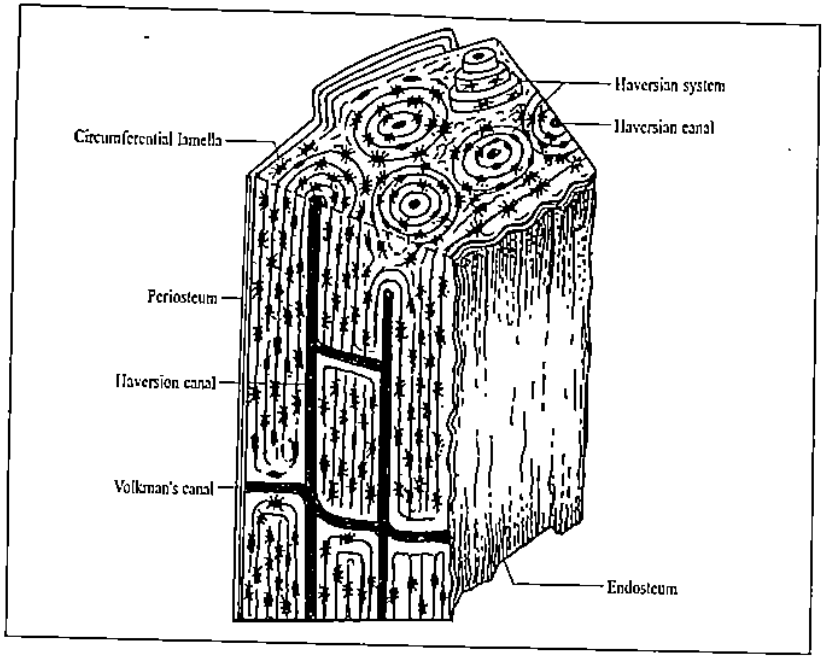


Fig. 2.4

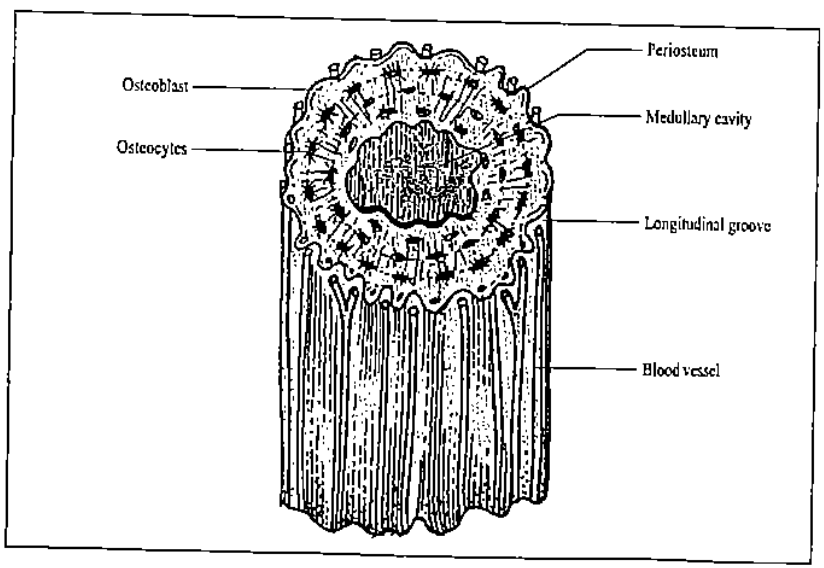


Fig. 2.5

and form a hard structure of spongy appearance, known as spongy substance. These substance make the bulk of small and irregular bones as well as ends of the long bones. There is no Haversian system of arrangement in the spongy substance. The bony trabeculae are arranged along the line of maximal internal stress in such a way that the bone can resist stress and strain to which it is subjected.

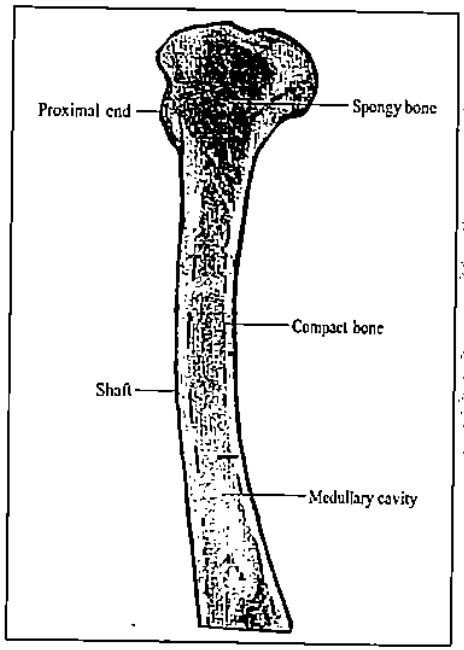


Fig. 2.6 Section of a long bone.

Periosteum—Bones are covered by a membrane except at the articular surfaces. This membrane is known as periosteum. Its outer layer is fibrous (collagen) and inner layer is cellular. The cellular layer contains osteoblast cells which help in ossification and hence called osteogenic layer. Periosteum is not present on the sesamoid bones.

Function of periosteum

1. As a cover it protects the bone.
2. It helps growth and repair of bone.
3. It helps in the supply of nutrition to the outer part of the bone.

Articular cartilage—Most of the articular cartilages are hyaline in nature. They cover the articular surfaces of bones to provide very smooth surfaces of the synovial joints and thereby make a friction-free environment during movement. Its deep surface is attached with the underlying bone. The cells of these cartilages are almost round or elongated and are arranged singly or in groups of even number of cells. These are presumed to be off-springs of a common parent cell. The ground substance is either transparent or granular in appearance. This cartilage normally does not ossify. It derives nutrition from synovial fluid and surrounding vessels.

Endosteum—The marrow cavity and various marrow spaces are lined by a layer of areolar tissue which is very rich in fine blood vessels. This lining membrane is known as endosteum.

Bone marrow—The medullary or marrow cavity of long bones and marrow spaces of all the bones are occupied by a soft and pulpy tissue, known as bone marrow. There are two types of bone marrow—yellow and red. The composition varies from bone to bone and depends on age. At birth and in the prenatal life, most of the marrow is red. With the advancement of age, the yellow marrow replaces the red marrow. In the adult, red bone marrow is found only in the skull, ribs, sternum, vertebrae, cancellous part of some short bones and in the ends of some long bones. Red bone marrow consists of reticular connective tissue, various blood cells at their different stages of development, fat cells, lymphoid cells and blood vessels. Megakaryocytes (giant cells) are also found in red bone marrow. However, the marrow of the cranial bones

degenerates in the old animals. The reticular connective tissue consists of an interlacing network of reticular fibers into which reticular cells are attached. The latter have phagocistic properties and present amoeboid movements. The storma is permeated with sinusoidal vessels which are lined by reticulo endothelial cells.

It is important to note that, in the adult, yellow marrow is replaced by red marrow under exceptional circumstances, such as in certain types of anaemia.

Yellow bone marrow is composed of connective tissue, blood vessels, fat cells and also some mature and immature red blood cells.

Blood vessels and nerves of bones—One or two nutrient (diaphysal) arteries enter the shaft of long bones generally in oblique direction through nutrient foramina. These foramina in most cases are constant. It then passes through the nutrient canals without much branching, reaches the medullary cavity and divides into ascending and descending branches. When the branches reach the ends, divide into a number of smaller branches and join with metaphysal and epiphysal arteries. These meta and epiphysal arteries are derived from periarticular vascular arcades. The medullary arteries give some branches to the bone marrow and a series of cortical branches for

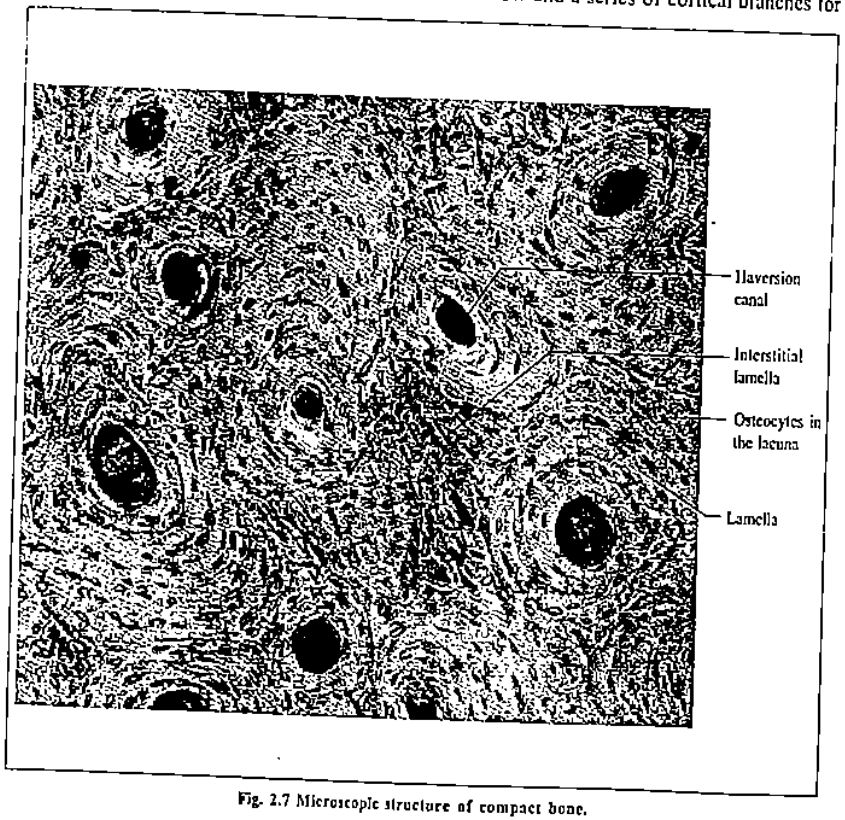


Fig. 2.7 Microscopic structure of compact bone.

the arteries of Haversian canals. The nerve fibers are distributed within the layers of periosteum. Some fibers enter the interior of the bone along with the nutrient vessels.

Bone cells—There are two types of bone cells—(a) *mature cells*—the osteocytes and (b) *immature cells*—the osteoblasts and osteoclasts.

Osteocytes are derived from osteoblasts and remain in tiny spaces surrounded by matrix, known as lacunae. They get nutrition through canaliculi. These are flattened cells with centrally placed nuclei. They have numerous cytoplasmic processes.

Osteoblasts are derived from mesenchymal tissue. They produce calcium ion and alkaline phosphatase. The alkaline phosphatase hydrolyses the locally available hexose phosphate and produces free phosphate ions. The phosphate ions combine with calcium and become precipitated as calcium phosphate crystals in the matrix. The cytoplasm is strongly basophilic. The cells have eccentric nucleus and numerous cytoplasmic processes.

Osteoclasts are multinucleated cells with eosinophilic cytoplasm. They do not have processes but are provided with brush borders. These cells are also believed to be derived from osteogenic cells.

Osteoclasts helps in resorption of bone salts. Sometimes few osteoblasts fuse together to form a osteoclast.

OSSIFICATION

The process of bone formation is known as ossification. Calcification is an event in the process of ossification. There are two types of ossifications—(a) Intramembranous or mesenchymal ossification and (b) Intracartilaginous or endochondral ossification. However, there is no much difference between the two processes.

Intramembranous ossification—Bones of cranial cavity and face ossify in this process. At a point (center of ossification) osteoblasts are differentiated from mesenchymal cells. A meshwork of collagen fibres produced by the osteoblasts, appear between the cells. It becames vascularised by capillary network. The osteoblasts produce other organic intercellular substances like mucoprotein, glycoprotein, mucopolysaccharide, *etc.* The organic non-clacified matrix is known as osteoid. Now the matrix is calcified by osteoblasts as stated earlier. 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 center. 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 mesenchyme.

Intracartilaginous ossification—In this process most of the bones ossify. This process occurs in stages.

Stage—I

At the beginning a cartilaginous model is formed by the condensation of mesenchymal tissue. A perichondrium appears around the cartilage.

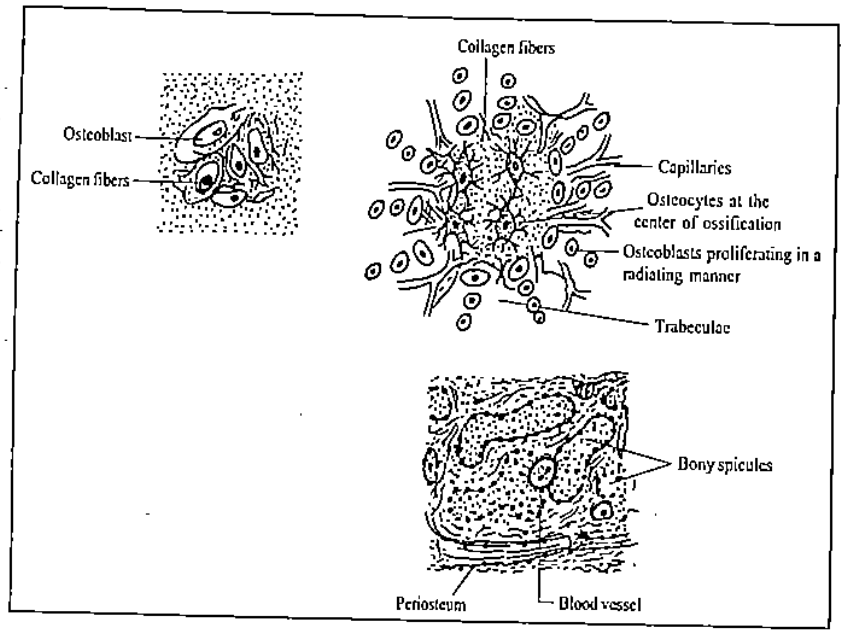


Fig. 2.8 Intra-Membranous Ossification.

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 get hypertrophied.

The hypertrophic 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 center.

At the same time osteoblasts appear at the inner layer of perichondrium and form subperiosteal collar bone around the primary ossification center. The perichondrium is then called periosteum.

Stage—II

At this stage the collar bone is eroded by the increased activity of the subperiosteal osteoclasts and the periosteal buds containing osteoblasts, osteoclasts and blood vessels enter into the primary ossification center. 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 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 appear on the outer surface on the circumferential bony lamellae. The ridges of each groove proliferate and enclose a small blood vessel which already developed along the periosteum and convert the grooves into tunnels. The

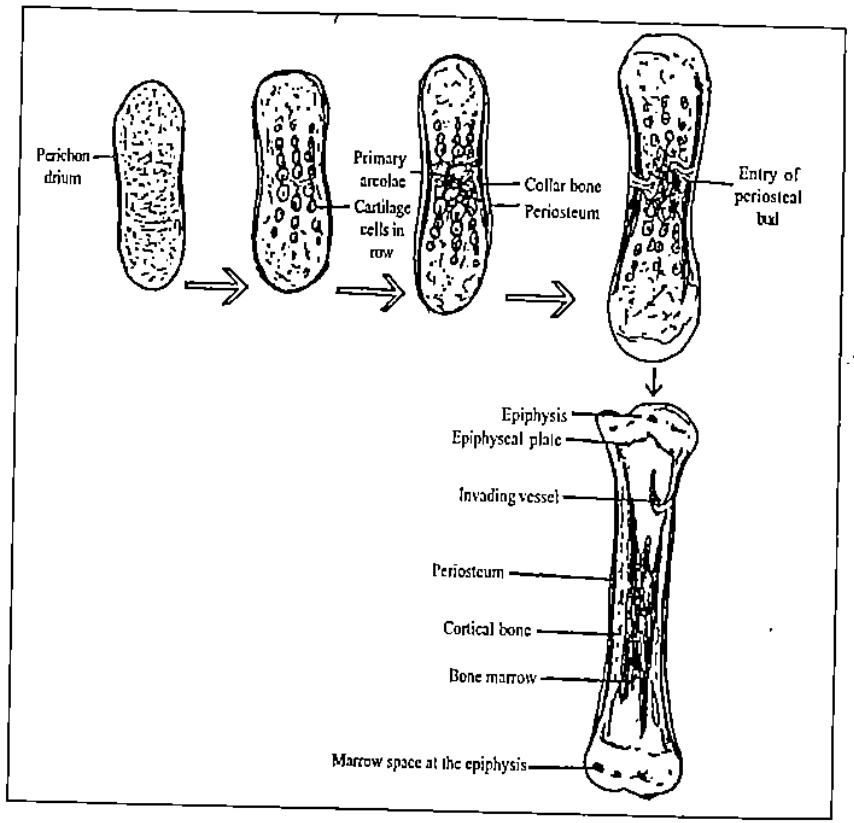


Fig. 2.9 Intra-Cartilagenous Ossification.

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 centers appear at the ends of the cartilagenous model at birth. This zone is called epiphysis. Ossification occurs in the similar way in both directions.

At the ends of a long bone a layer of cartilage does not ossify and remains as articular cartilage throughout life. In the growth phage a portion of the cartilagenous

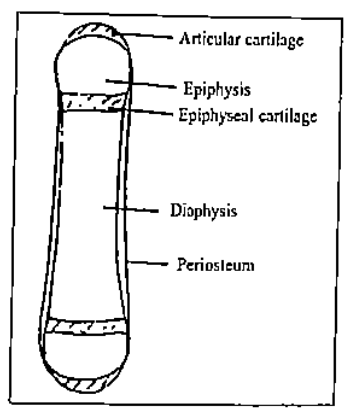


Fig. 2.10 Parts of Bone in Growing stage.

model remains as epiphyseal cartilage between the epiphysis and diaphysis. This epiphyseal cartilage helps in longitudinal (interstitial) 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 epiphyseal cartilage. The growing part of the diaphysis adjacent to the epiphysal cartilage is called **Metaphysis**. But with the advancement of age the growth of this metaphyseal cartilage slows down and the calcification become more rapid. So the whole epiphyseal cartilage become ossified and the growth in length ceases. The width increases by the deposition of subperiosteal membrane bone.

Factors affecting growth of bones

The following factors are responsible for proper growth of bones :

a) Nutritional factor

b) Hormonal factor

c) Mechanical factor

d) General factor

Nutritional factors

i) Vitamin A deficiency – It causes a disturbance between bone formation and destruction. It causes reduction in the size of the spinal and cranial foramina and may lead to *compression of nerve roots*.

ii) Vitamin C deficiency – It interferes with the production of organic intercellular matrix.

iii) Vitamin D deficiency – Vitamin D is essential for the absorption of calcium and phosphorous from the intestine and maintain their concentration in blood. Calcification of the osteoid matrix is hampered in deficiency of Vitamin D and may lead to *rickets* in younger animals and osteomalacia in adult animals.

Hormonal factors

Parathyroid

Maintenance and regulation of calcium ion concentration in blood is made by parathyroid hormone and calcitonin of para follicular cells. If parathyroid hormone is secreted in excess, calcium is removed from the bones by stimulating osteoclastic resorption. This cause rarefaction of bone known as *osteitis fibrosa*.

Pituitary

Gigantism may occure due to persistent growth at the epiphysal cartilages if excess secretion of α-cells occur before puberty.

Acromegaly is developed due to renewed subperiosteal deposition of bones in various parts of the body (limbs, skull) when excess secretion of α-cells occur after puberty.

Dwarfism may result due to hypo-pituitarism which causes the failure of normal growth of bones in young animals.

Mechanical factor

When any bone is placed under stress and strain, it is observed that tensile force helps bone formation and compressive force favours bone reabsorption.

General factor

Castration in growth period, delay the union of epiphysis and may lead to disproportionate elongation of limbs. This is sometimes observed in eunuchs.

Disuse atrophy may develop due to occurance of local osteoporosis when a limb is paralysed or immovable.

OSTEOLOGICAL TERMS

For convenient description some common terms are used for different surface markings on bones. These markings are the indications for attachments of various ligaments, tendons and muscles and also suggest location of important structures.

Facet	=	A small articular surface.
Fovea	=	An articular surface in the form of a very small pit.
Fossa	=	A depression which is moderately deep.
Sulci or grooves	=	Elongated depressions.
Incisura	=	A notch like depression.
Condyles	=	Knuckle shaped paired articular surfaces.
Epicondyle	=	A small projection adjacent to a condyle.
Trochlea	=	A pully like grooved articular surface.
Process	=	A large projection.
Spine	=	A slender or pointed projection.
Cornu or hamulus	=	Curved horn like process.
Tuberosity	=	A large round projection.
Tubercle	=	A small projection.
Trochanter	=	A very large prominence.
Crest	=	An elongated elevation.
Line	=	A faint elongated elevation.
Protuberance, Prominence, Eminence, torus	=	Varieties of bony projections.
Head	=	An expanded and nearly round proximal end.
Neck	=	The constricted part below head.
Foramen	=	A hole or perforation through a bone.
Cleft	=	A fissure in a bone.
Lamina	=	A thin plate like structure.

Number of bones found in the skeleton of different domestic animals and birds

	Skull (including hyoid and mandible)	Vertebral column (approx)	Ribs Sternum & Clavicle	Fore limb	Hind limb	Visceral bone	Total (approx)
Ox	32	51	26+1+0	24×2	24×2	2 Os cordis	208
Horse	32	51	36+1+0	20×2	20×2	—	200
Dog	32	51	26+1+2	44×2	45×2	1 Os penis	291
Pig	30	52	28 to 30+1+0	40×2	40×2	1 Os rostrale	274
Rabbit	34	46	24 to 26+1+2	31×2 (excluding sesamoid)	29×2	—	229
Fowl	40	41	14+1+1+2	13×2 (Coracoid)	21×2	2 Os opticus	169

Bones of fore limb

SCAPULA

It is a flat triangular bone situated at the cranio-lateral aspect of the thorax. It is directed downward and forward and extends from 3rd to 4th thoracic spine to the distal end of first rib. It possesses two surfaces, three angles and three borders.

Lateral surface is divided into two unequal halves by a spine. The ratio is 1 : 3. The superior one is smaller and termed as **supraspinous fossa** and the inferior one is known as **infraspinous fossa.** The supraspinous fossa accommodates the supraspinatus muscle and the infraspinous fossa accommodates the infraspinatus muscle. The spine is little broad and bent backward at the middle to attach the trapezius muscle. The spine has terminated below into a pointed projection known as **acromion process.** The process is directed downward and forward. From this process a part of the deltoid muscle originates. The medial surface has a shallow fossa at the middle, known as **subscapular fossa.** It accommodates subscapular muscle. At the upper part of this surface, cranially and caudally there are two **rough triangular areas** for the attachment of serratus cervicis and serratus thoracis muscles respectively. The angles are **cranial, caudal** and **distal.** The cranial angle is thin and formed by the anterior and dorsal borders. The anterior border is thin and convex. Dorsal border is rough for the attachment of the scapular cartilage. The caudal angle is thick and formed by dorsal and posterior borders. Posterior border is thick and convex. Generally the nutrient foramina is found on this border at the distal end.

The distal angle comprises of the glenoid cavity and the tuber scapulae. The glenoid cavity is a shallow circular articular surface for the articulation with the head of the humerus. The rudimentary

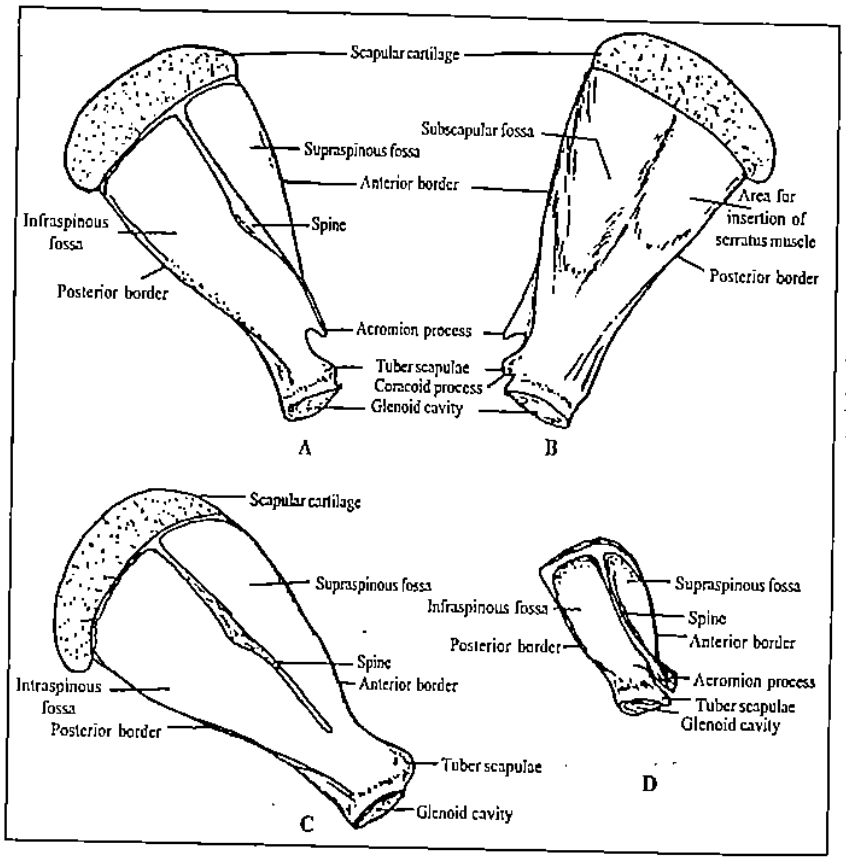


Fig. 2.11
A. Right scapula of ox (Lateral view) B. Right scapula of ox (Medial view) C. Right scapula of horse (Lateral view) D. Right scapula of dog (Lateral view).

glenoid notch is situated at its lateral aspect. The tuber scapulae or supra glenoid tubercle is small and is situated at the cranial aspect of the glenoid cavity. Biceps brachii muscle originates from this tuber. The **coracoid process** is a small projection from the medial aspect of the tuber scapulae from which coraco-brachialis muscle originates.

Scapula of horse

1. The spine is placed further backward.
2. Acromion process is absent.
3. The tuber scapulae is large and is placed further away from the glenoid cavity.
4. Coracoid process is well developed.
5. Glenoid notch is deep and distinct.
6. Subscapular fossa is deep.

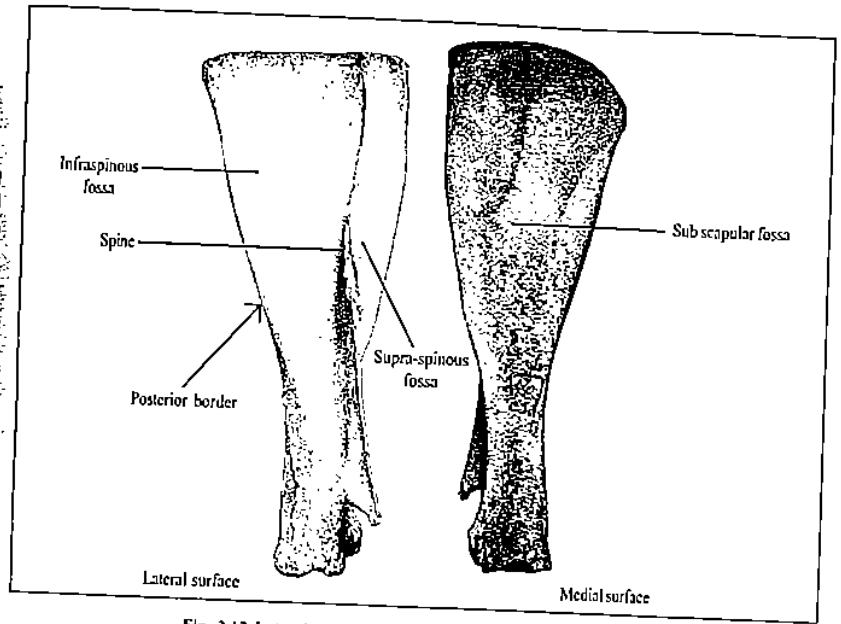


Fig. 2.12 Lateral and medial surface of Right scapula of Ox.

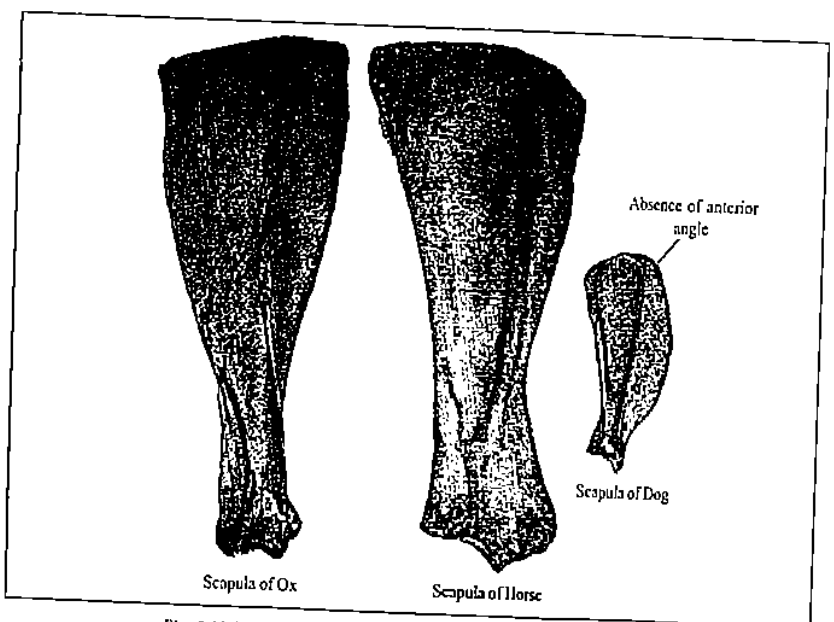


Fig. 2.13 Lateral surface of right scapula of Ox, Horse and Dog.

Scapula of dog

1. The spine is placed at the middle and divides the leteral surface in two equal halves.
2. Both the anterior and dorsal borders are convex and the anterior angle is practically absent.
3. The tuber scapulae is blunt.
4. The coracoid process is absent.
5. Acromion process is short and blunt and extended to the level of glenoid cavity.
6. Subscapular fossa presents few rough lines.

Scapula of pig

1. The ratio between the supraspinous fossa and infraspinous fossa is 1:0.8
2. The spine is wide and further directed backward.
3. Acromion process is rudimentary.
4. Glenoid notch is absent.

Scapula of rabit

1. Spine is situated more cranially.
2. Acromion process is broad and continued backward in the form of a projection, known as metacromion process.
3. Cranial angle is blunt.
4. Coracoid process is developed.

Scapula of fowl

1. It is elongated and situated parallel to the vertebral column.
2. It articulates cranially with the coracoid and furculum to form glenoid fossa for the head of the humerus and leave a space between them. This aperture is known as foramen triosseum which gives passage to the tendon of supracoracoideus muscle.

HUMERUS

It is a long bone situated obliquely downward and backward, forms shoulder joint above with the scapula and elbow joint below with radius and ulna. The cylindrical shaft is twisted and presents four surfaces. The lateral surface is spiral, smooth and presents a **musculo spiral groove**, which accommodates the brachialis muscle. Medial surface is rounded. At the middle there is a tubercle for the insertion of teres major and latissimus dorsi muscles. This tubercle is known as teres tubercle. The anterior surface is triangular, wide and smooth above and narrow and rough below. Between anterior and lateral surfaces there is a prominent border known as **crest of humerus**. At the middle of the crest there is a prominence for the insertion of deltoid muscle, termed **deltoid tuberosity**. The posterior surface is round and smooth. The nutrient foramen is usually situated at the distal third of this surface.

The proximal end is large and presents head, neck, tuberosities and grooves. The head is circular, convex and articulates with the glenoid cavity of the scapula. Neck is the constricted part just below the head. The **tuberosities** are lateral and medial. These are separated by intertuberal groove. The lateral tuberosity is large and prominent. It has two parts—a summit and a convexity. The summit is placed anteriorly and is curved over the **bicipital groove**. The infraspinatus muscle

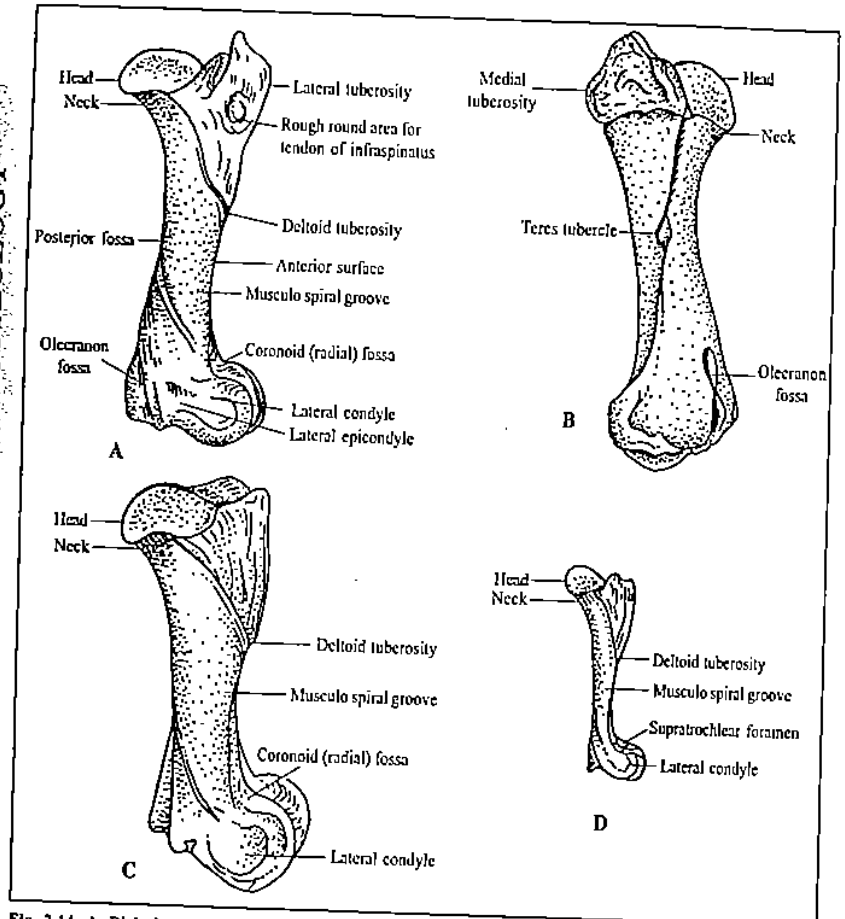


Fig. 2.14 A. Right humerus of ox (Lateral view) B. Right humerus of ox (Medial view) C. Right humerus of horse (Lateral view) D. Right humerus of dog (Lateria view).

inserts at a **circular rough area**, which is situated below and lateral to the summit. The bicipital groove gives passage to the tendon of biceps muscle.

The distal end is articular, expanded and basically a modified condyle. This end consists of a trochlea (medial condyle), the capitulum (lateral condyle), the medial and lateral epicondyles, the olecranon fossa and the radial or coronoid fossa. The **trochlea** is larger and is traversed by a groove. The groove extends cranially to the **radial fossa** and caudally to the **olecranon fossa**. The radial fossa accommodates coronoid process of radius during flexion and the olecranon fossa receives the anconeus process of ulna during extension of the joint. **Capitulum** is small and situated further distally and caudally. The medial and lateral **epicondyles** are small projections from the concerned condyles. Medial epicondyle gives origin to the flexor muscles and the lateral one gives origin to

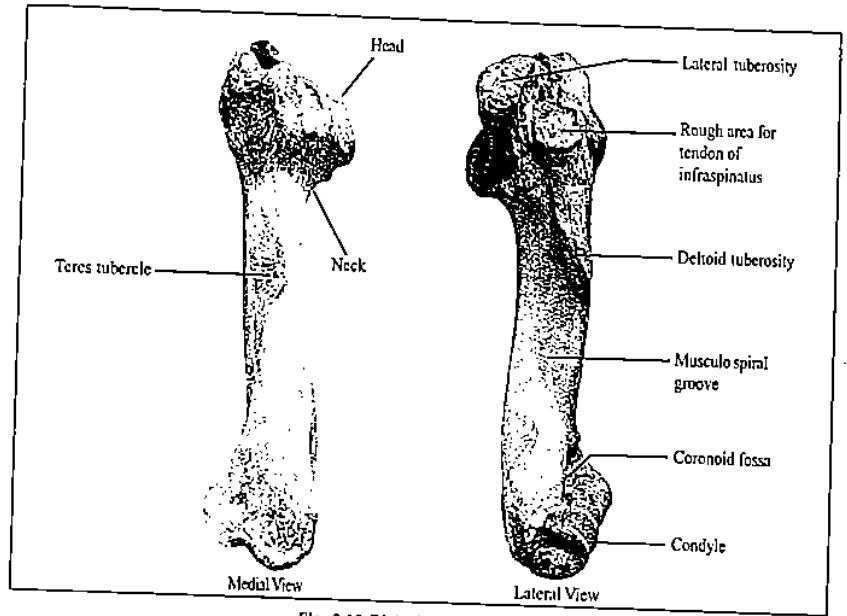


Fig. 2.15 Right humerus of Ox.

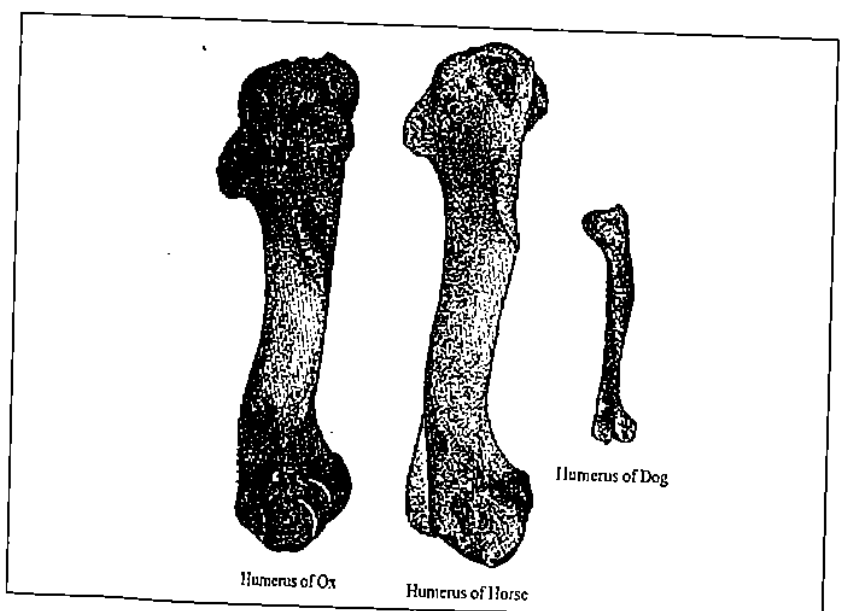


Fig. 2.16 Right humerus of Ox, Horse and Dog.

extensor carpi radialis. The **epicondyloid crest**, a part of the lateral epicondyle, forms the lateral boundary of the musculospiral groove.

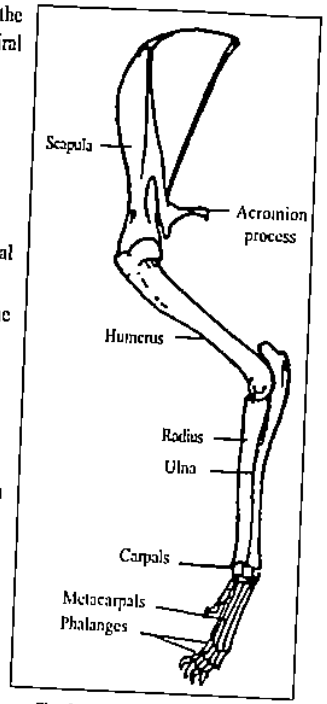


Fig. 2.17 Bones of fore limb of rabbit.

Humerus of horse

1. The deltoid tuberosity is very prominent.
2. The musculospiral groove is more deep and twisted.
3. The bicipital groove is again divided by a ridge.
4. The summit is not raised and does not overhang the bicipital groove.
5. The nutrient foramen is situated at the distal third of the medial surface.

Humerus of dog

1. The bone is comparatively more long and less twisted.
2. Head is rounded and is more convex.
3. Radial and olecranon fossa are communicated by a large **supratrochlear foramen**.
4. The deltoid tuberosity is in the form of a ridge.
5. The nutrient foramen is situated at the posterior surface.
6. Musculospiral groove is not prominent.

Humerus of pig

1. Both the proximal and distal ends are inclined.
2. Musculospiral groove is shallow.
3. Supratrochlear foramen is present in most of the animals.

Humerus of rabbit

1. Head is elongated.
2. Deltoid tuberosity is in the form of a ridge.
3. Musculospiral groove is shallow.
4. Supratrochlear foramen is present.

Humerus of fowl

1. Proximally this bone articulates with scapula and coracoid.
2. The pneumatic foramen is situated medially below the head.
3. The body is less twisted.
4. The head is oval in form.

RADIUS AND ULNA

Unlike those of other animals, the radius and ulna are fused with each other in cow. However they are described separately.

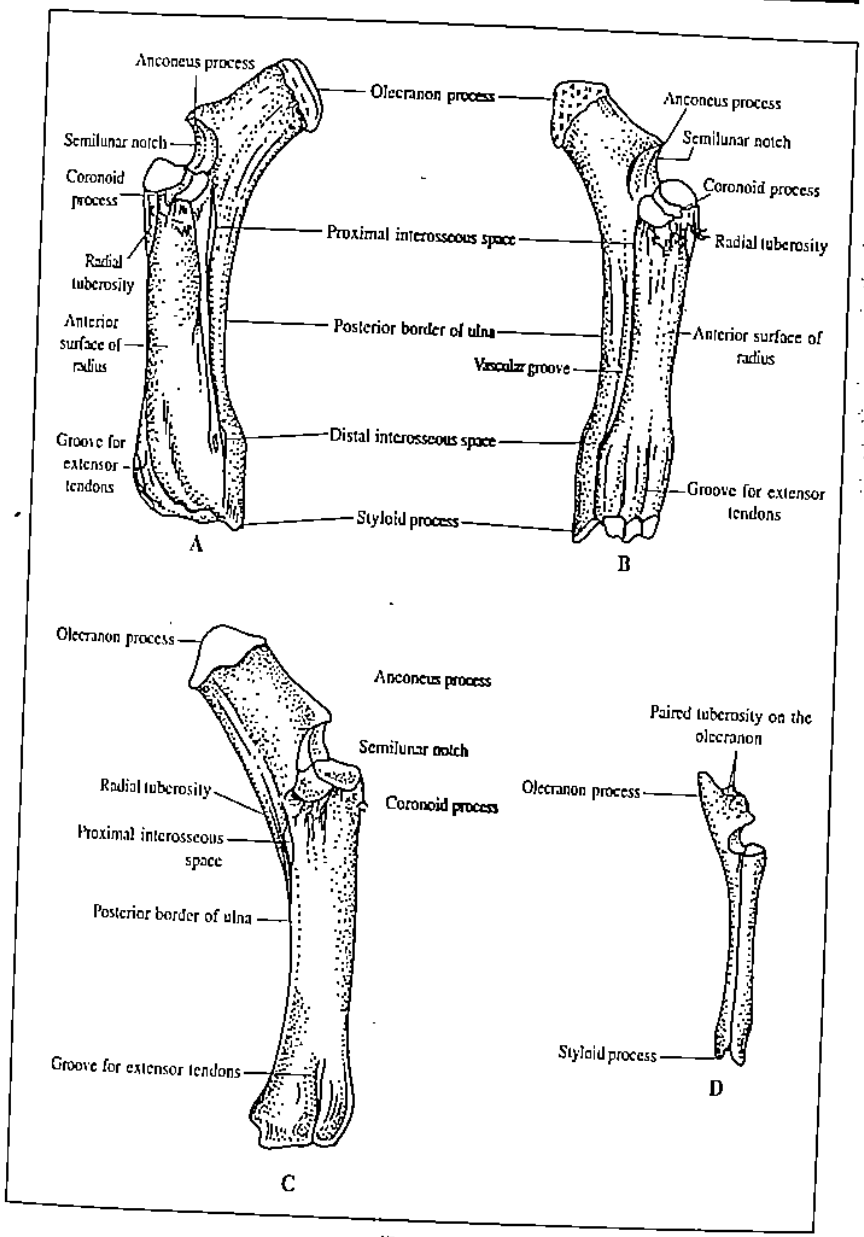


Fig. 2.18

A. Right radius and ulna of ox (Medial view) B. Right radius and ulna of ox (Lateral view) C. Right radius and ulna of horse (Lateral view) D. Right radius and ulna of dog (Lateral view).

RADIUS

It is larger but not longer of the two bones. It is situated in a vertical direction, forms elbow joint with the humerus above and carpal joint with the carpal bones below. The bone is faintly curved and presents a shaft and two ends.

The long shaft is flattened craniocaudally and curved longitudinally. It presents four surfaces. The **anterior surface** is convex, smooth and is occupied by extensor muscles. Below, this surface presents **three grooves** for the accommodation of the tendons of extensor muscles. At the middle of the upper part of this surface there is a rough elevation, known as **radial tuberosity** where biceps brachii muscle inserts. The **posterior surface** is concave and throughout the whole length along the lateral part, it is attached with the cranial surface of the shaft of the ulna excepting at two interosseous spaces. These spaces are proximal and distal. The fusion between the two bones above the proximal interosseous space is not complete. The radial surfaces of the spaces are smooth for the passage of interosseous vessels. **Lateral surface** is rounded and smooth. This surface has formed a vascular **groove** with the same surface of the ulna for the accommodation of interosseous artery. The **medial surface** is smooth and continuous with the anterior and posterior surfaces at its upper part. A little above the middle, there is a rough area for the insertion of brachialis muscle. Rest of the surface is separated from the posterior surface by a ridge.

The **proximal** end articulates with the condyles of the humerus and therefore, possesses two articular surfaces separated by a groove. The cranial rim of this articular surface presents a projection, known as coronoid process. The **medial** and **lateral tuberosities** are placed at the corresponding aspect of this end just below the margin of the articular surface. The lateral tuberosity is well marked.

The **distal** end articulates with the proximal row of carpal bones and presents three **articular surfaces**. The medial one is for radial carpal, middle one is for the intermediate carpal and the lateral facet articulates with the ulnar carpal. The lateral facet is formed partly by the radius and partly by the ulna. All these facets are craniocaudally oblique in direction.

ULNA

This is an ill developed long bone, fused with the radius along its postero-lateral aspect. The shaft is roughly prismatic and therefore, presents three surfaces and three borders. The **anterior surface** is fused with the posterolateral aspect of the radius excepting at the proximal and distal interosseous spaces. This surface at the level of proximal interosseous space is in the form of an arch. At the upper part of this surface there are two articular facets for articulation with the corresponding facets of radius. The medial surface is smooth, concave and blends with the posterior surface of radius and provides accommodation for flexor muscles. Lateral surface is narrow and presents a faint ridge. Out of the three borders, the medial and lateral borders are fused with the radius and the posterior one is smooth and concave on its length.

The **proximal end** is expanded and comprises of one large **olecranon process** and a semilunar notch. The **olecranon process** has two surfaces and two borders. The lateral surface is convex and the medial surface is concave. The summit of this process is tuberous. The anterior border is limited by **semilunar notch** and thereby formed a beak like projection, known as **anconeus process**. This process along with semilunar notch is inserted into the olecranon fossa of humerus during extension of the limb. The semilunar notch is smooth and broader distally.

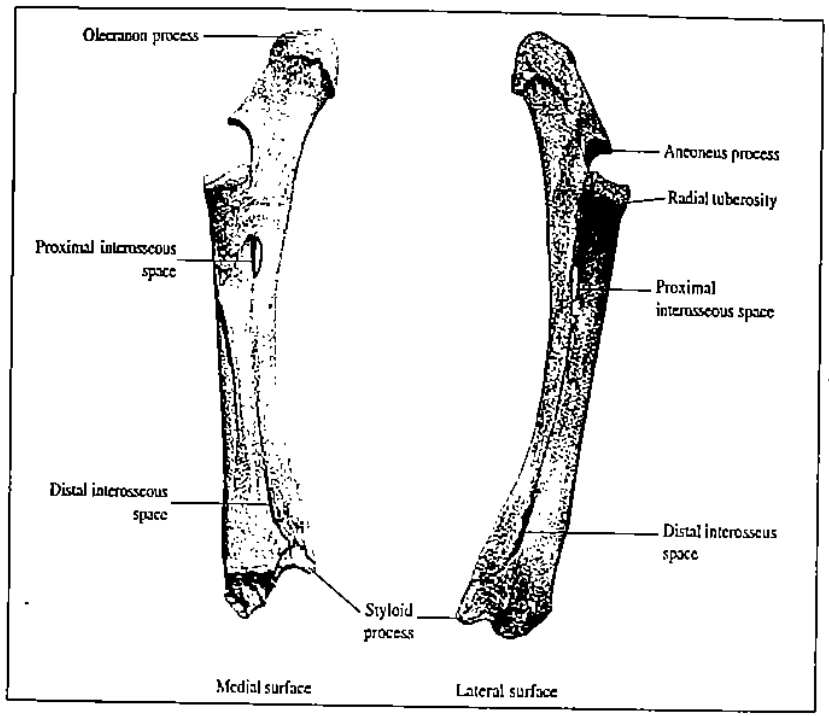


Fig. 2.19 Medial and lateral surfaces of Right radius and Ulna of Ox.

The **distal end** is projected downward and fused with the radius for the formation of the lateral facet for the ulnar carpal bone. This pointed projection is known as **styloid process.**

Radius and ulna of horse

1. Ulna is further ill developed and extends only up to the distal third of radius and therefore, only one interosseous space is formed.
2. The radial tuberosity is well marked.
3. At the distal third of the posterior surface a tuberosity is present close to the medial border. This is for the superior check ligament.
4. The medial surface of the olecranon process is more concave.
5. Semilunar notch is more extensive.
6. The facets at the carpal articular surface at the distal end are not obliquely directed as found in cow.

Radius and ulna of dog

1. They are two separate bones and are in contact with each other by their ends.
2. The interosseous space is narrow and is extended throughout the length of the bones.

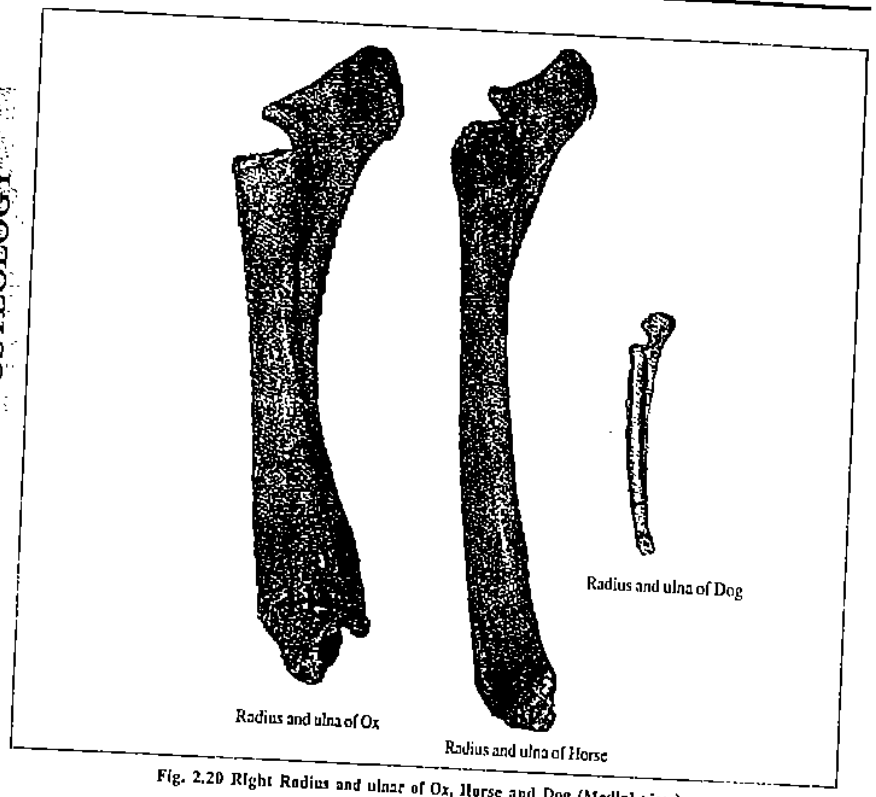


Fig. 2.20 Right Radius and ulnar of Ox, Horse and Dog (Medial view).

3. Proximal end of radius presents only one articular facet for lateral condyle of the humerus. The medial condyle of humerus articulates with a facet on the semilunar notch of ulna.

4. The olecranon process at its anterior part presents a pair of small tubercles.

Radius and ulna of pig

1. Radius is comparatively thin and short.
2. The ulna is massive and the body is curved backward.
3. The interosseous space is very narrow due to close apposition of both the bones.

Radius and Ulna of rabbit

1. These are two separate bones but cannot move over one another.
2. Interosseous space is very narrow or practically absent.
3. Olecranon process is blunt.

Radius and ulna of fowl

1. Ulna is comparatively massive.

2. Both the bones are in contact at two ends.
3. The interosseous space is wide.
4. Semilunar notch is not well marked.

CARPALS

These are six short bones arranged in two rows between the radius and ulna above and metacarpal bones below. The proximal row consists of Radial Carpal (**Scaphoid**), Intermediate Carpal (**Semilunar**), Ulnar Carpal (**Cuneiform**) and Accessory Carpal (**Pisiform**). The distal row has two bones—second and third fused Carpal (Os magnus) and fourth Carpal (**Uneiform**). The first one at the distal row is absent in this species.

CARPALS OF POXIMAL ROW

Radial carpal (Scaphoid)

It is placed at the medial aspect of the proximal row. All the six surfaces are irregular. The dorsal articular surface of this bone of left leg presents an irregular outline which resembles the map of Africa. The ventral surface has an anterior convexity and a posterior concavity. Anterior medial and posterior surfaces are continuous and rough. The lateral surface is articular.

Intermediate carpal (Semilunar)

It is situated between the radial and ulnar carpal bones. Anterior surface is non articular and broad. Posterior surface is narrow. Lateral and medial surfaces are articular. The dorsal articular surface resembles a bicycle seat. Ventral surface is ridged and articulates with 2nd and 3rd fused and fourth carpal bones.

R	I	U	A
2 + 3		4	

Ulnar carpal (Cuneiform)

This bone is more irregular and compressed laterally. It is placed at the lateral aspect of the proximal row in an oblique manner. The dorsal articular surface presents an obliquely placed concave facet for styloid process of ulna. Ventral surface articulates with the fourth carpal. There is an elongated facet at its posterior border for accessory carpal bone.

Accessory carpal (Pisiform)

It is roughly a rounded structure. Anterior surface presents an concave articular facet for articulation with the ulnar carpal bone.

CARPALS OF DISTAL ROW

Second and third fused carpal (Os magnus)

This is larger of the two bones of this row. This is formed by the fusion of second and third carpal bones. It is placed at the medial aspect of the joint. Anterior and medial surfaces are nonarticular,

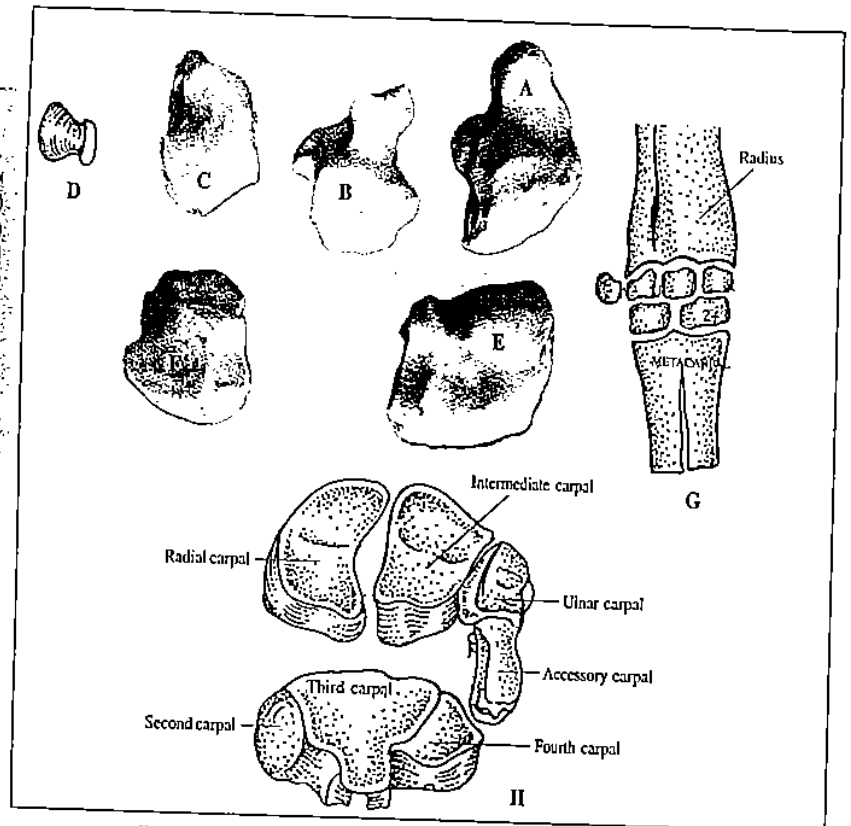


Fig. 2.21 Carpal bones of right limb of ox and horse (Postero dorsal view).
A. Radial carpal B. Intermediate carpal C. Ulnar carpal D. Accessory carpal E. Second and third fused carpal F. Fourth carpal G. Diagramatic figure of right carpal set of ox (Front view) H. Carpal bones of horse-right set (Postero-dorsal view).

smooth and continuous. The lateral surface is articular and irregular. Dorsal surface is concave and divided into two unequal halves by a ridge. This surface articulates with radial carpal and partly with intermediate carpal. Ventral surface is flat and articulates with the proximal end of large metacarpal bone. Posterior surface is continuous with the dorsal surface.

Fourth carpal (Unciform)

This bone is situated at the lateral aspect of the carpus. Anterior and lateral surfaces are non articular and continuous. The medial surface articulates with the second and third fused bone. Posterior surface is irregular. Dorsal surface articulates with the intermediate carpal and ulnar carpal.

Carpal bones of horse

There are total seven bones in the carpus of horse, four in the proximal row and three in the distal row. Proximal row bones are radial carpal, Intermediate carpal, Ulnar carpal and Accessory carpal.

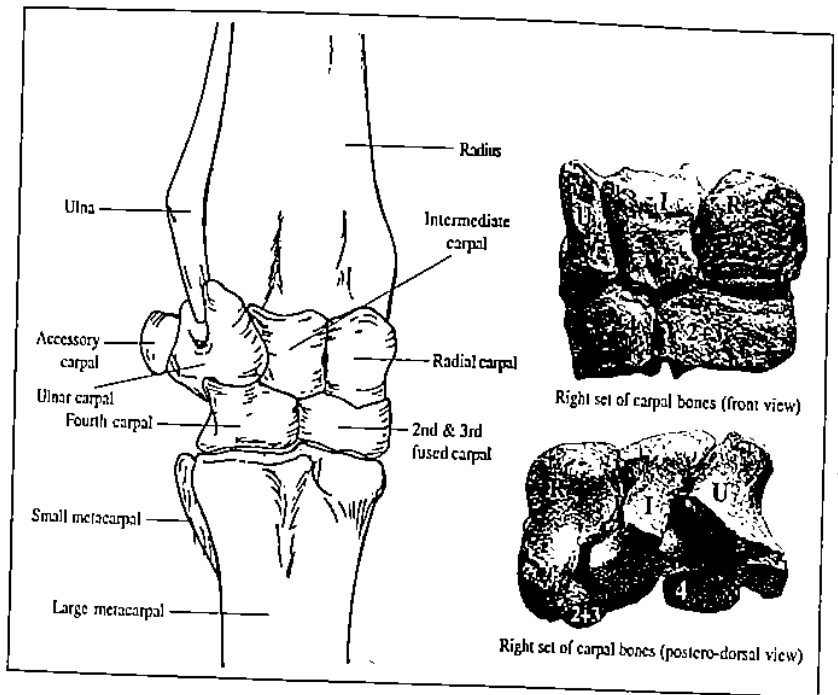


Fig. 2.22 Right carpus of cow (front view).

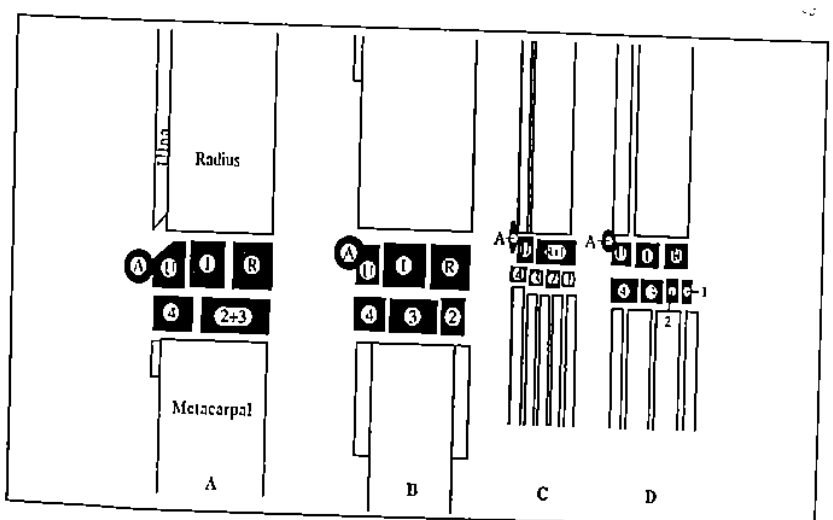


Fig. 2.23 Disposition of carpal bones in Ox (A), Horse (B), Dog (C) and Pig (D).
R – Radial carpal, I – Intermediate carpal, U – Ulnar carpal, A – Accessory carpal, 1–4 – Carpal bones of the distal row.

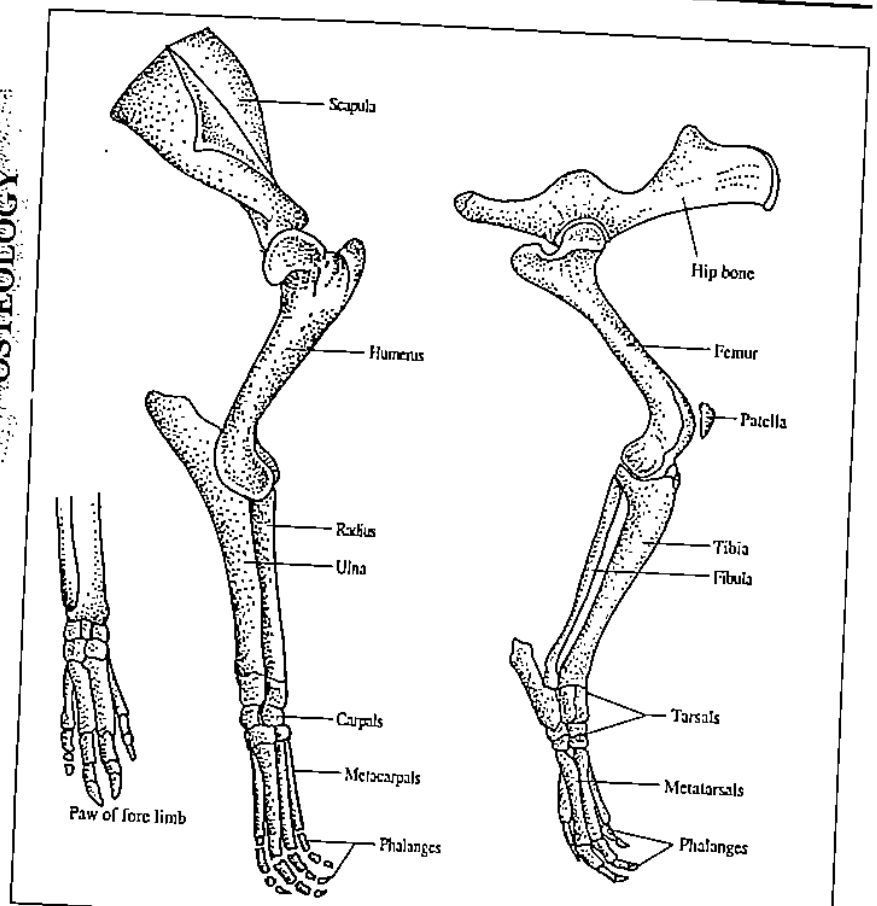


Fig. 2.24 Bones of fore limb and hind limb of pig.

The distal row bones are second carpal, third carpal and fourth carpal. Occasionally the first carpal in the form of small nodule is found.

R	I	U	A
2	3	4	

Carpal bones of dog

There are seven bones in the carpus of dog; three at the proximal and four at the distal row. The bones of the proximal row are radial and intermediate fused carpal, ulnar carpal and accessory carpal. The bones of the distal row are first carpal, second carpal, third carpal and fourth carpal.

R+I		U	A
1	2	3	4

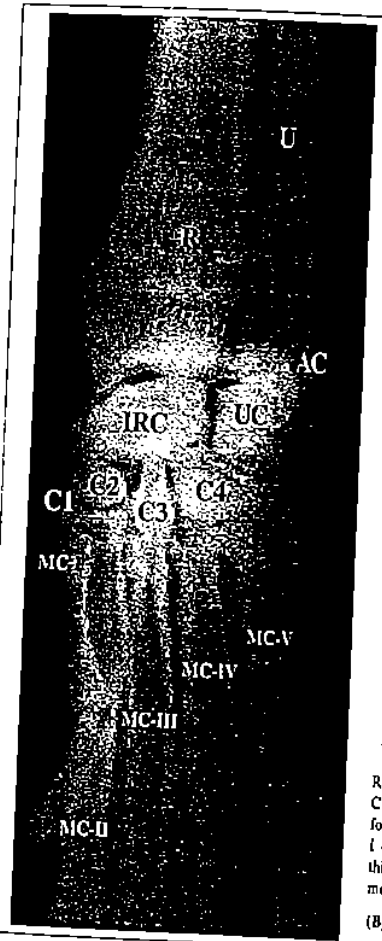


Fig. 2.25 Radiograph of posterio-anterior or palmo-dorsal view of the carpus of right forelimb of dog. R – radius, U – ulna, IRC – intermediate-radial fused carpal, C1 – first carpal, C2 – second carpal, C3 – third carpal, C4 – fourth carpal, UC – ulnar carpal, AC – Accessory carpal, MC-I – first metacarpal, MC-II – second metacarpal, MC-III – third metacarpal, MC-IV – fourth metacarpal, MC-V – fifth metacarpal.

(By courtesy Dr. Rajesh Mondal)

Carpal bones of pig

There are eight carpal bones in the carpus of pig. Proximal row bones are radial carpal, intermediate carpal, ulnar carpal and accessory carpal. The distal row bones are 1st, 2nd, 3rd and 4th.

R	I	U	A
1	2	3	4

Carpal bones of rabbit

In rabbit there are eight carpal bones. Proximal row has three and distal row has five carpal bones. Proximal row bones are Radial, Intermediate and Ulnar. The distal row bones are 1st, 2nd, 3rd, central and 4th and 5th fused.

R		I		U
1	2	3	C	4 + 5

Carpal bones of fowl

There are two bones—Radial carpal and ulnar carpal at the proximal row. The distal row bones are fused with the metacarpal bones.

METACARPAL BONES

There are two metacarpal bones in ox. One is large and the other is small.

Large metacarpal bone

This is also sometimes referred as **cannon** bone.

It represents third and fourth metacarpal bones. The fusion of the two bones are well marked by grooves externally and by the presence of double medullary cavities inside.

The shaft is irregularly cylindrical and presents two surfaces. The **anterior surface** is convex from side to side and blended with lateral and medial surfaces. At the middle there is a vertical groove along the lenght of the bone. There are two foramina, one at the proximal part and other at the distal part of this groove. They communicate with the similar foramina at the posterior surface. The **posterior surface** is flat and broad at both the ends. This surface also presents a vertical groove and two foramina and accommodates the superior sesamoidean ligament.

The **proximal end** presents two articular facets. The medial one is large and articulates with second and third fused carpal bone. The lateral facet is small and articulates with fourth carpal bone. Below the lateral facet there is another small articular area for small metacarpal bone. The metacarpal tuberosity is situated at the anteromedial aspect of this end. The distal end is divided by a cleft into two condyles. Each condyle is divided into two articular areas by a ridge. These condyles articulate with the corresponding proximal ends of first phalanges. At the posterior aspect and just above the condyles there are four depressions. Each of these depressions gives accommodation to the concerned sesamoid bone of the proximal row.

Small metacarpal bone

This is small elongated piece of bone situated at the postero lateral aspect of the large metacarpal bone. It is broader at its proximal end and narrow at the distal end. In most of the cases it remains fused with the large metacarpal bone.

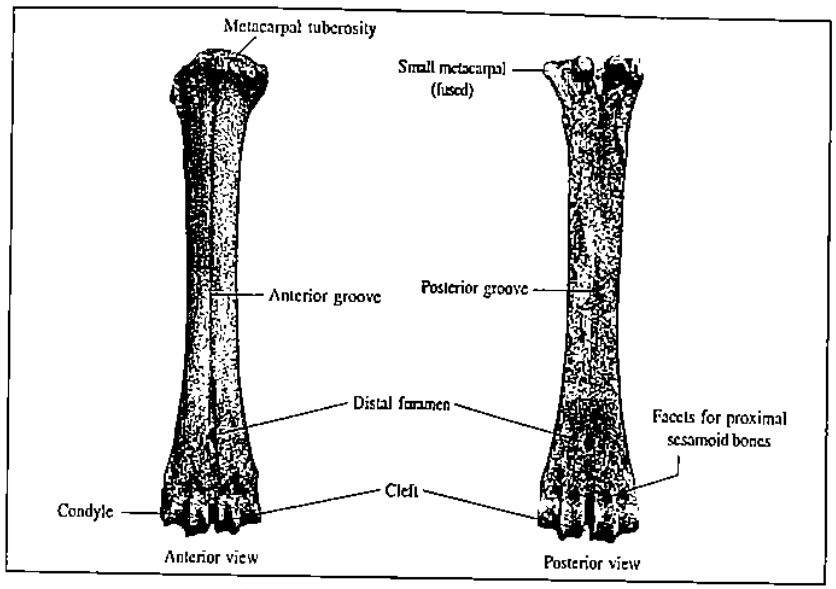


Fig. 2.26A Left large metacarpal bone of ox.

Metacarpal bones of horse

There is one large metacarpal bone representing the third and two small metacarpals representing second and fourth. The large metacarpal is a long cylindrical and a massive bone. Anterior surface is rounded. The posterior surface presents on either sides two facets for the articulations with the small metacarpal bones. The proximal end is broad and presents facets for small metacarpals. The metacarpal tuberosity is prominent. The distal end resembles one condyle of the distal end of the metacarpal bone of ox. The small metacarpal bones are lateral and medial. The medial bone is slightly larger. The proximal ends are larger and articulate with the large metacarpal. The distal ends are pointed. Small metacarpal bones in horse are known as **splint bones**.

Metacarpal bones of dog

There are five metacarpal bones in this animal. The first one is shortest. Third and fourth bones are largest and the second and fifth are almost of equal in length. The shafts are antero-posteriorly compressed. The distal ends bear a ridge at the middle and articulate with corresponding first phalanges. The proximal ends are articular and collectively form facets for the carpal bones. There are two sesamoid bones for each metacarpal bone.

Metacarpal bones of pig

Metacarpal bones are four in number. The first one is absent. Second and fifth are small and the third and fourth are well developed. The second and fifth bones are placed caudally.

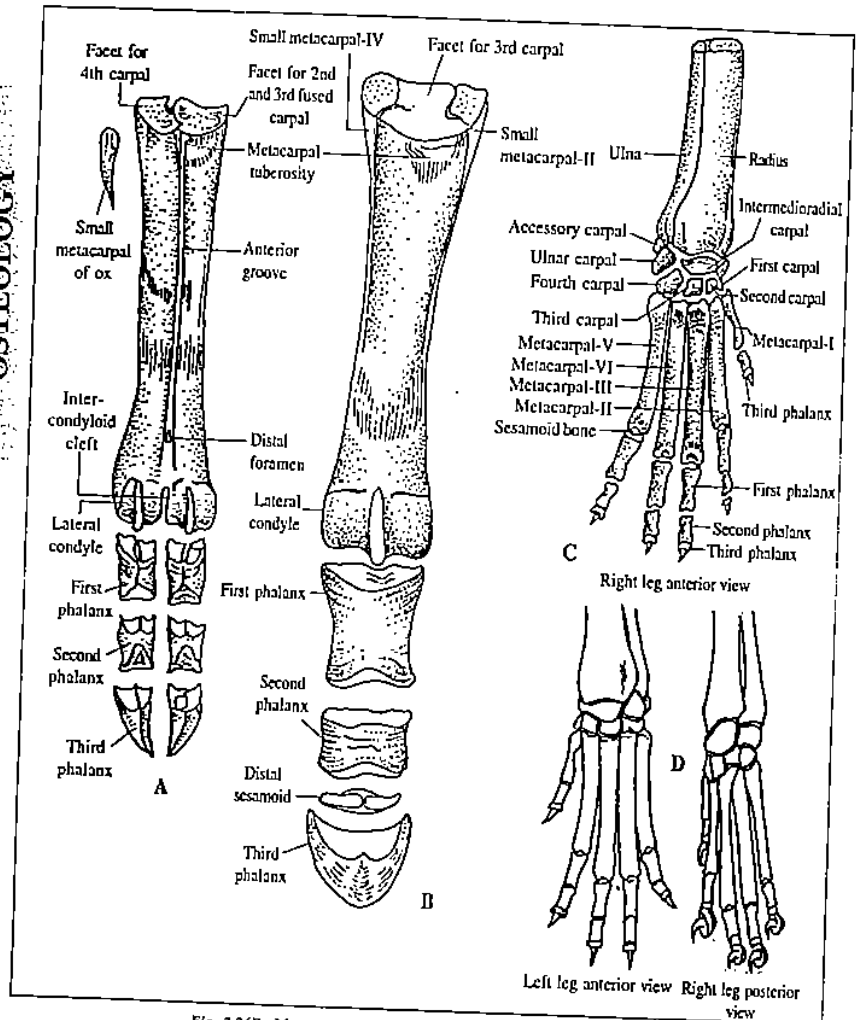


Fig. 2.26B Metacarpals and phalanges of ox, horse and dog.
A. Metacarpal and phalanges of right leg of ox (Anterior view) B. Metacarpal and phalanges of right leg of horse (Anterior view) C & D. Carpals, metacarpals and phalanges of dog.

Metacarpal bones of rabbit

A rabbit has five metacarpal bones in each leg. They are all cylindrical in shape. First one is smallest and third and fourth are longest.

Metacarpal bones of fowl

Three metacarpal bones (I, II and III) fuse with the distal row of carpal bones and form an irregular D shaped structure, known as Carpometacarpus.

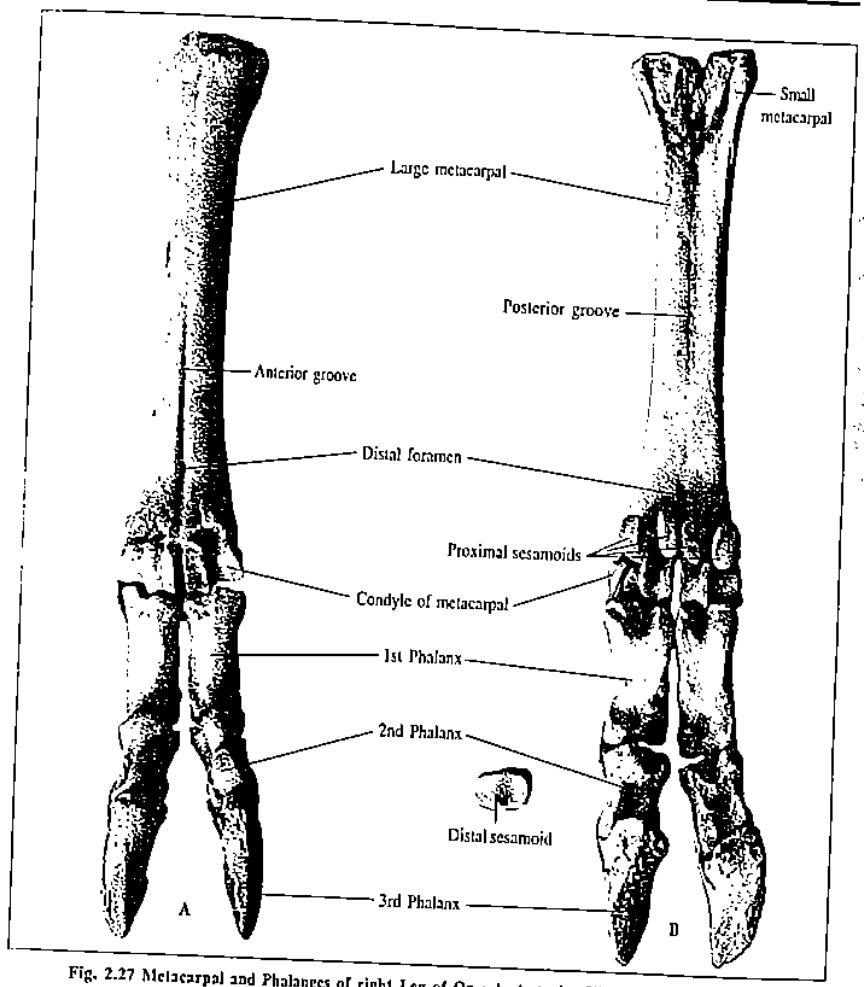


Fig. 2.27 Metacarpal and Phalanges of right Leg of Ox ; A. Anterior View, B. Posterior View.

PHALANGES

Two fully developed digits (3rd, and 4th) are present in the ox. Second and fifth digits are rudimentary and remain as dew claws at the posterior aspect of the metacarpo-phalangeal joint without forming any articulation with any bone.

Each of the developed digits has three phalanges.

First phalanx—It is an elongated bone situated between the large metacarpal bone and second phalanx in downward and forward direction. The anterior and lateral surfaces are continuous. Axial surface is flat and rough. The proximal end is broad and bears a concave articular surface,

which is divided by a anteroposterior groove. The lateral portion is larger. Posteriorly there are two articular facets for sesamoid bones. The distal end is condyloid. The lateral condyle is larger.

Second phalanx—This is shorter than the first phalanx and situated between the first and third phalanges in downward and forward direction. The shaft has three surfaces. The lateral surface is rounded, and irregularly concave. The posterior surface is flat and the axial surface is depressed. The proximal end presents two concave facets for corresponding condyles of the first phalanx. At the posterior aspect there are two tubercles for the attachment of the tendons of superficial digital flexor muscle. The distal end is condyloid. The lateral condyle is larger.

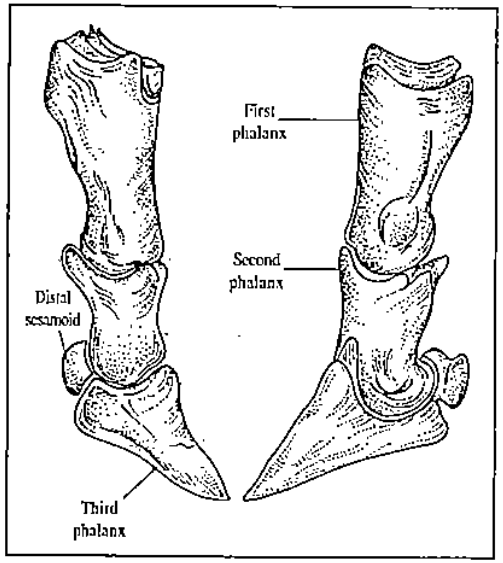


Fig. 2.28 Phalanges of Cow.

Third phalanx—It resembles the shape of a hoof in which the whole of the bone is situated. Proximally it articulates with the distal end of the second phalanx. It presents four surfaces. The abaxial surface is convex, rough and traversed by a antero-posterior groove. At the distal part there are several perforations for vessels. The axial surface is rough above and smooth below. There is a groove at the distal part. The articular surface possesses concavities for the condyles of the second phalanx. Posteriorly there is a facet for distal sesamoid bone. The solar surface is slightly concave and flat.

SESAMOID BONES

Proximal sesamoids—They are four in number in each limb. They articulate with the corresponding facets at the posterior aspect of the distal end of the large metacarpal as well as with the proximal ends of first pair of phalanges. They are two for each digit and the axial bone is larger in size. All the bones are oval elongated in shape. Their anterior surfaces are concave and articular and the posterior surfaces are convex.

Distal sesamoids—They are two in number, one for each digit. They are also called **navicular** bones. Each bone is flat and situated transversely between second and third phalanges. Anterior surface is convex with a ridge at the middle and faces upwards. Posterior surface is flat and also bears a ridge at the middle.

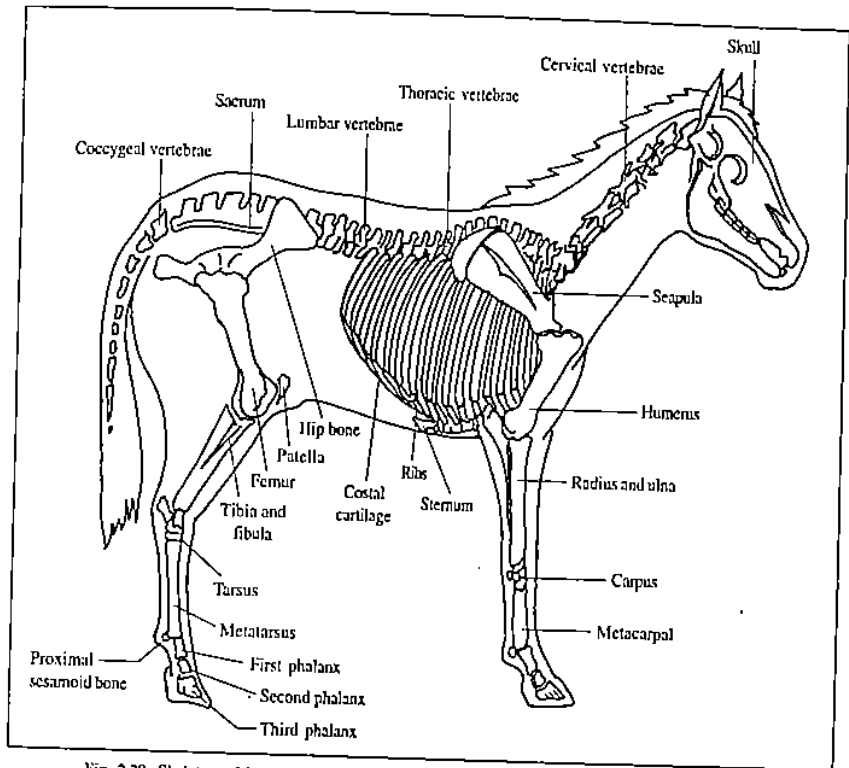


Fig. 2.29 Skeleton of horse (Legs and ribs of one side only has been drawn to get a clear view).

Phalanges of horse

Since there is only one digit in horse, the manus consists of one first phalanx, one second phalanx, one third phalanx and three sesamoid bones.

The first phalanx is long as well as wide. Anterior surface is convex and smooth. Posterior surface is flat and marked by a triangular rough area for distal sesamoidean ligament. The second phalanx is short and anteroposteriorly compressed. The width is more than length.

The third phalanx resembles the shape of the hoof and is covered by it. It has three surfaces — anterior, solar and articular.

In the horse there are two proximal sesamoid and one distal sesamoid bones. They are comparatively larger than those of ox.

Phalanges of dog

The first digit is underdeveloped and possesses only two phalanges. Other four digits have three phalanges each. Third and fourth digits have maximum length. Each first phalanx has four surfaces.

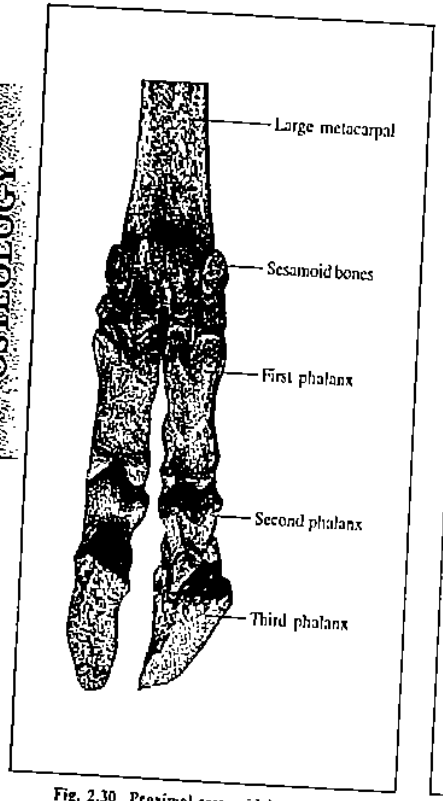


Fig. 2.30 Proximal sesamoid bones and phalanges of ox (Posterior view).

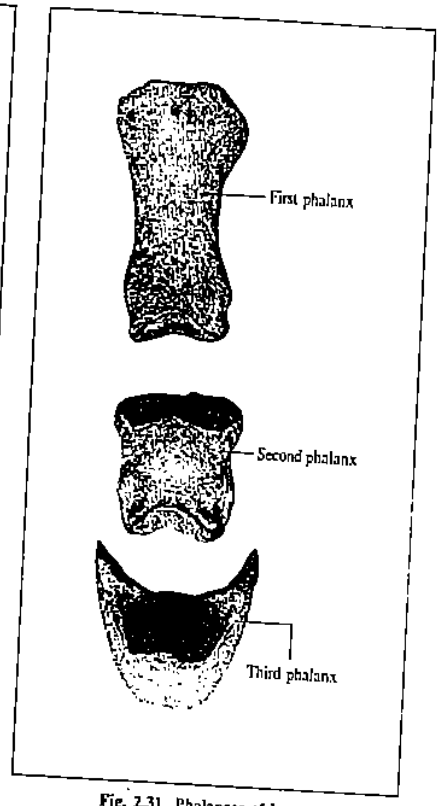


Fig. 2.31 Phalanges of horse (Anterior view).

Proximal end is concave and lower end is trochleated. The second phalanx is short. Its proximal end is concave and the distal end is condyloid. The third phalanx resembles the shape of a claw. Proximal end is articular and bears a bony border around it. Distal end is pointed.

In the dog there are nine posterior (two for each developed digit and one for first) and five anterior sesamoid bones in the proximal group. Distal sesamoids are cartilagenous.

Phalanges of pig

Each digit has three phalanges. The phalanges of third and fourth digits are well developed. The phalanges of second and fifth digits are small and generally do not reach the ground. There are two proximal and one distal sesamoid bones in each digit.

Phalanges of rabbit

The first digit has two phalanges and the remaning four digits have three phalanges each. All the 3rd phalanges bear horny claws.

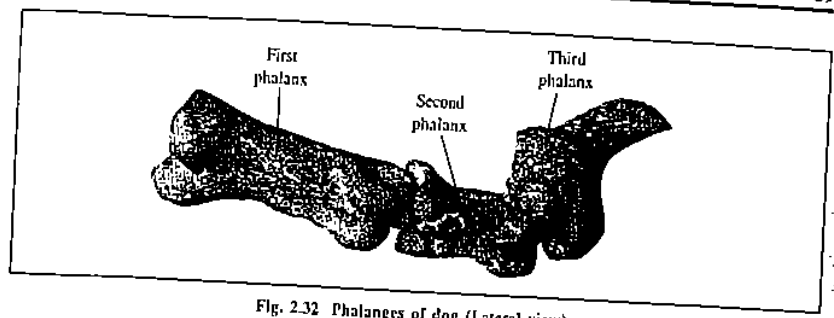


Fig. 2.32 Phalanges of dog (Lateral view).

Phalanges of fowl

There are three digits in the fowl. The first and second digits have two phalanges each and the third digit has only one phalanx. They extend in a radiating manner from the corresponding area of carpometacarpus.

BONES OF THE HIND LIMB

HIP BONES (*OS COXAE*)

The bony pelvis or pelvic girdle is formed by the right and left hip bones, sacrum and one or two coccygeal vertebrae.

Each hip bone consists of three large flat bones—Ilium, Ischium and Pubis. These bones join together to form a large acetabular cavity which articulates with the head of femur. Hip bones of one side join with those of other side at the pelvic symphysis.

ILIUM

This is a triangular flat bone situated at the craniolateral aspect of the pelvis. It has two surfaces three angles and three borders. The upper part is flat, known as **wing** and the distal angle is narrow and considered as shaft. The dorsal border is thin and concave. The lateral border is thin rough and also concave. The medial border is concave and at the begining of the shaft it divides into one anterior (pubic) and a posterior (ischiatic) border. The anterior becomes continuous with the anterior border of pubis and the posterior one forms the **greater ischiatic notch** and then raised on the cotyloid cavity to form the **superior ischiatic spine**. The *gluteal surface* is smooth and concave. A linear ridge traverse on this surface, parallel to the lateral border and continues distally with the superior ischiatic spine is known as gluteal line. The pelvic surface faces towards the pelvic cavity. There is a triangular articular area at the medial aspect of the wing of this surface for articulation with the sacrum and the lateral part is smooth and remains covered by iliacus muscle. At the middle of the medial surface of the shaft, there is a raised prominence known as **psoas tubercle** for attachment of posas minor muscle. The external angle is known as **tuber coxae**. It is expanded and presents 3 to 4 tuberculus prominences. The internal angle is blunt and inclined backward. This angle is termed **tuber sacrale**, as it articulates with the wings of sacrum. The distal (cotyloid) angle is expanded and

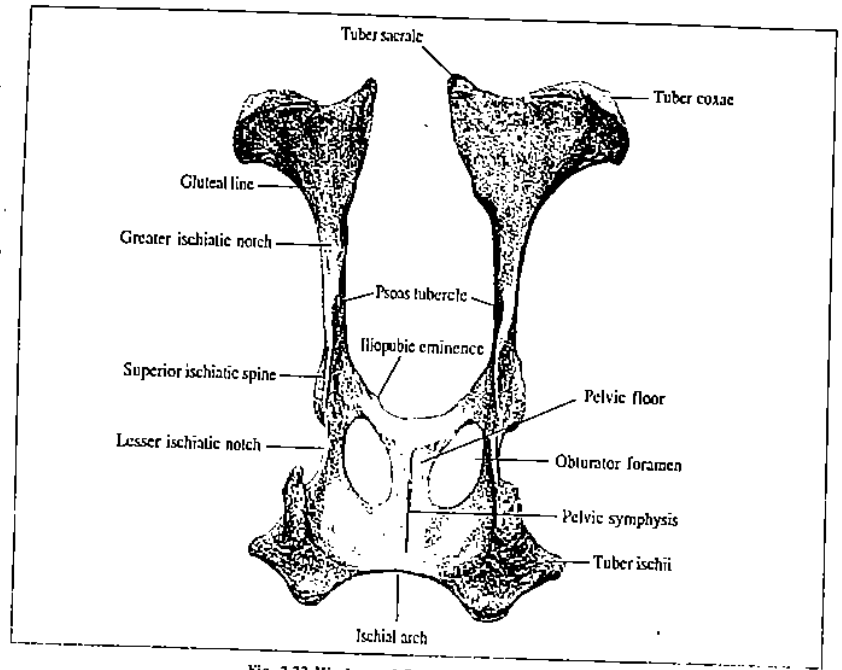


Fig. 2.33 Hip bone of Ox (Caudo - dorsal view)

joins with the corresponding angles of pubis and ischium to form the **cotyloid cavity.** At the anterior aspect of this angle there is a fossa for origin of rectus femoris muscle which may be termed as **supra acetabular fossa.**

ISCHIUM

It is roughly a quadrilateral plate of bone situated behind the pubis and forms most part of the pelvic floor. It has two surfaces, four borders and four angles. The **dorsal (pelvic) surface** is concave, smooth and presents impression of obturator internus muscle close to the obturator foramen. **Ventral surface** is slightly convex and rough for the origin of adductor muscle. The **anterior border** is concave and thin. It forms the posterior boundary of the obturator foramen. The **posterior border** is thick and inclined forward and forms **ischial arch** by joining with its fellow. The **lateral border** is concave and forms the **lesser ischiatic notch.** The medial border joins with the similar border of the bone of the opposite side and forms the **ischial symphysis.** Ventrally at the middle of the symphysis there is a prominence, known as **ventral tubercle.** The anterointernal angle is narrow and joins with the posterior angle of pubis. The antero external angle is wide and joins with the cotyloid angles of ilium and pubis to form cotyloid cavity. The postero-internal angle meets with the similar angle of the other bone at the middle of the ischial arch. Postero-external angle is expanded to form a trifid **ischial tuberosity.** This prominent tuber ischii is sometimes reffered as **pin bone.**

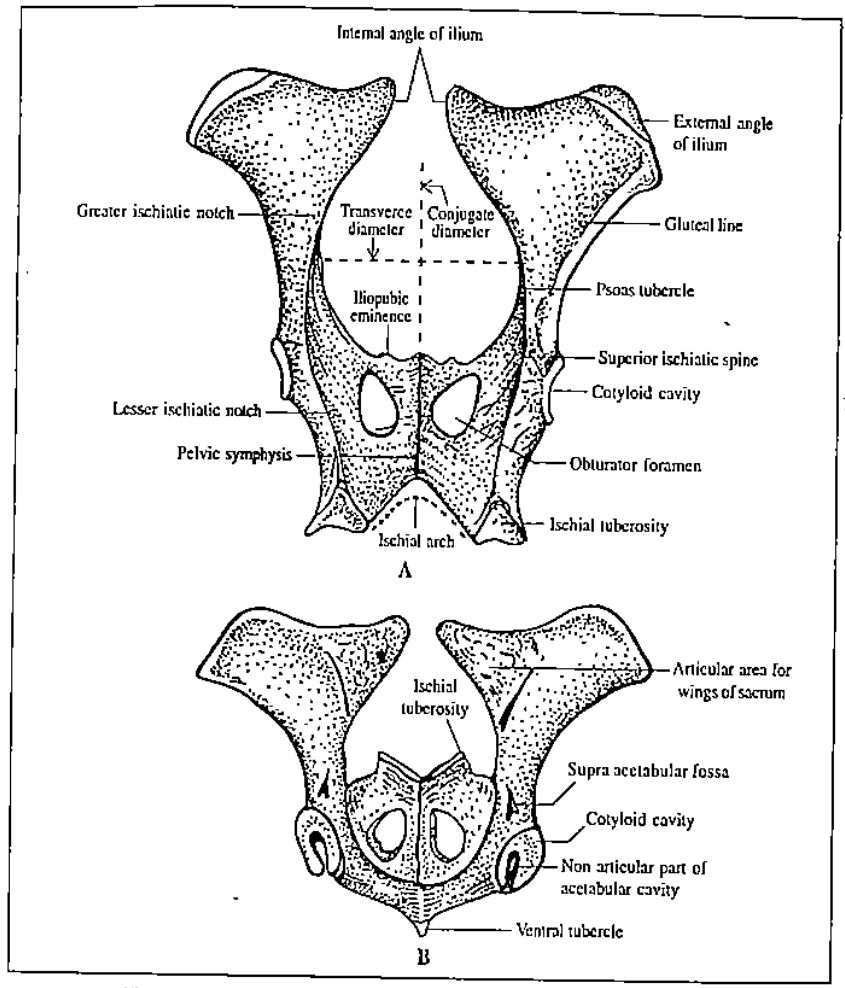


Fig. 2.34 A. Hip bone of ox (Posterior view) B. Hip bone of ox (Anterior view).

PUBIS

It is a small triangular plate of bone situated at the anteromedial aspect of the pelvic floor. It has two surfaces, three angles and three borders. The **dorsal (pelvic) surface** is smooth or sometimes little depressed. It lodges the body of the urinary bladder. **Ventral surface** is convex and rough for muscular attachment. The *anterior border* is thin, little depressed and on the lateral part presents a prominence, known as **iliopubic eminence.** The **lateral border** is thin and concave to form the anterior boundary of the obturator foramen. The *medial border* forms the pubic symphysis along with the same border of the opposite bone.

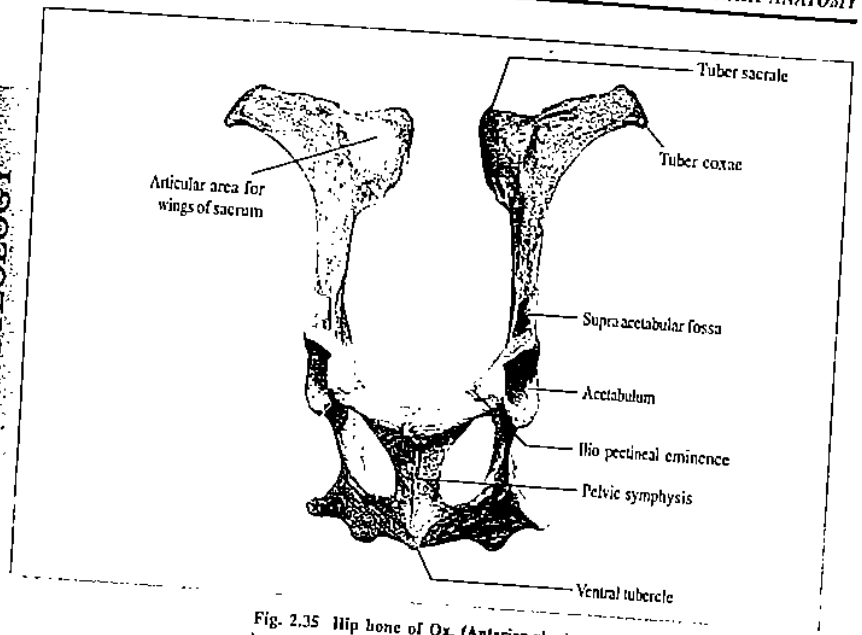


Fig. 2.35 Hip bone of Ox. (Anterior view)

Acetabulum—This is a cotyloid cavity formed by the union for corresponding angles of Ilium, Ischium and pubis and accommodates the head of the femur. It has an outer smooth articular part which is notched at the postero medial aspect. The non-articular part is at the middle and the deep part of this fossa. It is connected with the acetabular notch. A smaller secondary notch is present at the antero-medial border of the cotyloid cavity.

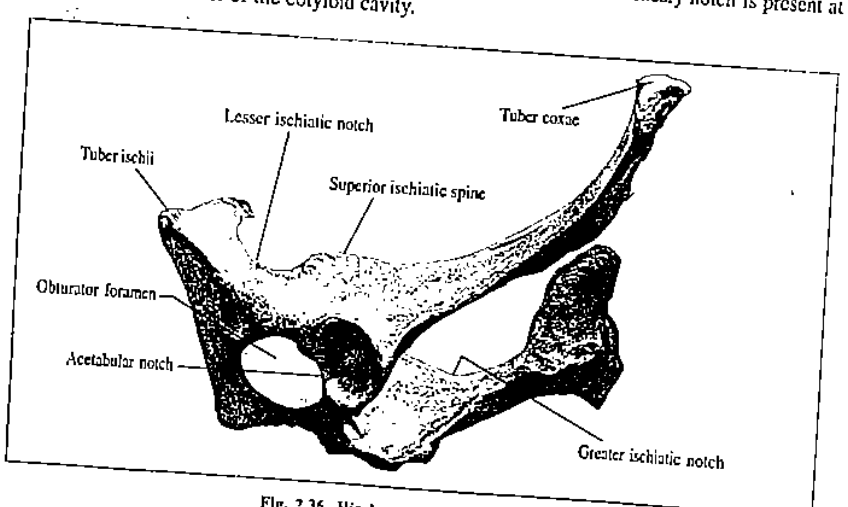


Fig. 2.36 Hip bone of ox (Lateral view).

Obturator foramen—It is the largest foramen of the body situated between the pubis and ischium. It is an oval or egg shaped aperture whose axis is directed outward and forward. In life time it is closed by fibrous membrane and muscles, leaving a narrow space for passage of vessels and nerves.

General Consideration

The cranial opening of the bony pelvis is known as **pelvic inlet.** It is formed by the cranial end of sacrum, shaft of Ilium and the anterior border of pubis. The **pelvic outlet** is smaller and formed by coccygeal vertebra above and ischial arch and ischial tuberosity below. Posterior borders of sacro-sciatic ligaments form the lateral walls of the pelvic outlet. This enclosure is also known as **perinium.** At the pelvic inlet, the length between the body of the sacrum and the cranial end of the pubic symphysis is known as **conjugate diameter** and the distance between the two psoas tubercles is termed as **transverse diameter.**

Differences in the male and female hip bones

1. Both the conjugate and transverse diameters are more in the female.
2. In the female the bone is more inclined forward.
3. Pelvic outlet and ischial arch are larger in female.
4. The ischia of both sides join in more wide angle in female and make the cavity more roomy.

Hip bone of horse

1. It is more inclined forward.
2. Gluteal line is not prominent.
3. Ventral tubercle is absent.
4. The ischial tuberosity is not trifid.
5. The superior ischiatic spine is not sharp.
6. Cotyloid cavity is very wide.
7. Acetabular notch is also wide.
8. The secondary acetabular notch is absent.
9. Tuber sacrale is further inclined backward.
10. Psoas tubercle is underdeveloped.
11. Supra acetabular fossa is not prominent.

Hip bone of dog

1. The ilium of left side and that of right side are almost parallel to each other.
2. The gluteal surface of the ilium is concave.
3. The crest of ilium is strongly convex.
4. Ischium is twisted.
5. Ischial tuberosity is flat.
6. The superior ischiatic spine is blunt and both the greater and lesser ischiatic notches are shallow.
7. Acetabular notch is wide.

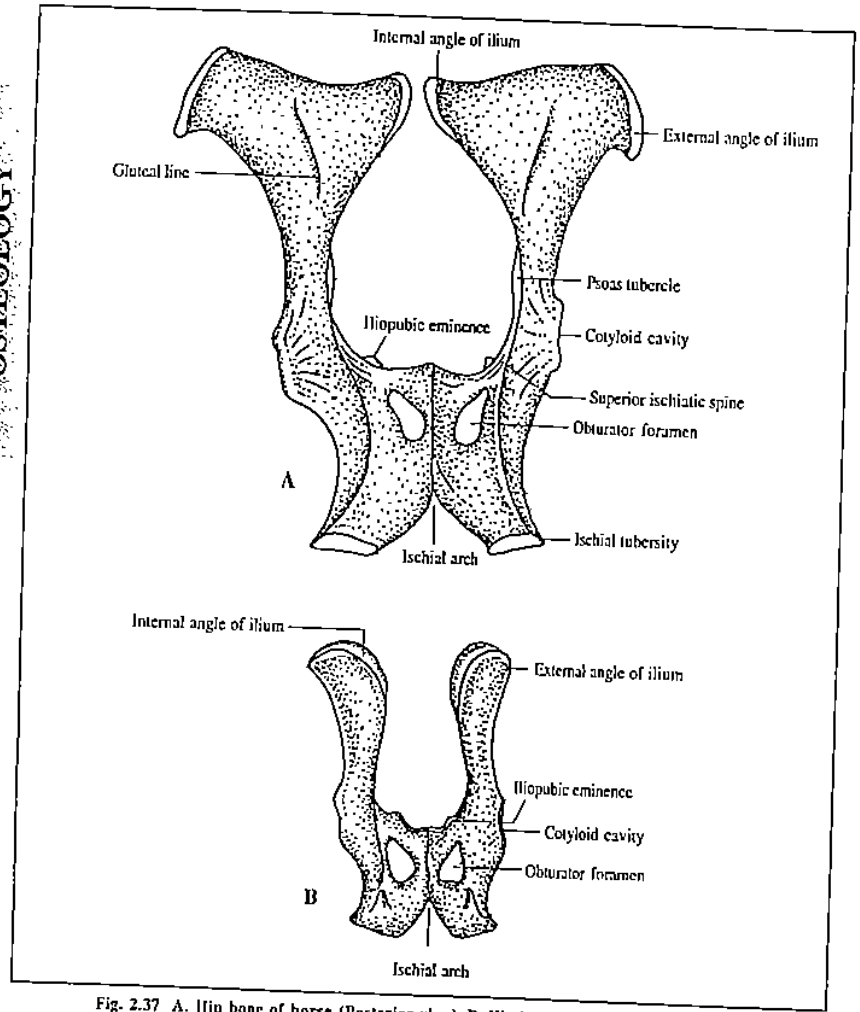


Fig. 2.37 A. Hip bone of horse (Posterior view), B. Hip bone of Dog (Posterior view).

Hip bone of pig

1. The ilium is not much extended laterally.
2. The dorsal border of ilium is convex.
3. The tuber sacrale is inclined caudally.
4. The ischial tuberosity bears three prominences.
5. The psoas and pectineal tubercles are prominent.
6. The rim of acetabulum is thicker.

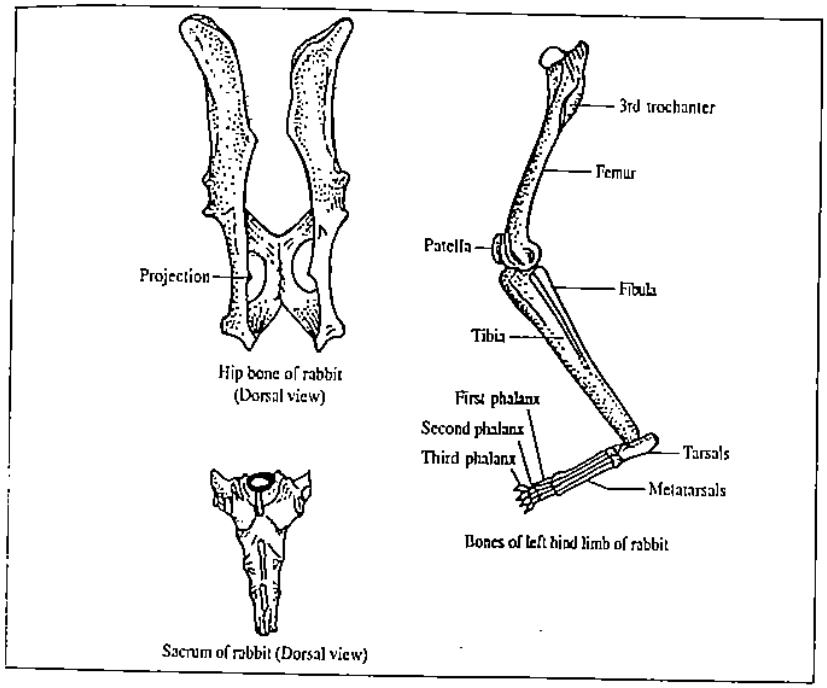


Fig. 2.38

Hip bone of rabbit

1. The whole bone is more inclined forward.
2. Ilium and ischium are almost parallel to the vertebral column.
3. Superior ischiatic spine is blunt and presents a small but sharp projection at its caudal part.
4. Obturator foramen is very large.
5. Just in front and at the lateral aspect of the acetabular cavity a small tuberosity is present.
6. Ischial tuberosity is trifid.
7. Tuber sacrale are blunt and therefore the space between these tubers is wide.
8. Ventral tubercle is absent.
9. It is said that the pubic bone does not take part in the formation of acetabulum because it is separated from the others by a small piece of cotyloid bone.

Hip bone of fowl

1. The ilia are fused with the sacrum.
2. The pubis is long and in the form of a thin elongated stick.
3. The Acetabulum is perforated.
4. Between the ilium and ischium, there is an extra large aparture, known as ilioischiatic foramen.

FEMUR

It is cylindrical and the *largest long bone* in the skeleton. It is directed downward and forward in an oblique manner. This bone articulates with the hip bone above to form hip joint and with tibia, fibula and patella below to form the stifle joint. It has a body and two ends. The body is cylindrical at the middle and three sided below. Since the body appear round in cross section, the femur is sometimes referred as **round bone**. Lateral medial and anterior surfaces are smooth and continuous. They remain covered by quadriceps muscles. The **posterior surface** is not smooth and wide at ends. The **lesser trochanter** is in the form of a small tuberosity, situated at the upper part of the medial border of this surface. There is a rough depression at the medial aspect of the trochanter for the attachment of iliacas and psoas major muscle. Distally the medial border of this surface presents a rough prominence known as **medial supracondyloid crest**. From this crest the medial head of the gastrocnemius muscle originates. At the same level and on the lateral border there is a depression, known as **supracondyloid fossa**. The lateral margin of this fossa is called lateral **supracondyloid crest**.

The upper end comprises of head, neck, greater trochanter, trochanteric fossa and trochanteric ridge. The head is rounded, smooth and is directed medially. It bears a small depression at the middle,

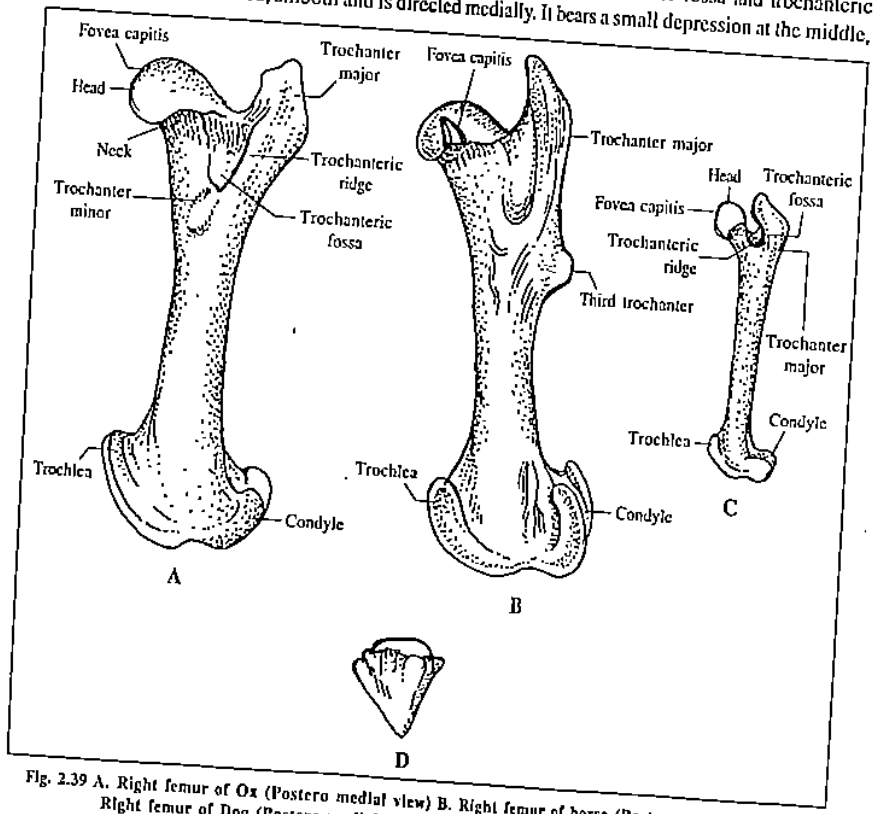


Fig. 2.39 A. Right femur of Ox (Postero medial view) B. Right femur of horse (Postero medial view) C. Right femur of Dog (Postero medial view) D. Right patella of cow (Anterior view).

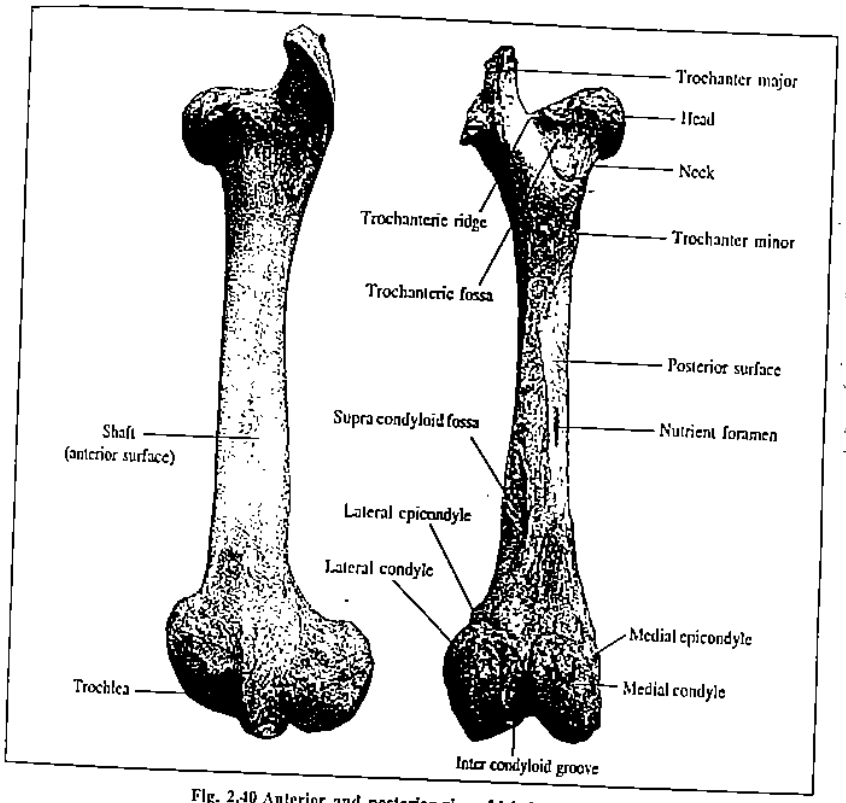


Fig. 2.40 Anterior and posterior view of left femur of Ox.

known as **fovea capitis femoris**. The head is inserted into the cotyloid cavity in the hip joint. The constricted part below the head is known as **neck**. **Greater trochanter** is a large tuberosity situated at the lateral aspect of this end. Its lateral surface is convex and rough. **Trochanteric ridge** connects greater and lesser trochanters. **Trochanteric fossa** is a enclosed depression between the ridge and the head.

The distal end is expanded and consists of condyles and trochlea. The trochlea is situated anteriorly. It presents two ridges which articulate with the posterior surface of the patella. The medial ridge is larger. The condyles, lateral and medial, are situated at the posterior aspect of the bone. The **intercondyloid fossa** is deep and accommodates the spine of tibia. Extensor fossa is present between the lateral ridge of the trochlea and the lateral condyle, which gives origin to the extensor muscles. Medial and lateral epicondyles are small prominences attached to the outer (abaxial) aspect to the corresponding medial and lateral condyles.

Femur of horse

1. The bone is more massive.
2. At the upper part of the lateral border, there is an extra prominence, known as **third trochanter**.

3. Trochanter minor is in the form of a ridge.
4. Fovea capitis is deep and notched.
5. Supracondyloid fossa is deeper.
6. Trochanteric ridge is directed along the length of the bone.

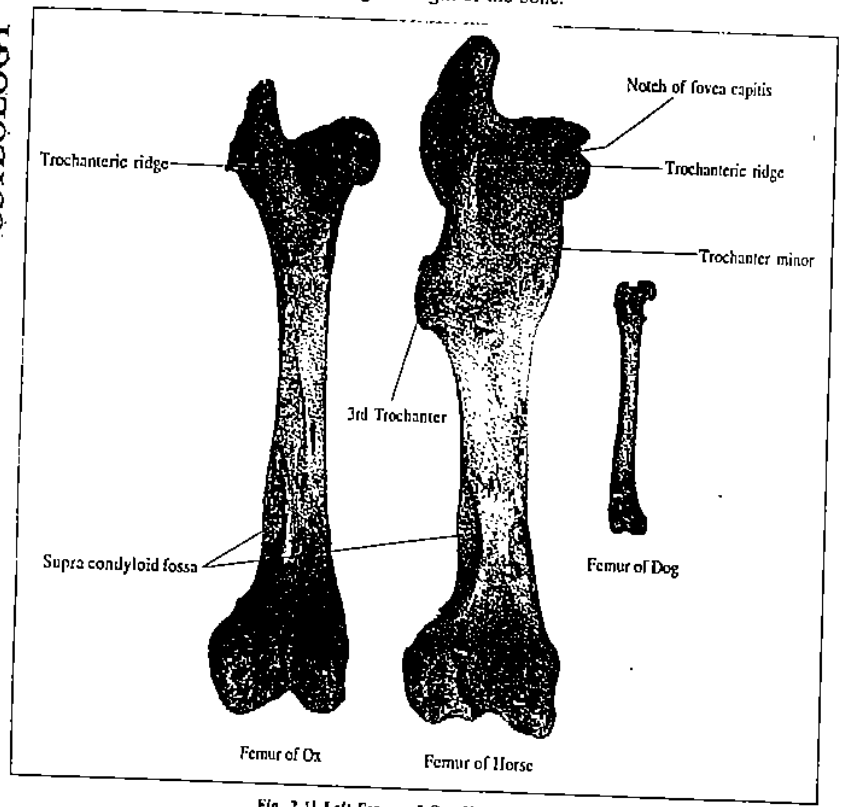
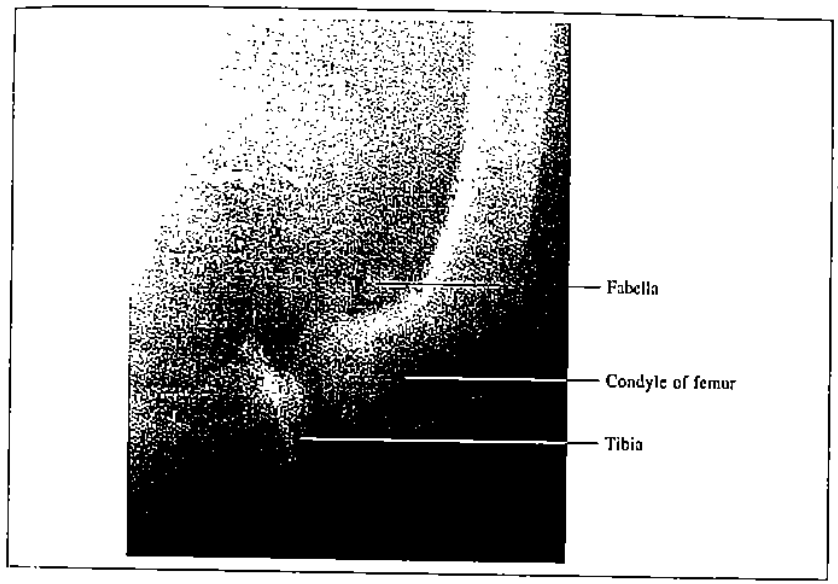


Fig. 2.41 Left Femur of Ox, Horse and Dog.

Femur of dog

1. The supracondyloid fossa is absent.
2. There is no third trochanter.
3. The trochlear ridges are of equal shape and size.
4. Greater trochanter is at a lower level to that of head.
5. Lesser trochanter is tuberculus.
6. Above each condyle and at the posterior aspect of the distal end of the bone presents a facet for the sesamoid bone. These two sesamoid bones are sometimes called Fabella and probably work as sesamoids for gastrocnemius muscle.



X-ray of stifle joint of dog.
(By Courtesy Dr. Subir Bhattacharya)

Femur of pig

1. The bone is well built.
2. Head is more curved.
3. The greater trochanter does not extend above the head.
4. Third trochanter is absent.
5. Trochlear ridges are of equal size.

Femur of rabbit

1. The bone is comparatively long.
2. Just little below the proximal end a third trochanter is present at the lateral aspect. This has a close similarity to that of horse.
3. Trochlear ridges are almost equal.
4. Supracondyloid fossa is absent.

Femur of fowl

1. The head is comparatively small and rough.
2. Only the greater trochanter is present.
3. The trochlear ridges are widely apart.
4. The bone is bent along the length.

PATELLA

This is a triangular sesamoid bone placed in front of the trochlea of femur. It has two surfaces, three borders and three angles. The anterior surface is rough and convex. The posterior surface is smooth, presents a vertical ridge and articulates with corresponding groove of trochlea. The dorsal border is convex and known as base. Lateral and medial borders are irregular. Medial angle is large. Lateral angle is blunt. The ventral angle is pointed and called apex.

Patella of horse

1. It is not as triangular as in ox.
2. The apex is blunt.
3. The medial and lateral borders also meet at the base at an wide angle.
4. The medial and lateral angles are not prominent.

Patella of dog

1. The bone is comparatively longer.
2. The anterior surface is more convex.
3. Posterior articular surface is concave along the length and convex across the width.

Patella of pig

1. Smaller in size.
2. It has three surfaces.

Patella of rabbit

1. The bone is triangular but elongated.
2. Apex is blunt.
3. Base is comparatively narrow.

Patella of fowl

1. It is thin triangular bone.
2. The width is comparatively more.

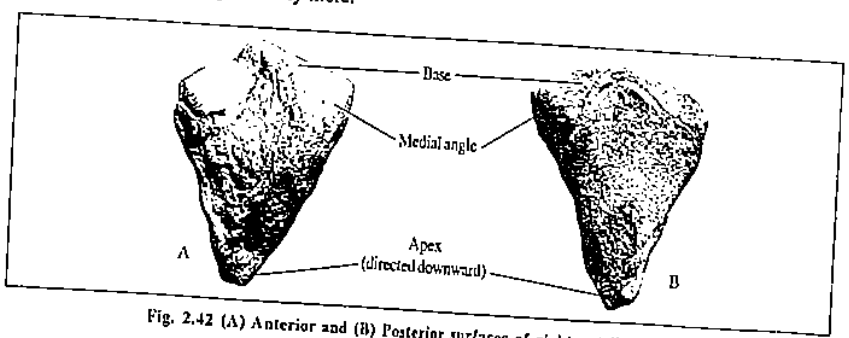


Fig. 2.42 (A) Anterior and (B) Posterior surfaces of right patella of Ox.

TIBIA

It is a strong and massive long bone extends obliquely downward and backward from stifle to hock. It presents a body and two ends.

The shaft is expanded and prismatic at its upper part and narrow and flat at its lower part. The bone is twisted in appearance. **Lateral surface** is faintly concave and gradually spiral down to the front. This surface accommodates anterior tibial and complex muscles. **Medial surface** is wide above and narrow below. Sartorious, gracilis and semi-membranosus muscles are attached here. **Posterior surface** is rough and traversed by a number of rough lines for the attachment of flexor muscles. These are known as popliteal lines. There is a smooth triangular area at the upper part and close to the medial aspect for the attachment of popliteus muscle. The upper part of the anterior border is very prominent and termed as **tibial crest**. At the distal part of the crest, towards the medial aspect, there is a small prominence for insertion of semitendinosus muscle. The distal part of this border is not prominent. *Lateral border* is concave and in life, it forms an interosseous space with the attachment of fibrous cord of the fibula. The *medial border* is rounded.

The **proximal extremity** is expanded and presents two condyles (lateral and medial) and a tuberosity. The tuberosity is blunt and situated above the tibial crest. It is separated from the lateral condyle by **sulcus muscularis**. This sulcus gives passage to the tendons of extensor muscles. The condyles are articular prominences. These are saddle shaped structures, articulate with the corresponding condyles

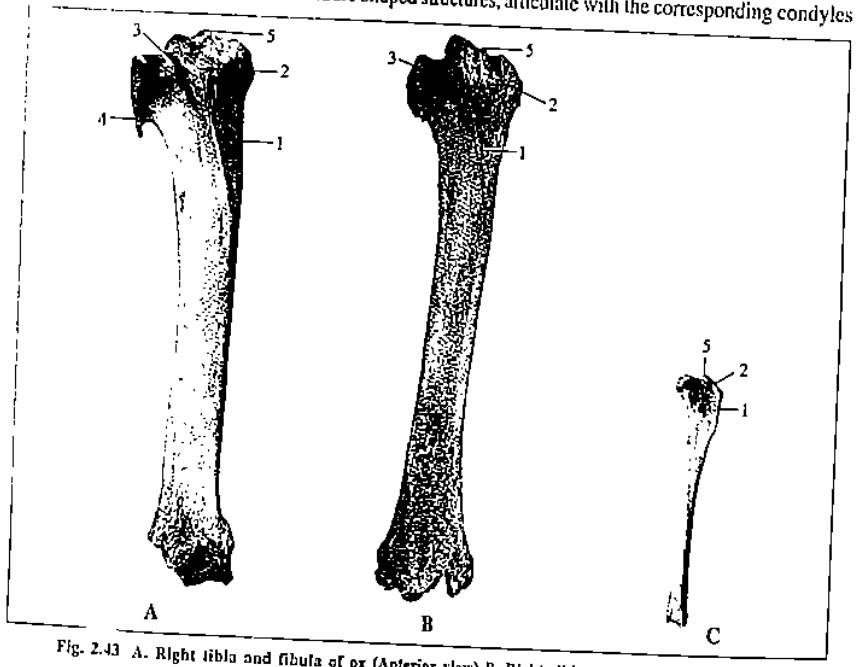


Fig. 2.43 A. Right tibia and fibula of ox (Anterior view) B. Right tibia of horse (Anterior view) C. Tibia and fibula of dog (Anterior view).
1 – Tibial crest, 2 – Anterior tuberosity, 3 – Sulcus muscularis, 4 – Fibula, 5 – Interosseous space, 6 – Spine.

of femur. The tibial spine is the intercondyloid eminence and is bifid. The medial part is more projected upwards. The peripheral part of the articular surfaces of the condyles are flat. Upon each condyle corresponding miniscus rests. The **popleteal notch** separates the condyles at the posterior aspect. The head of the rudimentary fibula is attached to the lateral part of lateral condyle.

The distal extremity presents two grooves for articulation with the ridges of tibial tarsal bone. The lateral border of the lateral groove articulates with lateral malleolus, a small separate piece of bone. This malleolus bone has two surfaces and four borders. Ventrally it articulates with the fibular tarsal. Dorsally it possesses a small spine and articulates with tibia. The anterior and posterior borders are convex. The medial border of medial groove of the distal end of tibia projects ventrally as it is fused with medial malleollus.

Tibia of horse

1. The bone is larger and longer.
2. The sulcus muscularis is wider.
3. There is a facet below and lateral to the lateral condyle for the head of fibula.
4. Anterior tuberosity is grooved.
5. The grooves at the distal end for the ridges of tibial tarsals are oblique.
6. Both melleoli bones are fused at the distal end of tibia.

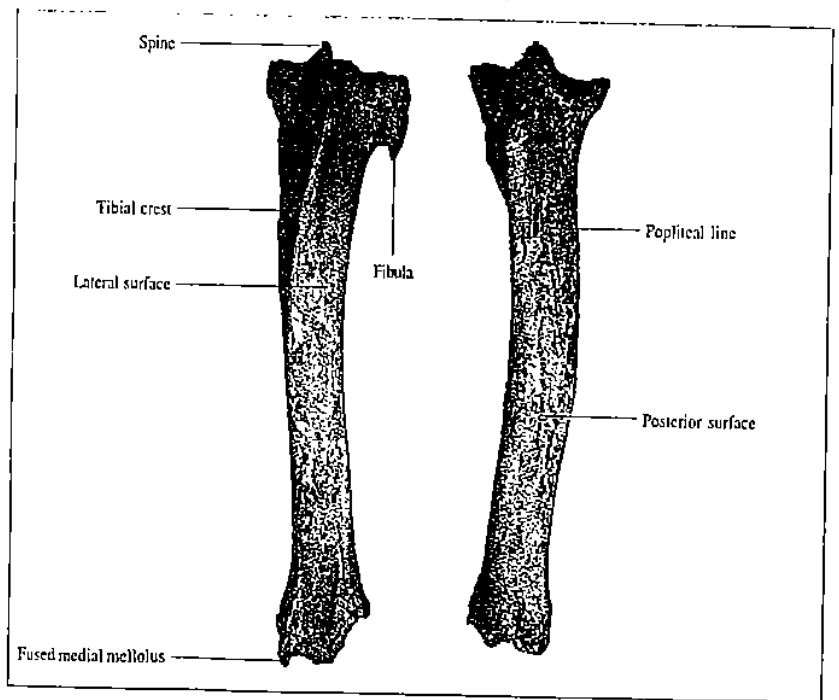


Fig. 2.44 Anterior and Posterior view of Left tibia and fibula of Ox.

Tibia of dog

1. The shaft along the length is convex medially at the upper part and again convex laterally at the lower part.
2. Tibial crest is very prominent.
3. Upper part of the body is prismatic and lower part is cylindrical. The cylindrical part presents a facet laterally for articulation with the fibula.
4. At the proximal end, caudolateral to the lateral tuberosity, there is a facet for the proximal end of fibula.

Tibia of pig

1. The general feature has a similarity with that of cow.
2. Anterior tuberosity is grooved.
3. It presents a proximal and a distal facet for the ends of the fibula at the lateral aspect.
4. The sulcus is narrow.

Tibia and fibula of rabbit

1. The distal end of fibula is completely fused with the distal third of the tibia.
2. Spines are blunt.
3. The tibial crest in prominent and sharp.
4. The popliteal line is usually single.
5. Fibula is thin and there is an elongated interosseous space between the two bones.

Tibia of fowl

1. The bones of the proximal row of tarsus are fused with the distal end of the tibia and hence it is called tibiotarsus.
2. Tibial crest is prominent.
3. Distal end is condyloid.
4. This is the longest bone in the body.

FIBULA

This bone is highly rudimentary in ox. The proximal end (head) is fused with the lateral condyle of tibia. The body and the distal end remains as a blunt prolongation.

Fibula of horse

1. It is an aborted long bone and to some extent better developed in comparison to that of ox.
2. The bone presents a head, a body and a pointed distal end.
3. It is placed along the lateral border of tibia.
4. Proximal end is little large, flat and articulates with the lateral condyle of tibia.
5. The distal end extends to the distal third of tibia.
6. The interosseous space between tibia and fibula is wide.

Fibula of dog

1. It is a long and thin bone and extends the whole length of tibia.

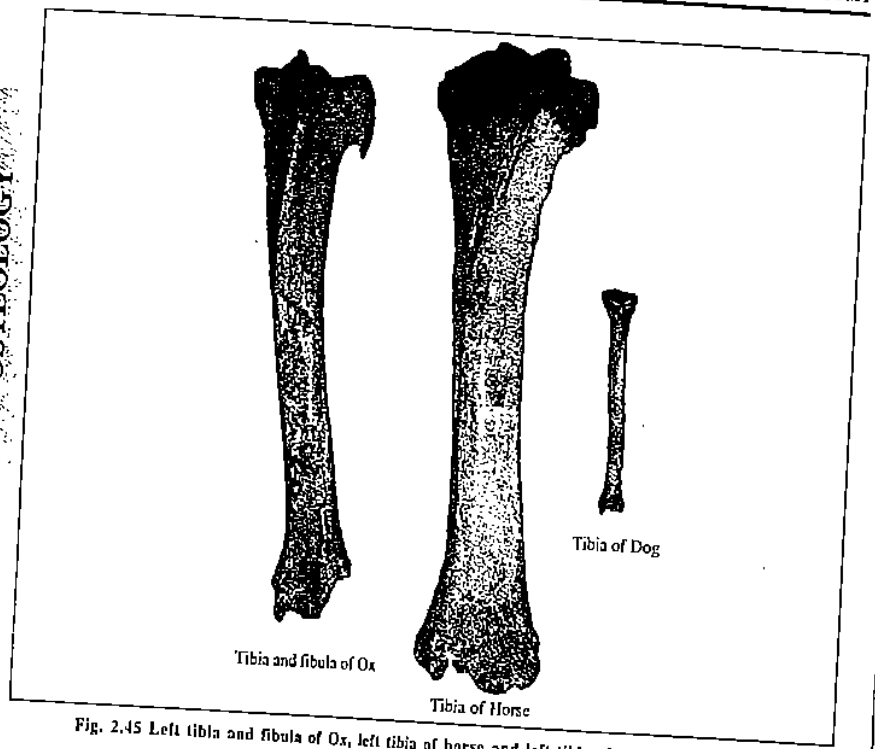


Fig. 2.45 Left tibia and fibula of Ox, left tibia of horse and left tibia of dog (anterior view).

2. Proximal end is flat and articulates with the lateral condyle of tibia.
3. The upper part of the bone is separated from the tibia to form proximal interosseous space.
4. The distal end is thick.

Fibula of pig

1. It is a thin elongated bone.
2. The body is flat from side to side and extends along the lateral border of tibia.
3. Interosseous space is wide.

Fibula of rabbit

1. It is narrow and thin.
2. Distal end is fused with tibia.
3. Proximal interosseous space is wide.

Fibula of fowl

1. It is a thin rod shaped long bone remains attached to the lateral part of the proximal end of tibia.
2. Distally it is pointed and extends up to the distal third of the tibia and fuses with it.

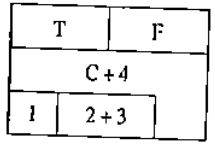
TARSAL BONES

Tarsal bones are five in number in Ox. However, Lateral malleolus remains as a separate piece of bone in this species at the hock region. These short bones are situated between the distal end of tibia and proximal ends of metatarsal bones to form hock joint.

At the proximal row there are two bones – the tibial tarsal and the fibular tarsal. At the distal row there are three bones – central and fourth fused tarsal, second and third fused tarsal and first tarsal.

Tibial tarsal (*Talus*)

This bone is in the form of an elongated pully. There are two ridges at the proximal end and two condyles at the distal end. It presents a deep fossa at the anterior surface and an articular smooth area at the posterior surface. The medial surface is flat and rough. The lateral surface is irregularly concave and articular. It is placed in a vertical manner at the medial aspect of hock. Posterolaterally it articulates with the fibular tarsal, proximally with tibia and distally with central and fourth fused tarsal.



Fibular tarsal (*Calcaneous*)

It is an elongated short bone situated obliquely lateral and posterior to tibial tarsal bone. Its proximal end is tuberous and known as **tuber calcis** or calcaneal tubercle. The distal end is irregular. Lateral portion of distal end articulates with the lateral surface of tibial tarsal. A thick projection extends from the medial aspect, which articulates with the posterior surface of tibial tarsal, known as **sustentaculum tali**. The anterior border and medial surface are short. The posterior border and the lateral surface extend upto the full length of the bone.

Lateral malleolus

This small piece of bone is placed between the proximal end of the tibial tarsal and distal end of fibular tarsal at their lateral aspect. Its upper border presents a small spine and medial surface is marked by a curved groove for the corresponding ridge of tibial tarsal bone.

Central and fourth fused tarsal

This plate like bone extends throughout the entire thickness of the joint. Dorsal surface has two concavities separated by a ridge to accommodate the condyles of the tibial tarsal. There is a spine at the posteromedial angle of this surface. The ventral surface has two different levels for the fusion with the fourth tarsal bone. This surface articulates with first tarsal bone, second and third fused tarsal bone and the metatarsal bones. The anterior, lateral and medial surfaces are rough and continuous. Posterior surface is irregular.

First tarsal

It is a small nodule like bone with three articular surfaces. It articulates proximally with central and fourth fused bone, anteriorly with the second and third fused bone and distally with metatarsal bone.

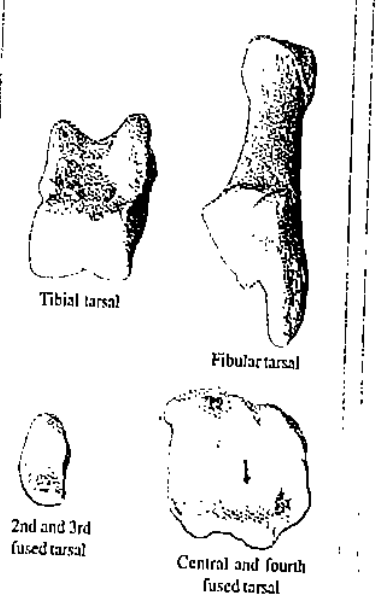


Fig. 2.46A Left set of tarsal bones (Ox).

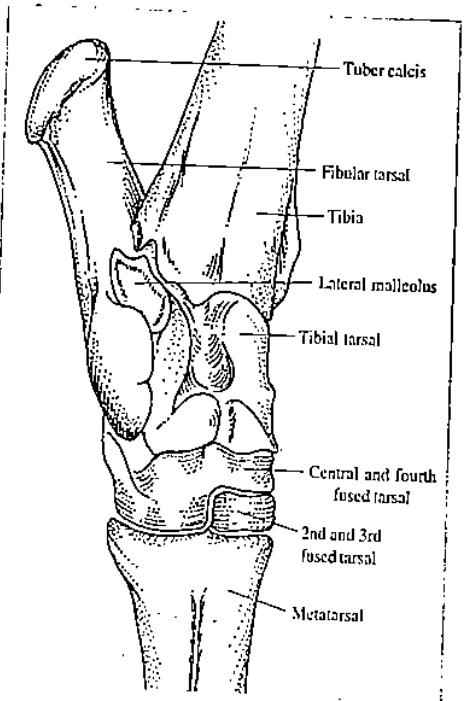


Fig. 2.46B Tarsal of cow (Right leg) Antero-Lateral view.

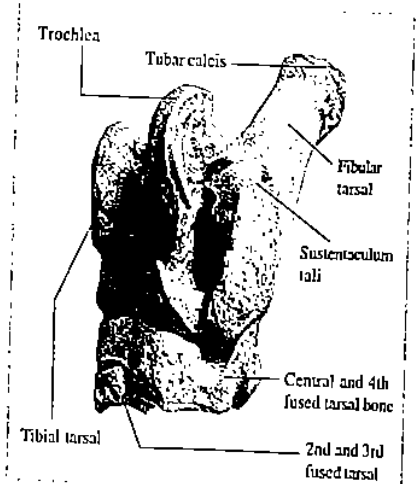


Fig. 2.47A Left tarsal bones of Ox (Medical view), in position.

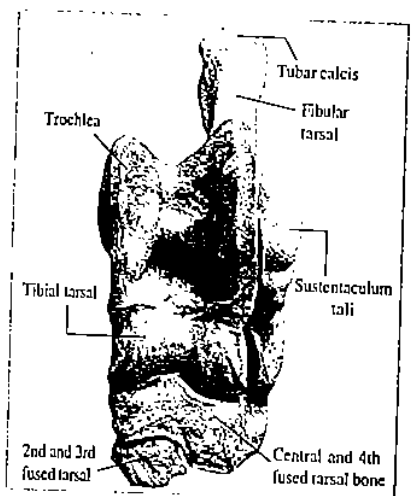


Fig. 2.47B Left tarsal bones of Ox (Anterior view), in position.

Second and third fused bone

It looks like one-fourth piece of a thick coin. Anterior and medial surfaces are non-articular and continuous. Dorsal, ventral, lateral and posterior surfaces are articular.

Tarsal bones of horse

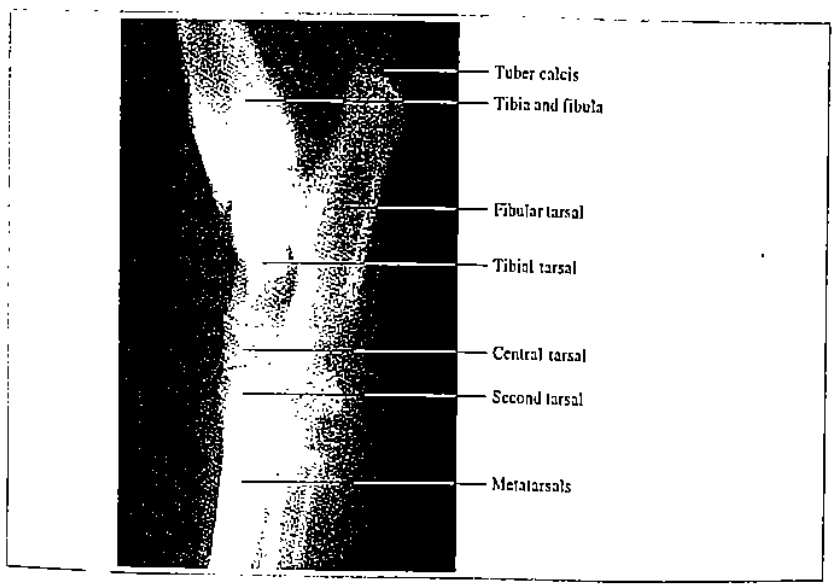
There are six tarsal bones in this species. These are tibial tarsal, fibular tarsal, central tarsal, first and second fused tarsal, third tarsal and fourth tarsal. The tibial tarsal and fibular tarsal bones are shorter and thicker. Central tarsal and third tarsal bones are flat in shape. First and second fused bone is small and the fourth tarsal bone is irregular.

T		F
C		
1+2	3	4

Tarsal bones of dog

There are seven tarsal bones in dog. These are tibial tarsal, fibular tarsal, central tarsal, first tarsal, second tarsal, third tarsal and fourth tarsal. Tibial tarsal has a body, a head and a neck. Fibular tarsal is elongated. Central tarsal articulates with the head of tibial tarsal. First tarsal is quadrilateral in shape. Second tarsal is smallest. Third is wedge shaped. Fourth is in the form of a irregular cube.

T		F	
C			
1	2	3	4



X-ray of hock joint of dog (medio-lateral view). (By Courtesy Dr. Subir Bhattacharya)

Tarsal bones of pig

The tarsal bones are seven in number. They are tibial tarsal, fibular tarsal, central trasal, first tarsal, second tarsal, third tarsal and fourth tarsal. The tibial tarsal and fibular tarsal bones are similar in shape to those of ox. Second is small. The third and fourth are larger.

T		F	
C			
1	2	3	4

Tarsal bones of rabbit

Six tarsal bones are arranged in three rows. Proximal row has two (tibial tarsal and fibular tarsal) bones, middle row has one (Central) and the distal raw has three bones.

T	F
C	

Tarsal bones of fowl

The tarsal bones are not found in the birds as they are fused with concerned long bones in embryonic life. Some of the tarsal bones of the proximal row are fused with the tibia to form tibiotarsus and bones of distal row are fused with metatarsal bone to form tarsometatarsus.

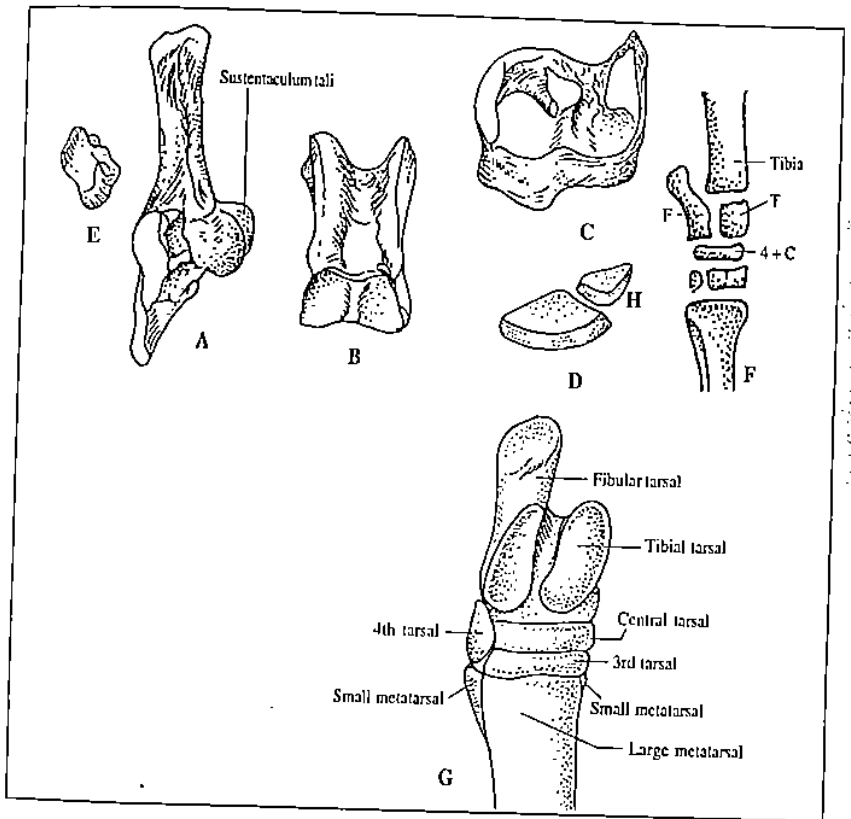


Fig. 2.48 A—E Tarsal bones of ox (Right leg).
A. Fibular tarsal ; B. Tibial tarsal ; C. Central and 4th fused tarsal ; D. Second and 3rd fused tarsal ; E. Lateral malleolus ; F. Diagramatic representation of right tarsus of ox ; G. Tarsal bones of horse in position (Right set) ; H. First tarsal.

METATARSAL BONES

There is one large bone representing 3rd and 4th fused metatarsal and a small bone representing 2nd metatarsal.

LARGE METATARSAL BONE

This bone has structural similarity with that of large metacarpal bone. The differentiating points are mentioned below.

(a) Length of metatarsal bone is more.
(b) Shaft is four sided.
(c) Proximal end bears a facet at its medial aspect for small metatarsal bone.
(d) The dorsal longitudinal groove is more deep and wide.

SMALL METATARSAL BONE

This medial small metatarsal bone is rudimentary and quadrilateral in form. It articulates with the large metatarsal by a facet at its anterior aspect.

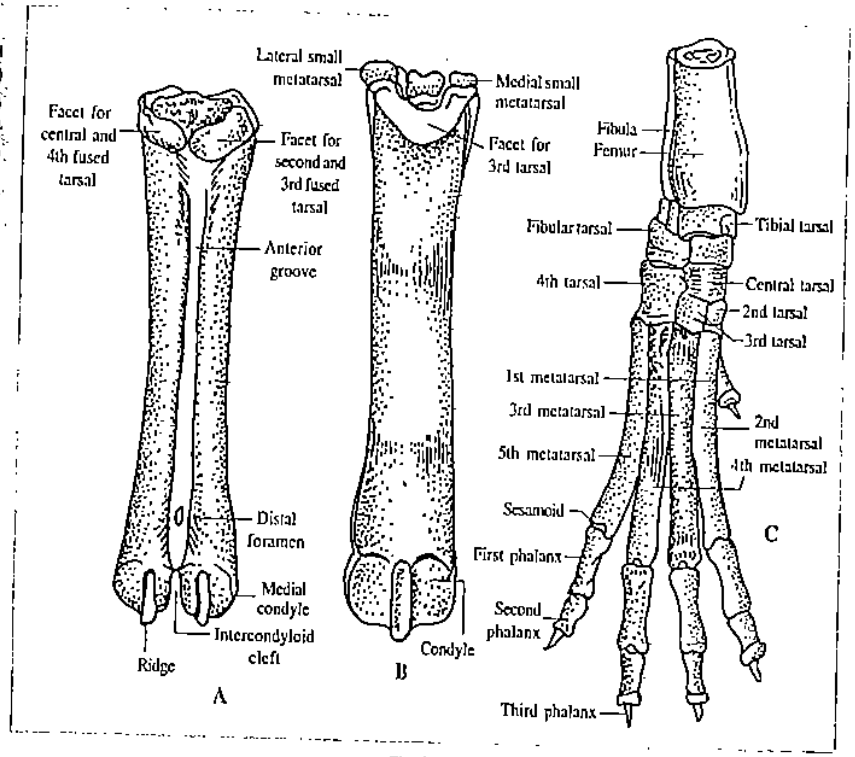


Fig. 2.49.

A. Right large metatarsal bone of ox (Anterior view) B. Right large and small metatarsals of horse C. Right tarsus metatarsals and phalanges of dog (Anterior view).

Metatarsal bones of horse

There is one large (3rd) and two small (2nd and 4th) metatarsal bones in this species. The small metatarsals articulate with the large bone on either side of the posterior aspect and extend up to the distal third. Large metatarsal is longer than large metacarpal bone. Its proximal end is also comparatively wider.

Metatarsal bones of dog

There are five metatarsal bones in this animal. The first one is ill developed and is in the form of a flat cone. Rest of the metatarsal bones are comparatively longer to those of metacarpal bones. Other features are more or less same to those of metacarpals.

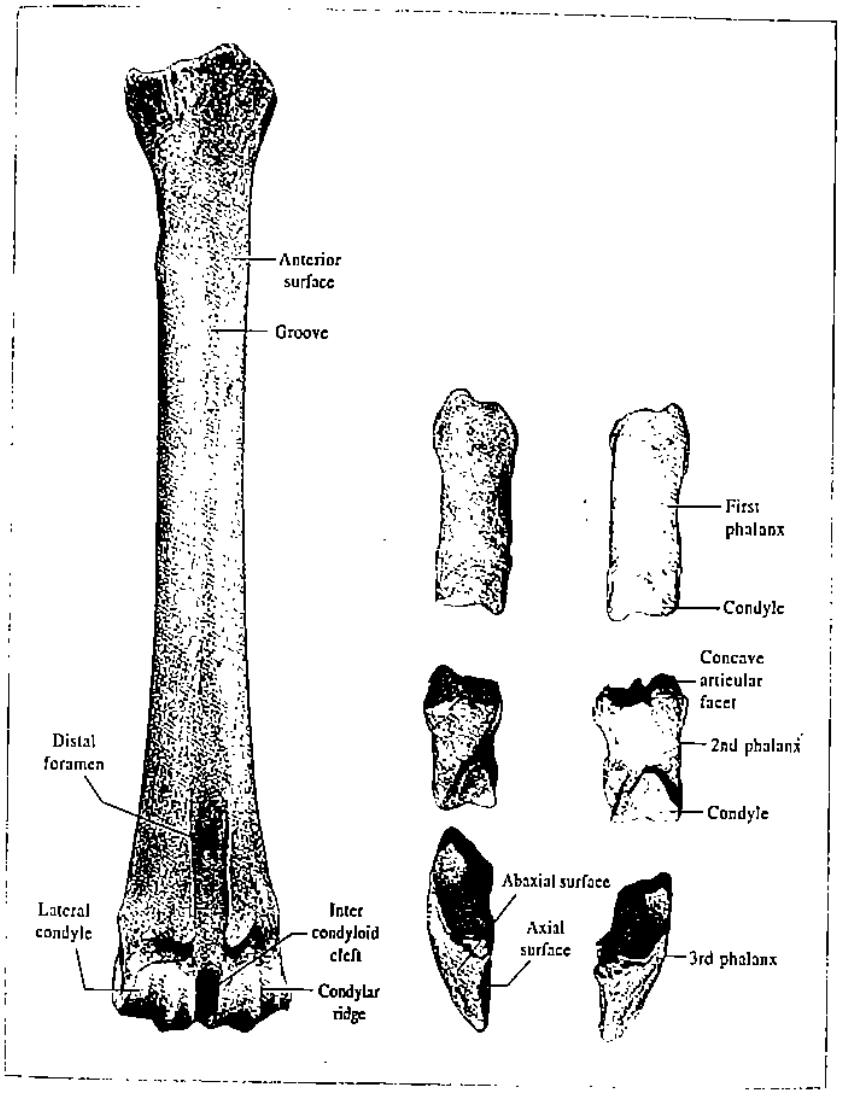


Fig. 2.50 Metatarsal and Phalanges of cow (Antero dorsal view).

Metatarsal bones of pig

They are four in number and present similar features to those of metacarpal bones. The proximal ends of third and fourth metatarsals bear facets at their caudal surface for a metatarsal sesamoid bone. All the bones are little longer than metacarpals.

Metatarsal and digits of rabbit

First digit is absent. Metatarsal bones are four in number. They are very narrow rod shaped structures. Each digit has 3 phalanges.

Tarso metatarsus of fowl

This is a single long bone. The proximal end is irregular for the fusion with the distal row of tarsal bones. It presents facets for articulation with tibiotarsus. Distal end presents three trochleae for articulation with 2nd, 3rd and 4th digits. In the male a bony spur arises from the medial aspect of the body of the tarsometatarsus. A very small bone located at the posterior aspect of the distal end of the tarsometatarsus is considered as first metatarsal bone.

There are four digits in the fowl. The first digit arises from the first metatarsal and is directed backward and inward. It has two phalanges. Other three main digits are directed forward in a diverging manner. The 2nd digit has three phalanges. The 3rd has four phalanges and the fourth digit possesses five phalanges.

Phalanges and Sesamoids

They are almost similar in both fore and hind legs in cow, horse and dog and are not described separately. In the pig the first and second phalanges are comparatively longer but narrower to those of fore limb.

THE SKULL

Skull is the skeleton of the head. The skull comprises of two essential parts – the cranial cavity and the skeleton of face. Excepting the mandible all the bones are united immovably with the help of sutures. Most of these bones are irregular in shape. Some bones are bilaterally present and some are remaining singly. Cranial bones form the cranial cavity for accommodation of brain and parts of the orbits for accommodation of eyes. These bones also provide spaces for middle and internal ears and allow passages for spinal cord, cranial nerves and vessels.

Facial bones are arranged in such a way that the organs of the begining of G.I. tract and respiratory tract are accommodated. Beside these, the bones form few empty spaces to keep the head light.

The bone of the skull may be grouped as follows :

Cranial bones		*Facial bones*	
1. Occipital	— Single	1. Lacrimal	— Paired
2. Interparietal	— Paired	2. Malar	— Paired
3. Parietal	— Paired	3. Maxilla	— Paired
4. Sphenoid	— Single	4. Pre-maxilla	— Paired
5. Ethmoid	— Single	5. Palatine	— Paired
6. Frontal	— Paired	6. Nasal	— Paired
7. Temporal	— Paired	7. Pterygoid	— Paired
		8. Turbinate	— Paired
		9. Vomar	— Single

Occipital (*Single*)

This bone forms the superior, as well as posterior aspect of the skull and presents three parts—*Lateral mass, basioccipital and supraoccipital.*

The *lateral mass* comprises of condyles, foramen magnum, paramastoid process, condyloid fossa, hypoglossal foramen and condyloid foramen. The condyles are oval-elongated structures, wide above and narrow below. They are two in number and include the foramen magnum between them. It gives passage to the spinal cord. The condyles articulate with atlas behind. **Paramastoid processes**, one on either side are situated external to the corresponding condyle. The depression between the condyle and paramastoid process is termed condyloid fossa. Within this fossa **hypoglossal** foramen is situated close to the condyloid border and transmits hypoglossal nerve. **Condyloid foramen** is placed behind the hypoglossal foramen.

Basilar part—It is a thick bony plate forms the posterior part of the floor of the cranial cavity. Anteriorly it joins with the post sphenoid bone and bears two basilar tubercles ventrally. Its thick lateral border forms medial boundary of a narrow cresent shaped aperture, the jugular foramen. On the cranial surface of this part of the occipital bone medulla oblongata is situated.

Supraoccipital or squamous part is a bony plate like structure above the foramen magnum which joins dorsally with parietal and interparietal bones and laterally with temporal bones. At the center of the external surface, there is a rough prominence, known as **external occipital protuberance.** This protuberance gives attachment to the ligamentum nuchae. **Mastoid foramen** is situated on either side at the area of junction of this part with the temporal bone. Cranial surface is concave and rough.

Sphenoid (*Single*)

It consists of two parts—Presphenoid and post-sphenoid. This bone forms the floor of the cranial cavity. **Pituitary** fossa (Sella turcica) is situated at the middle of the cranial surface. Anteriorly it articulates with ethmoid bone and posteriorly with the occipital bone. This bone helps in the formation of foramen ovale and orbitorotundum. **Foramen ovale** is situated at the middle of the wings of post sphenoid. In between the wings of pre and post sphenoid bones **foramen orbitorotundum** is situated. **Optic foramen** is situated at the anterior aspect of the pre sphenoid bone.

Interparietal *(Paired)*

Individually this bone is not well recognised in mature skull due to its fusion with the same bone of opposite side at the middle, parietal bone above and occipital bone below.

Parietal *(Paired)*

Each parietal bone is situated at the lateral aspect of the postero superior portion of the skull. It fuses with occipital bone below and frontal bone above. It has an upper horizontal and a lower vertical part. Outer surface is concave and helps in the formation of temporal fossa. The parietal crest is continuous with temporal crest.

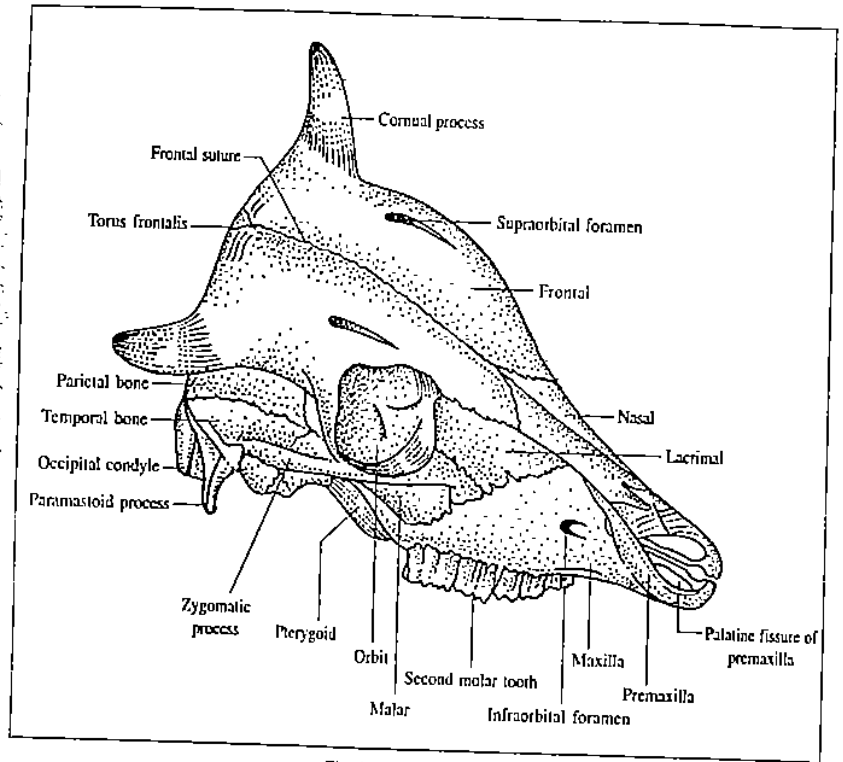


Fig. 2.51 Skull of a Ox.

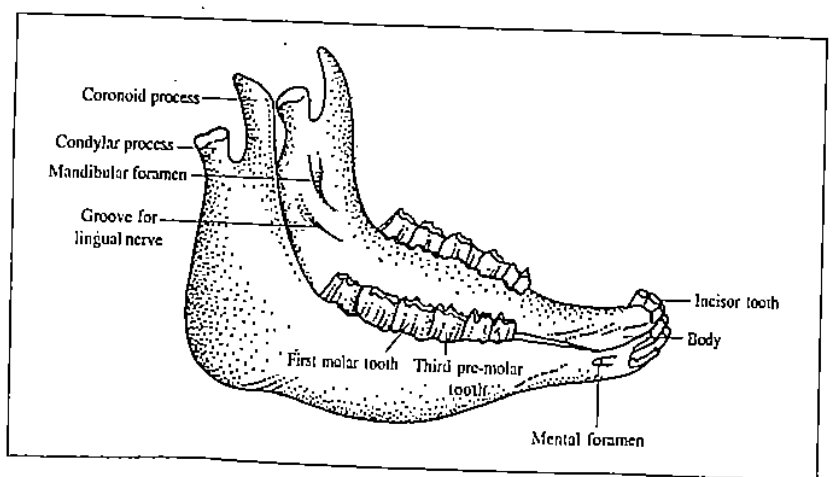


Fig. 2.52 Mandible of a ox.

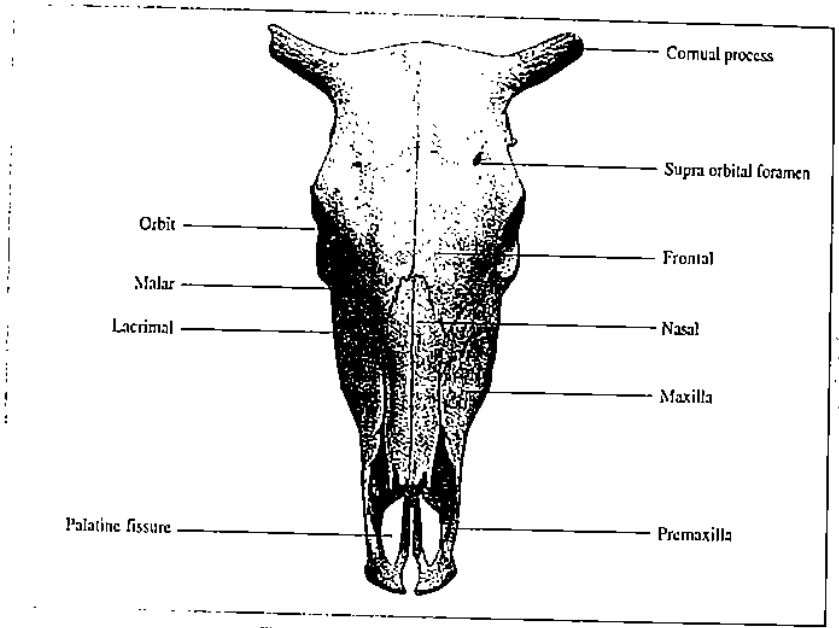


Fig. 2.53 Frontal Surface of Skull of Ox.

Frontal bones *(Paired)*

Each bone is situated at the anterodorsal aspect and forms the skeleton of forehead. The characteristic shape of the forehead of ox is formed by these bones. The frontal surface presents supraorbital groove and foramen. The supraorbital canal extends from this foramen to the orbit. At the area of junction between the two frontal bones at the dorsal border, there is a large eminence, known as frontal eminence or **torus frontalis**. The horn core or **cornual process** projects from the dorsolateral angle. Its outer surface is rough and porous. The hollow of the horn is partially divided by bony plates and is communicated with the frontal sinus. The superior part of the orbital rim is formed by its supra **orbital process**. Each of the two bones articulates with the parietal bones dorsally, nasal bones ventrally and lacrimal and temporal bones laterally.

Temporal bones *(Paired)*

These bones form a part of lateral wall of the cranial cavity. Each temporal bone has two parts—*squamous* and *petrous*.

The squamous part is thin and comprises of a body and a zygomatic process. The body partially forms the temporal fossa. The **zygomatic process** joins with the same process of malar bone. It presents **post glenoid foramen** behind the glenoid cavity. **Petrous temporal** is the hardest bone in the skeleton. It accommodates the whole internal ear. It bears **external auditory meatus, hyoid process, auditory bulla, stylomastoid foramen** and **internal auditory meatus**. Its cranial surface is free and irregularly marked.

Ethmoid *(Single)*

This bone forms the anterior part of the floor of the cranial cavity and the partition between the cranial and nasal cavities. Its horizontal part includes a median crest, (**crista galli**), olfactory fossae (right and left) and cribriform plate. This **cribriform plate** is a bony net between the cranial cavity and nasal cavity. The perpendicular part forms the dorsal portion of the osseous nasal septum. Lateral masses consist of a number of **ethmoid cells**. This bone is enclosed by presphenoid, vomer, palatine and frontal bones.

Lacrimal bones *(Paired)*

Each lacrimal bone is situated at the anterolateral portion of the skull and articulates with frontal and nasal bones superiorly and anteriorly, **maxilla** ventrally and malar posteriorly. At the orbital crest this bone presents **lacrimal fossa** which lodges the lacrimal sac.

Malar bones *(Paired)*

Each malar bone is situated at the lateral aspect of the face and also called zygomatic bone. This bone also helps in the formation of orbit. The upper part of this bone bifurcates and forms (a) **frontal process** by uniting with the supraorbital processes of frontal bone and (b) **zygomatic process** by joining with the similar process of the squamous temporal bone.

Maxillae *(Paired)*

The maxilla is the **largest bone** in the facial group. It takes part in the formation of the upper jaw, roof of the oral cavity and floor of the nasal cavity. It articulates with nasal, premaxilla, lacrimal, malar and palatine bones. This bone possesses **facial tuberosity, alveolar sockets, osseous lacrimal canal** and a **number of foramina,** such as infraorbital, sphenopalatine, maxillary and posterior palatine and encloses maxillary sinus.

The palatine process joins with the same bone of the opposite side and forms the skeleton of hard palate. **Infraorbital foramen** is situated at the lateral surface of this bone at the level of first premolar tooth. This foramen is the external opening of the infraorbital canal. Facial tuberosity is placed just above the infraorbital foramen.

Premaxillae *(Paired)*

They form the skeleton of the anterior part of the upper jaw. Each bone has a *body*, a *nasal process*, a **palatine process** and a **palatine fissure** between them. The **nasal process** joins with the maxilla. The palatine process articulates with the vomar bone and palatine process of maxilla.

Palatine bones *(Paired)*

A palatine bone presents two parts—*perpendicular* and *horizontal*. Its **perpendicular part** is in the form of a quadrilateral plate of bone which takes part in the formation of the upper part of the nasal civity. This part articulates with pterygoid bone along its dorsal border. The **horizontal part** forms the bony palate. Anterior palatine foramen is within this part. It also encloses the palatine sinus. Ventrally it articulates with the palatine process of the maxilla.

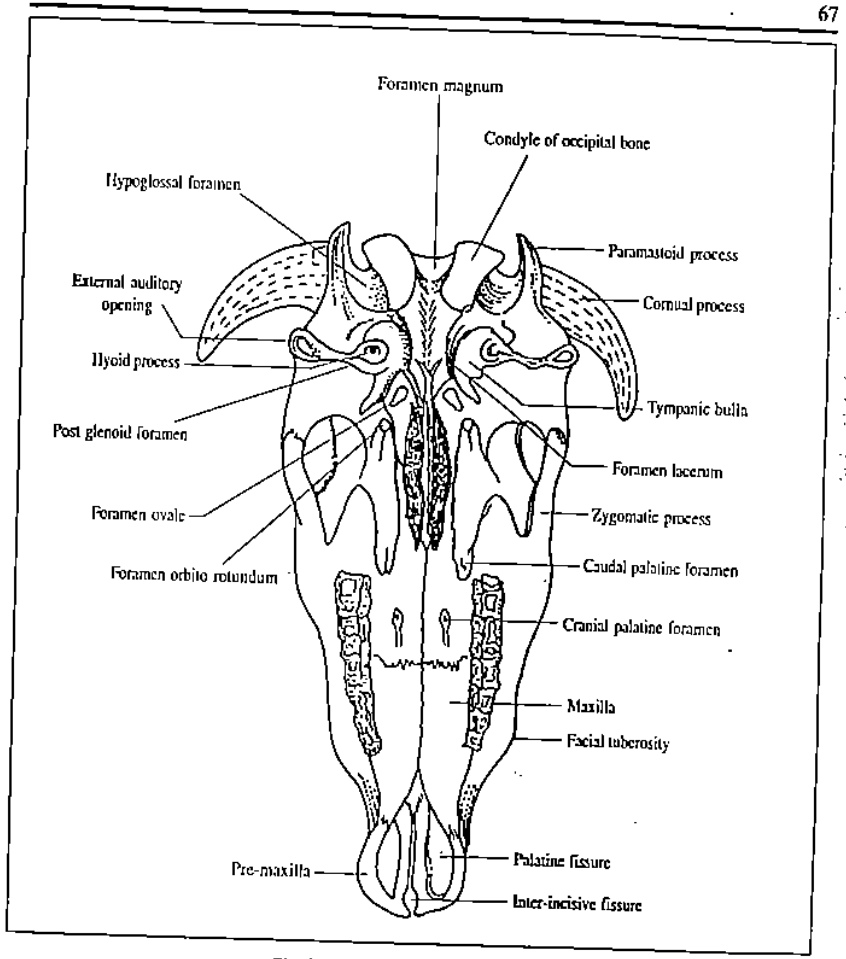


Fig. 2.54 Skull of ox (Ventral view)

Nasal bones *(Paried)*

These two bones remain side by side without fusion and form the roof of the nasal cavity. Outer surface of each bone is convex. Nasal surface is concave and is attached with the anterior turbinate bone. Proximal end is pointed and is very close to the opposite bone. Distal end is also pointed and is separated from its fellow by a notch.

Pterygoid bones *(Paired)*

Each bone is in the form of a thin plate. Medial surface forms the lateral wall of the nasal cavity and the lateral surface articulates with the palatine and pterygoid process of sphenoid bone. The ventral end is projected in the form of a hook and is known as pterygoid hamulus.

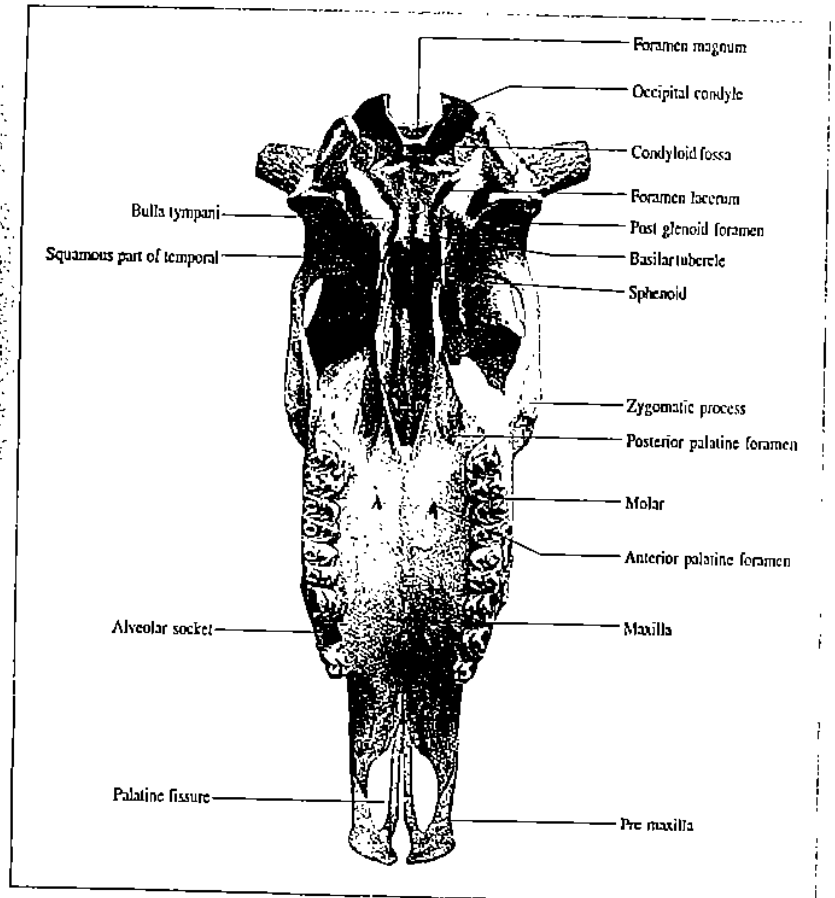


Fig. 2.55 Ventral surface of Skull of Ox.

Turbinate bones *(Paired)*

There are two bones, dorsal and ventral in each of the nasal cavity. They are also known as **nasal conchae**. These bones are formed by thin plate of bony net, rounded in the form of a scroll. The **dorsal tubinate** extends from the ethmoid bone and is attached to the ethmoid crest of the nasal bone. It is the largest. It's anterior end is pointed. The **ventral turbinate** is broad, occupies the ventral part of the nasal cavity and is attached to the maxilla by a basal lamina. The **ethmoturbinate bone** situated between the dorsal and ventral bones at their caudal part. It enlarges to form the **middle turbinate bone**. Spaces above dorsal turbinate, between the dorsal and ventral turbinate and below ventral turbinate are known as dorsal, middle and ventral meatuses respectively.

Vomar bone *(Single)*

It is a thin plate of bone situated at the median plane and extends from presphenoid to premaxilla. It takes part in the formation of nasal septum. Its proximal end is attached to presphenoid. The distal end is grooved and articulates with the palatine process of premaxilla.

CRANIAL CAVITY

This is an oval elongated irregular cavity encloses the brain. It has a roof, a floor and four walls.

Roof—This is formed by frontal bone and by parts of parietal and occipital bones. From the **crista galli** to the **internal occipital protuberance**, a **crest** is extended along the midline of the roof. Falx cerebri remains attached with it.

Floor—This is formed by basi occipital and sphenoid bones. It presents at the middle, a depression, the **hypophyseal or pituitary fossa** (sella turcica). Caudally there is a faint depression for lodgement of medulla oblongata. Floor is perforated by a number of foramina.

Lateral walls—These are formed by temporal bones and by the parts of parietal, frontal and orbital wings of sphenoid bone. They are highly concave to make room for the bulk of cerebrum

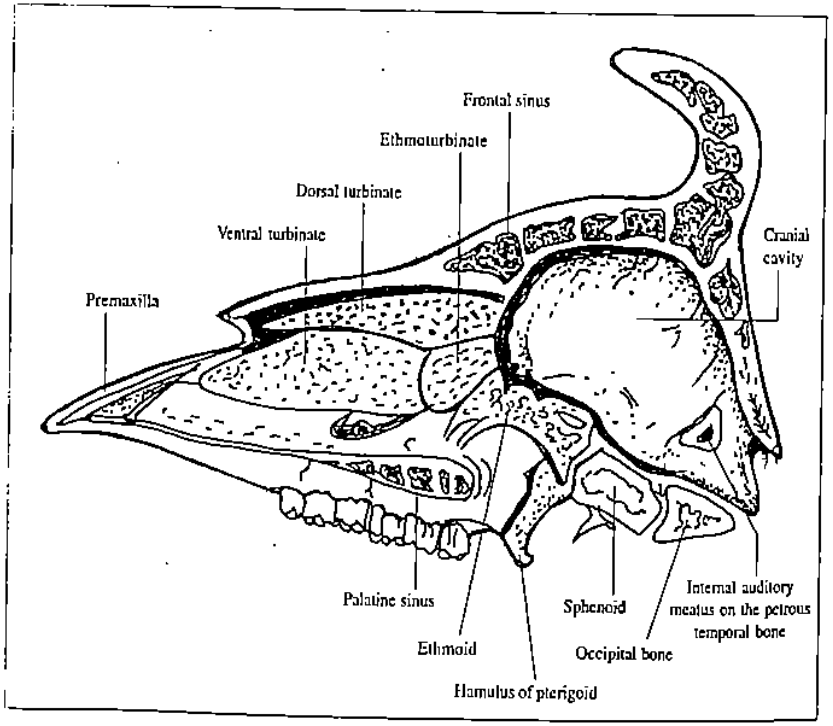


Fig. 2.56 Sagital Section of Skull.

anteriorly and cerebellum posteriorly. The walls have impressions of the cerebral cortex. The petrous temporal bone is marked with the opening of internal acoustic meatus and opening of vestibular aqueduct.

Anterior wall—It is formed by the ethmoid bone and sphenoid bone. It lodges the frontal and olfactory parts of the cerebrum. The olfactory bulbs are housed in the ethmoid fossa on either side of the ventral aspect of this wall which are separated by a bony crest, the crista galli.

Posterior wall—It is formed by the occipital bone and is perforated by a large opening—the foramen magnum.

The cranial cavity may be divided into three parts — a) Anterior, b) Middle and c) Posterior. The *anterior* or olfactory part is formed by the sphenoid and ethmoid bones and accommodates the olfactory bulbs and some minor parts of cerebrum. The *middle* or the cerebral part is the widest and formed by frontal, post sphenoid, temporal and parietal bones. It gives accommodation to the cerebral hemispheres.

The *posterior* or cerebellar part is smaller and formed by occipital bone and petrous temporal bones. Cerebellum, pons and medulla oblongata are lodged in this part of the cranial cavity.

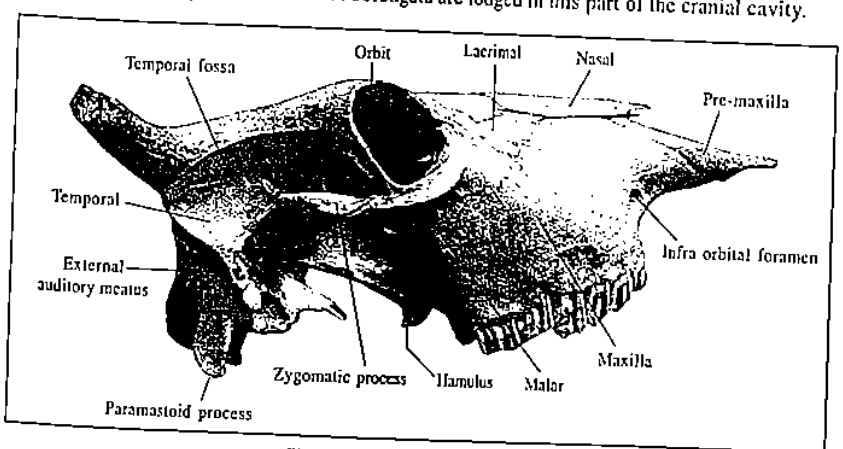


Fig. 2.57 Skull of ox (Lateral view).

NASAL CAVITY

This is an elongated cavity enclosed by some facial bones and divided by a septum. The **roof** is formed by nasal and frontal bones. The **floor** is formed by the horizontal parts of palatine, maxilla and by the pre-maxilla bone. The body of the maxilla, parts of palatine, pterygoid and nasal process of pre-maxilla form the **lateral walls**. The **septum** is formed by vomar, perpendicular part of ethmoid and by the septal cartilage. The anterior bony opening is bounded by premaxilla and nasal bones. The posterior opening is bounded by sphenoid, palatine and pterygoid bones. The nasal cavities are partly occupied by turbinate bones.

Orbit (Described in the Aesthesiology Chapter)

Temporal fossa

It is a large elongated depression situated behind and little above the orbit and below the horn in case of ox. Medial wall is concave and formed by parts of frontal, parietal and body of the squamous part of temporal bone. This fossa gives accommodation to the coronoid process of the mandible.

FORAMINA OF THE SKULL

Name of the foramen	Passage of vessels	Passage of nerves
Magnum	spinal arteries and veins	Spinal cord, spinal roots of 11th cranial nerve
Supra orbital/ orbital opening of supra orbital canal	Supra orbital artery and vein	Supra orbital a branch of frontal nerve of ophthalmic branch of 5th cranial nerve
Cribriform plate		Olfactory nerve bundles
Ethmoid	Ethmoid artery and vein	Ethmoid nerve – branch of nasociliary of the ophthalmic branch of 5th cranial nerve
Optic	Ophthalmic artery	Optic nerve
Orbitorotundum		3rd, 4th, 6th, maxillary and ophthalmic branches of 5th cranial nerve
Palatine (Posterior)	Posterior palatine artery and vein	Posterior palatine nerve – a branch of maxillary of 5th cranial nerve
Palatine (Anterior)	Anterior palatine artery and vein	Anterior palatine nerve – a branch of maxillary of 5th
Infra orbital	Infraorbital artery and vein	Infraorbital nerve – continuation of maxillary of 5th cranial nerve
Ovale	Accessory meningeal artery	Mandibular division of 5th cranial nerve. Lesser petrosal nerve occasionally
Lacerum/ jugular	Internal carotid artery, artery of the pterygoid canal, inferior petrosal sinus, middle meningeal artery	9th, 10th and 11th cranial nerve, nerve of the pterygoid canal
Internal aquastic meatus	Labyrinthine artery	7th and 8th cranial nerve
Hypoglossal		12th cranial nerve
Condyloid	Condyloid branch of the occipital artery	
Stylomastoid	Stylomastoid artery	7th cranial nerve

PARANASAL SINUSES

These are the cavities in the bones of the skull, lined by mucous membrane and are directly or indirectly communicated with the nasal cavity. These paired cavities are situated bilaterally. The mucous membrane is loosely attached to the bones and is less vascular. The main function of these sinuses are to lighten the skull. The sinuses are ill developed in young animals.

Frontal sinus

This is a very extensive sinus spread inside the whole frontal bone and extends inside the cornual process. It has one posterior part and one anterior part. The latter comprises of few smaller compartments. The rostal most compartment is communicated with middle meatus of nasal cavity.

Maxillary sinus

This cavity extends inside the maxilla, lacrimal and malar bones. It is connected with palatine sinus by a large oval opening. It communicates with the middle meatus of nasal cavity at the dorsal aspect. Ventral surface is rough and the alveolar sockets of premolar and molar teeth invaginate inside the cavity.

Sphenoid sinus

It is formed within the body of pre-sphenoid and extends into the wings. It is connected with ethmoidal meatus. The sinus is very small and mostly absent in young skull.

Ethmoid sinuses

These are few small air cells within the ethmoid bone and placed between the nasal cavity and orbit.

Palatine sinus

It is an excavation within palatine bone and palatine process of maxilla. It is connected with the maxillary sinus. It extends from the posterior border of palatine to the anterior aspect of the first cheek tooth. The palatine sinus also communicates with the nasal cavity through a narrow opening at the middle meatus.

MANDIBLE

It forms the skeleton of lower jaw and comprises of a body and two rami. The two halves of this bone fuse incompletely at the mandibular symphysis, situated at the midline within the body.

Body—It is the horizontal part of the bone. It has mainly two parts—(a) *anterior* or *incisival part* and (b) *posterior* or *molar part*. The posterior parts are two in number. The incisival part possesses two surfaces. The lingual surface is concave and the labial surface is convex. The alveolar border presents eight alveoli for incisor teeth. The posterior parts extend from corresponding side of the body and bears two borders, two surface and two extremitis. The dorsal border of each part is alveolar and possesses six sockets for the lower cheek teeth. Ventral border is thick. Mental foramen is situated at the anterior aspect of the lateral surface. This foramen is the external opening of the mandibular canal.

Ramus of mandible—The rami are the vertical parts of mandible. Each ramus has two surfaces, two borders and two ends. The ventral end is continuous with the horizontal part. Dorsal end has a

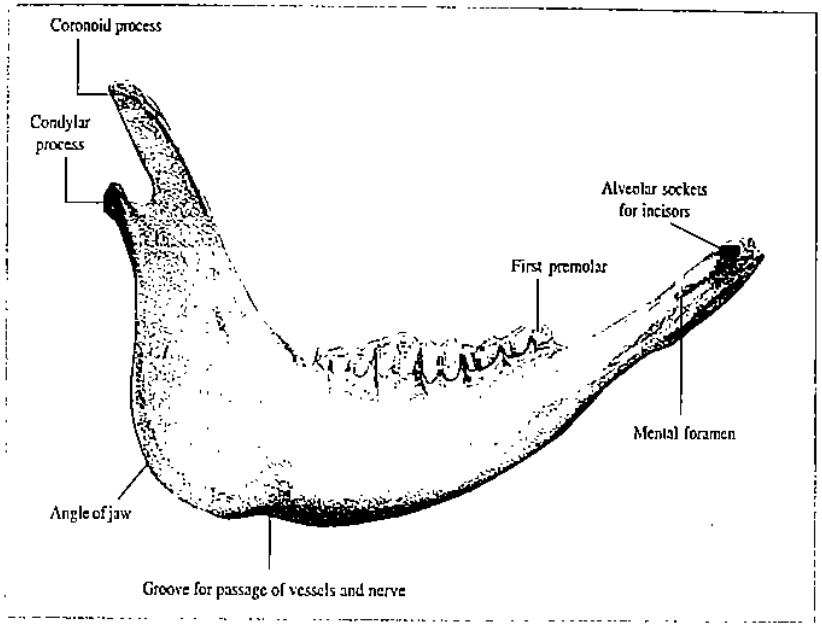


Fig. 2.58 Right ramus of mandible of Ox (Lateral surface).

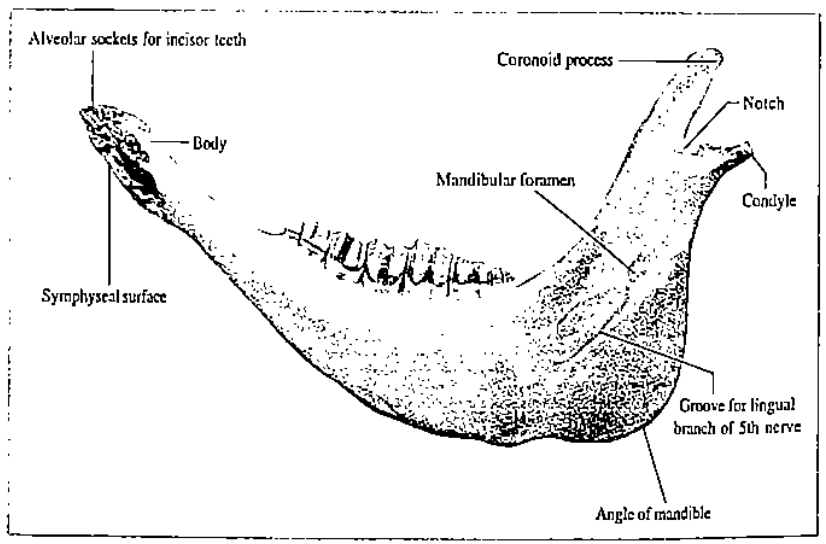


Fig. 2.59 Right ramus of mandible of ox (Medial surface).

condylar and a **coronoid process**. The condylar process is situated behind and articulates with squamous part of temporal bone. The coronoid process projects upward and inward into the temporal fossa.

The depression between the coronoid process and the condyle is known as **mandibular notch** and the constriction below the condylar process is known as neck of the mandible. The medial surface is slight concave and presents the **mandibular foramen** and a groove for **lingual nerve**. The mandibular foramen is the posterior opening of the mandibular canal which gives passage to the mandibular nerve and vessels. The angle of the jaw formed by the union of the ventral border of the posterior part of the body and posterior border of the ramus is prominent. A **faint notch** situated at the ventral border of the posterior part of the body and in front of the angle of the jaw, is for the passage of the maxillary vessels and parotid duct.

The two halves of the bone diverge from each other posteriorly and enclose the mandibular space.

Skull of horse

1. The skull is long and four sided.
2. The foramen lacerum is extensive

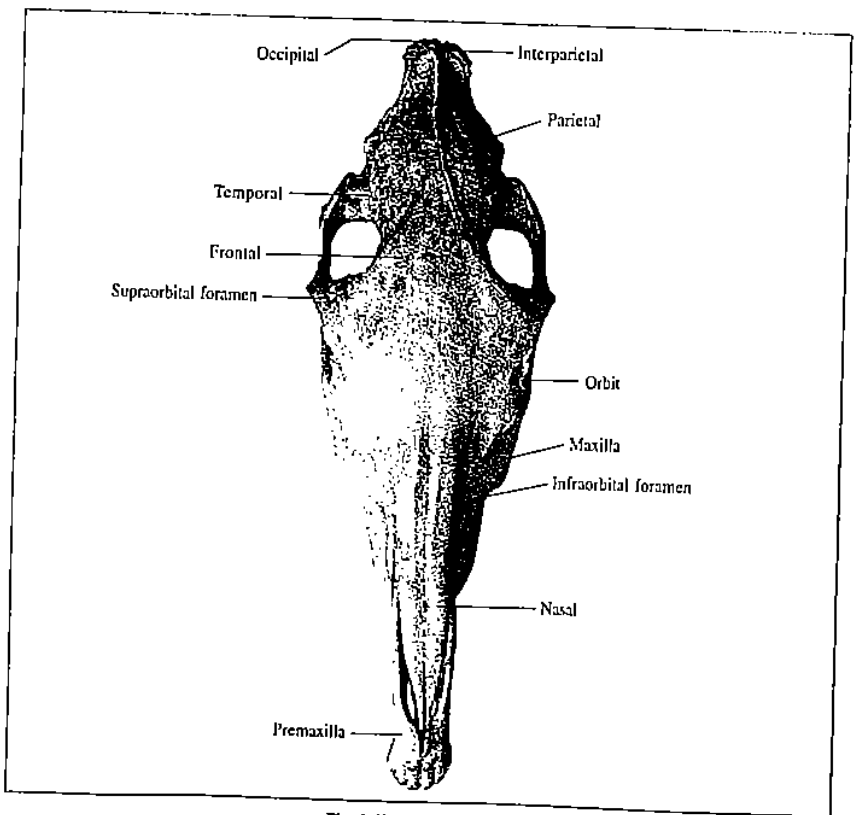


Fig. 2.60A Skull of horse.

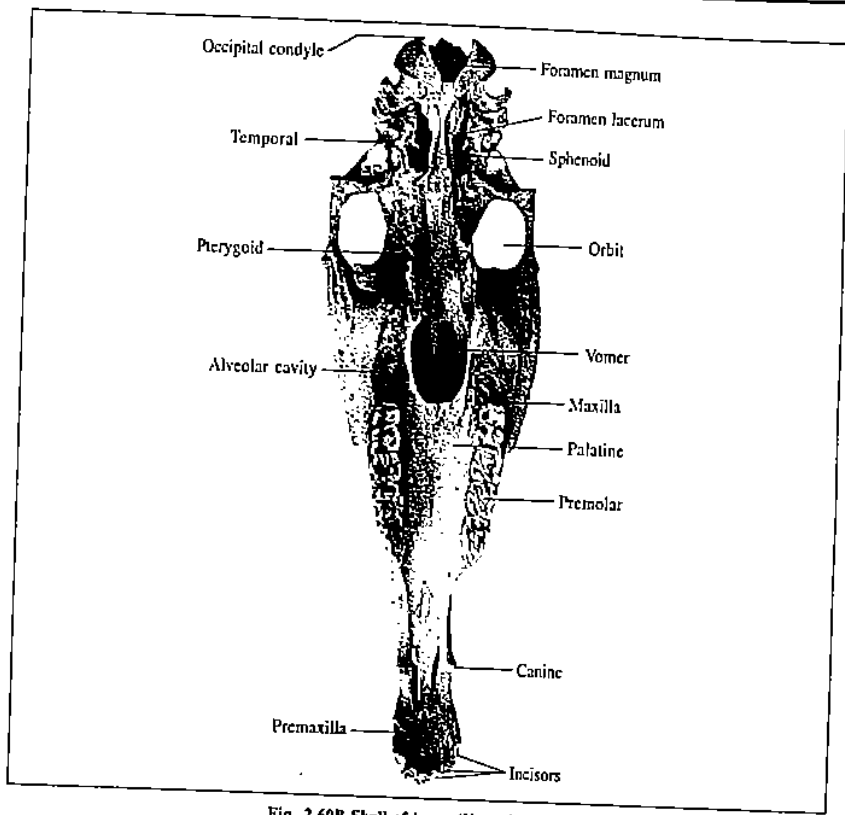


Fig. 2.60B Skull of horse (Ventral view).

3. The cornual processes are absent.
4. Zygomatic process meets malar as well as supraorbital process.
5. Interparietal is centrally placed and considered as a single bone.
6. Parietal bones take part in the formation of the roof of cranial cavity.
7. Premaxilla presents six alveolar sockets for upper incisors.
8. At the junction between maxilla and premaxilla there is a alveolus for canine tooth.
9. The fusion between two halves of the mandible is complete.
10. The alveolar border of the body of the mandible presents six alveoli for incisor teeth. Other two alveoli in males are present for the canine tooth, which are placed further caudally.

Skull of dog

1. The skull is oval elongated in shape but varies highly from breed to breed.
2. Basioccipital joins with the bulla tympani.
3. Horns are absent.

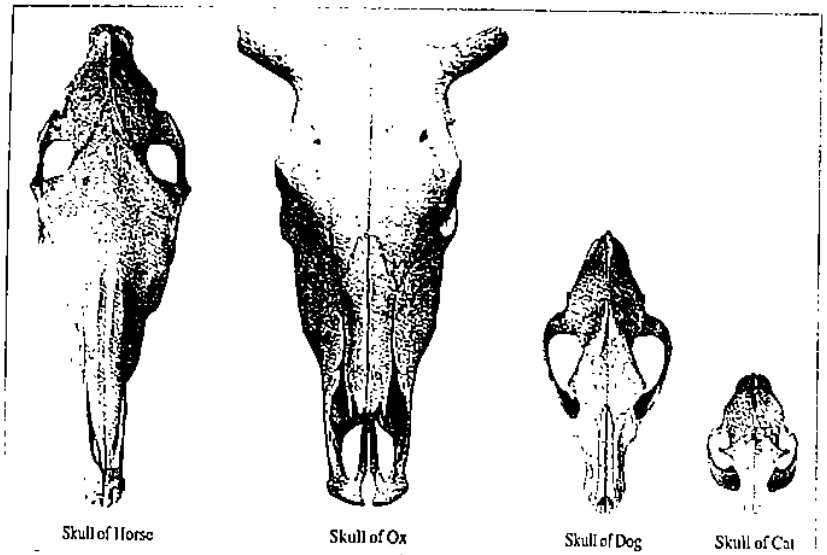


Fig. 2.61 Skulls of Horse, Ox, Dog and Cat.

4. Zygomatic process is highly curved.
5. Interparietal fuses with occipital before birth.
6. Parietal bones take part in the formation of roof of the cranial cavity.
7. Premaxilla has sockets for incisors. The alveolus for canine tooth is well developed.

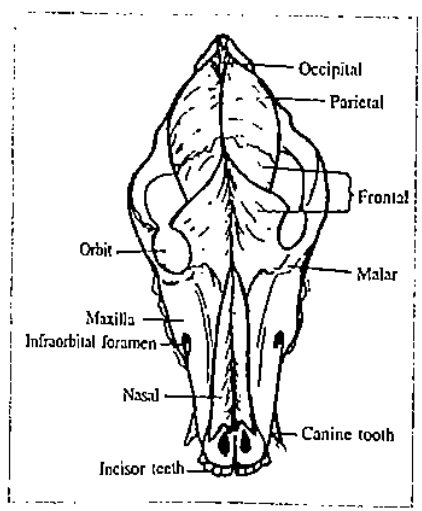


Fig. 2.62A Skull of dog (Dorsal view).

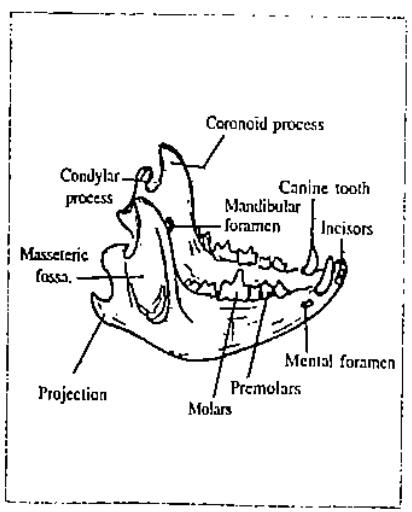


Fig. 2.62B Mandible of dog (Lateral view).

8. The orbital rim is incomplete
9. The two halves of the mandible fuses incompletely. Each half of the mandible has three alveoli for incisors, one alveolus for canine and seven alveoli for premolar and molar teeth. Behind the angle of the jaw there is a notch and a projection.
10. Laterally the ramus presents a depression known as masseteric fossa.

Skull of pig

1. The skull is elongated in shape.
2. Basilar part of occipital bone is hexagonal in shape and depressed.
3. Orbital ring is not complete.
4. Canine teeth are well developed.
5. Paramastoid processes are long and extended downward.
6. Coronoid process of the mandible is short but pointed.
7. The angle between the two rami are comparatively wide.
8. Cranial cavity is comparatively small.
9. It has a visceral bone at the rostral aspect of the nasal septal cartilage, known as os rostrale.

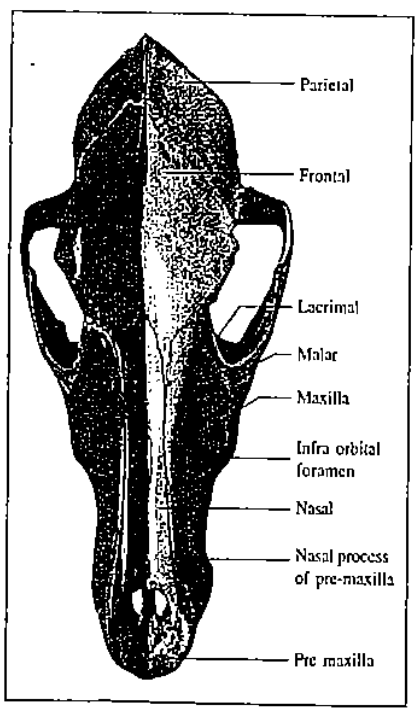


Fig. 2.62C Skull of Dog (Dorsal view).

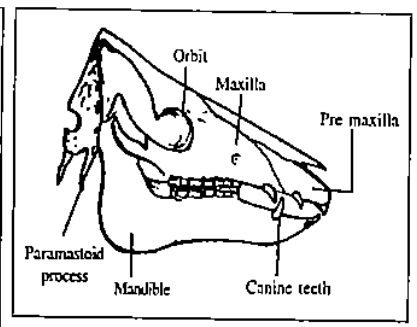


Fig. 2.63 Skull of pig.

Skull of rabbit

1. The orbit is very wide and spacious.
2. Maxilla is fenestrated.
3. Nasal bone is well developed.
4. The pre-maxilla bears two large chisel-shaped incisors in front and two small incisors behind.
5. External auditory meatus is wide.
6. Supraorbital foramen is large and elongated.
7. Occipital condyles are small and therefore foramen magnum is large.
8. The mandible is massive. Condylar process and coronoid process are fused together. A little

above the angle of the jaw, the mandible presents a notch and a backward projection. Masseteric fossa is shallow.

Skull of fowl

1. Most of the bones are fused.
2. Upper jaw is movable due to the presence of nasal-frontal hinge.
3. Orbit is large.
4. Occipital condyle in single.
5. Each half of mandible is formed by the fusion of five bones.
6. Teeth are absent.

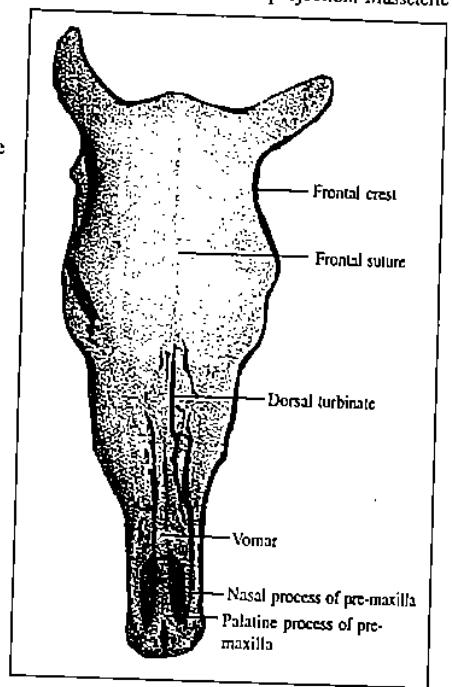


Fig. 2.64 Skull of Ox. Nasal bones removed to show turbinate and vomar.

HYOID BONE

This bone is situated between the rami of the mandible and gives support to the root of the tongue, larynx and pharynx. It comprises of a **transverse body**, a pair of **thyroid cornua**, a pair of **small cornua** a pair of middle cornua and a pair of **great (styloid) cornua**. The **lingual process** extends from the anterior aspect of the body. The proximal extremities of the styloid cornua articulate with the hyoid process of temporal bone by a piece of cartilage.

Cephalic index

It indicates the shape of the skull and measured by the formula

$$\frac{\text{Breadth} \times 100}{\text{Length}}$$

where Breadth = Space between the supraorbital processes and

Length = Space between torus frontalis to the middle point on the margin of dental pad.

The animal will be short-faced if the index value is more and it will be long-faced if the index value is less.

Sex Determination

Sex differentiation on the basis of morphological characteristics is not possible. However, the contour of the skull of females appear to be less massive and more rounded.

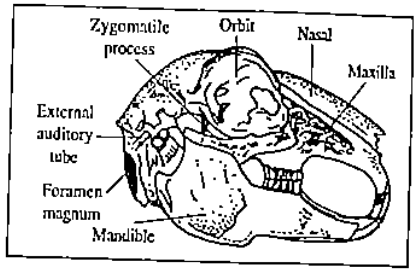


Fig. 2.65. Skull of rabbit along with mandible.

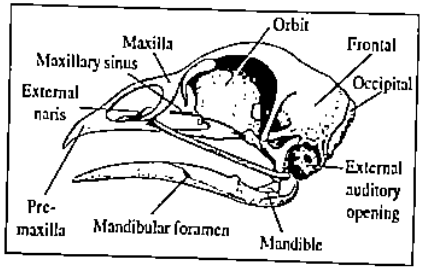


Fig. 2.66 Skull of fowl.

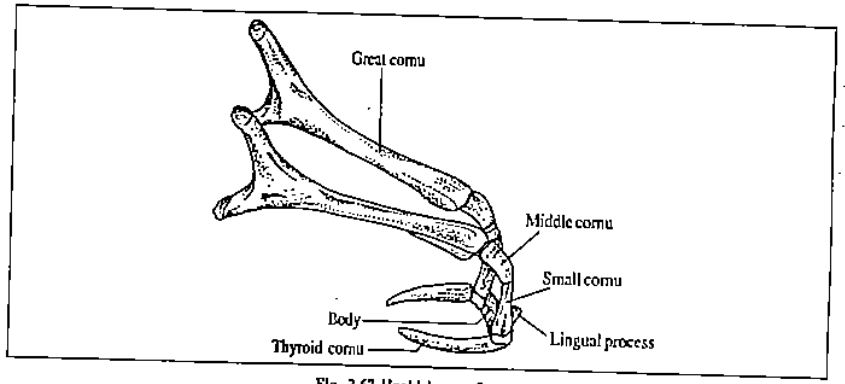


Fig. 2.67 Hyoid bone of cow.

VERTEBRAL COLUMN

A series of bones (vertebrae) articulate together to form a long column of axial skeleton in the body is known as vertebral column. This is commonly called spine. Vertebral bodies and intervertebral discs form a solid rod upon which vertebral archs are placed to form a hollow canal for the protection of the spinal cord. When two adjacent vertebrae are articulated, two intervertebral foramina are formed on two sides. They give passages to the spinal nerves and vessels.

On the basis of position and shape the vertebrae has been classified into five regions and each region consists of variable number of vertebrae in different animals as presented in the table.

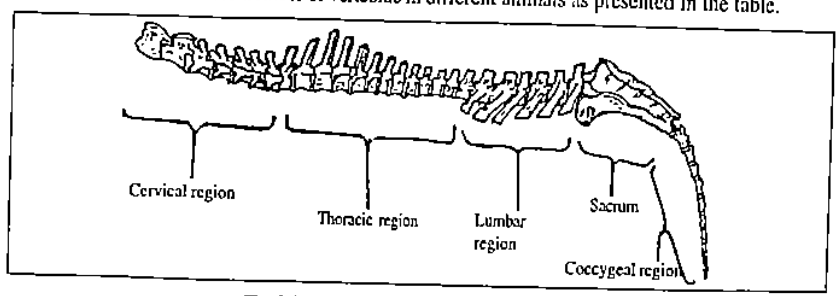


Fig. 2.68 Vertebral column of ox (Lateral view).

A COMMON VERTEBRA

A typical vertebra has a body, arch and processes.

Body—It is a solid cylindrical rod which supports other structures of the bone. The cranial end is convex and the caudal end is concave. Both the ends are attached to the corresponding intervertebral fibrocartilaginous discs. Dorsal surface forms the floor of the neural canal. The ventral surface presents ill developed spines for muscular attachment.

Arch—Each of the two halves is composed of a pedicle and lamina. **Pedicles** form the lateral walls and the laminae form the roof of the neural ring. The pedicles bear notches at their cranial and caudal aspects. The intervertebral foramina are formed between the notches of adjascent vertebrae.

Processes—These are spinous, transverse and articular. The **spinous process** is single and projects upward from the junction of the laminae. **Transverse processes** are on either side and project outward from the lateral aspects of the neural ring. **Articular processes** are two on each cranial and caudal aspects. They project from the junction of lamina and pedicle.These articular processes form diarthrodial joints with similar processes of the adjacent vertebra. The main function of these processes is to prevent undesirable movement between adjacent vertebrae.

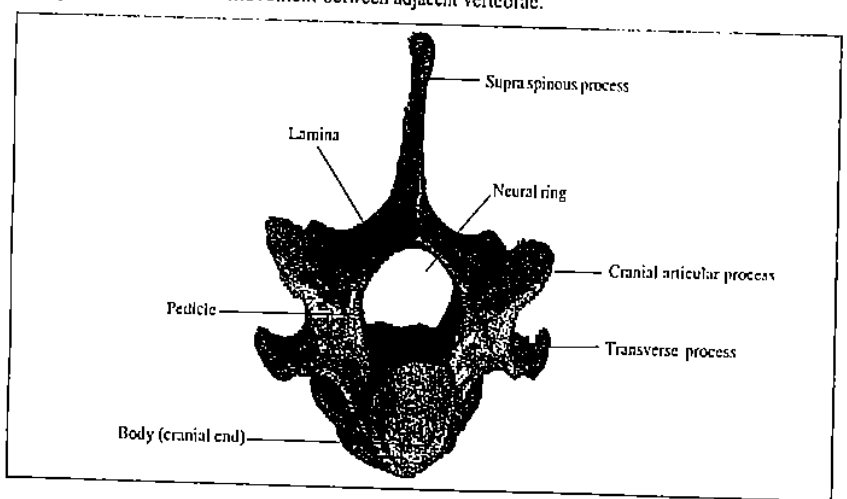


Fig. 2.69 Typical vertebra.

CERVICAL VERTEBRAE

These vertebrae form the skeleton of the neck and are characterised by presence of short processes of various shapes and the foramen transversarium.

They are seven in number in almost all the mammals. However, exceptions are there. *Sloths* have six and *Great Anteaters* have eight to nine cervical vertebrae. The first, second, sixth and seventh are atypical in this group. Rest have almost similar structures as follows :

1. Body is long and the crest along the midventral axis is prominent. The convexity at the cranial end and the concavity at the caudal end are very prominent in this group of vertebrae.

2. Articular processes are well developed. They are in the form of plates, convex cranially and concave caudally.

3. Spinous process is inclined foward. It is short and tuberous.

4. Transverse processes are divided into one upper and a lower part. The upper one is tuberous and the lower one is like a plate.

5. The base of each transverse process is perforated by **foramen transversarium**. These foramina are one of the characteristic feature of this group of vertebrae.

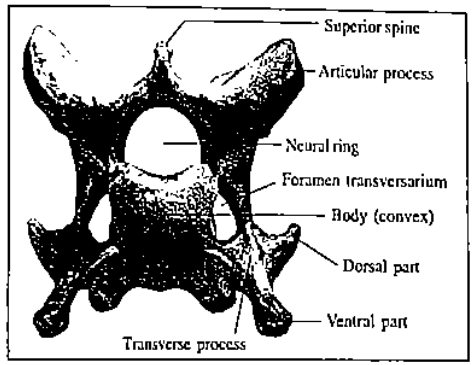


Fig. 2.70 4th Cervical vertebra of Ox (Cranial view).

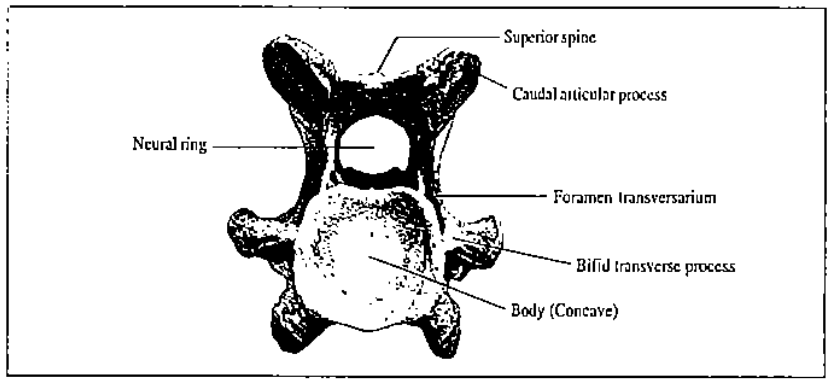


Fig. 2.71 A Typical Cervical vertebra (Caudal view).

Number of vertebrae in different regions of spine of domestic animals and birds :

	Cervical	Thoracic	Lumbar	Sacral	Coccygeal (approx)
Ox	7	13	6	5	15–25
Horse	7	18	6	5	16–22
Dog	7	13	7	3	18–25
Pig	7	14–15	6–7	4	18–24
Rabbit	7	12–13	6–7	4	14–18
Fowl	14	7	L+S=14		4–9

ATLAS

It is the first cervical vertebra. As it carries the round head in human and therefore the name 'Atlas' has been given to it. The bone comprises of a larger neural ring and two wings. The body

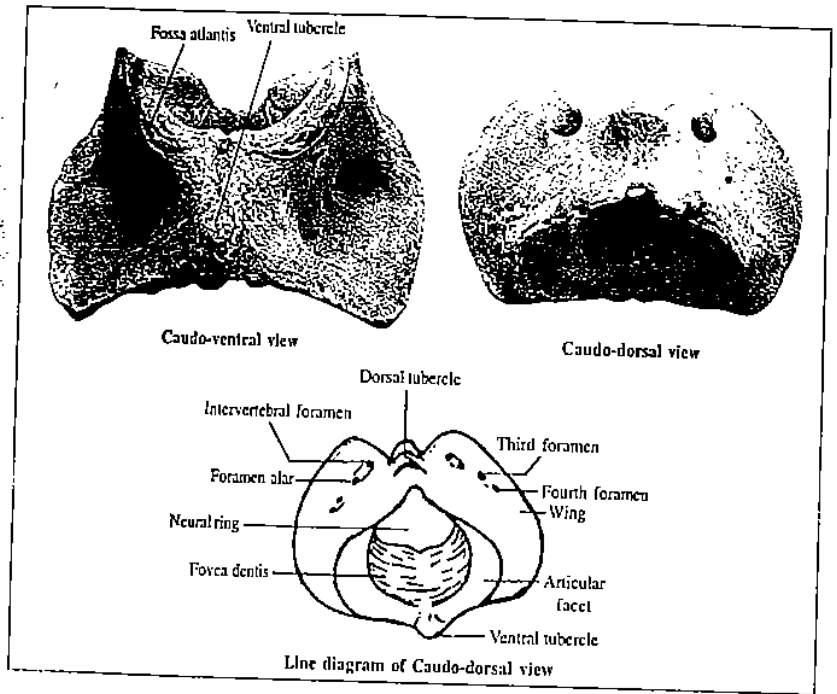


Fig. 2.72 Atlas of Ox.

is in the form of a thick plate and forms the ventral wall of the neural ring. The wings are bony plates projected from either side of the neural ring. The **supra-spinous process** as well as the **ventral spine** are in the form of tubercles. On the cranial aspect of the dorsal surface there are two foramina. The medial one is the **intervertebral foramen** and the lateral one is known as **alar foramen.** Both the foramina are lodged in one depression. The intervertebral foramen gives passage to first spinal nerve and a branch of vertebral artery and the alar foramen gives passage to the dorsal branch of first spinal nerve. Caudal to this depression there are other two small foramina in a linear groove. At the caudal part of the floor there is a depression, the **fovea dentis**, which articulates with the odontoid process of the axis. Cranial aspect of the bone is highly concave to accommodate the occipital condyles. Caudal end bears saddle shaped **articular facets** for axis. The borders of the wings are convex. The ventral surface of each wing is concave and termed **fossa atlantis.**

Axis

It is the second cervical vertebra. This bone has been named as axis because the skull along with the atlas rotates partially around it. The body is long and the ventral spine is extended caudally. The cranial end of the body is modified in the form of projected plate. This projected part is known as **odontoid process.** The spinous process is inclined forward and increases in thickness and in hight

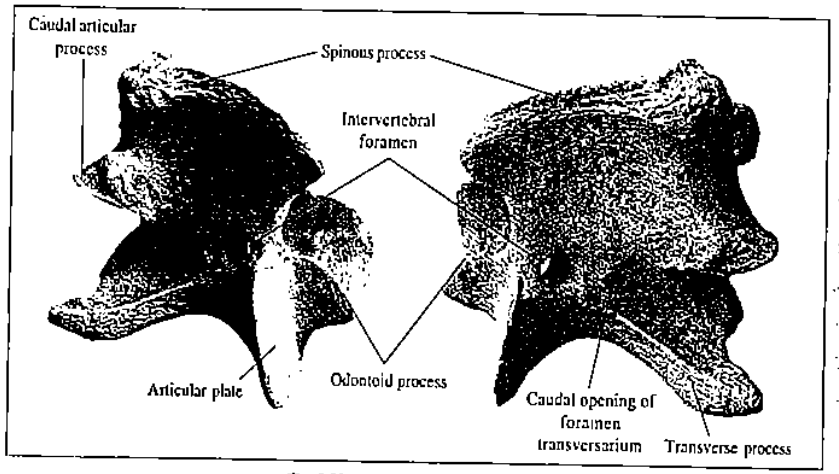


Fig. 2.73 Axis of ox (Lateral view).

backward. Cranial articular processes are absent. The caudal articular processes are well developed and directed backward. Intervertebral foramen is behind the notch. Foramen transversarium is narrow. Transverse processes are undivided and projected backward.

Sixth Cervical Vertebra

The articular processes and the spinous process are well developed. The lower part of the transverse process is in the form of a **quadrilateral plate** of bone. The ventral spine is absent. Other features are similar to those of 5th cervical vertebra.

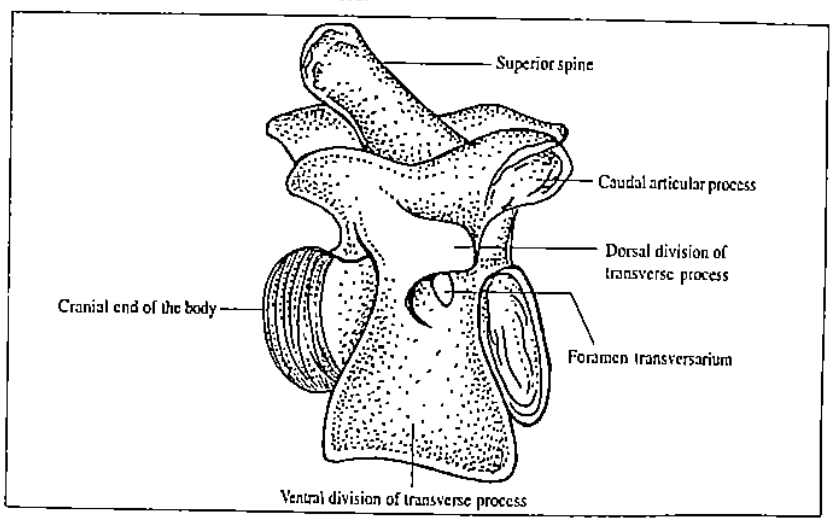


Fig. 2.74 Sixth cervical vertebra.

Seventh Cervical Vertebra

The body of the vertebra at its caudal aspect bears two facets for articulation with the heads of first pair of ribs. The foramen transversarium is absent. Spinous process is flat and well developed.

THORACIC VERTEBRAE

These vertebrae make the bony roof of the thoracic cavity along with the proximal ends of the ribs. These are characterised by long supraspinous process and cylindrical body.

They are 13 in cow, 18 in horse, 13 in dog 14 to 15 pig, 12-13 in rabbit and 7 in fowl. They present the following characteristic features :

1. Spinous processes are long and directed backward.

2. Either side of the arch is pierced by additional intervertebral foramen.

3. Transverse processes are short, thick and undivided. Each of them bears a non-articular mamillary process and a ventral articular facet for articulation with the tubercle of the corresponding rib.

4. The articular processes are not developed. They are in the form of facets situated at the corresponding aspect of the neural arch.

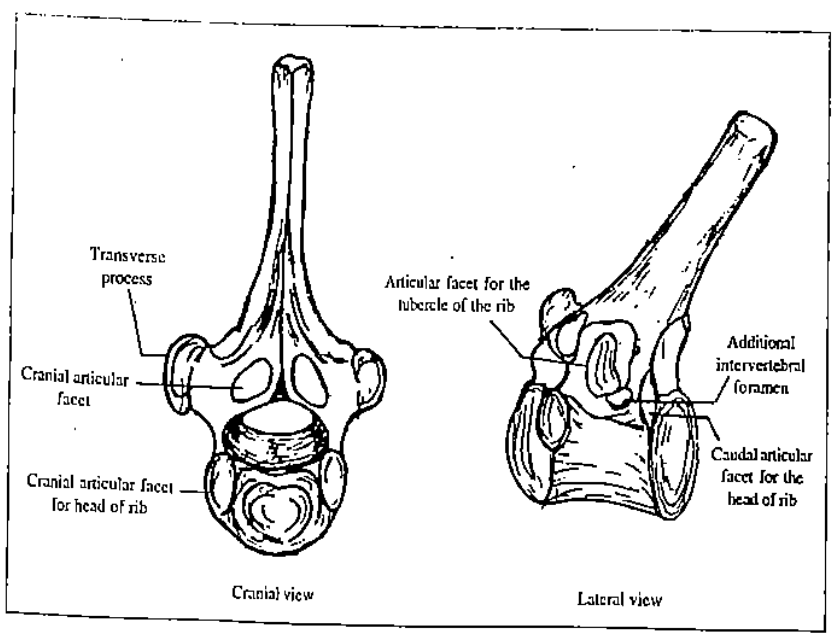


Fig. 2.75 A Typical thoracic vertebra.

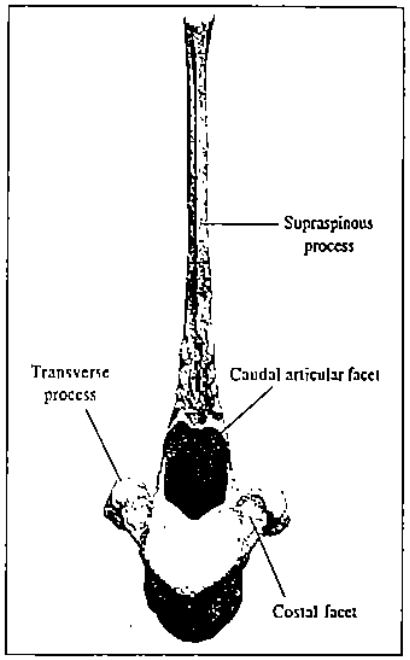


Fig. 2.76A A typical thoracic vertebra (Caudal view).

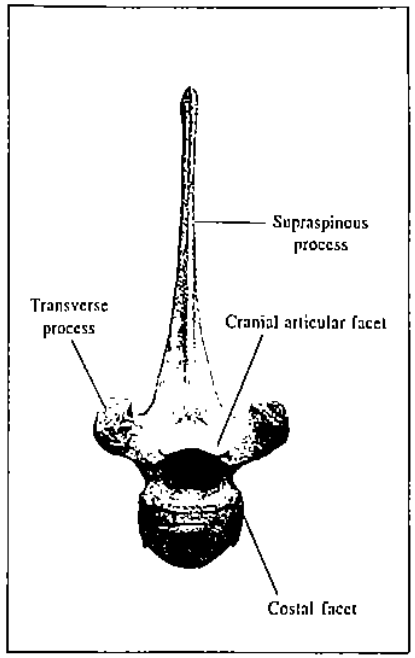


Fig. 2.76B A typical thoracic vertebra (Cranial view).

5. Four facets, two on the either end of the body are present for articulation with the concerned heads of ribs. These concave facets are situated bilaterally on the dorsolateral aspects of the body of the vertebra.

The last thoracic vertebra bears only two such costal facets at the cranial aspect of the body for last pair of ribs.

The supra spinous processes of 3rd and 4th thoracic vertebrae are maximum developed in length and breadth. The tubercular facet decrease in size from front to back. Distance between costal and tubercular facets decrease with the receding number. Summits of some supraspinous processes are bifid.

LUMBAR VERTEBRAE

These vertebrae with their bodies and long transverse processes form the bony roof of the abdomen.

They are 6 in cow, 6 in horse, and 7 in dog, 6-7 in pig and 6-7 in rabbit. In the fowl the lumbar bones fuse with sacrum to form synsacrum. These vertebrae have the following features :

1. Transverse processes are long and in the form of bony plates. They are inclined cranially.

The transverse processes of first lumbar are shortest and those of last lumbar are narrow. The length of these processes gradually increases up to 4th or 5th vertebra and those of 6th again become shorter.

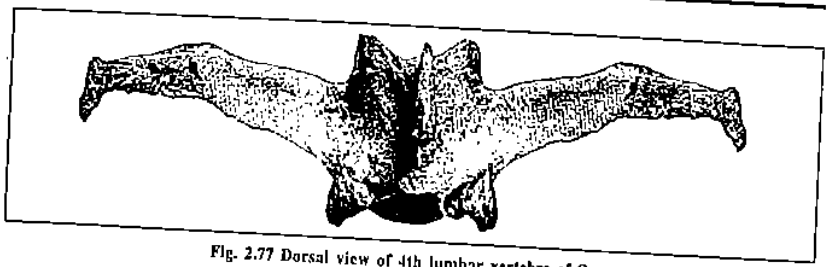


Fig. 2.77 Dorsal view of 4th lumbar vertebra of Ox.

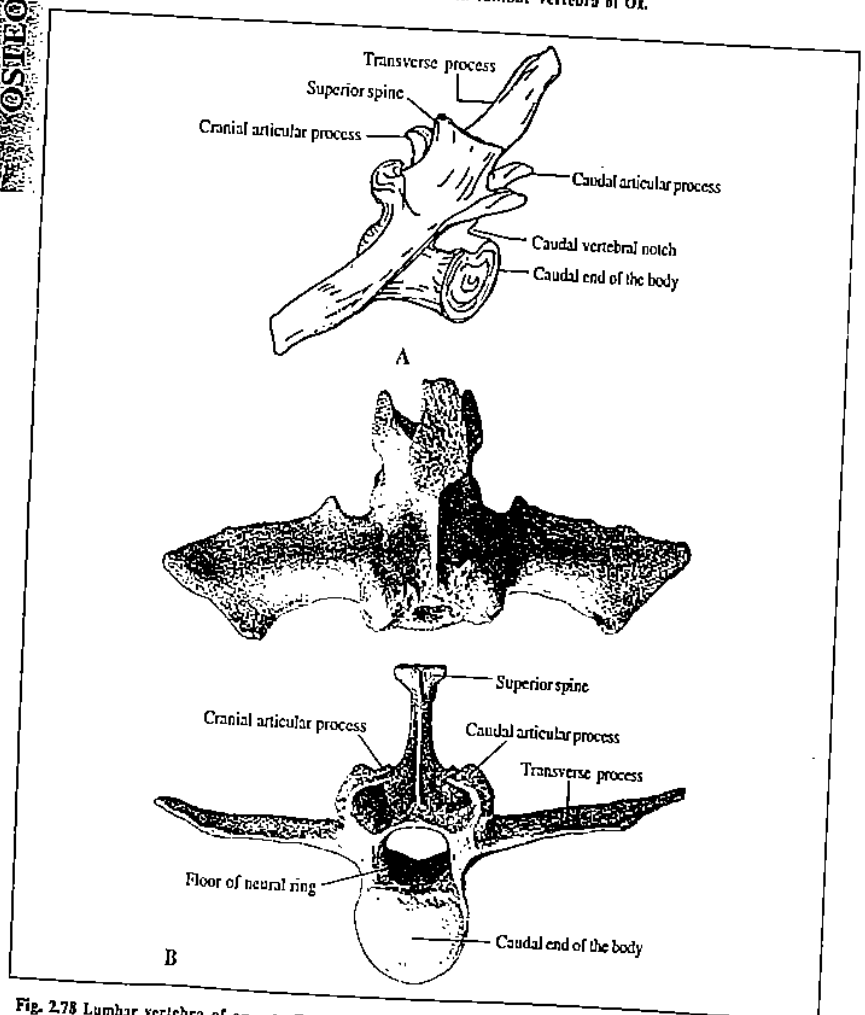


Fig. 2.78 Lumbar vertebra of ox. A. Caudo lateral view. B. Dorsal view (above) and Cranial view (below).

2. Articular pocesses are well developed. Cranial processes are curved inward and the caudal processes are convex and pointed.

3. Spinous process is in the form of a quadrilateral plate and are of uniform height. The summits are sometimes bifid.

4. Body of the last lumbar is little compressed dorsoventrally. Its transverse processes are narroow. It articulates with the cranial end of the sacrum.

5. Neural rings up to 3rd are round and then gradually becomes triangular.

6. Inter vertebral foramen are larger. Anterior few foramina are double.

SACRUM

This bone is formed by the fusion of five sacral vertebrae in cow and in horse. In the dog only three sacral vertebrae fuse for this purpose. Sacrum is roughly triangular in outline and forms the roof of the pelvic cavity. It articulates cranially with last lumber vertebra, caudally with first coccygeal vertebra and craniolaterally with ilium of the pelvic bone. It has two surfaces, two borders, a base and an apex. Dorsal surface is rough. At the midline it presents a median sacral crest, which is formed by the fusion of spinous processes of the vertebral segments. On either side and parallel to

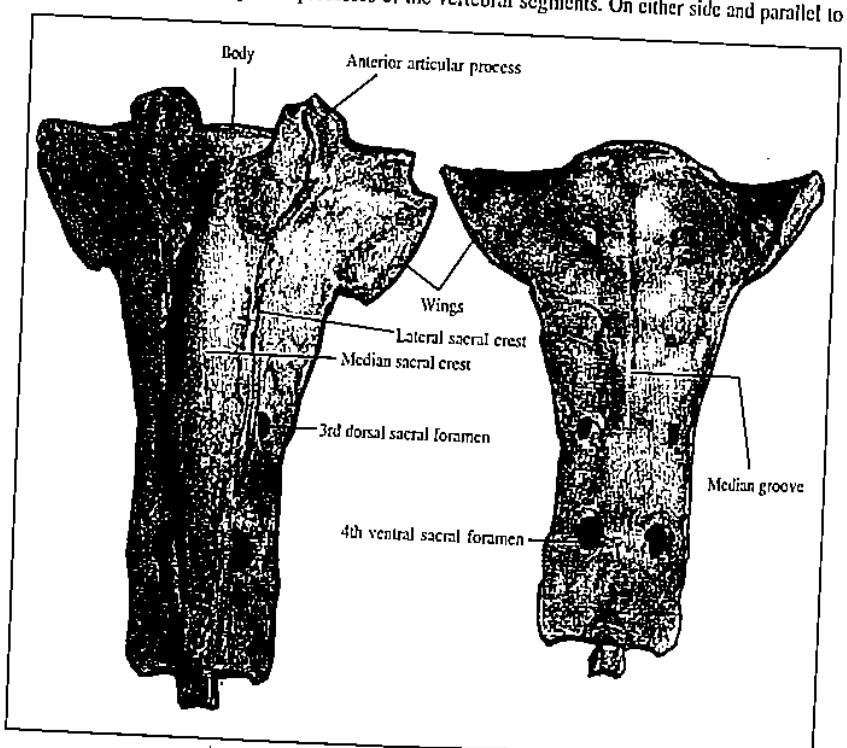


Fig. 2.79 Dorsal and ventral surfaces of sacrum of Ox.

the median crest, **lateral sacral crests** are situated. These are of low hights and are formed by the fusion of articular processes.

There are four **dorsal sacral foramine**, cranial two are situated at the medial side and caudal two are placed at the lateral side of the lateral sacral crest. **Ventral surface** is concave and presents a longitudinal median groove, four transverse grooves and four pairs of **ventral sacral foramina**. A dorsal and a corresponding ventral sacral foramina join together to form one intervertebral foramen which opens into the neural canal. The **base** comprises of the cranial end of the body, anterior articular process and neural ring. The body is dorsoventrally flat and the neural ring which leads to the caudal narrow end of the neural canal is triangular. Transverse processes of the sacral vertebrae are fused together to form broad wings cranially and **lateral plate** caudally. The lateral borders are thin and concave. The wings are twisted and articulate with the corresponding articular surfaces of the ilium. The **apex** is formed by the fifth sacral vertebra and in most cases incompletely fused with the fourth.

Sacrum of horse—The ventral surface of the body is less concave. Supraspinous processes are distinct due to their incomplete fusion. Lateral sacral crests are ill developed. The wings are

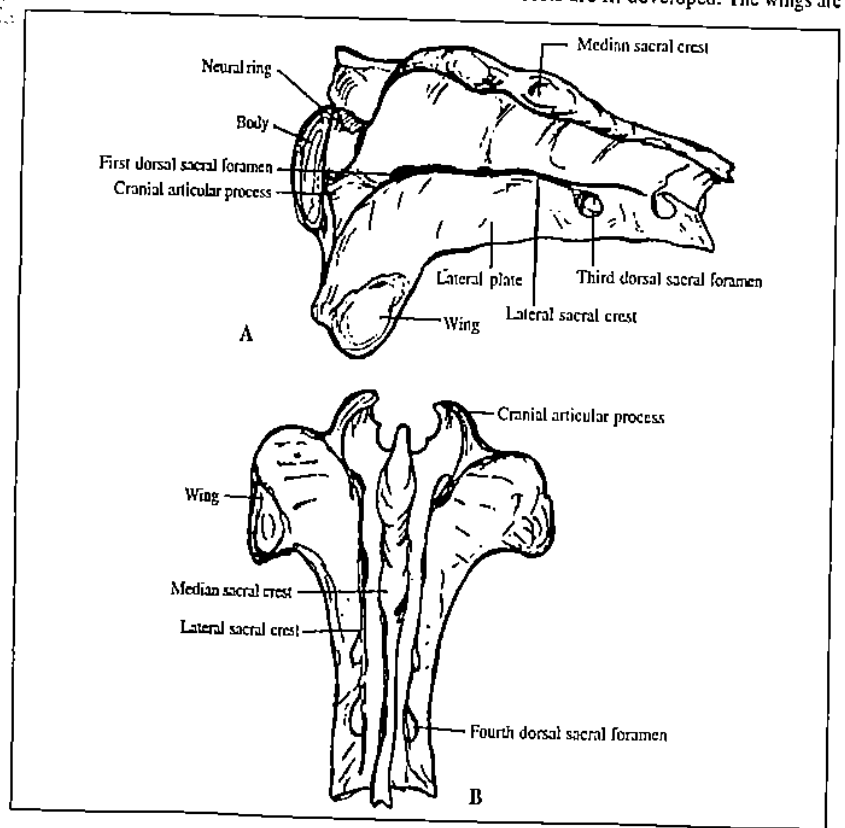


Fig. 2.80 Sacrum of ox. A. Lateral view B. Dorsal view.

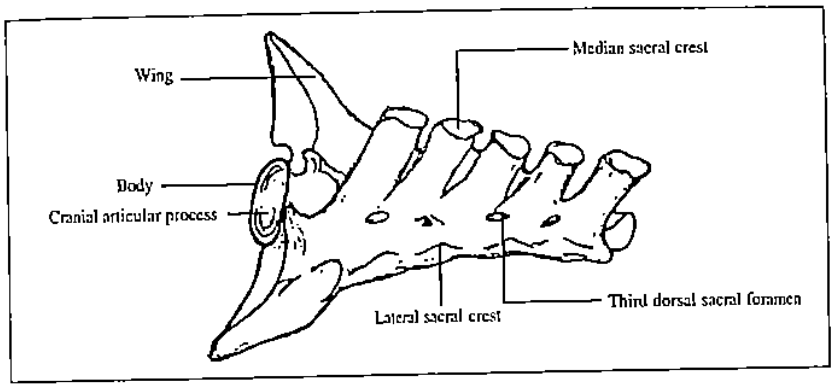


Fig. 2.81 Sacrum of horse (Lateral view).

pointed and prismatic. Lateral borders are rough. The bone is formed by the fusion of five sacral vertebrae.

Sacrum of dog—Only three vertebrae fused to form this bone and therefore the bone is small in length. The articular surfaces on the wings are wide. Ventral surface is concave. There are two dorsal and two ventral sacral foramina. The median sacral crest is notched.

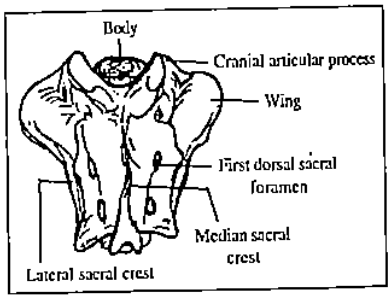


Fig. 2.82 Sacrum of dog (Dorsal view).

Sacrum of pig—It is formed by the fusion of four vertebrae. The supraspinous processes are ill-developed. The body is less curved. The cranial articular processes are well-built.

Sacrum of rabbit—Four vertebrae fuse to form this bone. The bone is comparatively elongated in appearance. The supraspinous processes are not fused. Ventral sacral foramina are large but dorsal foramina are indistinct (Fig. 2.30).

Sacrum of fowl—Lumbar and sacral vertebrae are fused to form a single synsacrum. This bone remains articulated with the ilia along their lateral borders.

COCCYGEAL VERTEBRAE

These are **incomplete** vertebrae and form the skeleton of the tail. The number is variable. It may range from 15 to 25 in cow, 16 to 22 in horse, 18 to 25 in dog, 18 to 24 in pig, 14 to 18 in rabbit and 4 to 9 in fowl. First five bones have neural rings, bodies and processes. They gradually reduce in size and last few bones possess only rod shaped bodies with convex ends. Ventrally they form a median groove for accommodation of median coccygeal artery.

Vertebral column of horse

$C_7T_{18}L_6S_5Cy_{16\text{-}22}$

1. The bodies of the cervical vertebrae are longer.

2. The wings of the atlas are pierced posteriorly by foramen transversarium.

3. The mammillary processes in few caudal segments of thoracic vertebrae are more developed.

4. The number of lumber vertebrae is usually six. Sometimes the number may be five.

5. The spinous process of the sacrum is not fused.

6. The wings are not twisted but prismatic and pointed.

7. The bone is less concave.

8. Coccygeal verebrae are ill-developed.

Vertebral column of dog

$C_7T_{13}L_7S_3Cy_{18-25}$

1. Foramen transversarium is present in the atlas at its posterior aspect.

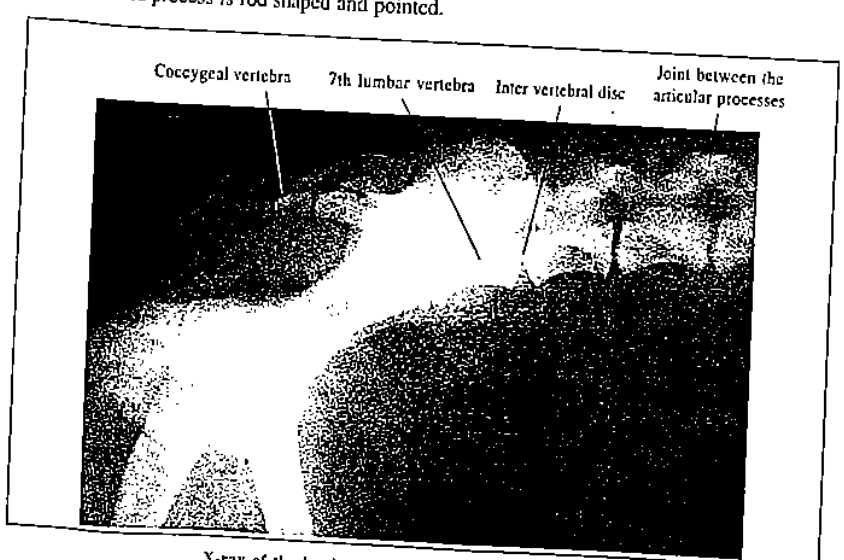
2. The spinous processes are comparatively short. They are broad ventrally and narrow dorsally in the lumber region.

3. The number of Lumbar vertebrae is seven. Transverse processes are directed cranially and ventrally. There is a pair of accessory processes which are directed caudally over the caudal notch on either side.

4. Sacrum is short and consists of only three vertebrae.

5. Coccygeal vertebrae are better developed.

6. Odontoid process is rod shaped and pointed.



X-ray of the lumbo sacral region of dog (lateral view).
(By Courtesy Dr. Subir Bhattacharya)

Vertebral column of pig

$C_7T_{14-15}L_{6-7}S_4Cy_{18-24}$

1. Cervical vertebrae are short and bodies are wide.

2. Spinous processes are short in general but in axis it is large.

3. Thoracic vertebrae are comparatively long.

4. Spinous processes of sacrum is ill developed.

5. First few coccygeal vertebrae presents well developed articular processes.

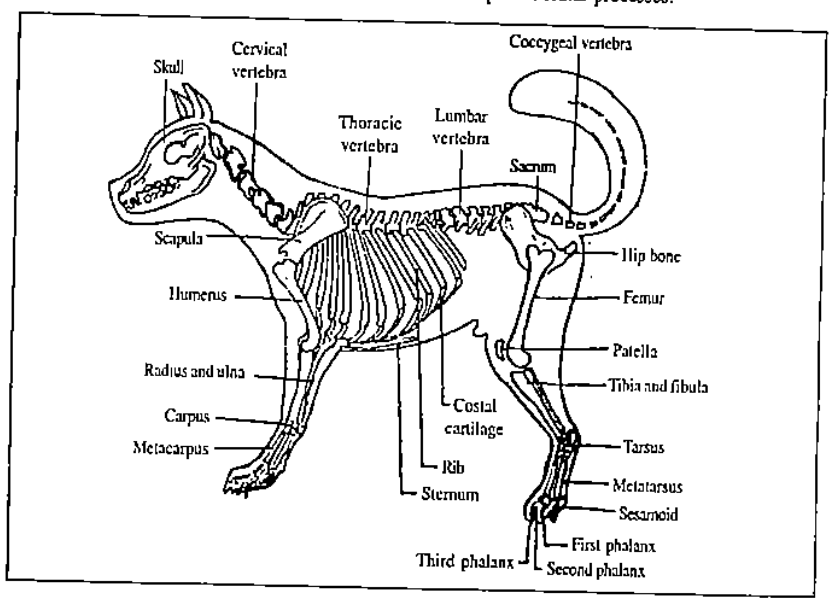


Fig. 2.83 Skeleton of dog. (For clear view, the legs and ribs of one side has only been drawn).

Vertebral column of rabbit

$C_7T_{12-13}L_{6-7}S_4Cy_{14-18}$

1. Cervical vertebrae are comparatively short and lumbar vertebrae are long.

2. Lumbar transverse processes are well developed.

3. Sacrum is elongated and placed parallel to ilium.

Vertebral column of fowl

$C_{14}T_7L+S_{14}Cy_{+9}$

1. As a whole, the vertebral column is stiff due to fusion of some vertebral segments.

2. The atlas is in the form of a ring. It presents only one articular facet at its cranial end for single occipital condyle.

3. Cervical vertebrae have styloid projections from transverse processes.
4. Last few caudal vertebrae fuse to form a pointed bony projection, known as pygostyle.

STERNUM *(Breast bone)*

It is a long plate of osteo-cartilagenous structure placed at the midline of the floor of the thoracic cavity. During development, the costal cartilages proceed towards the midline at the thoracic floor, where the ends reach towards their fellows of the opposite side. The mesenchyme between the ends of the costal cartilages ossify to form the sternum.

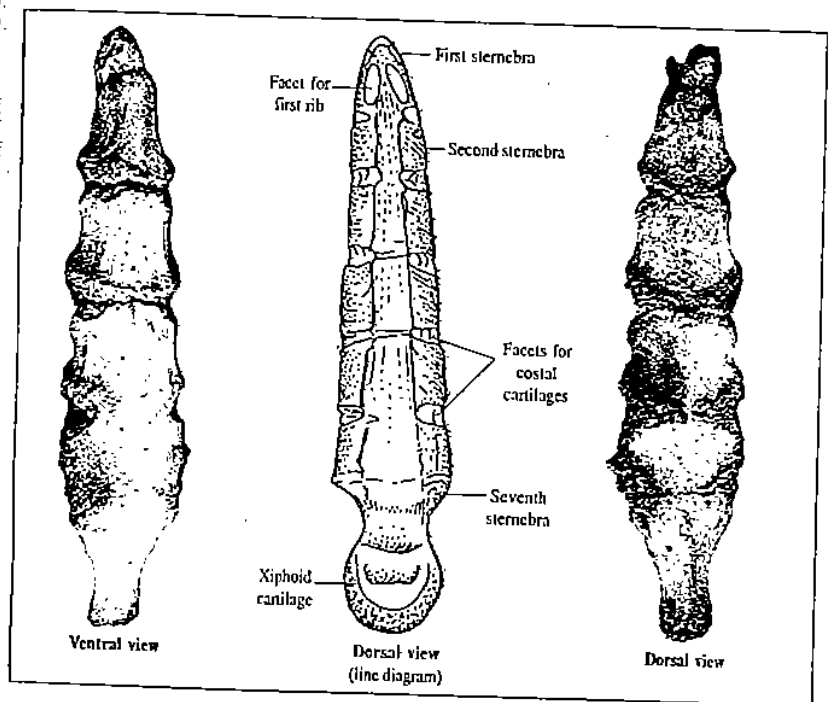


Fig. 2.84 Sternum of cow.

It is composed of seven sternal segments (sternebrae). It is flat except at its cranial end which is compressed laterally. The cranial end or **manubrium** is formed by the first sternebra. It forms a diarthrodial articulation with the second segment. Other segments are fused together. The caudal extremity is formed by xiphoid cartilage which is a thin plate like structure attached to the last sternebra. Dorsally the cartilage gives attachment to the diaphragm and ventrally to abdominal muscles. The body of the sternum is flat and thick. Dorsal surface is wide and remains covered by superior ligament and transversus thoracis muscle. Ventral surface is also flat but little concave and gives origin to the pectoral muscles. The lateral borders are thick and accommodate seven pairs of sternal facets on either side of the intersternal junctions. The first pair facets are placed on the dorsolateral

surface of manubrium sterni. The eighth pair costal cartilages join the sternum between 6th and 7th sternebrae along with seventh pair costal cartilages.

Sternum of horse

This bone is also formed by the fusion of seven sternebrae. It is boat shaped, compressed laterally towards the cranial end and dorsoventrally at the caudal end. Ventrally it presents a prominent crest. Lateral surfaces are convex. Xiphoid cartilage is flat and rounded. Manubrium sterni has a cranial cartilagenous extension.

Sternum of dog

It is formed by eight sternal segments which generally do not fuse with each other. They may fuse at very old age. First sternebra is longest. The cranial end is blunt and the Xiphoid cartilage is narrow.

Sternum of pig

Six sternebrae has fused together to form this bone. The manubrium sterni is elongated and compressed from side to side. Others are dorso-ventrally compressed. Xiphoid process is long and the xiphoid cartilage is small.

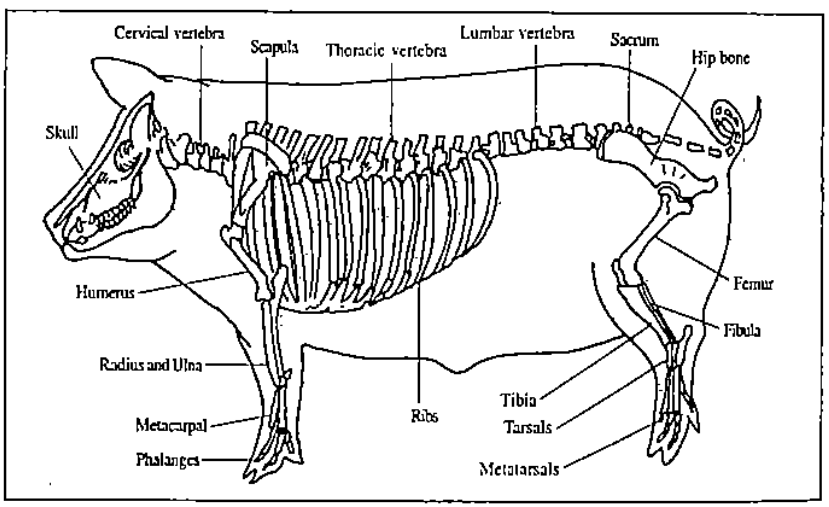


Fig. 2.85 Skeleton of pig.

Sternum of rabbit

The sternum comprises of seven sternebrae. The first segment is long and also articulates with clevicles on either side. The last segment is long and the xiphoid cartilage is in the form of an expanded plate.

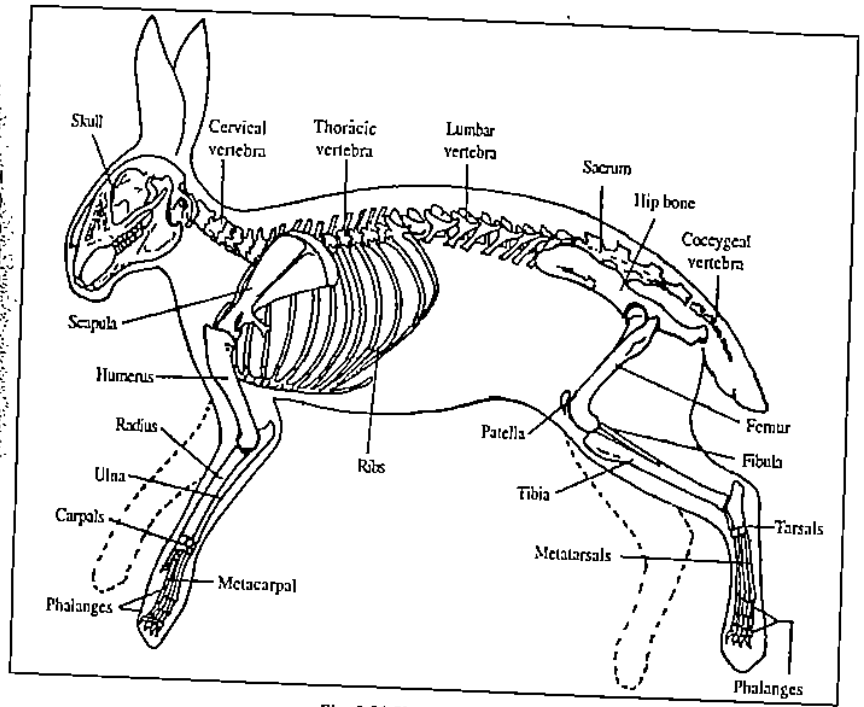


Fig. 2.86 Skeleton of rabbit.

Sternum of fowl

It is a large irregular plate of bone composed of a **cranial mass**, a cranial projection — the **rostrum**, a **caudal extension of the metasternum** and **lateral processes**.The dorsal surface of the cranial mass is concave. Ventrally it presents a plate like bone which is extended upto the metasternum, known as **sternal crest** or **keel** or **craina**. The rostrum presents two facets for coracoid. The lateral processes are two in number. Cranial one is flat and the caudal one is divided into a dorsal and a ventral part (Fig. 2.87).

CLAVICLE

This bone is absent in ox and horse. In the dog this bone is found embedded in brachiocephalic muscle in front of shoulder joint. It is roughly triangular osteo-cartilagenous plate of a structure without having any articulation with the skeleton. In pigs it remains occasionally in the form of indistinct tendinous band. In rabbit the clavicle is present in the form of a thin rod. In the fowl it is well developed.

Clavicle of fowl

It is a thin rod extends from the proximal end of coracoid towards the apex of the sternum. The bones of both sides ventrally unite to form a 'V' shaped structure, known as **furculum**. The junction

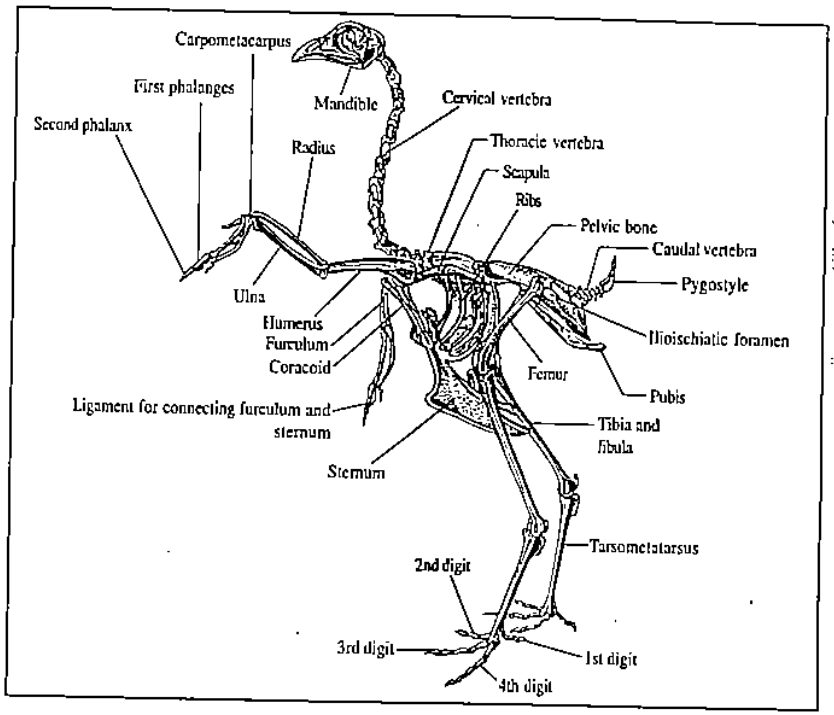


Fig. 2.87 Skeleton of fowl.

is in the form of a flattened plate which is connected to the apex of the sternum by ligament. This flattened plate is called **hypocleidium**.

CORACOID

It is found in the fowl. This bone is long and directed downward and backward between the scapula and sternum. It accommodates air sac. Proximal end is in the form of hook which articulates with scapula and clavicle. The distal end is flat and articulates with sternum.

RIBS

These are curved elongated bones arranged one after another from either side of the vertebral column and form the thoracic cage. In the cow there are 13 pairs of ribs, out of which first eight pairs are sternal and rest five pairs are **asternal**. The shape and size of the ribs varies at different levels. The sternal ribs are connected to the sternum directly through their own costal cartilages and are also called **true ribs**. The asternal ribs reach the sternum indirectly by their costal cartilages which join with the preceding cartilage. The asternal ribs are also called **false ribs**. Few ribs, either single or in pair at the end of the series which are not connected with the sternum directly or indirectly are called **floating ribs**.

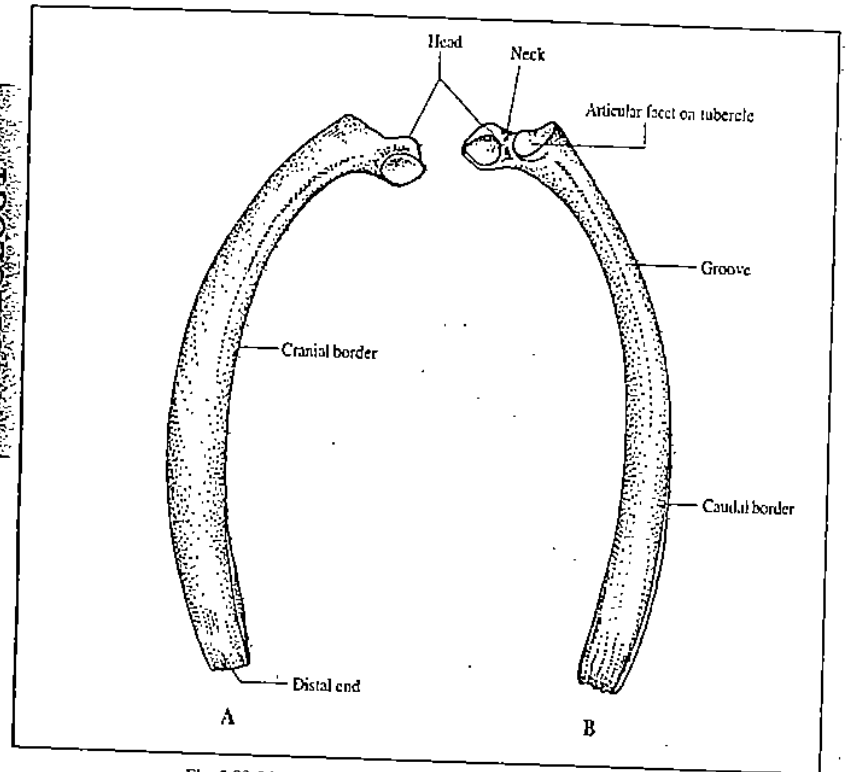


Fig. 2.88 6th right rib of ox. A. Lateral view B. Medial view.

A typical rib has a head at the proximal end a costal cartilage at the distal end and a shaft. The **shaft** or the body is curved and presents two surfaces and two borders. The curvature at the upper part is more and the distal end is inclined inward. The lateral surface is convex and has a wide groove at its upper part. Medial surface is smooth and concave. Cranial border is thick and concave. Caudal border is convex and lodges the costal groove for intercostal vessels. This groove is prominent at the upper part. The head presents two articular facets separated by a groove. The tubercle is situated behind the head and the two structures are separated by a constricted portion—the neck. The length of the neck is variable.

The distal end is little expanded and articulates with costal cartilage. These cartilages are cylindrical and little compressed from side to side.

The first rib is least curved. It is short and thick. Neck is also short. Cranial border presents a faint groove for axillary vessels. Occasionally it presents a small tubercle above the groove, which marks the origin of scalenus muscle. Costal groove is absent.

The last rib is slender and curved. The head and the tubercle are fused.

8th, 9th and 10th ribs are longest and widest.

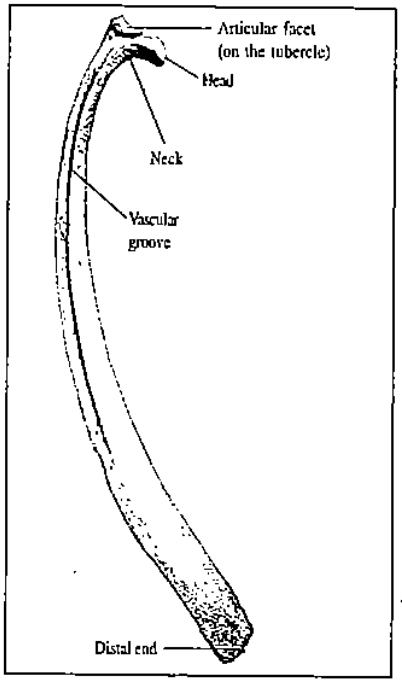


Fig. 2.89 A typical rib of cow (Right).

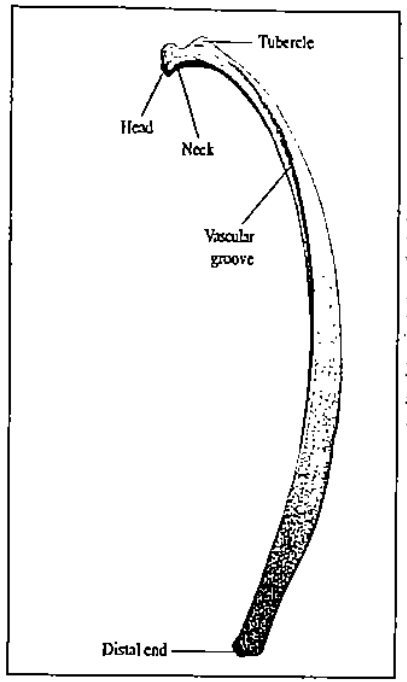


Fig. 2.89B A typical rib of cow (Right).

Ribs of horse

There are 18 pairs of ribs in this animal, out of which first 8 pairs are sternal and rest 10 pairs are asternal. Width in the 6th rib and length in the 11th rib are maximum. The body is less wide and less flat in comparison to that of ox.

Ribs of dog

There are 13 pairs of ribs in this animal. Nine are sternal and four are asternal. The body is cylindrical and more curved. Generally the last rib is floating.

Ribs of pig

Pigs have 14 to 15 pairs of ribs of which seven pairs are sternal and remaining 7 to 8 pairs are asternal. The last rib is usually small and floating. The first rib has a prismatic body.

Ribs of rabbit

There are 12 to 13 pairs of ribs in rabbit of which 7 pairs are sternal ribs and remaining 5 to 6 pairs are asternal ribs. All the ribs excepting last four have prominent head and articular processes.

Ribs of fowl

There are seven pairs of ribs in fowl. Each rib has a **dorsal segment** and a **ventral segment**. First two ribs do not extend upto the sternum. Each of the dorsal segments of 2nd to 6th ribs

possesses a caudal extension, known as uncinate process which supports the thoracic cage in a better way by overlaping the succedding rib.

VISCERAL BONES

In certain organs of some animals and birds, few bones are found to be embedded in the parenchyma. They are believed to be modified musculature of the organs and have no connection with the skeleton. These floating bones within the viscera are known as visceral or splanchnic bones. These are as follows :

Ossa cordis—These are two small triangular bones embedded in the myocardium on either side of the aortic ring of heart in cow. The right one is larger in size. In the horse they are cartilagenous but sometimes calcify in old age.

Ossa penis—This is an elongated bone placed in the corpus cavernosum panis muscle at the cranial part of penis in dog. Ventrally it presents a groove for urethra.

Ossa opticus—This is a thin U shaped bone placed in the scleral cartilage of the eye in some cocks.

Ossa rostrale—It is a small flat bony structure embedded within the rostral aspect of the nasal septal cartilage in pig.

FRACTURE OF BONE AND ITS REPAIR

A fracture means a break in the continuity of a bone. The fracture may be simple or compound. A simple or closed fracture does not communicate with a skin wound. A compound or open fracture, on the other hand, is connected with the skin wound.

According to the shape, the fracture may be classified as transverse, oblique or spiral.

Repair of a fracture is a *continuous process*, and three stages may be recognised – repair by granulation tissue, union by callus and remodelling by mature bone.

Repair by granulation tissue

The immediate effect of fracture is a collection of blood from the torn vessels, and the blood coagulates to form a clot in and around the site of fracture. Due to interruption of blood supply across the fracture line, bone dies for a considerable distance on each side of the fracture, new blood capillaries and fibroblasts invade the blood clot and convert it into a granulation tissue. In this way repair of fractured ends is established by soft tissue which is known as the *temporary callus*.

Union by callus

The *callus* is a hard tissue which bridges across the fragments of bones in the process of repair. Callus may be of three kinds-external, intermediate and internal. *External callus* appears outside the fractured ends and beneath the périosteum ; *intermediate callus* lies between the fragments of bones, whereas *internal callus* appears within the medullary cavity.

Within a few days after fracture, the osteogenic cells of deep layers of periosteum and endosteum of both fragments proliferate, and form a distinct *collar* around each fragment of bone. Within the

collar, the osteogenic cells differentiate into the osteoblasts and chondroblasts ; the former grow close to the bone in presence of blood supply, and the latter develop in a non-vascular environment away from the bone. Therefore, the external callus presents three layers from within outwards :

a) The layer close to the bone consists of bony trabeculae ;

b) Intermediate layer consists of cartilage cells ;

c) The outer layer consists of proliferating osteogenic cells.

The collars continue to grow over each bony fragment. Later the collars from the two fragments meet and fuse. This causes the union of the fractured ends.

Remodelling by mature bones

The cartilage cells of the callus are calcified and eventually die. As a result, all cartilage cells are replaced by bones by the endochondral ossification laying down cancellous bone. Simultaneously, osteoclast cells remove the matrix of the dead bones, and new living bones are laid down by the osteoblasts between broken fragments.

Nabarun Chandra

3 SYNDESMOLOGY

Joints or articulations are the structures, formed by the union of two or more articular ends of bones or cartilages with the help of certain binding materials, *i.e.*, the ligaments. The joints are responsible for different types of movement of the skeleton and thereby help in locomotion. Stability of a joint is maintained by bony configuration, ligaments and tone of different muscle groups which act on the joint.

Classification

Broadly joints can be classified into three groups (1) *Synovial* (diarthrodial) or *movable joints*, (2) *Fibrous* (Synarthrodial) or *immovable joints* and (3) *Cartilaginous* (amphiarthrodial) or *joints* with restricted movement.

SYNOVIAL JOINTS

These joints are formed by articular cartilages, joint capsule and ligaments.

Articular cartilage—They are mostly hyaline in nature and cover the articular ends of the bones. These cartilages provide low friction lubricated surface and make the movement easy. It is thicker in young and thinner in old subjects. The cartilage is non vascular and devoid of nerves too. It is believed that this tissue derives its nutrition from vascular network of synovial membrane, synovial fluid and from blood vessels of underlying marrow spaces.

Besides these articular cartilages, in some joints other varieties of cartilages such as intra articular cartilage, circumferential cartilage, *etc.*, are present.

Intra-articular cartilage—These are fibrocartilaginous pad or disc like structures placed between two articular surfaces. They minimise the pressure and friction which are produced during the activity of the joint. These cartilagenous discs sometimes fuse with synovial membrane around its periphery and divide the joint cavity into two compartments.

Circumferential cartilages—These are also made up of fibro cartilages and placed at the margin of the articular cavity to make it deeper and capacious.

Joint Capsule —Joint capsule or capsular ligament is a membranous tube like Sac which covers or encapsulates a diarthrodial joint. The ends of this tubular sac are attached around the articular surface of the concerned bones. The capsule has an external fibrous part and an internal membranous part. The fibrous part is made up of parallel and interlacing bundles of white connective tissue fibers. It is perforated in some places for the passage of vessels and nerves.

The membranous part is thin and vascular. It secretes the synovial fluid and called the synovial membrane. The **synovial membrane** lines the outer fibrous capsule but never lines the articular surfaces of bones. Sometimes a portion of the synovial membrane protrudes out through small aperture of the fibrous capsule to assist formation of synovial bursa and synovial tendon sheath.

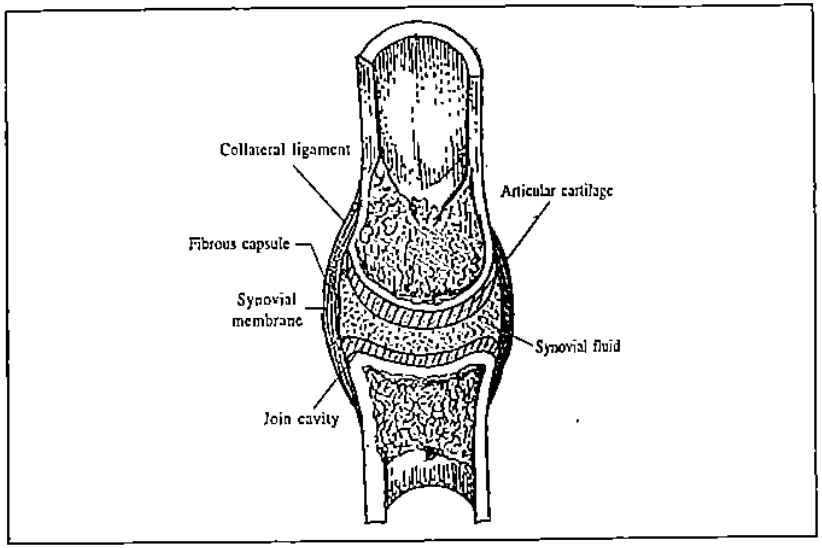


Fig. 3.1 A Synovial joint (Longitudinal section).

Synovial membrane therefore not only lines the joint cavity but also lines the synovial bursa and tendon sheath. The functions of synovial membrane are as follows :

(a) It secretes synovial fluid which provides nutrition to the articular cartilage.

(b) Hyaluronic acid is libarated from this membrane which maintains viscosity of the fluid.

(c) It removes particles and worn-out cartilage cells by the phagocytic activity.

The **synovial bursa** is a sac like structure containing synovial fluid which occurs at the site of friction in between a tendon and a bone or subcutaneously over a bony prominence. **Synovial tendon sheath** is a tubular bursa which surrounds a tendon where it runs in a tunnel and is subjected to friction on all sides. Majority of these bursae communicate with the nearby joint cavity.

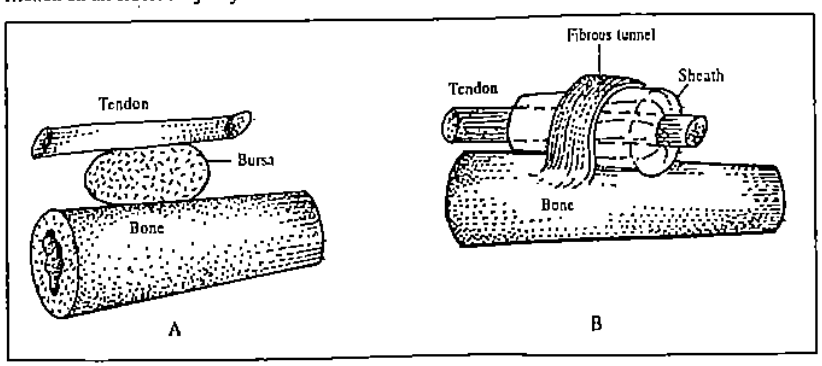


Fig. 3.2 A. Synovial bursa B. Synovial tendon sheath.

In some places synovial membrane produces internal folds. These folds are known as **synovial villi. Articular fat pads** are the occasional accumulation of adipose tissue in or around these folds which project internally. The **lamina propria synovalis** is composed of one to four layers of synovial cells situated on the granular intercellular matrix.

Synovial fluid—It is a lubricant fluid secreted by the synovial membrane. It resembles the egg albumin but have a yellowish tinge. It is composed of albumin, mucin, salts, water and a small mixed population of cells. Its reaction is slight alkaline at rest. It also contain hyaluronic acid. The viscosity of the fluid depends on the concentration of this acid.

BLOOD SUPPLY AND NERVE SUPPLY TO THE JOINTS

Blood supply—Near the attachment of the fibrous capsule, the epiphysal vessels enter the long bones. These vessels branch and rebranch and ultimately break up into a rich capillary plexus in the synovial membrane. This periarterial plexus is known as circular vasculosus.

Nerve supply—Most of the diarthroidal joints are innervated generally by the nerves supplying near by muscles. The articular nerves contain sensory and autonomic fibers.

Some sensory fibers convey proprioceptive sensation from joint. They are concerned with the reflex control of posture, locomotion and perception of positional movement. Other fibers carry pain sensation from the fibrous capsule.

Hilton's law—The nerves which supply a joint also furnish branches to the group of muscles regulating the movement of the joint. Therefore irritation of the nerves in the joint disease cause reflex spasm of the muscles which fix the joint in position of greatest comfort. The pain may be reffered to the overlying skin.

LIGAMENTS

These are binding materials of the joints. They are made up chiefly of closely packed bundles of collagen and are usually in the form of strong bands or membranes. Ligaments connect bone to bone and arrangement of collagen bundles is less regular. The fibers are continuous with those of periosteum. The ligaments may be of following varieties :

(a) Joint capsule (already described).

(b) Collateral ligaments—These are fibrous bands situated on either side of the joint. They are generally attached to the lateral and medial aspects of the ends of bones outside joint capsule.

(c) Intra-articular ligament—These connecting bands remain within the joint cavity and is covered by synovial membrane.

(d) Interosseous ligaments—The apposed surfaces of the bones are connected by these ligaments.

(e) Annular ligaments—These are in the form of rings or tunnels, over or near the joints for passage and protection of tendons.

Factors maintaining stability of joints

1. *Bony configuration* – Proper configuration of the articular ends/surfaces/areas of bones are necessary for the stability of the joints.

2. *Ligaments* – They not only bind the ends of the bones but prevent undesirable movement. Ligaments can withstained stress for a short duration.

3. *Muscles* – The tone of different muscle groups which act on the joint is indispensable for maintaining stability of joints.

MOVEMENTS OF SYNOVIAL JOINTS

1. *Translation or gliding*—When one surface slides over another, *e.g.*, Femoropatellar articulation.

2. *Angular movements*—During these movements the angles between two adjoining bones change. The angular movements are as follows :

(a) Flexion—In this movement the angle reduces and the segments come close together.

(b) Extension—The angle increases or the segments straightens

(c) Abduction—Outward movement of one segment from central axis.

(d) Adduction—Inward movement of a bone towards the central axis.

3. *Circumduction*—In this movement the distal end of a bone circumscribes a conical space. It is produced by the shoulder or hip joint.

4. *Rotation*—Here one bone rotates around the longitudinal axis of other bone. This movement is marked in atlanto – axial articulation.

CLASSIFICATION OF SYNOVIAL JOINTS

On the basis of the axis of movement the synovial joints are classified as follows :

1. *Uniaxial*—These joints permit movement in one plane only. Hinge joints and pivot joints belong to this group. In the **Hinge or ginglymus joints** the main movements are extension and flexion *e.g.*, elbow joint. The movement of **Pivot or Trochoid joint** is around a longitudinal axis, *e.g.*, Atlanto – axial articulation. **Condylar joints** are also similar to uniaxial joints. Here, in addition to a principal movement in one plane a limited rotation movement is also permitted, *e.g.*, temporo mandibular joint.

2. *Biaxial*—These joints permit movement in two planes at right angles, *e.g.*, extension – flexion and abduction – adduction. A combined circumduction movement may also be available.

Ellipsoid and sellar or saddle joints are the main subdivisions of this group. In this Ellipsoid joint a convex male surface is received by a concave elliptical female surface. Carpal joint is an example of this joint. In the saddle joint the apposing surfaces are convexo concave or saddle shaped. Interphalangeal articulations in dogs belong to this catagory.

3. *Multi-axial*—These articulations are also called **ball and socket joints**. Here a round head is received by a cup like concavity. These joints permit angular, rotation and circumduction movements. Hip joint is the example of ball and socket joint.

SOUND IN THE JOINTS

Joint crack—Sometimes a sound in the joint is produced by the development of vacuum within it due to sudden separation of articular surfaces on pressure or force. Water vapour and blood gas fill up the vacuum.

FIBROUS JOINTS

These are temporary joints and subsequently the uniting medium (fibrous tissue) is invaded by process of ossification. These joints practically provide no movement and hence also termed as immovable joints. These joints are of following types :

1. *Sutures*—These joints are mostly found in the skull. The borders of adjacent bones are united by fibrous connective tissue, the sutural ligament. The sutures are classified according to the shape of apposing edges of the bones.

(a) **Sutura serrata**—The edges are serrated or like the teeth of saw. The edges interdigitate with each other *e.g.*, frontal suture.

(b) **Sutura squamosa**—In this articulation the edges are in the form of thin plates. They overlap with each other to make union, *e.g.*, suture between parietal and temporal bone.

(c) **Sutura harmonia or plane suture**—In these articulations the edges are plane or slightly roughened, *e.g.*, Nasal suture.

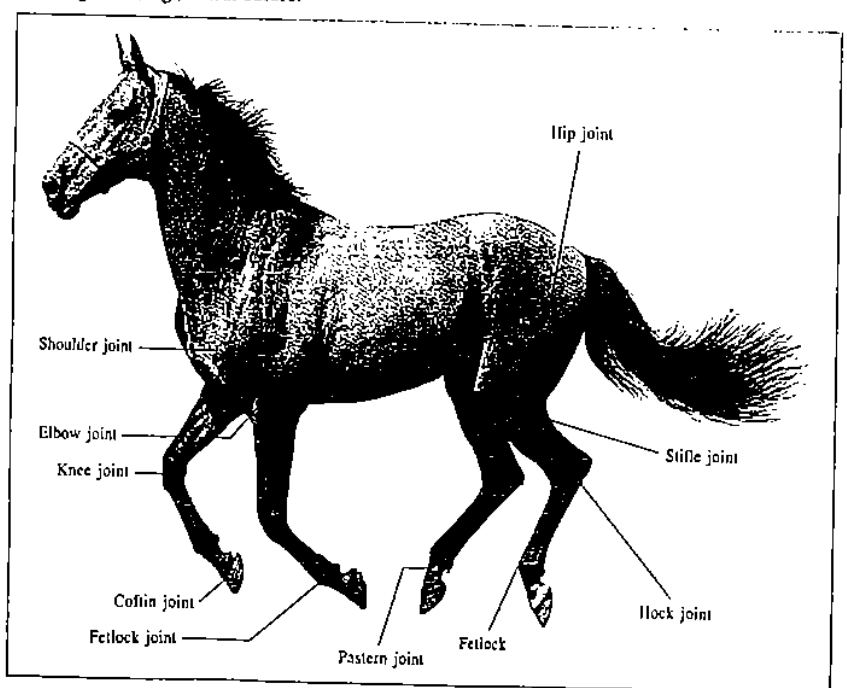


Fig. 3.3 A horse showing positions of joints.

2. *Syndesmosis*—In these articulations the uniting medium is white fibrous tissue, *e.g.*, joints between bodies of metacarpal bones or attachments between costal cartilages.

3. *Schindylesis*—When a bone is fitted into a groove of another bone, the term schindylesis is applied, *e.g.*, junction between vomar and sphenoid bone.

4. *Gomphosis*—The articulation between the roots of the teeth in the alveolar sockets are termed as gomphosis. Here the peg like roots of teeth are implanted in to the alveolar sockets.

CARTILAGINOUS JOINTS

The bones are articulated by fibro cartilage or by hyaline cartilage or by both. They permit limited movement. These are of two types—*Synchondrosis* and *Symphysis*.

1. *Synchondrosis*—They are articulated by hyaline cartilage. These are temporary joints and subsequently may get ossified, *e.g.*, junction between sphenoid and occipital bones.

2. *Symphysis*—These are fibrocartilaginous articulations between symmitrical bones. They are also called secondary cartilaginous joints and persist throughout life. They permit certain amount of movement. Pelvic symphysis is an example of this group. These articulations are generally placed at the longitudinal median plane of the body.

JOINTS OF THE SKULL

Temporo mandibular articulation

Type—Ginglymo-arthrodial joint.

Movement—Hinge like movement associated with slight gliding and rotation.

Bones involved—Condyle of the mandible and the squamous part of temporal bone.

Articular disc—It is placed between the joint surfaces. It is convexo concave at the dorsal surface and concave at the ventral surface. This cartilage has divided the cavity into upper and lower compartments.

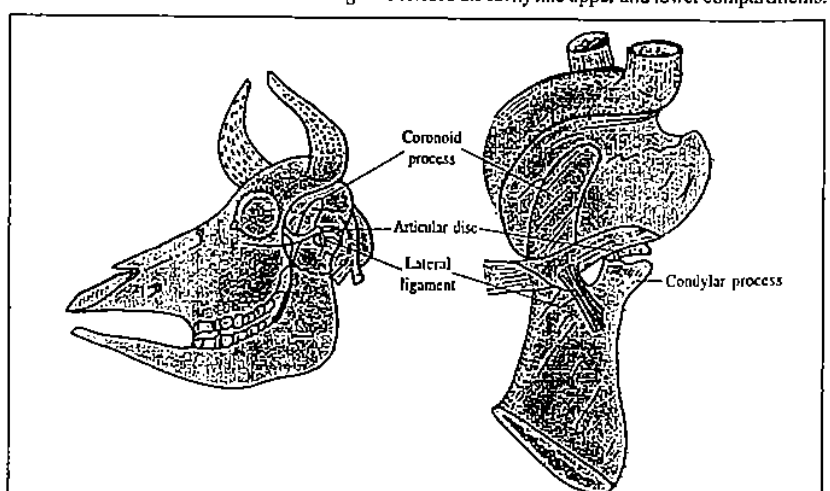


Fig. 3.4 Temporo mandibular articulation.

Ligaments—

(a) Capsular ligament.

(b) Lateral ligament—It extends from the zygomatic arch and terminates at the outer side of the neck of the mandible.

HYOID ARTICULATIONS

Temporo hyoid articulation

Type—Amphiarthrosis

Movement—Restricted

Bones involved—Articular angle of the great cornu of hyoid bone and hyoid process of the petrous temporal bone.

Ligaments—No ligament. Only a piece of cartilage is interposed in between the articular surfaces.

Proximal and distal intercornual articulations

Type—Amphiarthrosis.

Movement—Restricted.

Bones involved—

(i) Proximal joint—Distal end of the great cornu and proximal end of the middle cornu of the hyoid bone.

(ii) Distal Joint—Distal end of the middle cornu and proximal end of small cornu of hyoid bone.

The uniting media in both the joints are cartilages.

Basi cornual articulation

Type—Hinge

Movement—Extension and flexion.

Bones involved—Distal end of small cornu and the cartilage joining the body with the thyroid cornu.

Ligament—Capsular ligament.

SUTURES OF SKULL

Most of the joints between the bones of the skull are synarthrosis. Few of them are joined by cartilage and one (temporo mandibular) is a synovial joint. The sutural articulations have been named according to the bones involved in their formation, *e.g.*, Interparietal suture, Interfrontal suture, Fronto-parietal suture, Temporo parietal suture, *etc.*

SYNCHONDRIAL ARTICULATIONS OF SKULL

The main articulations of this group in the skull are between the occipital and post sphenoid; between postsphenoid and presphenoid and between different parts of occipital bones. Most of these joints ossify in adult life.

Mandibular symphysis

The medial rough surface of the anterior part of the body of one half of the bone meets with the similar half at the midline and form symphysis mandibulae. These two halves of mandible are bound to this place by fibrous connective tissue. This symphysis do not ossify even in adult life. In macerated bone it is observed that the articular surfaces are very rough but interdigitate with each other. In horse this symphysis ossify within few months and therefore remain as a single piece of bone. In dog it does not ossify.

JOINTS OF FORE LIMB

SHOULDER JOINT

Type—Ball and socket joint

Movement—Poly axial. The position of this joint is not fixed because both the bones can move, as none of the bones articulate with the axial skeleton.

Bones involved—The glenoid cavity of scapula and head of humerus.

Ligaments—The only ligament is the capsular ligament. It is capacious and encloses the whole joint. It is reinforced by surrounding tendons and muscles. The short muscles of scapula make the shoulder joint stable in movements of fore limb. From the tuber scapulae two diverging elastic bands extend in front up to tuberosities of humers. These bands give support to the capsular ligament.

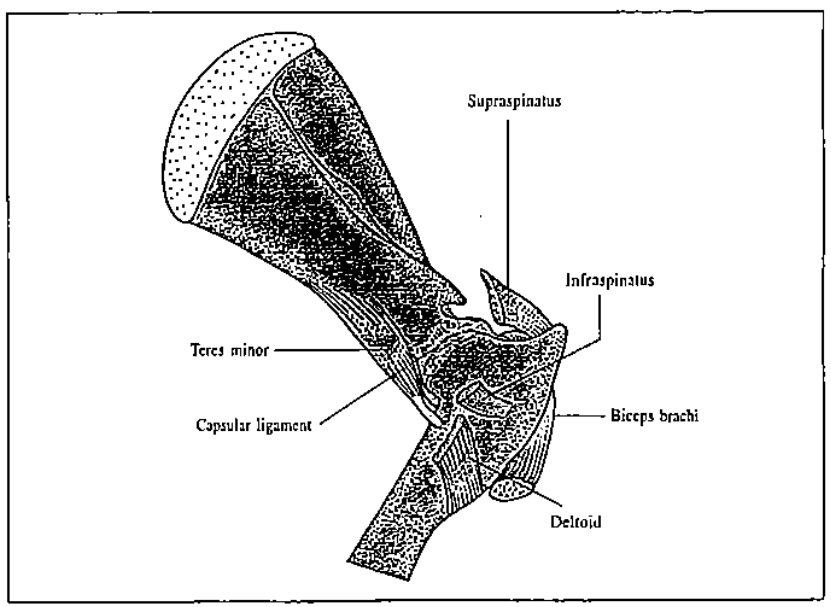


Fig. 3.5 Shoulder Joint of cow Right leg (Lateral view).

ELBOW JOINT

It is a composite joint comprises of (i) Radioulnar articulation and (ii) Humero-radial articulation.

Radio-ulnar articulation

Type—This is amphiarthrosis in young and synarthrosis in adults.

Movements—Very restricted in young calves and immovable in adult animals.

Bones involved—Postero-lateral aspect of the shaft of radius and anterior surface of the body of ulna.

Ligaments—

(a) Capsular ligament—It encloses the joint above the proximal interosseous space. This portion of the joint does not ossify even in adult life.

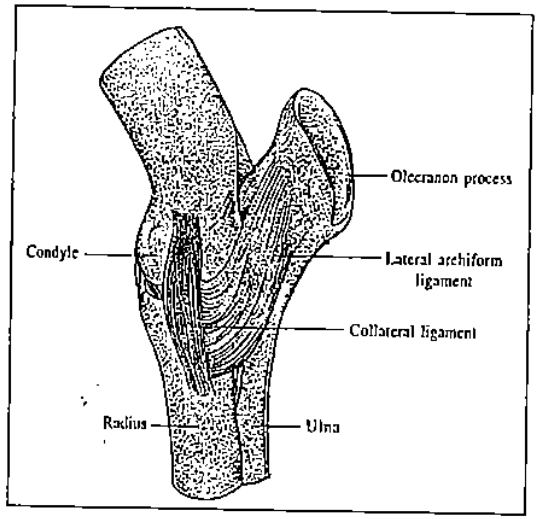


Fig. 3.6 Elbow joint (Lateral view).

(b) Interosseous ligament—These are white connective tissue fibres remain in between the apposed surfaces of the corresponding bones. These ligaments except at the proximal part are replaced by osseous tissue in adults.

(c) Archiform ligaments—These are lateral and medial and are arch shaped ligaments, connect the corresponding aspect of proximal ends of radius and ulna. These archiform fibers blend with the corresponding collateral ligaments of the humero-radial articulation.

Humero-radial joint

Type—Hinge joint.

Movement—Extension and flexion.

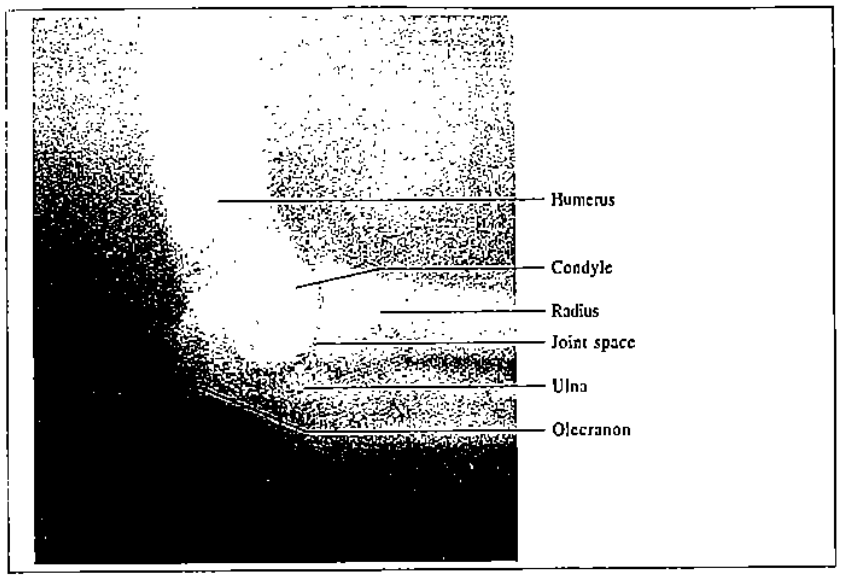
Bones involved—The condyles of humerus articulate with the proximal end of radius.

Ligaments—

(a) Capsular ligament.

(b) Lateral collateral ligament—It extends from the depression on the lateral condyle of humerus to the tuberosity on the lateral aspect of the upper end of radius.

(c) Medial collateral ligament—Proximally this ligament is attached to the tubercle on the medial condyle of humerus and divides into superficial and deep parts. The deep part terminates at the medial tuberosity of radius and the superficial part extends further little downward and terminates below medial tuberosity.



X-ray of elbow joint of dog (latero-medial view). (By Courtesy Dr. Subir Bhattacharya)

CARPAL JOINT *(KNEE)*

Knee of an animal is a composite joint and formed by the union of the distal ends of radius and ulna, carpal bones in two rows and proximal end of metacarpal bone. It comprises of the following articulations:

(a) Radioulnar carpal articulation;

(b) Intercarpal articulation; and

(c) Carpometacarpal articulation.

Type—Hinge joint.

Movement—Slight gliding movement is available in the carpo-metacarpal articulation. Other two articulations provide extension and flexion movements.

In this joint there are some liganents which involves the whole joint, called common ligaments and some small ligaments which are attached to two individual bones, called special ligaments.

Common ligaments

(a) Capsular ligament—It is a loose sac. It's anterior part is called the dorsal carpal ligament and the posterior part is called the volar carpal ligament. The synovial membrane is three in number – Radio-ulnar-carpal sac, Intercarpal sac and carpometacarpal sac.

(b) Medial ligament—It extends from medial tuberosity of the distal end of radius to the medial aspect of the proximal end of large metacarpal bone. On the way it is attached to the radial carpal and second and third fused carpal bones by short fasciculi.

(c) Lateral ligament—It extends from the lateral tuberosity of the distal end of radius and styloid process of ulna to the lateral aspect of the upper end of large and small metacarpal bones. It also detaches two fesciculi, which are attached to the ulnar carpal and fourth carpal respectively.

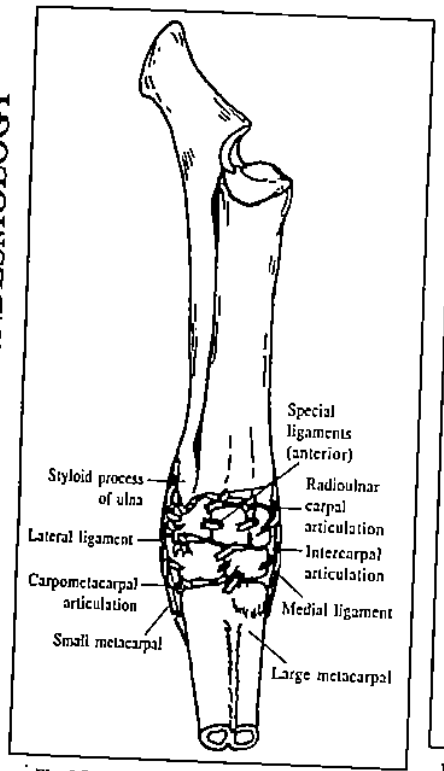


Fig. 3.7a Carpal joint (Right leg, front view).

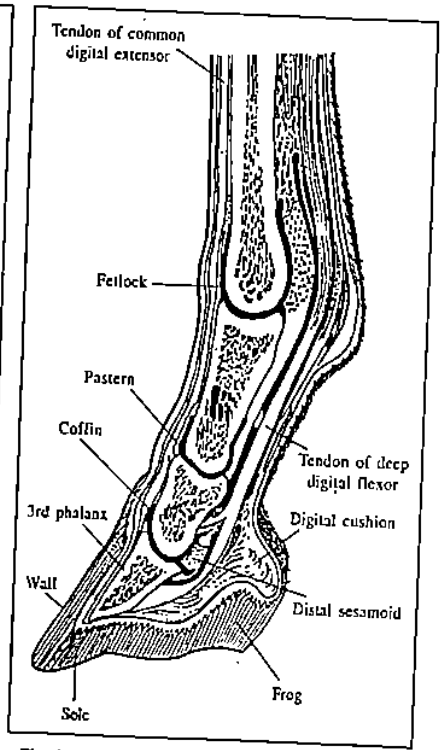


Fig. 3.7b Longitudinal section of the distal part of fore limb (horse).

Special ligaments

The radio-ulnar carpal joint is bound by two anterior and three posterior ligaments. The carpal bones of proximal row (radial, intermediate, ulnar and accessory) are attached by three anterior, two posterior and three interosseous ligaments.

The intercarpal joint has two anterior and three posterior ligaments. The distal row of carpal bones (second and third fused and fourth) are connected by one anterior and one interosseous ligament. The carpometacarpal joint is held by two posterior and two interosseous ligaments. However, these short ligaments are sometimes weak or inconstant in number.

METACARPO-PHALANGEAL JOINT (*FETLOCK*)

There are two articulations in one limb of ox *i.e.*, one for each digit. In the horse there is only one such joint in each limb. In dog these are five in number.

Type—Hinge joint.

Movement—Extension and flexion.

Bones involved—Distal end of metacarpal bone and proximal ends of 1st pair of phalanges and proximal sesamoid bones. The distal end of the metacarpal bone of Ox is divided symmitrically into two condyles by a cleft. Each condyle articulates with the proximal end of corresponding first phalanx.

Ligaments—Each articulation has one capsular ligament, one lateral (abaxial) and one medial (axial) collateral ligaments. The sesamoidean ligaments are common for both the articulations.

(a) Capsular ligament. It encloses the articulation but not capacious.

(b) Lateral collateral ligament—Proximally it is attached to the lateral aspect of the distal end of large metacarpal bone and distally to the lateral aspect of the upper end of first phalanx.

(c) Medial collateral ligament—It extends from the cleft of large metacarpal to the upper end of first phalanx at its interdigital surface.

(d) Sesamoidean ligaments—

(i) **Superior sesamoidean ligament**—It is also called the suspensory ligament. It extends from the distal row of carpals and proximal end of large metacarpal bone as a flat band, descends down along the posterior surface of the latter and at the middle it divides into an anterior and a posterior part. The anterior part passes down to the distal end of metacarpal bone, divides into four, and each of them inserts to the corresponding sesamoid bone. Fibres are given off from the two outer bands which pass obliquely to join with the respective extensor tendons. Some fibres also arise from two inner bands which pass through the interdigital space and ultimately joint with the common digital extensor tendon.

The posterior part divides into two at the distal third of the metacarpal bone. Each of these divisions unites with the corresponding part of superficial digital flexor tendon to form a tube through which the respective tendon of deep digital flexor passes. This ligament also sends fibers to 3rd phalanx, distal sesamoid and accessory digits.

(ii) **Inferior or distal sesamoidean ligaments**—For each metacarpophalangeal joint there are four such ligaments, two superficial and two deep. The superficial ligaments connect the corresponding sesamoid bones with the tubercles at the posterior surface of the proximal end of the first phalanx. The deep ligaments start from the respective sesamoid bone, cross each other and become attached to the posterior tubercle of first phalanx.

(iii) **Intersesamoidean ligaments**—They are three in number and are placed in between the four proximal sesamoid bones and connect the corresponding surfaces.

(iv) **Collateral sesamoidean ligaments**—These are lateral and medial. They connect the lateral and medial sesamoid bones to the corresponding surfaces of the metacarpal and first phalanx.

PROXIMAL INTERPHALANGEAL JOINT (*PASTERN*)

Type—Hinge.

Movement—Extension and flexion.

Bones involved—Lower end of first phalanx and upper end of second phalanx.

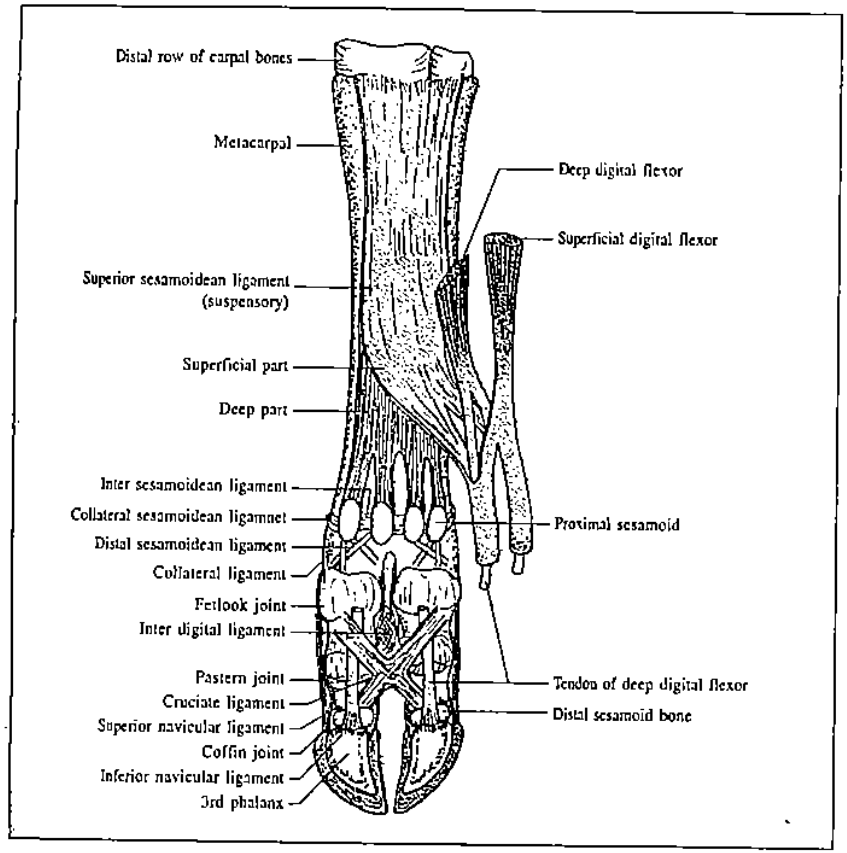


Fig. 3.8 Metacarpo-phalangeal and Interphalangeal Joints (Posterior view).

Ligaments—

(a) Capsular ligament.

(b) Lateral collateral ligament—It extends from the lateral aspect of the distal end of first phalanx and continues downward to the lateral aspect of third phalanx.

(c) Medial collateral ligament—It starts from the medial aspect of distal end of first phalanx and divides into two parts. The inner one attaches to the second phalanx and the outer part extends down to the third phalanx.

(d) Postero-central ligament—It attaches the ventral end of first phalanx with the upper end of second phalanx at their posterior surfaces.

(e) & (f) Postero lateral ligaments (Axial and Abaxial)—They connect corresponding borders and ends of first and second phalanges.

DISTAL INTERPHALANGEAL JOINT *(COFFIN)*

Type—Hinge.

Movement—Extension and flexion.

Bones involved—Distal end of second phalanx and proximal end of third phalanx and distal sesamoid bone.

Ligaments—

(a) Capsular ligament

(b) & (c) Lateral and medial collateral ligaments—They originate from the corresponding depressions at the distal end of second phalanx, pass downward and terminate at the respective surfaces of third phalanx.

(d) Cruciate ligaments—There are two such ligaments for the whole limb, one for each digit. Each ligament extends from the lateral aspect of the proximal end of second phalanx, crosses with the similar ligamnt of the opposite side at the posterior aspect of the interdigital space and terminates on the distal sesamoid bone of the opposite digit (fig. 3.8).

(e) Superior navicular ligament—These are some fibers detached from the collateral ligaments and are attached to the upper border of distal sesamoid bone.

(f) Inferior nevicular ligament—It connects the ventral border of distal sesamoid bone to the posterior surface of third phalanx.

Interdigital ligaments

These two are common for both the digits and do not belong to any individual joint. The proximal interdigital ligament connects the axial surfaces of first phalanges. The distal interdigital ligament originates from the second phalanges at their posterior surface and end at the upper part of axial surfaces of the third phalanx of the opposite side.

JOINTS OF HIND LIMB

SACRO ILIAC ARTICULATION

Type—Amphiarthrosis.

Movement—Restricted in young and not appreciable in adult.

Bones involved—Articular surface of the wings of sacrum and articular surface of ilium.

Ligaments—

Capsular ligament—It is ill developed.

Accessory ligaments—There are some other ligaments in the pelvic girdle all of which are not directly associated with this joint. These are as follows :

1. *Sacro-iliac ligament (dorsal)*—This band starts from the tuber sacrale, goes caudorsally to the sacral spine and blends with supraspinous ligaments.

2. *Sacro-iliac ligament (lateral)*—It is a four sided thick sheet of a ligament and is attached cranially to the tuber sacrale and medial border of ilium and ventrally to the lateral border of sacrum. It is continuous ventrally with the sacro-sciatic ligament.

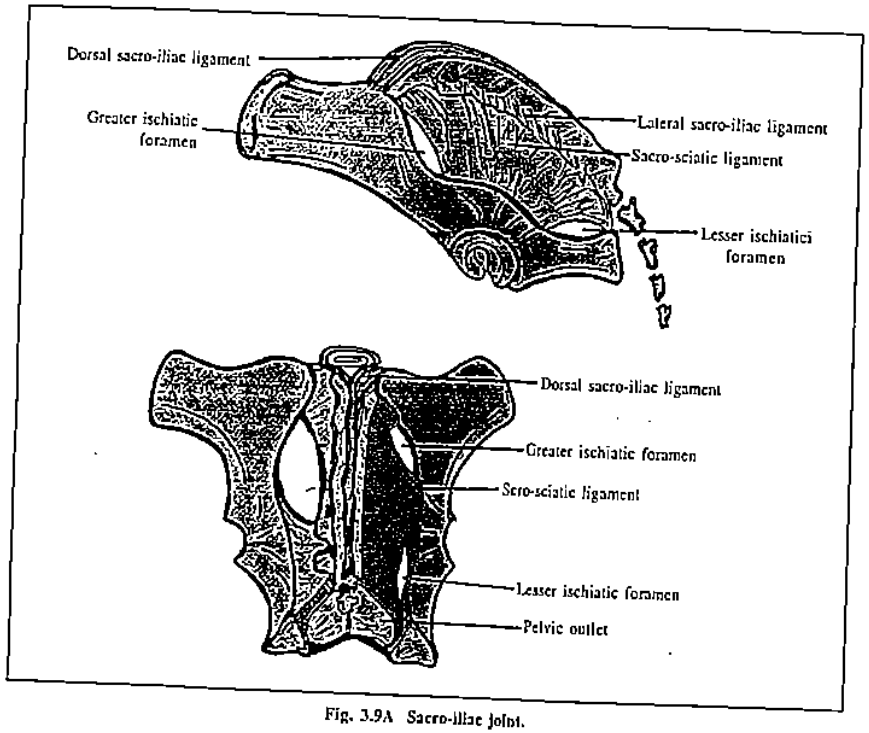


Fig. 3.9A Sacro-iliac joint.

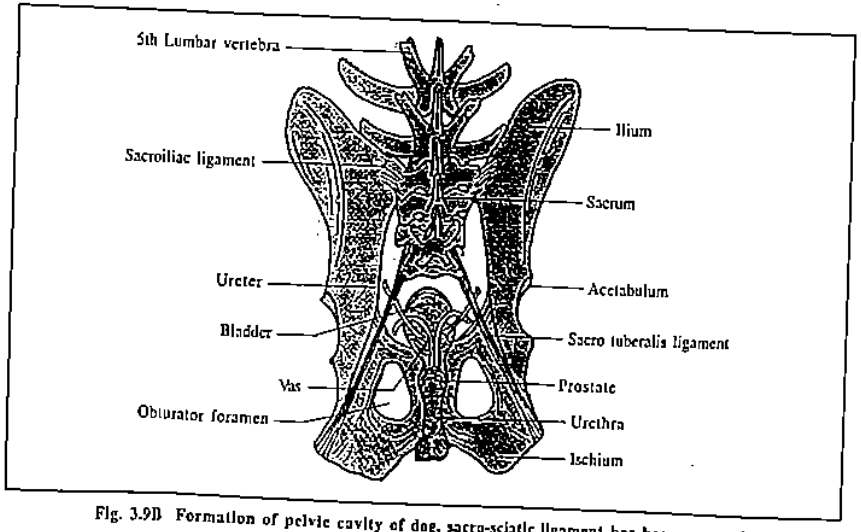


Fig. 3.9B Formation of pelvic cavity of dog, sacro-sciatic ligament has been removed (Postero-dorsal view).

3. *Sacro-sciatic ligament*—The lateral wall of the pelvic cavity is practically formed by this extensive sheet of membrane. Dorsally it is attached to the lateral border of sacrum and transverse processes of first and second coccygeal vertebrae. Anterior border forms the greater ischiatic foramen with greater ischiatic notch of ilium. The posterior border makes the lateral boundary of the pelvic outlet with the ischium and coccygeal vertebra. Between its ventral attachments to the superior ischiatic spine and ischial tuberosity it forms the lesser ischiatic foramen with the lesser ischiatic notch of ischium.

4. *Ilio lumber ligament*—This is a thin ligament connects the medial angle of the ilium to the lumber transverse processes.

Obturator membrane—A thin fibrous membrane which covers the obturator foramen leaving a passage for vessels and nerve is known as obturator membrane.

PELVIC SYMPHYSIS

The pubis and ischium of one side meet with the similar bones of the opposite side in the median plane and form a cartilagenous joint – the pelvic symphysis. The layer of cartilage is replaced by bone in adult life. The cranial portion of this joint is formed by medial borders of pubis bones and therefore, called pubic symphysis and the caudal portion similarly called ischial symphysis. The union of the bones is reinforced by connective tissue fibres, situated dorsally, ventrally, cranially and caudally.

HIP JOINT

Type—Ball and socket.

Movement—Polyaxial.

Bones involved—Cotyloid cavity of os coxae and head of femur.

Ligaments—

(a) Capsular ligament—It extends from the rim of the cotyloid cavity to the border around the head of femur. The synovial membrane is reflected on the round ligament. The joint cavity is capacious.

(b) Round ligament—It is an intra articular ligament extends from the fovea capitis at the head of femur to the non articular depression of the acetabular cavity.

(c) Cotyloid ligament—This is a fibro-cartilaginous structure attached along the rim of the cotyloid cavity to make it more deep. The part of the cotyloid ligament which makes bridge over the acetabular notch, is known as **transverse ligament.**

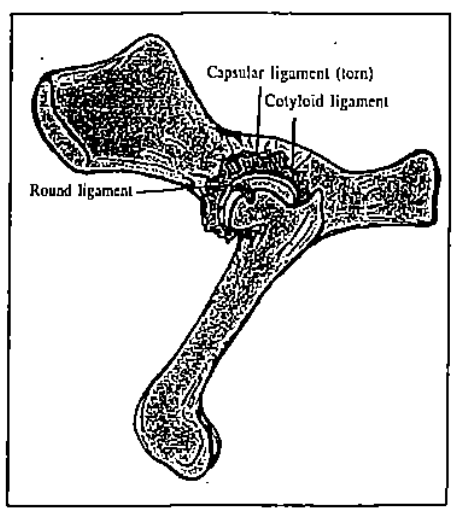
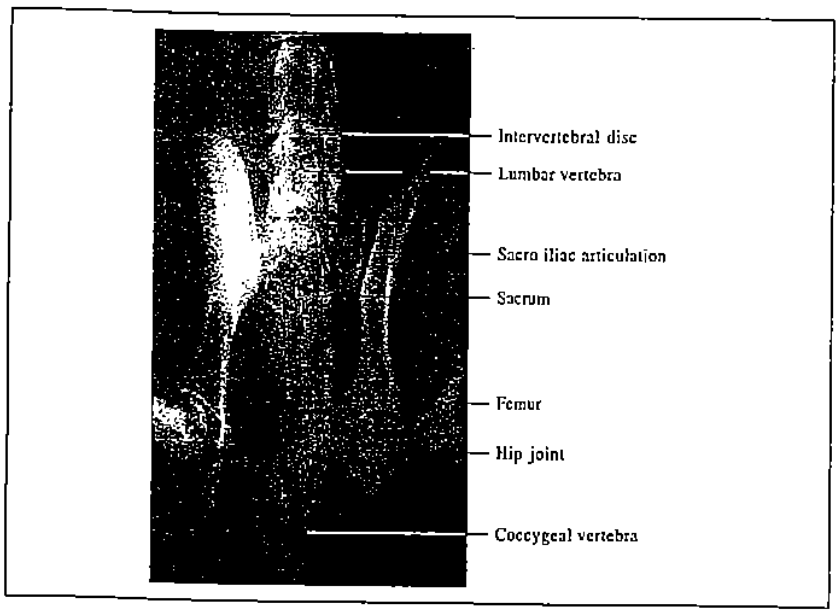


Fig. 3.10 Hip joint.

The number of ligaments in this joint is very less. Therefore the surrounding muscles help to keep the bones in position.

Accessory ligament of femur (Check ligament)—In the hip joint of equines an extra ligament is available. It is a strong band, detached from the symphysal tendons of abdominal muscles, pass through the aperture formed by the acetabular notch and transverse acetabular ligament and finally terminates in the wide notch on the head of femur along with the round ligament. However, this ligament is not found in other domestic mammals. Both this accessory (check) ligament and the round ligament restrict the abduction movement of hip joint in equines.



X-ray of the pelvic region of dog (ventral view).
(By Courtesy Dr. Subir Bhattacharya)

STIFLE JOINT

It is a complex joint comprises of two articulations—

(a) *Femoro-patellar articulation,* and

(b) *Femoro tibial articulation.*

Femoro-patellar articulation

Type—Gliding

Movement—Translation.

Bones involved—Trochlea of femur and articular surface of patella.

Ligaments—

1. Capsular ligament—It is capacious.

2. Lateral collateral ligament—It extends from the lateral condyle of femur to the lateral border of patella.

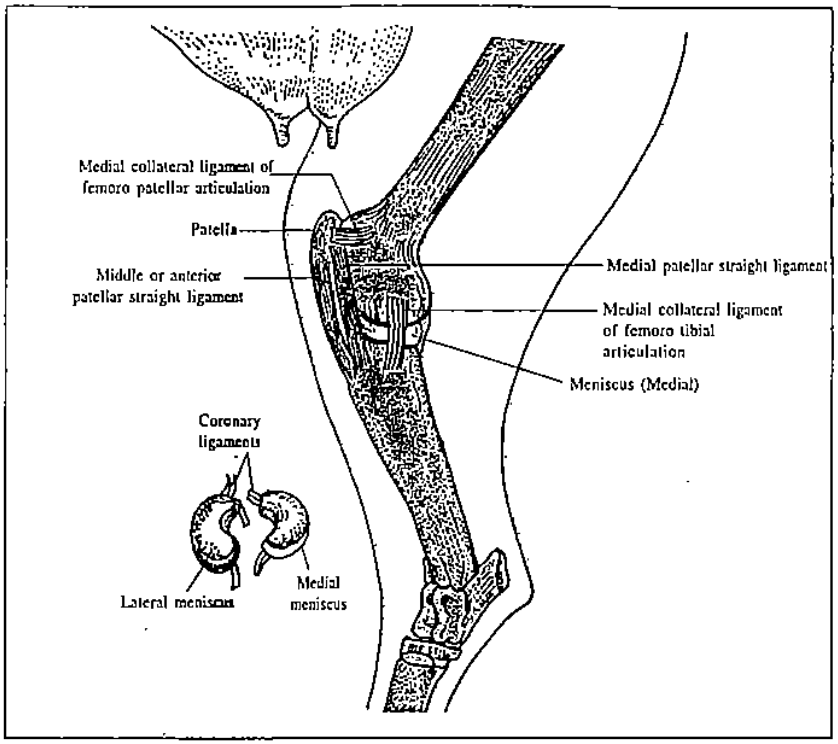


Fig. 3.11 Stifle Joint (Medial view).

3. Medial collateral ligament—It originates from the medial epicondyle of the femur and terminates at the medial border of patella.

4. Patellar straight ligaments—These ligaments connect the patella with the tibia. These are in the form of strong flat bands and are three in number—(i) *Medial* (ii) *Middle* and (iii) *Lateral.*

(i) ***Medial patellar ligament***—It starts from the medial border of patella, passes over the groove formed by the ends of femur and tibia and ends on the medial aspect of anterior tuberosity at the proximal end of tibia. When an animal suffers from **Lateral luxation of patella**, this ligament is cut transversely at the middle by surgical approach. [Fig. 4.15]

(ii) ***Middle or anterior patellar ligament***—It is the strongest of the three ligaments. The ligament extends from the apex of the patella to the anterior tuberosity of tibia.

(iii) *Lateral patellar ligament*—This ligament is extensive. It is attached proximally to the lateral portion of the anterior surface of patella and distally to the lateral aspect of the anterior tuberosity of tibia.

In this joint two *bursae* are found. One is situated between Middle patellar ligament and upper part of the trochlea and another bursa is present between Lateral patellar ligament and lateral condyle of femur.

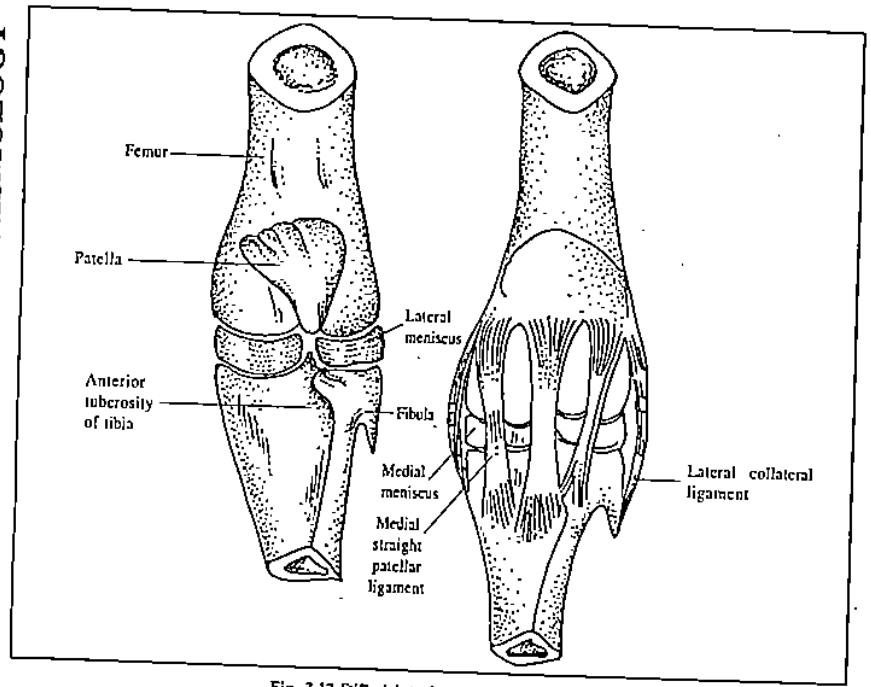


Fig. 3.12 Stifle joint of cow (Anterior view).

Femoro tibial articulation

Type—Ginglymus.

Movement—This joint provides extension, flexion and a limited rotatory movement.

Bones involved—Condyles of femur and proximal end of tibia. The menisci are placed between the articular surfaces.

Menisci—These are two orange flake (cresent) shaped fibro cartilagenous structures situated between the corresponding articular surfaces. These cartilages work as padding materials between the two heavy articular surfaces to prevent concussion during the movement. Each of these cartilages are fixed to the corresponding articular surface of the proximal end of tibia by one anterior and one posterior ligament which are attached to the cranial and caudal aspect of the tibial spine. The lateral meniscus has one extra posterior ligament which is extended to the intercondyloid groove. These ligaments are known as coronary ligaments.

Beside the weight transmission, the menisci increase the concavity of tibial condyle for better adaptation with femoral condyles; maintain potential joint space and help in the complex mechanism of gliding and angular movements.

Ligaments—

(a) Capsular ligament—Due to the presence of intra-articular menisci the joint cavity is divided partially into two compartments and there are two synovial membranes. This capsular ligament is also capacious.

(b) Medial collateral ligament—It extends from the medial condyle of femur to the medial tuberosity of tibia.

(c) Lateral collateral ligament—It starts from the lateral condyle of femur and terminates on the head of fibula.

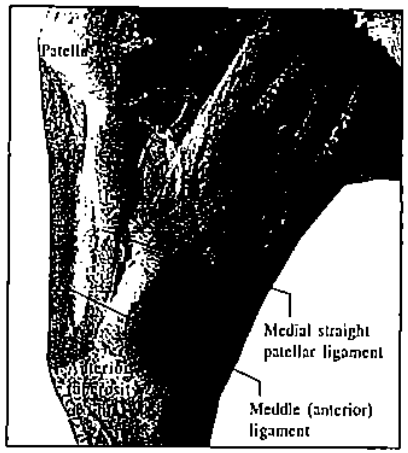


Fig. 3. 13 Stifle joint (Medial view).

(d) Cruciate ligament—These intra-articular ligaments are anterior and posterior. The anterior ligament springs from the tibial spine and inserts on the lateral wall of intercondyloid groove. The posterior cruciate ligament arises from a tubercle of the tibia situated behind the articular margin, goes craniodorsally, crosses the anterior ligament and inserts at the anterior part of intercondyloid groove.

HOCK JOINT

It is a compound joint consists of (a) **Tibiotarsal articulation,** (b) **Intertarsal articulation** and (c) **Tarsometatarsal articulation.**

Type—Tibiotarsal articulation—Ginglymus. *Other articulations*—Gliding.

Bones involved—Distal end of tibia, tarsal bones, Lateral malleolus and proximal ends of metatarsal bone.

Movement—Tibio-tarsal articulation—Extension and flexion. *Other articulations—Gliding.*

Ligaments (common)—

(a) Capsular ligament—It is divided into an anterior and a posterior part. Both are lined by synovial membranes. The posterior surface of posterior part possesses a tendon sheath for the passage of deep digital flexor tendon.

(b) Medial collateral ligament—It starts from the medial malleolus and divides into superficial middle and deep parts. The superficial part inserts to the medial aspect of large and small metatarsal bone. The deep part attaches the tibial tarsal and the middle division terminates on the sustentaculum tali.

(c) Lateral collateral ligament—It arises from the lateral malleolus and divides into superficial and deep parts. The superficial part goes down vertically and terminates on the large metatarsal bone. The deep part is short. It turns backward below the superficial part and inserts on the fibular tarsal bone.

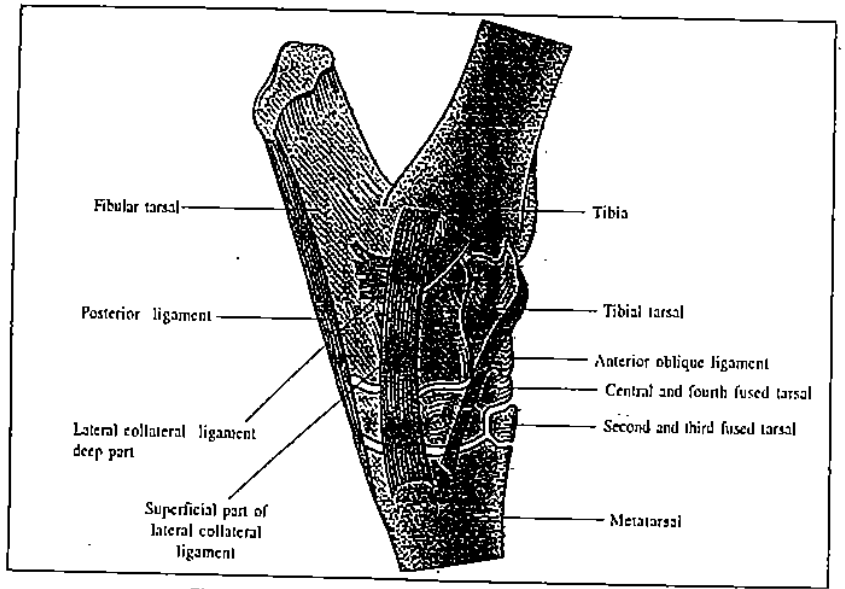


Fig. 3. 14 Hock joint of cow. Right leg (Antero-lateral view).

(d) Anterior oblique ligament—This narrow band starts from the medial surface of tibial tarsal, crosses the anterior surface of the joint obliquely downward and terminates on the lateral aspect of the proximal end of large metatarsal bone.

(e) Posterior ligament—It starts from the tuber calcis, attaches the posterior border of oscalcis, central and fourth fused tarsal and terminates at the large metatarsal bone.

JOINTS OF THE VERTEBRAL COLUMN

The bones of the vertebral column are serially articulated by their bodies and by their neural processes. These joints are called intercentral articulations and interneural articulations respectively. Most of these joints are articulated by some common or common variety of ligaments and therefore termed common vertebral articulations. There are few joints in the vertebral column which are not articulated by common ligaments and are called special vertebral articulations.

INTER CENTRAL ARTICULATIONS

This is a series of joints formed between the bodies of the vertebrae. They are structurally almost same but have different restricted movements depending upon the shape of the bodies.

Type—Amphiarthrosis.

Bones involved—Caudal concave surface of the body of the preceding vertebra and cranial convex end of the body of the receding vertebra.

Movement—Restricted multisided movement.

Intervertebral disc or cartilage—

These are fibro-cartilaginous convexo concave discs placed between the articular surfaces of the bodies of two adjacent vertebrae. The margin is thick and the center is soft. The soft center is known as Nucleus pulposus. The periphery of the disc is composed of concentric layers of fibers known as annulus fibrosus. The thickness of the discs varies from region to region of the column. They are thick at the cervical, lumber and coccygeal regions and thin at the thoracic region. The disc acts as shock-absorver and helps in distribution of compressive forces.

Prolapse of the nucleus pulposus and Slipped disc generally occures in the lumbar region during violent hyperflexion of the vertebral column. When it takes place dorso laterally, the protruding mass may compress an adjacent spinal nerve root and thereby cause pain along the area of distribution of the nerve.

Ligaments—

(a) Dorsal longitudinal ligament—It is a long ligament spread like a carpet along the floor of the neural canal and extends from axis to sacrum. Dorsally it is in contact with the duramater and ventrally it is attached with the dorsal surfaces of the bodies of the vertebrae and intervertebral discs.

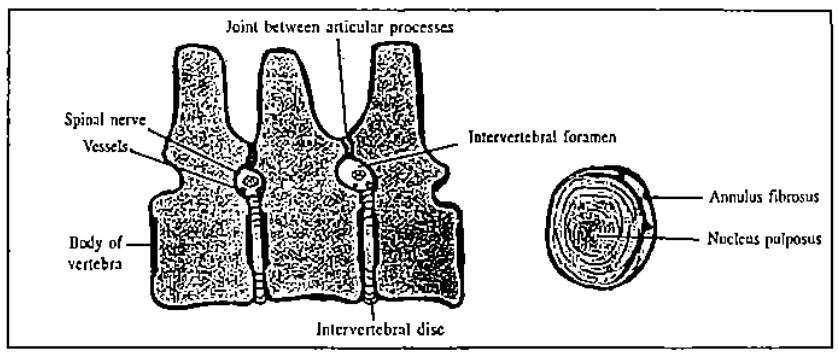


Fig. 3.15 Intervertebral articulations.

(b) Ventral longitudinal ligament—It extends from 6th or 7th thoracic vertebra, attaches the ventral surfaces of the bodies of the vertebrae and intervertebral discs and terminates at the pelvic surface of sacrum in the form of a broad strip.

INTER NEURAL ARTICULATIONS

These are the joints of vertebral arches and processes. Synovial joints are formed between the articular processes of the adjacent vertebrae. The spines, transverse processes and lamina are connected by other ligaments.

Ligaments—

(a) Capsular ligament—They encapsule the joints between the articular processes. They are well developed in cervical region.

(b) Ligaments of the arches—(Ligamenta flava)—They connect the arches of the adjacent vertebrae. These ligaments are thin and made up of yellow elastic tissue.

(c) Intertransverse ligaments—These ligaments connect the adjacent transverse processes. They are well developed in the lumbar region.

(d) Interspinous ligaments—They are thin and connect the adjacent borders of supraspinous processes. These are composed of white fibers and are directed downward and backward.

(e) Supraspinous ligament—This is a very strong and long ligament extends from the occipital bone to the sacrum. This is very well developed in cattle due to their grazing habit by extending the head towards ground. The ligament is composed of yellow elastic tissue. For description purpose this ligament is divided into (1) *thoraco-lumber part* and (2) *cervical part;* although there is no practical demarcation between them.

Thoraco-lumber portion starts from the sacral spine attaches the summits of the spines of lumber and thoracic vertebrae, proceeds forward and continues as cervical part. As the superior spines of few (2nd to 5th) thoracic vertebrae are very long, this ligament divides at the region into two bands and attaches the sides of these processes.

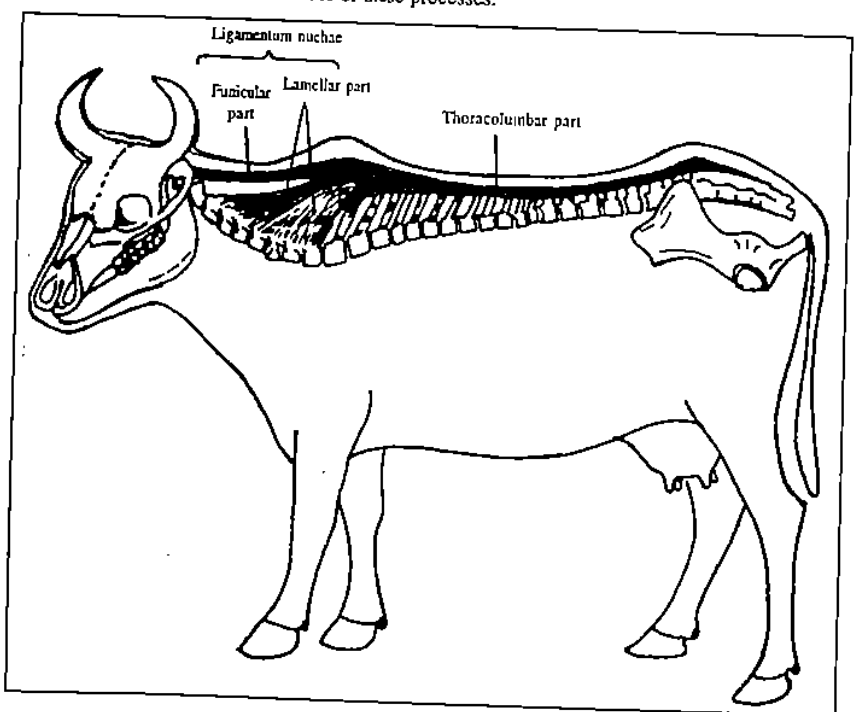


Fig. 3.16 Supra spinous ligament.

The cervical part of this ligament is known as ligamentum nuchae and has two components—*Lamellar* and *Funicular.* The funicular part extends from external occipital protruberance in the form of a rounded bundle, becomes wide and flat as it goes caudally and continues with the thoracolumber part. The lamellar part originates from the wide funicular part at the level of 2nd or 3rd thoracic vertebra. It proceeds downward and forward in a radiating manner and divides

into cranial and caudal portions. The cranial protion is thin and double. It terminates on the spines of 2nd, 3rd and 4th cervical vertebrae. The caudal part is single and terminates on the spines of 5th, 6th and 7th cervical vertebrae.

In horse few bursae are found below the supraspinous ligament. The bursa which is found between the funicular part of the ligamentum nuchae and the dorsal arch of atlas, is known as **Atlantal bursa.** The bursa which is situated over the spine of 2nd thoracic vertebra is called **supraspinous bursa.** On the spine of axis a third bursa may be sometimes available.

It is believed that infection of these bursae lead to 'pollevil' and 'fistulus withers'.

SPECIAL VERTEBRAL ARTICULATIONS

OCCIPITO ATLANTAL JOINT

Type—Hinge.

Movement—Extension and flexion.

Bones involved—Condyles of the occipital bone articulate with the concavities at the cranial aspect of atlas.

Ligaments—

(a) Capsular ligament

(b) & (c) Right and left lateral ligaments—They extend from the corresponding paramastoid processes, pass laterally and terminate at the cranial border of the wings of the atlas.

(d) Dorsal membrane—Two thin bands of fibers extend from the dorsal margin of the foramen magnum, pass caudally, cross each other at the middle and terminate at the dorsal border of the atlas.

(e) Ventral membrane—It connects the cranial aspect of the ventral border of atlas and the ventral margin of the foramen magnum.

ATLANTO AXIAL JOINT

Type—Pivot.

Movement—Rotation.

Bones involved—Ventral articular surface of the odontoid process of axis and the caudal part of the neural ring of atlas.

Ligaments—

(a) Capsular

(b) Odontoid ligament—It connects the dorsal surface of the odontoid process and the floor of the neural ring of atlas. It is also called ligament of dens.

(c) Dorsal ligament—It extends from the dorsal part of the atlas to the spine of axis.

(d) Ventral ligament—It connects the ventral tubercle of the atlas to the ventral spine of axis.

Sacro coccygeal articulation

The body of the last sacral vertebra articulates with the body of the first coccygeal vertebra. As the coccygeal vertebra is rudimentary, only intercentral articulation is developed.

Inter coccygeal articulations

The bodies of the coccygeal vertebrae are joined by thick intervertebral disc and connective tissue. The surrounding muscle also help the bones to remain united. These muscle are responsible for movement of the tail.

JOINTS OF THORAX

COSTO-VERTEBRAL JOINT

Upper ends of ribs articulate with the vertebral column to form these joints. There are two varieties of articulations in each joint—(a) Costo-central articulation and (b) Costo-transverse articulation.

Costo-central articulation

Type—Ball and socket.

Movement—Although ball and socket in structure, this joint permits only sight gliding and rotatory movement.

Bones involved—Head of the rib is inserted in the cavity, formed by the corresponding costal facets of two consecutive vertebrae and a small part of the margin of intervertebral disc in between them.

Ligaments—

(a) Capsular.

(b) Radiate ligaments—They are three in number and extend from the ventral aspect of the neck of the rib in a radiating manner and terminate at the ventral aspect of the concerned vertebrae and intervertebral disc.

(c) Conjugate ligament—It connects the heads of the ribs of both the sides at the same level. The ligament is attached to the rough area between the two smooth articular surfaces at the head of the rib. It crosses the floor of the neural ring under the dorsal longitudinal ligament.

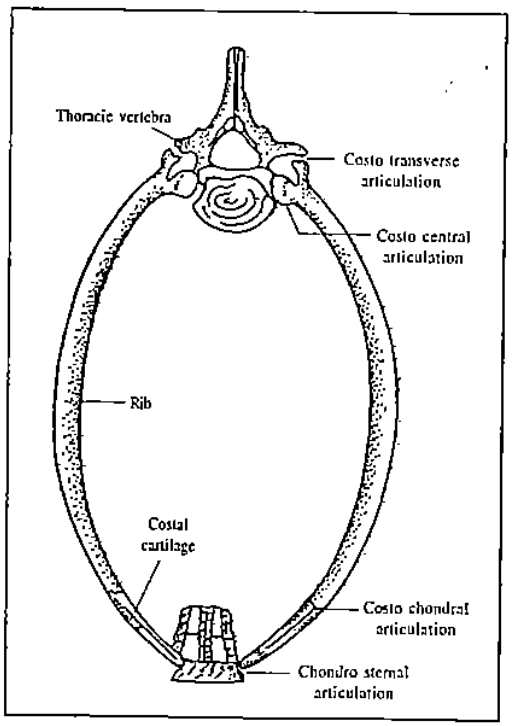


Fig. 3.17 Joints of thorax.

(d) Ligament of neck—It connects the neck of the rib with the corresponding vertebra above the costal facet.

Costo-transverse articulation

Type—Gliding.

Movement—Translation.

Bones involved—Tubercle of the rib articulates with the facet below the transverse process of the vertebra behind.

Ligaments—

(a) Capsular ligament.

(b) Anterior ligament—It connects the neck of the rib and the transverse process of the vertebra at its cranioventral aspect.

(c) Posterior ligament—It extends from the tubercle of the rib to the lateral part of the transverse process of the vertebra.

Costo-chondral junctions

The rounded end of costal cartilage is inserted in the depression at the end of the concerned rib. The junction is covered by perichondrium and periosteum.

Movement—Inappreciable.

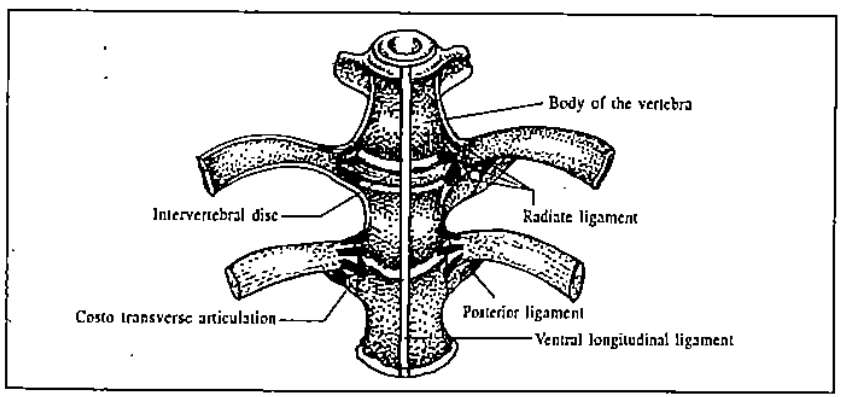


Fig. 3.18 Costo vertebral articulation (Viewed from ventral aspect).

Chondro-sternal articulation

First chondro sternal joint

Type—Synchondrosis.

Movement—Restricted.

Bones involved—Ventral ends of first pair of ribs and the first segment of sternum.

Ligaments—

(a) Capsular ligament—There is a common capsular ligament for first pair of joints.

(b) Cruciate ligament—The fibres of this ligament are strong. They extend diagonally from one joint to the opposite joint and cross at the middle.

Other chondro sternal joints (second to eight)

Type—Unclassified diarthroses.

Movement—Restricted rotation and gliding.

Bones of cartilages involved—Distal ends of costal cartilages and concerned concavity of sternum at its lateral aspect.

Ligaments—

(a) Capsular ligament

(b) Radiate ligament—It extends from the ventral end of the cartilage to the dorsal surface of the sternum. The fibers are arranged in a radiating manner.

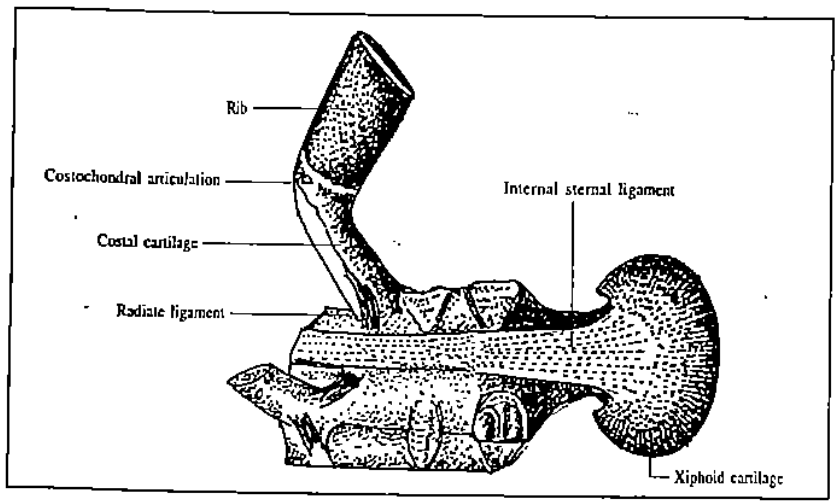


Fig. 3.19 Chondro sternal articulations.

(c) Costo-xiphoid ligament—The cartilage of the 8th rib is connected with xiphoid cartilage by this ligament.

Inter-chondral articulations

The cartilages of last two sternal and all the asternal ribs articulate with each other by fibrous connective tissue. These are known as interchondral articulations.

STERNAL JOINTS

The manubrium and the body of the sternum articulate to form a synovial joint. This is enclosed by a joint capsule. A small range of lateral movement is available in this articulation.

Rest of the sternal segments are fused together in adult life due to ossification of the cartilages between the sternal segments. A ligament lies on the dorsal surface of the sternum and extends from the first segment to the xiphoid cartilage, along the midline. It is known as **internal** sternal ligament. The ligament is wide at the begining on the first sternebra, gradually becomes thick and narrow and finally becomes flat at the termination on the xiphoid cartilage.

4 MYOLOGY

Muscles are the structures formed by the bundles of muscle cells in the form of fibers and possess the property of contraction on stimulation. They are derived from mesenchymal cells. However, few small muscles such as muscles of iris and myo-epithelial cells of salivary, sweat and lacrimal glands are derived from ectoderm. **Skeletal, smooth** and **cardiac** are the three main types of muscles available in the body. The term muscle or musculus is originally a Latin word.

A. ***Skeletal muscles*** are attached to the bones of the skeleton. These are striated in appearance and can be controlled by will and that is why ***voluntary***. The fibers are grouped together into bundles. These bundles are known as fasciculi. Each fiber has many nuclei which generally remain under the **sarcolemma**, which is actually the cell wall of the muscle fiber. The cytoplasm of a muscle fiber is known as **sarcoplasm**. The covering of a muscle fiber which is made up of delicate areolar tissue is known as **endomysium**. Each bundle of muscle fibers is covered by a layer of connective tissue, termed **perimysium**. The covering of the whole muscle is known as **epimysium**. These muscles can contract very ripidly but become fatigue easily. Each muscle fiber (cell) consists of (a) **Sarcolemma** – the cell membrane, (b) **Sarcoplasm** – the cytoplasm, (c) **Nuclei**, (d) **Myofibrils** – parallel contractile threads along the long axis, (e) **Myofilaments** – protein filament component of myofibrils, (f) **Sarcoplasmic reticulum**, (g) **Mitochondria** and (h) **Paraplasmic granules**.

Although most of the muscles are attached to the bones, sometimes one end may be attached to a cartilage or ligament or fascia. Each muscle has a body and ends. Generally the proximal fleshy and fixed end is called **origin** and the distal fibrous narrow or flat end is called **insertion**. When the insertion is in the form of a fibrous cord, it is called ***tendon*** and when in the form of a thin sheet, it is termed **aponeurosis**. The aponeurosis provides the muscle a wide area of attachment.

The **tendons** contain closely packed bundles of collagen and connect muscles with bones. They have a shiny white appearance. The collagen bundles are arranged in such a manner so as to produce maximum resistance during contraction of the muscle. The collagenous bundles are continuous with the collagenous bundles of perichondrium or periosteum at one end and continuous with those of fibrous muscle sheath (epimysium) at the other end.

Voluntary muscles can be classified in different ways

1. According to the colour of the muscle :

(a) **Red muscles**—They are red in colour due to presence of more amount of Myo-haemoglobin in it. They are generally situated at the deeper aspect of the body.

(b) **White muscles**—They are less red, possess abundant sarcoplasmic reticulum and are placed superficially.

2. According to the direction of fibers :

(a) **Parallel muscles**—Its fibers are long and are placed parallel to the line of pull. Fibers are less in number but they are long in structure *eg.*, Biceps brachi. The range of movement is more in these muscles.

(b) **Pennate muscles**—Fibers in these muscles are short and are oblique to the line of pull. They may be Unipennate, Bipennate, Multipennate etc., according to the direction of fibers in relation to the tendons.

(i) *Unipennate*—All fleshy fibers are directed into one side of the tendon and looks like half of a feather.

Example—Peroneus tertius.

(ii) *Bipennate*—The fibers are directed in two sides of the centrally placed tendon along the axis.

Exemple — Rectus femoris.

(iii) *Multipennate*—A series of bipennate muscle lie side by side to form multipennate muscle.

Example — Deltoid.

(c) **Spiral muscles**—Here the fibers are arranged in a twisted manner. *e.g.,* Brachialis. They help rotational movements.

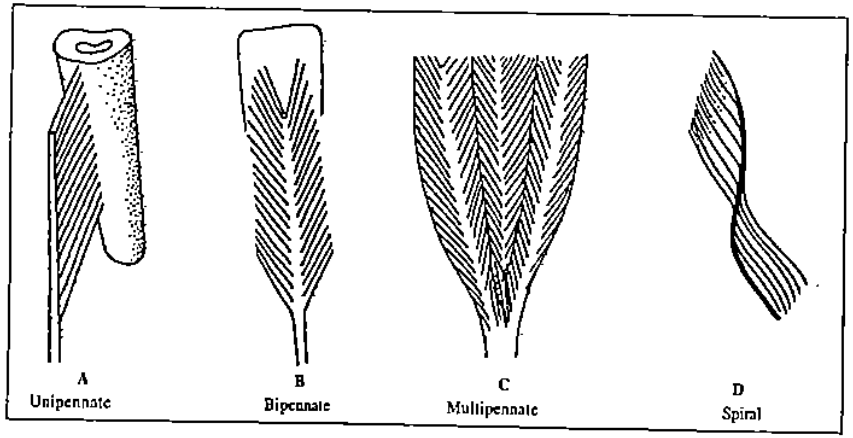


Fig. 4.1 Types of muscles

(d) **Cruciate muscles**—In these muscles the fibers are arranged in superficial and deep plane, crossing like 'X'. *e.g.,* Massater.

3. According to the force of action :

(a) **Spurt muscles**—They provide acceleration motion to a joint.

Example — Brachialis.

(b) **Shunt muscles**—These muscles provide stabilizing centripetal force on a joint. *e.g.,* flexor carpi radialis.

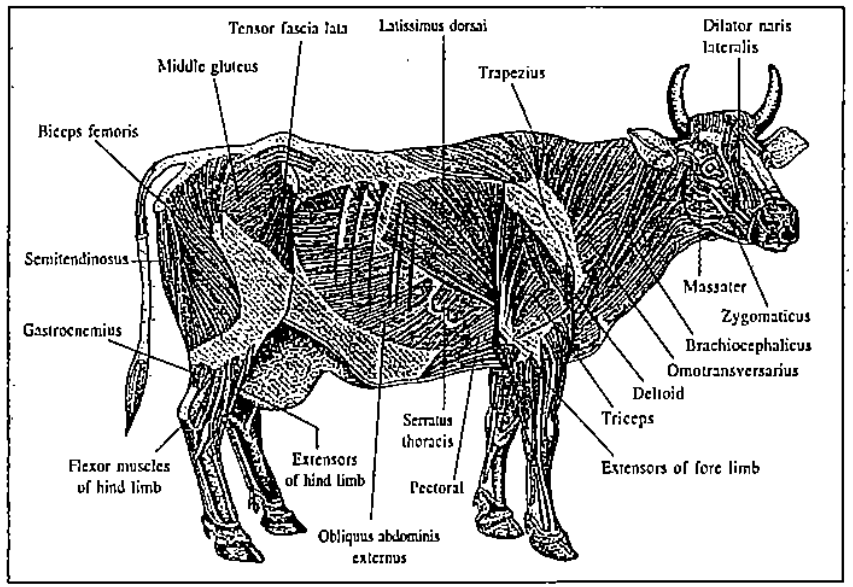


Fig. 4.2 Superficial muscles of cow.

B. *Smooth muscles* make the bulk of the walls of the organs. The striations as available in skeletal muscles are not found in smooth muscle. The muscle is composed of fusiform or spindle shaped cells with centrally placed nucleus. The fibers are generally arranged parallel to each other in a sheet. These muscle work without the intervention of the will and for that reason they are termed *involuntary*.

C. ***The cardiac muscle*** or myocardium is composed of muscle fibers which join with surrounding fibers in a irregular manner to form a network. Each muscle fiber exhibits centrally placed nucleus cross strifions and side branches. These fibers are arranged spirally into the wall of the heart. The fibers are branched or irregular at their ends or junctions. Intercalated discs in the form of cross bands are found at the junction of cells, which are actually the membranes of the adjacent cells. This muscle is also ***involuntary*** in nature.

CUTANEOUS MUSCLES

Some striated muscles placed at the subcutis of some parts of the body are known as cutaneous muscles. In some places these fibers are inserted into skin and thereby cause twitches of the skin on contraction. They may or may not have any connection with the skeleton. Some fibers are attached to the fascia covering superficial muscles. These muscles are characteristics to the quadrupeds.

MOTOR UNIT

Few to few thousand muscle-fibers which are supplied by the branches of one nerve cell, are considered as the motor (functional) unit of a muscle.

FASCIA

These are membranes made up of dense fibrous connective tissue which separate the muscles from each other and keep them in position. Actually a considerable amount of mesoderm do not undergo much differentiation at the time of development but remain accumulated between whole muscles, viscera and other large structures and form investing fascia. The layer of areolar or adipose tissue sheet placed deep to the skin is called superficial fascia. Deep fascia are mainly composed of collagen fibers and remain in more compact form. They generally invest groups of muscles and send intramuscular septa. Sometimes a deep fascia attaches with a bone.

BURSA AND SHEATHS

Bursa, a thin walled bag, contains a small amount of synovial fluid and interposed at the point of pressure between muscles, between muscle and tendon or between muscle/tendon and bones to provide friction-less environment. When friction from all sides is expected, a tubular synovial bag encircles a tendon, known as synovial sheath. A bursa may communicate with the joint capsule which is situated very close to it.

MUSCLES OF FORE LIMB

MUSCLES OF SHOULDER GIRDLE

These muscles attach the forelimb with the body.

TRAPEZIUS

It is a thin triangular muscle at the upper most part of the fore limb. Its dorsal border extends from the atlas to a considerable part of thoracic region. It elevates the shoulder [Fig. 4.3].

Origin—Supraspinous processes from the level of 12th thoracic vertebra to atlas.

Insertion—Scapular spine and fascia of shoulder and arm.

Blood supply—Deep cervical branch of costo cervical artery and intercostal artery.

Nerve supply—11th cranial nerve.

RHOMBOIDEUS

This muscle is roughly triangular and thick. Laterally it is covered by trapezius. It helps to move the shoulder forward and upward.

Origin—Summits of 1st to 8th thoracic spine and ligamentum nuchae.

Insertion—Medial surface of the scapular cartilage.

Blood supply—Deep cervical branch and dorsal branch of costo-cervical artery.

Nerve supply—Branches from 5th to 7th cervical spinal nerve.

BRACHIOCEPHALICUS

It is a long flat muscle placed diagonally at the side of the neck and extends from the arm to the cephalon. It acts to extend the head and neck. It also extends the shoulder when the head and neck are fixed. It is divided into a dorsal part (cledo-occipitalis) and a ventral part (cledo-temporalis) [Fig. 4.2 and 4.3].

Origin—The dorsal part originates from occipital bone and ligamentum nuchae and the ventral part originates from temporal bone, wings of atlas and mandible.

Insertion—Both the dorsal and ventral parts unite together and inserts to the cranial border of musculospiral groove of humerus.

Blood supply—Anterior circumflex, inferior cervical, vertebral and carotid arteries.

Nerve supply—11th cranial nerve and cervical spinal nerves.

LATISSIMUS DORSI

It is a very wide and thin muscle spread at the dorso-lateral aspect of thorax. The muscle is aponeurotic at the origin and becomes thicker and narrower towards the arm. It helps in flexing the shoulder [Fig. 4.3].

Origin—Lumbar and dorsal spines.

Insertion—At the termination it becomes blended with tendons of teres major, and inserts to the teres tuberosity of humerus.

Blood supply—Thoracodorsal branch of subscapular artery, intercostal and lumbar arteries.

Nerve supply—Thoracodorsal branch from brachial plexus.

SERRATUS VENTRALIS

It is a serrated fan shaped fleshy muscle, spread on the lateral side of the neck and thorax. The part which covers the neck is known as serratus cervicis and the portion which covers the thorax is known as serratus thoracis.

SERRATUS CERVICIS

This muscle is placed partly on the neck and partly on the thoracic wall. It extends from 2nd cervical vertebra to the 5th rib. It helps to extend the neck and to pull the cervical angle of scapula cranially [Fig. 4.17].

Origin—Transverse processes of 2nd to 7th cervical vertebrae and lateral surfaces of 1st to 5th ribs.

Insertion—The rough triangular area at the cranio-dorsal part of the medial surface of scapula.

Blood supply—Dorsal branch of costocervical artery, Intercostal and deep cervical arteries.

Nerve supply—5th to 8th cervical spinal nerves.

SERRATUS THORACIS

This part is thin, flat and ventrally presents six prominent digitations. It covers the posterior part of serratus cervicis. Muscles of both sides together act to rise the thorax and individually pull the scapula dorso caudally. In resting condition it acts as a muscles of inspiration [Fig. 4.17].

Origin—Lateral surfaces of 4th to 9th rib.

Insertion—The rough triangular area at the caudodorsal part of the medial surface of scapula.

Blood supply—Intercostal arteries.

Nerve supply—7th and 8th cervical spinal nerves.

OMO TRANSVERSARIOUS

It is a flat long muscle, extends from atlas to shoulder and remains mostly covered by brachiocephalicus. The muscle pulls the ventral angle of scapula craniodorsally [Fig. 4.3].

Origin—Wings of atlas.

Insertion—Spine of the scapula.

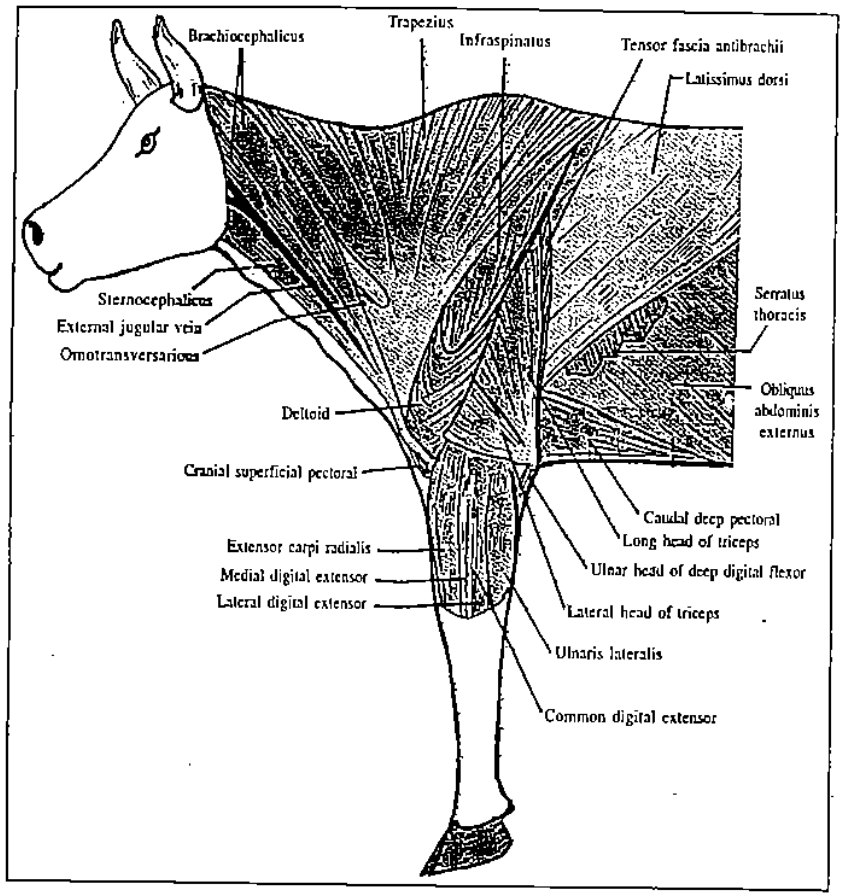


Fig. 4.3 Muscles of lateral aspect of shoulder, arm, neck and thorax.

Blood supply—Branches from carotid and inferior cervical arteries.

Nerve supply—11th cranial and some cervical spinal nerves.

SUPERFICIAL PECTORAL

Anterior superficial pectoral

It extends from first sternebra to the arm. This is thick and forms prominence at the brisket. It helps in adduction of the limb.

Origin—1st sternebra.

Insertion—Ventral part of the crest of humerus in common with brachiocephalicus.

Blood supply—External thoracic, Internal thoracic and anterior circumflex arteries.

Nerve supply—Pectoral branch from brachial plexus.

POSTERIOR SUPERFICIAL PECTORAL

Its anterior part is blended with the anterior superficial pectoral. The muscle is thin and extends from sternum to arm. It acts to adduct the limb.

Origin—Cranio lateral aspect of Sternum.

Insertion—Crest of the humerus and fascia of forearm.

Blood supply—External and internal thoracic and cranial circumflex arteries.

Nerve supply—Branch from brachial plexus.

DEEP PECTORAL

This is a fleshy muscle extends from last sternebra to the shoulder. It adducts and retracts the limb.

Origin—Ventral surface of the sternum.

Insertion—Medial tuberosity of humerus and the fascia covering the tendon of biceps brachi.

Blood supply—Cranial circumflex, internal and external thoracic arteries.

Nerve supply—Pectoral branch of brachial plexus.

In birds pectoralis is the largest fleshy muscle of the body and comparises of three parts—Thoracic, propatagialis and abdominalis. The main action of this muscle is to draw the wings cranially in the down stroke flapping movement during flight.

MUSCLES OF SHOULDER—(Lateral aspect)

1. Deltoideus.
2. Supra spinatus.
3. Intra spinatus.
4. Teres minor.

DELTOIDEUS

It is a *V*-shaped muscle placed at the lateral aspect of shoulder joint. The hands of *V* are attached to the cranial and caudal border as well as ventral end of the infraspinatus muscle. It abducts the limb and flex the shoulder [Fig. 4.3].

Origin—The cranial hand originates from acromion process and the caudal hand originates from the posterior border of scapula and fascia of infraspinatus muscle.

Insertion—The two hands unite at the level of lateral tuberosity of humerus and inserts to the deltoid tuberosity and fascia of triceps.

Blood supply—Subscapular and posterior circumflex arteries.

Nerve supply—Circumflex nerve.

SUPRASPINATUS

Most portion of this muscle is accommodated within the supraspinous fossa. It extends the shoulder.

Origin—Scapular spine and Supraspinous fossa [Fig. 4.4].

Insertion—Ventrally it divides into lateral and medial tendons and inserts to the lateral and medial tuberosities of humerus respectively.

Blood supply—Superficial cervical and suprascapular arteries.

Nerve supply—Suprascapular nerve.

INFRASPINATUS

This is a thick muscle accommodated mostly in the infraspinous fossa. It abducts the limb and helps in slight rotation of the arm [Fig. 4.4].

Origin—Scapular spine, infraspinous fossa and scapular cartilage.

Insertion—Ventrally this muscle also divides into two. The lateral part inserts to a round rough area above the deltoid tuberosity of humerus and the medial part inserts to the medial aspect of lateral tuberosity of humerus.

Blood supply—Subscapular and posterior circumflex arteries.

Nerve supply—Supra scapular nerve.

TERES MINOR

This muscle is in the form of a small elongated bundle situated below infraspinatus muscle. It helps in abduction of fore limb and in slight rotation of the arm [Fig. 3.5].

Origin—Distal part of infraspinatus fossa and posterior border of scapula.

Insertion—Deltoid tuberosity.

Blood supply—Subscapular and posterior circumflex arteries.

Nerve supply—Circumflex nerve.

MUSCLES OF SHOULDER—(medial aspect)

1. Subscapular.
2. Teres major.
3. Coracobrachialis.

SUBSCAPULAR

The muscle has three portions *(cranial, middle* and *caudal)* and most of the bulk is accommodated in the subscapular fossa. It helps in adduction of the limb [Fig. 4.8].

Origin—Subscapular fossa and scapular cartilage.

Insertion—Medial tuberosity of humerus.

Blood supply—Suprascapular and subscapular arteries.

Nerve supply—Subscapular branch of brachial plexus.

TERES MAJOR

Teres major is a thin elongated muscle placed along the caudal border of subscapular muscle. It adducts the limb and flex the shoulder [Fig. 4.8].

Origin—Posterodorsal angle of scapula.

Insertion—Medial tuberosity of humerus.

Blood supply—Subscapular artery.

Nerve supply—Branch from brachial plexus.

CORACOBRACHIALIS

This is a small elongated muscle placed at the medial aspect of humerus. The body is divided into a upper and a lower part. It helps to adduct the limb and to flex the shoulder joint [Fig. 4.8].

Origin—Coracoid process of scapula.

Insertion—The area above the teres tuberosity and anterior surface of the distal third of the shaft of humerus.

Blood supply—Anterior circumflex artery.

Nerve supply—Musculo cutaneous branch from brachial plexus.

MUSCLES OFARM

1. Brachialis.
2. Biceps brachii.
3. Triceps brachii.
4. Tensor fascia antibrachii.
5. Anconeus.

BRACHIALIS

The musculo spiral groove is occupied by a fleshy muscle with spiral fibers. This muscle is known as brachialis. It helps in flexion of elbow.

Origin—The area behind the head of humerus.

Insertion—Medial aspect of the proximal end of radius and proximal end of ulna.

Blood supply—Branch from brachial artery.

Nerve supply—Branches of radial and median nerve.

BICEPS BRACHII

It is an elongated spindle shaped muscle placed in front of humerus. This prominent muscle remains covered externally by brachio cephalicus and superficial pectoral muscle. This muscle helps to flex the elbow joint [Fig. 4.8].

Origin—The tuber scapuli.

Insertion—Radial tuberosity and proximal end of ulna.

Blood supply—Anterior circumflex artery.

Nerve supply—Musculocutaneous branch of brachial plexus.

TRICEPS BRACHII

The angle formed by the scapula and humerus at the shoulder is filled up mostly by triceps. It presents three parts—(a) lateral head, (b) long head and (c) medial head [Fig. 4.3, 4.4 and 4.8].

Long head of triceps

It is triangular and largest of the three parts. It assists to extend the elbow joint.

Origin—Caudal border of scapula and a small portion of the same border of humerus.

Insertion—Olecranon process of ulna.

Blood supply—Deep brachial and posterior circumflex arteries.

Nerve supply—Branch from radial nerve.

Lateral head of triceps

This is also triangular in shape and lies below the long head of triceps. Its action is similar to that of long head.

Origin—Cranio-lateral border of the upper part of shaft of humerus and caudal margin of deltoid tuberosity.

Insertion—Olecranon process of ulna.

Blood supply—Deep brachial and posterior circumflex arteries.

Nerve supply—Branch from radial nerve.

Medial head of triceps

This muscle is the smallest of the three and not triangular like other parts. This muscle also helps to extend the elbow joint.

Origin—Medial surface of shaft of humerus at its upper third.

Insertion—Olecranon process of ulna.

Blood supply—Deep brachial artery.

Nerve supply—Branches of radial nerve.

TENSOR FASCIA ANTIBRACHII

This is a thin strip of muscle situated at the posteromedial aspect of the long head of triceps. It tenses the fascia of forearm and extend the elbow [Fig. 4.4].

Origin—Upper part of caudal border of scapula and the fascia covering the long head of triceps and latissimus dorsi.

Insertion—Olecranon process of ulna.

Blood supply—Subscapular artery and branches from brachial artery.

Nerve supply—Branch froms radial nerve.

ANCONEUS

Anconeus is a small muscle which remains under the cover of the triceps. Partly it covers the olecranon fossa. It assists to extend the elbow.

Origin—Caudal surface of the distal third of humerus.

Insertion—Olecranon process of ulna.

Blood supply—Posterior circumflex artery.

Nerve supply—Branch of radial nerve.

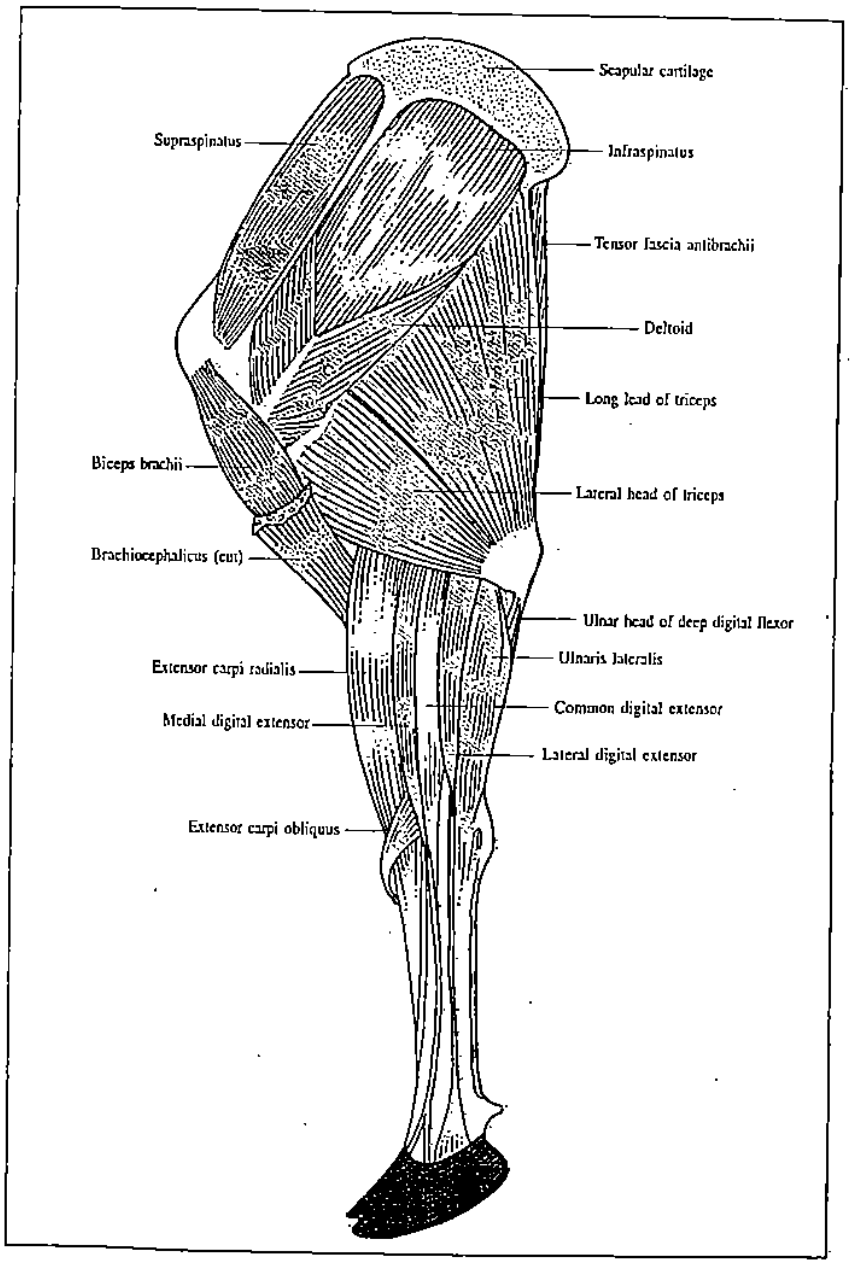


Fig. 4.4 Muscles of the lateral aspect of left arm and leg.

Muscles of forearm and manus

EXTENSOR GROUP

These muscles are situated at the antero lateral aspect of forearm and manus.

1. Extensor carpi radialis.
2. Extensor carpi obliquus.
3. Medial digital extensor.
4. Common digital extensor.
5. Lateral digital extensor.

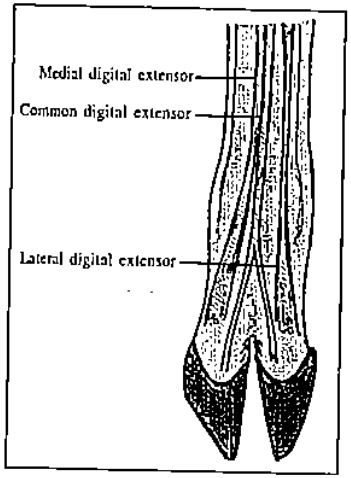


Fig. 4.5 Terminal extensors of ox.

EXTENSOR CARPI RADIALIS

This is a fleshy muscle placed vertically along the anterior surface of radius. It acts to extend the carpus [Fig. 4.4].

Origin—Crest of lateral condyle and depression at the side of coronoid fossa of humerus.

Insertion—Metacarpal tuberosity.

Blood supply—Branch of brachial artery.

Nerve supply—Branch of radial nerve.

EXTENSOR CARPI OBLIQUUS

It is a small triangular muscle placed in an oblique direction at the distal part of fore arm. It assists to extend the carpus [Fig. 4.4]

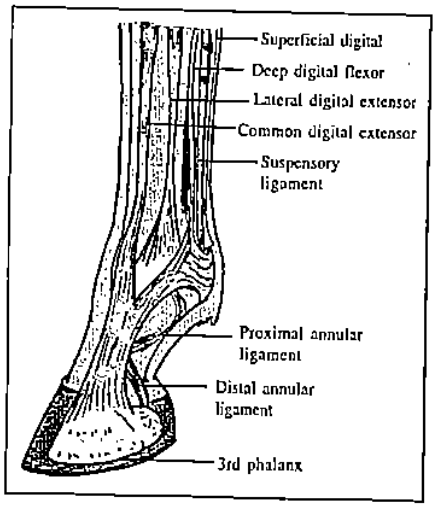


Fig. 4.6 Terminal extensors of horse.

Origin—Antero lateral surface of radius and lateral border of ulna at their distal fourth aspect of the shafts.

Insertion—Its tendon is very thin which crosses obliquely over the tendon of extensor carpi radialis and inserts to the upper end of metacarpal bone at the postero medial aspect.

Blood supply—Branch of interosseous artery.

Nerve supply—Branch of radial nerve.

MEDIAL DIGITAL EXTENSOR

It is a long narrow muscle placed behind the extensor carpi radialis. It helps to extend the medial digit [Fig. 4.4 and 4.5].

Origin—Depression by the side of coronoid fossa of humerus, together with extensor carpi radialis.

Insertion—The muscle becomes long tendinous at the lower part of forearm and inserts on 2nd and 3rd phalanges of medial digit.

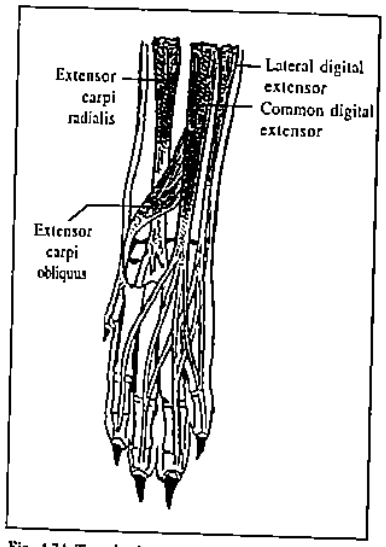


Fig. 4.7A Terminal extensors of dog (fore limb).

Blood supply—Branch of brachial artery.

Nerve supply—Branch of radial nerve.

COMMON DIGITAL EXTENSOR

This muscle is of similar shape to that of medial digital extensor and lies parallel to it. It assists to extend the fore limb as a whole [Fig. 4.4 and 4.6].

Origin—Lateral epicondyle of humerus and lateral border of ulna above proximal interosseous space.

Insertion—It also becomes tendinous at the distal third of radius, runs parallel to that of medial digital extensor along the groove of radius and over carpus in a common sheath and divides into two at the level of fetlock joint. Each branch inserts finally on the extensor process of the concerned third phalanx.

Blood supply—Branch of brachial artery.

Nerve supply—Branch of radial nerve.

In dog the tendon of this muscle divides into four branches which pass over the tarsus and each of them inserts to the corresponding third phanges [Fig. 4.7].

LATERAL DIGITAL EXTENSOR

This is comparatively thicker than medial and common digital extensors and placed between common digital extensor and ulnaris lateralis. It extends the lateral digit.

Origin—Lateral aspect of the proximal end of radius and lateral surface of radius and ulna.

Insertion—The long tendon descends down along the lateral aspect of the forearm and manus like other digital extensors and inserts to the 2nd and 3rd phalanges of lateral digit.

Blood supply—Branches of brachial and interosseous arteries.

Nerve supply—Branch from radial nerve.

In *horse* medial digital extensor is absent. Common digital extensor inserts to the extensor process of 3rd phalanx along with the proximal ends of 1st and 2nd

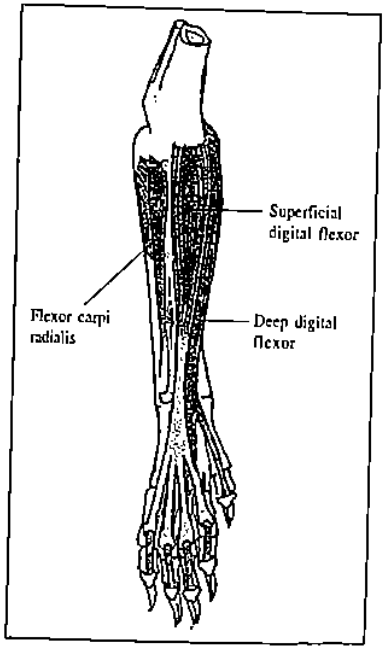


Fig. 4.7B Flexor muscles of fore limb of dog.

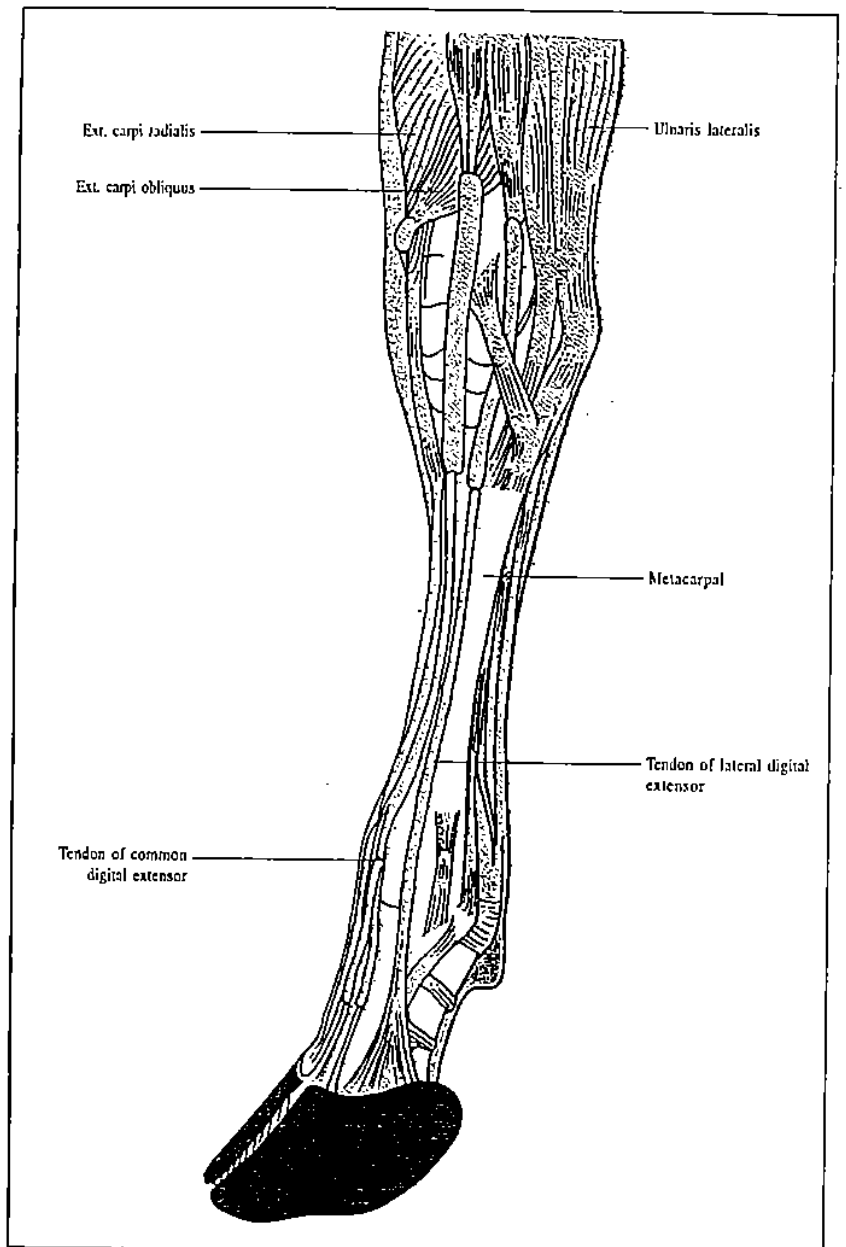


Fig. 4.8 Muscles and tendons of distal part of fore limb of ox (Lateral view).

phalanx. Lateral digital extensor inserts to a prominence on the anterior aspect of the proximal end of 1st phalanx. Pronator teres is absent.

In *dog* medial digital extensor is not developed. Common digital extensor divides into four and each of which inserts to the corresponding 3rd phalanges at their extensor processes. Three divisions of the tendon of lateral digital extensor insert to the proximal ends of all the phalanges of 3rd, 4th and 5th digits. Divisions of tendons superficial digital flexor and deep digital flexor insert to the corresponding aspect of all the 3rd phalanges. However superficial digital flexor does not inserts to 1st phalanx.

FLEXOR GROUP

1. Pronator teres.
2. Flexor carpi radialis.
3. Flexor carpi ulnaris.
4. Ulnaris lateralis.
5. Superficial digital flexor.
6. Deep digital flexor.
7. Interosseous medius (Suspensory ligament).

Most of these flexor muscles are situated at the postero-medial aspect of fore limb. Ulnaris lateralis, however, is placed at the postero-lateral aspect.

PRONATOR TERES

This is a very ill developed thin and small muscle placed at the medial aspect of elbow joint. Due to the small structure its action is inappreciable [Fig. 4.8].

Origin—Medial condyle of humerus.

Insertion—At the upper third of the medial surface of radius.

Blood supply—Branch of median artery.

Nerve supply—Branch of median nerve.

FLEXOR CARPI RADIALIS

This is a long slender muscle situated at the medial aspect of radius. It helps to flex the carpus and extend the elbow [Fig. 4.9].

Origin—Medial condyle of humerus.

Insertion—On the nodule at the posterior aspect of the proximal extremity of large metacarpal bone.

Blood and Nerve supply—Similar to those of pronator teres.

FLEXOR CARPI ULNARIS

This is a thin and flat muscle situated at the postero-medial aspect of forearm. Its action is similar to that of previous muscle [Fig. 4.9].

Origin—There are two origins – **humeral** and **ulnar**. At the humerus it originates from the medial condyle and at the ulna it originates from medial aspect of olecranon process. The upper part of the muscle with its two origins looks like *Y*.

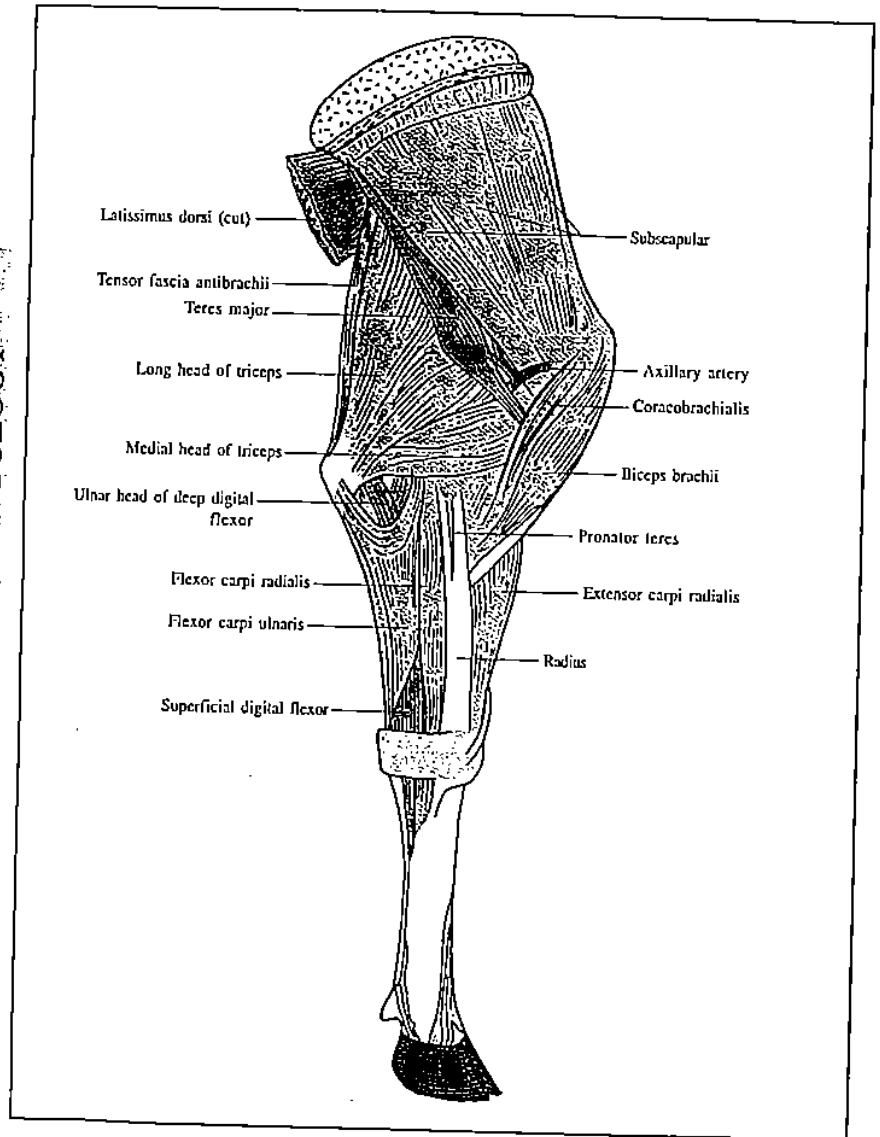


Fig. 4.9 Muscles of medial aspect of shoulder, arm and leg.

Insertion—Accessory carpal bone.

Blood supply—Branches of brachial and median arteries.

Nerve supply—Branches of ulnar and median nerves.

ULNARIS LATERALIS

This is a fleshy muscle situated behind the radius and at the lateral aspect of ulna. It assists in flexion of the carpus and in extension of elbow [Fig. 4.4].

Origin—Lateral condyle of humerus.

Insertion—Accessory carpal and lateral surface of the proximal end of large metacarpal bone.

Blood supply—Branches of brachial and interosseous arteries.

Nerve supply—Branch of radial nerve.

SUPERFICIAL DIGITAL FLEXOR

This muscle remains covered mostly by flexor carpi ulnaris. Although it originates in the form of a single bundle, divides at its belly into a superficial and a deep part. Each form a tendon. Both the tendons unite behind the metacarpal bone and bifurcate again. Each tendon joins with corresponding division of posterior part of superior sesamoidean ligament to form a ring for the passage of the concerned tendon of deep digital flexor. Slips detach from each tendon pass down and inserte to the 2nd phalanx. The muscle helps in flexing the fore limb [Fig. 4.9].

Origin—Medial condyle of humerus.

Insertion—2nd phalanx.

Blood supply—Branches of median and interosseous arteries.

Nerve supply—Branches of ulnar and median nerve.

DEEP DIGITAL FLEXOR

This fleshy muscle occupies the space at the postero-medial aspect of radius and ulna and remains covered by superficial digital flexor. It flexes the fore limb [Fig. 4.4 and 4.8].

Origin—It originates in three bundles – one from the olecranon process of ulna, one from medial condyle of humerus and the third from the posterior surface of radius close to proximal interosseous space.

Insertion—The three divisions unite to form a single tendon which passes through the carpal sheath, goes further downward and divides into two at the distal third of metacarpus. Each of the divisions inserts to the 3rd phalanx.

Blood supply—Branches from median and interosseous arteries.

Nerve supply—Branches from median and ulnar nerve.

INTEROSSEOS MEDIUS

Actually the superior sesamoidean or the suspensory ligament is little fleshy in young animals and sometimes reffered as interosseous medius muscle.

Lateral and medial interosseous muscles are absent in ox but present in horse. These are very small muscles originate from the proximal ends of corresponding small metacarpal bones and terminate in the fascia of fetlock

Lumbricalis (Lateral and medial) muscles are absent in ox. In the horse there two very small muscles originate from the deep digital flexor tendons and terminate in the fibrous tissue close to ergot.

MUSCLES OF HIND LIMB

Muscles of lateral aspect of thigh :

1. Tensor fascia lata.
2. Superficial gluteus.
3. Middle gluteus.
4. Deep gluteus.
5. Biceps femoris.
6. Semitendinosus.

TENSOR FASCIA LATA

It is a triangular muscle situated at the cranial aspect of hip and thigh. It tenses the fascia lata and covers the lateral aspect of the thigh. [Fig. 4.10]

Origin—Tuber coxae.

Insertion—Fascia lata and lateral straight ligament of patella.

Blood supply—Deep circumflex artery.

Nerve supply—Cranial gluteal branch of lumbo sacral plexus.

SUPERFICIAL GLUTEUS

Absent in ox but present in horse and dog. It originates from tuber coxae and gluteal fascia and inserts to the third trochanter of femur in horse. In the dog it originates from the sacrum, first caudal vertebra and sacrotuberous ligament and inserts to the proximal aspect of femur.

MIDDLE GLUTEUS

It is a very fleshy muscle covers an extensive part of the gluteal surface of ilium. It is partially covered by biceps femoris muscle. It helps to abduct the limb and to extend the hip [Fig. 4.10].

Origin—Tuber coxae, tuber sacrale, gluteal surface of ilium, sacrosciatic ligament, *etc.*

Insertion—It inserts in three parts. The cranial part inserts below trochanter major of femur, middle part to the dorsal border of trochanter major and the caudal fleshy part to the trochanteric ridge.

Blood supply—Gluteal and lumber arteries.

Nerve supply—Branches from cranial part of lumbosacral plexus.

DEEP GLUTEUS

It remains covered by middle gluteus. This is thin and quadrilateral in shape. It is directed caudoventrally. Its origin is wide and insertion is narrow. It helps to abduct the limb. [Fig. 4.12]

Origin—Tuber coxae, gluteal surface of ilium, ischiatic spine and sacrosciatic ligament.

Insertion—To a tubercle below trochanter major.

Blood supply—Gluteal arteries.

Nerve supply—Cranial gluteal nerve.

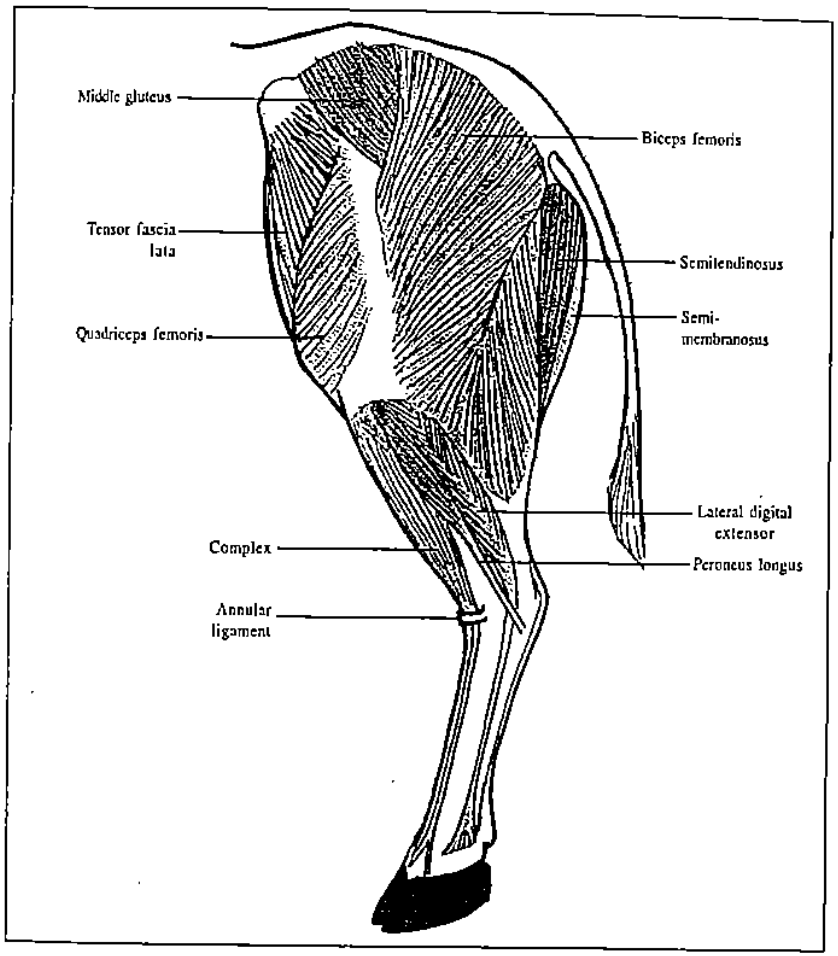


Fig. 4.10 Muscles of lateral aspect of hip, thigh and leg.

BICEPS FEMORIS

It is an extensive and flat muscle which covers most of the lateral aspect of hip and thigh. [Fig. 4.9]. It extends the hip and abducts the limb.

Origin—Spine of the sacrum, sacro sciatic ligament, and ischial tuberosity.

Insertion—Ventrally the muscle is divided into three parts. The cranial part inserts to the patella, middle part to the tibial crest and lateral patellar ligament. The caudal part inserts to the fascia lata and the tuber calcis.

Blood supply—Caudal gluteal and deep femoral arteries.

Nerve supply—Sciatic and posterior gluteal nerves.

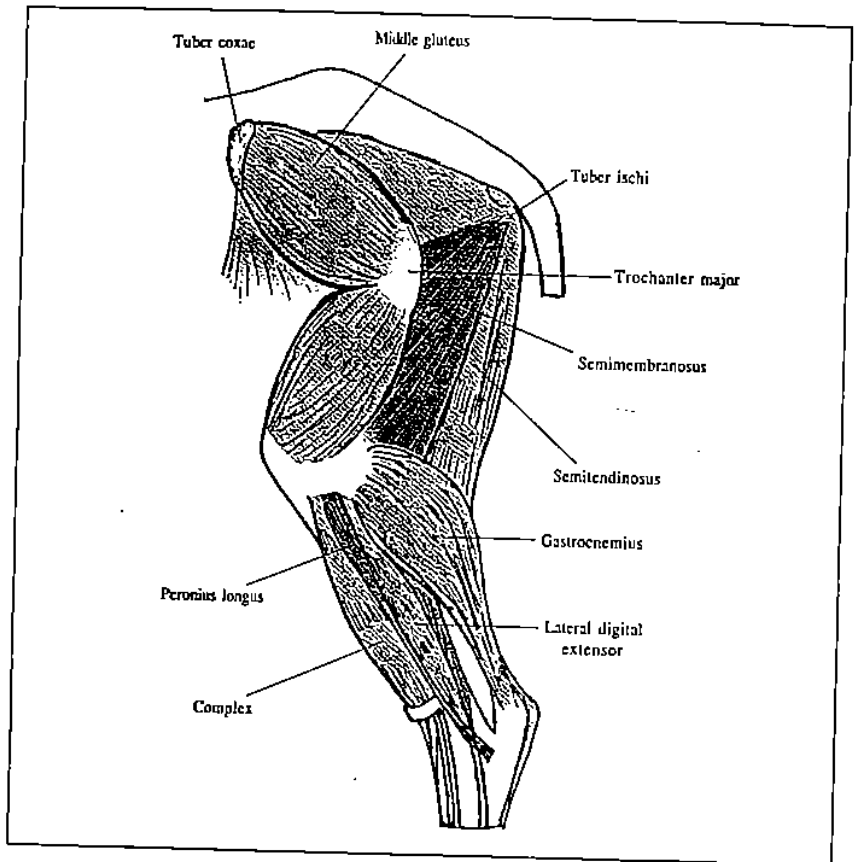


Fig. 4.11 Muscles of hip and thigh (after removing biceps femoris).

Hamstring

The posterior femoral muscles (biceps femoris, semitendinosus and semimembranosus) are collectively called hamstrings.

SEMITENDINOSUS

This long muscle (tendon like) extends from ischium to tibia along the caudal aspect of hip and thigh. It helps to extend the hip and hock and to flex the stifle [Fig. 4.10 and 4.11].

Origin—Ischial tuberosity

Insertion—Anterior border of tibia, tuber calcis and fascia lata.

Blood supply—Caudal gluteal and deep femoral arteries.

Nerve supply—Caudal gluteal and sciatic nerves.

MUSCLES OF THE MEDIAL ASPECT OF THIGH

These muscles are arranged in three layers as follows :

1. Sartorius.
2. Gracialis.

} Superficial layer.

1. Pectineus.
2. Adductor
3. Semimembranosus.

Middle layer.

1. Quadratus femoris.
2. Obturator internus.
3. Obturator externus.
4. Gemellus.

} Deep layer.

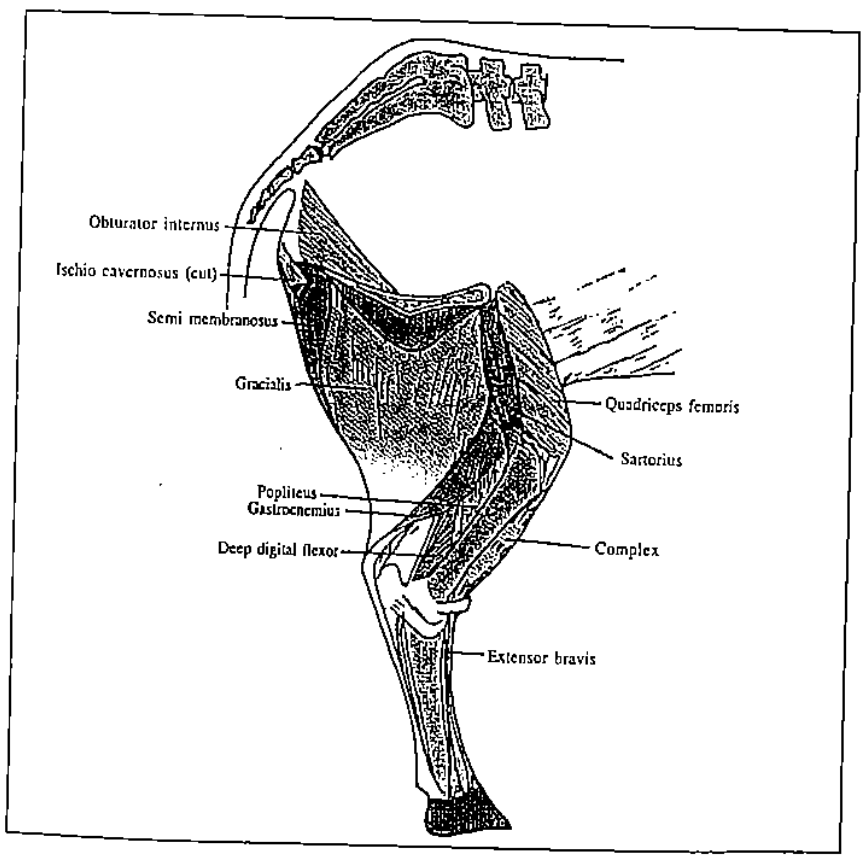


Fig. 4.12 Muscles of medial aspect of thigh and leg.

SARTORIUS

It is a thin flat muscle of the superficial layer placed cranial to gracialis. It tenses the fascia and helps to adduct the limb.

Origin—Shaft of ilium, psoas minor and iliac fascia.

Insertion—Medial patellar ligament, medial aspect of proximal end of tibia and fascia lata.

Blood supply—Branches of femoral and saphenous arteries.

Nerve supply—Branch of saphenous nerve.

GRACIALIS

This is a flat extensive muscle of the superficial layer and placed behind the sartorious. Its action is almost similar to that of sartorious [Fig. 4.12].

Origin—Pelvic symphysis and prepubic tendon.

Insertion—Medial patellar ligament, medial surface of tibia at the proximal end and fascia lata.

Blood supply—Deep femoral and a branch of femoral artery.

Nerve supply—Obturator nerve.

PECTINEUS

Pectineus is an elongated conical muscle of the middle layer and placed cranial to adductor and behind the vastus medialis. It helps to adduct the limb and rotate the femur medially [Fig. 4.11].

Origin—Ventral surface of pubis and pre pubic tendon.

Insertion—Posterior surface of femur at the distal end, medial patellar ligament and medial tuberosity of tibia.

Blood supply—Femoral arteries.

Nerve supply—Obturator and internal saphenous nerve.

ADDUCTOR

Adductor is a triangular muscle of the middle layer situated between the pectineus and semimembranosus. It assists to adduct the limb and to extend the hip.

Origin—Pelvic symphasis as well as ventral surfaces of pubis and ischium.

Insertion—Distal end of femur at its postero lateral aspect and supracondyloid crest.

Blood supply—Branches of femoral artery.

Nerve supply—Obturator nerve.

SEMIMEMBRANOSUS

This is a wide and flat muscle of middle layer placed at caudal aspect of the medial region of hip and thigh. It assists in adduction of the limb [Fig. 4.13]. This is thin above and thick and fleshy below. The muscle extends from tuber ischi in an oblique manner towards the medial surface of leg.

Origin—Ischial symphysis, ventral surface of ischium and ischial tuberosity.

Insertion—Area above the supracondyloid crest and medial tuberosity of tibia.

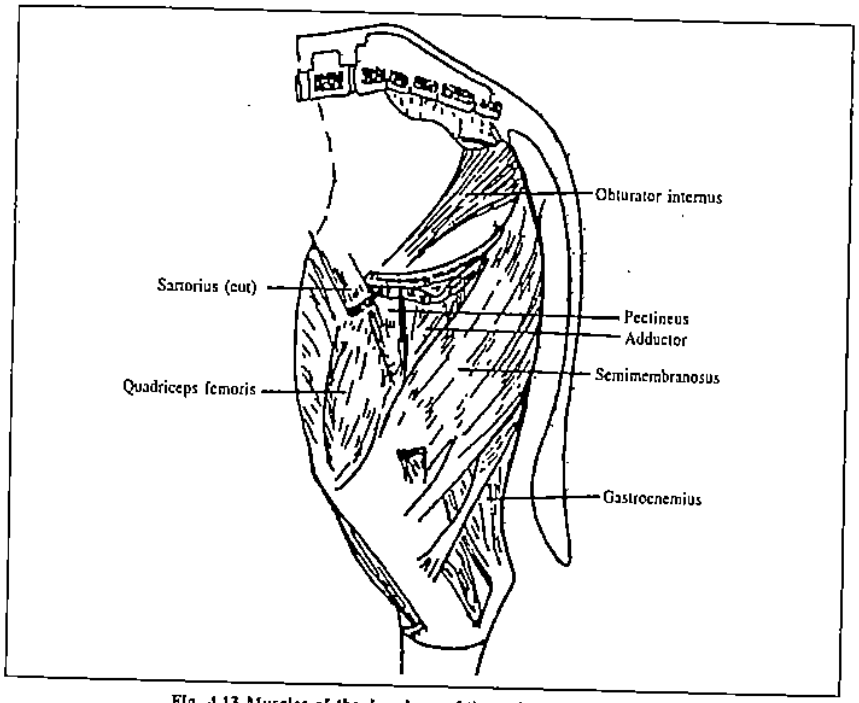


Fig. 4.13 Muscles of the deep layer of the medial aspect of thigh.

Blood supply—Branches from femoral and posterior gluteal arteries.

Nerve supply—Branches from Sciatic nerve.

QUADRATUS FEMORIS

This muscle is in the form of a bundle and situated mostly at the posterior aspect of ischium and femur and placed ventral to gomellus. It helps to extend the hip and adduct the limb. [Fig. 4.14]

Origin—Ventral surface of ischium.

Insertion—Trochanter minor and posterior surface of femur close to the trochanter minor.

Blood supply—Posterior gluteal and deep femoral arteries.

Nerve supply—Branch of sciatic nerve.

OBTURATOR INTERNUS

This is a very thin muscle and spreads over the pelvic floor behind the obturator foramen. Its tendon passes through the obturator foramen, and unite with the tendon of obturator externus. It helps to rotate the femur laterally [Fig. 4.12 and 4.13].

Origin—Ischium and pubis, at their pelvic surfaces.

Insertion—The tendon in common with that of obturator externus inserts to the trochanteric fossa of femur.

Blood supply—Obturator branch of internal iliac artery.

Nerve supply—Obturator nerve and branch of sciatic nerve.

OBTURATOR EXTERNUS

This is a small muscle in the form of few bundles placed ventral to ischium and pubis. It assists to adduct the limb and rotate the thigh outwards.

Origin—Ventral surface of ischium and pubis.

Insertion—Trochanteric fossa.

Blood supply—Branch of deep femoral artery.

Nerve supply—Obturator nerve.

GEMELLUS

Gemellus is a thin and roughly triangular muscle situated at the ventro-lateral aspect of ischium. It pulls the femur laterally.

Origin—Ventral surface and lateral border of ischium and posterior part of sacrosciatic ligament.

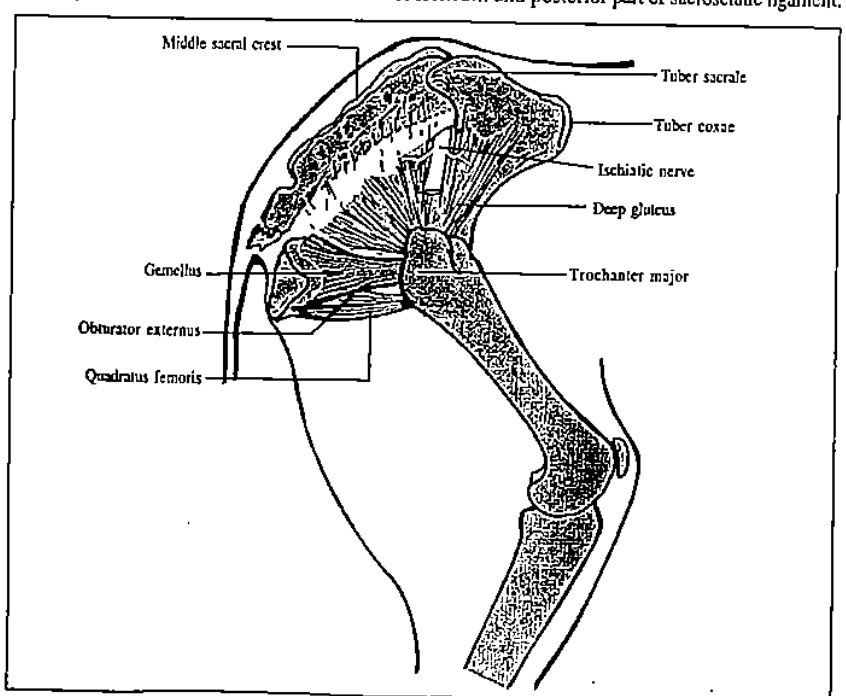


Fig. 4.14 Muscles of deep layer of lateral aspect of hip.

Insertion—Trochanteric fossa.

Blood supply—Posterior gluteal artery.

Nerve supply—Branch of sciatic nerve.

MUSCLES OF ANTERIOR ASPECT OF THIGH

1. Quadriceps femoris.
2. Articular genu.

QUADRICEPS FEMORIS

Anterior, lateral and medial surfaces of femur are covered by this muscle. The muscle is large, fleshy and consists of four parts – Vastus lateralis, Vastus medialis, Vastus intermedius and Rectus femoris. The first three parts are placed at the lateral, medial and anterior aspect of femur and the rectus femoris is placed infront of Vastus intermedius. The muscle helps to extend the stifle joint [Fig. 4.12 and 4.13].

Origin—The rectus femoris originates from the ridge and depression outside the cotyloid cavity and the other parts originate from trochanter major, neck and anterior surface of proximal end of femur.

Insertion—Anterior lateral and medial aspect of patella and medial patellar ligament.

Blood supply—Lateral circumflex and genicular arteries.

Nerve supply—Anterior crural (femoral) nerve.

ARTICULAR GENU

This is a small muscle placed on the anterior surface of the distal end of femur. It tenses the capsule of femoropatellar articulation.

Origin—Distal part of the anterior surface of femur.

Insertion—Patellar cartilage and medial patellar ligament.

Blood supply—Genicular artery.

Nerve supply—Anterior crural nerve.

MUSCLES OF ANTEROLATERAL ASPECT OF HIND LIMB

1. *Complex*—(a) Peroneus tertius. (b) Medial digital extensor. (c) Common digital extensor.
2. Lateral digital extensor.
3. Peroneus longus.
4. Tibialis anticus.
5. Extensor brevis.

COMPLEX

This is a composite muscle consists of three part : Peroneus tertius, common digital extensor and Medial digital extensor. The bulk of the muscle is situated at the anterolateral aspect of the tibia. They act together to flex the hock and to extend digits [Fig. 4.10, 4.11 and 4.12].

Origin—All the components originate combinedly from the extensor fossa situated between the lateral ridge of trochlea and lateral condyle at the distal end of femur.

Insertion—The Peroneus Tertius is inserted to the cranio medial part of the proximal end of large metatarsal bone.

The tendon of common digital extensor goes down along the anterior aspect of the limb, reaches the distal end of metatarsal bone and divides into lateral and medial branches. Each branch inserts on the extensor process of the concerned 3rd phalanx.

The long tendon of medial digital extensor also goes down to the medial digit and terminates on 2nd and 3rd phalanges. All the three tendons while going along the anterior aspect of the distal end of tibia, pass through a ring shaped annular ligament.

Blood supply—Anterior tibial artery.

Nerve supply—Deep peroneal nerve.

All these components of complex muscle are enclosed by an annular ligament in front of the hockjoint.

LATERAL DIGITAL EXTENSOR

This is a long muscle placed along the postero lateral aspect of tibia. It assists in extending the limb [Fig. 4.10]. At the hock the tendon of this muscle passes below the tendon of peroneus longus.

Origin—Lateral tuberosity of tibia and rudimentary fibula.

Insertion—Second and third phalanges of lateral digit.

Blood supply—Anterior tibial artery.

Nerve supply—Deep peroneal nerve.

PERONEUS LONGUS

This is a short elongated muscle situated between the complex and lateral digital extensor muscles. The tendon of this muscle crosses over the lateral digital extensor while terminating at the hock. It helps to rotate the hock joint medially [Fig. 4.10].

Origin—Lateral tuberosity of tibia.

Insertion—First tarsal and upper end of large metatarsal bone.

Blood and *Nerve* supplies are similar to that of lateral digital extensor.

TIBIALIS ANTICUS

This is a thin muscle placed anterior to the lateral surface of tibia and below the complex muscle. It helps to flex the hock joint.

Origin—Anterior tuberosity and crest of tibia and the rudimentary fibula.

Insertion—Second and third fused tarsal and the upper end of large metatarsal bone.

The muscle gets *similar* blood and nerve supplies to those of complex muscle.

EXTENSOR BREVIS

Extensor brevis is a very small muscle situated in front of the upper part of the metatarsal bone. It is too small to produce any appreciable function [Fig. 4.12].

Origin—Ventral surface of tibial tarsal.

Insertion—To the tendons of medial and common digital extensor muscles.

Blood supply—Dorsal metatarsal artery.

Nerve supply—Deep peroneal nerve.

In *dog* the muscles of antero-lateral group are (a) cranial tibial, (b) common digital extensor, (c) peroneus longus (d) lateral digital extensor and (e) extensor bravis.

Distally the common digital extensor divides into four tendons and are inserted to each principal digit. Tendon of lateral digital extensor join with the 5th of common. Sometimes a delicate extensor hallucis longus muscle is found.

In *horse*, medial digital extensor is absent. Peroneus longus is not developed. Disposition of common digital extensor is similar to that of common digital extensor of the fore limb.

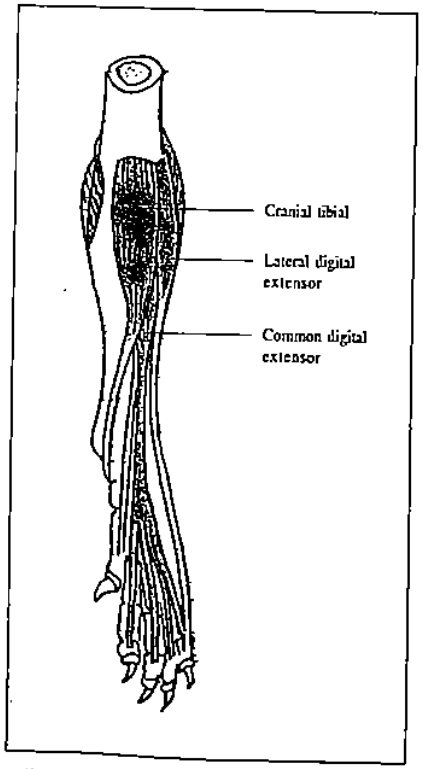


Fig. 4.15A Extensor muscles of hind limb (dog).

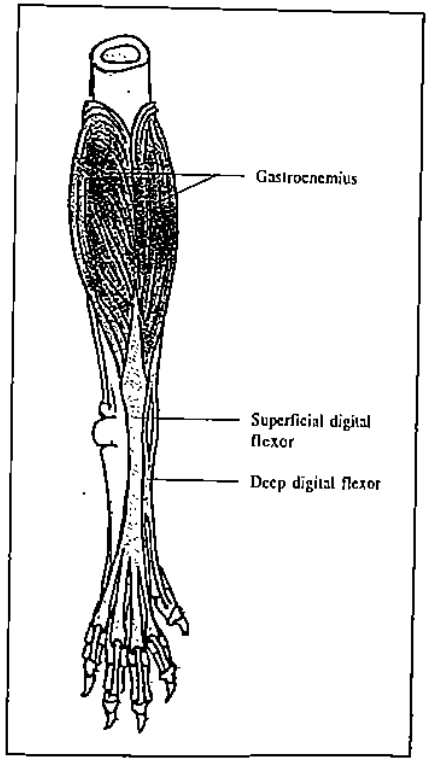


Fig. 4.15B Flexor muscles of hind limb (dog).

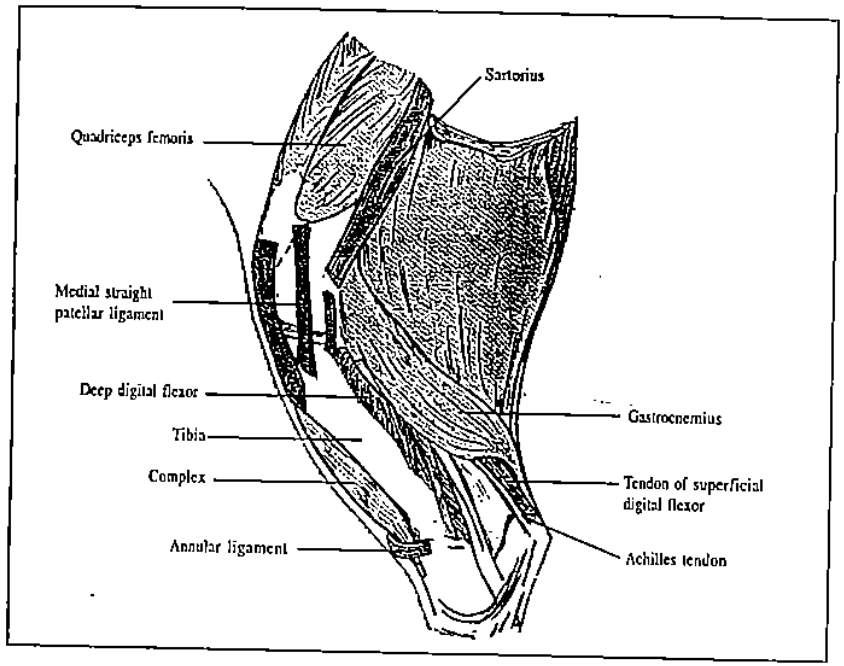


Fig. 4.15 Muscles of the medial aspect of thigh, stifle and hock.

MUSCLES OF POSTERO-MEDIAL ASPECT OF HIND LIMB

1. Gastrocnemius.
2. Soleus.
3. Superficial digital flexor.
4. Deep digital flexor.
5. Popliteus.

GASTROCNEMIUS

Gastrocnemius is a bulky muscle situated behind the upper part of the tibia. It begins in the form of two distinct stumps. It extends the hock region [Fig. 4.11 and 4.15]. The two heads of this muscle unite together after forming a groove between them. The united mass is bulky and receives the insertion of soleus at its anterior face.

Origin—The medial and the lateral heads arise from medial supracondyloid crest and lateral supracondyloid crest of femur respectively.

Insertion—*Tuber calcis.*

Blood supply—Femoral artery.

Nerve supply—Branch of popleteal nerve.

SOLEUS

Soleus is a very thin muscle situated under the gastrocnemius. It helps gastrocnemius in action.

Origin—Lateral tuberosity of tibia.

Insertion—The muscle inserts to the gastrocnemius at distal third of the tibia.

Blood and *Nerve supplies* are similar to that of gastrocnemius.

SUPERFICIAL DIGITAL FLEXOR

After the origin this muscle lies between the two portions of gastrocnemius. Close to the hock its tendon winds round the tendon of gastrocnemius and reaches the posterior surface. The tendon passes down along the groove of the tuber calcis and ultimately terminates in a similar manner to that of superficial digital flexor muscle of fore limb. The muscle helps to flex the digit.

Origin—Supracondyloid fossa of femur.

Insertion—Upper end of second phalanx.

Blood supply and *nerve supply* are similar to those of gastrocnemius.

Achilles Tendon — The tendon of gastrocnemius remains at first behind that of superficial digital flexor. Then a twisting occures and it comes in front of superficial digital flexor tendon. The later passes over a groove on the tubercalcis where as the tendon of gastrocnemius inserts on it. These two tendons at the point of hock, combinedly called Achilles tendon (Fig. 4.15).

DEEP DIGITAL FLEXOR

It covers the posterior surface of the tibia except a small upper medial portion which is occupied by popliteus. It assists to flex the digit. It has three heads – Medial, Superficial and Deep.

Origin—Lateral tuberosity as well as posterolateral aspect of the proximal end of tibia and fibula.

Insertion—At the insertion the tendons of all the parts join together and divide into two and ultimately inserts to the flexor tubercle of corresponding third phalanges, after passing through the ring formed by superficial digital flexor and posterior part of suspensory ligament.

Blood supply—Posterior tibial artery.

Nerve supply—Branch of popliteal nerve.

POPLITEUS

This is a triangular and fleshy muscle, placed at the posterior surface of the tibia at its upper medial part. It assists to flex the limb.

Origin—Lateral condyle of femur.

Insertion—Posterior surface of tibia at its upper and medial aspect.

Blood supply—Branch from popliteal artery.

Nerve supply—Branch of popliteal nerve.

Stay apparatus in horse

The action of the gastrocnemius muscle is to extend the hock and to flex the stifle joint in other animals. But in horse, the effect of contraction of this muscle is almost nullified by the resistance offered by the peroneus tertius muscle, which is tendinous rather than muscular. Therefore the static condition of the gastrocnemius muscle enables the horse to rest on its hind limb and popularly known as stay apparatus in horse.

In *dog* the muscles of postero medial group are (a) gastrocnemius, (b) popliteus, (c) superficial digital flexor and (d) deep digital flexor. In each tendon of origin of the two heads of Gastrocnemius there is a sesamoid bone (fabella) which articulate with the caudo-dorsal aspect of the corresponding condyles. The tendon of superficial digital flexor divides into four and each is inserted to the corresponding principal digit along with those of deep digital flexor.

MUSCLES OF ABDOMEN

Abdominal tunic—It is the deep fascia which covers the external aspect of the muscles of abdomen. The tunic is well developed towards the floor. In the inguinal region the fibers of the tunic support the penis, median septum of scrotum and the median (paired) suspensory laminae of mammary glands.

Linea alba—It is a white fibrous raphe extends from the xiphoid cartilage to the pubic symphysis. The aponeurosis of the oblique and transverse muscles of both the sides of the abdomen unite together to form this line.

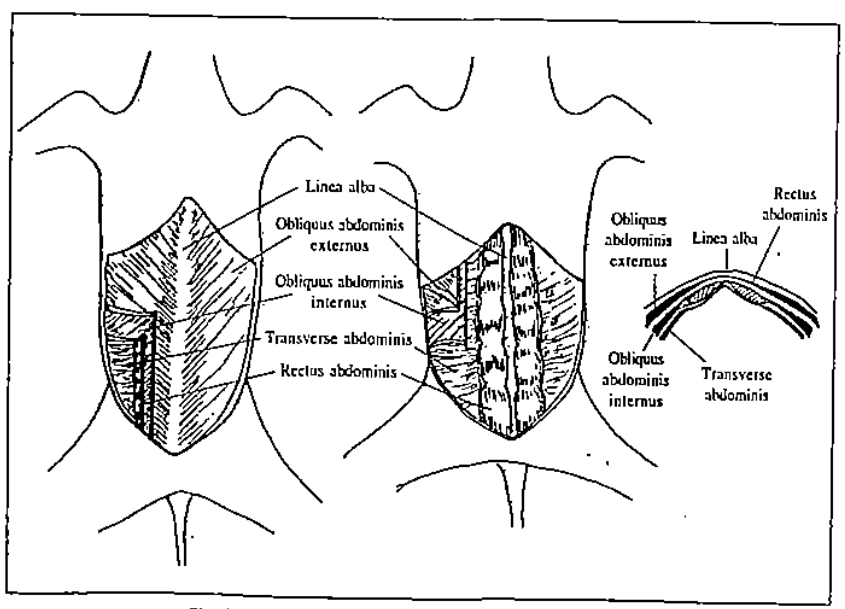


Fig. 4.16A Schematic diagram of abdominal muscles in dog.

MUSCLES

1. Obliquus abdominis externus.
2. Obliquus abdominis internus.
3. Transverse abdomins.
4. Rectus abdominis.

The abdominal muscles help in defecation, micturation, rumination, coughing, respiration, *etc.*

OBLIQUUS ABDOMINIS EXTERNUS

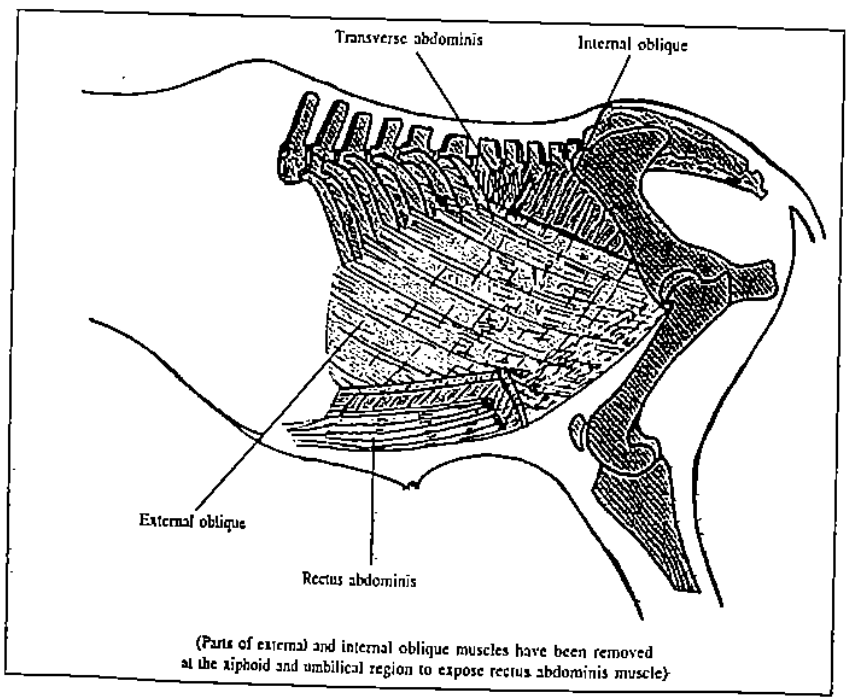
It is an extensive muscle of the lateral abdominal wall. The fibers are directed downward and backward. At the inguinal region it is pierced by external inguinal ring. A fibrous membrane is detached from its aponeurotic part at its insertion to the prepubic tendon which goes to the external angle of ilium. The inguinal part of the aponeurosis of this muscle is called inguinal or poupart's ligament [Fig. 4.17].

Origin—Lateral surfaces of ribs from the level of 5th intercostal space and lumbodorsal fascia.

Insertion—Linea alba and prepubic tendon.

Blood supply—Anterior and posterior abdominal arteries, intercostal and lumbar arteries and circumflex iliac artery.

Nerve supply—Intercostal and lumbar nerves.



(Parts of external and internal oblique muscles have been removed at the xiphoid and umbilical region to expose rectus abdominis muscle)

Fig. 4.16B Muscles of abdomen

OBLIQUUS ABDOMINIS INTERNUS

It is placed below the externus muscle. The fibers are directed in opposite (forward and downward) direction.

Origin—Tuber coxae, pouparts ligament and lumbo dorsal fascia.

Insertion—Linea alba, prepubic tendon and last few ribs and cartilages.

Blood and *nerve supplies* are Similar to those of obliquus abdominis externus.

TRANSVERSE ABDOMINIS

This is thin and innermost muscle of the abdomen. The fibers are directed transversely downward. Its internal surface is attached to the peritonium and the external surface is related to oblique and rectus muscles [Fig. 4.16B and 4.17].

Origin—Transverse processes of lumbar vertebrae and some asternal cartilages.

Insertion—Linea alba and xiphoid cartilage.

Blood and *nerve supplies*—Similar to those of obliquus abdominis externus.

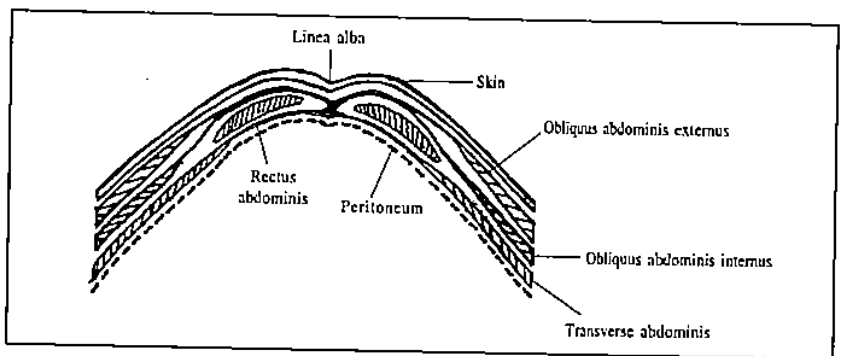


Fig. 4.16C Disposition of the abdominal muscles (Diagramatic).

RECTUS ABDOMINIS

It is an elongated flat muscle extends from sternum to pubis along the floor of the abdominal cavity. While terminating at the pubis it forms the **prepubic tendon** [Fig. 4.16B]. It is a strong muscle and lies between the aponeurotic parts of obliques abdominis in ternus externally and transversus internally.

In the umbilical region, the external sheath of rectus abdominis is formed by joint aponeuroses of external oblique and internal oblique muscles and the internal sheath is derived from the aponeurosis of transverse abdominis.

Origin—Lateral and ventral surface of sternum.

Insertion—Pubis and linea alba. The insertion of this muscle is popularly known as **prepubic** tendon.

Blood and *nerve supplies* are similar ot those of other abdominal muscles.

Functions of abdominal muscles : (a) Support for abdominal viscera; (b) Help in expulsive acts (micturation, defecation, parturition); (c) Help in forceful expiratory act (coughing, sneezing, blowing); (d) Assist in the movement of the trunk.

MUSCLES OF BACK THORAX AND SUB-LUMBAR REGION

1. Longissimus dorsi.
2. Longissimus costarum.
3. Levator costarum.
4. Multifidus dorsi.
5. Serratus dorsalis anticus.
6. Serratus dorsalis posticus.
7. External intercostal.
8. Internal intercostal.
9. Retractor costarum.
10. Rectus thoracis.
11. Transversus thoracis.
12. Latissimus dorsi.
13. Serratus thoracis.
14. Psoas major.
15. Psoas minor.
16. Iliacus.
17. Quadratus lumborum.
18. Inter transversales lumborum.

LONGISSIMUS DORSI

This is a long and strong muscle extendeds from sacrum to the neck. It helps to extend the back and loin [Fig. 4.17]. **It is the longest muscle of the body.** It occupies spaces between superior spine and transverse processes of the vertebrae.

Origin—Tuber coxae, iliac crest, cranial surface of ilium, supra spinous processes of sacral, lumbar and thoracic vertebrae.

Insertion—Articular and transverse processes of lumbar, thoracic and last four cervical vertebrae and lateral surface of few ribs.

Blood supply—Lumbar, thoracic and cervical arteries.

Nerve supply—Branches of spinal nerves of the concerned segments.

LONGISSIMUS COSTARUM

This thin muscle is spread over the dorso lateral aspect of ribs, just below and lateral to the longissimus dorsi. It helps to extend the spine [Fig. 4.17].

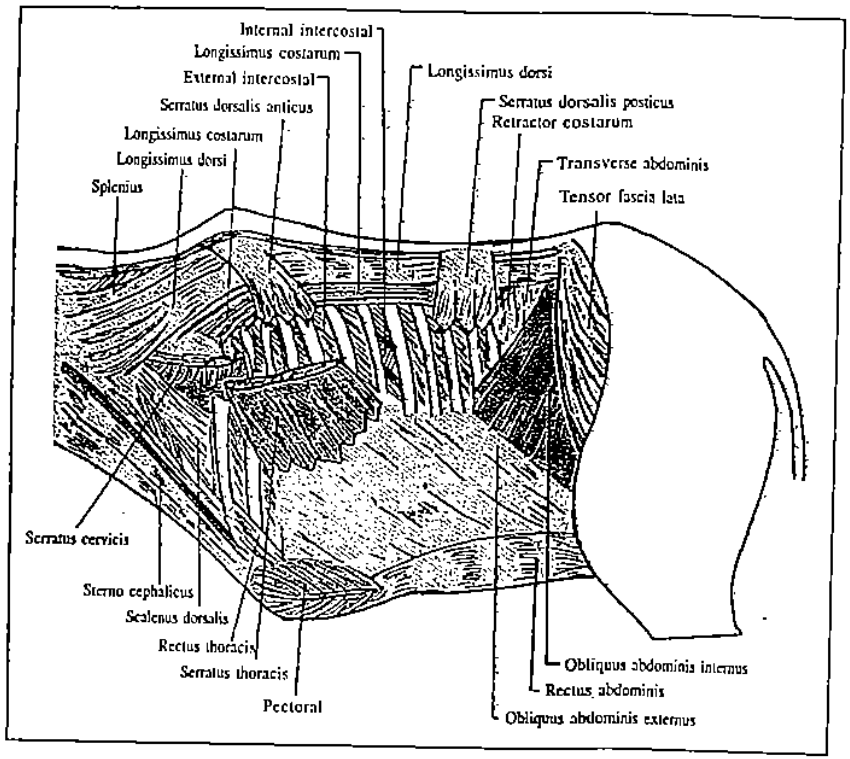


Fig. 4.17 Muscles of thorax and abdomen (Lateral view).

Origin—Tuber coxae, lumbar transverse processes and lateral surfaces of few ribs.

Insertion—Caudal borders of different ribs and transverse process of 7th cervical vertebra. Blood and nerve supplies are similar to those of longissium dorsi.

LEVATOR COSTARUM

The uppermost part of the intercostal spaces are occupied by these bundles of muscles. They are about twelve in number and assist in inspiration.

Origin—Corresponding transverse processes of thoracic vertebrae.

Insertion—Cranial borders of the corresponding ribs situated behind.

They are supplied with intercostal arteries and nerves.

MULTIFIDUS DORSI

These muscular bundles are arranged in a series and extends from mid cervical region to sacrum.

Origin—Articular processes of cervical and lumabr vertebrae, transverse process of thoracic vertebrae and the lateral surface of sacrum.

Insertion—Caudal borders of spinous processes of corresponding vertebrae in front.

Blood supply—Lumbar and intercostal arteries.

Nerve supply—Branches of corresponding spinal nerves.

SERRATUS DORSALIS ANTICUS

It is a small flat serrated muscle placed under rhomboideus. Generally 3 to 4 serrations are found. It helps in inspiration [Fig. 4.17].

Origin—4th to 7th thoracic spine and lumbodorsal fascia.

Insertion—Lateral surface of 5th to 8th rib.

Blood supply—Intercostal arteries.

Nerve supply—Branches of spinal nerves.

SERRATUS DORSALIS POSTICUS

Structure of this muscle is similar to that of serratus dorsalis anticus. It assists in expiration [Fig. 4.15].

Origin—10th to 13th thoracic spine and lumbo dorsal fascia.

Insertion—Lateral surfaces of last three ribs.

Blood and *Nerve supplies* are similar to those of serratus dorsalis anticus muscle.

EXTERNAL INTERCOSTALS

These muscles are placed laterally in the intercostal spaces. Their fibers are directed downward and backward. They help in inspiration [Fig. 4.17].

Origin—Caudal border of a rib in front.

Insertion—Cranial border of the rib behind.

Blood supply—Intercostal arteries.

Nerve supply—Intercostal nerves.

INTERNAL INTERCOSTALS

There are similar muscles placed internal to the external intercostals. The interosseous parts help in expiration and the interchondral parts help in inspiration. Their fibers are arranged in downward and forward direction [Fig. 4.17].

Origin—Cranial borders of a rib behind.

Insertion—Caudal borders of the ribs in front.

Blood and *Nerve supplies* are similar to those of external intercostal muscles.

RETRACTOR COSTARUM

This small triangular muscle is situated behind the upper end of last rib and below external oblique muscle. It helps in expiration [Fig. 4.17].

Origin—Transverse processes of first three or four lumbar vertebrae.

Insertion—Caudal border of last rib.

The muscle is supplied with lumbar arteries and nerves.

RECTUS THORACIS

Rectus thoracis is a small triangular thin muscle placed obliquely at the ventral aspect of the cranio lateral angle of thoracic wall. It helps in inspiration [Fig. 4.17].

Origin—Lateral surface of the distal end of first rib.

Insertion—Cartilage of 4th to 6h ribs and sternum.

Blood supply—Internal thoracic artery.

Nerve supply—Intercostal nerves.

TRANSVERSUS THORACIS

The thoracic surface of the sternum is covered by transversus thoracis muscle. The fibers are directed transversely. It helps in expiration.

Origin—Internal sternal ligament.

Insertion—Thoracic surface of sternal cartilages (third to eight).

Blood supply—Internal thoracic artery.

Nerve supply—Intercostal nerves.

LATISSIMUS DORSI

Already described.

SERRATUS THORACIS

Already discussed.

PSOAS MAJOR

It is a long muscle partially remains covered by Psoas minor and is extended at the sub-lumbar region. It helps to flex the hip [Fig. 4.18 and 4.19].

Origin—13th rib, 12th thoracic vertebra and transverse processes of lumbar vertebrae.

Insertion—Trochanter minor of femur.

Blood supply—Lumbar arteries and deep circumflex iliac artery.

Nerve supply—Lumbar spinal nerves and branch of sciatic nerve.

PSOAS MINOR

This thin muscle is placed at the ventro lateral aspect of the bodies of lumbar and few thoracic vertebrae. It helps to flex the hip [Fig. 4.18 and 4.19].

Origin—Last thoracic intervertebral disc and bodies of lumbar vertebrae.

Insertion—Psoas tubercle.

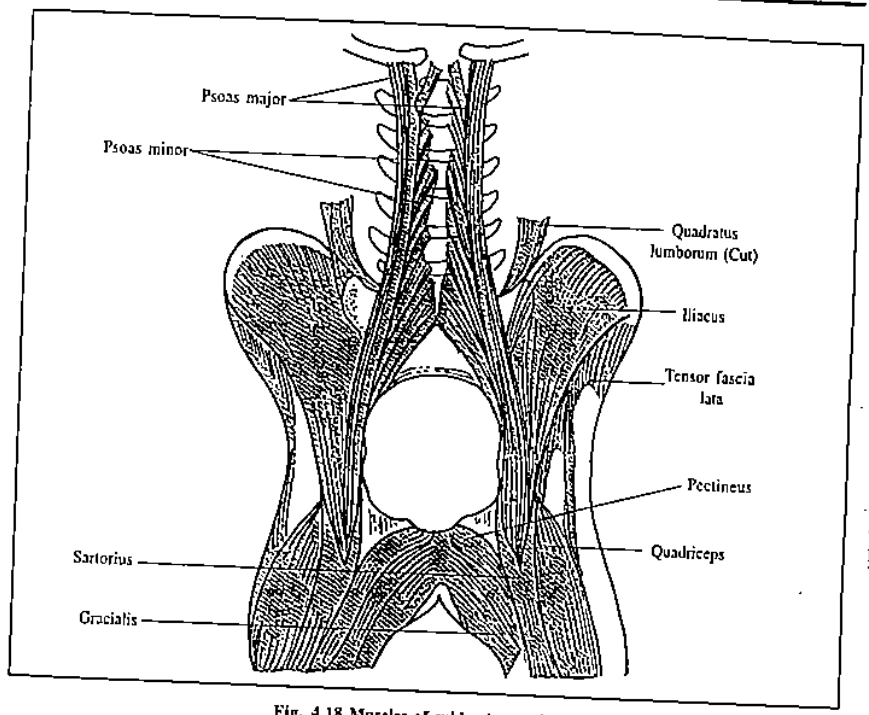


Fig. 4.18 Muscles of sublumbar region.

Blood supply—Lumbar arteries.

Nerve supply—Lumbar nerves.

ILIACUS

This thin muscle is mostly placed at the cranial surface of ilium. It assists to flex the hip [Fig. 4.16].

Origin—Ilium, last lumbar vertebra and base of sacrum.

Insertion—Trochanter minor.

Blood supply—Lumbar and branch of external iliac arteries.

Nerve supply—Iliomuscular nerve.

QUADRATUS LUMBORUM

This muscle is placed on the ventrolateral aspect of the caudal thoracic and lumbar region. It assists to flex the loin laterally [Fig. 4.18].

Origin—Ventral surfaces of the bodies of 11th to 13th thoracic vertebrae and last few ribs.

Insertion—Wings of Sacrum.

Blood supply—Lumbar arteries.

Nerve supply—Lumbar nerves.

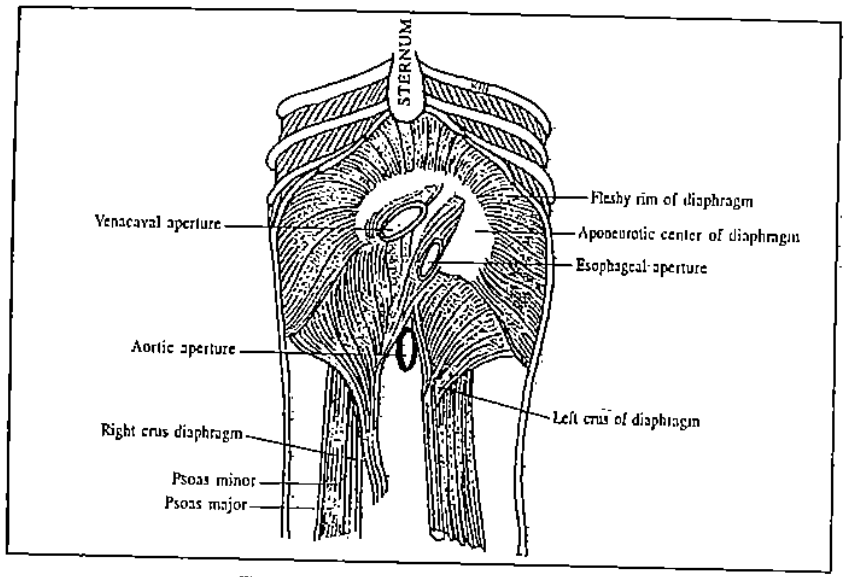


Fig. 4.19 Diaphragm and sublumbar muscles.

INTERTRANSVERSALES LUMBORUM

The spaces between the transverse processes of lumbar vertebrae are filled up by these muscles. Muscles of both sides act together to keep the back rigid. Individually it helps to flex the back laterally.

Origin—Cranial border of transverse process of a lumbar vertebra behind.

Insertion—Caudal border of transverse process of the lumbar vertebra in front.

Blood supply—Lumbar arteries.

Nerve supply—Lumbar nerves.

DIAPHRAGM

This is a musculo-aponeurotic dome shaped partition between the thoracic and abdominal cavities. Its rim is fleshy and the center is aponeurotic. Thoracic surface is convex and the abdominal surface is concave. The thoracic surface is covered by pleura and the abdominal surface is covered by peritonium. It is the chief inspiratory muscle. This muscle provides additional power to each effort of expulsive acts *e.g.*, coughing, sneezing, vomiting, defecation etc.

Attachments

It is attached to the lateral thoracic wall from 8th to 13th rib. Ventrally it is attached to the xiphoid cartilage. Dorsally it is attached strongly with lumbar vertebrae by two crura. The right crus is large and is attached to the ventral surfaces of first four or five lumbar vertebrae. The left crus is small and is attached to first and second lumbar vertebrae.

This partition presents three perforations for the passage of aorta, esophagus and venacava. The aortic aperture is situated below 13th thoracic vertebra between the two crura. The esophageal aperture passes through the right crus and is placed six to eight inches below the 8th thoracic vertebra. The venacaval aperture is situated close to the tendinous center and to the right of the median plane. Beside these, the muscle has a good number of smaller openings for small vessels and nerve trunks, out of which the left crus presents a little larger aperture for the passage of vena hemi azygos.

Blood supply—Phrenic and musculo phrenic arteries.

Nerve supply—Phrenic nerve.

MUSCLES OF THE NECK

Ventral Cervical group	*Lateral Cervical group*
1. Brachiocephalicus.	1. Splenius.
2. Sternocephalicus.	2. Longissimus capitis et atlantis.
3. Sterno-thyro-hyoideus.	3. Complexus.
4. Rectus capitis ventralis major.	4. Obliquus capitis anterior.
5. Rectus capitis ventralis minor.	5. Obliquus capitis posterior.
6. Omo hyoideus.	6. Multifidus cervicis.
7. Rectus capitis lateralis.	7. Rectus capitis dorsalis major.
8. Longus coli.	8. Rectus capitis dorsalis minor.
9. Intertransverse coli.	

Ventral Cervical group

BRACHIOCEPHALICUS

Already described (See page 119).

STERNOCEPHALICUS

This muscle has two parts — (1) Sterno-mandibularis (superficial) and
(2) Sterno-suboccipitalis—(deep).

The deep part forms the ventral border of jugular furrow. They help to flex the neck [Fig. 4.20].

Origin—First sternebra and first costal cartilage.

Insertion—

(a) Superficial part inserts to the mandible, massator and fascia of buccinator.

(b) The deep part inserts to massater muscle, temporal bone and to the basilar part of the occipital bone.

Blood supply—Branch of carotid artery.

Nerve supply—11th cranial nerve.

STERNO THYRO HYOIDEUS

This is a thin tape like muscle applied along the ventral surface of the trachea except at the cranial part where it covers the ventro-lateral aspect. It retracts the hyoid apparatus [Fig. 4.20].

Origin—Cranial portion of first sternebra.

Insertion—Thyroid cartilage and hyoid bone.

Blood supply—Branch from carotid artery.

Nerve supply—Branches of 1st and 2nd cervical spinal nerves.

RECTUS CAPITIS VENTRALIS MAJOR

This muscle is placed along the ventrolateral aspect of the cervical region. It helps to flex the head.

Origin—Transverse processes of 3rd to 6th cervical vertebrae [Fig. 4.23].

Insertion—At the junction between the basilar part of the occipital and sphenoid bones.

Blood supply—Branches of carotid and vertebral arteries.

Nerve supply—Branches of cervical spinal nerves.

RECTUS CAPITIS VENTRALIS MINOR

It is a small muscle lie close to the preceding muscle. It assists to flex the head.

Origin—Ventral aspect of atlas.

Insertion—At the junction between basilar part of occipital and sphenoid bones.

Blood and *Nerve supplies* are similar to those of rectus capitis ventralis major.

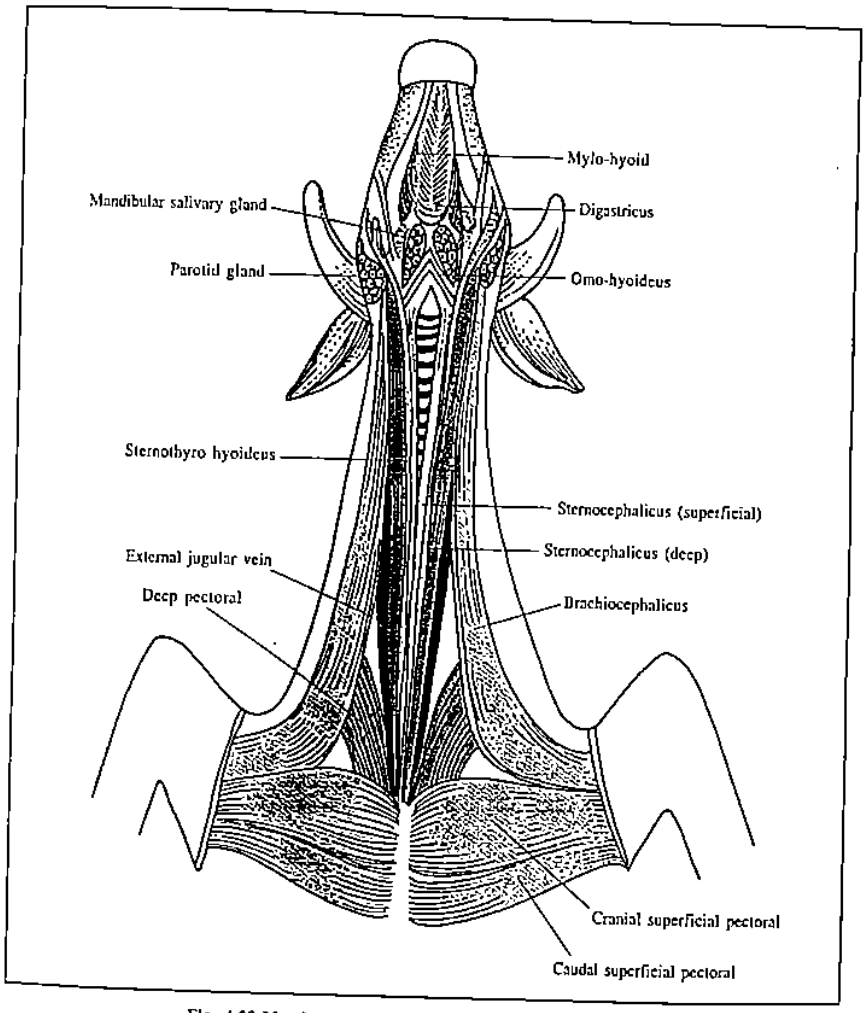


Fig. 4.20 Muscles of the ventral surface of the neck and head.

OMOHYOIDEUS

This is a small muscle placed at the ventral aspect of hyoid bone. It retracts the hyoid bone.

Origin—Serratus cervicis and the fasciae of 3rd and 4th cervical vertebrae [Fig. 4.18].

Insertion—Glossal process of hyoid bone.

Blood supply—Branch of carotid artery.

Nerve supply—Branch of 1st cervical spinal nerve.

RECTUS CAPITIS LATERALIS

This small muscle is placed lateral to the occipito-atlantal joint. It helps to flex the head.

Origin—Ventral aspect of atlas.

Insertion—Paramastoid process of the skull.

Blood supply—Branch of occipital artery.

Nerve supply—Branch of 1st cervical spinal nerve.

LONGUS COLI

A series of musculo-tendinous bundles are extended along the ventral surfaces of 6th thoracic vertebra to the atlas to form this muscle. It assists to flex the head.

Origin—The thoracic part originates from the ventral surfaces of the bodies of 1st to 6th thoracic vertebrae. The cervical part originates from the transverse processes of all cervical vertebrae except atlas.

Insertion—The thoracic part inserts to the bodies and transverse processes of 6th and 7th cervical vertebrae. The cervical part inserts to the infraspinous processes of cervical vertebrae and ventral tubercle of atlas.

Blood supply—Branches of carotid, vertebral and intercostal arteries.

Nerve supply—Branches of cervical and first four thoracic spinal nerves.

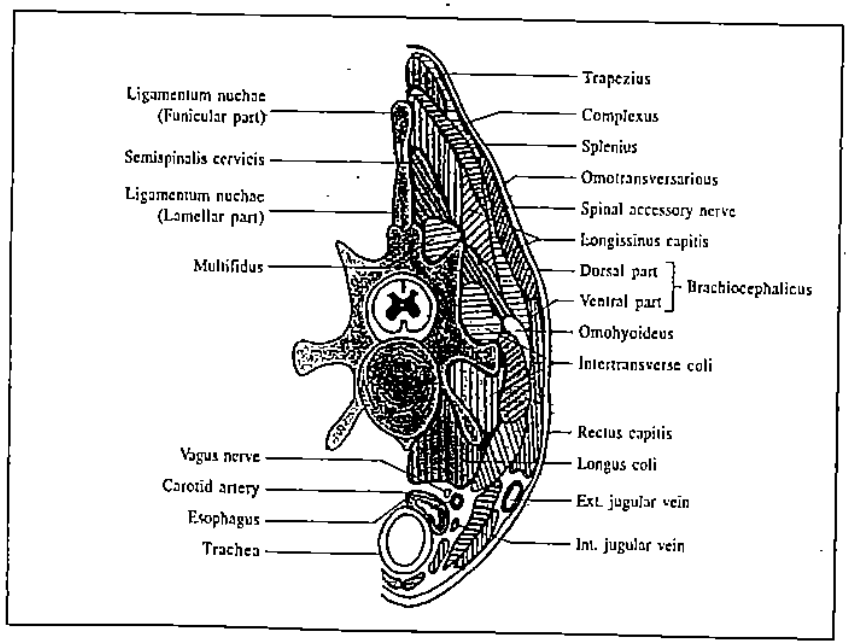


Fig. 4.21 Transverse section of neck at the level of 3rd-4th cervical vertebrae in ox (schematic).

INTER TRANSVERSE COLI

In the cervical region six muscular fasciculi occupy the spaces between articular and transverse processes except in the first intervertebral articulation. These are collectively called intertransverse coli. They help in lateral flexion of the neck.

Attachments

Each muscle has two bundles. The superior bundle originates from the transverse process of a vertebra, passes forward and inserts to the articular process of another vertebra. The inferior bundle attaches the adjacent transverse processes.

Blood supply—Branches of vertebral artery.

Nerve supply—Branches of cervical spinal nerves.

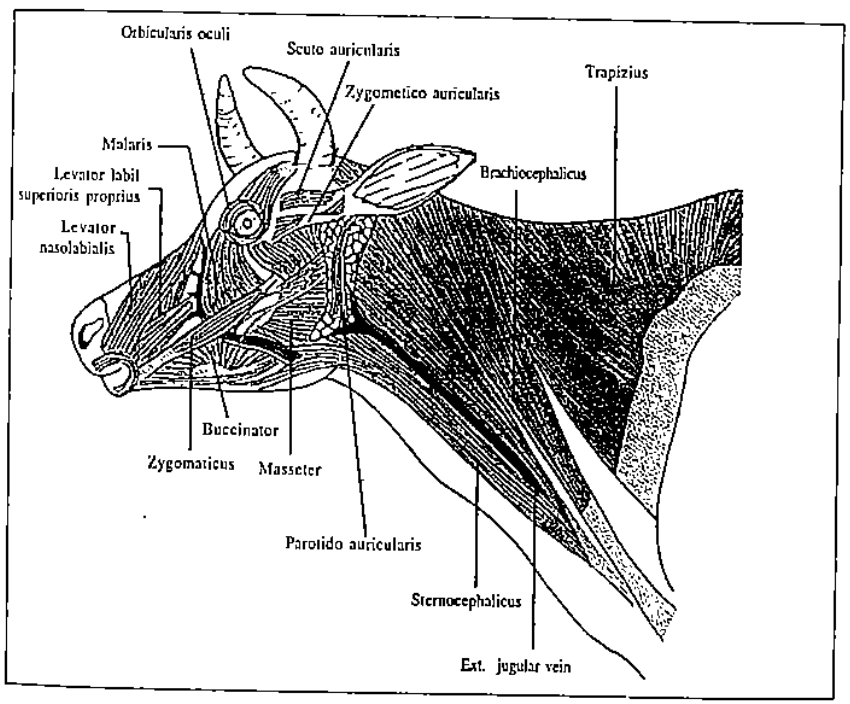


Fig. 4.22 Superficial muscles of Head and neck.

Lateral Cervical Group

SPLENIUS

This is a flat muscle placed at the dorsolateral aspect of the neck. It helps to extend the head [Fig. 4.23].

Origin—Supra spinous processes of first three or four thoracic vertebrae.

Insertion—Wings of atlas, transverse processes of axis and 3rd cervical vertebra.

Blood supply—Branches of costo cervical artery.

Nerve supply—Branches of cervical spinal nerve.

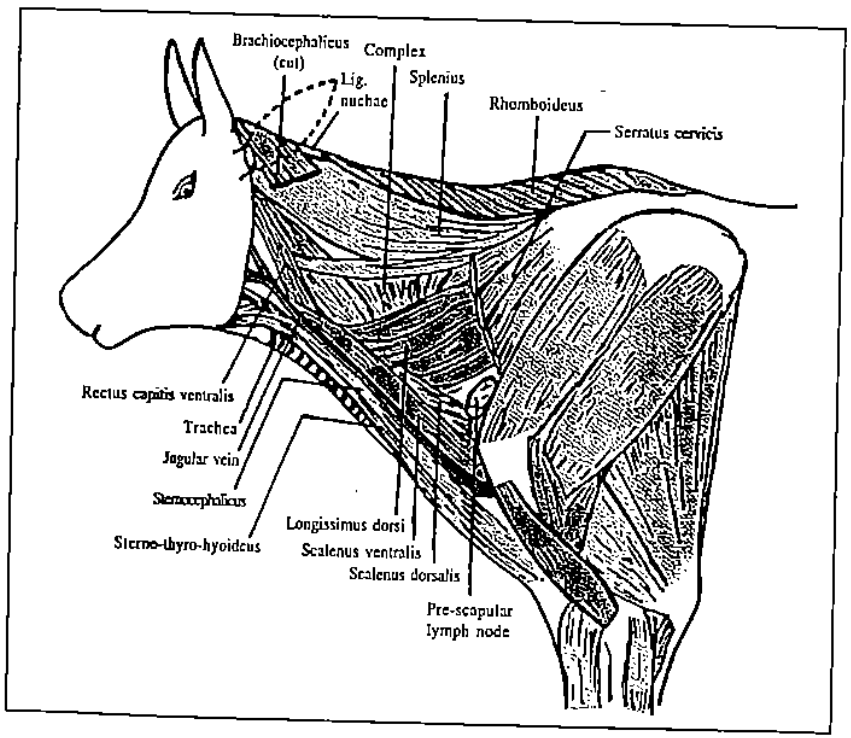


Fig. 4.23 Muscles of neck (after removing superficial layer).

LONGISSIMUS CAPITIS ET ATLANTIS

The muscle is placed at the lateral aspect of the neck between the splenius and complex. It assists to extend the neck.

Origin—Transverse processes of last three cervical and first two thoracic vertebrae and articular processes of 3rd to 7th cervical vertebrae.

Insertion—Lateral border of atlas and the mastoid process.

Blood supply—Vertebral arteries.

Nerve supply—Branches of 3rd to 8th cervical spinal nerve.

COMPLEXUS

This muscle is placed lateral to the ligamentum nuchae and partly covered by splenius and longissimus et atlantis. It helps to extend the neck [Fig. 4.20].

Origin—Transverse processes of first nine thoracic vertebrae, articular process of 3rd to 7th cervical vertebrae and ligamentum nuchae.

Insertion—Close to external occipital protuberance.

Blood supply—Branches of vertebral and superior cervical arteries.

Nerve supply—Branches of all the cervical spinal nerves excepting first two.

OBLIQUUS CAPITIS ANTERIOR

This muscle is placed lateral to occipito atlantal joint. It helps to extend the neck.

Origin—Dorso lateral aspect of atlas.

Insertion—Close to external occipital protuberance.

Blood supply—Branch of occipital artery.

Nerve supply—Branch of 1st cervical spinal nerve.

OBLIQUUS CAPITIS POSTERIOR

It is placed at the dorsolateral aspect of axis and atlanto axial articulation. The muscle helps to extend the neck.

Origin—Supraspinous process and posterior articular processes of axis.

Insertion—Wings of atlas.

Blood and *Nerve supplies* are similar to those of previous muscle.

MULTIFIDUS CERVICIS

This is also known as semispinalis of the neck. This muscle is placed in a series with the multifidus dorsi and comprises of six bundles. It helps to extend the neck.

Origin—Articular processes of last four or five cervical and 1st thoracic vertebrae.

Insertion—Each muscular fasciculus after the origin passes forward, upward and inserts to the supraspinous process and articular processes of the respective preceding cervical vertebra (3rd to 7th).

Blood supply—Vertebral and superior cervical arteries.

Nerve supply—Branches of 3rd to 8th cervical spinal nerves.

RECTUS CAPITIS DORSALIS MAJOR

This small muscle extends from axis to occipital bone. It assists to extend the head.

Origin—Spine of axis.

Insertion—Close to external occipital protuberance.

Blood supply—Occipital artery.

Nerve supply—Branch of 1st cervical spinal nerve.

RECTUS CAPITIS DORSALIS MINOR

This small muscle lies under the major muscle and also assists it to extend the head.

Origin—Cranial aspect of wings of atlas.

Insertion—Close to external occipital protuberance.

Blood and *Nerve supplies* are similar to those of rectus capitis dorsalis major.

Muscles of Face and Head

All these muscles are small and will be described in short.

Region of lips cheeks and nostrils.

1. Orbicularis oris.
2. Levator nasolabialis.
3. Levator labii superioris proprius.
4. Levator labii superioris accessorius.
5. Zygomaticus.
6. Depressor labii superioris
7. Levator labii inferioris.
8. Depressor labii inferioris.
9. Buccinator.
10. Dilatator naris lateralis.
11. Dilatator naris apicalis.
12. Dilatator naris superioris.
13. Dilatator naris inferioris.

Auricular region.

1. Parotido auricularis.
2. Cervico auricularis.
3. Parieto auricularis externus.
4. Parieto auricularis internus.
5. Temporo auricularis.
6. Zygomatico auricularis.
7. Scuto auricularis externus.
8. Scuto auricularis internus.

Temporo maxillary region

1. Orbicularis oculi.
2. Corrugator supercilli.
3. Malaris.
4. Levator palpebrae superioris.

Temporo maxillary region (muscles of mastication).

1. Masseter
2. Pterygoideus medialis.
3. Pterygoideus lateralis.
4. Temporalis.
5. Digastricus.

Hyoid region.

1. Mylo hyoideus.
2. Stylo hyoideus.
3. Genio hyoideus.
4. Kerato hyoideus.
5. Occipito hyoideus.
6. Hyoideus transversus.
7. Sterno thyrohyoideus.
8. Omo hyoideus.

Lip, cheek and nostril region

ORBICULARIS ORIS

The fibers of this muscle are arranged as sphincter around the opening of mouth. It receives fibers from other muscles which converge to it [Fig. 4.24].

Blood supply—Terminal branches of maxillary and mandibulo alveolar arteries.

Nerve supply—Branches of facial and maxillary nerves.

LEVATOR NASOLABIALIS

This thin muscle arises from nasal and frontal bone and terminates on nasal cartilage and premaxilla. It helps to elevate the upper lip [Fig. 4.24].

Blood supply—Branch of maxillary artery.

Nerve supply—Branch of facial.

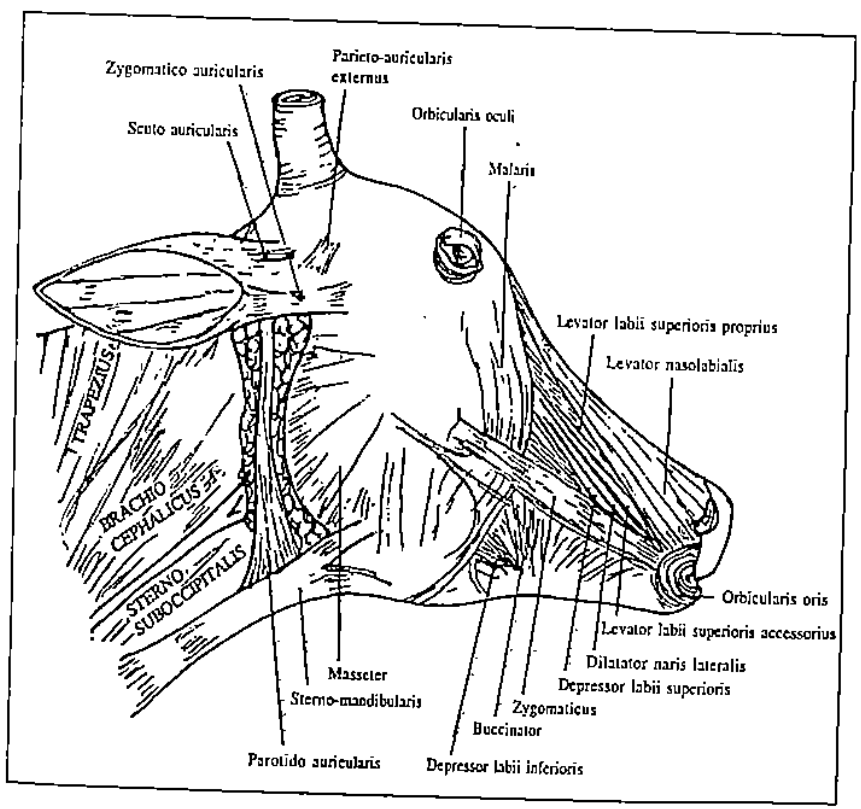


Fig. 4.24 Muscles of face.

LEVATOR LABII SUPERIORIS PROPRIUS

This muscle is placed below levator nasolabialis. It originates from facial tuberosity and inserts to the muzzle and upper lip. It elevates the upper lip [Fig. 4.24].

Blood supply—Branches of maxillary artery.

Nerve supply—Branches of infraorbital and facial nerves.

LEVATOR LABII SUPERIORIS ACCESSORIUS

This small bundle of muscle arises from the facial tuberosity and terminates to the upper lip. It is placed almost parallel to the proprius muscle. It helps the proprius muscle in action [Fig. 4.24].

Blood supply—Branch of maxillary artery.

Nerve supply—Branch of infraorbital and facial nerves.

ZYGOMATICUS

This thin flat muscle extends from the temporal process of the zygomatic bone to the angle of the lips. Its fibers blend with the orbicularis oris muscle. It retracts the angle of mouth [Fig. 4.24].

Blood supply—Facial artery.

Nerve supply—Facial nerve.

DEPRESSOR LABII SUPERIORIS

It is placed parallel to the dilator naris lateralis muscle, just above the zygomaticus. It helps to depress the upper lip. The muscle originates from facial tuberosity and terminates at the upper lip and muzzle [Fig. 4.24].

Blood supply—Facial artery.

Nerve supply—Branch of superior buccal nerve.

LEVATOR LABII INFERIORIS

(Incisivus Mandibularis)

This small muscle originates from the ventral aspect of the body of mandible and terminates at the lower lip. It helps to elevate the lower lip.

Blood supply—Facial artery.

Nerve supply—Mental nerves.

DEPRESSOR LABII INFERIORIS

This is placed along the ventral border of buccinator. It originates from the alveolar border of mandible and inserts to the lower lip. It helps to depress the lower lip [Fig. 4.24].

Blood supply—Branch of facial artery.

Nerve supply—Branch of superior buccal nerve.

BUCCINATOR

It is the main cheek muscle. It originates from the alveolar borders of maxilla and mandible and terminates by blending with orbicularis oris. It helps to retract the angle of mouth.

Blood supply—Mandibular labial and branches from maxillary arteries.

Nerve supply—Facial nerve.

DILATATOR NARIS LATERALIS

This narrow bundle is placed above the depressor labii inferioris and runs parallel to it. It extends from facial tuberosity to the wings of nostril. The muscle assists to dilate the nostril.

Blood supply—Branches of facial artery.

Nerve supply—Branches of superior buccal and superior maxillary nerve.

DILATATOR NARIS APICALIS

This small muscle is confined in the muzzle. It extend from the premaxilla to the wing of the nostril. It helps to dilate the nostril.

Blood supply—Facial artery.

Nerve supply—Superior buccal nerve.

DILATATOR NARIS SUPERIORIS

It is also very small muscle. It extends from the parietal cartilage to the medial wing of nostril. Blood and nerve supplies are similar to those of previous muscle.

DILATATOR NARIS INFERIORIS

This small muscle starts from parietal cartilage and premaxilla and terminates to the lateral wings of nostril. It helps to dilate the nostril.

Blood supply—Facial artery.

Nerve supply—Branches of facial and infraorbital nerves.

PALPEBRAL REGION

ORBICULARIS OCULI

Surrounding the border of the orbit the fibers of this sphincter muscle is spread between the skin and palpebra. This muscle controls the aperture between the palpebrae.

Blood supply—Malar artery.

Nerve supply—Branch of facial nerve.

CORRUGATOR SUPERCILLI

(Levator anguli oculi medialis)

This muscle is ill developed in ox and found in horse and dog. This is a very thin muscle which starts from the zygomatic process, spread to the upper eye lid and blend to the orbicularis oculi. It helps to raise the upper eye lid.

LEVATOR LABII SUPERIORIS PROPRIUS

This muscle is placed below levator nasolabialis. It originates from facial tuberosity and inserts to the muzzle and upper lip. It elevates the upper lip [Fig. 4.24].

Blood supply—Branches of maxillary artery.

Nerve supply—Branches of infraorbital and facial nerves.

LEVATOR LABII SUPERIORIS ACCESSORIUS

This small bundle of muscle arises from the facial tuberosity and terminates to the upper lip. It is placed almost parallel to the proprius muscle. It helps the proprius muscle in action [Fig. 4.24].

Blood supply—Branch of maxillary artery.

Nerve supply—Branch of infraorbital and facial nerves.

ZYGOMATICUS

This thin flat muscle extends from the temporal process of the zygomatic bone to the angle of the lips. Its fibers blend with the orbicularis oris muscle. It retracts the angle of mouth [Fig. 4.24].

Blood supply—Facial artery.

Nerve supply—Facial nerve.

DEPRESSOR LABII SUPERIORIS

It is placed parallel to the dilator naris lateralis muscle, just above the zygomaticus. It helps to depress the upper lip. The muscle originates from facial tuberosity and terminates at the upper lip and muzzle [Fig. 4.24].

Blood supply—Facial artery.

Nerve supply—Branch of superior buccal nerve.

LEVATOR LABII INFERIORIS

(Incisivus Mandibularis)

This small muscle originates from the ventral aspect of the body of mandible and terminates at the lower lip. It helps to elevate the lower lip.

Blood supply—Facial artery.

Nerve supply—Mental nerves.

DEPRESSOR LABII INFERIORIS

This is placed along the ventral border of buccinator. It originates from the alveolar border of mandible and inserts to the lower lip. It helps to depress the lower lip [Fig. 4.24].

Blood supply—Branch of facial artery.

Nerve supply—Branch of superior buccal nerve.

BUCCINATOR

It is the main cheek muscle. It originates from the alveolar borders of maxilla and mandible and terminates by blending with orbicularis oris. It helps to retract the angle of mouth.

Blood supply—Mandibular labial and branches from maxillary arteries.

Nerve supply—Facial nerve.

DILATATOR NARIS LATERALIS

This narrow bundle is placed above the depressor labii inferioris and runs parallel to it. It extends from facial tuberosity to the wings of nostril. The muscle assists to dilate the nostril.

Blood supply—Branches of facial artery.

Nerve supply—Branches of superior buccal and superior maxillary nerve.

DILATATOR NARIS APICALIS

This small muscle is confined in the muzzle. It extend from the premaxilla to the wing of the nostril. It helps to dilate the nostril.

Blood supply—Facial artery.

Nerve supply—Superior buccal nerve.

DILATATOR NARIS SUPERIORIS

It is also very small muscle. It extends from the parietal cartilage to the medial wing of nostril. Blood and nerve supplies are similar to those of previous muscle.

DILATATOR NARIS INFERIORIS

This small muscle starts from parietal cartilage and premaxilla and terminates to the lateral wings of nostril. It helps to dilate the nostril.

Blood supply—Facial artery.

Nerve supply—Branches of facial and infraorbital nerves.

PALPEBRAL REGION

ORBICULARIS OCULI

Surrounding the border of the orbit the fibers of this sphincter muscle is spread between the skin and palpebra. This muscle controls the aperture between the palpebrae.

Blood supply—Malar artery.

Nerve supply—Branch of facial nerve.

CORRUGATOR SUPERCILLI

(Levator anguli oculi medialis)

This muscle is ill developed in ox and found in horse and dog. This is a very thin muscle which starts from the zygomatic process, spread to the upper eye lid and blend to the orbicularis oculi. It helps to raise the upper eye lid.

MALARIS

This is a thin sheet of a muscle, spread over the buccinator and masseter. It originates from the lacrimal bone and inserts to the fascia of the dorsal border of buccinator. It helps to elevate the cheek.

Blood supply—Malar artery.

Nerve supply—Facial nerve.

LEVATOR PALPEBRAE SUPERIORIS

This muscle is placed partly in the orbit. It extends from the pterygoid crest to the upper eye lid. It elevates the upper eye lid.

Blood supply—External ophthalmic artery.

Nerve supply—Occulomotor nerve.

Tempro-maxillary Region

(These are the Muscles of Mastication)

MASSETER

This is a flat and strong muscle placed on the external surface of the ramus of mandible. Its fibers are directed backward and downward. It originates from facial tuberosity and zygomatic arch and inserts to the lateral surface of ramus of mandible. It helps to close the jaw [Fig. 4.24].This muscle is multipennate and better developed in herbivores.

Blood supply—Branches of facial artery.

Nerve supply—Masseteric nerve.

PTERYGOIDEUS MEDIALIS

It is a flat muscle placed on the medial surface of the vertical part of mandible. It helps to close the mouth and produces lateral motion.

Origin—Pterygoid process of sphenoid and perpendicular part of palatine bone.

Insertion—Medial surface of vertical part of the ramus of mandible.

Blood supply—Pterygoid artery, a branch of maxillary artery.

Nerve supply—Branch of mandibular nerve.

PTERYGOIDEUS LATERALIS

This is a thin short muscle placed medial to the temporo mexillary articulation. It helps the pterygoideus medialis muscle in action.

Origin—Pterygoid process of basisphenoid and pterygopalatine fossa.

Insertion—Condyle and neck of the mandible.

Blood and *nerve supplies* are similar to those of pterygoideus medialis.

TEMPORALIS

This muscle is better developed in carnivores. This is placed in the temporal fossa. It assists to raise the mandible for closing the mouth.

Origin—Temporal fossa.

Insertion—Coronoid process and adjacent medial and lateral surfaces of the mandible.

Blood supply—Deep temporal artery.

Nerve supply—Branch of mandibular nerve.

DIGASTRICUS

This is a long tendinous muscle placed at the medial aspect of the mendible. It has two bellies—cranial and caudal. The muscle helps to open the mouth and to raise the tongue.

Origin—Jugular (paramastoid) process of occipital bone.

Insertion—Medial surface of the mandible.

Blood supply—Branch of facial artery.

Nerve supply—Branches of facial and mylohyoid nerves.

MUSCLES OF HYOID REGION

Mylo-hyoideus—It extends from the medial face of the mandible just below the alveolar border to the lingual process of hyoid bone. It helps to elevate the tongue. It is provided with sublingual artery and branch of mylohyoid nerve.

Stylo-hyoideus—This thin muscle starts from the muscular angle of the great cornu and terminates at the thyroid cornu of the hyoid bone. It retracts the tongue by drawing the hyoid bone dorsally and caudally. Branches of facial artery and facial nerve supply this muscle.

Genio-hyoideus—This muscle connects the medial surface of the horizontal part of mandible and the glossal process of the body of the hyoid bone. It draws the tongue forward. It is supplied with branches of lingual artery and glossopharyngeal nerve.

Kerato-hyoideus—It originates from small cornu, ventral border of great cornu and middle cornu and inserts to the dorsal border of thyroid cornu. It raises the thyroid cornu and larynx. It gets blood supply from lingual artery and nerve supply from glossopharyngeal.

Occipito hyoideus—It extends from the paramastoid process to the proximal end of great cornu of hyoid bone. This muscle draws the hyoid apparatus caudally. Branches of occipital artery and facial nerve supply blood and nerve to this muscle respectively.

Hyoideus transversus—This unpaired small muscle is extended transversely between two small cornua of hyoid bone. It is supplied with the branches of lingual artery and 9th cranial nerve.

Sterno thyro hyoideus—Already described.

Omo hyoideus—Already discribed.

MUSCLES OF AURICULAR REGION

These muscles get blood supply from branches of occipital and superficial temporal arteries and nerve supply from facial and lacrimal nerves.

Parotido-auricularis—This is in the form of a fibrous sheet, originates from parotid fascia, passes upward and inserts to the base of the auricular cartilage. It draws the ear externally and ventrally [Fig. 4.24].

Cervico-auricularis—This is composed of three parts—*external, middle* and *internal*.All the parts originate from the funicular part of the ligamentum nuchae and inserts to the base of the conchal cartilage. These three parts are arranged layer by layer. These muscles rotate the ear and draw it backward.

Parieto-auricularis externus—It arises from the base of the horn and terminates on the scutiform and conchal cartilages. It rotates the concha forward [Fig. 4.24].

Parieto-auricularis internus—This muscle also arises from parietal bone and terminates to the conchal cartilage. It is placed partially under the parieto-auricularis externus muscle. It adducts the ear.

Temporo auricularis—This small muscle originates from the posterior border of the external auditory process of the temporal bone and inserts to the conchal cartilage. It assists to draw the conchal cartilage downward.

Zygomatico-auricularis—This muscle starts from the zygomatic arch and terminates on the scutiform and conchal cartilages. It has two parts—medial and lateral. The medial one is short. It draws the ear forward [Fig. 4.24].

Scuto-auricularis externus—It extends from the scutiform cartilage to the anteromedial aspect of the conchal cartilage. It has three layers—superficial middle and deep. It helps to turn the opening of the ear forward [Fig. 4.24].

Scuto-auricularis internus—It has two parts—*Major* and *Minor*. The minor one is placed superficially. The fibers of this muscles extend from the scutiform cartilage to the conchal cartilage. It helps to rotate the ear.

MUSCLES OF TAIL

All these muscles surround the tail bones on either side and are supplied with caudal spinal nerves and branches of dorsolateral caudal artery and median sacral artery.

Sacro-coccygeus dorsalis medialis—It is placed at the dorso medial aspect of the tail. It arises from the sacral spine and lateral sacral crest and inserts on the dorsal surface of caudal vertebrae. It helps to extend the tail.

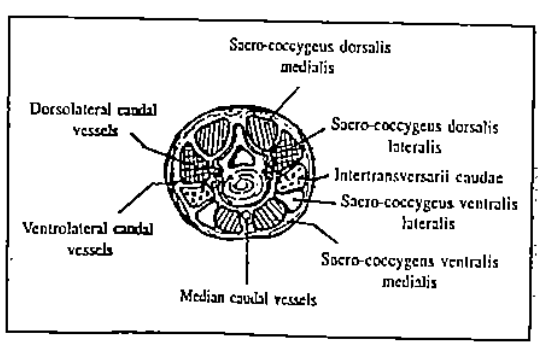


Fig. 4.25 Transverse section of the tail of ox.

Sacro-coccygeus dorsalis lateralis—The muscle is situated at the dorso lateral aspect of the tail. It originates from the articular processes of 5th and 6th lumber vertebrea and inserts to the transverse processes and lateral surface of caudal vertebrae. It assists to extend the tail.

Intertransversarii caudae—It is placed at the lateral aspect of the tail. The fibers are incompletely divided into dorsal and ventral bundle. It originates from the lateral aspect of sacrum and transverse processes of coccygeal vertebrae. The muscle inserts to the transverse processes of succeeding vertebrae. It helps in lateral flexion of the tail.

Sacro-coccygeus ventralis lateralis and sacro-coccygeus ventralis medialis—They occupy the ventral aspect of the tail. Both the muscle originate from the ventral aspect of the sacrum and insert to the ventral surface of the bodies and transverse processes of coccygeal vertebrae. These muscles help in flexion and lateral movement of the tail.

Rigor mortis—1 to 7 hours after death the body gets stiffned due to hardening of muscular tissues as a result of coagulation of Myosinogen and Paramyosinogen. The condition disappears after one to five days or when decomposition starts.

5. BIO MECHANICS

This chapter deals with action of force (internal and external) which works on a living body. This action of force obeys the same physical laws of nonliving materials.

Biodynamics

It comprises of Biokinematics and Biokinetics.

Biokinematics deals with the motions of the animals/object without considering the forces which is responsible for the motion.

Biokinetics is related to force and motion. It accounts for the requirement of force for production of a particular motion or change of motion.

Biostatics

Normally biostatics means the relation between structure and function in a living organism. The force that act upon an animal or on its organs in the state of rest or in uniform motion is considered for calculation. However, variations in the morphological adaptations in the same variety of animals sometimes make this mechanical factors secondary.

Usefulness of Biomechanics

Since we use some domestic animals to generate mechanical power, which is directly related to the locomotory system of the body a basic knowledge of the mechanical process is useful for better understanding the disorders and tranmatic complications and their management.

Force

It is the energy or strength which produce or tends to produce motion or change the motion or stress in a stationary body.

Vector

It is the quantity of force having direction as well as magnitude.

A force is specified by its (a) magnitude, which is expressed in kilograms or Newton (1 Kg = 10 Newtons), (b) its point of application and (c) its line of action.

Equilibrium

When two equal and opposite forces are applied on a particular point of the body, the equilibrium is maintained. For example, F_1 and F_2 being two opposite and equal forces are applied in the same straight line at a point O of

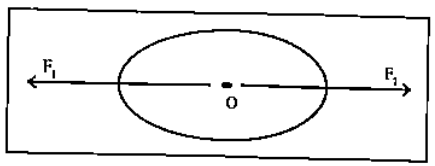


Fig. 5.1

the body, equilibrium will be maintained by the balance between F_1 and F_2, since in every action there is an equal and opposite reaction. Therefore in every force, there must be an equal and opposite force.

When an animal stands on the ground with a body weight (W) transmitted by the legs, a reaction is developed called (N).

When only one force (f) is applied on a body, whether the body move or not the resultant (R) will be Σf, i.e. $R = \Sigma f$

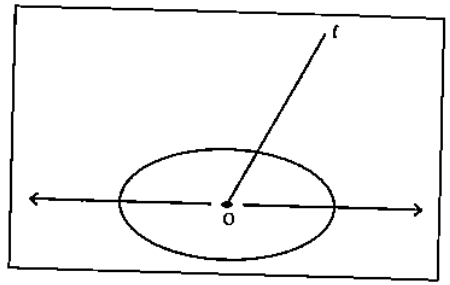


Fig. 5.2

When two different forces – f_1 and f_2 in different directions, the R will be represented by drawing diagonal line of the parallelogram, thus formed along the direction of forces in a same scale.

XA = direction of force f_1

XB = direction of force f_2

XAYB = Parallelogram

R = Resultant force

X = Point of intersection between the directions of two forces f_1 and f_2

In case of multiple unipolar forces – f_1, f_2, f_3 ..... f_n acting on any point 'O' each of those forces are to be divided into two components along X axis and Y axis for the purpose of calculating Resultant force R.

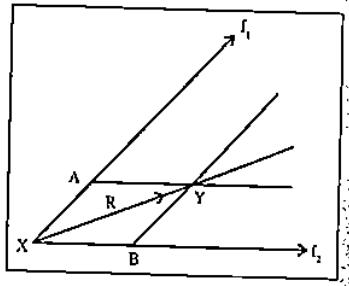


Fig. 5.3

If a force f is divided into two components along X and Y axis and the angle between f and X axis is 0, then the amount of force along X axis will be f cos 0 and the amount of force along Y axis will be f sin 0.

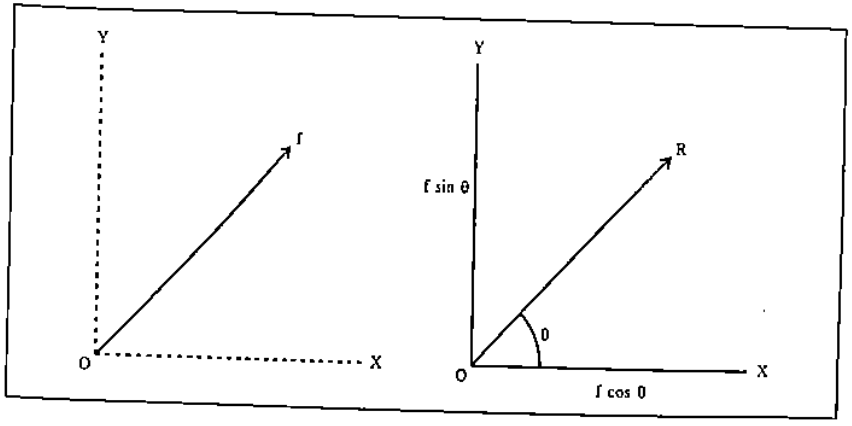


Fig. 5.4

Similarly in case of multiple forces, the resultant force may be calculated by the process of determining the value of the diagonal of a rectangle.

For example, if angle between force f_1 and X axis is 30°
angle between force f_2 and X axis is 45°
angle between force f_3 and X axis is 60°

The total force along X axis = $f_1 \cos 30° + f_2 \cos 45° + f_3 \cos 60°$

and

the total force along Y axis = $f_1 \sin 30° + f_2 \sin 45° + f_3 \sin 60°$

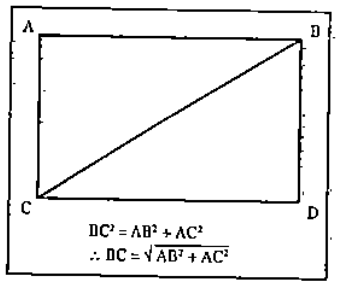


Fig. 5.5

Resultant force R can be calculated as follows :

$$R^2 = (f_1 \cos 30° + f_2 \cos 45° + f_3 \cos 60°)^2 + (f_1 \sin 30° + f_2 \sin 45° + f_3 \sin 60°)^2$$

$$\therefore R = \sqrt{(f_1 \cos 30° + f_2 \cos 45° + f_3 \cos 60°)^2 + (f_1 \sin 30° + f_2 \sin 45° + f_3 \sin 60°)^2}$$

Since the values of f_1, f_2, f_3 etc. are known and the values in respect of various degrees of cos (x) and sin (x) etc. are available from the Trigonometric table, the value of resultant force (R) can be determined.

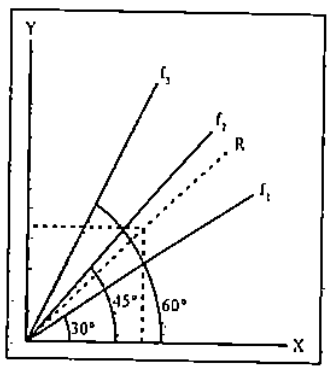


Fig. 5.6

Strain and Stress

The word *Tensile* means the capability of a material of being drawn out or stretched. *Tensile strength* is the resistance of a material to breaking under tension.

When a force exerted by a tendon on a bone, the bone is now under *strain*. It may change the shape or linear dimention of the bone. The strain is visible. Therefore

$$\text{Stain} = \frac{\text{Change in length}}{\text{Original length}}$$

The reaction of the material of bone upon this strain is the *stress*. Therefore the pressure or tension exerted on a material is the stress. Therefore

$$\text{Stress} = \frac{\text{Force}}{\text{Area of action}}$$

If a force 'f' exerted by a tendon on a bone at an angle θ with the perpendicular (XX) plane at the long axis (AB), the *normal* force (N) will be $N = f \sin \theta$, acting along the surface of the bone. The sharing force (H) will be $H = f \cos \theta$, acting perpendicularly at the surface of the bone.

Now at the center of the section, p, the force N is equivalent to the parallel force N'. If u is the radius of the bone, the

	0°	30°	45°	60°	90°
Sin	0	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{3}}{2}$	1
Cos	1	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$	0
Tan	0	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$	∞
Cot	0	$\sqrt{3}$	1	$\frac{1}{\sqrt{3}}$	∞

Trigonometric Table

couple N N' will have a Moment N × u. The 'Moment' is the bending tendency of the material of the bone and in this case and may be denoted by Mb.

$$\text{Therefore the Normal Stress} = \frac{N}{\pi u^2}$$

$$\text{Shear Stress} = \frac{H}{\pi u^2}$$

and Bending moment Mb = N × u

This bending moment would cause a *compressive stress* on the side of the bone where the tendon exerting the force is attached and a tensile stress at the opposite side.

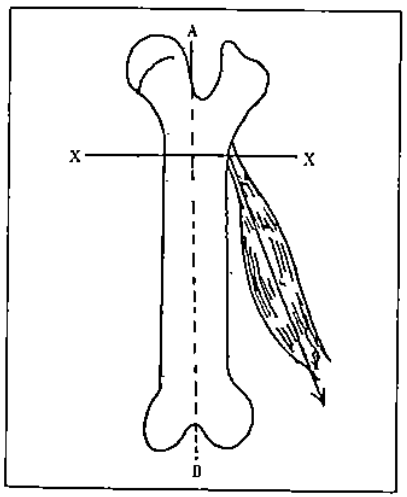


Fig. 5.7

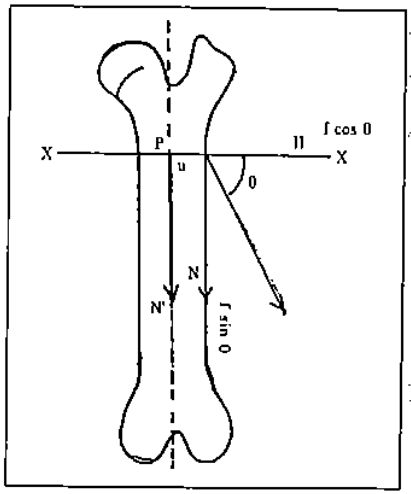


Fig. 5.8

Center of Gravity (CG)

This is a point representing the mean position of the body from which the weight of the body is considered to act. The load distribution upon the limbs is basically related to the location of Center of Gravity.

The location of the CG depends on the type of support. Therefore this point changes with the movement of the animal. Quadriped animals stand with the support of four legs. Suppose ABCD are the four points where the legs are touching the ground. A and B are the fore limbs and C and D are the hind limbs. If we draw lines between A and D and between B and C, two triangles ABO and CDO are formed by joining AB and CD.

If the center of gravity (CG), (W1) is located within the triangle ABO, the animal will be able to lift any one of the hinds. On the other hand if the CG, (W2) is located within the triangle CDO, it can lift any one of the fore limbs.

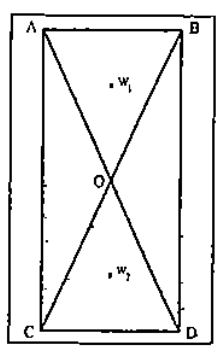


Fig. 5.9

The load distribution upon the limbs can be calculated in the following method :

AB = A platform on which an animal is standing. It is placed on a hinge (A) and an weighing machine (B). The fore foot is placed at point M and hind foot at N.

W = Weight of the animal.

w = Center of Gravity (CG).

O = Point fo intersection between the platform and CG.

P = Weight at the point B where a weighing machine is fixed. It will be less than the whole weight (W) of the animal. This is due to the fact that the whole weight is distributed at different points of the platform which can be calculated by the formula.

$$P = \frac{AO}{AB} \times W$$

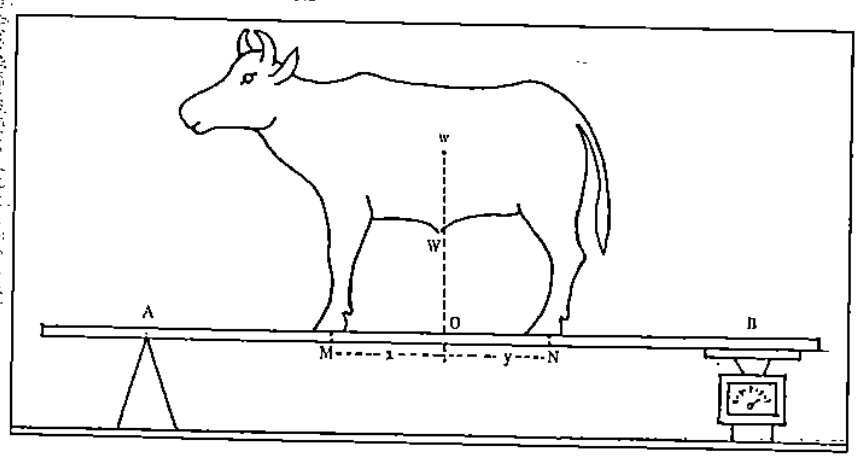


Fig. 5.10

$$\text{Therefore, } = \frac{P}{I} = \frac{AO \times W}{AB}$$

$$\therefore P \times AB = AO \times W$$

$$\text{so, } AO = \frac{AB \times P}{W}$$

Length of platform can be measured. Say it is 2.5 meter. Weight (P) indicated in weighing machine. Say it is 20 kg. Total body weight (W) can be measured. Say it is 50 kg.

$$\text{Thus } AO = \frac{2.5 \times 20}{50} = 1 \text{ meter}$$

If AO value is thus available, the distance between MO i.e., x and the distance between ON i.e. y can be easily calculated by simple scale.

x will be AO-AM Say it is 30 cm.

y will be BO-BN Say it is 40 cm.

$$\text{Therefore the reaction on fore foot } M = \frac{y}{x+y} \times W = \frac{40}{30+40} \times 50 \text{ kg} = 28.57143 \text{ kg.}$$

$$\text{Similarly the reaction on hind foot } N = \frac{x}{x+y} \times W = \frac{30}{30+40} \times 50 \text{ kg} = 21.42857 \text{ kg.}$$

Biomechanics of spongy substance of Bone

The bars of spongy substance are arranged in relation to working line of operant forces. The direction of the bars coincide with the line of compressive and tensile stress.

The direction of spongy bars at the proximal end of femur show trabecular pattern and it is revealed that a well developed bundle of bars arising from the medial aspect of the cortical substance of the neck intersects with a less developed bundle which arises from the lateral cortical zone of the body. This arrangement points to the fact that the spongy substance at the proximal and of femur has a **trajectorial pattern**, i.e. the direction of an object move under the action of given force.

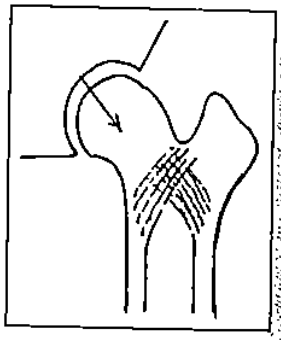


Fig. 5.11

The weight transmitted from the acetabulum on the proximal end of femur is maximum at the point of intersection.

This principle is also applicable in other boones of the skeleton with the consideration that the architecture of spongy substance has been fabricated to achieve maximum strength with use of minimum material.

Biomechanics of articular cartilage

Articular cartilage is composed of chondrocytes and the intercellular substance containing mucopolysaccharides and fine collagen fibers. Three zones of an articular cartilage have been described.

(a) Superficial zone contains parallel bundles of fibers and responsible for smoothness of the surface as well as have a property of load diffusion.

(b) Intermediate zone contains coiled fibers and form a meshwork. It is the deformable area and responsible for storing energy.

(c) Deep zone. fibers are mostly arranged in a radiating manner and connects the cartilage with underlying bone.

In this cartilage the fibers are extended perpendicular to the compressive strain caused by the pressure exerted by the articular end of another bone.

Biomechanics of the body

Previously construction of the axis of the body of an four footed vertebrate was compared with bridges. With this concept it was speculated that the axis (vertebral column) is supported by the pillars of the bridge which represent pectroal and pelvic limbs of the animal. However, this view has not been accepted much by the subsequent workers and the 'Bow and string' theory has been promalgamated.

In this theory the whole of the vertebral column with intervertebral discs along with its curvatures is considered as a bow. The curvatures are maintained by ligaments and muscles along the axis and those of ventral and lateral aspect of thorax and abdomen works as strings. The Dorsal string is formed by the muscles of dorsolateral side of the vertebral column (bow) i.e. Longissimus dorsi, etc.

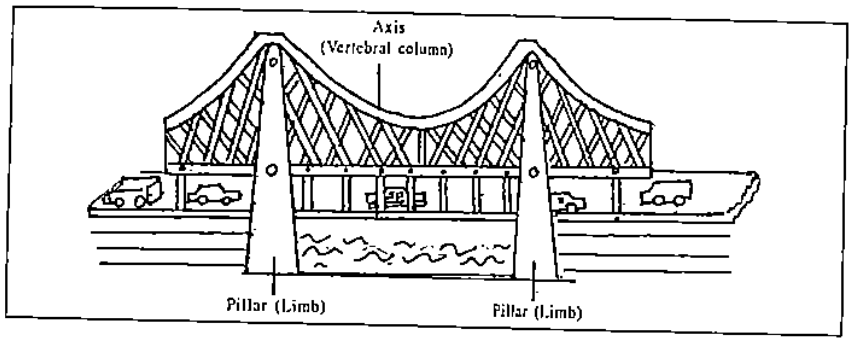


Fig. 5.12

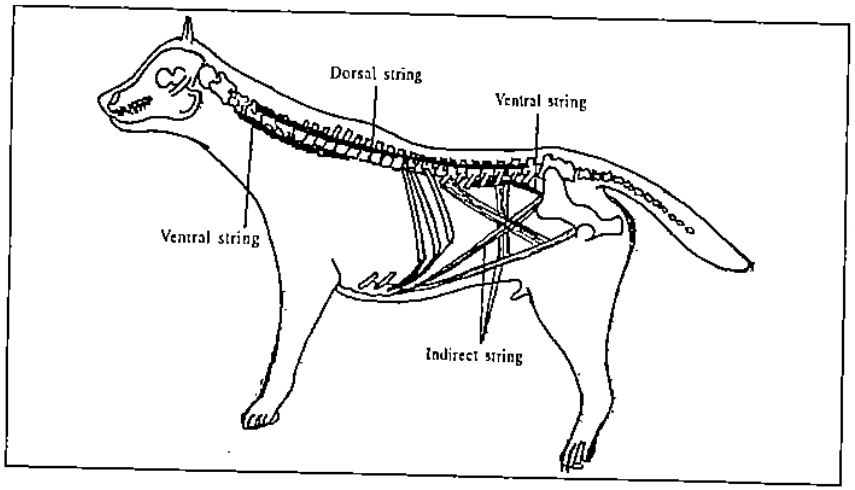


Fig. 5.13

The **Ventral string** is formed in two places in interrupted manner. One group of muscles, longus coli, etc. are intimately attached to the ventral aspect of cervical and cranial throcic region of the bow and another group (Psoas) at the caudal throrac and lumber region.

The 3rd **Indirect string** consists of oblique and rectus abdominal muscles which are indirectly attached to the bow by thoracic and pelvic skeleton.

It is believed in this concept that the body trunk does not exert strains in craniocaudal direction at the points of support, as it is statically balanced on itself.

Since the head with cervical region and the sacrum with tail extend to a considerable length from the supporting pillars (concerned legs) of the bow, there are arrangement identical to the cantilevers. There is a front cantilever for head and neck and a back cantilever for sacrum and tail.

The front cantilever is large and fixed with the trunk in such a way that it can move freely and carry the load of the head and the long neck. The hind cantilever is small and firmly attached with the trunk.

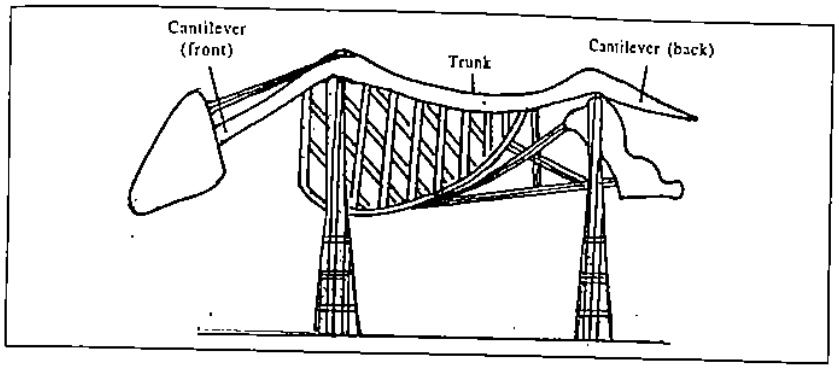


Fig. 5.14

Morphology and Biomechanics

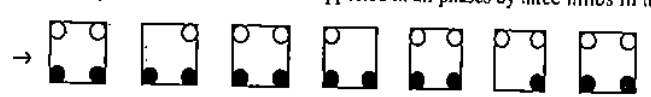
There are reasons to believe that there is a good relation between morphology and biomechanics. Various types of supporting tissue i.e. bones, cartilages etc. are developed from mesenchymal tissue. The mesenchymal tissue can sustain mechanical stress. It is also believed that hydrostatic pressure can induce intengive proliferation of cells with the collagen fibriles which form protective frame work. According to this theory, such hydrostatic pressure leads to the formation of cartilaginous model of the endochondral ossification within the mesenchymal tissue. Formation of protective frame of the body induced by alteration of shape combined with linear extension of mesenchymal cells is another concept of this relationship.

Locomotion

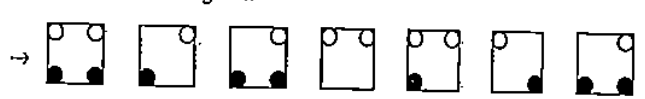
Types of locomotion (Kinematics) in four footed animals are characterized by *Gait formula* which has been prepared by cinematographic analysis of the gaits of various animals.

Some natural types of locomotion are considered for description. Point of arrow denotes cranial aspect of the animal.

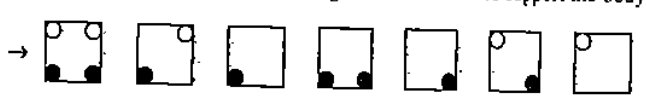
1. *Walk* – The body of the animal remains supported in all phases by three limbs in this gait.



2. *Accelerated walk or slow trot* – In this gait the body is supported by two or three limbs. Here the sequence of limb movement is diagonal.



3. *Leisurely walk or Amble* – Two or three diagonal or lateral limbs support the body alternately.

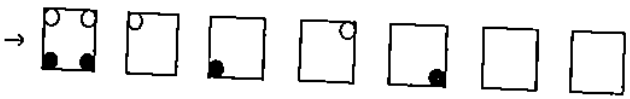


4. *Rack* – In this locomotion, about one half of every phase the body would float and the body remains supported by one or two lateral limbs.



5. *Gallop* – This is a rapid locomotion. The back does not move in this gait. From the phase of floating the contacts of limbs occure in the following manner :

Left hind – Right hind – Left fore – Right fore.



Kinetics

It is related to force and motion. The horizontal driving force is nil when are animal is not in motion. It will start moving when a cranially directed resultant force is exerted on the acetabulum at its cranial margin.

With the contraction of biceps femoris, semitendinosus, semimembranous etc., a horizontally directed force would develop by the following mechanism. If that force of contraction of those muscles is denoted as F, the hip joint would have a moment (bending tendency) + ($F x \pi r^2$) where r is the radius of the area of the joint. This force (F) can be replaced by a couple FF' which is also have a moment + ($F x \pi r^2$).

This force of contraction of these muscle will rotate the femur in a clockwise direction at the right and anticlockwise direction at the left and a force F" by which head of femur exert pressure on acetabulum.

This force is counteracted by an equal couple SS' and will lead to develop a forward propulsive force S" which is horizontally directed. If the W is the weight of the limb, another couple GG' is to be considered to get the Resultant reaction Rn on the joint with that of S.

However, the above mentioned explanation is placed considering a single group of muscles only. But during the movement of animal in desired direction with appropriate rapidity and force, a number of muscles, namely, extensors, flexors, retractors etc. act together with different magnitude of contraction with the impulses coming from the C.N.S.

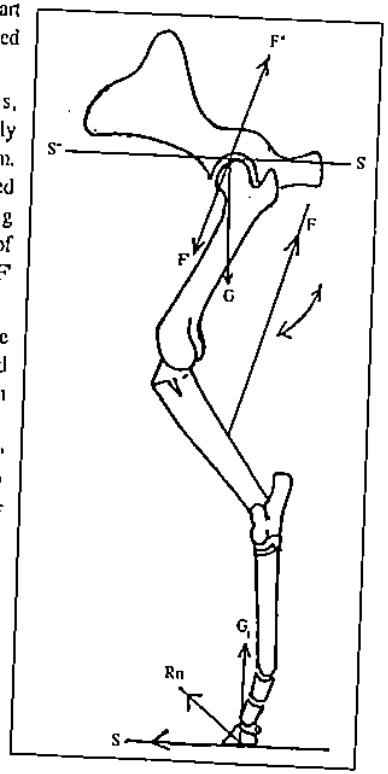


Fig. 5.15

6 SPLANCHNOLOGY

THE DIGESTIVE SYSTEM

The alimentary canal or Gastro-intestinal tract or Digestive tract is a musculo membranous tube, which extends from the mouth to the anus, *i.e.*, throughout the length of the body. Various parts of this canal has become modified according to the need of the body and has been named differently as mouth, pharynx, oesophagus, stomach and intestine. Tongue, salivary glands, teeth, liver and pancreas are the accessory organs of this system.

Starting from esophagus to anus the wall of the G.I. tract presents a common architectural design which consists of four distinct layers. From the lumen to out side these layers are (1) Mucosa, (2) Submucosa, (3) Tunica muscularis and (4) Serosa or adventitia.

The mucosa lines the lumen and composed of an epithelial lining, a lamina propria and a thin smooth muscle layer.

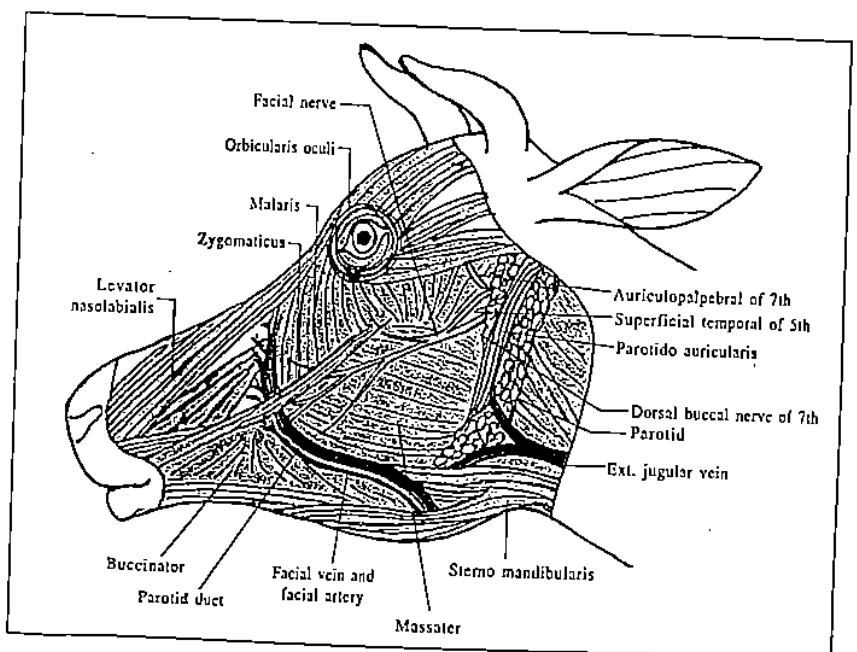


Fig. 6.1 Anatomy of the lateral aspect of head

The submucosa is the connective tissue between the mucosa and tunica muscularis. This layer supports the mucosa. It is composed of loose connective tissue.

The tunica muscularis is composed of an inner circular layer and an outer longitudinal layer of smooth muscles. These muscles wrap the tract in such a way that the tube can propel the luminal content.

The tunica serosa or adventitia is the outermost layer. The intraperitoneal part is covered by serosa and other parts are attached to the surrounding structures by tunica adventitia.

MOUTH

It is an elongated cavity at the begining of the alimentary canal and comprises of the vestibule of the mouth and mouth cavity proper. The vestibular part is bounded externally by lips and cheeks and internally by gums and teeth. The *mouth cavity proper* is bounded in front and laterally by alveolar arches, gums and teeth. It is continuous with the pharynx behind by the oropharyngeal opening. The

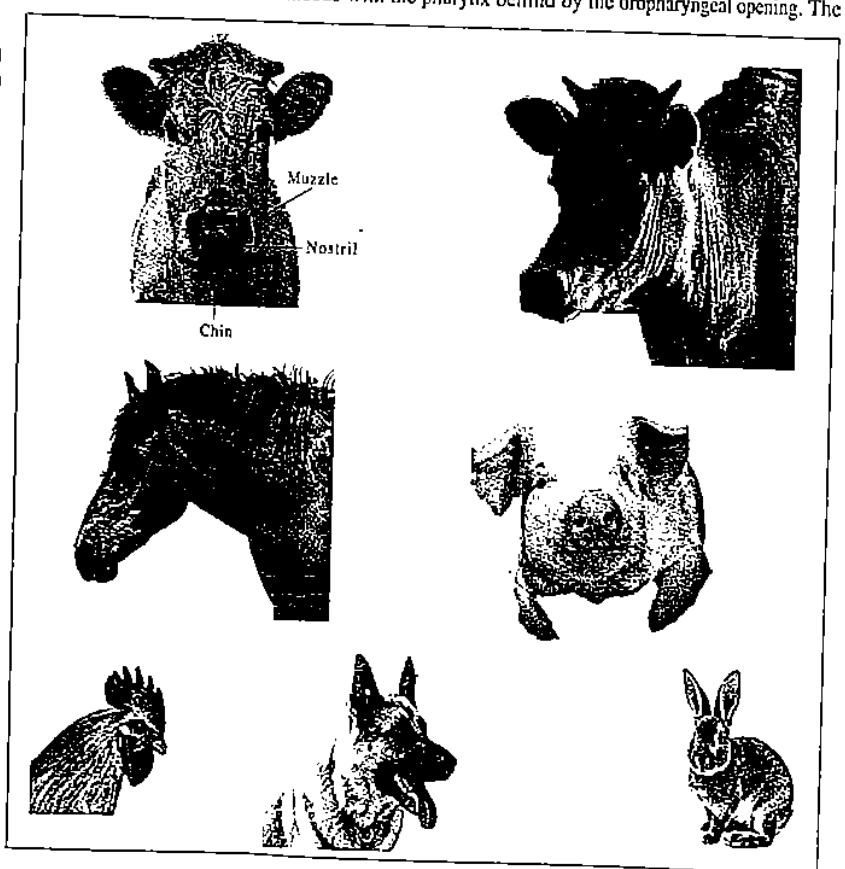


Fig. 6.2 Faces of different domestic animals and fowl.

roof is formed by the palate and the floor is formed by the mandible, muscles and mucous membrane. The mucous membrane is continuous anteriorly with that of lips and posteriorly with that of pharynx.

The **lips** (upper and lower) are thick and rigid musculo-membranous structures, situated at the orifice of the mouth. Externally it is formed by the skin and internally it is lined by pigmented epithelium. The muscle orbicularis oris is placed between these layers. This muscle blends with the muscles of face. The area between the nostrils and the upper lip is keratinous and generally black in colour. This area is known as **muzzle** or **planum nasolabiale**. It remains moist by the secretions of the nasolabial glands. The surface is marked by grooves. **Frenum labii inferioris** is a fold of mucous membrane between the lower lip and the gum.

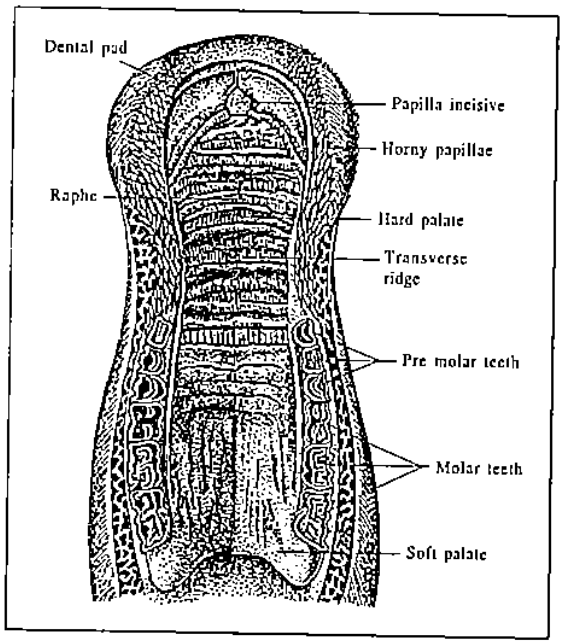


Fig. 6.3 Oral surface of upper jaw of cow.

The **cheeks** are composed of skin, muscles, glands and mucous membrane. They form the lateral walls of the mouth. The skin is continuous with that of other parts of the face. Muscular layer is formed by buccinator, levator and depressor muscles of the face. The buccal glands are arranged in three (dorsal, middle and ventral) rows within the musculature. The mucous membrane bears a large number of cornified pointed papillae which are directed backward. They are large at the angle of the mouth. The **papilla salivalis** is situated in the mucous membrane opposite to the second molar tooth where parotid duct opens into the mouth.

The **gingiva** or gum is composed of a thick layer of dense fibrous tissue, which is closely attached to the periosteum of the alveoli bearing bones and surrounds the necks of the teeth. The epithelium of the gum is reflected towards the alveoli and are attached to the root of the tooth.

The **palate** is divided into an anterior (hard palate) and a posterior (soft palate) portions. The **hard palate** forms the roof of the mouth and is composed of a dense connective tissue which is covered by mucous membrane. It is attached to the bony palate, *i.e.*, the palatine, maxilla and premaxilla. Anterior to the hard palate there are two dental pads, one on either side. As there is no incisor teeth at the upper jaw of this animal, these **dental pads** occupy their positions. These pads are formed by a thick layer of connective tissue on the body of the premaxilla and are covered by cornified epithelium. A small triangular structure—the **papilla incisive** is present on the midline between the dental pads and the first transverse ridge of the hard palate. The incisive ducts open on either side of this papilla. A linear groove or raphe devides the surface of the hard palate into two equal-halves. About 15 to 19

transverse ridges are present in each half of the hard palate. They are slightly concave backwards and serrated at the margins.

Posteriorly the hard palate is continuous with the *soft palate* which acts as a partition between the mouth and pharynx. It is composed of muscles and glands and is suspended from the posterior border of the hard palate in a sloping manner. The oral surface is concave and the pharyngeal surface is convex. One fold of mucous membrane extends laterally from each side of the free posterior border of the soft palate to the lateral walls of the pharynx is known as **palatopharyngeal arch (posterior pillar)**. Another fold of mucous membrane extends similarly from the soft palate and terminates at the root of the tongue is known as **palato glossal arch (anterior pillar)**. The oropharyngeal opening or aditus pharyngis is formed by the left and right palatoglossal arches, soft palate and the tongue. In between the palatoglossal and palatopharyngeal arches the **tonsilar sinuses** are situated. Each sinus accommodates the corresponding palatine tonsils. The soft palate is attached to the root of the tongue by palato glossus muscle, with the lateral wall of the pharynx by palato pharyngeus muscle, with the petrous temporal bone by tensor palati and levator palati muscles and with palatine bone by palatinus muscle.

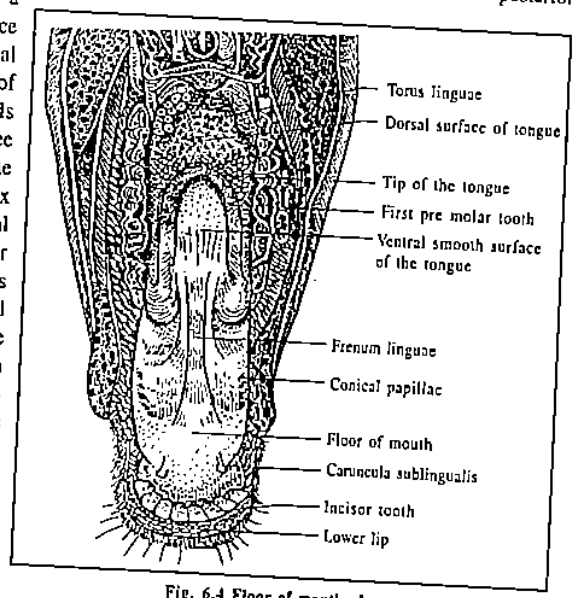


Fig. 6.4 Floor of mouth of cow
(Tip of the tongue folded upward to show the floor of mouth).

The floor of the mouth is mostly attached to the ventral surface of the tongue. A small anterior portion is free and is formed by the body of the mandible and mucous membrane. A wide fold of mucous membrane connects the floor of the mouth and the ventral surface of the tongue is known as **frenum linguae**. On either side and behind the 3rd incisor tooth there is a large papilla known as **sublingual caruncle**. The ducts of the mandibular and inferior sublingual salivary glands open at the base of this papilla. Behind the sublingual caruncle there is a row of small papillae on either side of the frenum. The ducts of superior sublingual glands open at the bases of these small papillae. In small ruminents lips are mobile and thin. Muzzle is narrow. The hard palate is also narrow and the ridges are irregular.

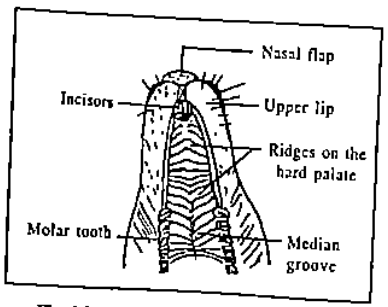


Fig. 6.5 Upper jaw of rabbit (oral surface).

Blood supply—Lips get blood from maxillary and mandibular labial vessels. Cheeks are supplied by facial and buccal arteries and palates are provided with palatine arteries.

Nerve supply—Branches of trigeminal and facial nerves.

Mouth of horse

The vestibular part is less capacious. The lips are thin and more mobile. The planum nasolabiale is not keratinous but bears a groove known as **philtrum**. Papilla salivalis is placed opposite to the last per-molar tooth. The whole of the hard palate bears the ridges. Papilla incisiva is situated behind the central incisor. Soft palate is more extensive and embraces the base of the epiglottis and for that reason the oral breathing is not possible and this animal **vomits through nose**. Dental pads are absent due to the presence of incisor teeth.

Mouth of dog

The orifice of the mouth is more extensive. The upper lips covers the lower lip. The lower lip is partially denticulate in appearance. The papilla salivalis is situated opposite to 3rd pre-molar tooth. The papilla incisiva is placed behind the central incisor teeth. The palatine tonsils are well developed. Dental pads are absent.

Mouth of pig

Angles of mouth are extended caudally. Upper lip is close to snout. Hard palate is elongated. Ridges are very much prominent and about 20 in number.

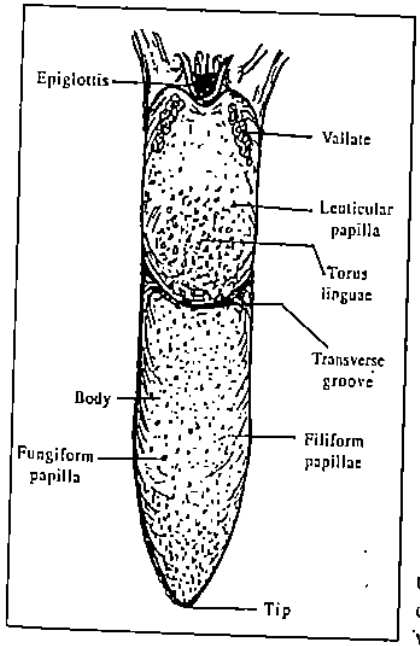


Fig. 6.6 Dorsal surface of the tongue of cow.

Mouth of rabbit

The upper lip is fleshy and divided into two equal halves which are placed on either side of the incisors below nasal flap. Plenty of tactile hairs spring from the skin covering the upper lip. Buccal cavity is elongated. Hard palate presents about 15 ridges. The ridges at the posterior part are directed backward. A faint median groove is present at the posterior part of the hard palate. Muzzle is absent.

Mouth of fowl

It is cone shaped. The cheek, lips and teeth are absent. Anteriorly it bears the upper and lower horny pointed beaks. The hard palate is narrow. A chonal slit extends longitudinally at the midline of the posterior part of hard palate.

TONGUE

It is a highly movable muscular structure and is the main organ for prehension, mastication and deglutition. It is also an organ for taste and plays very important role for speech in human. It is situated on the floor of the mouth, between the

two rami of the lower jaw. It has a root, a body and an apex. The *root* is very thick and is attached to the hyoid bone and mandible by hyo-glossus and genio-glossus muscles, with the soft palate by anterior pillars, with the pharynx by muscles and membranes and with the epiglottis by glosso-epiglottic fold. The dorsal surface is free and the most part of the ventral surface is fixed.

The *body* has three surfaces—Two laterals and dorsal. The dorsal surface is free and is known as **dorsum linguae**. Behind a transverse groove this surface presents a raised area at the posterior part. The prominence is known as **torus linguae** and the transverse groove is known as **lingual fossa**. When the mouth is closed, this surface remains in contact with the hard palate.

The apex is thin and blunt with a rounded border. Its anterior portion is free and is highly protactile. The posterior part is broad and continuous with the body.

The tongue is composed of mucous membrane, muscles, glands, vessels and nerves. The mucous membrane is pigmented. A fold of the mucous membrane which connects the ventral surface of the tongue with the floor of the mouth is known as **frenum linguae**. At the dorsal surface, this membrane is firmly attached to the underlying muscle by connective tissue and presents a variety of papillae. These are **filiform, fungiform, lenticular** and **vallate**. *Filiform* papillae are numerous and are distributed throughout the dorsal surface rostral to transverse groove. These are directed backward. *Fungiform* papillae are larger in size and are scattered among the filiform papillae. These papillae bear the taste buds. The mucous membrane of torus linguae presents some rounded *lenticular papillae*.

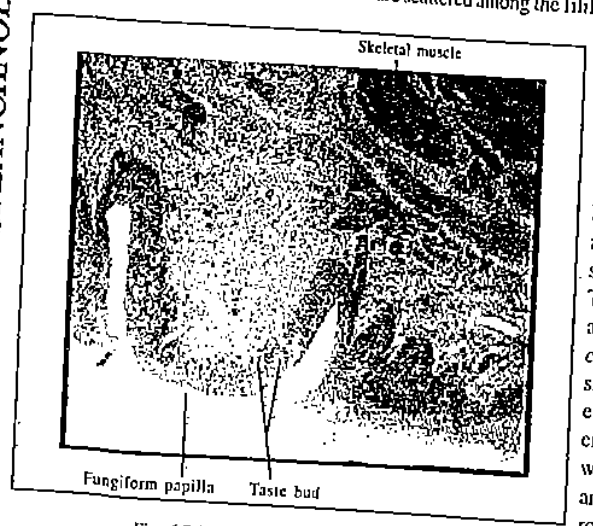


Fig. 6.7 Microscopic structure of Tongue.

At the anterior and anterolateral aspect of the torus lingue another variety of papillae are found, which are conical in shape called **conical papillae**. They are directed anteriorly or anterolaterally. *The vallate or circumvallate* papillae are large in size and are 7 to 8 in number in each side. Each papilla is encircled by a wall and that is why called circumvallate. They are arranged in irregular double rows at the posterior part of the dorsal surface of the tongue. The taste buds or organs of taste sensation are situated in the epithelium of circumvalate and fungiform papillae. A taste bud has a oval body, a neck and a taste pore. Each bud comprises of elongated sustantacular (supporting) cells and few Neuroepithelial (taste) cells. The sensory nerves begin as remifications of unmyelinated fibers around the base of these taste (gustatory) cells [Fig. 6.8]. Beside the papillae, the mucous membrane of the tongue is composed of a thick layer of stratified squamous epithelium. The lingual glands are lobulated and small. They remain under the mucous membrane and are embedded within the muscles. The number of glands are more at the **root**. Those glands open at the vallet papillae are known as

gastatory glands. There are some aggregations of lymphoid follicles at the root of the tongue. These are known as **lingual tonsils**. The bulk of the tongue is formed by the muscles which are of extrinsic and intrinsic varieties. The **intrinsic muscles** consist of bundles of skeletal muscles which are directed in longitudinal, transverse and vertical directions. Generally the longitudinal muscles are disposed in two layers — superior and inferior. The **extrinsic muscles** are also skeletal and have attachments outside the tongue. These are stylo-glossus, hyoglossus, palatoglossus and genioglossus. The styloglossus and hyoglossus muscles extend from the hyoid bone to the tongue. Palatoglossus connects the tongue with the soft palate and the genio glossus attaches the tongue with the mandible. In sheep and goat, the torus linguae is less prominent. The filliform papillae are soft and smooth. Fungiform papillae are more in number.

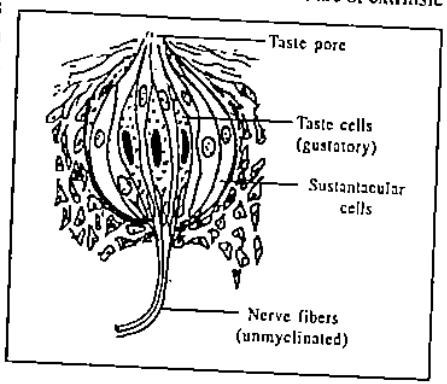


Fig. 6.8 Taste bud (schematic).

Blood supply—Lingual branch of the linguofacial artery.

Nerve supply—Sensory – Branches from 5th, Corda tympany branch from 7th and a branch from 9th cranial nerves. Corda tympany nerve carries taste sensation from the anterior two-third and the branch of 9th carries from posterior one-third of the tongue. General sensations like touch, pain, temperature, etc. are carried by trigeminal nerve.

Motor—Hypoglossal nerve.

Tongue of horse

The body is narrow and the apex is spatula shaped. Torus linguae is absent. On either side of the root and in front of the anterior pillars some foliate papillae are present. Vallate papillae are usually two in number and are placed one on either side of the median plane.

Tongue of dog

It is highly mobile. Dorsal surface presents a median groove. The vallet papillae are 2 to 3 in number in each side. Foliate papillae are present. A thick fibromuscular cord situated along the middle of the ventral surface of the tip of the tongue is known as Lyssa. It is composed of fibrous connective tissue, adipose tissue, striated muscle fibers, vessels and nerves.

Tongue of pig

Torus linguae is absent. Filliform papillae are soft. At the dorsal surface of the root there are a good number of caudally directed sharp papillae. Vallet papillae are 2-3 in number. Glosso-epiglottic fold is well developed. There are two frenum linguae in this animal. Foliate papillae are present.

Tongue of rabbit

The tongue is comparatively thin. The tip is blunt. Torus linguae is absent. It possesses filiform, fungiform, vallate and foliate papillae. The vallate papillae are few in number. The root presents a wide and white coloured prominence which extends upto the middle of the tongue at the dorsal surface.

Tongue of fowl

It is a triangular rigid structure comprises of a fixed base and a considerable free part. It is attached with a well developed hyoid bone. Rostrally on the dorsal surface there is a median groove. At the dorsal surface of the base there is a transverse row of papillae, called **lingual papillae.**

TEETH

The number and classification of the permanent teeth is fixed to a species. However, this number varies greatly from species to species. In a particular species teeth are developed in different manner — in terms of shape, size etc. for the purpose of performing specialised jobs. This character is known as **heterodonty.**

Teeth are the hardest structures in the body. They are implanted into the alveolar sockets of the upper and lower jaw bones, along their margins. This arrangement is known as **Thecodont.**

The exposed portion of a tooth which is covered by a very hard translucent material (enamel) is known as the body *or* crown. The implanted narrow part which is covered by a thin yellowish material (cement) is known as root. The junction between the corwn and root is little constricted and is termed as neck. The bulk of the tooth is formed by the **dentin.** *The dentin is composed of well organised dentinal tubules.* Within the dentin there is a central canal known as **pulp cavity.** The cavity is expanded at the closed end to form the pulp chamber. The canal is narrow at the root which opens into the apical foramen at the tip of the root. The pulp canal is lined by a layer of odontoblast cells. The pulp cavity also contains connective tissue, arterioles and nerve fibers. In between the bony alveolus and the cement there is a layer of collagenous tissue which helps in suspending the tooth into its socket is known as **periodontal membrane.**

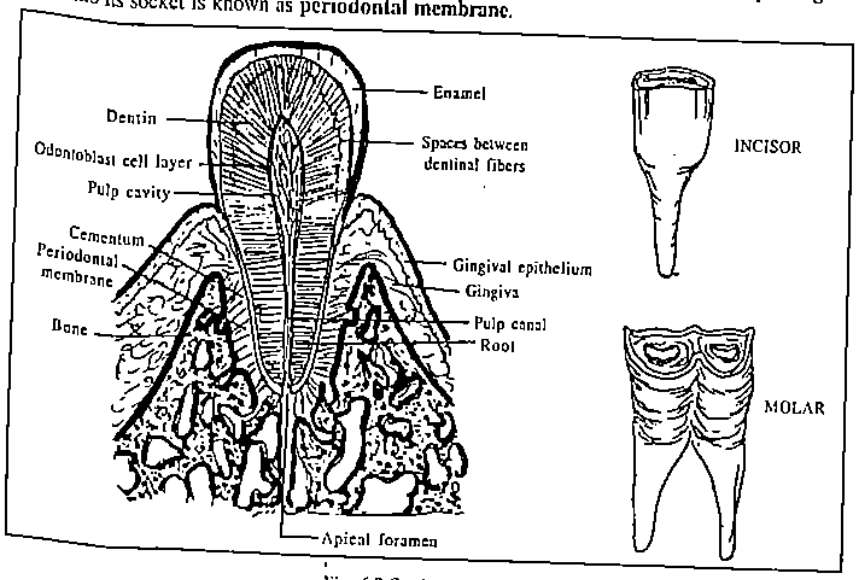


Fig. 6.9 Section of a tooth.

Teeth are classified according to their placements in the oral cavity. The incisors are most anterior in position. Next to them on either side are the canines. Canines are followed by pre molars and then

by Molars. *Premolars* and *molars* are placed laterally and therefore, also called cheek teeth. The corwn of a tooth has five surfaces. The anterior or the outer surface is the labial surface and the posterior or the inner surface is the lingual surface. On either side there are two contact surfaces and the surface which remians in contact with the similar surface of a tooth of the opposite jaw is the table or the grinding surface. A horizontal ridge on the crown close to the root is found mainly in dog is known as cingulum. Most of the animals have one set of temporary or deciduous teeth which erupt in early life and subsequently are replaced by permanent teeth. Except the molars all the teeth are replaced by permanent teeth.

When one set of teeth is replaced by only one set of permanent teeth, the character is known as **Diphyodonty.** This character is found in man and most of the mammals. However, in some of the animals several set of teeth are formed in succession throughout life and that character is called **Polyphyodonty.**

Deciduous or milk teeth

This is a temporary set of tooth and is replaced by permanent set. These milk teeth are found at birth or within few weeks after birth. The formula of the milk teeth is :

$$DI\ \frac{0-0}{3-3},\ DC\ \frac{0-0}{1-1},\ DP\ \frac{3-3}{3-3}$$

(DI = Deciduous Incisor; DC = Deciduous Canine; DP = Deciduous Premolar).

The last tooth of the rostral (incisor) group although resembles the other incisors, is called canine on the basis of developmental and evolutionary stand point.

Permanent teeth

The eruptions of permanent teeth starts from the age of one year and become completed by 3 to 4 years.

The dental formula of permanent teeth of ox :

$$I\ \frac{0-0}{3-3},\ C\ \frac{0-0}{1-1},\ P\ \frac{3-3}{3-3},\ M\ \frac{3-3}{3-3}$$

In these animals the incisors at the upper jaw are absent. Their positions are occupied by dental pads. Incisors and canines are present only in lower jaw and are of short shovel shaped structures arranged in a radiating manner. The labial surface in convex and the lingual surface is concave. The root is not tightly fixed with the alveolus and slight movement is observed.

As the face of most of the animals are elongated, some considerable spaces between teeth in the form of arcades are available. These interdental spaces are called Diastema. This space is well noticed between canine tooth and first premolar tooth. The vestibular cavity and the oral cavity of mouth communicate through the diastema.

Premolars and molars are three each in either side of the jaw. These are four sided compound teeth with multiple roots. The molars are far larger than the premolars. These teeth at the lower jaw are comparatively narrower. The first premolar is very small.

Eruption of permanent tooth in ox

Although variable from breed to breed, there is a general rule for the eruption of permanent tooth in cow.

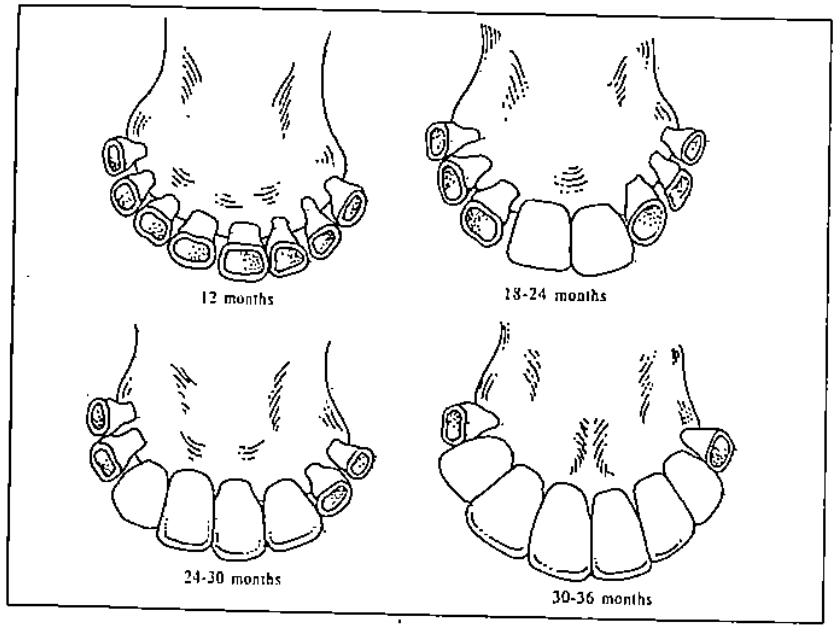


Fig. 6.10 Eruption of incisor tooth in Ox.

Incisor 1 erupts at the age of 18–24 months.
Incisor 2 erupts at the age of 24–30 months.
Incisor 3 erupts at the age of 30–36 months.
Incisor 4 (so called canine) erupts at the age of 40–48 months.

All the permanent premolars erupt with in 36 months Molars appear early. First molar generally erupts at the age of 6 months. Other molars appear within 30 months.

Dental formula of horse

Deciduous :

$$DI\frac{3-3}{3-3}, DC\frac{0-0}{0-0}, DP\frac{3-3}{3-3}$$

Permanent :

$$I\frac{3-3}{3-3}, C\frac{1-1}{1-1}, P\frac{3-3}{3-3}, M\frac{3-3}{3-3}$$

The canine tooth is absent or vestigial in mare.

Dental formula of dog

Deciduous :

$$DI\frac{3-3}{3-3}, DC\frac{1-1}{1-1}, DP\frac{3-3}{3-3}$$

Permanent :

$$I\frac{3-3}{3-3}, C\frac{1-1}{1-1}, P\frac{4-4}{4-4}, M\frac{2-2}{3-3}$$

The canine tooth is well developed. It is large and pointed.

Dental formulae of sheep and goat are similar to those of ox.

Dental formula of pig

Deciduous :

$$DI\frac{3-3}{3-3}, DC\frac{1-1}{1-1}, DP\frac{3-3}{3-3}$$

Permanent :

$$I\frac{3-3}{3-3}, C\frac{1-1}{1-1}, P\frac{4-4}{4-4}, M\frac{3-3}{3-3}$$

In the male pig the canine teeth are well developed. The canine tooth of upper jaw is curved laterally and dorsally. The tooth in lower jaw is more large and is curved laterally and caudally.

Dental formula of rabbit

$$I\frac{2-2}{1-1}, C\frac{0}{0}, P\frac{3-3}{2-2}, M\frac{3-3}{3-3}$$

In the rabbit each half of the upper jaw has two sharp chisel shaped incisors. The larger one is situated in front and the smaller one is placed behind, as if to support the larger one.

Blood supply—The teeth of the upper jaw get blood supply from the terminal branches of maxillary artery and those of lower jaw get from the branches of mandibulo alveolar artery.

Nerve supply—Teeth of upper jaw are innervated by the branches of maxillary division and those of lower jaw by the branches of mandibulo alveolar trunk of trigeminal nerve.

The vessels and nerves are distributed within the pulp cavities of the teeth.

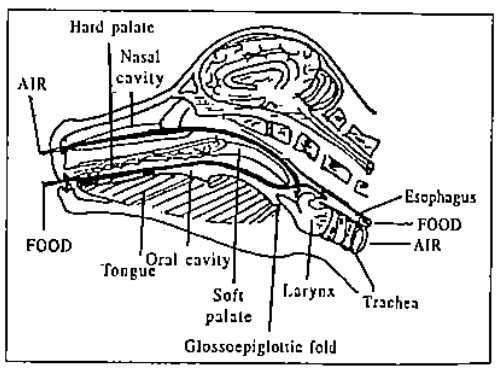


Fig. 6.11 Crossing of air and food in the pharynx.

PHARYNX

It is roughly a funnel shaped space at the base of the cranial cavity and behind the posterior nasal apertures. Its walls are formed by the muscles, fibers, and mucous membrane. This tube is common to the digestive and respiratory passages. It is attached to the temporal, peterygoid, palatine, Vomar, sphenoid and occipital bones of the skull. Pharynx is related to the base of the cranial cavity and supra-pharyngeal lymph nodes above, to pterygoid muscle, hyoid bone, mandibular salivary gland, external carotid and external maxillary arteries, superior laryngeal, 9th and 12th nerves and pharyngeal lymph glands laterally and to the root of tongue and larynx ventrally.

The cavity of the pharynx communicates with other structures by *seven openings* – 2 for eustachian tubes, 2 for posterior nares, 1 for esophagus one for mouth and one for larynx.

The *muscles* which take part in the formation of the walls of pharynx are palato pharyngeus, thyro pharyngeus, hyopharyngeus, crico pharyngeus arytenopharyngeus, pterygo-pharyngeus and stylo-pharyngeus. The muscles, mainly responsible for sending the food bolus from pharynx to esophagus by their successive contractions are — Anterior constrictor (Pterygopharyngeus), Middle constrictor (Hypopharyngeus) and Posterior constrictor (Thyropharyngeus). The fibrous layer is placed in between the muscles and mucous membrane. There are plenty of mucous glands in this layer. The mucous membrane is continuous with that of other structures through above mentioned seven openings.

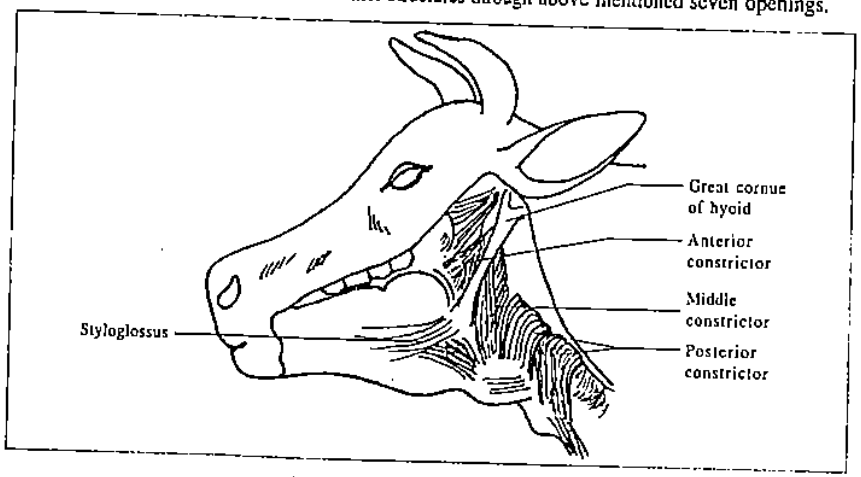


Fig. 6.12 Pharyngeal muscles of ox.

The dorsal part of the pharynx above the soft palate is known as Nasopharynx. The choanae or posterior naris are separated dorsally by the crest of vomar which is covered by mucosa.

The part of the pharynx between the soft palate and root of the tongue is known as *Oropharynx*. The portion, dorsal and lateral to the larynx is known as Laryngo pharynx. Pharynx gets blood supply from carotid, occipital and external maxillary arteries and nerve supply from 9th and 10th cranial nerves and from superior cervical ganglion.

Pharynx of horse

It is comparatively longer and narrower. Superiorly it is related to guttural pouches. Esophageal opening is narrower. The posterior nares are larger.

Guttural pouches—These are a pair of large mucous sacs situated on either side of the midline above pharynx. These are downward diverticulum from the auditory tubes and are found only in equines. The average capacity in about 300 c.c. The pouch is lined by ciliated epithelium. The wall contains mucous glands and lymph nodules.

Pharynx of dog

Shape varies according to the breed. Esophageal opening is small. Orifices of auditory tubes are narrow.

Pharynx of pig

It is comparatively narrow and long. The cavity of pharynx extends up to the level of second cervical vertebra.

Pharynx of rabbit

This is a narrow and elongated passage. Oropharynx is extensive.

Pharynx of fowl

Soft palate is absent. The roof presents a median **infundibular slit** which is the common opening for right and left auditory tubes.

ESOPHAGUS

It is a muscular tube extends from pharynx to stomach. For the purpose of description it has been divided into two parts-cervical and thoracic. The average length is about 90 cm. Cervical part is 40 cm and thoracic part is 50 cm. The abdominal part is practically absent due to the close apposition of the stomach to the diaphragm. The thickness of the tube is about 4 cm. In the small ruminents it is about 40 cm in length and about 2 cm in diameter. In pigs the length is short but diameter is more.

Course and relation—It starts as the continuation of the pharynx. It is related ventrally to the dorsal aspect of the trachea and dorsally to the longus coli muscle. At the level of 3rd cervical vertebra the esophagus descends to the left surface of the trachea and maintains this relation upto 6th cervical vertebra. Then it goes little upward and enters the thorax through the dorsolateral aspect of the thoracic inlet. At the level of 3rd to 4th cervical vertebrae it is related superiorly to the left longus coli, laterally to the vagosympathetic trunk, common carotid artery and internal jugular vein. In the thorax it gains the dorsal surface of the trachea and continues with this relation up to the level of the tracheal bifurcation. At the middle mediastinum it is pushed slightly to the right of the median plane. It goes upward and backward to the posterior mediastinal space, inclines again to the left of the median line and enters the abdominal cavity through esophageal hiatus along with the dorsal and ventral continuations of vagus nerves. At the base of the heart it is related to the aortic arch at the left side. In the posterior mediastinum it is related to the mediastinal lymph nodes and corresponding lung on either side. Just after entering the abdomen it opens into the stomach at a dome shaped area between the dorsal sac of rumen and reticulum, known as **atrium ventriculi**.

Structure—The wall of the esophagus consists of fibrous, muscular, submucous and mucous coats from outside inwards. The muscular coat consists of outer and inner layers of spiral fibers. These muscles are striated throughout the length of the tube. The submucous coat contains plexus of blood vessels, lymphatics, nerves and mucous secreting esophageal glands. The mucous coat consists of muscularis mucosae, lamina propria and surface epithelium.The epithelium is composed of noncornified stratified epithelium.

Blood supply—Common carotid, esophageal and reticular arteries.

Nerve supply—Vagus, recurrent laryngeal and sympathetic nerves.

Esophagus of horse

The average length is about 140 cm. Cervical part is 75 cm and the thoracic part is about 63 cm. It has a small abdominal part which is about 2 cm. The muscular layer is striated up to the base of the heart. Next portion is composed of smooth muscle. It becomes thicker at the posterior part.

Esophagus of dog

It is comparatively wider. Length is variable. It has a very small abdominal part. There is a constriction at the begining of the esophagus. This is due to the presence of a thick submucous gland at the ventral wall. The muscular coat is striated and consists of two layers of spiral fibers.

Esophagus of pig

The tube is comparatively short and straight. Its potential caliber is wide. Except the terminal part, the muscular coat is striated. It has a small abdominal part.

Esophagus of rabbit

The tube is about 8 cm long and thin walled. The cervical part is longer than the thoracic part. It has a considerable length of abdominal part, which is little more than 1 cm.

Esophagus of fowl

The wall is thin and the lumen is wide. The cervical part is larger and just before passing into the thoracic inlet, the tube is enlarged ventrally to a great extent to form the crop. The esophagus has a small abdominal part which opens into proventriculus. Close to the junction with the proventriculus an esophagial tonsil is present.

ABDOMINAL CAVITY

This largest cavity of the body extends from the diaphragm to the pelvic inlet. Its cranial wall is formed by the concavity of the diaphragm. Caudally it is continuous with the pelvic cavity. The roof is formed by lumbar vertebrae, lumbar muscles and part of diaphragm and the floor is formed by two recti muscles, aponeurosis of the muscles of the lateral abdominal walls and xiphoid cartilage. The lateral walls are formed by external and internal oblique and transverse abdominal muscles and some parts of few caudal ribs. The parietal peritonium is attached to the abdominal wall with the help of subserous tissue. The muscles are covered by a superficial and a deep fascia. The deep fascia is a sheet of elastic tissue and intimately attached to the obliquus externus muscle. This is also known as **abdominal tunic** and supports the muscles to bear the weight of abdominal viscera.

The abdominal cavity is pierced by three openings at the diaphragm, namely aortic aperture, esophageal aperture and venacaval aperture and in the males by two openings at the inguinal region. However, in fetus an extra—Umbilical opening is present. In the female animals another opening through the genital tract is also considered. A scar formed by the remnants of the root of the umbilical cord is present at the mid ventral region of the abdomen, termed umbilicus.

ABDOMINAL REGIONS

If the abdominal cavity is divided imaginarily by two sagittal and two transverse (cranial and caudal) planes, nine regions will be available. These regions are useful for location of different viscera in the abdomen. These are (1) Left and (2) Right hypochondriac, (3) Xiphoid, (4) Left and (5) Right lateral abdominal (6) Umbilical, (7) Left and (8) Right inguinal and (9) Prepubic [Fig. 6.13].

The triangular depressed area below the lumbar transverse processes is known as **paralumbar fossa**. The area close to the paralumbar fossa at the upper abdominal wall is known as **flank region**.

Placement of different organs in the respective abdominal regions are as follows :

1. **Right hypochondriac region** contains part of right kidney, caudate and main lobe of liver, gall bladder and a part of the pylorus and begining of duodenum.

2. **Left hypochondriac region** contains spleen, fundus of stomach in horse dog and pig, part of reticulum and cranial end of the dorsal sac of rumen in ruminents and part of left kidney in nonruminents.

3. **Xiphoid region** accommodates part of liver and stomach, pancreas, parts of aorta and venacava. In the ruminents it contains the reticulum, omasum, part of abdomasum and cranial end of the ventral sac of rumen. In the horse however, the xiphoid region contains diaphragmatic and sternal flexwres of colon and the apex of cecum.

4. **Left lateral abdominal region** contains caudal part left kidney, parts of colon and small intestine in dog, pig and horse. In ruminents this region is occupied by the part of dorsal and ventral sacs of rumen.

5. **Right lateral abdominal region** is occupied by caudal part of right kidney, parts of duodenum, and cecum. In horse and pig parts of colon are also occupying the space.

6. **Umbilical region** accommodates parts of small intestine, mesentry and portion of duodenum in dog. In pig some part of colon also occupies the space. In cow this region contains parts of abomasum, ventral sac of rumen and parts of small intestine.

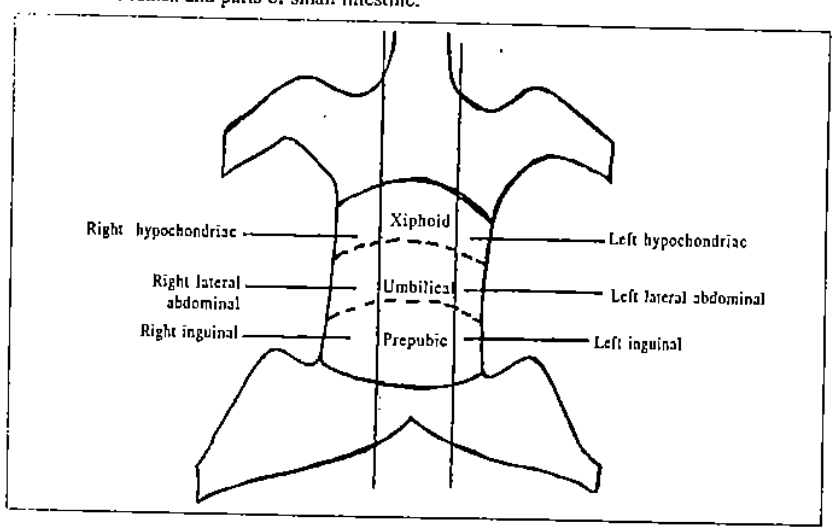


Fig. 6.13 Different regions of abdomen (ventral view).

7. **Left inguinal region** contains left ureter, part of colon and small portions of female genitalia. In the ruminents the caudodorsal blind sac of rumen is placed in this region.

8. **Right inguinal region** provides space for right ureter, cecum, caudal flexure of dudenum and parts of intestine.

9. **Prepubic region** contains bladder, coils of small intestine and part of uterus.

PERITONEUM

It is a serous membrane which lines the abdominal walls and is reflected over the viscera. The lining portion is the parietal part and the reflected portion is the visceral part of the membrane. In the male animals it is a closed sac and in the female the cavity is communicated to the exterior by the open ends of fallopian tubes. A mesothelial layer covers the free surfaces which secrets a small amount of serous fluid. This is helpful for free movement of viscera. The peritoneal fluid is composed of water, electrolytes, proteins, desquammated mesothelial cells, macrophages, fibroblasts and lymphocytes.

This space between the parietal and visceral layers is known as peritoneal cavity. The main cavity is known as greater sac and the diverticulum from the greater sac is known as lesser sac. The two sacs communicate with each other through the epiploic **foramen** which is also known as **foramen of winslow**. Internal hernia may occur into the lesser sac throught this foramen.

The connecting folds of visceral peritoneum are known as **mesentery, omentum** and **ligament** according to their disposition. They help in transmitting the vessels and nerves to and from the organ. The fold which is invested around the wall of the intestine and attaches the intestine to the dorsal wall of the abdomen is known as **mesentery**. The fold of peritoneum which is attached to the stomach is known as **Omentum**. There are two portions of omentum—*Greater omentum* and *lesser omentum*.

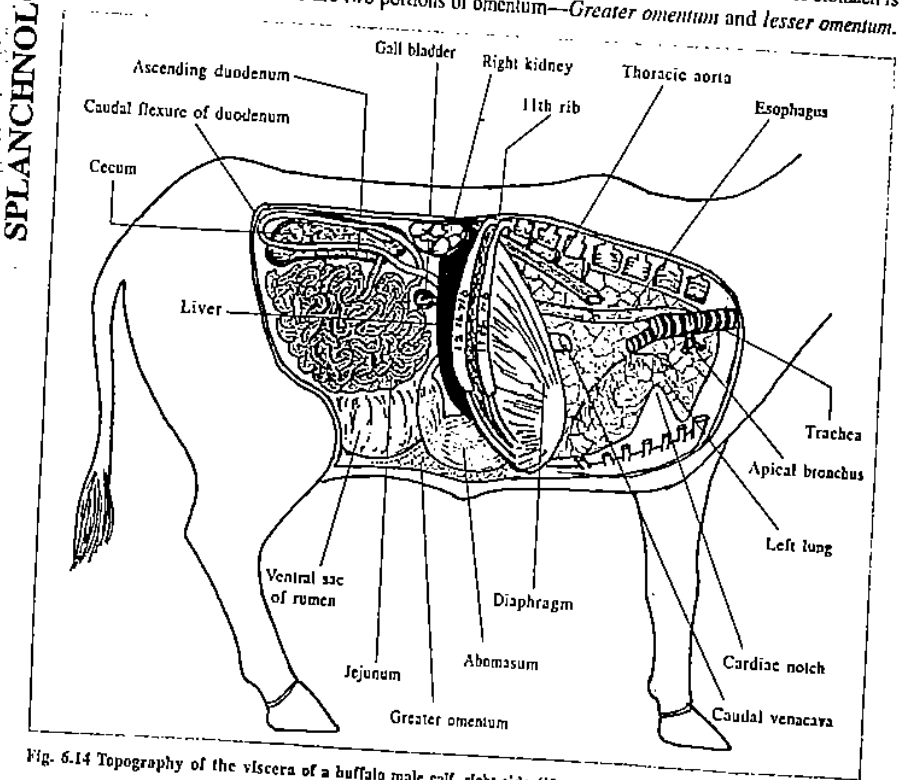


Fig. 6.14 Topography of the viscera of a buffalo male calf, right side (Heart and right lung have been removed).

The fold which connects the greater curvature of the stomach to the dorsal abdominal wall is termed **greater omentum**. The fold which connects the lesser curvature of the stomach to the liver is known as **lesser omentum**. The contents of lesser omentum are Hepatic artery, Portal vein, Bile duct, Hepatic plexus of nerves, Lymph nodes and Lymphatics. *Ligaments* are the folds which pass between the viscera and are connected with abdominal wall. Pelvic peritonium is continuous with the abdominal peritonium. It lines the pelvic cavity and reflectes on to the viscera. The fold which connects the rectum with the roof of the pelvic cavity is known as **mesorectum**. In between the bladder and rectum, there is a transverse fold of peritonium which is attached to the lateral walls of the pelvic cavity is know as **genital fold**. In male this ligament enclose the Vas deferens and uterus masculinus. In female this transverse fold is further reinforced by muscle fibers and connective tissue which encloses the uterus and fallopian tubes. This ligament in female is known as **broad ligament**. The bladder is connected with the floor of the pelvic cavity by middle ligament of bladder.

While investing over various organs in the pelvic cavity it forms **rectogenital** pouch between the rectum and the genital fold and **Vesicogenital** pouch between the genital fold and bladder. Dorsally it forms **pararectal fossa** and ventrally it forms **pubovesical pouch** [Fig. 6.15].

Functions of peritoneum

1. It provides a slippery surface for free movement of abdominal visera.
2. The phagocytic cells of peritoneum guard the viscera against infection.
3. The mesothelium absorb fluid and solutes, as it acts as a semipermeable membrane.
4. It helps in healing and adhision by transformation of mesothelium into fibroblasts.
5. It acts as storage of fat.

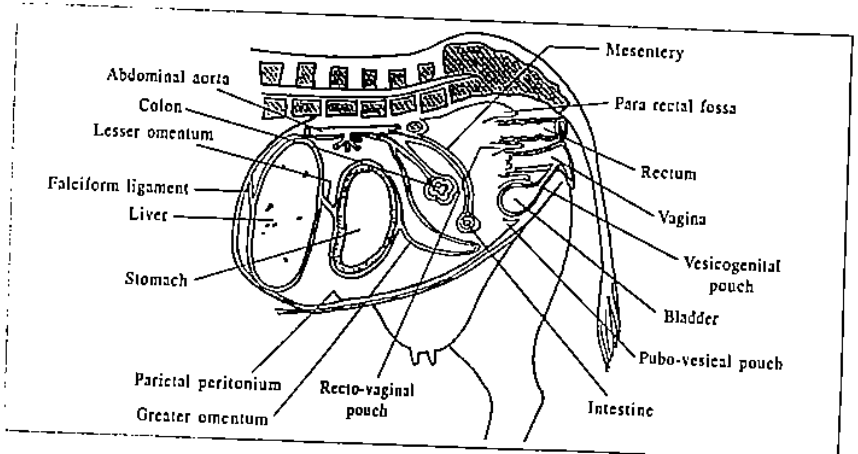


Fig. 6.15 Disposition of peritoneum (Diagramatic).

STOMACH

The ruminent stomach is very capacious. Nearly three fourth of the abdominal cavity is occupied by stomach. It has four compartments—**rumen, reticulum, omasum** and **abomasum**. They fill up the whole of the left half and a part of the right half of the abdomen. In the left side a small part is left by the stomach for the accommodation of spleen and a portion of intestine.

The average capacity of the stomach in adult animals ranges from 100 to 230 liters, depending upon the size of the animal. Out of the total volume rumen occupies 80%, reticulum occupies 5% and omasum and abomasum occupy 7-8% each. This relative capacities vary in newborns and infants because they do not consume grass and other usual foods at that time. In the new born calves the abomasum is the largest of all the compartments because they live only on milk. At the age of nearly one and half years the compartments gain normal relative sizes. Some volumetric data are available regarding the gradual changes of sizes of different compartments in different ages as follows :

New born — (Rumen + reticulum) × 2 = Abomasum

8th week — Rumen + reticulum = Abomasum

12th week — (Rumen + reticulum × ½ = Abomasum

RUMEN

Rumen is a big muscular elongated sac which is compressed from side to side. It is placed in the abdominal cavity from the level of 8th rib to the pelvic inlet. It occupies most part of the left half and a small part of right half of the abdominal cavity. It has two surfaces, two curvatures and two ends. The parietal surface (left) is convex and related to left abdominal wall and diaphragm and spleen. This surface presents left longitudinal groove. The visceral surface is related to a number of structures, such as omasum, abomasum, liver, intestine, pancreas, left kidney, adrenal gland, aorta, posterior venacava, *etc.* This surface presents right longitudinal groove. Sometimes the right longitudinal groove is divided into a dorsal and a ventral branch. They usually enclose an elongated swelling, termed **Insula ruminis**. Dorsal curvature is convex and related to crura of diaphragm and sublumbar muscles. This curvature is attached to them by peritonium and connective tissue. Ventral curvature is convex and related to the floor of the abdominal cavity. The cranial end is divided into two blind sacs by cranial transverse groove. This end is related to the diaphragm. However, the dorsal sac of this end is

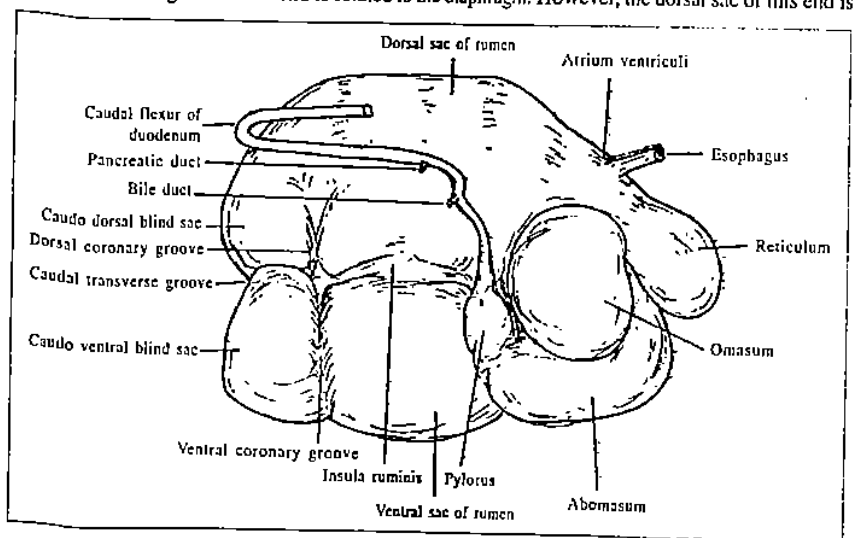


Fig. 6.16 Stomach of cow (Right surface).

related and connected to reticulum. The caudal end is also divided into two blind sacs by the caudal transverse groove. This end is related to intestine and bladder. The cavity of the rumen is incompletely divided into a dorsal and a ventral sac. The longitudinal grooves (left and right) and the transverse grooves (cranial and caudal) together make the outer demarcations between the two sacs. The **caudo-dorsal and caudo-ventral blind sacs** are separated from their original sacs by corresponding dorsal and ventral coronary grooves. The **coronary grooves** are prominent on both parietal and visceral surfaces. Rumino reticular groove is the external demarcation of the said junction at the cranial end. Here rumen and reticulum form the atrium **ventriculi**, a dome shaped area, on which esophagus joins the stomach.

In sheep and goat, the ventral sac of rumen is comparatively large. Ventral coronary groove of the right side is more prominent. The dorsal coronary grooves of both the sides are indistinct.

The internal surface of the ruminal wall has a number of infoldings to form shelf like projections which are strengthened by additional muscle fibers. These are known as pillars. They correspond to

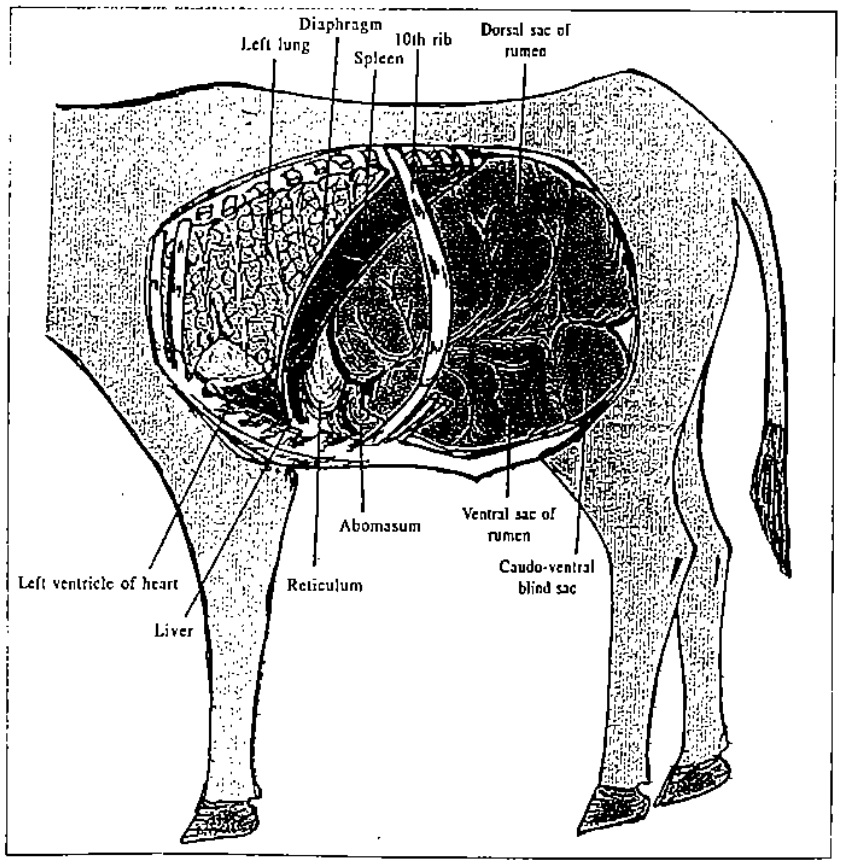


Fig. 6.17 Topography of viscera of buffalo calf (Left side exposed).

the external grooves, responsible for dividing the cavity of the rumen into dorsal and ventral sacs. The cranial pillar is a tilted oblique fold between the cranial ends of dorsal and ventral sacs of rumen. The caudal pillar is very thick and separates the caudodorsal and caudoventrial blind sacs of rumen. Right and left longitudinal pillar extends from the corresponding right and left ends of cranial pillar. An accessory pillar extends from the dorsal aspect of right longitudinal pillar. From the left and right ends of caudal pillar dorsal and ventral corronary pillars extend along the corresponding grooves. The mucous membrane is heavily studded with large variety of papillae except at the edges of the pillars. The colour of the mucous membrane is brown.

The **reticular groove** starts from the cardia, passes to the right wall of atrium ventriculi, then to the reticulum and terminates at the reticulo-omasal orifice. This groove possesses two lips – right and left as well as a floor and thereby encloses a tubular bypass to the rumen. Omasal groove is the second part of the gastric groove which passes from reticulum to abomasum. This combined groove is probably functional in suckling calves by reflex closure of the lips, making the bypass a potent tube so that milk can pass from esophagus to reticulo-omasal orifice and thereby to the abomasum directly bypassing rumen, reticulum and omasum. In adult animals such functions are not observed.

However, some chemicals like copper sulphate, sodium salt, etc., may produce reflex closure of the groove even in adult animals.

Histology of Rumen

The wall of rumen is composed of tunica serosa, tunica muscularis, tunica submucosa and tunica mucosa.

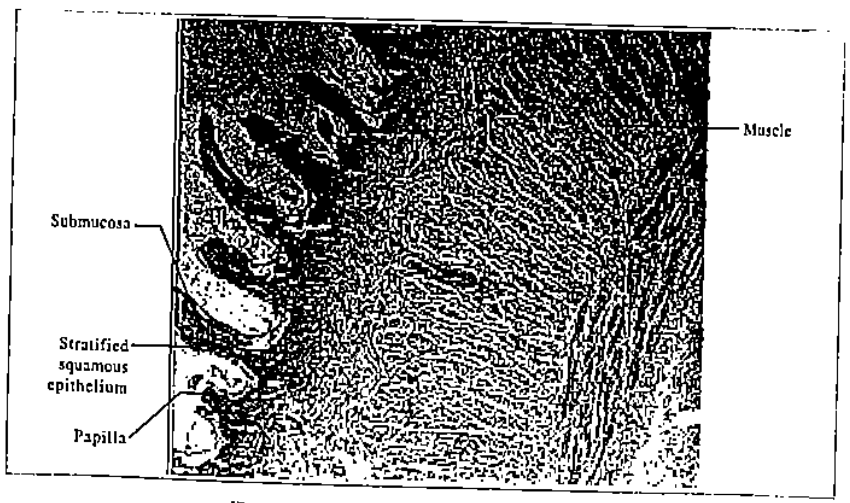


Fig. 6.18 Histological section of the wall of rumen.

Tunica serosa—This outermost covering is composed of collagen and elastic fibers, covered by simple epethelium (mesothelium).

Tunica muscularis—This layer comprises of two layers of smooth muscle fibers. Although basically iner and outer muscles are arranged in circular and longitudinal manner respectively, but in places they are disposed in various irregular directions. In this layer nerve plexus and ganglia are present. Fibers from this layers extend into the core of the pillars.

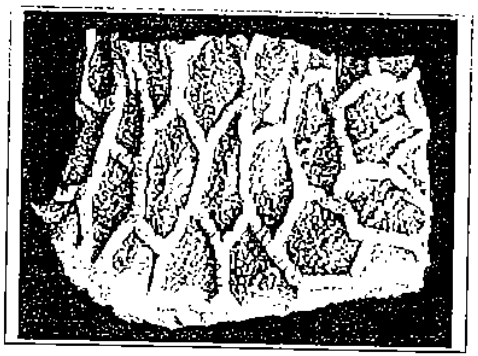
Tunica submucosa—This is continuous with the lamina propria, which extend into the core of the papillae. It is composed of collagen, elastic fibers and reticular fibers along with plenty of blood capillaries. Muscularis mucosae and glands are absent.

Tunica mucosa or the ruminal epithelium is made up of stratified squamous epithelium. It is spread all around the papilla and the spaces between the papillae and for that reason the lamina propria extends within the core of the papillae. Like those of epidermis it presents stratum corneum, stratum granulosum, stratum spinosum and stratum basale.

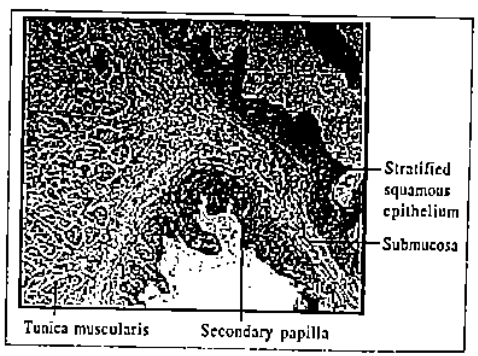
The stratum corneum is variable in thickness. Stratum granulosum is 1–3 cell thick. The cells contain keratohyalixe granules. Cells of the stratum spinosum are polydedral in shape and 1 to 10 cells thick. Stratum basale is formed by single layer columnar cells placed on a basement membrane.

RETICULUM

This pyriform sac is the smallest of all other compartments and situated between the diaphragm and liver in front and dorsal sac of rumen and omasum behind. It has two surfaces, two curvatures and two ends. Parietal surface is convex and related to diaphragm and liver. Visceral surface is related to atrium ruminis. Dorsally this surface is continuous with the wall of the rumen. Greater curvature is the left ventral border situated at the level of 7th rib and related to diaphragm. The lesser curvature is placed at the right dorsal aspect and is joined with omasum. The interior of the reticulum is honeycomb in appearance. This is due to the foldings of mucous membrane. Plenty of 4 to 6 sided cells (small chambers) are enclosed by the mucous folds. These cells are also subdivided into smaller areas by smaller folds which are covered by pointed horney papillae. These polygonal chambers are large at the fundus and small at the neck. The mucous membrane close to the reticulo-omasal orifice presents some claw like horny papillae.



6.19 Interior of reticulum (Honey comb).



6.20 Histological section of the wall of reticulum showing a long fold. (By Curtesy Dr. Indranil Chatterjee)

Reticulum in sheep and goat is comparatively larger in size. The ventral part is slightly curved backward.

Histology of Reticulum

The tunica serosa, tunica muscularis, lamina propria and submucosa are similar to those of rumen. The epithelium is also keratinised and made up of stratified epithelium, as found in rumen. However, the vertical wall is studded with numerous secondary and tertiary papillae and within the lamina propria of these reticular folds, isolated mass of smooth muscle present.

Due to the formation of honeycomb, the reticular folds intersect with other folds and the smooth muscles of one fold become continuous with those of other folds.

A reticulo-omasal sphincter is formed by the contribution of muscular fibers from the walls of the lips and floor of the groove and from the external layer of the reticulum.

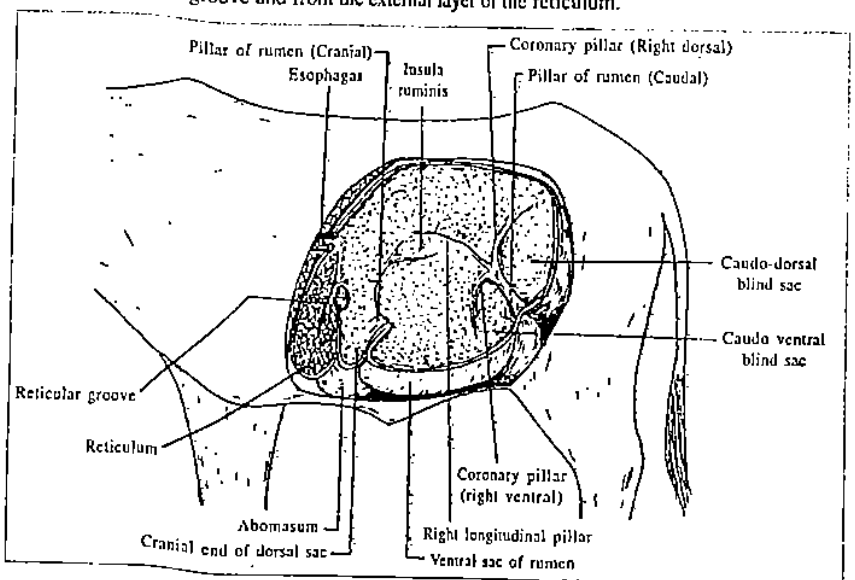


Fig. 6.21 Internal structures of the stomach of a bullock.

OMASUM

It is roughly oval in shape and laterally compressed. It is situated at the level between 7th and 11th rib at the right side of the median plane. The parietal or right surface is related to diaphragm and liver. The ventral border sometimes remains in contact with the abdominal floor. The visceral or left surface is related to rumen, reticulum and abomasum. The reticulo-omasal and omaso-abomasal orifices are at the upper part of this surface. The whole structure is mostly confined in the right hypochondriac region. There are about 100 crecent shaped folds (laminae) occupying the cavity of the omasum. On the basis of the height these folds are of four or five varieties, arranged one after another in a cronological manner as shown in diagram. The largest variety of folds are about 12 in number. They

are attached to the wall of the organ with their greater curvatures. The lesser curvatures remain free. The surfaces are studded with numerous papillae. In sheep and goat this compartment is comparatively small and therefore does not come in contact with the floor of the abdomen.

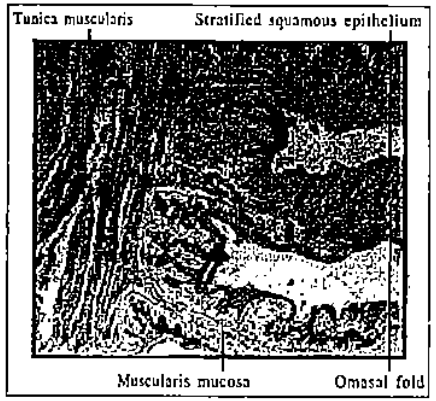


Fig. 6.22 Histological section of a omasal fold.

Histology of omasum

The tunica serosa, tunica mascularis and tunica submucosa are similar to those of rumen and reticulum. The keratinised mucous membrane is also similar and covers the folds as well as papillae.

A thick layer of smoth muscle fibers extend from the tunica muscularis upto the end of the fold. Lamina muscularis mucosae is thick and situated below lamina propria. Within the lamina the lamina muscularis is found on both sides of lamina propria.

ABOMASUM

It is the true stomach and elongated saccular in shape. Its two parts – fundus and pylorus are separated incompletely by a constriction. The fundic part is extended along the length of the body and related to the ventral sac of rumen, reticulum and omasum. It is placed at the xiphoid region. The right lateral surface is related to liver. The pyloric part turns upward along the caudal border of omasum and becomes continuous with the duodenum. The parietal surface is related to the abdominal floor and the visceral surface is related to the rumen and omasum. The body is placed more towards the left side of the median plane. The greater and lesser curvatures are attached to the greater omentum and lesser omentum respectively.

In the interior of the abomasum three glandular areas are seen. Cardiac glands are present in a narrow zone close to the omaso-abomasal orifice. The fundic and pyloric glands are found at the respective zones of the abomasum. There are about twelve oblique folds within the fundus which are extended from the abomasal groove to the greater curvature of the organ. These folds are thick glossy and reddish in colour. The mucous membrane of pyloric part is devoid of any fold but wrinkled in appearance. The circular muscle fibers at the wall become very thick at the junction between the duodenum and pylorus to form the pyloric sphincter.

Histology of abomasum

The histological structure of abomasum is similar to that of simple glandular stomach. Tunica serosa and tunica muscularis similar to those of other compartments. The muscular layer is relatively thick. The submucosa is composed of collagen, elastic and reticular fibers. In addition to blood vessels, nerves and lymphatics the submucosa contains adipose tissue and loose connective tissue.

Lamina propria contains loose connective tissue. It is thick and accommodates gastric glands.

Lamina muscularis mucosae is present.

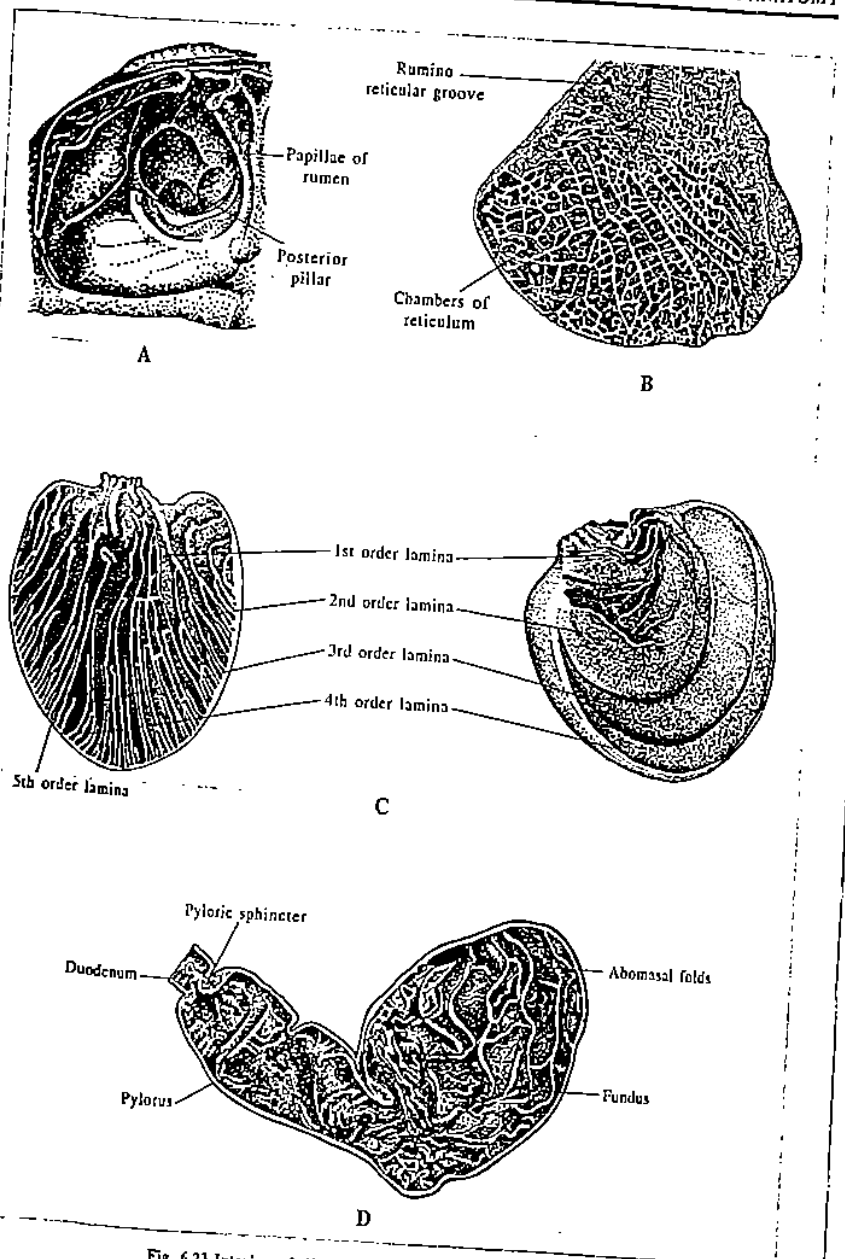


Fig. 6.23 Interior of different compartments of stomach.
A. Rumen B. Reticulum C. Omasum D. Abomasum



Fig. 6.24 Histology of the wall of abomasum.

The mucous membrane is thick and thrown into folds. The lining cells are simple columnar and secrete mucin. Gastric glands are situated within the mucous membrane. These are branched tubular glands and communicate with gastric lumen through gastric pits.

These glands are of three types—(a) Cardiac glands—they are small in number, (b) Fundic glands—highest in number and (c) Fundic glands —less in number.

The cardiac glands have a neck and body. The neck and upper part of the body is lined by mucous secreting cuboidal cells. Other cells are columnar in shape. There are some pyramidal cells in between lining cells, called Argentaffin cells. They do not produce any secretion in the lumen. Their secretions are distributed into the lamina propria and therefore called gastrointestinal endocrine cells. There cells secrete serotonin gastrin etc.

The fundic glands have base, body, neck and isthmus. Isthmus is the area where it opens at the gastric pit. Three types of cells are found.

(a) **Chief or peptic cells**—They are situated at the wall of the base and secrete pepsinogen.

(b) **Oxyntic or parietal cells**—They are situated at the neck and at the base. They secrete Hydrochloric acid. These cells contain extensive microcanalicular system which communicates with the lumen of the gland.

Peritoneal attachment of the stomach

The line of attachment of the lesser omentum starts from the ventral side of esophagus. It attaches along the parietal surface of the omasum, lesser curvature of abomasum and cranial part of duodenum. The greater omentum starts from dorsal side of esophagus. It attaches the right longitudinal groove, left longitudinal groove, visceral surface of reticulum, greater curvature of abomasum and cranial part of duodenum.

The stomach is supplied by the branches of celiac artery and by the branches of vagus and sympathetic nerves. The arterial branches are left reminal, right ruminal, reticular, omasoabomasal and a branch of hepatic artery.

Surface Anatomy of ruminant stomach

The rumen extends from the level of 8th intercostal space to the level of tuber coxae. Therefore it is palpable in the left paralumbar fossa. Ventral sac lies on the ventral abdominal wall. It is enclosed in the grater omentum. The left abdominal wall at the level of ventral ends of 6th and 7th intercostal spaces remains in contact with the reticulum.

Although in young large ruminants and in adult small ruminants the omasum can not come in contact with the abdominal wall, in large adult ruminants it comes in contact with right abdominal wall at the level of ventral ends of 7th to 9th intercostal space.

The fundic part of abomasum lies on the xiphoid region.

Stomach of horse

1. The stomach is in the form of a simple saccular structure. Capacity is about 12 liters.

2. It is placed at the left side of the median line on the dorsal aspect of abdomen behind liver and diaphragm.

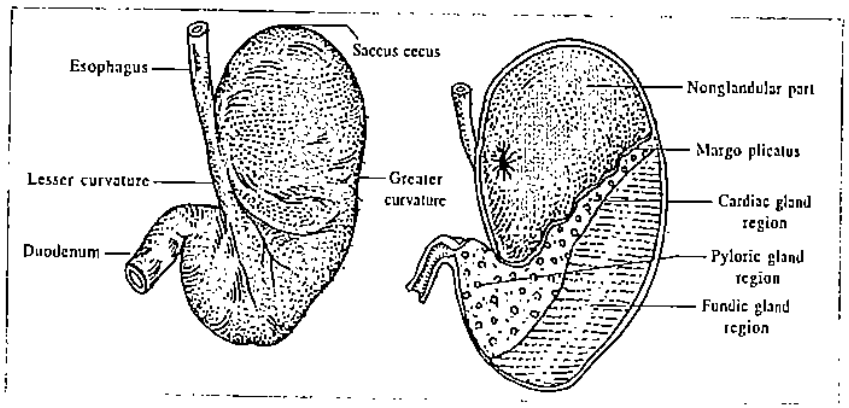


Fig. 6.25 Stomach of horse. A. Exterior view B. Interior view

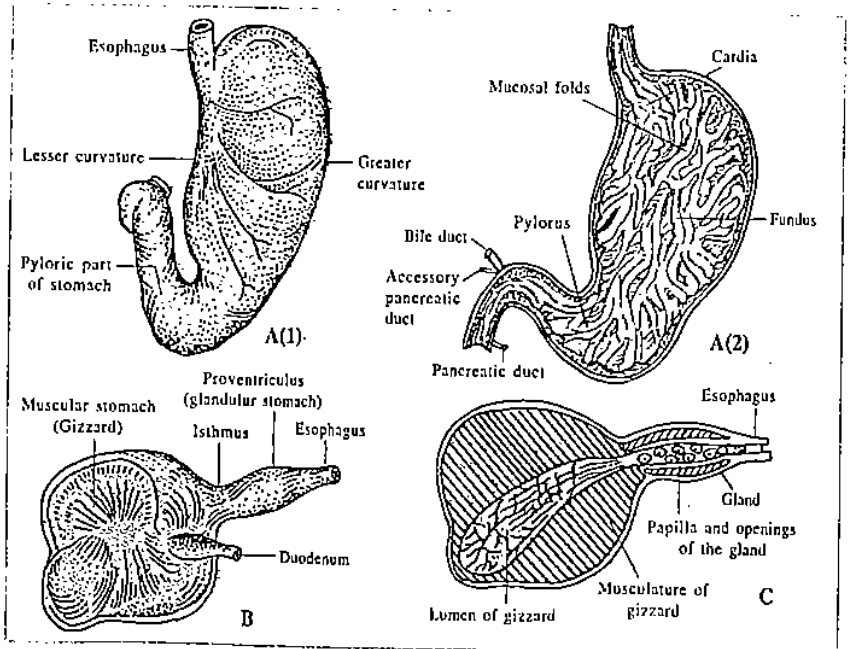


Fig. 6.26 A(1). Stomach of dog A(2). Stomach of dog, interior view
B. Stomach of fowl C. Stomach of fowl (exposed)

3. It is curved and J shaped sac.

4. The lesser curvature is short. The cardia and pylorus are very close.

5. At the left extremity of the stomach, close to the entrance of the oesophagus, there is a rounded cul-de-sac known as **saccus cecus.**

6. Pyloric end is comparatively smaller.

7. The mucous membrane is divided into the esophageal (non-glandular) and a glandular parts, which are separated by a rough line, termed **margoplicatus.**

8. The pyloric sphincter is well developed.

9. The glandular part is divided into cardiac, fundic and pyloric gland regions according to the presence of different types glands in the mucous membrane.

10. The muscular coat of the stomach comprises of three layers of fibers — external longitudinal, middle circular and internal oblique. However these layers are not complete in all the places. The **pyloric sphincter** is formed by the thickening of circular fibers. The oblique fibers form a remarkable loop around the cardiac orifice and form a **cardiac sphincter.**

Stomach of dog

1. It is also simple in form. Capacity in an adult large dog is about 2 liters.

2. The stomach is pyriform in shape. It has two surfaces, two orifices (cardiac and pyloric) and two curvatures (lesser and greater).

3. The pyloric (right) part is narrow and the fundic (left) part is large and rounded.

4. The parietal surface is convex. It faces ventrally and to the left. This surface is related to liver, diaphragm and left ventral abdominal wall.

5. There is a marked constriction between the fundic and pyloric parts.

6. The fundic glands occupy about two third of the total area of mucous membrane.

7. The mucous membrane has three glandular (cardiac, fundic and pyloric) regions. There is no nonglandular area in the stomach of dog. The pyloric part presents some folds in empty condition.

Stomach of pig [Fig. 6.27]

1. The stomach is simple but comparatively large. Capacity is about 6 liters.

2. The shape of the stomach resembles the shape of a human embryo.

3. Left part is large rounded and presents a conical diverticulum.

4. The right narrow part is the pyloric portion of the stomach. It presents a ridge like prominence which projects from the wall of the lesser curvature and extends towards the lumen know as **Torus pyloricus.**

5. The mucous membrane presents a proventricular part close to the esophageal opening. The rest part has as usual three glandular zones – cardiac, fundic and pyloric glandular regions.

Stomach of rabbit [Fig. 6.35]

1. It is simple in structure.

2. Fundic part is comparatively big.

3. The pyloric part is well developed and connected with the fundic part by a wide constriction.

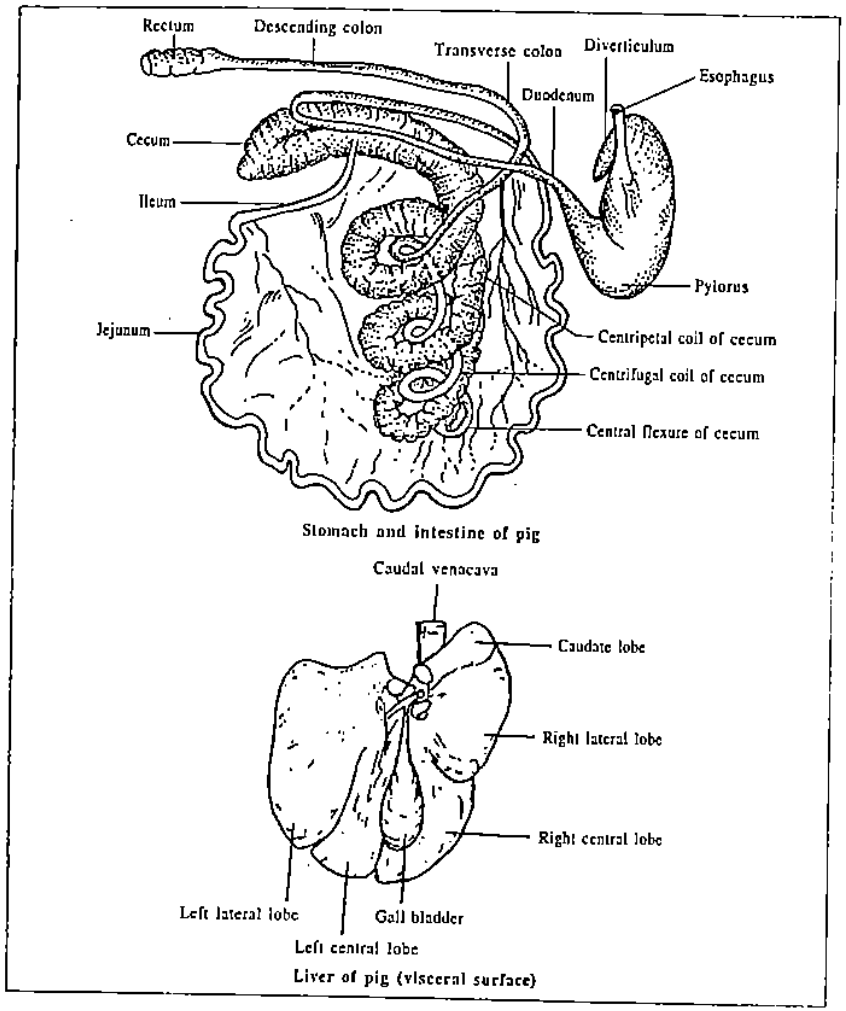


Fig. 6.27

4. Volume is 40-50 ml.

5. Wall of the pyloric part is thick and bears few transverse folds.

Stomach of fowl [Fig. 6.26]

1. It has two distinct parts – glandular stomach and muscular stomach.

2. The glandular stomach is spindle shaped elongated tubular structure connected with the muscular stomach by a constriction – the isthmus. Glandular stomach is also called **Proventriculus.**

3. A number of papillae project into the lumen of glandular stomach at the apex of which open the excretory ducts of small submucosal glands.

4. The muscular stomach resembles a biconvex disc which is popularly known as gizzard.

5. The wall is thick and muscular.

6. Dorsolaterally the gizzard presents two orifices for communication with the glandular stomach and duodenum.

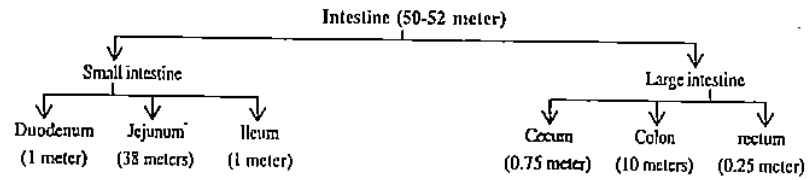
7. The lining epithelium of the internal surface of the muscular stomach is lined by simple columnar epithelium. It is covered by a tough membrane of yellowish-brown colour. This membrane can be pilled off by finger after dissection.

There are some longitudinal parallel folds and few transverse folds on the surface of this membrane.

INTESTINE

Intestine is a very long tube which begins at the pyloric end of stomach and terminates at the anus. Most of its parts are situated in the right side of the abdominal cavity.

It is divided into following parts.



Small intestine

Small intestine starts from pylorus and terminates at the ileocecal orifice. The average diameter of the tube is about 5-6 cm. It comprises of duodenum, jejunum and ileum. In small ruminents the length of the small intestine is about 20 meters. Diamater of the tube is about 2-3 cm.

DUODENUM

It begins at the pylorus passes dorsally and caudally at the visceral surface of liver and presents a S shaped curve. Then it passes further caudally to the level of tuber coxae. This portion is known as descending part of duodenum. Now it turns cranially by forming a caudal flexure and continues as ascending part. The ascending part passes forward and become continuous with the jejunum at the left side of the cranial mesenteric artery. The first part of the duodenum is attached to the liver by omentum. The descending part, caudal flexure and the ascending part are attached to pancreas, colon and cecum by a short peritoneal fold, known as meso-duodenum. The bile duct opens into the duodenum at the second bent of the S curve which is about 0·5 meter away from the pyloric end. The pancreatic duct enters the duodenum 0·25 meter caudal to the entry of the bile duct.

In sheep and goat the bile duct and pancreatic duct join together and open into the duodenum about 20 cm from the pylorus.

JEJUNUM

It constitutes most of the length of the small intestine and comprises of a good number of coils attached at the border of mesentery. These close coils are constricted and dilated and formed U

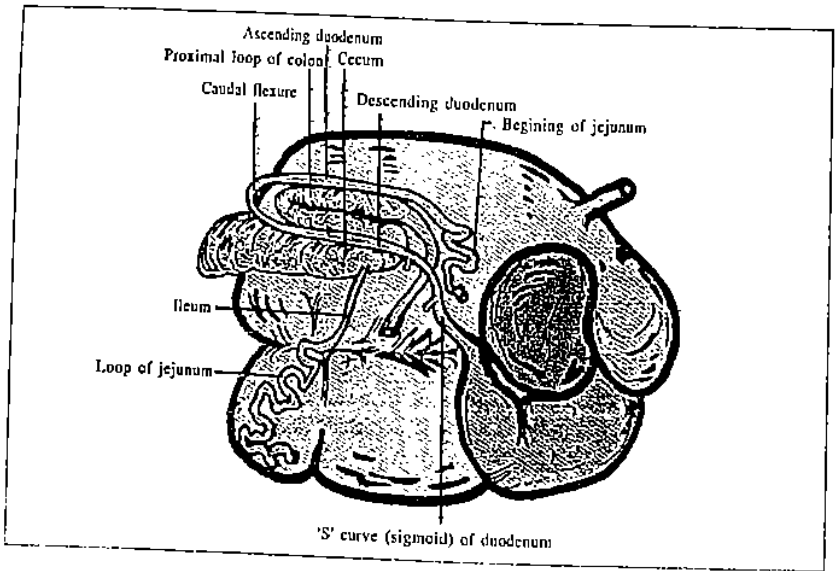


Fig. 6.28 Stomach and intestine (Part of cow).

shaped tubular loops by the attachment of the mesentery. To display the organ they can be straightened by removing the attachments. Jejunum is the mobile part of the intestine. It occupies the space between the right surface of rumen and right abdominal wall below the large intestine. The blood vessels of the jejunum are arranged in few layers of arches in the mesentery. Straight vessels connect the loops of jejunum with the convexity of vascular arches.

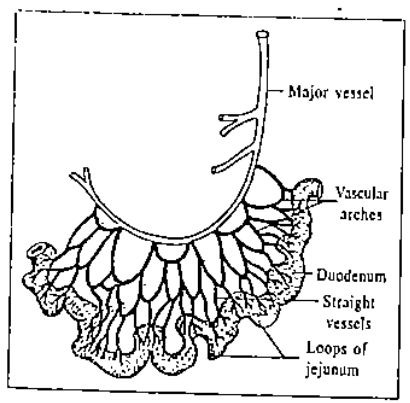


Fig. 6.29 Blood vessels of Jejunum.

ILEUM

It is the terminal part of small intestine and a thick tube. It is attached with cecum at its cranial part. It terminates at the medial surface of the cecum at the cecocolic junction.

STRUCTURE

The wall of the small intestine is composed of serous, muscular, submucous and mucous coats. The submucous coat accommodates the vessels nerves, duodenal glands and solitary and aggregated lymph nodes. The muscular coat is composed of inner circular and outer longitudinal muscles. The circular muscles are thicker. The mucous membrane presents permanent folds and villi. The aggregated **lymph nodules (Peyer's patches)** are about 20 to 35 in number.

The small intestine has been designed to perform two functions — (a) **digestive function** and (b) **absorptive function**. For the digestive function it needs enzymes. The glands which provide these enzymes are situated — (i) outside the intestine but connected by ducts (Liver, pancreas), (ii) in the submucous coat and (iii) in the lamina propria. Plenty of mucus is secreted by the Goblet cells which protect its own autodigestion. The absorptive function is done by its great length, mucosal fold, presence of **villi** and presence of microvilli on the free surface on the lining cells. The villi are finger like projections, plenty in number and are distributed all over the mucous membrane of small intestine. They are more in the Jejunum. Externally these villi are lined by **columnar** cells. These columnar cells are also called **enterocytes**.

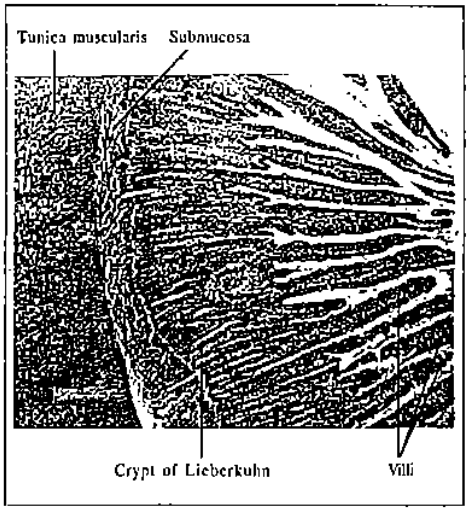


Fig. 6.30 Duodenum showing Crypts of Liberkuhn.

The core of a villus contains blood vessels, connective tissue fibers, muscle fibers and lymphatic vessels. These lymphatic channels are called **lacteals**. Blood vessels form loops through which arterial blood flows towards the tips and returns as venous blood. The surface epithelium inbetween villi deepens inside to form simple tubular glands lined by columnar cells called crypt of **Lieberkuhn.**

LARGE INTESTINE

The diameter of large intestine is greater (about 10 cm) at its first one to one and half meters and thereafter diminishes.

Most of its parts are situated at the dorsal aspect of the right side of the abdominal cavity, enclosed by the common mesentery. It comprises of cecum, colon and rectum.

CECUM

It is a blind sac which has a length of about 75 cm and the diameter of about 12 cm. The capacity is about 7 to 8 liters. Cranially it is continuous with colon. The caudal blind end is known as apex. It is extended upto the right side of the pelvic inlet. In some animals the apex may be curved ventrally. The organ is attached to the proximal loop of colon at its dorsal aspect and with ileum at the ventral aspect. Its right surface at the cranial part is in contact with the caudal flexure of duodenum. The ileo-cecal orifice is very small and presents longitudinal folds inside. In small ruminents, the length diameter and capacity of the organ is 25 cm, 6 cm, and 1.2 liters respectively.

COLON

According to the disposition the colon is divided into ascending colon, transverse colon and descending colon.

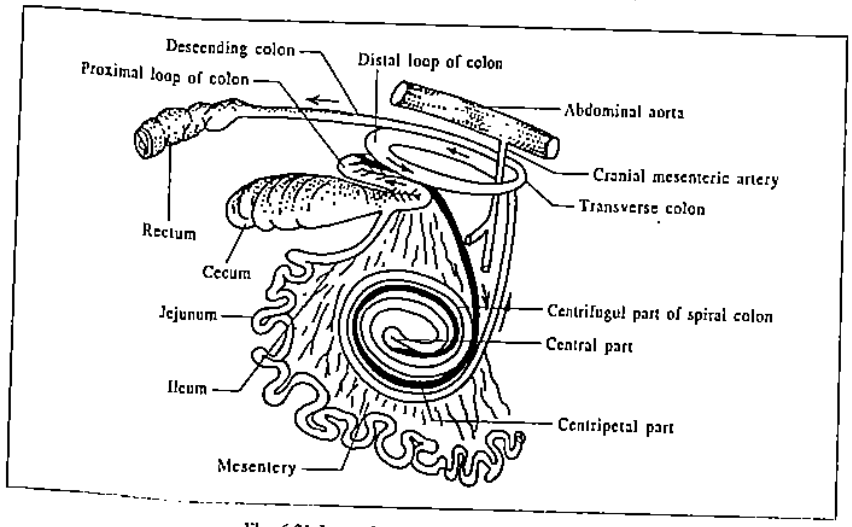
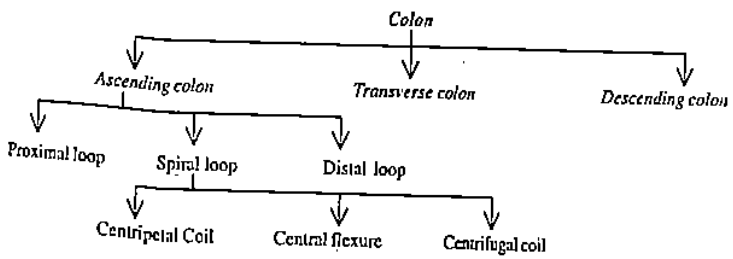


Fig. 6.31 Large Intestine of cow (Diagramatic).



Ascending colon—It consists of proximal loop, spiral loop and distal loop. The **proximal loop** is the first loop experienced by the colon and is situated at the caudodorsal portion of the right side of the abdominal cavity between the cecum and descending duodenum. The **spiral loop** is continuous with the proximal loop and consists of two centripetal coils, a central flexure and two centrifugal coils. These coils are adhered to form a disc which is situated at the right lateral abdominal region. The **distal loop** is continuous with the transverse colon. The terminal portion of the centrifugal part of spiral loop passes caudodorsally on the proximal loop and forms an elongated distal loop.

Transverse colon passes from the right to left around the cranial mesenteric artery. The descending colon runs caudally, curves near the pelvic inlet and becomes continuous with the rectum. The cecum, ascending duodenum, the proximal and distal loops and the cranial part of colon are adherent together by a fatty connective tissue around the root of mesentery. The body of the colon do not have any tenia and a sacculations. Villi are absent in the mucous membrane. Few Pyer's patches are present in the mucosa close to ileum.

In sheep and goat the length of the colon is about 4 meters. The last coil of the centrifugal part of the colon is closely related to the jejunum.

RECTUM

It is the terminal portion of the intestine and consists of two portions. The cranial part is covered by peritonium and the caudal part, which is little dilated is not covered by peritonium. Its walls is thicker and presents constrictions and dilatations. The fibers of **recto-coccygeus** muscles are derived from the dorsal part of external longitudinal layer of the muscular coat of rectum. These muscle fibers insert to the 2nd and 3rd caudal vertebrae. The **ventral fibers** pass downward decussate at the center and join the smooth muscles of labia in female and to the urethra in male. Anus is the terminal opening of the G.I. tract situated below the root of the tail. *Anal canal* is about 2.5 cm in length and the mucous membrane is continuous with the skin. The mucous folds at the cranial part in the lumen are known as anal columns. Caudal part of the lumen is covered by skin (see fig. 6.97).

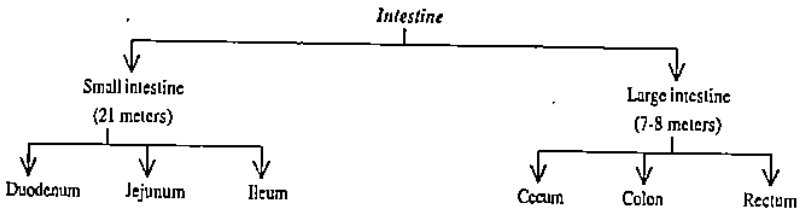
The **sphincter ani internus** is formed by the thickening of inner circular muscles of the rectal wall. A striped muscle situated external to sphincter ani internus is known as **sphincter ani externus**. The fibers of **levator ani** muscle inserts to the sphincter ani externus. Levator ani is a thin muscle which originates from the medial aspect of the ischiatic spine and inserts to sphincter ani externus. An inconstant band of unstriped muscle arises from the coccygeal vertebra passes down under the levator ani and join with its fellow of the opposite side below anus. In female it becomes continuous with constrictor valvae and in male it becomes continuous with retractor penis [See Fig. 6.97].

Coccygeus muscle—Although this muscle is not directly related to rectum but is closely associated with levator ani muscle. It originates by a common tendon with levator ani from the medial aspect of ischiatic spine and from the inside of broad sacro sciatic ligament. It crosses levator ani obliquely goes upwards and inserts at the transverse processes of first three caudal vertebrae.

Blood supply—Beginning of the duodenum is supplied by branches of celiac artery. Other portions of small intestine is supplied by cranial mesenteric artery. Large intestine gets blood through cranial and caudal mesenteric arteries and from internal pudendal artery.

Nerve supply—The intestine gets sympathetic fibers from celiac, cranial mesenteric and caudal mesenteric ganglions and parasympathetic fibers from vagus and pelvic splanchnic nerves. Rectum is also innervated by caudal rectal nerve.

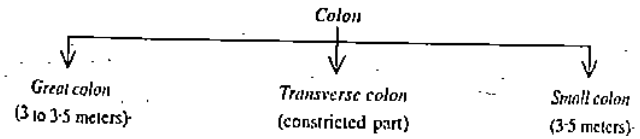
Intestine of Horse [Fig. 6.32]



Duodenum—The length is one meter. It has a descending part, the turning and an ascending part. The ascending part is continuous with the jejunum. The pancreatic duct and the hepatic duct together open into the duodenum 12 to 15 cm away from pyloric end in a pouch, the **hepatopancreatic ampula** (Ampulla of Vater). The cranial part of the duodenum is termed as mesoduodenum, as it is attached to a peritoneal fold. In the mucous membrane *solitary (scattered) nodules* and **Peyer's patches** (aggregated) are present. They are about 100 to 200 in number and placed about one meter beyond the pylorus.

Jejunum and ileum—The length of this tube is 20 meters and the diameter is about 6-7 cm. Practically no distinct demarcation is observed between these two parts. It also has coils which are situated at the dorsal aspect of left lateral abdominal region. Ileum is the last one meter of the tube and is a bit contracted. The ileum passes to the left surface of cecum and opens into it at the base.

Cecum—It is a very big comma shaped sac having a base body and apex. Its capacity is about 30 liters and the length is about 1.2 meter. It extends in a curved manner from the sublumber region to the xyphoid cartilage along the abdominal floor. The apex is directed forward. The body mostly rests on the ventral wall of the abdomen. The *apex* is placed at the abdominal floor close to xiphoid cartilage. It has four longitudinal bands and four rows of sacculations. Both the ileocecal and cecocolic orifices are situated in the lesser curvature at the base.



Great colon—is a very big tube and its different foldings have been named separately on the basis of their disposition in the abdominal cavity. These are Right ventral, Sternal flexure, Left ventral, Pelvic flexure, Left dorsal, Diaphragmatic flexure and Right dorsal from begining to end respectively. The wall has bands and sacculation. The bands are known as teniae coli.

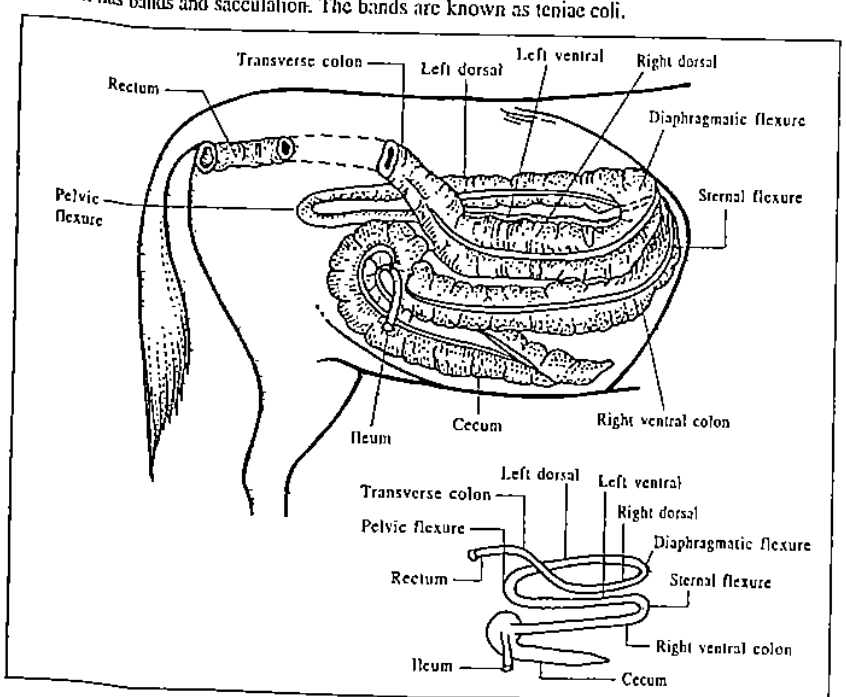


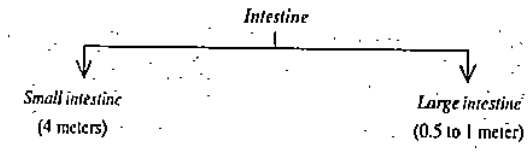
Fig. 6.32 Large intestine of horse (In situ and diagramatic).

Transverse colon—is the constricted part between the great colon and small colon.

Small colon—is placed between the stomach and pelvic inlet. It also has coils. The bands on the wall are less in number.

Rectum—Length is 30 cm. The caudal part is dilated. Only the cranial part is peritoneal. The structure of anus is similar to that of ox.

Intestine of Dog



Duodenum—It is the first shortest part of the tube. The bile duct and small pancreatic duct open into the duodenum about 5-8 cm from the pylorus and the large pancreatic duct opens 3–5 cm behind the preceding one.

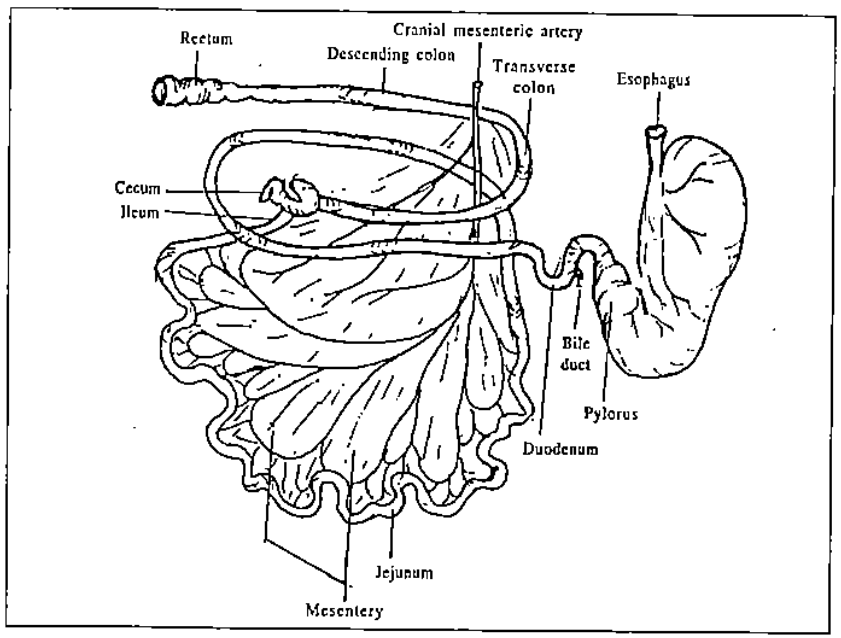


Fig. 6.33A Stomach and intestine of dog (Diagramatic).

Jejunum—is composed of 7 to 8 coils and is the longest part. It is situated between the stomach and pelvic inlet.

Ileum—is the last part of small intestine and is difficult to differentiate from jejunum grossly. Instead of opening into the cecum, the ileum opens into the colon directly. At the junction between the ileum and colon, there is a strong ileocolic valve.

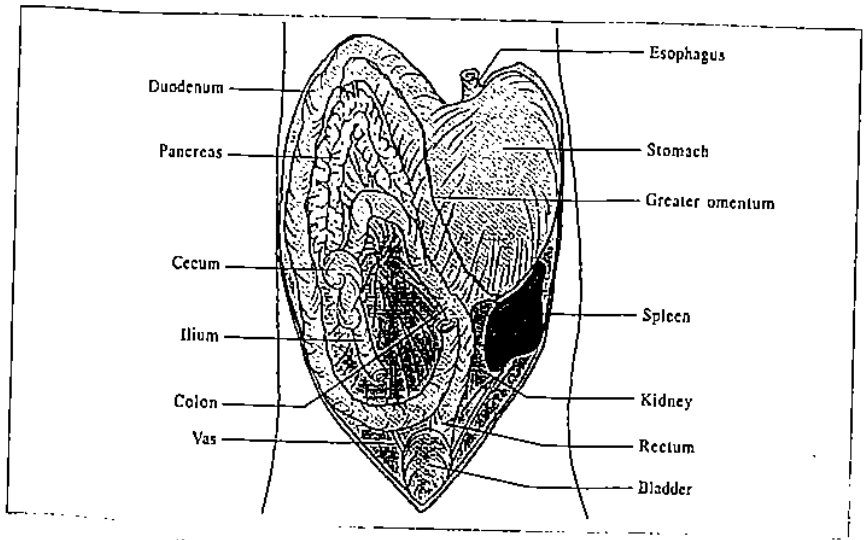


Fig. 6.33B Abdominal viscera of dog (Exposed from ventral aspect).

Cecum—is 12 to 15 cm long closed tubular and curved structure. Its cranial end opens into the begining of colon.

Colon has three parts—*acending, transverse and descending*. Ascending colon is short and extends cranially up to the pyloric part of stomach. It then turns caudally and continues as descending colon. The small part at the point of turning is the transverse colon.

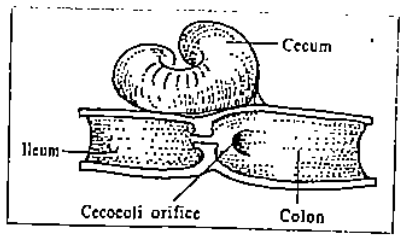
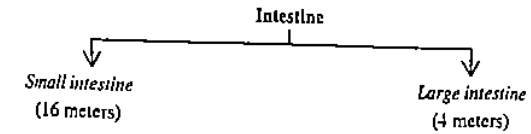


Fig. 6.34 Ileo-colic and ceco-colic junction of dog.

Rectum—is mostly peritoneal. The anal glands are situated at the submucous layer of the recto anal junction. There are two *lateral anal sacs*, the ducts of which open on either side of its lumen. The sacs contain grey coloured fatty substance having offensive smell.

Intesting of pig [Fig. 6.27]



Duodenum—It presents a descending part, a caudal flexure and an ascending part. Bile duct opens about 3 cm and the pancreatic ducts opens about 12 cm behind the pyloric end of the stomach.

Jejunum—It is long and comprises of numerous small loops supported by mesentery. The loops are placed at the right aspect of the abdominal cavity, dorsal to the colon and cecum.

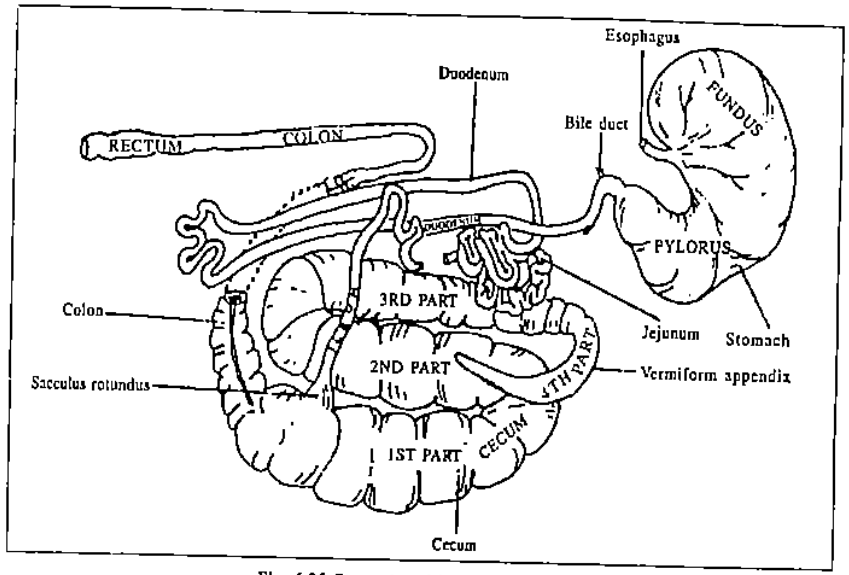


Fig. 6.35 Stomach and intestine of rabbit.

Ileum—It is the terminal and straight portion of the small intestine which opens into the cecum at ileo-cecal junction.

Cecum—This is about 20 cm long and 8 cm wide. Caudal end is blind and directed ventrally. Cranial end is continuous with the colon. The wall has bands and sacculations.

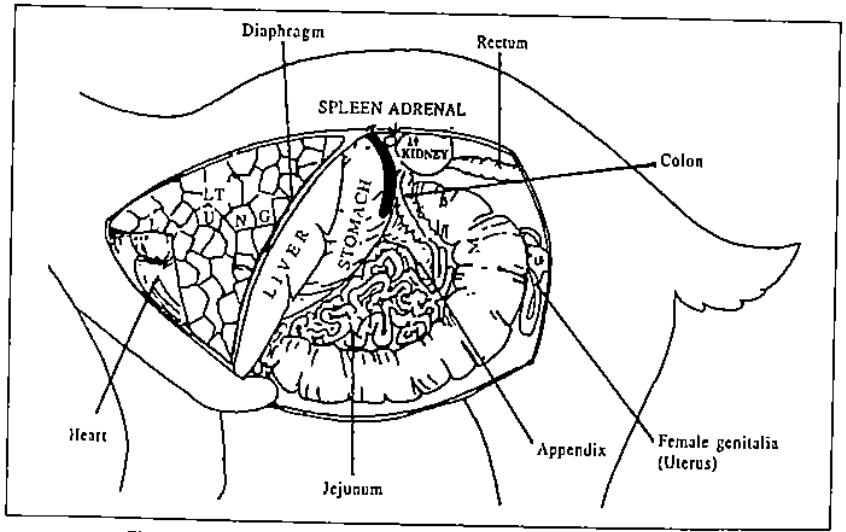


Fig. 6.36 Left side of abdomen and thorax of rabbit showing organs in situ.

Colon—It presents the ascending transverse and descending parts. The ascending colon has three wide centripetal coils, a central flexure and three narrow centrifugal coils [Fig. 6.27].

The centripetal part is sacculated.

Rectum—The terminal part of the descending colon dilate to form the rectum and remains surrounded by fat.

Intestine of rabbit [Fig. 6.35]

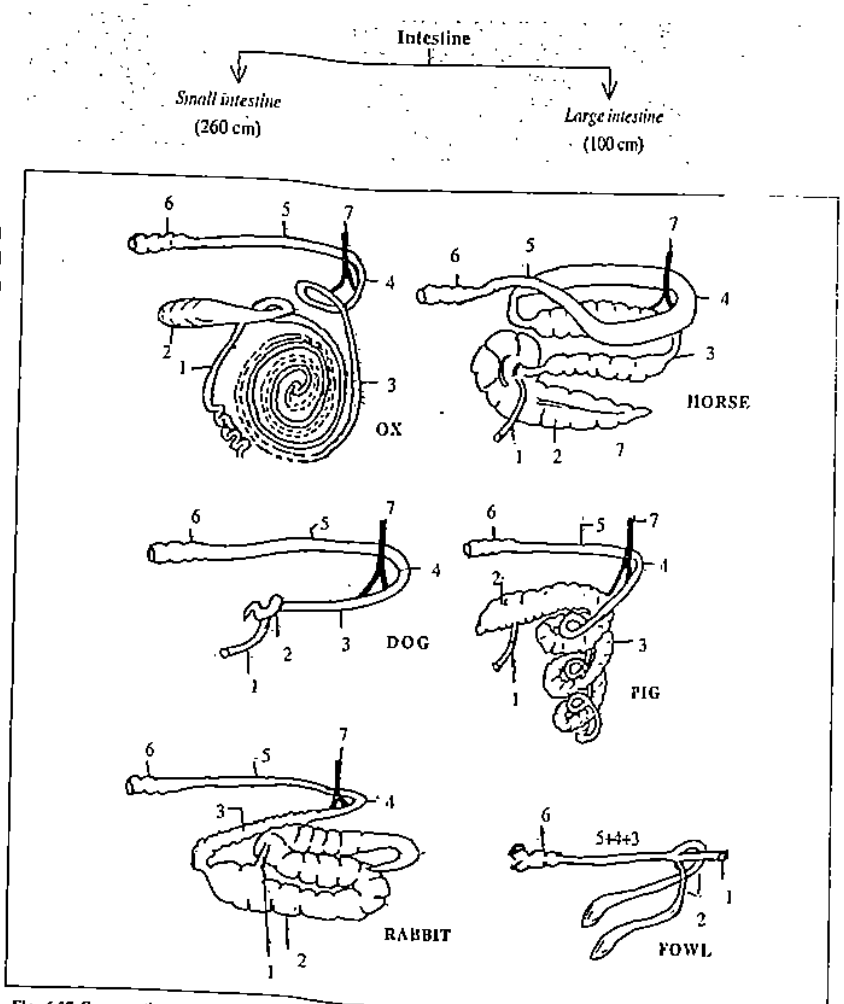


Fig. 6.37 Comparative structure (Schematic) of large intestine of Ox, Horse, Dog, Pig, Rabbit and Fowl. 1. Ileum, 2. Cecum, 3. Ascending colon, 4. Transverse colon, 5. Descending colon, 6. Rectum, 7. Cranial mesenteric artery.

Duodenum—It is a long tube (about 40 cm) and presents a descending part, a caudal flexure and ascending part. The caudal flexure comprises of few U shaped loops. Bile duct and pancreatic ducts open in to the duodenum separately.

Jejunum—It is composed of a number of close loops. It has a length of about 2 meters. The jejunal loops are situated above the cecum and behind the stomach and liver.

Ileum—This is the straighter part of the tube and has a length of about 15 cm. Close to the ilio-cecal junction, the terminal part of the tube is dilated. This is know as **saeculus rotundus.**

Cecum—This is a wide sacculus long tube and occupies the whole of the ventral part and a part of the right half of the abdominal cavity. Length is about 55 cm. and possesses about 25 sacculations. It remains coiled on itself and therefore comprises of first, second, third and a blind terminal part. The terminal part is slender and devoid of sacculation. This part is known as **vermiform appendix.** Average diameter of cecum is about 3 cm. [Fig. 6.35]

Colon—It has a ascending part, a transverse part and a descending part. Ascending colon begins from the base of the cecum in the form of a sacculated wide tube. First 8-9 cm of ascending part bears teneae and sacculations on its wall. Total length of ascending colon is about 25 cm. Transverse colon in small (4-5 cm) and continues backward as descending colon. It is about 12 cm in length and have constrictions and dilatations due to the presence of faecal balls in it.

Rectum—It is small, little dilated and remains surounded by fat.

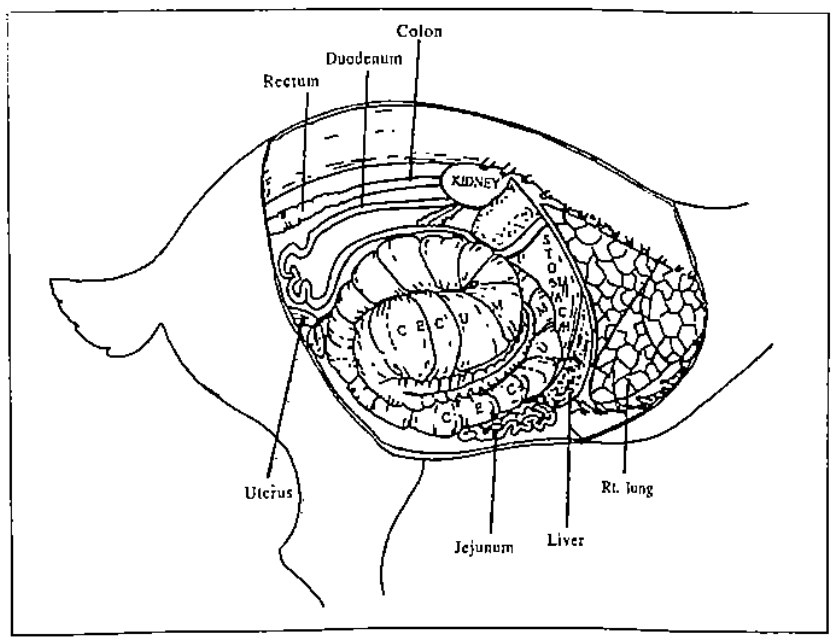


Fig. 6.38 Right side of abdomen and thorax of rabbit showing organs in situ.

Intestine of fowl [Fig. 6.39]

Duodenum—It is 22 to 35 cm long and 0.8 to 1.2 cm in diameter. It has an ascending and a descending parts. They are hold together by a fold of mesentery. The pancreas is placed between these two parts. Lumen of duodenum is comparatively wider. Pancreatic ducts and bile ducts open into the ascending part of duodenum.

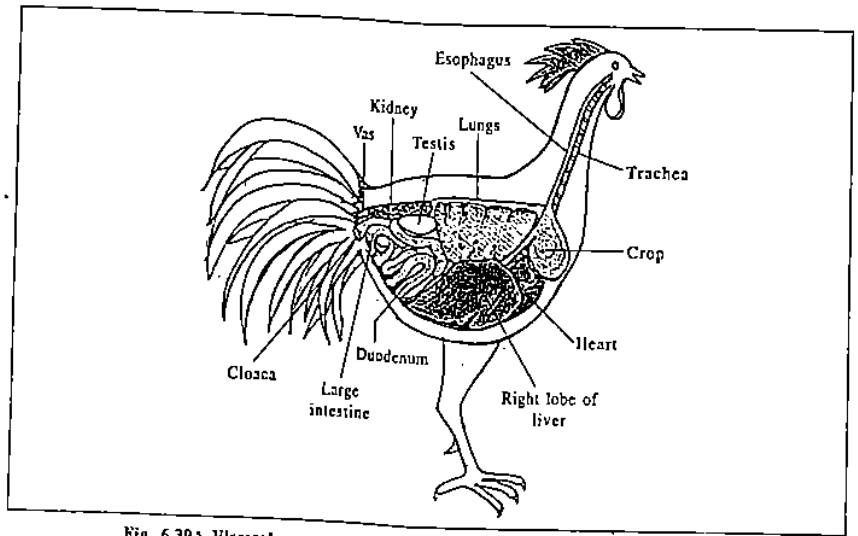


Fig. 6.39A Visceral organs of fowl as they appear after exposing the right side.

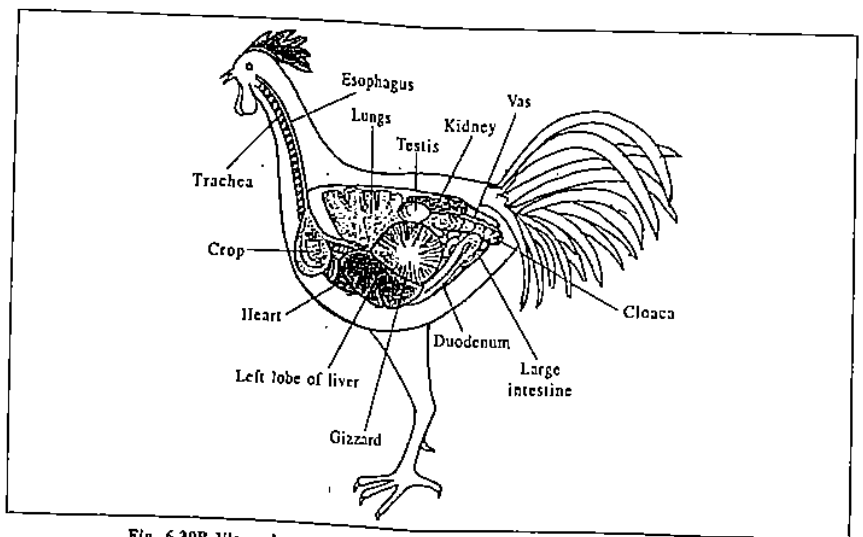


Fig. 6.39B Visceral organs of fowl as they appear after exposing the left side.

Jejunum—It is 85 to 120 cm long. Coils are present. The loops are placed at the right part of the body cavity. At about the middle portion of the jejunum a short closed remnant of yolk sac is present. This is known as **Meckel's diverticulum.**

Ileum is 12 to 18 cm long and yellowish grey in colour. It is continuous with jejunum and is placed ventral to the rectum and cloaca.

Ceca are two in number, left and right. They are connected with the gastro-intestinal tract at the junction between ileum and colo-rectum. Each of these tubular structures have a length of about

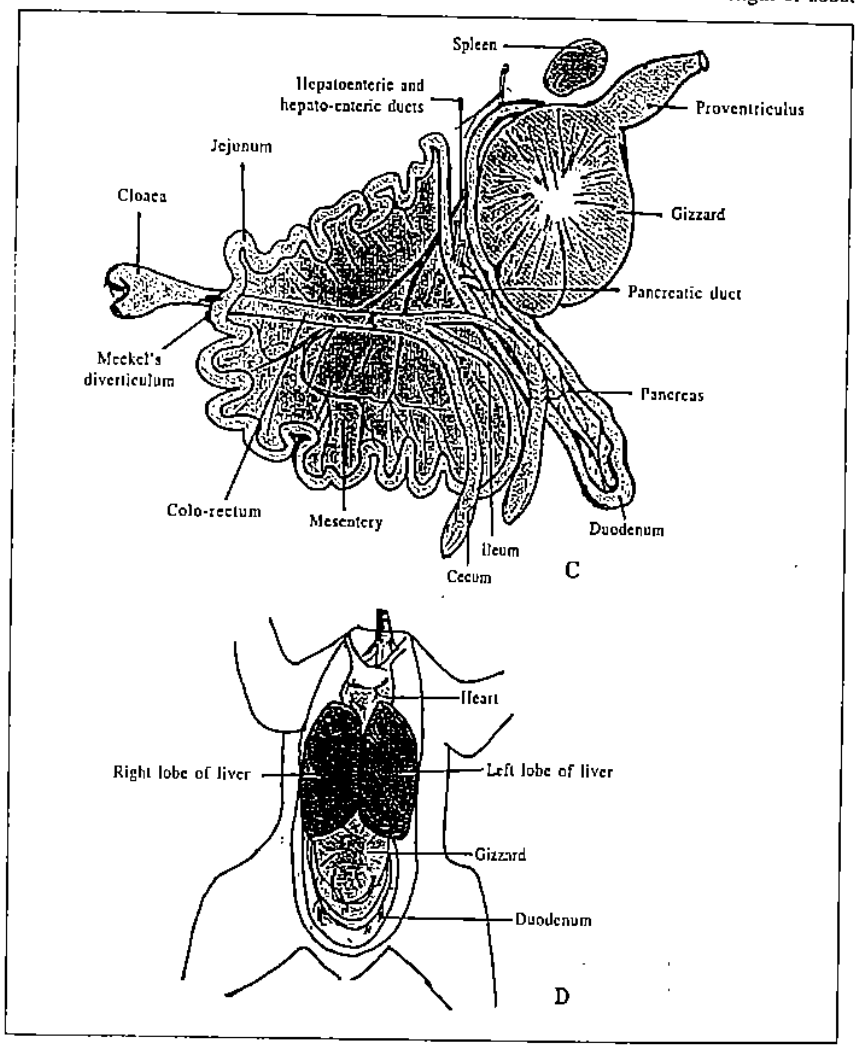


Fig. 6.39 C. Stomach and intestine of fowl ; D : Viscera in situ.

15 cm. They extend first cranially and then caudally parallel to the ileum. Each cecum has three parts – *proximal, middle* and *distal*. The proximal part is narrow and is connected with the intestine. Middle part is wide and the distal part is expanded. The distal part terminates in the form of a pointed end. The lumen of the ceca are wider than other parts of the intestine. The wall contains lymphoid tissue, mostly at the proximal part. This lymphoid tissue is known as **cecal tonsil**.

Colo-rectum—The striaght portion of the intestine which extend from ileum to the cloaca is termed colorectum. It is placed dorsally in the left part of the abdominal cavity. It has length of about 10 cm.

Cloaca

It comprises of three compartments – **coprodeum, urodeum** and **proctodeum**. However, these three chambers are not well distinguished in all birds. The caudal end of the colorectum expand to form the cloaca which lies in contact with caudal abdominal wall and opens to the outside through an opening, the *vent*.

Coprodeum is the first compartment and may be separated from colorectum by a mucous fold. Its lining mucosa contains villi.

Urodeum is the smallest of the three compartments. It is marked from others by the internal (cranial and caudal) folds. Urogenital ducts open on the dorso lateral wall of the urodeum. The ureters open dorsally and the genital ducts open laterally.

Proctodeum is also a short compartment. The cloacal bursa (**Bursa of Fabricius**) which is well-developed in immature birds situated at the dorsal aspect of the cloaca. It opens at the proctodeum at its dorsal surface. The organ is globular in shape and appears as a diverticulum from the proctodeum. It presents a narrow and irregular lumen and a thick wall. The wall accommodates lymphoid tissue in the form of small lobules in 10-12 folds. Therefore the external surface is found to be ridged. However the gland regresses with the advancement of age. The dorsal wall of the proctodeum also accommodates dorsal proctodeal gland. The mucosa is continuous with the skin. The anus in the birds is called vent which is guarded by dorsal and ventral lips.

STRUCTURE OF INTESTINE

The wall of the intestine is composed of serous, muscular, submucous and mucous layers. The muscular coat contains inner circular and outer longitudinal muscles. The submucous coat is composed of areolar tissue, vessels and nerves. Muscularis mucosae is present. The mucous of small intestine presents numerous folds and villi. The **duodenal glands (Brunner's)** are present at the first part of the small intestine. The number of **Peyer's patches (aggregated nodules)** are about 20-40 in cow and pig. They are arranged in the form of bands. They are about 100 in horse and 20 in dog.

There is no villi in the mucous membrane of large intestine. The intestinal glands are present throughout the tube. In the horse the bulk of the muscular coat is more at the bands of cecum and colon. In the rectum of horse the mucous membrane is loosely attached to the muscular layer and thereby presents numerous folds in empty condition.

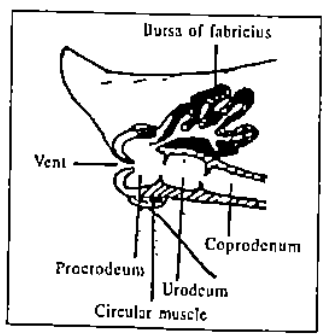


Fig. 6.40 Cloaca.

SALIVARY GLANDS

There are three pairs of salivary glands — *Parotid, Mandibular* and *Sublingual*.

Parotid Gland

It is triangular long reddish brown gland situated on the massater muscle along the caudal border of the vertical part of the ramus of mandible. Average weight is about 100 gm. Dorsal end is broad and placed close to the base of the ear. Ventral end is narrow and directed in front. The lateral surface is related to zygometaco-auricularis muscle at the base and parotido-auricularis muscle along the vertical length. The medial surface is related to parotid lymph gland, stylohyoid bone, massater, occipitohyoideus and digastricus muscles, external carotid artery, external jugular vein and superficial temporal nerve. Facial nerve passes through the parenchyma of the gland. The **Stenson's (parotid) duct** leaves the gland at its medial aspect of the ventral part, goes forward on the medial side of the ventral border of mandible between the massater muscle in front and external maxillary vein behind. It passes to the lateral surface at the vascular groove of the mandible, runs upward and forward between the anterior border of massater muscle and facial vein, pierces the buccinator and opens at the base of papillae salivalis opposite to second molar tooth of upper jaw.

Blood supply—From external carotid.

Nerve supply—From Glossopharyngeal, facial and sympathetic.

Mandibular Gland

It is an elongated pale yellow lobulated gland situated along the medial side of the angle of the mandible. It is longer than parotid and extends from the level of the wings of atlas to the basihyoid at

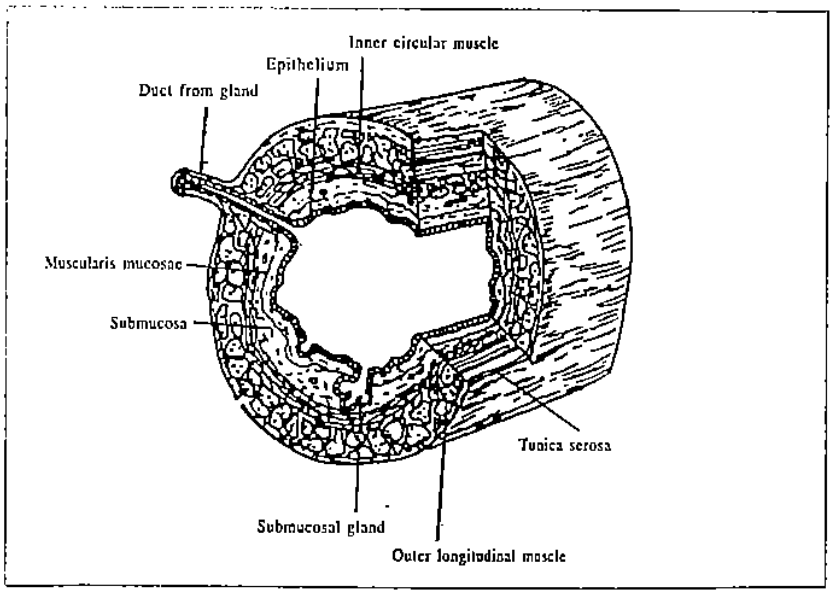


Fig. 6.41 Structure of the wall of intestine (Diagramatic).

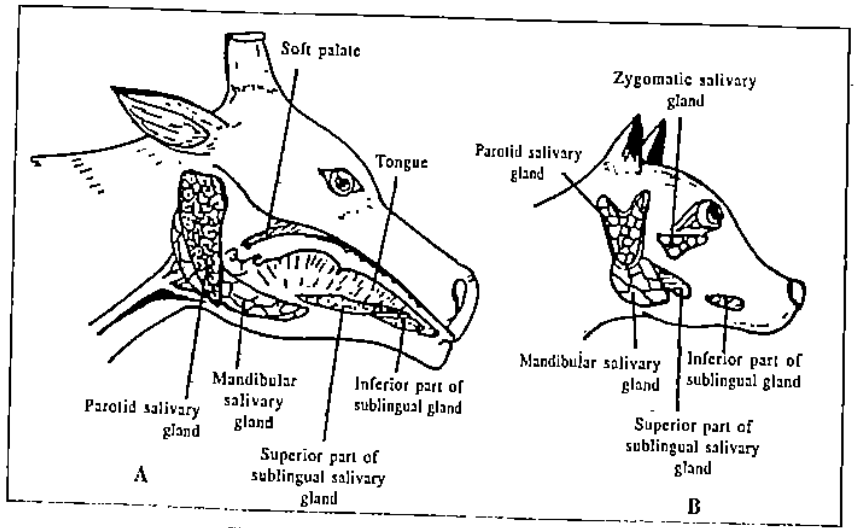


Fig. 6.42 Positions of salivary glands (A, ox, B, dog).

the intermandibular space. It weighs about 130 to 150 gms. Lateral surface is related to parotid gland, maxillary and facial veins, lymph nodes, sternomandibularis muscle and the angle of the mandible. The medial surface is related to lymph nodes, pharynx, larynx, carotid artery and 10th, 11th and 12th cranial nerves. The dorsal end is pointed. The ventral end is rounded and placed close to the opposite gland. Dorsal border is concave and the ventral border is convex. The **Wharton's (mandibular) duct** leaves the gland at the middle of the dorsal border, runs between mylohyoideus and hyoglossus muscles and then along the deep face of genioglossus. It passes through sublingual gland, goes further forward along the floor of the mouth and open at the caruncula sublingualis.

Blood supply—Branches of facial and lingual arteries.

Nerve supply—Branch of 7th cranial nerve and from sympathetic.

Sublingual Glands

There are two separate parts in each gland – superior and inferior. The **superior (polystomatic)** is a lobulated pale yellow gland situated under the mucous membrane of the floor of the mouth and extends from the mandibular symphysis to the palatoglossal arch. Laterally it is related to mylohyoideus muscle and medially to stylo – glossus and genio-glossus muscles. Its numerous ducts open at the base of the papillae situated in a line on either side of the frenum linguae at the floor of the mouth.

The **inferior (monostomatic)** is a pink coloured gland extended from the mandibular symphysis to the level of the last premolar tooth. It is thicker and shorter than the superior gland and is situated below it. There is only one duct for this gland which either joins the mandibular duct or opens separately at the base of the caruncula sublingualis, close to the opening of the mandibular duct.

Blood supply—Branch of sublingual artery.

Nerve supply—Branches of 7th and 5th cranial nerves.

Salivary glands of horse

1. Parotid gland is the largest of all the salivary glands.
2. Medial surface is related to guttural pouch in addition.
3. The parotid duct opens opposite to last upper premolar tooth.
4. Caruncula sublingualis is situated opposite to canine tooth.
5. Sublingual gland is single.
6. The ducts (about 30) of sublingual gland open at the base of small papillae at the sublingual fold.

Salivary glands of dog

1. Parotid is triangular in shape and its dorsal border is notched.
2. Parotid duct opens opposite to upper 3rd premolar tooth.
3. Mandibular gland is larger than parotid.
4. The sublingual glands are two in either side and the ducts are arranged similar to those of ox.
5. **Zygomatic salivary gland** is an extra (4th pair) gland found in this animal, situated at the anterior part of pterygopalatine fossa. Its ducts (4 to 5) open into the mouth opposite to last upper molar tooth.

Salivary glands of pig

1. Parotid gland is large and triangular. Parotid duct opens opposite to 4th or 5th upper check tooth.
2. Sometimes small accessory parotid duct is found.
3. Mandibular gland is small.
4. Sublingual gland has rostral polystomatic and caudal monostomatic parts like those of ox.

Salivary glands of rabbit

1. Rabbit has 3 pairs of salivary glands – Parotid, Sublingual and Infraorbital.
2. Mandibular glands are absent.
3. Parotid duct opens behind upper incisors.
4. Infraorbital gland lies below eye and its ducts open near upper molars.

Salivary glands of fowl

1. There are a *number of* salivary glands in fowl.
2. Ducts of some glands (Maxillary, Palatine, Cranial lingual, Submandibular and Angular) open into the mouth.
3. Others salivary glands (spheno pterygoid, caudal lingual, caudal submandibular, laryngeal) open into the cavity of pharynx.
4. Maxillary and Angular glands are monostomatic and the other are polystomatic.

LIVER

It is the largest solid gland of the body. In fresh condition it is reddish brown in colour. The weight is about 3 to 5 kg in a adult cow. It is placed in the right side of the abdominal cavity in

an oblique downward and forward direction. The gland extends from lumbo costal angle to the level of 7th to 8th rib and is kept attached in the abdomen with five ligaments. It presents two surfaces and four borders.

This organ develops from the ventral surface of the midgut as an outgrowth known as hepatic diverticulum, close to point where it is continuous with yolksac. The diverticulum proliferates to form liver. The connective tissue is formed from mesoderm.

Parietal surface—It is convex and most of this surface remains moulded with the abdominal surface of the right part of the diaphragm. The falciform ligament which extends from the oesophageal notch to the umbilical fissure along this surface, attaches the liver with the diaphragm. A portion of this surface is again attached directly to the diaphragm without being covered by serous membrane along a triangular area at the right lumbo costal angle. Caudodorsally this surface bears some impressions of ribs where diaphragm is closely associated with thoracic wall.

Visceral surface—It is concave and presents impressions of different organs and the portal fissure. The portal fissure is situated above the omasal impression. This area also gives attachment to the Pancreas. Omasal impression is large and deep. It is placed below the portal fissure. Reticular impression is narrow and shallow. It extends from the esophagial notch to the anterior part of ventral border of liver. Behind the reticular impression an abomasal impression is present at the ventral aspect of this surface. The cystic impression is found above and lateral to the omasal impression in many cases. The **lesser omentum** extends from the esophagial notch to the portal fissure. It attaches the liver with the omasum, pyloric end of abomasum, part of duodenum and pancreas. **Porta hepatis or portal fissure** is in the form of a linear depression which serves the purpose of hilus of the organ. It transmits portal vein, hepatic artery, bile duct and nerve fibers. A number of lymph nodes and portions of pancreas are attached to the fissure.

The borders are dorsal, ventral, lateral and medial. The dorsal border is thick. It presents the **caudate lobe** and the **renal impression**. The caudate lobe is connected with the right kidney by the

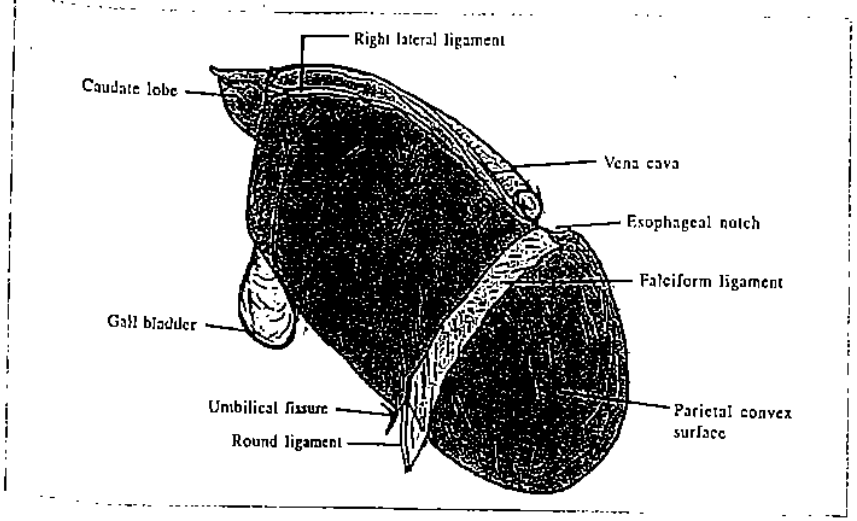


Fig. 6.43 Parietal surface of liver of ox.

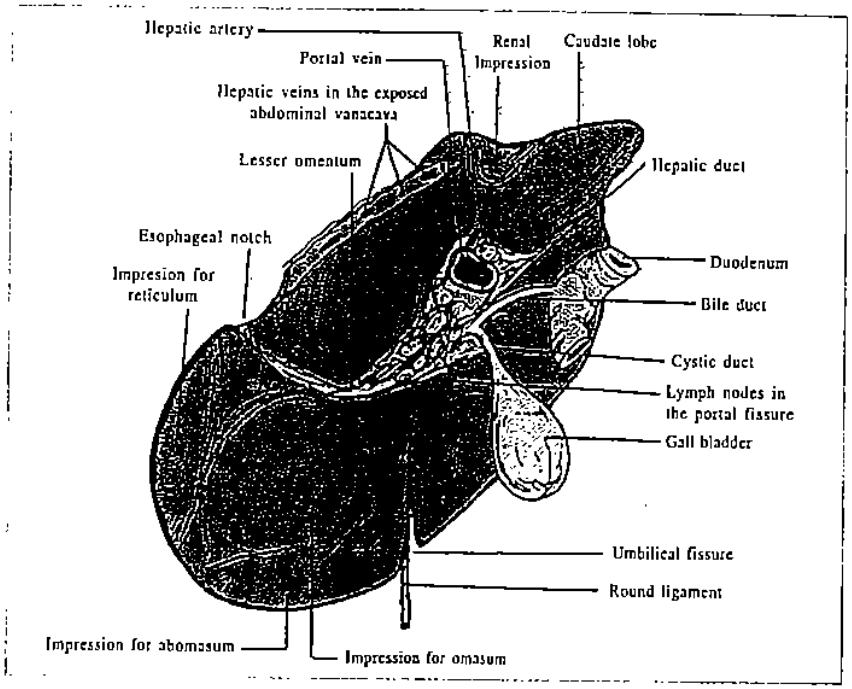


Fig. 6.44 Visceral surface of liver of cow.

caudate ligament and helps in the formation of renal impression. The renal impression is deep and gives accommodation to the right adrenal gland and cranial end of right kidney. Ventral border is convex and thin. The lateral or the right border is thin and is marked by the **umbilical fissure**. The **round ligament** extends from this fissure to the umbilicus. It is the vestigial umbilical vein. The medial or left border is thick and presents a notch for the passage of esophagus. Above the **esophageal notch** the posterior venacava passes caudally by embedding itself partially in the body of the liver. The hepatic veins (3 to 5) open directly into the venacava at this border.

Smaller hepatic ducts from different parts of main lobe and from caudate lobe join together to form the hepatic duct. **Hepatic duct** comes out of the liver through the portal fissure. Just after its exit a smaller duct arises from it and continue to the neck of the gall bladder, known as **cystic duct**. The ***gall bladder*** is a 12-15 cm long pear shaped musculo-membranous sac situated at the visceral surface of the liver above the omasal impression. When distended with bile a part of it remains in contact with the abdominal wall at the middle part of 10th or 11th intercostal space. The gall bladder presents three parts—Fundus, Body and Neck. The neck becomes continuous with cystic duct. Gall bladder not only functions as storage of bile but helps in concentration of bile, regulation of pressure in biliary system and in secretion of mucin. The ***bile duct*** is formed by the union of hepatic duct and the cystic duct. The bile duct opens into the duodenum at its second bend about 60 cm away from the pyloric end of stomach. In sheep and goat the pancreatic duct joins with the bile duct before opening into the duodenum without foramation of any ampula.

The hepatic ducts, common hepatic duct, gall bladder, cystic duct and bile duct are collectively known as *Extra hepatic biliary apparatus*.

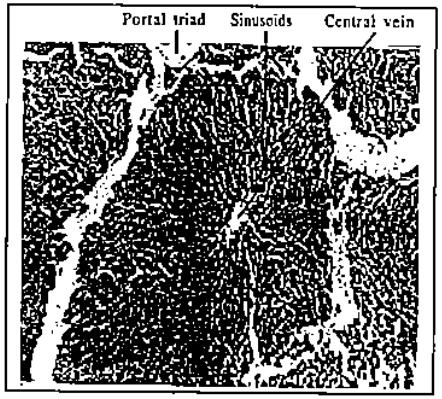


Fig. 6.45 Microscopic structure of Liver, showing inter lobular space.

The ligaments of the liver are as follows :

1. ***Falciform or anterior ligament***—It attaches the parietal surface of the liver with the diaphragm.

2. ***Right lateral ligament***—It connects dorsal part of the liver to the caudal part of diaphragm.

3. ***Round ligament***—It connects the umbilical fissure of liver to the umbilicus.

4. ***Caudate ligament***—It attaches the caudate lobe of the liver to the right kidney, abdominal venacava and part of pancreas.

5. ***Lesser omentum***—It is attached along the portal fissure and extends up to the esophageal notch. It connects the liver with the omasum and lesser curvature of abomasum.

Most of these ligaments of liver are derived from the folds of peritoneum.

Structure

After covering the whole gland the serous coat enters into the substance of the liver through the portal fissure along with the structures entering or leaving the gland to form interlobar connective tissue. The parenchyma comprises of a number of small lobules, separated by connective tissue. The hepatic cells are arranged in cords in a radiating manner from the central vein. The triangular space between the lobules accommodate small branches of hepatic artery, portal vein and bile ducts.

Under microscope each lobule appears as a polygonal areas whose center is occupied by the central vein. Each lobule is about 1 mm in diameter and composed of rows of hepatic cells radiating from the center. These lobular arrangements are better observed in pigs. Groups of three tubes which comprises of a interlobular branch of hepatic artery and portal vein and an interlobular bile ductule enclosed in a perivascular connective tissue (portal canal) are found in the spaces in between the lobules. These are known as **portal triads.**

Liver receives about 80% blood from portal vein and about 20% from hepatic artery. Within the liver they devide to form segmental vessels and redivide into inter-lobular vessels, which run into portal canal as stated above. Further divisions open into the hepatic sinusoids. Thus in the hepatic sinusoids both arterial and venous blood mix. The hepatic sinusiods are lined by kupffer cells which are phagocytic and presents clefts between them. During active phase each radiating column of hepatic cells has a vascular capillary in one side which joins the central vein and a bile capillary on the other side. The bile capillary goes out of the lobule to join bigger bile channel (ductule).

According to current concept the central vein of the lobule is surrounded by a single layer of liver cells forming inner limiting plate. Liver cells radiate from the inner limiting plate as sheets of cells known as hepatic laminae which are one cell thick, frequently branched and perforated. At the periphery of the lobule the hepatic laminae join with one another and form outer limiting plate which is also

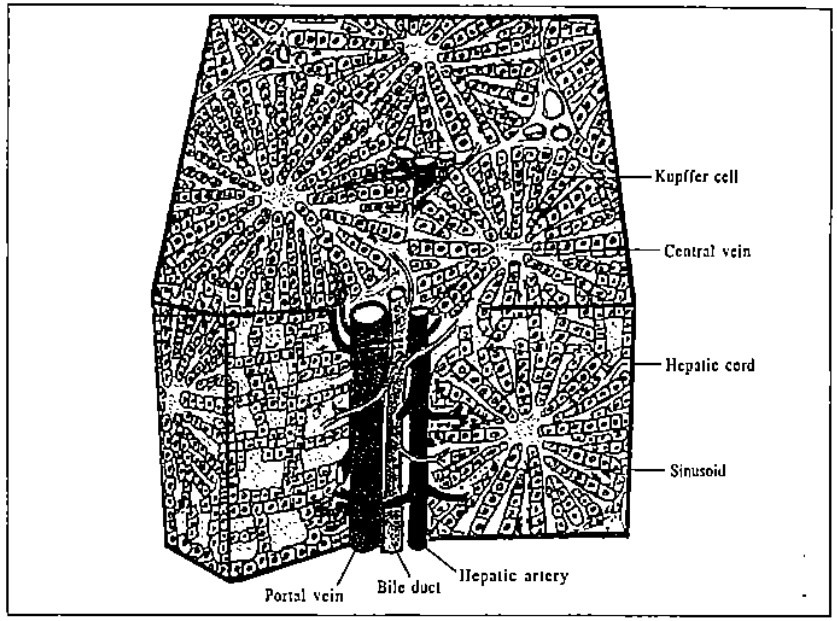


Fig. 6.46 Three dimentional microscopic figure of liver .

perforated for passage of vessels. The spaces between the laminae are known as hepatic lacunae which are occupied by hepatic sinusoids.

Blood supply—Nutritional—Hepatic artery

Functional—Portal vein

Liver receives approximately 20% blood from hepatic artery and 80% from portal vein. Due to absence of lymphatic pathways from liver to gall bladder, it rarely become involved in the malignancy of liver.

(For hepatic circulation *see* portal vein)

Nerve supply—From hepatic plexus.

Liver of horse

1. The organ is extensive and comparatively thin. Weight is about 5 kg.

2. It is placed obliquely on the abdominal surface of the diaphragm and the major part is being situated at the right side of the median plane.

3. The fissures of the ventral border have divided the liver into three main lobes – *right lobe, left lobe* and *the middle lobe.* The right lobe possesses the caudate lobe and process.

4. **Gall bladder is absent.**

5. Hepatic duct is about 5 cm. long and opens directly into the duodenum, 12 to 15cm. behind the pyloric end of stomach.

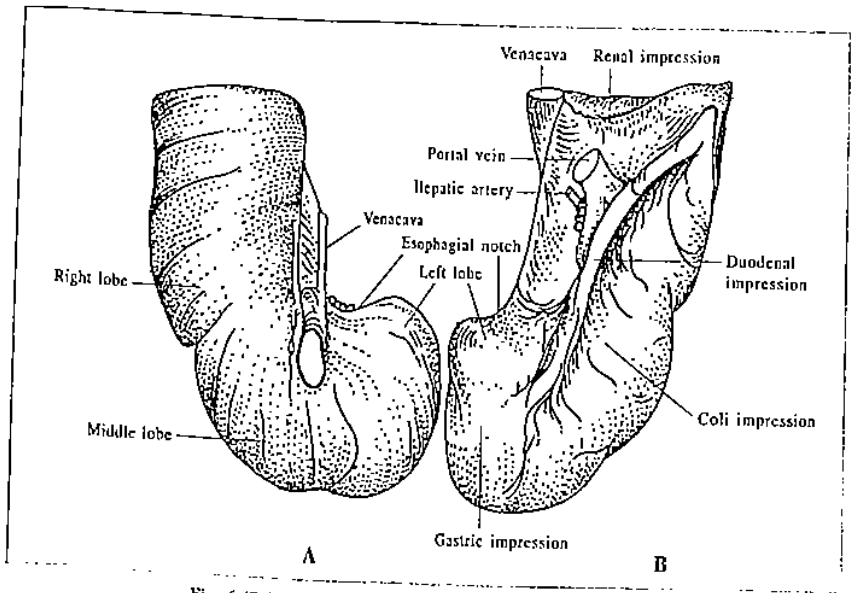


Fig. 6.47 A. Parietal and B. Visceral surface of liver of Horse.

6. Hepatic duct and pancreatic duct together open side by side into the duodenum at a place known as hepato pancreatic ampula.

7. Both the left and right borders are thin.

8. There is an extra left lateral ligament which connects the left lobe with the diaphragm.

Liver of dog

1. It consists of five lobes – **Left lateral, left central, right lateral, right central** and **caudate.**

2. The gall bladder is situated in a depression at the right central lobe.

3. The bile duct opens into the duodenum 5 to 7 cm behind the pylorus. Sometimes an accessory pancreatic duct joins with the bile duct and opens commonly into the duodenum. Occasionally the accessory pancreatic duct opens to the duodenum separately. In some breeds of dogs few smaller hepatic ducts join the bile duct directly without joining main hepatic duct.

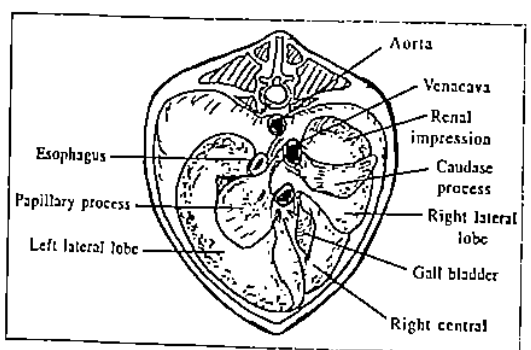


Fig. 6.48 Transverse section of the abdomen of dog showing visceral surface of liver.

4. This organ is larger in size in comparison to other domestic mammals.

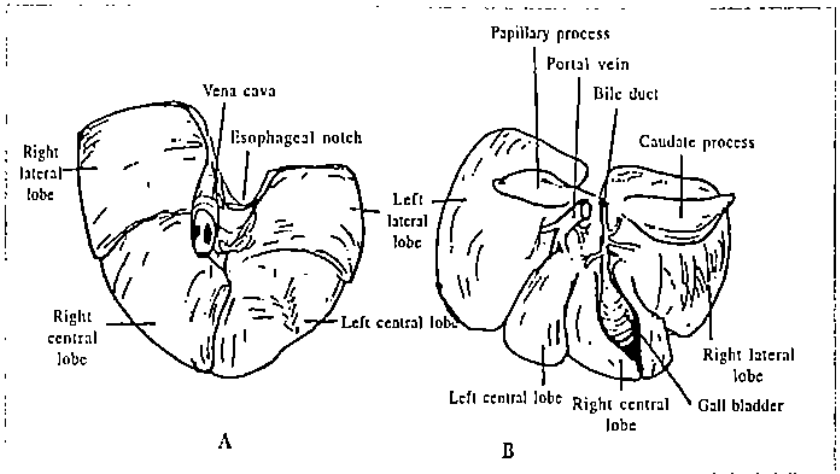


Fig. 6.49 A Parietal and B. Visceral surface of liver of dog.

5. The caudate lobe has two parts-one on the right side, the *caudate process* and the other on the left side the *papillary process.*

6. The parietal or diaphragmatic surface is highly *convex* and the visceral surface is irregularly *concave.*

Liver of pig [Fig. 6.27]

1. It comprises of 4 main lobes and a small caudate lobe. The main lobes are right lateral, right central, left lateral and left central.

2. The gland is comparatively large in size.

3. The gall bladder is placed in a depression on the right central lobe.

4. The bile duct opens at a papilla on the duodenum about 3 cm from pylorus.

5. The diaphragmatic surface is highly convex.

Liver of rabbit

1. It is extensive and comprises of 5 lobes.

2. Gall bladder is situated in a depression at the visceral surface of right central lobe.

3. Diaphragmatic surface is convex.

4. The renal impression at the right lateral lobe is wide and deep.

5. Parietal surface is convex and applied against diaphragm and the visceral surface is concave which partially accommodates the stomach.

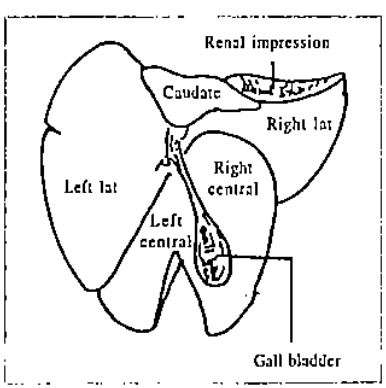


Fig. 6.50 Visceral surface of the liver of rabbit.

Liver of fowl

1. The liver comprises of two separate lobes–*left* and *right* which are connected ventrally by a double fold of peritoneum.

2. The lobes are situated at the floor of the abdominal cavity. As the diaphragm is rudimentary, the cranial ends of the lobes are very close to the heart.

3. The parietal surfaces are convex and the visceral surface is concave. This surface has impression of many viscera along with the stomach.

4. Right lobe has a large gall bladder. The left lobe has no gall bladder. The hepato-cystic duct of the right lobe and the hepato enteric duct of the left lobe open into the distal part of the ascending limb of duodenum separately, close to the openings of pancreatic ducts.

PANCREAS

It is a soft gland situated mostly at the right side of the median plane and is attached to the visceral surface of liver by the layer of mesentery. The colour of the gland is reddish yellow and the weight is about 350 to 500 gm. It is flat and irregularly quadrilateral in shape and has two surfaces and four borders. Dorsal surface is attached to diaphragm and liver and mostly covered by peritoneum. Other than liver and crura of diaphragm, this surface is related to right kidney, abdominal vena cava and celiac and mesenteric arteries. The ventral surface is related to dorsal sac of rumen, colon, hepatic artery, portal vein and some lymph glands. The borders are anterior, posterior, lateral and medial. Anterior border is more or less straight. Posterior border is notched for the accommodation of portal

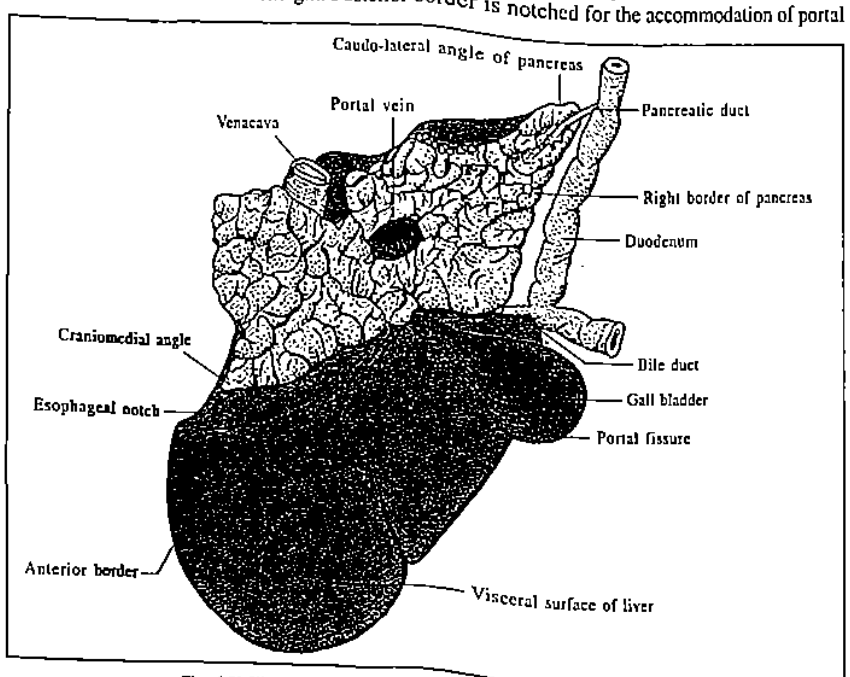


Fig. 6.51 Visceral surface of liver of ox showing the pancreas.

vein. Right border is long and is placed to some extent parallel to the duodenum (second curve). Left border is irregular and convex.

Histological Structure :

This is a compound (serous and tubulo acinar) gland and is composed of both exocrine and endocrine parts. This is covered by a thin layer of connective tissue which enters the gland and subdivides the gland into a number of lobules. Each lobule consists of numerous acini which are the ultimate ramifications of pancreatic duct. Each acinus is composed of several pyramid shaped cells possessing round nuclei at their bases and zymogen granules at the apical parts. Some small cells are located at the center, called centroacinar cells. Each acinus is connected to a duct known as intercalated duct. Numerous intercalated ducts join to form collecting duct. Few collecting ducts join to form pancreatic duct. The **islets of Langerhans** are the endocrine parts of the gland. These are the ovoid masses of cells which are dispersed throughout the entire organ. The cells are smaller than acinar cells and are arranged in groups, richly vascularised with capillaries. The islets contain peripherally placed glucagon secreting **Alpha cells**, centrally placed insulin secreting **Beta cells** and somatostatin and gastrin secreting **Delta cells**. However, these cells are only observed by special stains.

The pancreatic duct arises from the posterior part of the right border and opens into the duodenum about a foot behind the opening of bile duct. In some animals one small additional pancreatic duct drains the left lobe of pancreas and joins the bile duct. In small ruminants only one pancreatic duct is present. It joins with bile duct to open into the duodenum.

Blood supply—Branches of celiac, hepatic and ruminal arteries.

Nerve supply—From celiaco-mesenteric plexus.

Pancreas of horse

1. It is roughly triangular in shape.

2. It is situated transversely at the dorsal portion of the abdominal cavity mostly at the right side of the median plane.

3. Ventral surface is related to cecum and colon.

4. Pancreatic ducts are two in number. The large one opens into the duodenum by the side of the hepatic duct at the hepato-pancreatic ampula. The smaller pancreatic duct opens into the duodenum on a papilla opposite to the large duct.

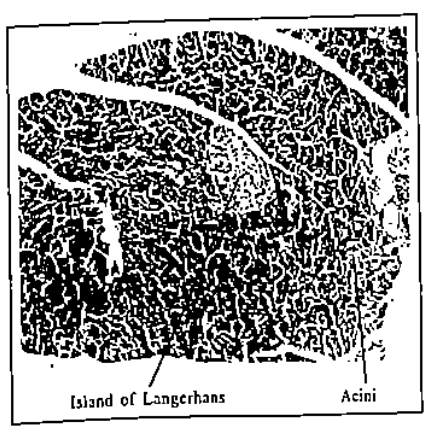


Fig. 6.52 Microscopic structure of pancreas.

Pancreas of dog

1. It consists of two branched parts–*right* and *left*.

2. Both the parts meet together behind pylorus and form a V shaped structure which extends caudodorsally, mostly up to the corresponding kidneys.

3. Generally there are two pancreatic ducts. The *main duct* opens into the duodenum, 4 cm

behind the opening of bile duct. The *accessory duct* usually joins the common bile duct or opens into the duodenum separately.

Pancreas of pig

1. It is triangular in shape.
2. The left lobe is related to stomach and the right lobe is attached to the duodenum.
3. The parenchyma contains good amount of fat.
4. Pancreatic duct opens into the duodenum about 10 cm from pylorus.

Pancreas of rabbit

1. It is a diffuse and delicate gland in this animal.
2. The gland is situated in the fold of mesentery passing accross the loops of duodenum.
3. The pancreatic duct single.

Pancreas of fowl

1. It is an elongated slight lobulated yellowish-red coloured gland.
2. The gland is placed between the ascending and descending parts of duodenum.
3. It comprises of a dorsal, a ventral and a third lobe.
4. 2 to 3 pancreatic ducts open into the ascending part of duodenum close to the openings of bile ducts.

SPLEEN

Spleen is a hemo-lymph organ situated obliquely downward and forward direction in the upper end and left part of the abdomen between the left face of the rumen and diaphragm. It filters bood and lymph. The organ forms erythrocytes in fetal life and lymphocytes after birth.

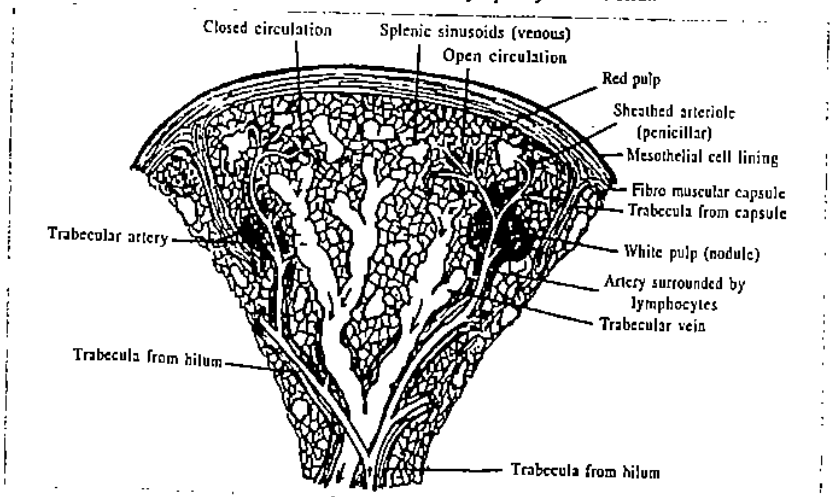


Fig. 6.53 Schematic diagram of a section of spleen showing splenic circulation.

It is elliptical in outline, 2 to 3 cm in thickness, 50 cm in length and about 15 cm in width. Average weight is about 900 gms. It presents two ends, two surfaces and two borders.

Both the ends are thin and rounded. The dorsal end is situated below the proximal end of last two left ribs and the ventral end is usually situated below the lower third of 8th and 9th ribs. The position of the ventral end is variable. The parietal surface is related to diaphragm and is convex. A small portion of this surface near the anterior border is devoid of peritoneal covering and is directly attached to the diaphragm. Visceral surface is concave and related to the left surface of rumen. Anterior border is little concave. The hilus is situated at the upper part of the visceral surface, close to the anterior border.

Histological structure of spleen

The spleen tissue is surrounded by a fibrous capsule containing smooth muscle cells. From the capsule fibromuscular trabeculae extend towards parenchyma of the gland. Externally the capsule is covered by the peritoneum. Also from the hilus many trabeculae carrying blood vessels radiate into the organ. The arteries leave the trabeculae and become surrounded by reticular tissue and lymphocytes and constitute the white pulp. In some places the lymphocytic infiltration is greater and appear as a large white pulp in histological section, known as splenic nodule.



Fig. 6.54 Microscopic structure of spleen.

The splenic tissue containing splenic sinusoids and splenic cords infiltrated with circulating blood is known as **red pulp.**

From the white pulp the arterioles enter the red pulp and subdivide into few radiating branches. These are called **penicillar vessels** and subsequently divide into capillaries. Before formation of the terminal capillaries each artery become sheathed by reticular cells. These are also called **ellipsoids.** According to the open theory these capillaries open in the splenic tissue of red pulp and from there the blood cells percolates into the venous sinus. As per closed theory arterial capillaries directly open into the splenic venous system.

Blood supply—Splenic artery.

Nerve supply—From splenic plexus.

The main functions of the spleen are **phagocytosis, haemopoieses, immune response** and **storage of RBC.**

Spleen of horse

1. It is roughly triangular in shape.
2. The organ is placed at the anterior and left part of the abdomen between the fundus of stomach and diaphragm.
3. Parietal surface is convex and the visceral surface is divided into two unequal areas by a ridge along its long axis.
4. Hilus is situated at a groove in the ridge near the base.
5. The broad proximal end is the base and the pointed ventral end is the apex of the organ.
6. The visceral surface has gastric impression in front and intestinal impression behind the ridge.

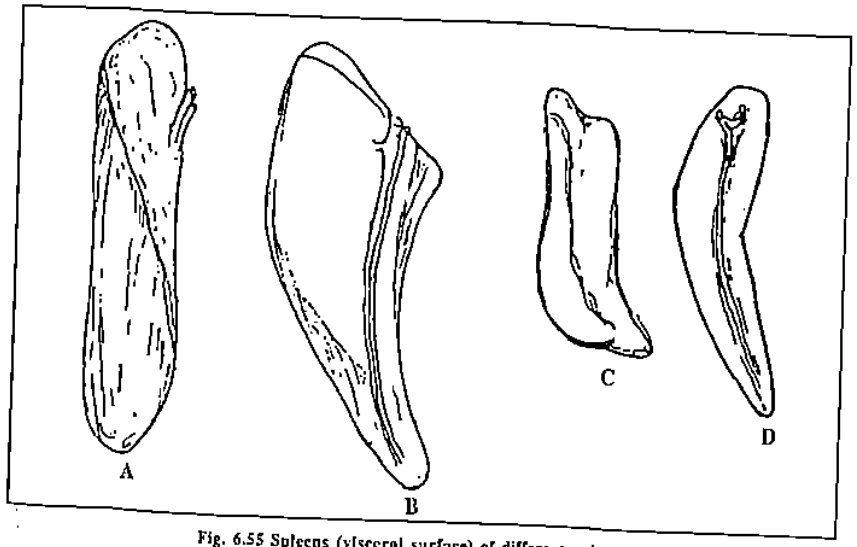


Fig. 6.55 Spleens (visceral surface) of different animals.
A. Spleen of Ox B. Spleen of horse C. Spleen of dog D. Spleen of pig

Spleen of dog

1. It is roughly a human foot-print shaped structure. Its ventral end is wider than dorsal end.
2. Its position is veriable except the upper end which is placed below the proximal end of last rib.
3. Parietal surface is convex and the visceral surface is concave. The hilus is placed in the ridge, which is situated along the length of the organ at its visceral surface.

Spleen of pig

1. It is a long and narrow structure extends dorsoventrally along left part of the greater curvature of stomach.
2. Length is about 50 cm width is about 7 cm and weight is about 300 gms.
3. Visceral surface is concave, presents a ridge and the hilus at the upper part.
4. Parietal surface is smooth and convex.

Spleen of rabbit

1. It is elongated and spatula shaped structure. Length is about 3 cm.
2. Colour is dark brown.
3. Proximal end is pointed and the distal end is blunt.
4. Anterior border is convex and the posterior border is irrigular.
5. It is extended dorsoventrally along the greater carvature of stomach.

Spleen of fowl

1. It is a small round reddish brown organ.
2. The organ is situated at the right side of the junction between proventriculus and gizzard.
3. Sometimes an accessory spleen is found.

THE RESPIRATORY SYSTEM

The components of the respiratory system are respiratory passages and lungs. The nose, pharynx, larynx, trachea and bronchi are continuous open passages to the lung and therefore, called respiratory passages.

NOSE/NASAL CAVITY

It is the first part of the respiratory passage and extends from exterior to nasopharynx. This bilateral irregular tubular passage is enclosed by facial bones and cartilages. The external openings are known as *anterior nares* (nostrils). These are comma shaped oblique openings placed on either ends of the muzzle. These are close together below than above. Nostrils are supported by alar cartilage and the rostral part of the cartilagenous nasal septum. The alar cartilage forms the dorsal wall by its lamina and lateral wall by its cornu and transverse bar which looks like an anchor. The medial wall is formed by nasal septum. The skin on the dorsal and lateral walls are covered by haris and the skin between, around and the lining of the nostrils is devoid of haris and remains moist. The nasal septum is a midline partition placed vertically which divides the nose into two cavities. Its posterior part is osseous and is formed by ethmoid and vomar bone. The anterior part is cartilagenous. This septal cartilage dorsally connected with nasal bones. It is expanded on either side to form **dorsolateral cartilages** and makes the roof. The posterior part of the roof is formed by the cells and cribriform plate of ethmoid bone. The ventral border of the septal cartilage is fitted with the groove of the vomar and connected to the palatine process of premaxilla. The anterior parts of the ventral border is expanded bilaterally to form **ventral lateral cartilages**. The floor of the nasal cavity is formed by palatine maxilla and premaxilla. The posterior nares *(choanae)* are thick slit like apertures, connect the nasal cavities with the nasopharynx.

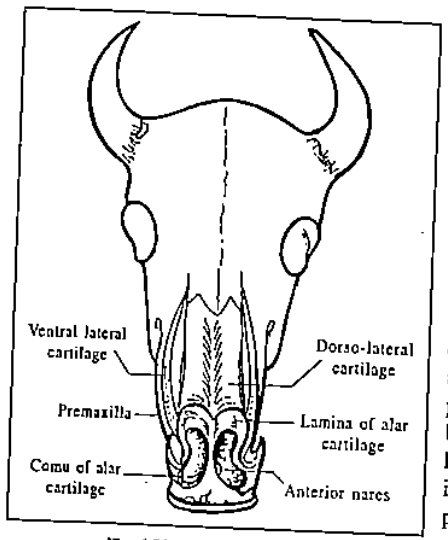


Fig. 6.56 Cartilages of nose.

Major portion of each half of the nasal cavity is occupied by dorsal and ventral *turbinate bones* (concha). These bones are projected from the lateral walls of the cavity and form dorsal middle and ventral meatus between the roof and dorsal turbinate, between the dorsal and ventral turbinates and between the ventral turbinate and floor respectively. The middle meatus is divided posteriorly into two for the presence of ethmoturbinate bone. The upper one communicates with the frontal sinus and the lower one is connected with maxillary sinus. However, there is a common space between the median septum and the turbinate bones. The whole of the cavity is lined by mucous membrane. The anterior $^3/_4$th part is the respiratory portion and the posterior $^1/_4$th part is the olfactory portion of the mucous membrane. The mucous membrane is closely attached to the perichondrium or periosteum. It is continuous with the conjunctiva through naso lacrimal duct, with the paranasal sinuses by their openings and with the pharynx by choanae.

The Vomaro-nasal organ (organ of Jacobson) are in the form of two small tubes, each of which is placed along the ventral border of nasal septum. They open in the oral cavity on either side of the papilla incisiva along with those of incisival ducts. Other ends of the tubes are blind. The two incisival (naso palatine) ducts are small and extend from the floor of the nasal cavity to the papilla incisiva. The nasal opening of nasolacrimal duct opens on the medial surface of the alar fold of the ventral nasal concha.

Blood supply—Sphenopalatine, ethmoidal and palatine arteries.

Nerve supply—Branches of olfactory and trigenimal nerves.

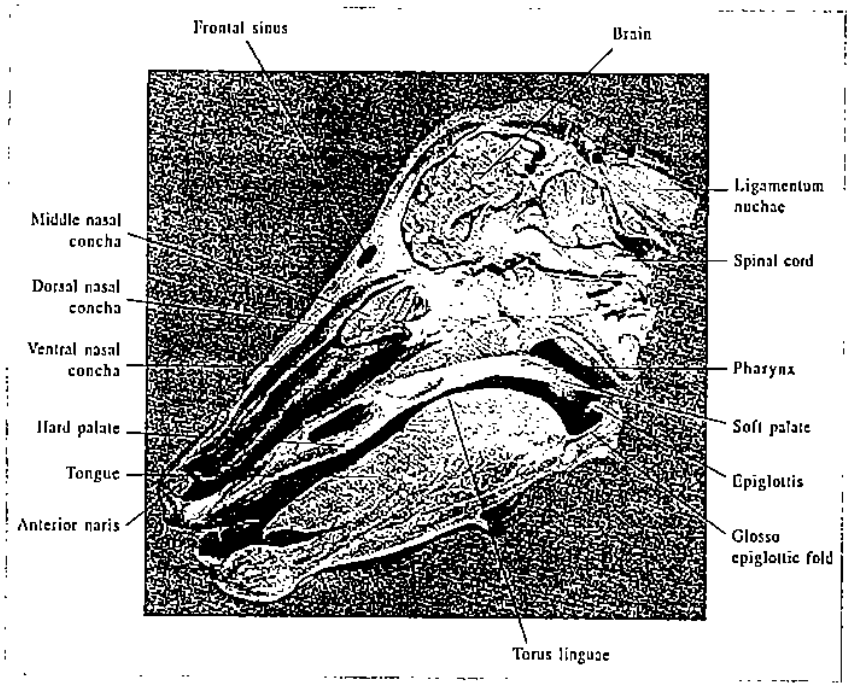


Fig. 6.57 Sagittal section of head of ox.

PHARYNX

The air that passes through nasal cavities reaches the nasopharynx and oropharynx to enter the larynx. The pharynx has been described in the previous chapter.

LARYNX

It is an elongated musculo-cartilaginous compartment situated between the pharynx and trachea. The roof is related to the pharynx and the begining of esophagus. The lateral walls are in relation to omohyoideus and sternomandibularis (constrictor) muscles. The ventral wall is related to sterno-thyro-hyoideus muscles.

The cartilages of the larynx are (1) *Thyroid*, (2) *Cricoid*, (3) *Arytenoid* and (4) *Epiglottis*.

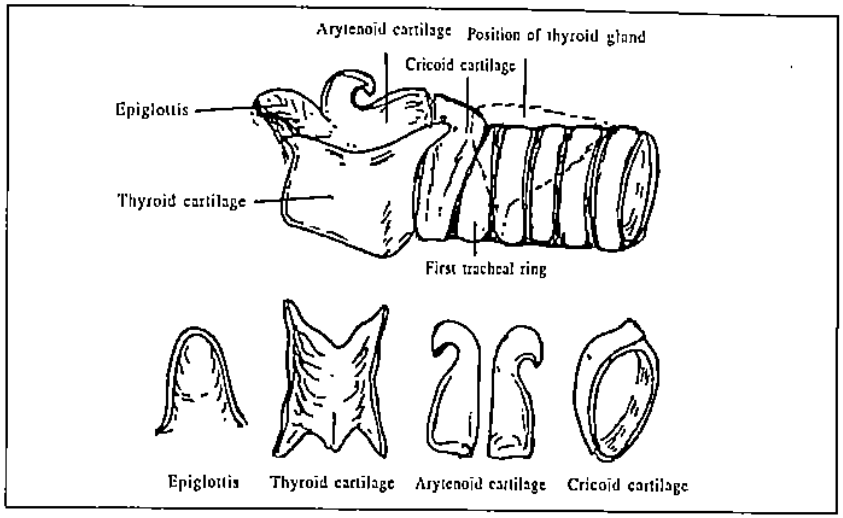


Fig. 6.58 Larynx of ox.

Thyroid cartilage—It is the largest of the four and forms the ventral and lateral walls of the larynx. It has a body and two laterally placed laminae. The dorsal surface of the body is related anteriorly with the base of epiglottis. The ventral surface presents a swollen area known as **laryngeal prominence**. The cranial angles of the lamina on either side are extended forward and upward. These are termed cranial cornua. The caudal cornua are blunt. Each cranial cornu articulates with the thyroid cornu of the hyoid bone. The caudal cornua articulates with the concerned aspect of cricoid cartilage. Ventral to the cranial cornu, a deep fissure forms a foramen with the help of fibrous tissue through which the cranial laryngeal nerve passes.

Cricoid cartilage—It is a signet ring shaped structure placed in front of first trachial ring and caudal to all other laryngeal cartilages. The dorsal broad part is the lamina of the cartilage.

Arytenoid cartilage—These are a pair of cartilages situated in front of the cricoid and form the caudal part of the roof of the laryngeal box. Each cartilage has three surfaces, a base and an apex. The surfaces are medial lateral and dorsal. The base is concave and articulates with the cricoid. The apex is free and curved backward and upward. The curved terminal part has been named as **corniculate cartilages** by some authors.

Epiglottis—This is a leaf or plate like structure and presents two surfaces, a base and an apex. The base is attached to the cranial part of the dorsal surface of thyroid cartilage by ligaments. The apex is free and curved forward and downward. The lingual surface is convexo-concave and is connected to the root of the tongue by a glossoepiglottic fold. The laryngeal surface is concave and smooth.

The cartilages of the larynx are functioned by a group of extrinsic and another group of intrinsic muscles. The extrinsic muscles are sterno-thyro-hyoideus, thyrohyoideus, and hyo-epiglottideus. There are four pairs of intrinsic muscles. These are crico-thyroideus, crico-arytenoideus posticus, crico-

arytenoideus lateralis and thyro-arytenoideus. Beside the paired muscles, there is one single arytenoideus muscle which is placed across the concave dorsal surfaces of the arytenoid cartilages.

Laryngeal cavity—It extends from the entrance of the larynx (aditus laryngis) to the caudal border of cricoid cartilage. The entrance is bounded ventrally by the epiglottis, laterally by lateral folds and dorso caudally by arytenoid cartilages. For description the cavity is divided into three parts – (a) *Vestibule*, (b) *Rima glottidis* and (c) *Caudal compartment*. Rima glottidis is the space between vocal cords. The space in front of rima glottidis is vestibule and the space behind is the caudal compartment.

Blood supply—Cranial and caudal laryngeal arteries.

Nerve supply—Laryngeal and recurrent laryngeal nerves.

TRACHEA

It is an elastic tube extends from larynx to the level of the base of the heart and is made up of cartilages and membranes. There are about 50 to 60 cartilages in the form of incomplete rings with the open end placed dorsally. The rings are completed by connective tissue and smooth muscle fibers of trachial muscle. The trachial tube is about 60 cm. long and terminates by bifurcating into two (right and left) bronchi at the base of the heart which enter into corresponding lung. For description it may be divided into a cervical part and a thoracic part.

Cervical part—It extends from the larynx to the level of thoracic inlet. The tube is dorsally related to the esophagus up to the level of 3rd cervical vertebra and then by longus coli muscles. Ventrally it is related to sterno-thyro-hyoideus muscles and laterally to the carotid artery, jugular vein, vagosympathetic trunk and recurrent laryngeal nerve. However, the dorsolateral aspect of the left side is related to the esophagus.

Thoracic part—It is situated at the dorsal aspect of the cranial mediastinum and a portion of the middle mediastinum. At the level of 3rd intercostal space it gives off an *extra bronchus* at the right side which ventilates the apical lobe of the right lung. This is known as apical bronchus. It is related dorsally to the esophagus and longus colli muscle; left laterally to the aortic arch, left axillary artery and thoracic duct; right laterally to the vagus and ventrally to the anterior venacava, brachiocephalic trunk and recurrent laryngeal nerves.

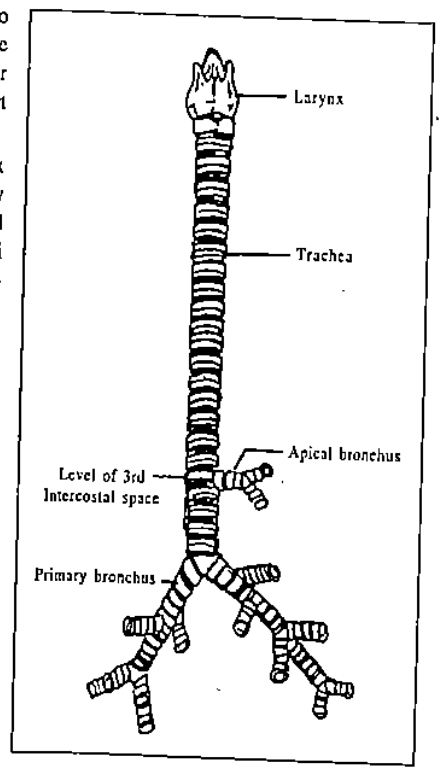


Fig. 6.59 Trachea of cow.

Structure—The trachea is composed of an outer fibrous adventitia, cartilagenous rings, a submucous coat and mucous membrane. The outer fibrous layer may possess some longitudinal muscle fibers on the dorsal wall. The cartilagenous rings are of hyaline in nature. The submucous coat has a good number of serous and mucous glands, occasional lymphoid follicles and plenty of elastin fibers. The mucous membrane is composed of pseudostratified ciliated columnar epithelium.

THORACIC CAVITY

It is a laterally compressed cone shaped cavity with an oblique and concave base which is directed backward. The cranial cone is the thoracic inlet. The inlet is an oval opening formed by 1st thoracic vertebra, first pair of ribs and the cranial end of the sternum. The base is formed by the diaphragm. Lateral walls are formed by the ribs and the thoracic muscles such as inter-costals, latissimus dorsi, Serratus thoracis, Serratus dorsalis anticus, Serratus dorsalis posticus, rectus thoracis, longissimus costarum *etc.* The roof is formed by the thoracic vertebrae, proximal ends of ribs and muscles such as longissimus dorsi, levator costarum and multifidus dorsi. The sternum, distal ends of costal cartilages along with the muscles such as transversus thoracis and pectorals from the floor of the thoracic cavity. The walls roof and the floor are externally covered by skin and subcutaneous tissue and internally lined by a serous membrane – the pleura. The contents of the thoracic cavity are lungs, heart, thoracic part of esophagus and trachea, begining of large vessels, lymphnodes, nerves and vessels. In younger animals it contains thymus.

PLEURA

This is a thin transparent serous membrane which encloses a lung and lines the interior of thoracic cavity. Out of the two separate sacs each comprises of a parietal and a visceral part. ***Costal pleura, diaphragmatic pleura*** and ***mediastinal pleura*** are the names of different parts of parietal pleura on the basis of their attachments with the concerned wall of the thorax. The visceral pleura which invests the surface of the lung is continuous with the parietal pleura at the root of the lung. The visceral pleura passes into the interlobar fissure and becomes blended intimately with the connective tissue framework of the lungs. The apex of each pleural sac is known as cupula. A part of the right pleura invaginates longitudinally to enclose the thoracic venacava, known as fold of venacava.

The pleural sacs always remain moist by the liquor pleurae, the secretion of the free surface of the membrane and therefore, provide a frictionless environment during inspiration. The pleura receives blood supply from the intercostal and bronchial arteries and nerve supply from vagus, sympathetic and intercostal nerves. The pleura is formed by a single layer of squamous mesothelial cells lying on a loose connective tissue layer. Numerous microvilli and few cilia are present on the free surface of the cells.

MEDIASTINUM

The right and left pleural sacs are separated from each other by an interpleural space at the midline – known as mediastinum. It extends from thoracic inlet to the diaphragm along the mid-axis of the thorax. Vertically the space extends from the vertebral column to the sternum. The cavity is imaginarily divided into three portions – cranial, middle and caudal. The space in front of the heart is the cranial mediastinum. It contains esophagus great vessels, lymph glands, vagus, phrenic and cardiac nerves. In fetus and young animals it also contains thymus. The middle mediastinum is occupied by heart, origin of great vessels, esophagus, bifurcating trachea, vagus and phrenic nerves. The caudal mediastinum is the space behind the heart. It accommodates the abdominal aorta, venacava, esophagus, vagus and phrenic nerves.

LUNGS

Lungs are a pair of main organ of respiration. They occupy most parts of the thoracic cavity and are separated by mediastinum. Each lung invaginates into the corresponding pleural cavity and is invested intimately by the visceral layer of pleura except at the hilar area. It is pink in fesh condition. The organ is soft and spongy in apearance. It crepitates to the touch and floats on water. In still-born calf lung tissue is solid and does not float on water because it did not breath earlier. Each lung is conical in shape, divided into lobes by fissures and presents two surfaces, two borders, a base and an apex. The right lung is bigger than the left. The surface presents numerous polyhedral markings of the underlying lung lobules.

Borders—Dorsal border is thick, rounded and related to the proximal ends of ribs and sympathetic trunk. Ventral border is irregular thin and shorter than dorsal border. Both the lungs presents cardiac notches at the level of the heart. The cardiac notch in the left lung is big and in the form of a 'L' gap. Due to the absences of parenchyma at the notches, portions of the lateral walls of the heart as well as the pericardium is related directly to the corresponding thoracic wall.

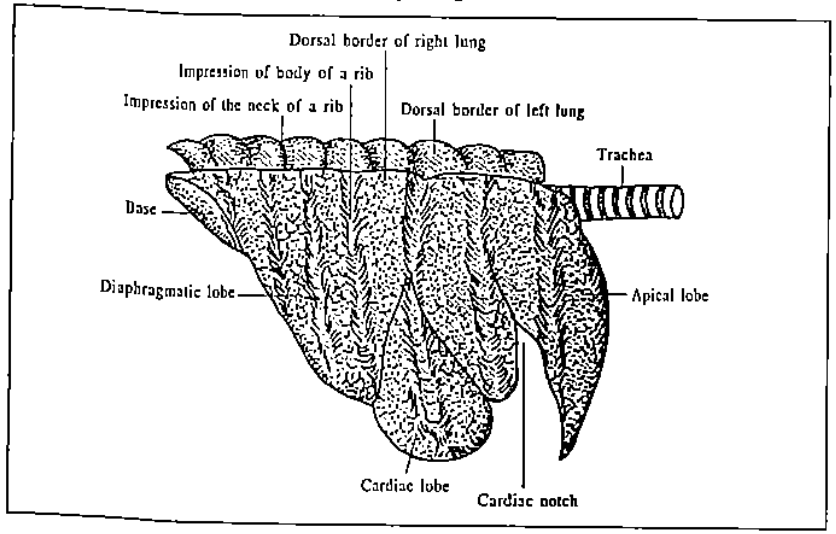


Fig. 6.60 Dorso-lateral view of the lungs of ox (right side).

Base—The base is concave and is moulded on the thoracic surface of diaphragm. The base of right lung is more concave due to the placement of liver at the other side of diaphragm. This surface is oval in outline and bounded by basal border.

Apex—The apex of each lung is placed within cupula pleurae. The apex of left lung is more or less pointed. In the right lung the apex is much larger, rounded and occupies the space in front of heart and extends also to the left side. The apical lobe of right lung is ventilated by a separate bronchus known as apical bronchus. This is a peculiarity in the ruminants.

Surfaces—The lateral or costal surface is convex, smooth and related to the inner aspect of thoracic wall and presents impressions of ribs and cartilages. The medial surface consists of the dorsal or vertebral part and the ventral or mediastinal part. The vertebral part is related to the bodies of the thoracic vertebrae and the mediastinal part is related to the structures present in the mediastinal space. The **hilum** of lung is roughly a triangular nonpleural area above and behind the cardiac notch which transmits the bronchus, pulmonary artery, pulmonary vein, bronchial artery, nerves of the pulmonary plexus and lymphatics. The cardiac impression is a deep concave area which lodges the heart covered by the fibrous pericardium. The **cardiac impression** of left lung is larger but it is deeper in right lung. Beside these the mediastinal surfaces present a number of impressions for various mediastinal structures. In the right lung a horizontal impression of trachea extends cranially from the hilus towards the apex along the dorsal aspect of the cardiac impression. Two horizontal grooves which are prominent in both the lungs extend caudally from the hilus; the dorsal one is for aorta and the ventral one is for the esophagus. In between the intermediate and diaphragmatic lobes of the right lung, the abdominal vena cava is lodged.

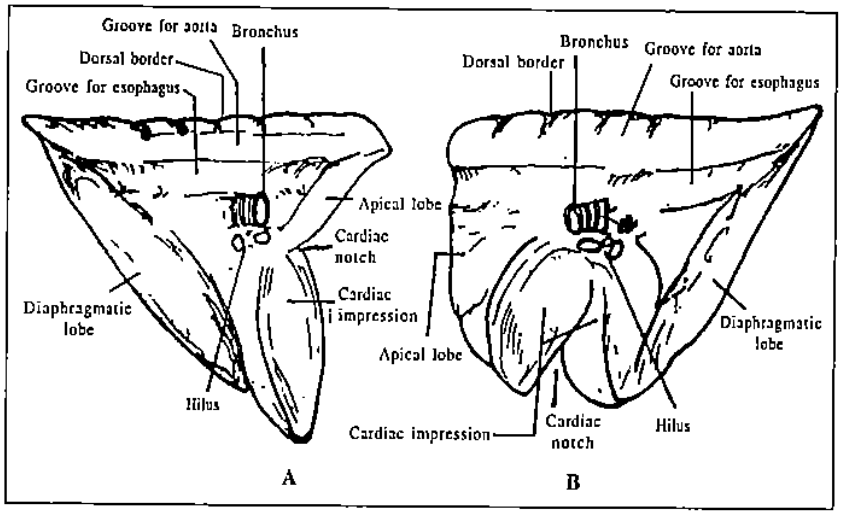


Fig. 6.61 Mediastinal surfaces of the lungs of ox.
A. Left lung B. Right lung

LOBES

The lungs are divided into lobes by fissures of variable depth. The **right lung** presents four lobes – (1) ***Apical***, (2) ***Cardiac***, (3) ***Diaphragmatic*** and (4) ***Accessory or intermediate***. The apical lobe is large and partially subdivided into a cranial and a caudal part. The cardiac lobe is elongated and related to the heart. The diaphragmatic lobe is the largest and is placed caudally. It is related to diaphragm. The accessory or intermediate lobe is in the form of a triangular mass attached to the diaphragmatic lobe of right lung at its medial aspect and placed just caudal to the hilus.

The **left lung** presents three lobes—(1) ***Apical***, (2) ***Cardiac***, (3) ***Diaphragmatic***. The apical lobe is small. The cardiac lobe along with the apical lobe forms the extensive cardiac impression. As the fissure between the apical and cardiac lobes is not deep, some authors have described both the lobes as a single one.

STRUCTURE OF THE LUNG

It is an organ that encloses spaces. Each lung is composed of an external serous coat, a subserous areolar tissue and pulmonary substance. The serous coat is derived from pulmonary pleura and invests the lung except at its hilum. The subserous coat is composed of elastic fibro areolar tissue, invests the lungs and enters the organ at the hilum to form interlobular septa.

Each lung contains several thousand lobules. The pulmonary substance is composed of these lobules. Each lobule receives a terminal bronchiole which again subdivides into few successive orders to form respiratory bronchioles. The area of lung parenchyma provided by one terminal respiratory bronchiole is known as the **pulmonary or lung unit**. The terminal respiratory bronchiole divides to form several alveolar ducts. These ducts lead to alveolar sacs and ultimately to alveolus. The alveolar duct, alveolar sac and alveoli constitute the respiratory portion of lobules. These portions do not have walls of their own. These are the enclosed spaces within the capillary bed where air can come in close contact with the blood. The alveolar epithelium is composed of **type I and type II pneumocytes**. The type I cells are squamous and possess centrally placed nucleus and thin cytoplasm. Type II cells are rounded in shape and project into the lumen of the alveolus. Alveolar phagocytes (macrophages) are also found in the cavity of the alveoli. In between the two layers of alveolar epithelium there remains a thin layer of connective tissue with rich network of capillaries surrounded by collagen and elastin fibers along with some cells such as fibroblasts, pericytes, lymphocytes, plasma cells, mast cells, and neutrophils. Internally the alveolar surface is covered by a thin film of surfactant which is probably produced by the type II pneumocytes. This surfactant reduces surface tension of the alveoli.

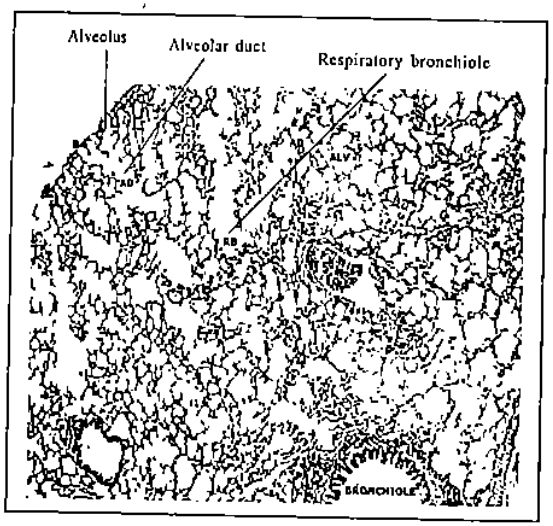


Fig. 6.62 Microscopic structure of Lungs.

BRONCHIAL TREE

Trachea after giving off apical bronchus at the level of 3rd rib, bifurcates into left and right *principal or Primary bronchi* at the base of the heart, each of which enter into the corresponding lung. Each primary bronchus divides into secondary bronchi, one for each bronchial lobe and hence called the **lobar bronchus**. Each lobar bronchus again divides into **tertiary bronchi**. Each of these teritary or segmental bronchus ventilate a particular portion of lung, called **bronchopulmonary segment**. Within the bronchopulmonary segment the tertiary bronchus will repeatedly divide, loose their cartilagenous component from the wall and then termed *bronchioles*. The bronchioles will give rise to **terminal broncheoles**.

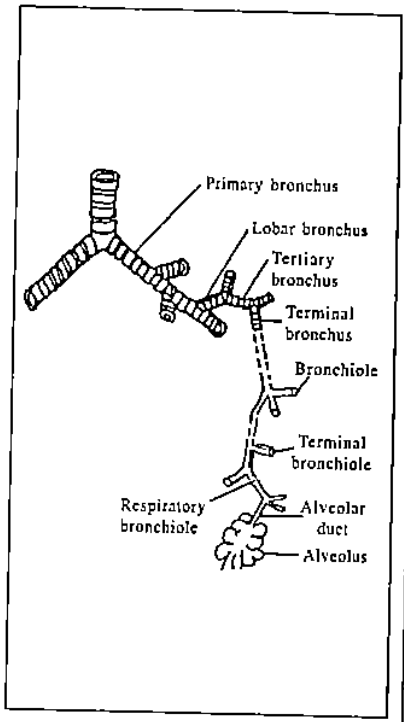


Fig. 6.63 Successive order of branches of the bronchi.

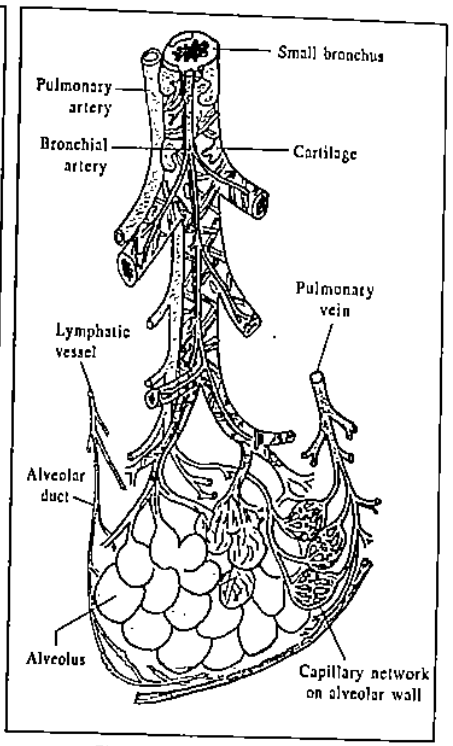


Fig. 6.64 Pulmonary circulation.

Blood supply—Functional – Pulmonary artery
Nutritional – Bronchial artery.

Nerve supply—Pulmonary branches from vagus and sympathetic.

PULMONARY CIRCULATION

Lungs get blood supply from two sources; (a) Pulmonary artery and (b) Bronchial arteries. The pulmonary artery originates from the right ventricle of heart and carries deoxygenated blood. The vessels breaks up into arterioles and finally capillaries to make network around alveoli. After gasious exchange the oxygenated blood ultimately returns to the heart via pulmonary vein. The bronchial arteries after its origin from the aorta enter the lung and branch along the divisions of bronchial tree. But the branches of bronchial artery supply only up to respiratory bronchioles. It carries oxygenated blood. The bronchial arteries also breaks up into capillaries, some of which join the alveolar network and some return via brochial vein or azygos vein. However the branches of bronchial artery and vein communicate with the branches of pulmonary artery and pulmonary vein respectively. The number of pulmonary veins which enter the left atrium are generally three or four. However the number is highly variable. Out of these three veins, one drains blood from cranial part of left lung; one drains the apical part of right lung and the other one drains the caudal parts of both the lungs.

Difference between left and right lungs

Right	*Left*
1. Larger.	1. Smaller.
2. 4. Lobes.	2. 3 Lobes.
3. Base more concave.	3. Less concave.
4. Apical lobe larger.	4. Apical lobe small.
5. Cardiac impression is more deep.	5. Cardiac notch is wide.
6. Apical bronchus present.	6. Absent.
7. Intermediate lobe present.	7. Intermediate lobe absent.

Respiratory organs of horse

1. Nasal cavity is larger and narrower.
2. Middle meatus is not divided posteriorly.
3. The nasal orifice of the nasolacrimal duct is visible at the floor of the nasal cavity about 5 cm. behind the ventral commissure of nostril. The nostrils are dialated.
4. The larynx presents a prominent vocal cord.
5. The epiglottis is long and pointed.
6. The thoracic cavity is larger.
7. The trachea is comparatively long.
8. The apical bronchus is absent.
9. The fissures in the lung are not deep and the lobes are not prominent.
10. The apical lobe of right lung is not as large as found in ox.
11. There are 3 unpaired (cricoid, thyroid, epiglottis) and 3 paired (Arytenoid, corniculate, cuneiform) cartilages in the larynx of horse.

Respiratory organs of dog

1. The shape and size of the nasal cavity varies according to breed.
2. Nostrils are comma shaped.
3. A pair of extra cartilages are found attached to the arytenoid cartilages of the larynx. They are known as cuneiform cartilages.
4. Vocal cords are prominent.
5. Trachea does not possess apical bronchus.
6. The fissures are deep and the lobes are prominent.
7. Number of laryngeal cartilages are similar to those of horse.
8. Right lung has 4 lobes — apical, cardiac, diaphragmatic and accessory. The left lung has two lobes — apical and diaphragmatic.

Respiratory organs of pig

1. The nose is extended from the snout to the level of the eye.
2. Nostrils cannot be dilated much becauses they are embedded within the skeleton of face.

3. The snout is formed by the apex of the nose and the upper lip. Two rounded openings (Nostrils) are situated in the snout.
4. The skin covering the snout is pigmented and divided by shallow grooves. These surface markings are specific for individual animals and helpful for identification.
5. The nasal cavity is comparatively long.
6. Larynx is elongated and the vocal fold is formed by the mucous membrane which covers the caudal part of vocal ligament and thyroarytenoideus muscle.
7. Right lung has 4 lobes – (a) apical (b) cardiac, (c) diaphragmatic and (d) intermediate. The left lung has 2 lobes—(a) apico-cardiac and (b) diaphragmatic.
8. The apical bronchus is present for right apical lobe at the level of 3rd rib.

Respiratory organs of rabbit

1. Nostrils are in the form of elongated slits between the nasal flap and upper jaw.
2. The nasal bones are well built and the nasal cavities are extended.
3. The tip of the epiglottis is rounded but bifurcated.
4. The trachea is about 6 cm long and possesses no apical bronchus.
5. Right lung has 4 distinct lobes – (a) apical, (b) cardiac, (c) diaphragmatic and (d) intermediate.

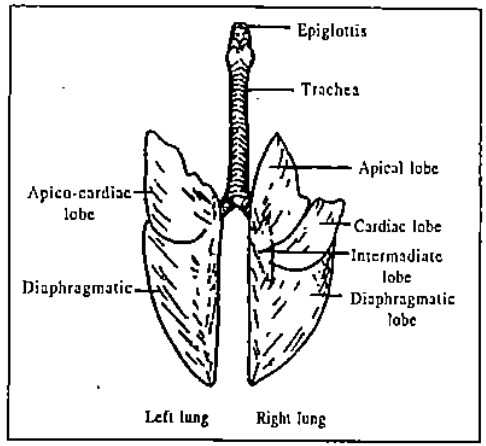


Fig. 6.65 Respiratory organs of rabbit. (Viewed from dorsal aspect)

The left lung has only two lobes – (a) apico-cardiac and (b) diaphragmatic.

Respiratory organs of fowl

1. The nostrils are slit like opening in the upper beak. Its dorsal border is bounded by a small piece of horny skin – the operculum.
2. Nasal cavities are narrow and each has 3 compartments (a) *vestible*, (b) *respiratory* and (c) *olfactory*; from front to back. The posterior nares form a common opening before joining the pharynx. The nasal cavities contain nasal glands.
3. The larynx comprises of four cartilages – cricoid, pre-cricoid and one pair of arytenoid.
4. Trachea is formed by about 115 complete cartilagenous rings. Except the first and last, these rings are signate rings.
5. The point of bifurcation of trachea into two primary bronchi is dilated to form a cartilagenous compartment. It is known as **syrinx**. It is respondible for the production of voice. The voice is produced by the membranes inside the organ.
6. The lungs are flat and rectangular in shape. The dorsal border has five deep impressions of ribs. The lateral surfaces are attached of the ribs. Inside the lung each primary bronchi gives rise to 4 sets of secondary bronchi. They are (i) Medioventral (ii) Medio-dorsal, (iii) Latero ventral and (iv) Latero

dorsal. Each secondary bronchi gives rise to numerous tertiary bronchi, which are also called parabronchi.

7. The bronchi end at the entrance of air sacs.

8. There are eight air sacs in the chicken. These are cervical (unpaired), Clavicular (unpaired), Cranial thoracic (paired), Caudal thoracic (paired) and Abdominal (paired). These are air filled membranous cavities communicated with the bronchi. They serve to keep the body light.

No gaseous exchange take place through the wall of air sacs. Diverticula from the air sacs extend into the cavities of the pneumatic bones. Ventral-cranial movement of sternum is necessary to change the body volume in the process of inspiration and expiration.

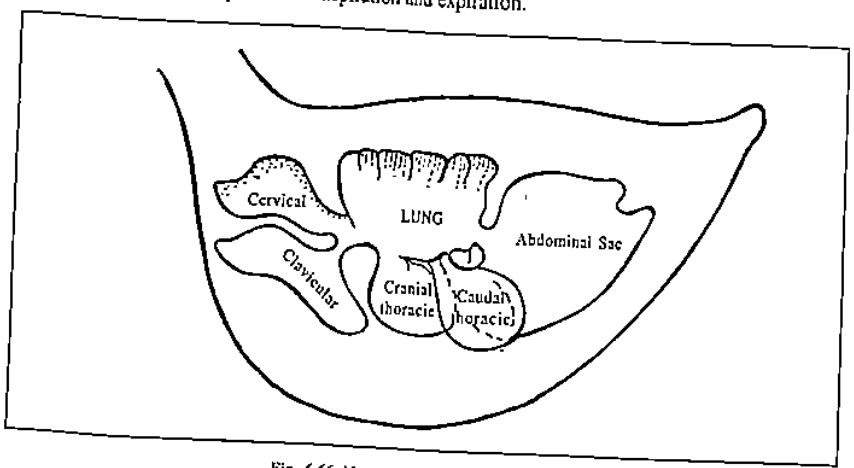


Fig. 6.66 Air sacs of a hen (Diagramatic).

URINARY SYSTEM

This system excretes waste products from blood and maintains its constant alkalinity and chemical composition. The organs of this system are *kidneys, ureters, urinary bladder* and *urethra.*

KIDNEYS

The kidneys are paired lobulated oval or bean shaped glands – *right* and *left*, situated at the upper cranial part of the abdominal cavity and above peritonium. Superficially each kidney is divided into a number of lobes by fissures which remain filled up by fat.

Situation

The right kidney is placed below the proximal end of last rib and first two or three lumbar transverse processes. The left kidney is variable in position. When the rumen is full, it is placed below and behind the right kidney at the level of the bodies of 3rd, 4th, and 5th lumbar vertebrae. When the rumen is not full it remains at the same level but partly at the left side of the median plane. Factors keeping the kidneys in position are (1) Pedicles (renal vessels and ureter) of the kidneys attached to the hilum, (2) Distribution of renal fat and disposition of renal fascia. The renal fascia is formed by condensation of extra peritoneal connective tissue around the kidneys which is continuous laterally with fascia transversalis, (3) Pressure exerted by the surrounding viscera.

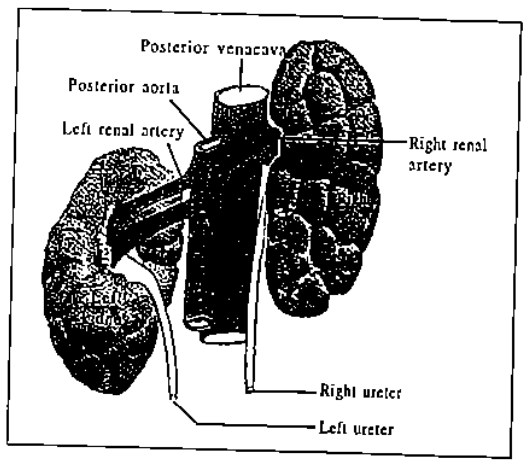


Fig. 6.67 Schematic diagram of the kidneys of cow along with vessels. (Dorsal view)

The average measurements of the kidneys of an adult healthy cow is as follows :

	Right Kidney	*Left Kidney*
Length	16 cm	14 cm
Width	9 cm	8 cm
Thickness	5 cm	6 cm
Weight	650 gm	700 gm

Shape

The right kidney is roughly bean shaped and flattened from above downwards. The dorsal surface is convex and remains in contact to the sublumbar muscles. The ventral surface has the hilus at its craniomedial aspect. The lateral border is convex and the medial border is straight and placed

parallel to the abdominal venacava. The cranial end is narrow and thick. This end is lodged in the renal impression of liver and also remain in contact with the right adrenal gland. The caudal end is free and rounded.

The left kidney has three surfaces (dorsal, ventral and ruminal), three borders (medial, lateral and ventral) and two ends. The dorsal surface is convex and presents the hilus at its cranial part. Ventral surface is convex and flat. The ruminal surface is flat and remains in contact with the rumen. The ventral border is in between ruminal and ventral surfaces and is convex. Lateral border is in between the ruminal and dorsal surfaces. It is slighly convex. The medial border is in between the dorsal and ventral surfaces. This border is convex at its cranial part and concave at the caudal part. The hilus is situated at the dorsal surface in a fissure which extends obliquely from the lateral border of the cranial end to the medial border, of the caudal end.

In goat and sheep the kidneys are bean shaped, smooth surfaced and without any superficial lobulations.

STRUCTURE

Capsule—Each kidney is covered by a fibrous capsule. After covering the whole organ, it lines the wall of the renal sinus and is reflected as tubular sheaths around minor and major calyces and the renal pelvis. This fibrous capsule can easily be separated from the parenchyma during dissection.

Cavity of kidney—The hilus of each kidney leads to the **renal sinus** which is occupied by the expanded funnel shaped end of the ureter – the **renal pelvis**. The pelvis divides into two (cranial and caudal) **major calices** and each calyx major again divides into several **minor calices**. The renal sinus remains filled up with fat. The calyces, pelvis and large intrarenal vessels remain embedded in this fat.

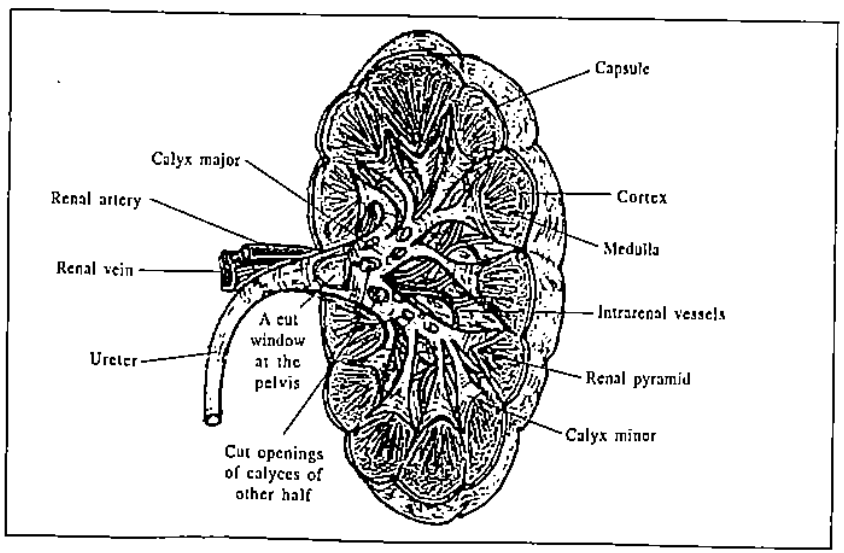


Fig. 6.68 Section of kidney of ox.

The kidney substance or the parenchyma—The outer pale area of a cut surface of a kidney is known as **cortex**. The inner darker area is known as **medulla**. The cortex is composed of convoluted portions of renal tubules, blood vessels, lymphatics and connective tissue. The **Malphagian corpuscles** are red dot like points distributed throughout the cortex. These are composed of Bowman's capsule and glomerular tuft of blood vessels. This glomerular tuft of blood vessels are derived from afferent arterioles within the Bowman's capsule. These branches re-unite to form efferent arteriole, which goes out of the capsule and subsequently re-divide into numerous branches to form peritubular capillary plexus. The medulla consists of triangular areas, each with its base adjacent to the cortex and its rounded apex project into a calyx minor. These triangular masses which are composed of straight protions of **uriniferous tubules**, connective tissue blood vessels and lymphatics are known as **renal pyramids** and their pointed ends which open into the calyx minors are known as **renal papillae**. In small ruminent the renal sapilla appears to be single.

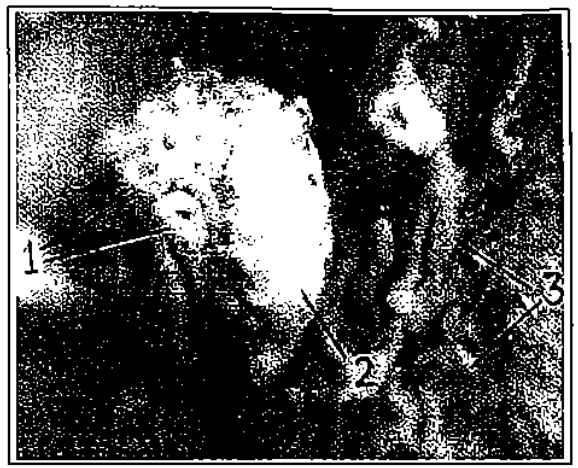


Fig. 6.69A Microfil (latex) cast of a single glomerulus.
1 – Microvascular loops, 2 – Glomerulus, 3 – Peritubular capillary plexus.

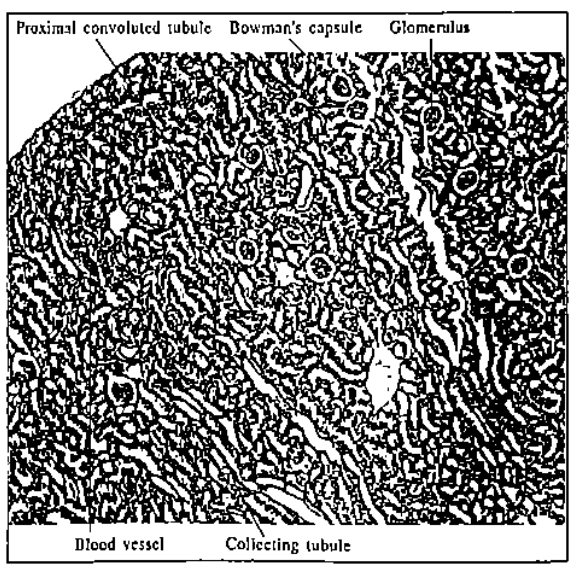


Fig. 6.69B Microscopic structure of Kidney

The structaral and functional unit of the kidney is the Nephron. Each nephron comprises of (a) a spherical expansion, the Bowman's capsule, (b) proximal convoluted tubule, (c) Henle's loop and (d) Distal convoluted tubule. These are different parts of the same tubular structure, has been namaed according to their shape, size, histological origination and function.

The spherical **Bowman's capsule** invaginates itself to receive the glomerular tuft of blood vessels which are derived from the affarent artery. The visceral layer of the capsule is closely invested on the capillaries of glomerular tuft, and the parietal layer which is composed of simple squamous epithelium, is continuous with the proximal convoluted tubule.

The **proximal convoluted tubule** is the longest and most convoluted. Its wall is formed by a single layer of low columnar or low pyramidal cells with round nucleus. The diamater is about 60 microns and length is about 12 mm.

The **Henle's loop** is thin and is a straight part of the nephron. It connects the proximal and distal convoluted tubules and is composed of a descending limb, an U turn and an ascending limb. Diameter is about 15 microns and the wall is composed of a single layer of flat epithelial cells.

The **distal convoluted** tubule – It is less convoluted. The diameter is about 50 microns and length is about 4 mm. Its wall is composed of a single layer of cuboidal cells. Its terminal part is continuous with the collecting tubule.

The collecting tubule, successively join to form the **duct of Bellini or papillary duct** which opens at the papilla of the renal pyramid along with several other papillary ducts. The apices of each renal pyramid project into a small funnel shaped structure, known as **calyx minor.** Therefore the

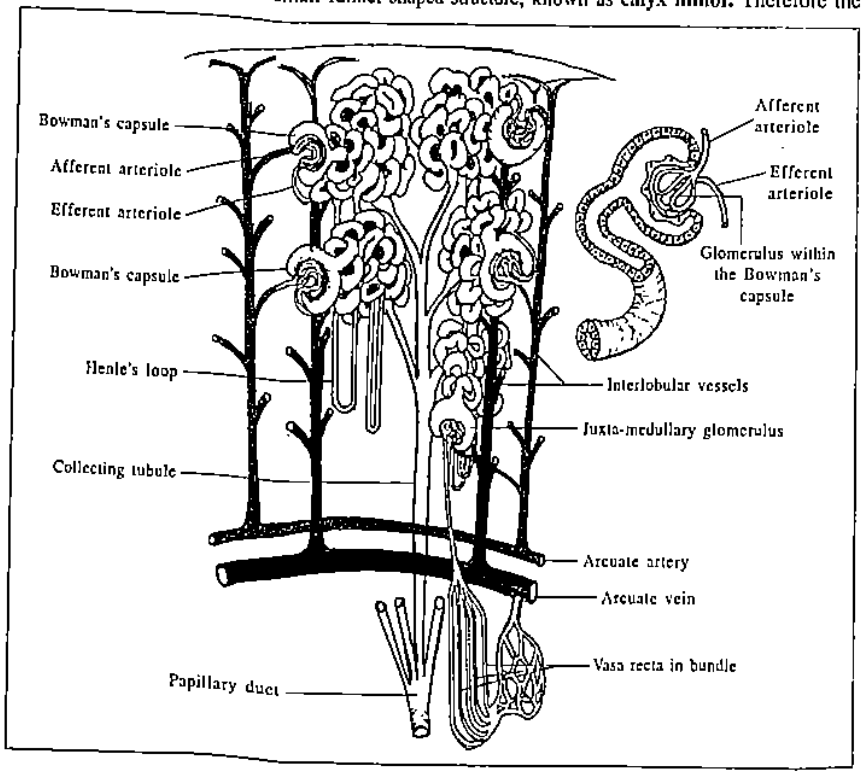


Fig. 6.70 Renal tubules and vessels (Diagramatic).

number of calyx minor is depended on the number of pyramids. The calyces minors of the cranial part unite to form a major calyx and similarly the calyces minors of caudal part join together to form another major calyx. These two major calyces unite to form the funnel shaped begining of the ureter, the **pelvis** of the kidney.

Blood supply—Renal arteries arise directly from the abdominal aorta. Each of them reaches the hilus and divides into 3 to 4 segmental branches. Each segmental artery divides into 4-8 seconds order (interlobar) arteries. They experience a straight course and at the corticomedullary junction they divide into 3-5 third order (arcuate) arteries. These are the end arteries and do not anastomose in the kidney. From arcuate arteries straight vessels radiate towards the surface through the cortical parenchyma. These are fourth order (inter lobular) arteries. The affarent glomerular arteries originate from these interlobular arteries.

Nerve supply—From renal plexus.

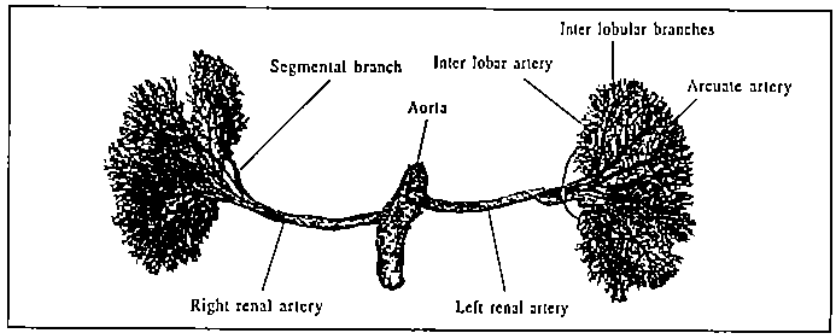


Fig. 6.71 Synthetic cast of renal arteries of goat (ventral view) showing intrarenal vascular pattern.

Kidneys of horse

1. Right kidney is heart shaped and the left kidney is bean shaped.

2. Right kidney is situated below the proximal ends of last three ribs and first lumbar transverse process. Left kidney is placed near the median plane below the proximal end of last rib and first 2 to 3 lumbar transverse process.

3. The surfaces are not lobulated.

4. Renal pyramids are not at all prominent.

5. The hilum of each kidney is situated in the middle of the medial border which leads to renal sinus.

6. The central portion of the intrarenal part of the medulla forms a concave ridge which projects into the pelvis and presents the orifices of the renal tubules is known as **renal crest.** This perforated area at the crest is known as **area cribrosa.** Probably the renal pyramids have fused together to form the renal crest.

Kidneys of dog

1. Both the kidneys are bean shaped.

2. The surfaces are smooth.

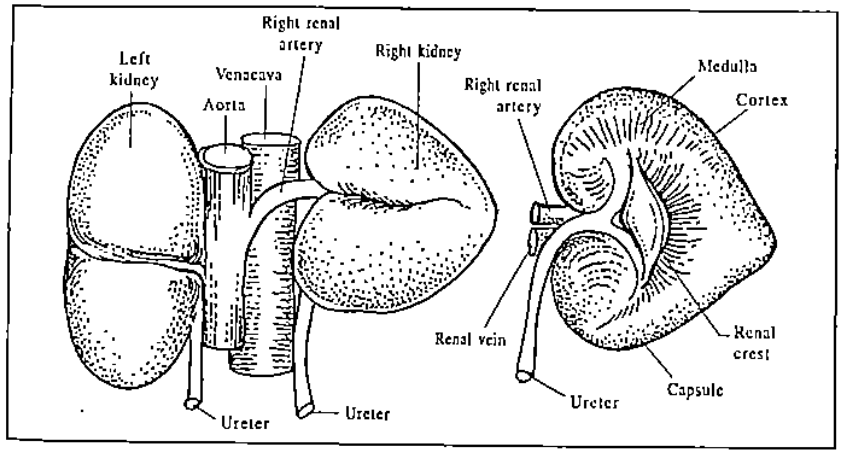


Fig. 6.72 Kidneys of horse (Dorsal view).

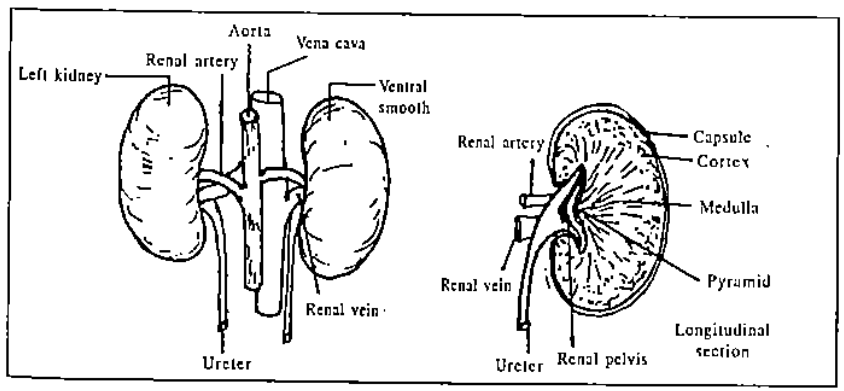


Fig. 6.73 Kidneys of dog (Dorsal view).

3. Right kidney is situated below the bodies of first three lumbar vertebrae and the left kidney is placed below 3rd to 5th lumbar vertebrae, when the stomach is full. It goes below 2nd to 4th lumbar vertebrae when the stomach is empty.

4. The hilus of each kidney is situated in the middle of the medial border and is relatively wide.

Kidneys of pig

1. Kidneys are bean shaped.

2. Surfaces are smooth but some lobations are visible.

3. They are situated below last four lumbar vertebrae. Left is little cranially placed.

4. Each kidney possesses 2 calyces majors and about a dozon of calyces minors.

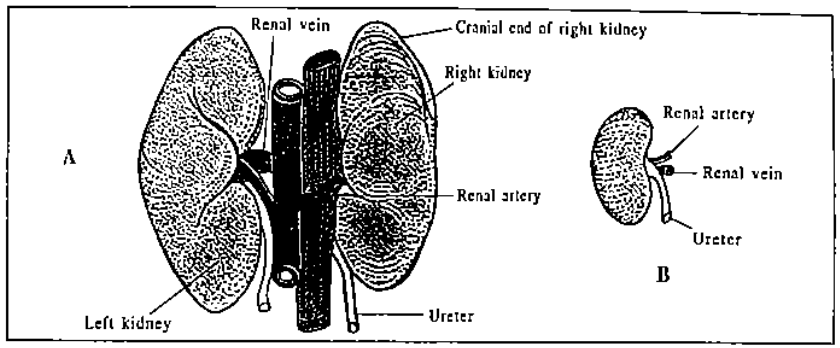


Fig. 6.74 A. Kidneys of Pig. B. Left Kidney of rabbit (Dorsal views).

Kidneys of rabbit

1. These are smooth surfaced and bean shaped organs.

2. Right kidney is situated below proximal end of last rib and first two lumbar transverse processes and the left kidney is placed below the bodies of 2nd and 3rd lumbar verebrae.

3. The kidneys are unipyramidal.

Kidneys of fowl

1. The kidneys are brown coloured elongated structures.

2. They are situated symmetrically on eitehr side of the vertebral column below pelvis and synsacrum.

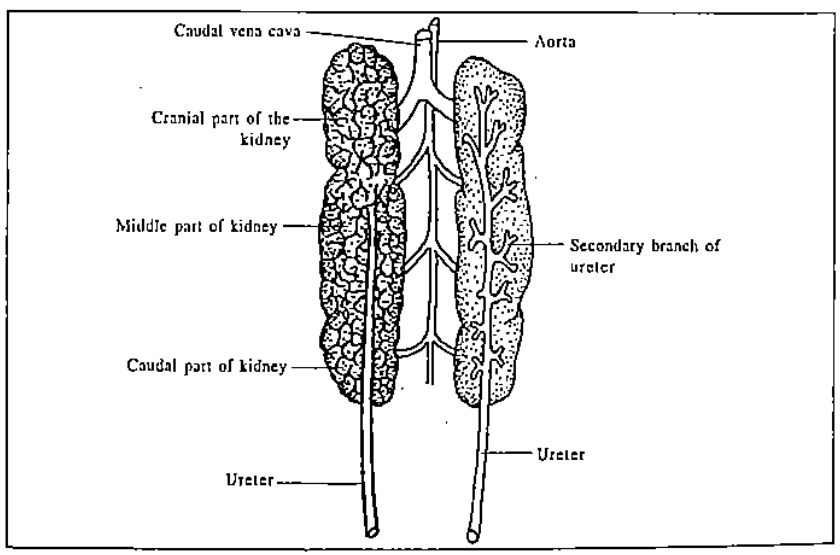


Fig. 6.75 Kidneys of fowl (Dorsal view).

3. Each kidney is divided into three divisions – *cranial, middle* and *caudal*. The middle part is narrow.

4. The surface is finely lobulated. This probably due to the fusion of numerous kidney units.

The surface lobulation and number of pyramids varies from animal to animals. The kidneys of cattle and buffalo (large ruminants) are distinctly lobated and the number ranges from 18 to 22. The sizes of these lobes are also variable. The number of pyramids generally corresponds to the number of lobes.

In birds the surface of each of the three large lobes are finely lobulated and therefore numerous small lobes club together and gives and irregular appearance.

In human and pig the surface lobation is not distinct but each kidney possesses multiple number of pyramids.

In small ruminants (goat, cat, rabbit and dog) there is no surface lobation and each kidney contains only one pyramid. Therefore these kidneys are unipyramidal and have no calyces minor.

In some animals (horse, sheep) there is a renal crest in place of pyramid which probably has been formed by the fusion of numerous (10-20) renal pyramids.

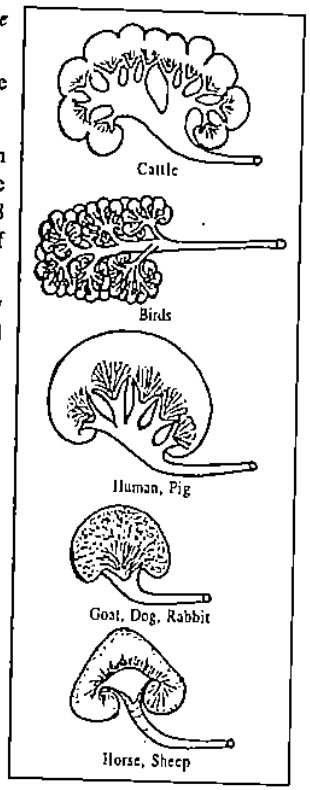


Fig. 6.76

URETER

These tubes, one for each kidney are formed in the renal pelvis by the union of two major calyces which pass caudally and finally terminate by opening at the urinary bladder. These are the excretory ducts of the kidneys. The diameter is about 6 to 8 mm. The average length of right urether is 60 cm and that of left ureter is 50 cm.

The terminal parts of these tubes experience an oblique intravesicular course and presents a valvular action which prevents the reflux of urine from bladder to ureter.

Right ureter

It originates from hilus at the ventral surface of the right kidney and passes inward and backward along the medial border of the organ, parallel to the abdominal venacava. It passes furtehr caudally, crosses the external iliac vessels and enter the pelvic cavity. It crosses the concerned vas in the male and enter into the genital fold, inclines inward and downward and opens into the bladder at the caudodorsal aspect. In the female, the ureter enters the broad ligament in the pelvic cavity and finally opens into the bladder in the similar manner.

Left ureter

It originates from the hilus of the left kidney at the cranial part of the dorsal surface. The tube crosses the dorsal surface in an oblique manner and then passes caudally. Rest of the course in the pelvic and abdominal cavities is similar to that of right ureter.

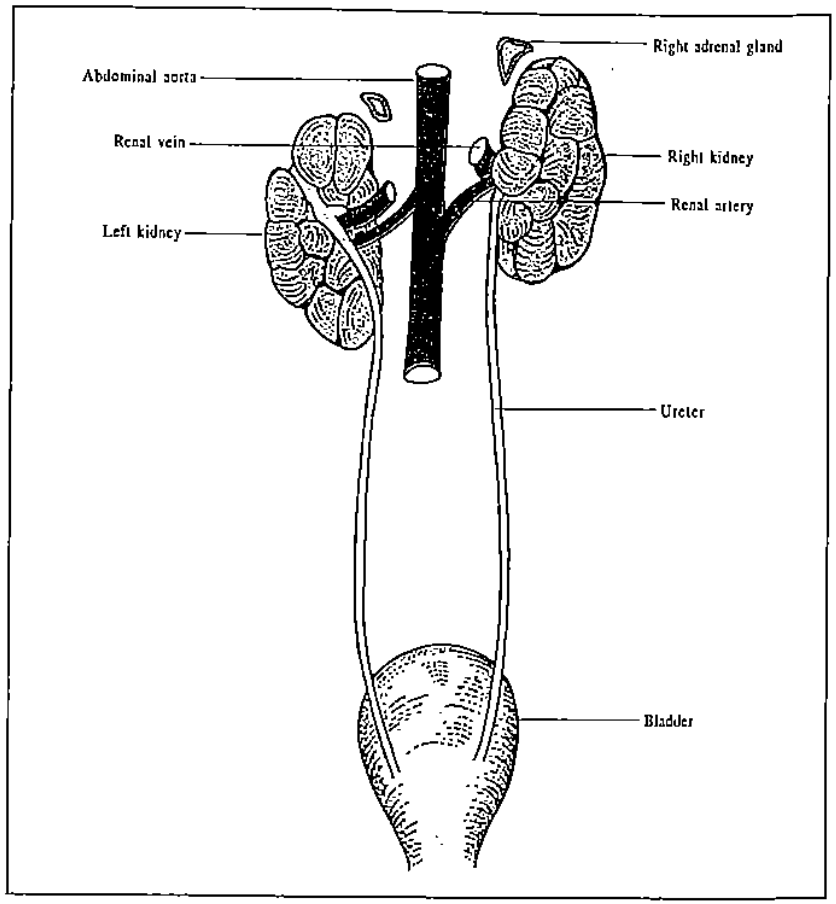


Fig. 6.77 Organs of urinary system of cow (Dorsal view).

Ureters of horse

1. They do not present any special feature except in their origin.
2. The renal pelvis is more dilated in horse.
3. The tube is narrow but longer in comparison to that of ox.

Ureters of dog

They are almost similar to those of ox except at their point of origins.

Ureter of pig

1. The tube is slight flexuous.
2. The cranial part is comparatively dilated.

Ureter of rabbit

The ureters are simple tubes, start from the hilus of the kidneys at the middle of the medial border and terminates at the dorsal aspect of the bladder on either side.

Ureters of fowl

1. Each ureter may be divided into two parts – the *renal part* and *pelvic part.*
2. The renal part is mostly embedded into the substance of the kidney.
3. The pelvic part runs from the caudal end of the kidney to cloaca.
4. Both the ureters open at the dorsal aspect of the urodeum.

BLADDER

This thick walled muscular sac serves as reservior for urine. The shape and size depends upon the amount of urine it contains. When empty it remains completely in a contracted condition on the floor of the pelvic cavity. It becomes oval in form and gets projected to the abdomen in distended condition. The cranial blind end is known as **vertex** and bears on its middle a cicatrical tissue – the remenent of urachus which was the communication between the fetal bladder and the allantois. If the urachus remain patent after birth an urinary fistula may develop and in that case urine may pass through unbilicus.

The **body** is rounded and dorsoventrally compressed. The dorsal surface is convex. In the male this surface is related to rectum, genital fold, vas deferens and seminal vesicle. In the female the dorsal surface is related to the ventral surface of vagina and uterus. The ventral surface is flat in both the sexes and related to the floor of the pelvic and abdominal cavities in distended condition. The caudal narrow tubular portion of the bladder is the neck. It is thick walled and is continuous with the urethra. The bladder is fixed in position by the following ligaments :

1. *Ventral ligament*—It connects the ventral surface of the bladder with the floor of the pelvis.

2. *Lateral ligaments*—They connect the lateral aspects of the bladder with the pelvic wall. These lateral ligaments are in the form of membranes and each contains in their free margin, a rounded cord like structure – the **round ligament.** These are the ***remnants of umbilical arteries***.

STRUCTURE

The wall is composed of interlacing bundles of involuntary muscles and a specialised mucous lining which can stretch to a great extent except in the area of trigone. The outer serous coat which is derived from the peritonium covers the dorsal surface and becomes reflected to form genital fold in the male and forms vesicogenital pouch in the female. The trigone is a triangular area of the mucous membrane on the dorsal wall, close to the neck. This trigone is angled by the orifices of the two ureters and the opening of urethra. The mucous membrane of this area is tightly attached and therefore do not form folds. A median crest is formed by the union of two mucous folds in the begining of urethra. These two mucous folds extend from the corresponding ureteral orifice to the neck of bladder. The circular muscle fibers around the neck form sphincter vesicae.

Blood supply—Branches from internal pudendal, obturator and umbilical arteries.

Nerve supply—From pelvic plexus.

Bladder of horse, dog, pig and rabbit

1. Structures are more or less same.
2. In horse the size is comparatively smaller.
3. In horse it does not extend up to the abdominal cavity even in distended condition.
4. The bladder is totally covered by peritonium in dog.
5. In the dog it extends considerably in distended condition.
6. In pig the bladder is comparatively large.
7. In rabbit it is little elongated. Wall is comparatively thin.

Fowl

In the birds there is no bladder as such. The ureters open directly to the urodeum of cloaca.

THE GENITAL SYSTEM

MALE GENITAL ORGANS

The organs of male genital system are Testicle, Vas deferens, Urethra and penis. Accessory sex glands are prostate, seminal vesicle and cowpers gland. The testicles are suspended in the scrotum by spermatic cord.

Scrotum

It is a cutaneous sac develops from genital swellings and situated in front of the inguinal region. It accommodates the testicles and a part of the spermatic cord. In adult bull it is about 20-25 cm long. The scrotum has the following layers from outside inwards :

(a) **Skin**—It is thick, elastic and reddish-yellow in colour. At the middle there is a longitudinal **scrotal raphe** which makes the septum scroti. The skin is smooth and thinly covered by small hairs.

(b) **Dartos**—This layer is made up of subcutaneous muscle and fibroelastic tissues and remain closely adherent to the skin. It contributes to a great extent along the median raphe to form the septum scroti. In the skin corrugations are developed due to constriction of this muscular layer.

(c) **Scrotal fascia**—There are three layers of scrotal fasciae – *the spermatic fascia, cremestic fascia and infundibuliform fascia*. The *spermatic fascia* is thin and is detached from the external oblique muscle. The *cremestic fascia* extends from internal oblique muscle. The *infundibuliform* fascia is derived from fascia transversalis. It remains closely adherent to the tunica vaginalis reflexa.

Blood supply—Branch of external pudendal artery.

Nerve supply—Branches from spermatic and 2nd and 3rd lumbar spinal nerves.

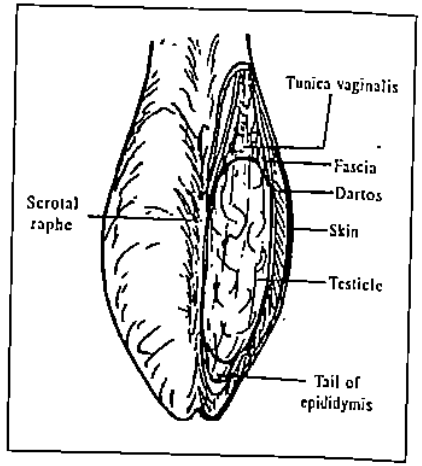


Fig. 6.78 Scrotum – Diagramatic (One side open).

The testis

The testes (left and right) are solid glands suspended in a vertical direction by spermatic cords and are housed in the scrotum. The sizes are variable and even they vary in the same bull. Often the left one is bigger than the right. The average weight of an adult testis is about 250-300 gms., length is about 12 cm, width is about 5 cm and thickness is about 5 cm. Each testicle presents two surfaces, two borders and two ends. Lateral surface is convex and medial surface is flat. The cranial border is convex and free. The caudal border is less convex and is attached with the body of the epididymis. The upper end is occupied by the head of epididymis. The lower end is slightly thicker and is connected to the tail of epididymis.

The testis is covered by tunica vaginalis (reflexa and propria), tunica albugenia and tunica vasculosa from outside inwards. The tunica vaginalis is derived from peritonium during the descent of testis

from the abdominal cavity. It has a parietal (reflexa) and a visceral (propria) layer. The **tunica vaginalis propria** covers the testis and epididymis except at the caudal border and then becomes continuous with parietal layer and encloses the vaginal sac.

Next to tunica vaginalis, a thick fibrous membrane invests the whole testis is known as **tunica albugenia**. Internal to albugenia there is a areolar and vascular membrane, known as **tunica vasculosa**. Along the central axis, deep into the gland a mass of tissue is extended, known as **Mediastinum testis**. From mediastinum testis numerous fibrous septa radiate and divide the gland into a number of (200-300 in human) chambers or *lobules of testis*.

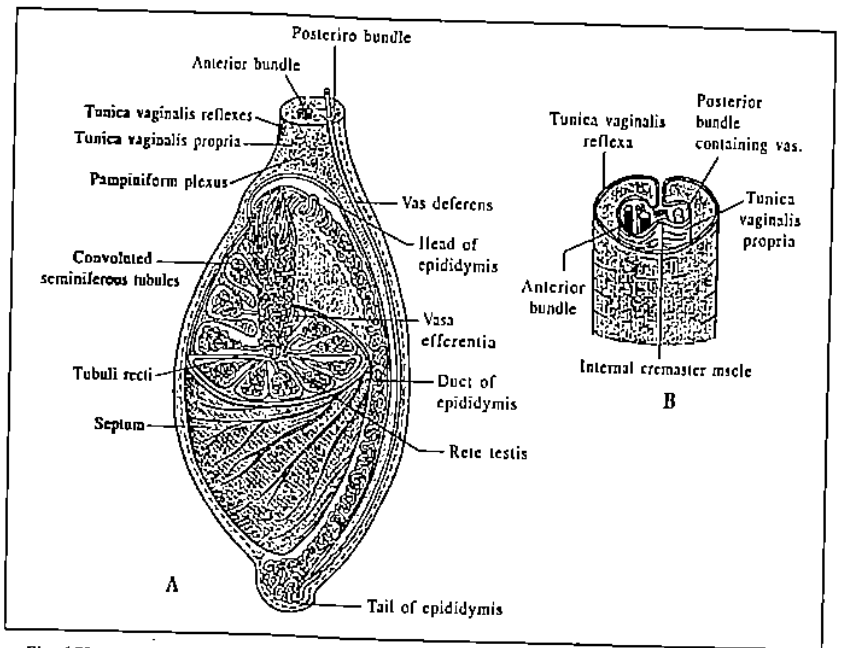


Fig. 6.79 A. Exposed testis of bull (diagramatic) B. Cross section of spermatic cord of ox (Diagramatic).

STRUCTURE

Each of these small chambers are filled with seminiferous tubules, which are connected by interstitial cells. The convoluted parts are placed at the fundus of these small chambers. This convoluted portion is known as **tubuli contorti**. From tubuli contorti straight tubes proceed towards the mediastinum testis. These are known as **tubuli recti**. The tubuli recti from different lobules reach the mediastinum testis and join with each other to form a network, known as **rete testis**. About a dozen of efferent ductules arise from the upper end of the mediastinum and enter into the head of the epididymis. These are known as **vasa efferentia**. These ductules unite in the head of epididymis to form a single duct, the **duct of epididymis**.

In matured males the seminiferous tubules are lined by five layers of cells. They are (a) spermatogonia, (b) primary spermatocyte, (c) secondary spermatocyte, (d) Spermatid and

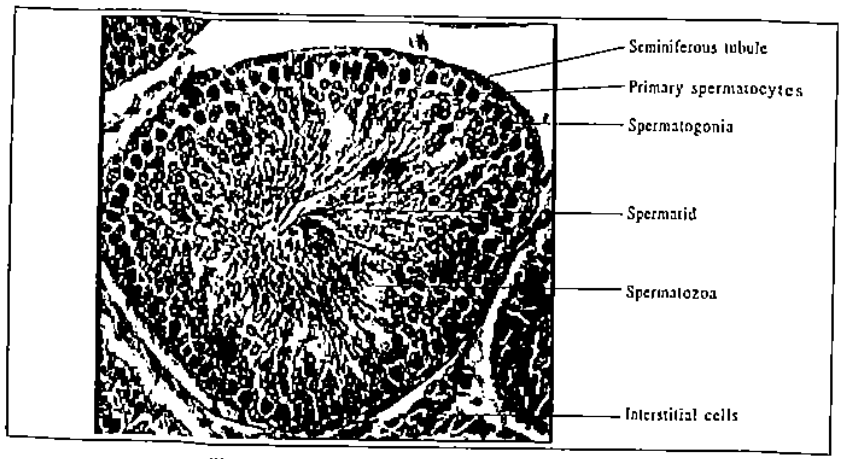


Fig. 6.80 Microphotograph of a seminiferous tubule.

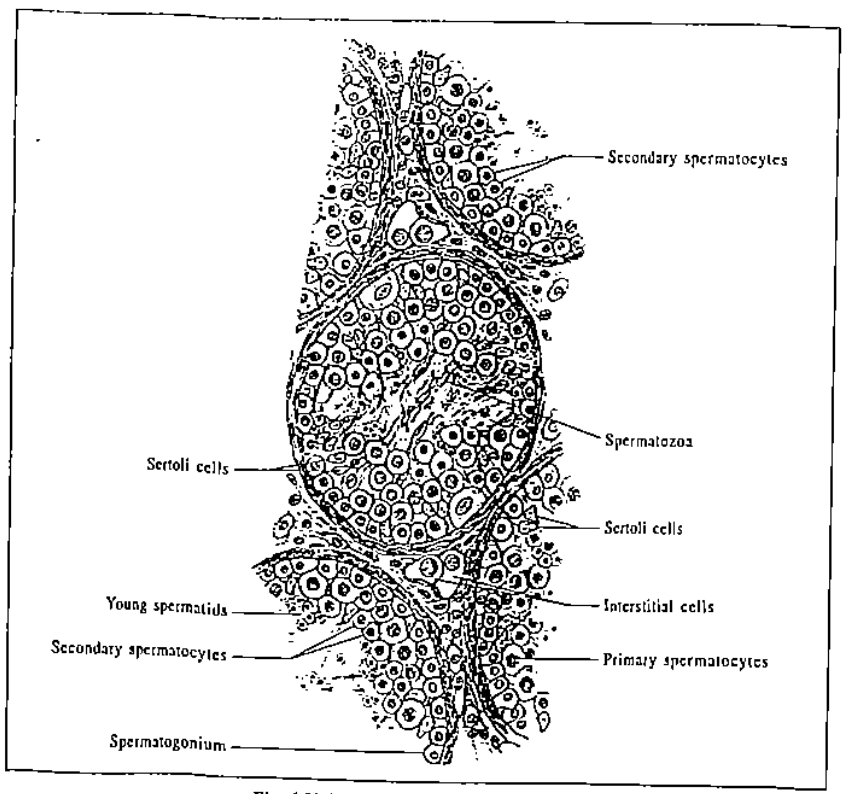


Fig. 6.81 Section of testis (Reconstituted).

(c) spermatozoa from out side inwards. These are the different cronological stages of the developing spermatozoa. At the outer layer some elongated sapporting cells are found. They are known as cells of Sertoli. In between the tubules, groups of polyhedral cells are found mainly in the matured animals. These are the interstitial cells which secret testosterone.

Epididymis

It is a curved elongated structure situated along the caudal border of testis and occupy a narrow space at the lateral surface. It has a head, a body and a tail. Head is the upper enlarged part which occupies the upper end of the testis. The head contains the coils of vasa efferentia which are covered by tunica albugenia. The body and tail are narrow and contain the single duct of epididymis. This highly coiled tube is formed in the head of epididymis by the union of efferent ductules. The canal of epididymis continues from the *tail of epididymis* as vas deferens.

Blood supply—Branch of spermatic artery.

Nerve supply—From spermatic plexus.

Inguinal canal—This is an oblique passage through the abdominal wall between deep and superficial inguinal rings. Each of these two passages are placed in front of the corresponding pubis and gives passage to round ligament of uterus in female, ilioinguinal nerves and vessels in both the sexes and spermatic cord in male. The cremaster muscle, derived from the caudal border of obliques abdominis internus muscle also passes through this canal in male in association with parietal vaginal tunic.

Vas deferens (Ductus deferens)

It is a thin tube starts from the tail of epididymis, passes upward along the caudal border of the testicle as well as a in close association with the medial aspect of the body of the epididymis in slight tortuous manner and gets incorporated into the caudal bundle of spermatic cord. The tube then passes through the inguinal canal, separates itself from other structures of the cord, turns backward, crosses the external iliac vessels and corresponding ureter, reaches the caudo-dorsal aspect of the bladder and disappear under the body of the prostate. Terminal portions of both the tubes are little dilated and known as ampulla. Both the ampullae are placed side by side under the bodies of seminal vesicles before their disappearance under the prostate at the neck of the bladder. The ducts open at the roof of the beginning of urethra on either side of the colliculus seminalis.

Blood supply—Branch of urogenital artery which is detached from internal iliac artery, supply the ampulla. The differential artery which originates from the umbilical artery supplies the rest of the vas.

Nerve supply—From pelvic plexus.

Spermatic cord [Fig. 6.79]

It extends from the internal abdominal ring of the inguinal canal to the upper end of the corresponding testis. It is composed of *two bundles—cranial* and *caudal*, which are enclosed by the tunica vaginalis propria. Through the cranial bundle arteries, vein, lymphatics and nerve pass. Cremaster internus muscle is included in this bundle. The caudal bundle accommodates only the vas deferens. Both the bundles are again covered by tunica vaginalis reflexa.

Blood supply—Spermatic artery from aorta, artery of the cord from external iliac and artery of the vas from umbilical artery.

Nerve supply—From spermatic plexus.

Pampiniform plexus

The veins from the head of epididymis and from the upper end of testis unite to form a convoluted plexus of veins around the spermatic artery. This plexus is known as pampiniform plexus. It forms the main bulk of the cord. Although 3-4 veins are observed close to the internal inguinal ring, ultimately, one vein is formed which drains into caudal venacava close to the opening of concerned renal vein.

Seminal vesicle

These are two lobulated and elongated glands situated at the caudodorsal aspect of the bladder below the rectum. Each gland is 10 to 12 cm long, 3 to 4 cm wide and 2 to 3 cm thick. The lump of the gland is formed by the irregular coiling of a single thick walled tube. Each gland has a single duct which opens on either side of the colliculus seminalis lateral to the opening of the corresponding vas deferens.

Blood supply—Vesicular artery, a branch of urogenital artery.

Nerve supply—From pelvic plexus.

Prostate

It is a fibromuscular gland situated at the neck of the bladder and the beginning of urethra. It is composed of glandular alveoli in the fibromuscular meshwork. The whole gland is invested by a thick fibromuscular capsule from which bands arise and enter into the gland proper in different directions to form mesh work. Although it is said to be having two lobes, but the lobulations are not at all distinct. The dorsal surface is related to rectum and the ventral surface is moulded on the corresponding part of urethra and neck of bladder. Its average cranio-caudal length is about 2 cm; transverse length is 6 cm and the thickness is about 1 cm. A number of prostatic ducts drain the secretion of the gland into the urethra on either side of the mucous folds at the roof behind the colliculus seminalis.

Bulbo-urethral gland (cowpers gland)

These are two small glands situated on either side of the dorsal part of urethra at the level of ischial arch under the covering of a layer of fibrous tissue. The average diameter of these oval glands are 20-30 mm. Each gland is composed of several lubules. A single duct arises from each gland which opens into the urethra on the dorsal wall within the fold of mucous membrane.

URETHRA

This tube extends from the neck of the bladder to the glans penis. It has two parts – the *pelvic part* and *penile part*. In male it serves as a common passage for the urine and semen. The pelvic part lies along the midline of the pelvic floor, arrives at the ischial arch, bends downward and becomes continuous as the penile part. The ventral and lateral walls are formed by the thick urethralis muscle. The dorsal wall is formed by the aponeurosis of this muscle. The *penile part* passes forward and downward between the roots of the corpus cavernosum and proceeds forward along the groove at the inferior surface of the *corpus cavernosum penis*, surrounded by *corpus cavernosum urethrae* upto the glans penis. In the glans it opens at the external urethral orifice. At the beginning, the penile part presents an enlargement – the bulbus urethrae. **Colliculus seminalis** is a small elongated or oval eminence at the midline on the dorsal luminal wall of the urethra, about 40 mm behind the internal urethral orifice. On each side of this structure, the corresponding vas deferens and duct of seminal vesicle open into the urethra. **Urethral crest** is an elongated prominence which extends forward from the colliculus seminalis to the neck of the bladder at the midline of the dorsal wall. The crest is formed by the union of the two mucous folds each of which extends from the corresponding ureteral orifice at the urinary bladder.

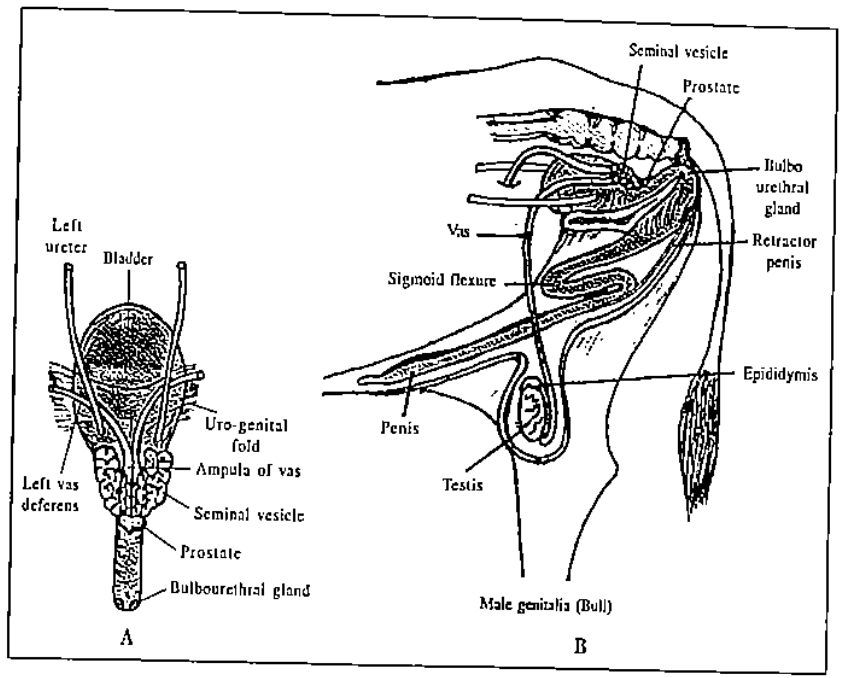


Fig. 6.82 A. Dorsal surface of bladder and pelvic urethra B. Urogenital organ of ox.

PENIS

This is a cylindrical structure and the organ of copulation. It consists of three parts – *root*, *body* and *glans*. At the development stage the genital tubercle at the cranial end of cloacal membrane lengthens to form phallus which enlarges to form penis.

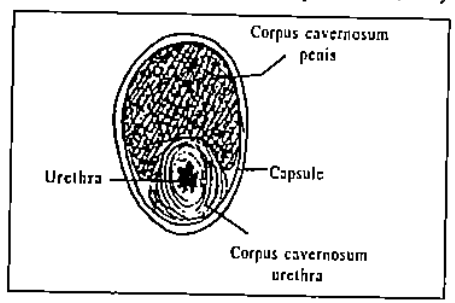


Fig. 6.83 Cross section of penis (after sigmoid flexure).

Root—It begins at the ischial arch. Here the urethra is enclosed between the two crura. The crura arise from the lateral part of the ischial arch and are made up of erectile tissue. They remain covered by erector penis (ischio-cavernosus) muscle.

Body—This is the largest part of the organ between the root and the glans. From the root it passes forward between the thighs and form a 'S' shaped curve – the **Sigmoid flexure** behind the scrotum. It then passes between the spermatic cords at the base of the scrotum along the midline of the ventral abdominal wall and then continues as glans within the prepuce. About 1 foot of the length remain folded in the sigmoid flexure. A portion of the body of the penis at the beginning remains attached to the ischial symphysis by suspensory ligament of penis.

The body of the penis is formed by a bulky muscle – the ***corpus cavernosum penis*** and another muscle which surround the urethra – the ***corpus cavernosum urethrae*** (corpus spongiosum penis). The corpus cavernosum penis presents a ventral groove along the length called urethral groove which gives accommodation of urethra surrounded by corpus cavernosum urethrae. The tunica albugenia surrounds the corpus cavernosum penis and send tabeculae or septa inside the muscle. These septa are composed of fibraelastic and smooth muscle fibers and form boundaries of cavernous space for erectile tissue. The septal arteries give rise to capillaries which open into cavernous spaces. The corpus covernosum urethrae possesses similar structures to that of corpus covernosum penis but the septa are of finer variety and cavernous spaces are less in number. The erectile tissue is less in bulls, buck and dog in comparison to that of stallion. In the dog the caudal half of corpus covernosum penis is divided in to two portions along the length which are separated by a layer of connective tissue. The cranial half accommodates the os penis.

Mechanism of erection—The trabecular/septal arteries of the corpus cavernosum give rise to ***helicine arteries*** which run spirally and open directly into blood sinuses (cavernous spaces). Normally these vessels remain contracted and the spaces remain almost empty. During erection these arteries are relaxed and the spaces become filled with blood. At this stage the venous return is minimized by compression and the penis remain tensed. After ejaculation the helicine arteries contract and reverse action takes place.

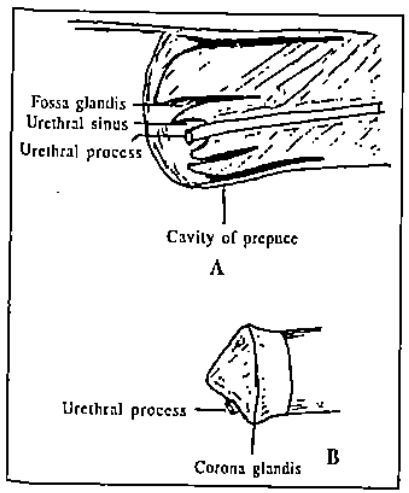


Fig. 6.84 Glans penis of horse.
A. Sagittal section B. Lateral view

Glans penis—It is the free conical end of the penis. This is slightly twisted and presents a groove at the tip. The external urethral orifice is situated at the end of this groove. The free portion of the penis in non erectile state remain covered by a cutaneous pouch, which extends from the scrotum to the umbilicus, known as **prepuce**. In **sheep** and goat, the urethra lies in a groove on the ventral surface of the corpus cavernosum penis and its terminal part extends from the glans. This extended urethral process is about 2-3 cm in length and twisted in appearance. Sigmoid flexure is present in these animals.

Muscles of penis

Ischio cavernosus—(erector penis)—It extends from the tuber ischi to the crus and the body of penis.

Bulbo spongiosus—It is the continuation of urethralis muscle. At the root it is bulky and then diminishes. It extends from ischial arch to the glans penis.

Retractor penis—Its fibers arise from the ventral aspect of the 1st and 2nd coccygeal vertebrae, descends by the side of the rectum under the levator ani and sphincter ani externus. The levator ani extends from ischiatic spine to sphincter ani externus. The fibers of retractor penis pass between the layers of bulbospongiosus and form a bundle of muscle on either side. The muscles of either side pass forward along the ventral surface of the body and finally terminate at the lateral aspect of the body of the penis at the second curve of the sigmoid flexure.

Blood supply—Dorsal artery of penis.

Nerve supply—Branch from pudic and from pelvic plexus.

Male genital organs – horse

1. Scrotum is short and oval.
2. The colour of the skin, covering the scrotum is black.
3. Testes are comparatively small.
4. The mediastinum testis is not developed.
5. The long axis of the testes are not placed vertically.
6. The head of the epididymis is cranially attached.
7. Vas is not tortuous and not related to any border of the testicle.
8. The seminal vesicles are in the form of elongated sacs. Each vesicle comprises of a fundus, a body and a neck. The lining mucous membrane is highly folded.
9. Two lobes of the prostate gland are distinct.
10. Bulbourethral glands are larger.
11. The penis is shorter and thicker.
12. Sigmoid flexure is absent.
13. The corpus cavernosum penis, which forms the bulk of the organ contains numerous trabeculae and erectile tissue. The corpus cavernosum urethrae is spongy.
14. At the base of the glans, there is a border, known as corona glandis.
15. Urethral process the projected end of urethra is situated at the fossa glandis. The urethral end is surrounded by a circular fossa, known as urethral sinus.
16. Uterus masculinus is inconstant. When present, it remains in the form of a miniature uterus and placed at the midline on the coudo-dorsal aspect of the bladder.

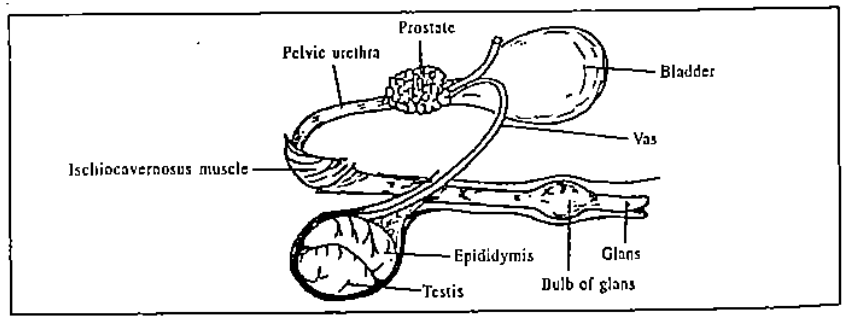


Fig. 6.85 Male genital organ of dog.

Male genital organs of dog

1. The scrotum is situated a below the anus.
2. Shape of scrotum is oval. Skin is brown or black.
3. The testicles are placed in oblique direction.
4. Mediastinum testis is well developed.

5. Epididymis is larger in size.

6. **Seminal vesicles are absent.**

7. Prostate glands are well developed. Two lobes are distinct.

8. **Bulbo urethral glands are absent.**

9. Sigmoid flexure is absent.

10. At the cranial portion of the body a bone is embedded along the length of the penis, known as os penis. Its dorsal surface is convex and the ventral surface presents a groove for urethra. It is believed that a part of corpus cavernosum penis is ossified to form this bone. In adult large dog it may be 10 cm in length.

11. External urethral orifice is at the tip of the glans.

12. The enlarged caudal part of the glans is known as **bulbus glandis.**

13. The uterus masculinus is in the form of a very small sac when present.

Male genital organs of boar

1. The scrotum is situated a little below the anus and is directed backward.

2. Testicles are large, comparatively soft and the tail of epididymis is directed upward.

3. The spermatic cord is large. Cremaster muscle is well developed.

4. Sigmoid flexure is present.

5. Cranial part of penis is twisted.

6. Seminal vesicles are very large and cover the caudal part of bladder and ureters. Prostate gland is similar to that of Ox. Cowper's glands are large, elongated and placed on either side on the dorsolateral aspect of the caudal part of the pelvic urethra.

7. Just above the orifice of the prepuce, there is an ovoid blind pouch known as **preputial diverticulum.**

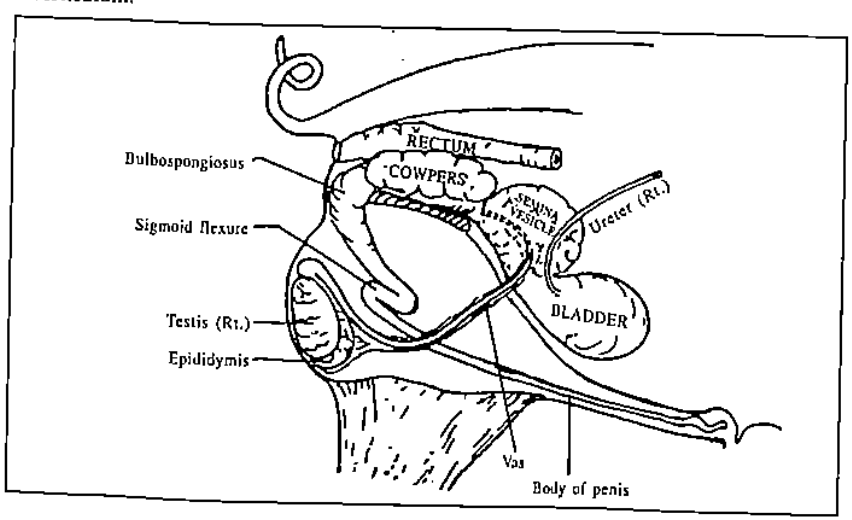


Fig. 6.86 Male genital organs of boar.

Male genital organs of rabbit

1. The **scrotal sacs are separate** and are placed at the caudal inguinal region.

2. From the root the body of the penis first proceed forward and just before reaching the testicles, it almost makes a 'U' turn backward. Therefore the glans penis is directed backward.

3. The glans is pointed with its urethral opening placed dorsally and little cranially.

4. The prepuce is well developed.

5. Vasa deferentia are comparatively thicker.

6. Seminal vesicle is in the form of an elongated sac. The tip of the sac is bifid. It is placed on the ampullae of vasa deferentia.

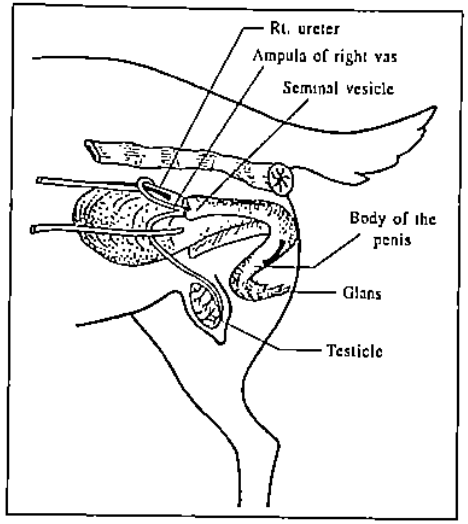


Fig. 6.87 Male genitalia of rabbit.

Male genital organs of fowl

1. The testicles are placed symmetrically on either side of the midline at the sublumbar region in the abdomen.

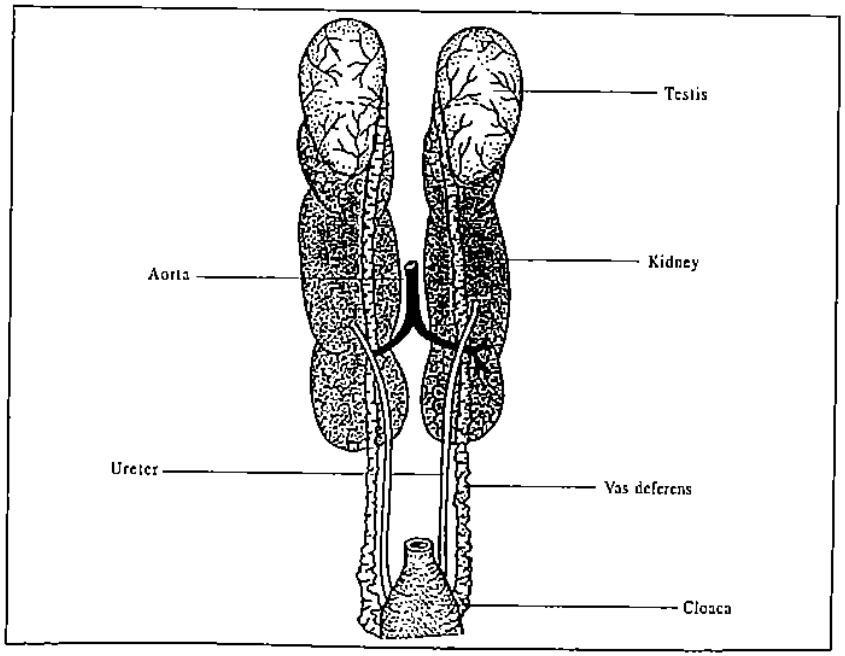


Fig. 6.88 Male uro-genital organs of fowl (Ventral view).

2. The testicles are oval or bean shaped yellowish structures. In matured birds the length is about 4 cm width is about 2.5 cm and thickness is about 2 cm. Generally left one is larger.

3. Epididymis is elongated and placed at the dorsomedial aspect of testis.

4. Vas deferens is highly tortuous and placed medial to the corresponding ureter. It opens at the dorsal wall of cloaca together with ureter.

5. The copulatory apparatus is placed at the ventral aspect of the caudal end of cloaca. It comprises of two papillae of vas deferens, two vascular bodies, a phallus and two lymphatic folds.

FEMALE GENITAL ORGANS

The organs of female genital system are ovaries, oviducts, uterus, vagina and vulva. The mammary gland is considered as an organ accessory to the female reproductive system as it becomes functionally active in the later stage of pregnancy.

OVARIES

These are two oval bodies one on each side, situated a little above the middle of the pelvic inlet and is attached to the broad ligament by a fold of peritonium. In most and the farm animals the ovary is situated in an open type bursa. This ovarian bursa is a pouch formed by a thin peritoneal fold and termed mesovarium. The size of the ovary is highly variable from animal to animal. Average length is 2-3 cm; width is 2 cm and thickness is 1 cm. They are richly supplied with blood vessels and nerves. Each ovary has two borders, two surfaces and two ends. The surfaces (lateral and medial) are convex and irregular in appearance. The ovary is attached with the mesovarium by one border and the free border is convex. Anterior end is also known as tubal end. It is wider and a part of fimbria of the infundibulum is attached with it. Posterior end is rounded and narrow. The attached or mesovarial border is considered as the hilus of the ovary.

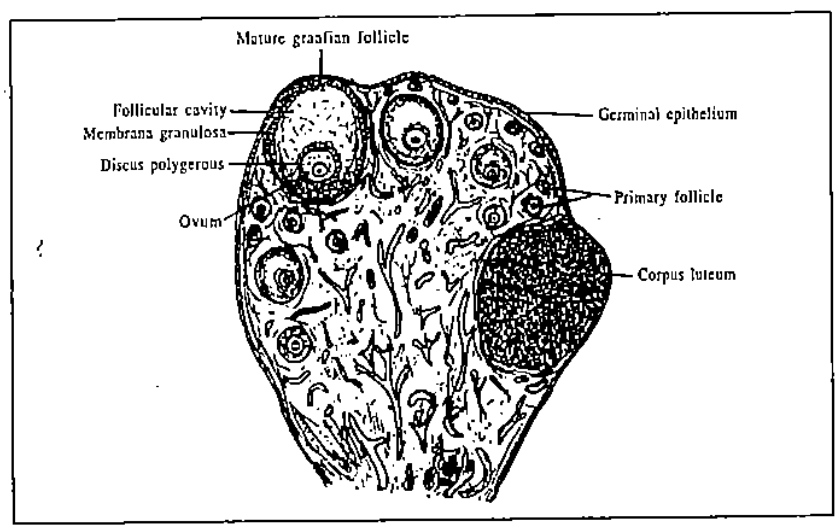


Fig. 6.89 Section of an ovary (Schematic).

STRUCTURE

This organ undergoes maximum histological variations at different phages of life. A normal matured ovary is externally covered by germinal epithelium, which is continuous with the peritonium. Graffian follicles actually do not develop from this layer. Tunica albugenia is a fibrous layer below germinal epithelium. The stroma is composed of connective tissue network, spindle shaped cells and few involuntary muscle fibers and gives support to other important structures and vessels of the ovary.

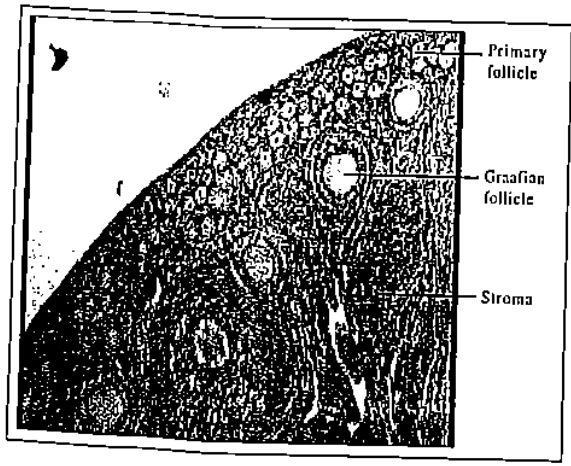


Fig. 6.90 Microscopic structure of ovary.

Graafian follicles are round bodies scattered mostly at the peripheral part of the ovary and found in different stages of development. According to the maturity they are called primary, secondary and mature follicles. The cell in the center of the follicle usually develops into an ovum. The remnents of ruptured follicle reorganise to form **corpus luteum.** It remains as a reddish yellow coloured outgrowth from the surface of the ovary for a restricted period of time.

There are some groups of cells which are polyhedral in shape and probably secret oestrogen, known as interstitial cells.

In infant stage of the animal the ovaries contain large number of primodial follicles and spindle shaped stroma cells. The germinal epithelium at this stage is made up of cuboidal cells. In puberty the cells of germinal epithelium become flattened and the ovary contains a large number of maturing follicles. In pregnant condition the ovary presents an well-developed corpus luteum. In the manopause stage the follicles disappear, fibrous scar tissues increase and the ovaries become smaller in size as they undergo atrophy.

Maturation of graafian follicles

In mature animals the follicles undergo incomplete development and subsequently degenerate to form **atretic follicle**. The mataration starts at puberty. In one estrus cycle only one follicle matures fully and discarges an ovum in cows. However in small ruminents, pigs, biteches and in rabbits multiple ovulation takes place. The cortex of the ovary is the area just deep to the tunica albugenia and houses the female germ cells the oogonia. The medulla is highly vascular. Oocytes are developed from oogonia. Ovarian follicles are formed when the oocytes become surounded by a layer of epithelial cells. When a primary oocytes is surrounded by a single layer of follicular cells, the structure is called **primordial follicle.**

Under the influence of follicle-stimulating hormone the single layer follicular cells become cuboidal in shape. At this stage it is called **Unilaminar primary follicle.**

Subsequently several layers of follicular cells are formed and an intervening membrane zona pellucida as well as an external membrane. **Theca interna** is developed. Thus a **Multilaminar primary follicle** is developed. Further development takes place and the follicle becomes bigger in size. A cavity within the follicular cells is formed to accommodate a fluid known as **liquor folliculi.** At this stage the whole structure is known as **secondary follicle.** With the further growth of the follicle, the antrum (cavity) become enlarged and the follicular cells become separated into a peripheral part and a central part. The peripheral cell layer which is now pushed towards the theca interna is called **membrana granulosa.** The visceral layer of cells which surround the oocyte is called **corona radiata.** The inner layer of these cells are attached to the outer covering of oocyte — the **zona pellucida.** The oocyte along with the cells of corona radiata remains attached with the peripheral layer at one pole with the help of a group of cells. These are known as **cumulus oophorus** or discus polygerous. In the meantime another membrane, **theca externa** is developed out side the theca interna and at this stage the entire structure is called mature Graafian follicle.

Ovaries of mare

They are large and bean shaped. They are situated at the sublumbar region. There is a depression on the free border of the ovary, known as **ovulation fossa.** Only the ovulation fossa is covered by germinal epithelium. The position of cortical and medullary tissue is reverse in this animal, i.e. follicles are situated at the medulla and the vessels and other stroma are placed outside.

Ovaries of bitch

These are oval elongated structures situated below the 3rd or 4th lumbar vertebrae. Each ovary is completely enclosed in a peritoneal pouch, known as ovarian bursa. The bursa has a small opening ventrally.

Ovary of hen

In the birds there is one ovary and one oviduct. The right set undergoes degeneration in early life and the left set persists throughout the life.

The ovary is situated at the upper part of the abdominal cavity below last two ribs. In mature stage it is in the form of a bunch of grapes. A number of follicles of various sizes are attached to it by small stalks.

OVIDUCT

These are two narrow flexuous tubes which are continuous with the pointed ends of corresponding uterine horns. Each has a length of about 20 to 30 cm and is attached to the free cranial border of the broad ligament. The diameter is about 2 to 3 mm. First half portion (uterine) is narrow and thick walled, called **isthmus.** The overian half is thin walled and little dilated. This part is the ampulla of the tube. The overian end is dilated to a great extent to form a funnel shaped structure, known as **infundibulum.** The margin of the infundibulum is fimbriated. A small aparture situated at the center of the funnel is the abdominal opening of the tube. The uterine opening of the tube is the communication between the horn of the uterus and the fallopian tube. This junctional portion is known as intramural part of the tube. The shape and size of the infundibulum varies from animal to animal and from species to species. In cattle the surface area of infundibulum is about 20 sq. cm. The ampulla is highly flexuous and constitute more than half of the oviduct.

Structure

The tube is composed of serous, muscular and mucous coats. The serous coats is derived from peritonium. The muscular coat consists of circular and longitudinal muscle fibers. The circular muscle fibers are plenty at the isthmus and therefore the lumen is narrow and the wall is thick. This structure is suggesting the existence of a sphincter which may prevent infection. The mucous membrane is formed by ciliated epithelium. This membrane forms plenty of longitudinal folds at the isthmus. In the ampulla these folds are branched and formed primary, secondary and even tertiary folds. These folds practically occupy the whole lumen of the tube keeping small spaces in between.

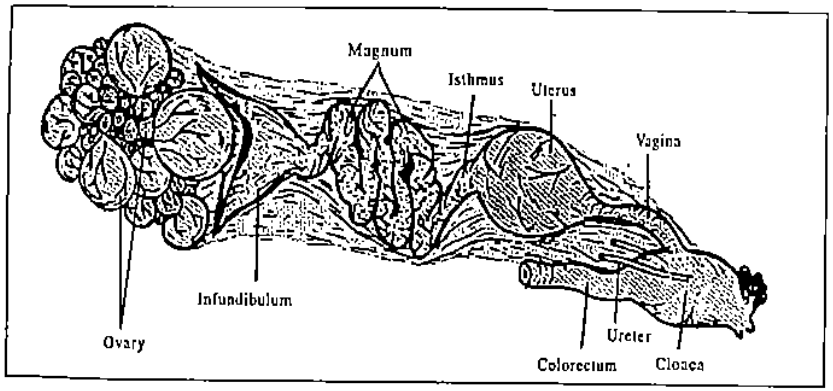


Fig. 6.91 Ovary and oviduct of chicken.

Oviducts of mare

The tubes are more flexuous and the length is shorter. The fimbriae are more extensive. As the tubal end of the horn is blunt, the junction between the horn and the fallopian tube is abrupt.

Oviducts of bitch

The fallopian tubes in this animal are less flexuous. Length of each tube is about 5 to 7 cm. Uterine opening is small. A portion of the fimbriated end projects into bursa ovarii through a slit like aparture.

Oviduct of hen

The female genitalia in birds comprises of a single ovary and one oviduct of a complex nature. The right duct degenerates and the left Mullerian duct persists to form the genitallia.

The length of the oviduct in nonlaying condition is about 15 cm and increase much in laying stage. This tube comprises of five parts. (i) **Infundibulum**—It is the membranous expanded funnel shaped cranial end of the tube. (ii) **Magnum or albumin secreting portion**—It constitute about the half of the total length and is next to infundibulum. The wall is thicker than infundibulum. (iii) **Isthmus or shell membrane secreting portion** is short and the diameter is less. (iv) **Uterus or shell gland region**—It is little thicker and expanded in laying condition. (v) **Vagina**—This is a short narrow and curved tube. There is a sphincter at its entrance into cloaca.

STRUCTURE OF AN AVIAN EGG

The eggs are generally oval in shape with one end more blunt. The colour is variable from species to species but generally white. In some birds eggs become pigmented. An egg is composed of the following components.

1. **Cuticle** – It is the outermost extremely thin layer in the form of a covering varnish on the egg shell.

2. **Egg shell** – It is thin but hard covering of the egg made up of delicate fibers and inorganic salts of calcium. It accommodates numerous minute pores. Number of these pores is more at the blunt end.

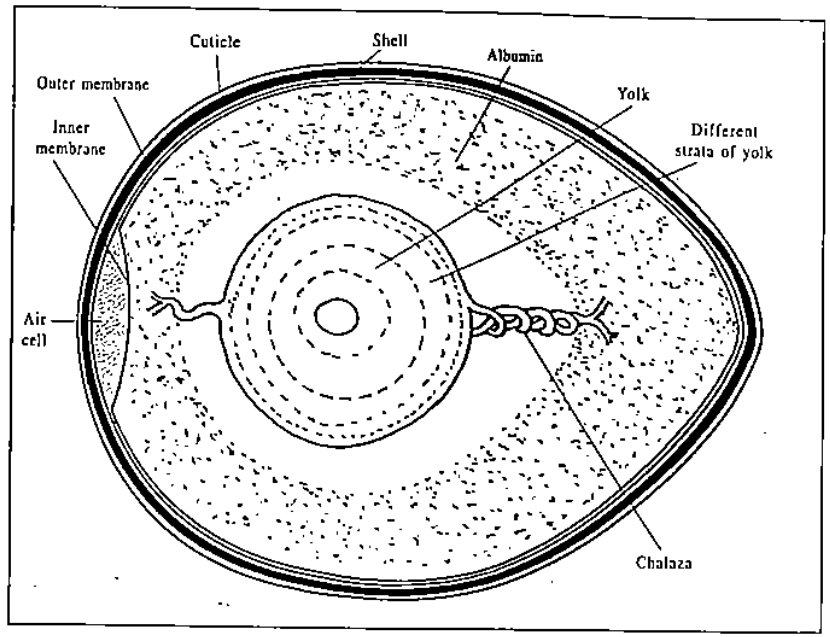


Fig. 6.92 Structure of an avian egg.

3. **Shell membrane** – It is a double layer thin membrane made up of protein fibers and albuminous cement and therefore very tough. There remains a air space between the two layers at the blunt end of the egg.

4. The albumin or the white of the egg surrounds the sphere of yolk. It is disposed in three layers – outer, inner and middle. The outer and inner layers are less viscus.

5. **Chalazae** – These are twisted cords and two in number. They are attached with the membrane of the yolk at both the ends and remain suspended in the albumin. These structures probably hold the yolk towards the center of the egg.

6. **Yolk** – It is a lump of spherical yellowish structure and produced by the ovary. It contains the cell which is visible on the surface of the yolk. It remains covered by a membrane which is derived from mature follicle of ovary.

UTERUS

It is a thick walled hollow muscular organ situated almost in the abdominal cavity and partly in the pelvic cavity between bladder below and the colon and rectum above. It is continuous cranially with the oviducts and caudally with the vagina. The organ is attached to the sublumbar region and to the lateral walls of pelvic and abdominal cavities by broad ligament.

The broad ligament is formed by double fold of peritonium with some connective tissue and muscle fibers in between them. It provides passage to the nerves and vessels to the uterus. The muscle fibers are continuous to those of uterus. Broad ligament on either side gives a fold to the uterus, which

extends upto internal inguinal ring, known as round ligament of uterus. Different portions are attached to different structures and have been named accordingly. The part which supports the ovary is the mesovarium. Mesosalpinx supports tube and the mesometrium supports the uterus.

The uterus has three main parts—*Horns, body* and *cervix.*

Horns of uterus—They are two in number—*right* and *left.* Each horn is a spiral muscular tube tapered cranially to join the oviduct. They are broad caudally and unite together to form the body of the uterus. Average length of a horn is about 30 cm in non-pregnant condition. They are directed downward, forward, outward, backward and finally upward and thus presents spiral appearance like the horns of a ram and hence named as horns of uterus.

Body of the uterus—Although very small, 4 to 5 cm in length, it appears to be longer due to the presence of a common peritoneal covering on the caudal most parts of the horns before their union. This is a dorsoventrally flat tube and is laterally attached with the broad ligament. The wall is thicker than horns. The body bifurcates cranially to form horns and caudally continuous with the cervix.

Cervix of the uterus—The cervix or the neck is about 8 cm long and is the caudal part of the uterus. The wall is very thick and the cavity has been transformed into a narrow canal and remains filled up by spiral folds of mucous membrane. This cervical canal communicates cranially with the body cavity and caudally with the vagina. The caudal part projects into vagina and presents a number of muscular folds on the surface. The tip of the projected part presents a depression, the external os, through which the cervical canal communicates with the vagina.

STRUCTURE

The wall of the uterus is composed of outer serous coat, the perimetrium; middle muscular coat, the myometrium and the inner mucous coat, the endometrium.

The ***perimetrium*** is derived from peritonium and covers the whole organ except the lateral borders. The peritonium then reflects on the rectum above to form rectovaginal pouch and bladder below to enclose the vesicogenital pouch. The ***myometrium*** is thick and composed of three layers of smooth muscles. Although poorly differentiated, these are outer longitudinal, middle circular and inner longitudinal in orientation. In the cervix the amount of circular muscle fibers are maximum and act as sphincter. The uterine blood vessels remify in the muscular layer. The growth of myometrium is stimulated by oestrogen. Further increase in the length and number of muscle fibers take place during pregnancy by the stimulation of placental oestrogen. The ***endometrium*** consists of surface epithelium and lamina propria. The endometrium or the mucous membrane is continuous with the peritonium through the fimbriated ends of fallopian tubes and with the mucosa of vagina through the external os. The epithelium is columnar ciliated at the horn, columnar in the body and neck and stratified at the external os. The cells of surface epithelium of the endometrium are tall at the time of estrus *i.e.,* in active secretary phase. They become low columnar or cuboidal at the postestrus phase. However these epithelial cells are ciliated columnar at the early life (before puberty) and subsequently become nonciliated at the reproductive period. The lamina propria consists of stroma cells, tubular uterine glands, lymphatics, blood vessels and nerves. The endometrial glands are coiled tubular and branched structures, which open on the endometrial surface but not on the caruncular area. These glands extend upto the inner surface of the myometrium and are lined by columnar cells with occasional cilia. In the endometrium of the horn and body, a large number (about one hundred) of raised pitted surfaced

button like structures remain in scattered manner. These are known as **uterine caruncles or cotyledons.** They are large at the middle and small at the ends of the horn. The crypts of the cotyledons receive chorionic villi of the placenta. In pregnent condition these caruncles enlarge to a great extent. Uterine vessels enter the caruncles through the attached surface with the uterine wall.

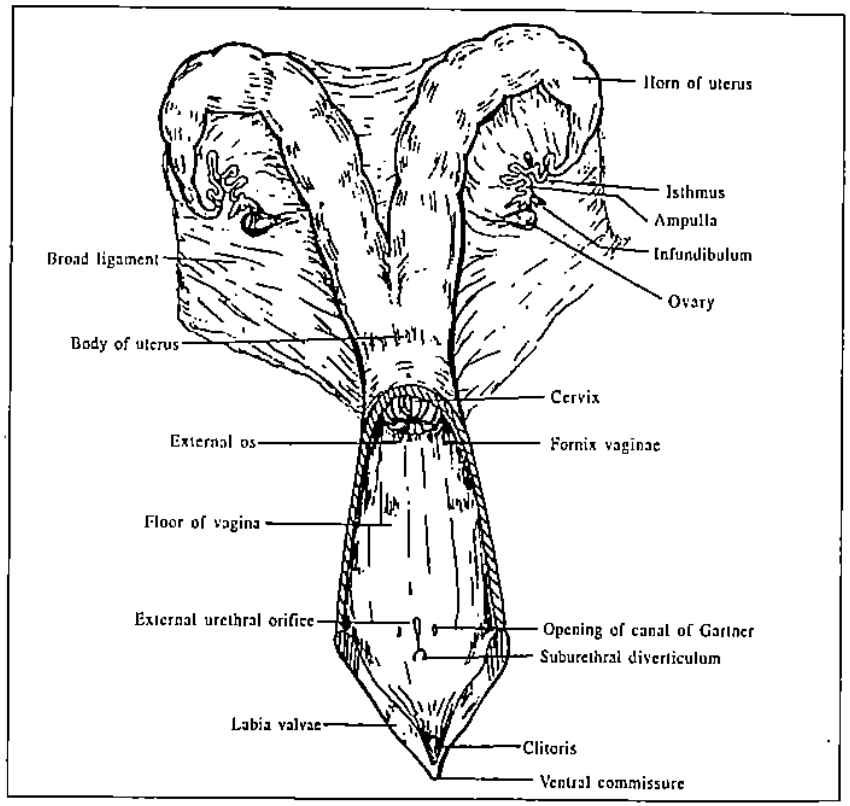


Fig. 6.93 Female genitalia of cow.
(Dorsal view. The roof of the vagina and vulva have been removed)

Blood supply—The ovary, fallopian tube and the apical part of the horn get blood supply from ***utero-ovarian artery***, which is a direct branch from the abdominal aorta as the spermatic artery in the male. ***Middle uterine artery*** supplies the caudal part of the horn and adjacent part of the body. It arises from umbilical artery, which is first major collateral branch of the internal iliac. This artery passes within the broad ligament, detaches a good number of branches for the body and horn of the uterus. These branches sometimes anastomose with each other. It can be palpated through rectum at the later stage of pregnancy. The ***caudal uterine artery*** is the 4th major collateral branch of internal iliac called urogenital artery, which supplies the caudal part of the uterus and cranial portion of the vagina.

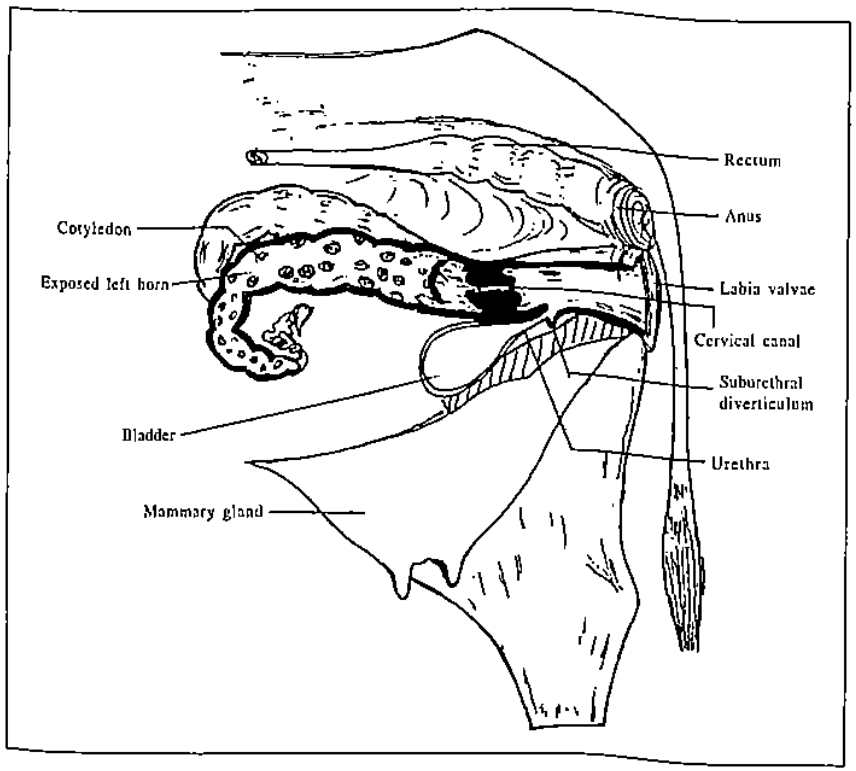


Fig. 6.94 Female genitalia of cow in situ.
(Valva vagina and the left horn of uterus is exposed)

Uterus gets nerve supply from pelvic plexus

Uterus of mare

1. The horns are short and their ends are blunt.
2. The body of the uterus is longer and wider than that of cow. Average length is about 20 cm.
3. Neck is short and cervical canal is straight.
4. The endometrium is devoid of any cotyledon.

Uterus of bitch

1. Body is short and the horns are very long.
2. The whole structure appear as a large V.
3. The average length of the body and horn are 2.5 cm and 13 cm respectively.
4. Horns are not tapered cranially.
5. Cotyledons are absent.

VAGINA

It is a muscular tube extends from caudal portion of cervix to the vestibule. Average length of this structure is about 20 cm. The length increases during pregnancy. It is related ventrally with bladder and urethra and dorsally with the rectum. Lateral surfaces are related to the walls of the pelvic cavity. The luminal space at the cranial end around the vaginal part of the cervix is known as **fornix vaginae**. Externally the cranial part of the tube is covered by peritonium and the rest portion is surrounded by loose connective tissue, plexus of blood vessels and fat. At the floor between the muscular and mucous coats there are two ducts along the length of the tube, known as *canals of Gartner* which open on either side of the urethral opening. These are the remnents of *Wolffian* (Mesonephric) ducts. The muscular coat is composed of inner circular and outer longitudinal muscles. The surface epethelium of the lumen is lined by non-keratinised stratified squamous epithelium. The mucous membrane possesses longitudinal folds.

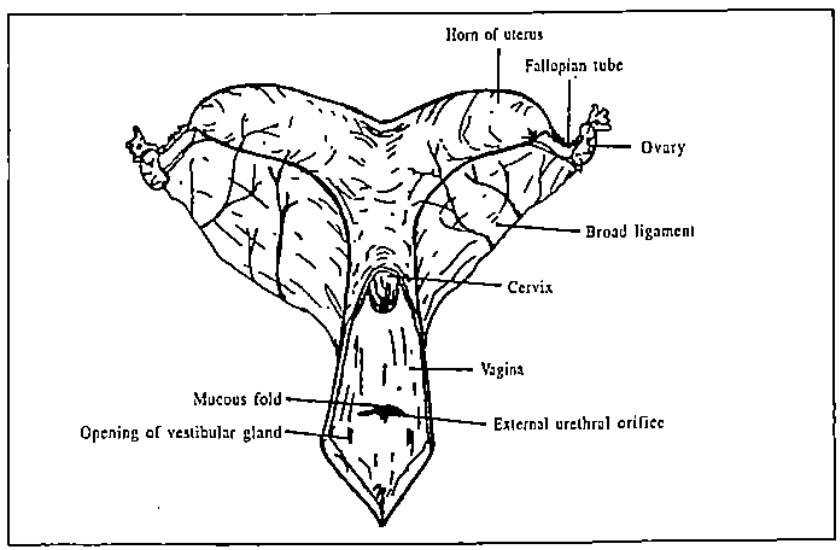


Fig. 6.95 Genitalia of mare.

Vagina of mare

1. It is shorter and less capacious.
2. Wall is comparatively thinner.
3. Length is about 18 cm and diameter is about 10 cm.
4. The external urethral orifice is covered by a transverse fold of mucous membrane.

Vagina of bitch

1. It is comparatively long.
2. Fornix is not distinct.
3. Canals of Gartner are generally absent.

Vulva (Vaginal vestibule)

It is the caudalmost part of the birth canal and extends from external urethral orifice to the vulvar cleft although there is no line of demarcation between vagina and vestibule. Cranially it is continuous with the vagina. The *vulvar cleft* is a vertical slit like aparture between two labia valvae. These labia meet dorsally and ventrally with each other and thus form dorsal and ventral commissures. The ventral commissure is further extended backward and downward and encloses the clitoris. The length of the tube is about 8 to 10 cm.

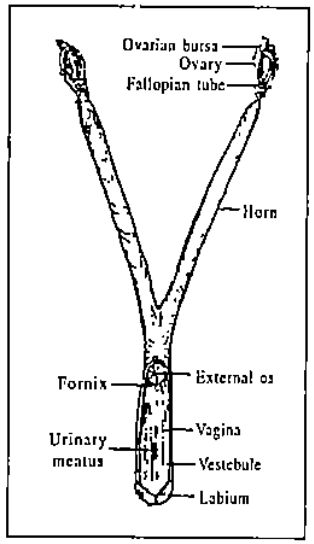


Fig. 6.96 Genitalia of bitch (Dorsal view).

It is related to rectum above and to the floor of the pelvic cavity below. Laterally it is related to pudendal vessels, nerves and sacrosciatic ligament. On the midline of the floor and at the junction between vulva and vagina there is a slit like aparture, the **external urethral orifice**. It is about 8 cm in front of ventral commissure. An indistinct fold of mucous membrane is present in front of the orifice, which directs the flow of the urine. In very young animals this fold extends to form **hymen**. There is a depression just behind the external urethral orifice known as **suburethral diverticulum**. At the floor a pair of large and some small vestibular glans are present. **Clitoris** corrosponds to a miniature penis without urethra and composed of erectile tissue. The small body or glans clitoris is lodged in the fossa clitoris. The fold of mucous membrane which covers the glans is considered as prepuce of clitoris. The mucous membrane is pink or yellowish red in colour.

Muscles

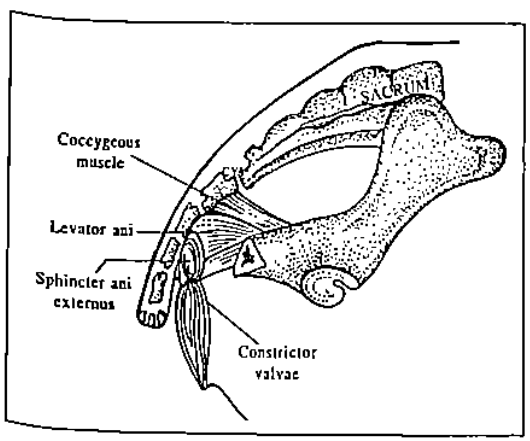


Fig. 6.97

The voluntary muscles of valvua are ***constrictor valvae*** and ***constrictor vestibuli***. Most of the fibers of sphincter ani externus continue downward to the opposite labium after crossing with the similar fibers of opposite side below the anus as constrictor vulvae. Some fibers of lateral aspect go to the labium of same side without crossing.

Constrictor vestibuli extends from the ventral border of levator ani to the caudal end of pelvic symphysis, where it meets with the tendon of opposite muscle. This muscle is placed ventrally and laterally at the cranial end of vulva.

Female urethra is a 8 to 12 cm long narrow tube extends from the neck of the bladder to the external urethral orifice. It is dorsally fused with the vagina and ventrolaterally covered by constrictor vestibuli muscle. The submucous layer is rich with blood vessels.

Valva of mare

1. The clitoris is short and thick.
2. The fossa clitoris is wide.
3. Suburethral diverticulum is absent.
4. Ventral commissure is thick. Mucous membrane is red.
5. Urethra is shorter but thicker than cow.

Valva of bitch

1. Clitoris is flat.
2. Labia are thick.
3. Ventral commissure is pointed.
4. Mucous membrane is red.
5. Urethra is about 5 cm in length.
6. The constrictor vestibule muscle is strong.

Female genitalia of sow

1. Mature ovary is lobulated in appearance due to the presence of graafian follicles on the surface. They are generally situated close to the pelvic brim and remain covered by ovarian bursa.

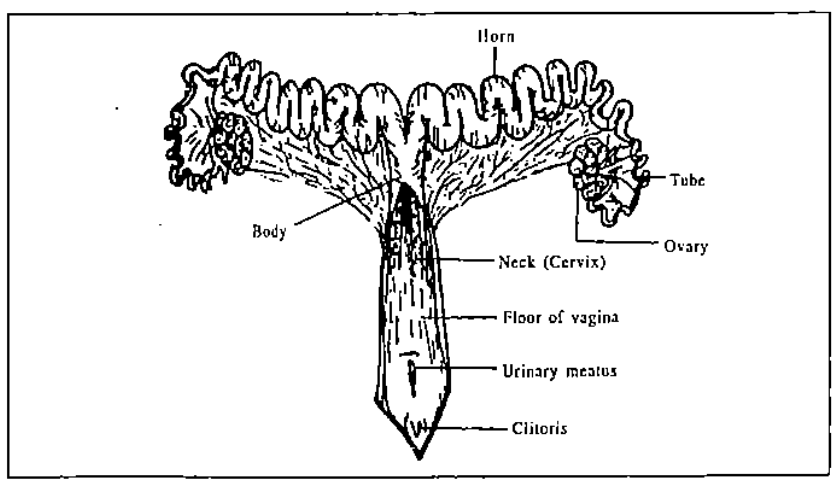


Fig. 6.98 Genitalia of sow (Roof of vagina and vulva removed).

2. Oviducts are about 20 cm long narrow flexous tubes. Abdominal opening of the tube is wide.
3. Uterus has a small body (about 5 cm) and long tubular flexous horns. The length of the horn may be one meter and presents numerous 'U' shaped coils. The neck (cervix) is elongated and presents

rounded prominences within the lumen. This arrangement helps in forming interdigitation and provide better occlusion during necessity. The wall of the neck is continuous with that of vagina and there is no cervical projection within the vagina.

4. The vagina is about 5-6 cm long and presents longitudinal folds in the lumen.

5. Valver lips are thick. Dorsal commissure is rounded and the ventral commissure is pointed.

6. Clitoris is in the form of a small projection.

Female genitalia of rabbit

1. The ovary is an elongated pinkish structure. It is about one cm long and 4 mm thick.

2. The fallopian tube is a slender flexous tube of about 5 cm length.

3. The horns are curved, narrow, slightly flexous and thick walled cylindrical tubes. The average length is about 9 cm and thickness is about 5 mm in non pregnant condition.

4. The lumen of the horn presents 3-4 longitudinal folds. These folds presents nodular elevations along its length.

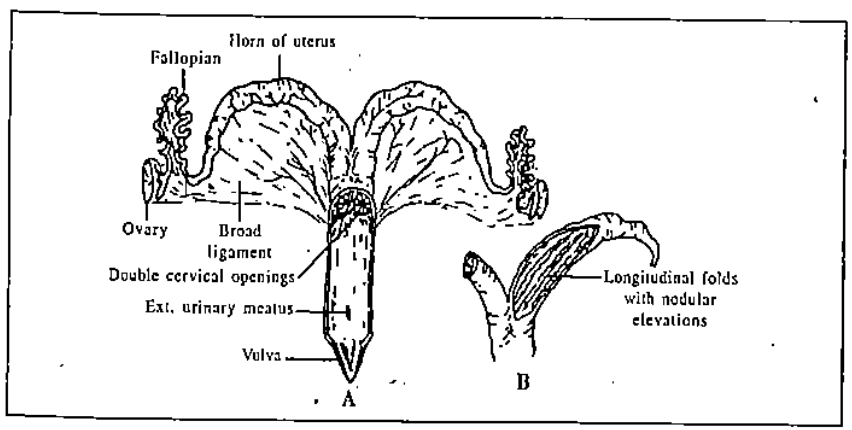


Fig. 6.99 A. Female genitalia of rabbit (Vagina exposed) B. Exposed horn of uterus of rabbit.

5. The caudal parts of the horns remain in close apposition without any union between them and open separately at the cranial end of vagina. Therefore the body of uterus is absent and external os are two in number.

6. The vagina is elongated tube and the valvar lips are pointed downward.

MAMMARY GLAND

It is regarded as an accessory organ of the reproductive system, because it developes with the influence of hormones during puberty and starts functioning actively in the later stage of pregnancy. It is a modified sweat gland.

These glands are four in number, situated in the inguinal region, two on either side of the median line between the thighs. In the male and immature female they are rudimentary. In small ruminants they are generally two in number.

They develop in the puberty and become more marked in the latter stage of pregnancy and specially after parturition.

The enlargement of the glands occure by the action of estrogen and progesterone which causes fat deposition, stromal development and growth of the lobules, ducts and alveali. However, for the purpose of lactation, stimulation from glucocorticoids, thyroid hormons and insulin are necessary, prolactin and growth hormons are also essential.

The glands of both sides (right and left) are separated by a septum. Demarcation between the two glands of each side is not distinct and also do not possess any septum between them. However, there is no communication between the duct systems of the glands. On the basis of external appearance, each of the glands are called quarters. Glands of each side have a concave base with which they are attached to the convex abdominal wall with the help of suspensory apparatus.

The suspensory apparatus comprises of thick membranes of fibrous tissue which invests over the surfaces of the glands and attaches them to the pelvic symphysis. The suspensory apparatus is made up of four thick membranes of yellow elastic tissue. Out of them two are median in position and form double septum between the glands of both sides. Other two are lateral membranes. They also arise from the pelvic symphysis, diverge to pass laterally and cover the lateral surfaces of the glands. Their pariatal layers are reflected to the medial surface of the thigh. [Fig. 6.101]

The medial surfaces of the glands are flat and the lateral surfaces are convex. The apex of each gland is directed ventrally and succeeded by a projected teat.

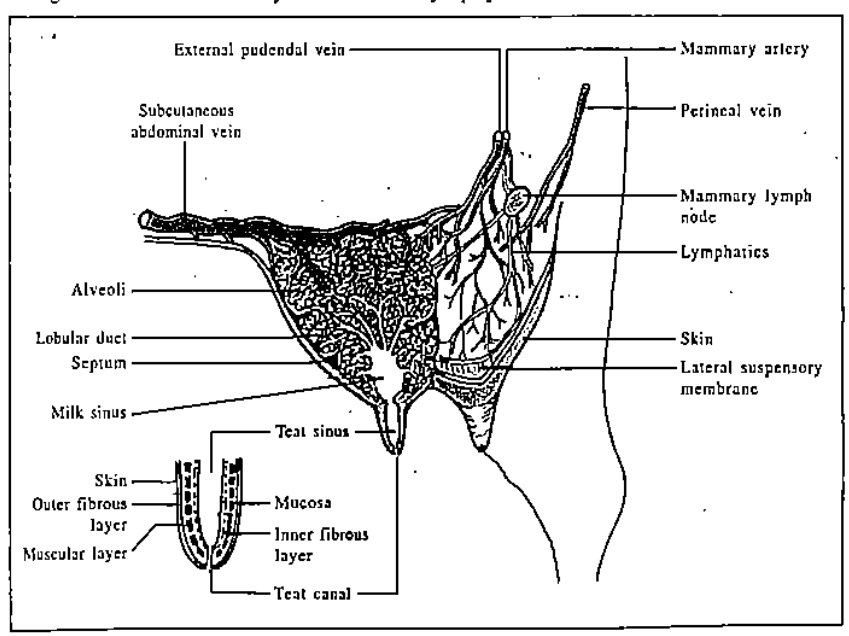


Fig. 6.100 A. Mammary gland of cow B. Longitudinal section of teat (Diagrammatic).

STRUCTURE

It has an epithelial component (parenchyma) and a connective tissue component (stroma) like all other glands. In resting stage the amount of epithelial parenchyma is very less.

Internal to skin, the gland is covered by two layers of fascia. The gland substance remain covered by a fibroelastic tissue which also contains fibers of smooth muscle. This layer sends a number of

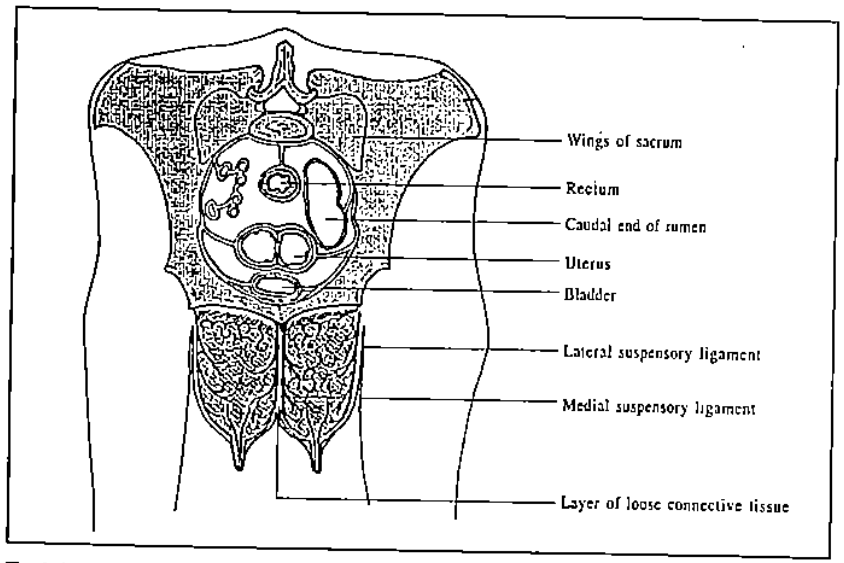


Fig. 6.101 Suspensory apparatus of udder A transverse section at the level of pelvic inlet of cow (schematic).

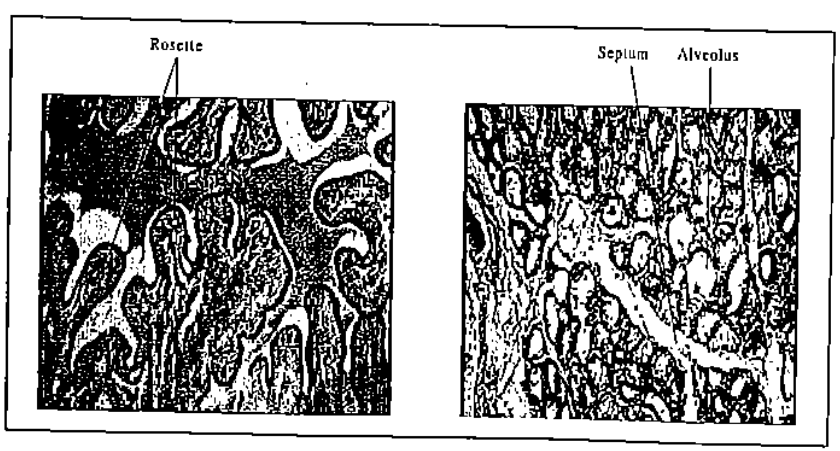


Fig. 6.102 Teat lumen showing Rosetter of Furstenburg. (By courtesy of Dr. Susanta Paul)

Fig. 6.103 Microscopic structure of mammary parenchyma, showing alveoli.

septa into the gland to support its lobules. Each *lobule* is composed of a number of alveoli. The alveolar cells vary in their form and contents according to the stages of activity of the gland. These cells secret milk. During lactation the distended alveoli are lined by single layer of epithelium which is cuboidal in resting condition and columnar in lactation. The average diameter of these alveoli is 100 to 200 microns. The alveoli and their ducts possess myoepithelial cells between the basement membrane and the epithelium. The alveolar ducts of each lobule join together to form excretory lobular ducts. The neighbouring excretory lobular ducts unite together to form *large ducts*. Many large ducts unite to form lobular ducts. They join again in the center of the gland to form a *sinus*. This sinus is known as **milk sinus** or milk cistern. The milk sinus is capacious and leads to the roomy cavity of the teat through a constriction at the level of the base of the teat. The cavity of the teat is called *teat sinus*. From the teat cavity a single lactiferous duct arises and passes through the apex and open into exterior. The canal is lined by stratified epithelium.

The teats are long and tubular in shape, with a conical distal end. The wall of the teat is composed of skin, outer fibrous layer, intermediate muscular layer, inner fibrous layer and mucosa of the teat canal. The mucosal lining of teat canal possesses many longitudinal ridges and appear in the form of radiating projections from the lumen in transverse section, called *'rosette of Furstenberg'*. The skin is devoid of hairs and the muscles are mostly circular with a thin layer of longitudinal fibers. Surrounding the base of the teat, there are a number of modified sebaceous glands which are developed during pregnancy. These are known as tubercles of Montgomery. These glands secret a lubricating substance which protect the teat during suckling. In goat and sheep only two glands (inguinal) are developed and others remain rudimentary. The glands are comparatively large in size. Therefore there are only two developed teats, one for each gland in this aminal.

Blood supply—Pudendoepigastric trunk is one of the chief branch of the external iliac artery. Its terminal branches are caudal (deep) epigastric and external pudendal artery. This external pudendal artery continues as mammary artery. During lactation this vessel becomes very large. This vessel divides into two branches to supply cranial and caudal aspect of the gland.

Nerve supply—Second and third lumbar spinal nerves, superficial perineal nerve and caudal mesenteric plexus of the sympathetic system are the nerves to these glands.

Mammary veins—A venous circle is formed around the base of the udder which is connected with (i) a large subcutaneous abdominal vein, (ii) external pudendal vein and (iii) the perineal vein.

Mammary lymph nodes—They are two in number, situated above the caudal border of the base of the udder, one on either side. They are 6 to 10 cm in length and 5 to 7 cm in thickness. The lymph vessels are numerous in these glands.

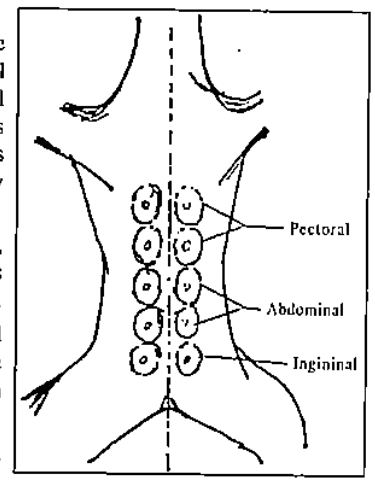


Fig. 6.104 Position of mammary glands of bitch.

Action of hormones on mammary gland

Estrogen stimulates the growth and branching of the ducts. Progesterone stimulates the formation of alveoli. Placental estrogen and progesterone stimulate formation of true secretary alveoli during pregnancy. Prolactin and growth hormone maintain lactation. Oxytocin helps in milk ejection.

Mammary glands of mare

1. They are two in number. Sizes are smaller.
2. Each gland has a teat with two lactiferous ducts.
3. Lactiferous sinus is small.
4. The glands are pre-pubic in position.
5. The teats are flattened transversely and comparatively shorter in length.

Mammary glands of bitch

1. There are ten glands, five on either side and are arranged in parallel longitudinal rows.
2. Out of five glands in one side, two are pectoral, two are abdominal and one is inguinal in position.
3. Lactiferous sinus is absent.
4. There are 8-12 lactiferous ducts in each of the teats.

Mammary glands of pig

1. There are 5 to 6 pairs of mammary gland in this animal.
2. Lactiferous sinus is not prominent.
3. Each teat generally has two ducts.

Mammary glands of rabbit

1. There are 3-4 pairs of glands in this species.
2. They are pectoral, abdominal and inguinal in position.
3. Lactiferous sinus is not prominent.

PLACENTA AND EXTRAEMBRYONIC MEMBRANES

Placenta

Placenta can be defined as an area, where a close apposition or fusion takes place between the uterine wall and embryonic tissue for exchange of materials.

It is formed by the union of some portions of outermost embryonic membrane (chorion and allantois) and some modified parts of uterine mucosa. Although there is no direct mixing of fetal and maternal blood within the placenta, the chorionic villi with their contained capillaries come in contact with the maternal vessels present in the cotyledons. Practically the fingerlike villi of the chorion burry themselves into the cotyledons, which are spongy network of blood sinuses. The tissue in between the two groups of blood capillaries is sufficiently thin to permit absorption of oxygen and nutritive materials into the fetal blood and elimination of waste products from it.

Other membranous structures which are developed from the three germinal layers for the protection and support of the embryo are (a) yolk sac, (b) amnion and (c) allantois.

The yolk sac is very small in mammals and remain functional for a short time; *i.e.*, to provide nutrition to the embryo. It comprises of a small sac and a stalk. The stalk is connected to the gut.

The Amnion is the innermost membrane enveloping the embryo. This is formed by the foldings of one layer of mesoderm and one layer of ectoderm. The layers fuse above and thereby envelope the embryo with its ectodermal component towards the embryo and mesodermal component outside. It is formed at about 18th day. The cavity is filled with the amniotic fluid in which embryo remains suspended. This arrangement protects the embryo against mechanical injury and allows it to move freely. In the advance stage of pregnancy the cavity expands fast and come close to chorion. During parturition, the amnion ruptures and the fluid escapes and thereby helps the delivary.

Allantois is another fetal membrane which develops from the hindgut. It is connected to the bladder with the help of urachus and contribute to the formation of umbilical cord and placenta. The allantoic cavity expands, come in contact with the outermost (trophoblastic) layer and combinely form the allanto-chorion. The chorion thus developed becomes very rich in blood vessels, surrounds the embryo and lie in apposition to the endometrium.

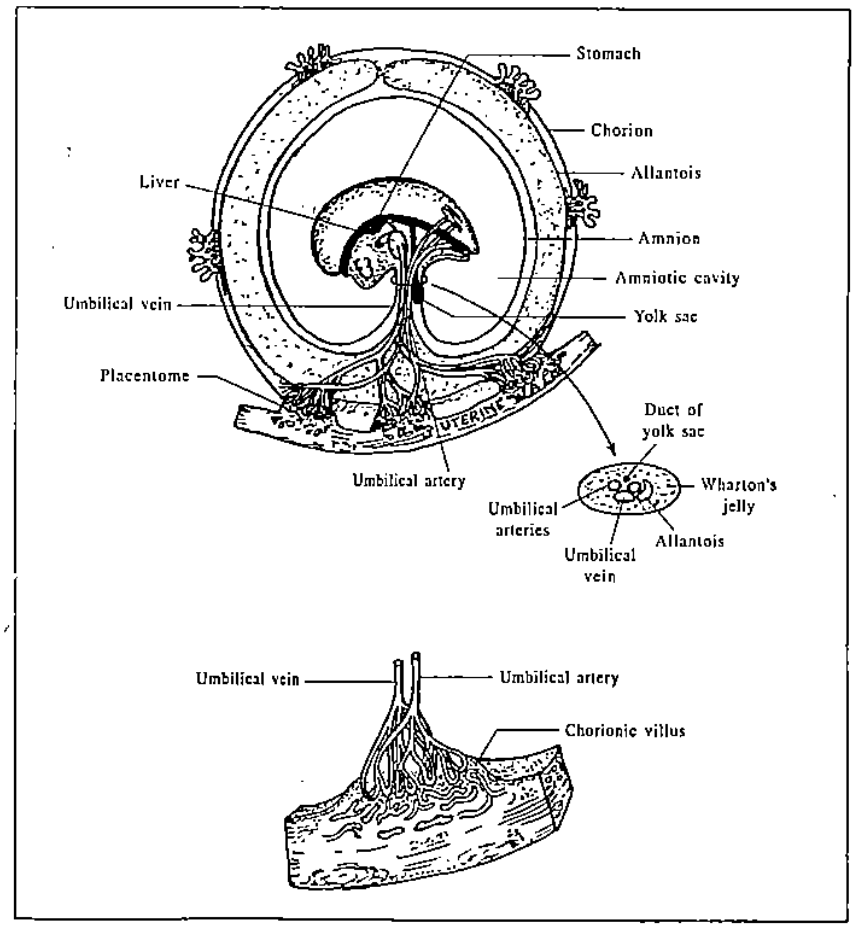


Fig. 6.105 Schematic diagram of bovine placenta and extra-embryonic membranes along with the section of the umbilical cord.

7 ANGIOLOGY

HEART

It is a hollow muscular organ consisting of two atria, the receiving chambers and two ventricles, the discharging chambers. It acts as a central pump for pulmonary and systemic circulation.

There are three layers in the wall of heart. Outer serous layer is known as **epicardium**, middle muscular layer called **myocardium** and inner endothelial membrane known as **endocardium**. The myocardium, unlike other visceral muscles are disposed in a complex manner. Muscular bundles are attached to the fibrous framework and are arranged in a circular pattern in the wall of the chambers. Contraction of these muscle bundles cause reduction in the size of the corresponding cavity and ejects the blood out through the orifices. The contraction of cardiac muscle is regulated by vagus nerve and sympathetic system. These nerves act on a special lump of tissue situated at the wall of the right auricle known as **sinu-atrial (SA) node** or **pace-maker** of heart. The impulse initiated at the SA node is relayed to the ventricles by **atrio-ventricular (AV) node**.

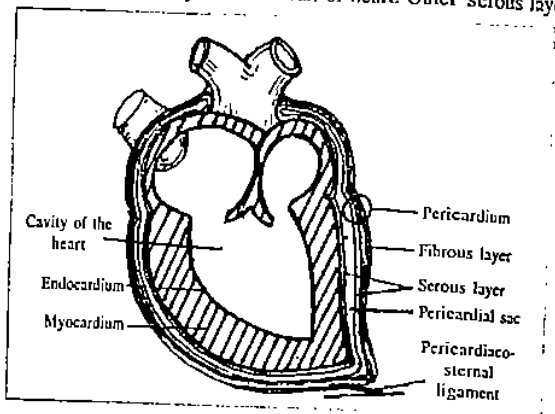


Fig. 7.1 Section of a heart showing different parts of pericardium (Diagrammatic).

The weight of an adult heart is about 0.4% to 0.5% of the body weight.

Skeleton of heart

The fibrous framework which forms tough rings around the orifices of the heart is considered as the skeleton of heart. They are attached to the muscles of the heart and the valves of the orifices. Two small triangular bones (right and left) are lodged at the base of the ventricles, on either side of the aortic ring. The left is smaller and inconstant. These are known as **oscordis**, and characteristic of domestic ruminents and not generally found in other domestic mammals.

Pericardium

It is the covering of heart and consists of a parietal and a visceral part. The parietal pericardium is composed of an outer fibrous layer which is lined internally by a serous membrane. This serous membrane is reflected and invested over the surface of the heart, called visceral pericardium or the **epicardium**. The parietal and visceral layers are separated by a small space, known as pericardial sac, which is occupied by a serous fluid known as liquor pericardii. This fluid keeps the apposed surfaces moist and smooth. Pericardium is attached to the dorsal surface of the sternum by two (left and right) **pericardiaco-sternal ligaments**. At the base it is pierced by ascending aorta, cranial and caudal venacava, two pulmonary arteries and four pulmonary veins. Pericardium keeps the heart in position and prevents overdilatation of heart.

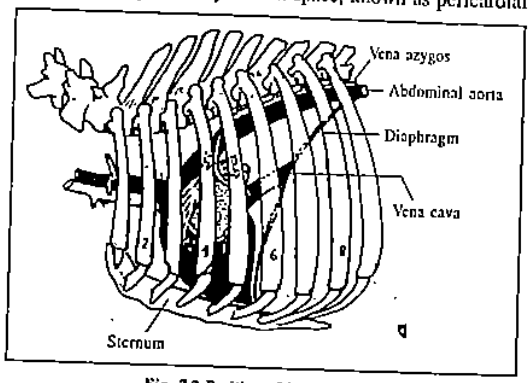


Fig. 7.2 Position of heart of ox.

Position of heart

It is a cone shaped organ situated at the ventral half of the middle mediastinum with the base directed upward and apex downward. The base extends from 3rd to 6th rib and is placed about 10 to 12 cm below the spine. The apex is placed opposite to the 6th chondrosternal joint and is very close to the diaphragm. About 5/7th portion of heart lies on the left side of the median plane, because right lung is considerably large in size.

Borders and surfaces

Anterior border is convex and its ventral part is parallel to the sternum. Posterior border is nearly vertical and correspond to the anterior border of 6th rib. Both the surfaces (right and left) are convex. The surfaces are traversed by transverse and longitudinal grooves for the occupation of the corresponding coronary vessels. The **transverse groove** which encircles the heart at the base of ventricles demarcates the separation between the auricles and ventricles. The **longitudinal grooves** are mainly two in number (left and right) which extend from the base of the ventricles and run towards the apex at the concerned surfaces. The left one is cranial and the right one is caudal in position. However, none of these longitudinal grooves reach the apex but becomes continuous with each other a little above the apex. There is small **intermediate longitudinal groove** which descends from the transverse groove along the posterior border of heart. The right and left longitudinal grooves mark the margin of the interventricular septum.

Right atrium

This thin walled muscular chamber is smaller than the left and receives venous blood from the body. It is placed at the anterior portion of the base of the heart. It possesses the sinus venosus, the main cavity and an appendix. It is related to the left atrium medially and right ventricle ventrally. It receives the cranial venacava at the level of 4th rib and the caudal venacava at the level of 5th rib. The appendix is a conical pouch winds round the cranial wall of the begining of aorta and ends at the left. The vena henii azygos opens below the opening of posterior venacava and very close to the coronary sinus. The vein which returns major part of blood from the wall of the heart itself, opens at the coronary sinus. Close to the septal wall there are some minute openings of small veins which return small quantity of blood from the substance of heart directly. The opening of the coronary sinus

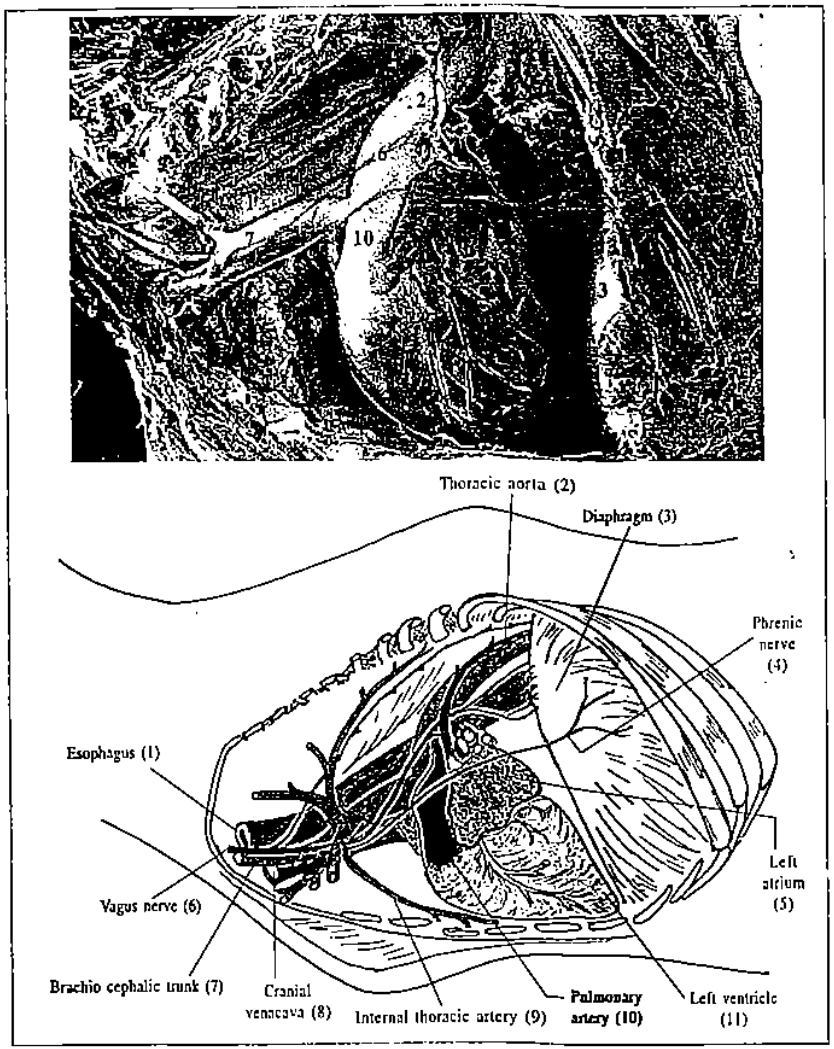


Fig. 7.3 Dissected thoracic cavity with line diagram.

remains guarded by a valve, which closes during contraction. Cranial to the opening of posterior venacava at the superior aspect of the interatrial septum, there is a depression known as fossa ovalis which marks the site of the foramen ovale of fetal life. The right atrioventricular opening is large oval and guarded by the tricuspid valve.

The wall of the atrium, particularly the appendix presents some vertical muscular ridges and looks like a comb and hence named pectinate muscle.

Right ventricle

It forms the right and cranial part of the heart. This thickwalled conical chamber receives blood from the right atrium through the tricuspid orifice and discharge it through the *conus arteriosus* into the pulmonary trunk. The conus is placed at the left side and the right atrio-ventricular orifice is placed at the right side of the base of this ventricle.

The wall is uneven internally due to the presence of muscular beams, known as **trabeculae carneae**. Some of these muscular prominences project into the cavity and give attachment to the **cordae tendineae**. They are called **papillary muscles**. One large muscular band (sometimes more than one) is found to extend from the lateral wall to the interventricular septum across the cavity of this ventricle, known as **moderator band**. It prevents excess dilatation of heart. It is also called **septomarginal trabecula**.

The **triangular tricuspid valves** are three in number and are formed by the infolding of the endothelial lining of the heart. Their free margines are attached to the chordae tendineae. In between the large cusps three smaller cusps are also present. The exit of the pulmonary artery is guarded by three **semilunar valves**. These are thin and convex at their ventricular surface and prevent re-entry of the blood, when the ventricle relaxes.

Left atrium

It occupies the left caudal part of the heart and is larger than the right atrium. It receives oxygenated blood through pulmonary veins which open on its dorsal wall of the sinus venosus. Usually four pulmonary veins, two from each lung open into the left atrium. The left atrio-ventricular orifice is situated at the base. This is comparatively smaller than the right one. The pectinate muscles are less in number. The appendix is little larger than that of right atrium. Its outer edge is serrated and placed

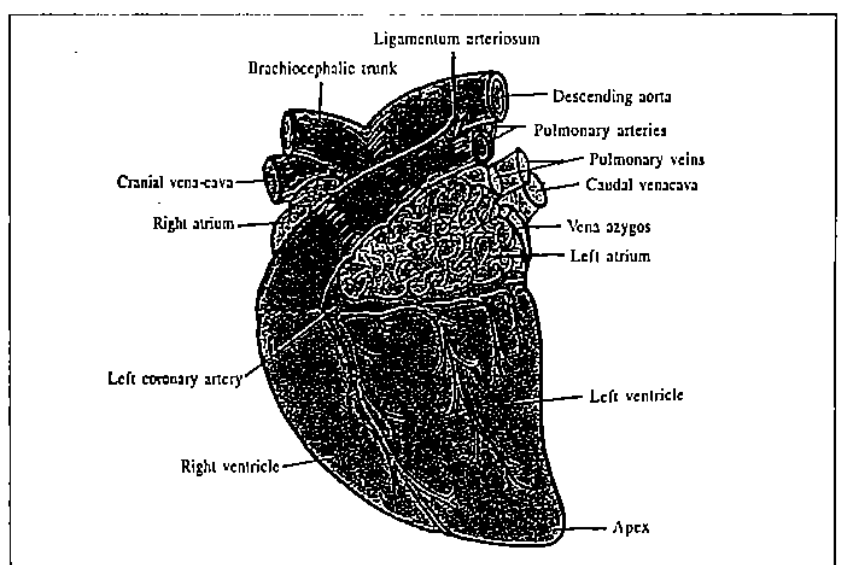


Fig. 7.4 Left lateral view of heart of ox.

at the left side of the pulmonary artery. Vena hemi azygos traverse along its lateral surface. The fossa ovalis is in the form of a faint depression.

Left ventricle

The wall of this chamber is thickest of all the compartments of heart. It forms the left and caudal part of the heart and extends from the transverse groove to the apex. So the apex is formed only by the left ventricle. Here the thickness of the wall is less. The structures such as trabeculae carneae, papillary muscles, chordae tendineae are similar to those of right ventricle. Moderator bands are usually two in number but far thinner than that of the right ventricle. The trabeculae carneae are more in number in this ventricle.

The great artery, the aorta leaves the left ventricle above and closely related to the right and caudal aspect of the pulmonary artery. Like the pulmonary artery its opening is also guarded by semilunar valves.

The left auriculo ventricular opening is guarded by two (bicuspid) valves which have similar attachments like those of tricuspids. These two cusps together look like bishop's mitre (cap) and therefore, called **mitral valves.**

Interventricular septum

This is situated in between the ventricles in a oblique manner. Its right ventricular surface is convex and left surface is concave. From outside anterior and posterior interventricular grooves indicate its attachments with the ventricular walls.

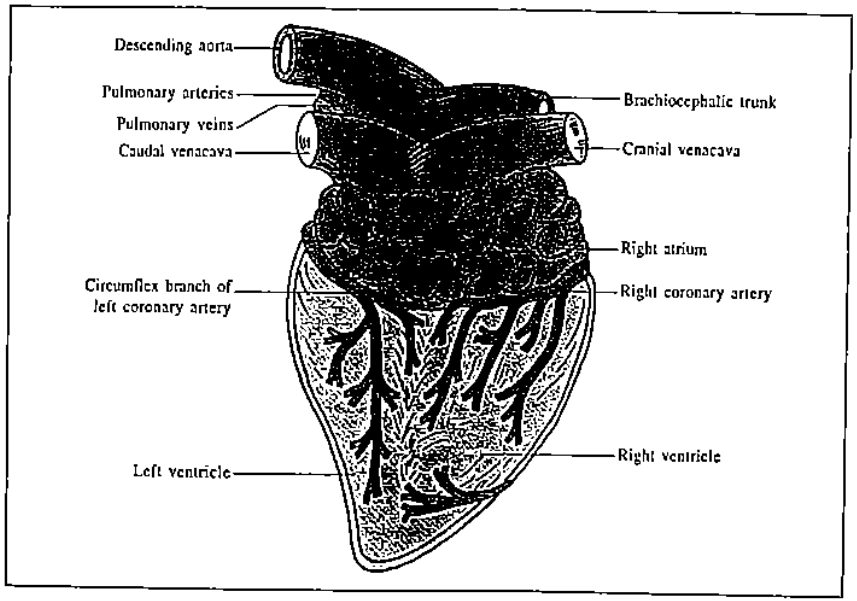
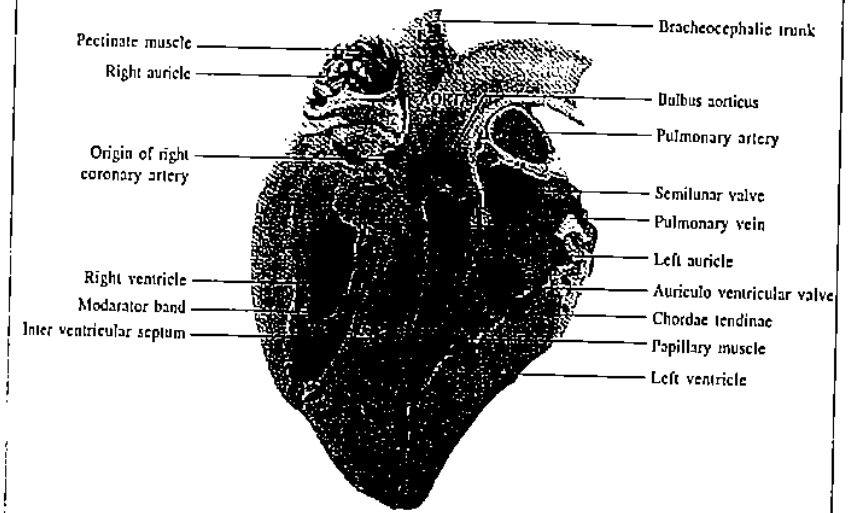
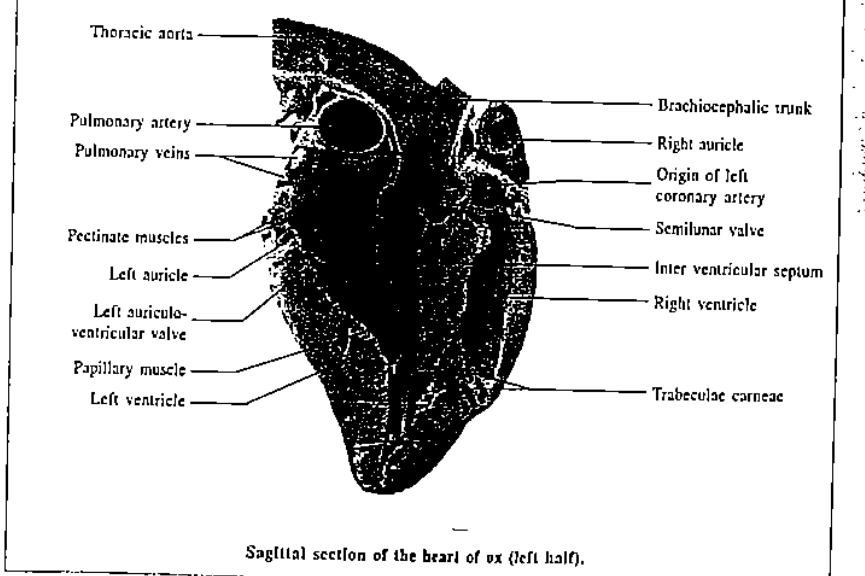


Fig. 7.5 Right lateral view of the heart of ox.



Sagittal section of the heart of ox (right half).



Sagittal section of the heart of ox (left half).

Fig. 7.6

Arterial supply to the heart

The structure of the heart is mostly supplied by left and right coronary arteries. These may be considered as vasa vasorum because heart itself is derived from blood vessels.

Anatomically coronary arteries are not end-arteries, although functionally they behave like end arteries.

Left coronary artery [Fig. 7.8]

It is larger than the right. It originates from the left side of the aortic sinus at the level of semilunar valves. It passes between the left atrium and the pulmonary artery, reaches the atrioventricular groove and divides into descending and circumflex branches. The descending branch goes down along the left longitudinal groove reaches the apical notch and make poor anastomosis with the branches of the right coronary artery at the right longitudinal groove. The circumflex branch winds round the transverse groove caudally reaches the right longitudinal groove and descends along it.

Right coronary artery

It is smaller and arises from the right side of the aortic sinus at the same level. It travels along the right part of the transverse groove and divides into a descending branch and a small caudal branch. The descending branch travels along the right longitudinal groove.

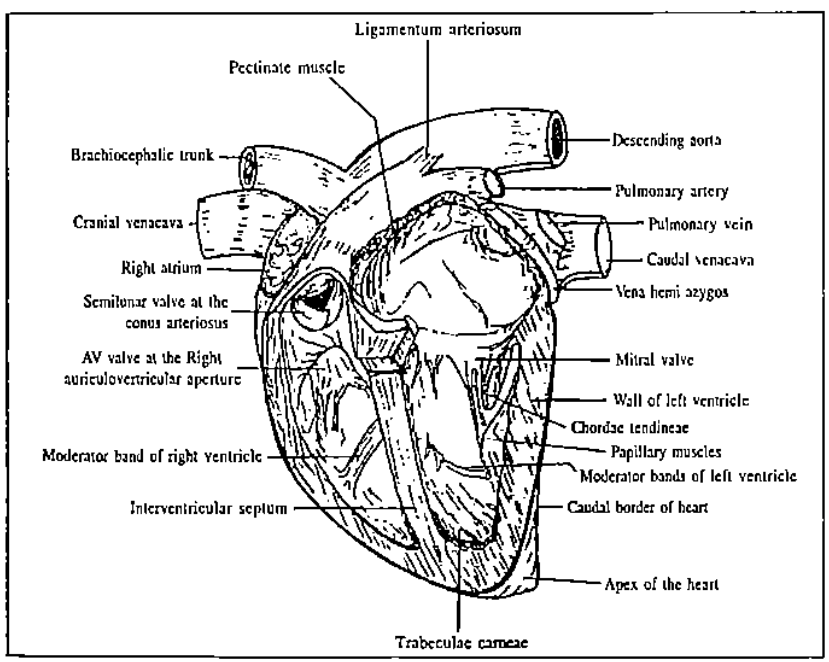


Fig. 7.7 Interior of heart of ox.

Both the right and left descending branches supply in interventricular septum. Separate septal arteries may arise directly from parent arteries.

Coronary veins

A number of veins drains the blood from the walls of the heart. Many small veins return blood from the wall of the right side and open into the right auricle at the coronary groove. The *great coronary vein* receives tributaries from the wall of both the ventricles and left atrium and join to the coronary sinus. The *middle coronary vein* comes from the region of interventricular septum.

Nerve supply to the heart

The sympathetic fiber from cranial, middle and caudal cervical ganglia and few thoracic ganglia and parasympathetic fibers from vagus nerve form cardiac plexus to innervate the heart. Stimulation of sympathetic nerves increase and the parasympathetic nerves decrease the heart rate.

Structure of the heart

The structure of heart comprises of epicardium, myocardium, endocardium, fibrous framework, cardiac bones, vessels and nerves. Everything has already been mentioned except the endocardium and myocardium.

Endocardium lines the cavities of heart and becomes continuous with the internal tunic of the vessels connected to the heart. The valves are derived by the folds of endocardium.

Myocardium

The atrial muscle fibers are separated from those of ventricular fibres at the fibrous ring of the atrioventricular groove. The atrial fibers are of two sets—superficial and deep. The superficial

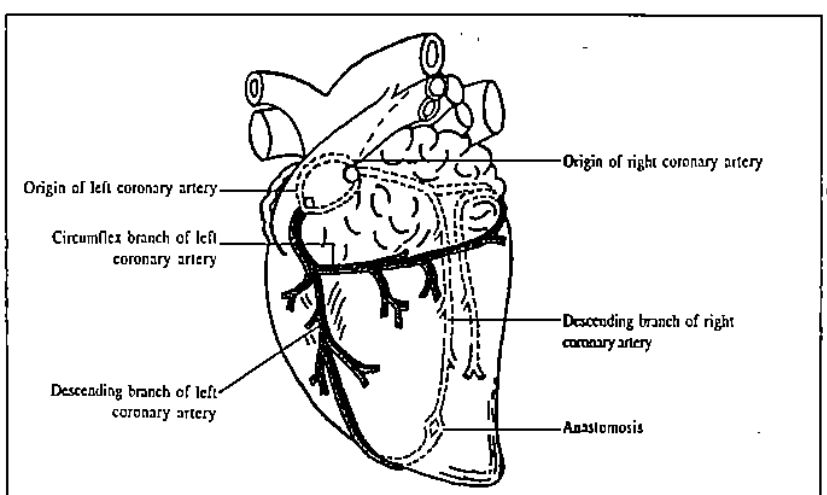


Fig. 7.8 Coronary arteries.

fibers are common to both the atria. The deep fibers are arranged in the specific atrium in the form of rings or in the form of loops.

The **ventricular musculature** is thicker and according to Leibel consists of three layers – *Superficial*, *Middle* and *Deep*. The superficial fibers arise from the skeleton of the heart and undergo a spiral course. Middle layer is the thickest, form a cylinder and presents a lower free margin. Deep layer fibers ascend at right angle to those of superficial layer.

The cardiac muscle and conduction system of heart

A cardiac muscle fiber consists of a number of short cylindrical cells which are joined end to end by intercalated discs and possesses side branches to connect with the adjacent fibers. A cardiac muscle cell contains usually one centrally placed nucleus, fat droplets, glycogen, golgi-apparatus, myofibrils and pigment granules. The intercalated disc is composed of apposition of cells membranes of the muscle cells and some electron dense materials.

The cardiac muscle cells are of four types – (a) ordinary cells, (b) nodal cells, (c) transitional cells and (d) purkinje cells. The last three are the specially differentiated cells and form the conduction system of heart.

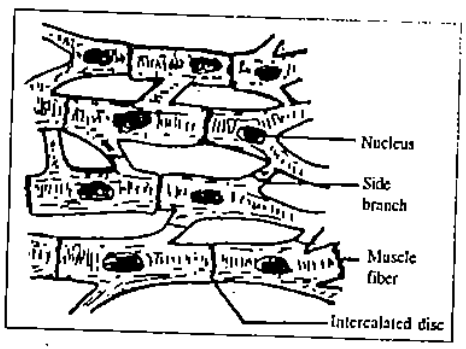


Fig. 7.9 Cardiac muscle.

The S.A. node (pace maker) regulates intrinsic rhythemic contractions of cardiac muscles. On the other hand the rhythemicity of pace maker in regulated by nerve impulses from the autonomic nervous system. However, it is also to be noted that the wave of contraction is myogenic rather than neurogenic in origin due to the fact that in the embryo cardiac muscle fibers starts rhythemic contraction before nerve fibers reach the developing heart.

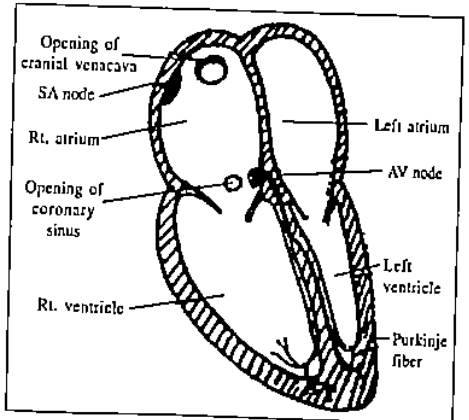


Fig. 7.10 Conducting system of heart (Diagramatic).

The nodal fibers which act as pace-maker of heart are present in the SA node and AV node. These fibers are fusiform in shape and are profusely branched. The SA node is situated in the right atrial wall, close to the opening of anterior vena cava and the AV node is situated under the endocardium of right atrium in the lower part of the inter-atrial septum. Purkinje fibers are present in the periphery of the SA and AV nodes and along the terminal branches of two fasciculi of atrio-ventricular bundle. The AV bundles remifies under the endocardium as a plexus in the ventricular wall and becomes continuous with oridinary myocardial fibers.

The impulse of contraction starts at the SA node, activates atrial musculature and conveyed to the AV node through internodal tracts. AV bundle, its two fasciculi and purkinje fibers transmit the impulse from AV node to ventricular myocardium.

Heart of horse

1. It is situated at the level of second intercostal space to 6th rib.
2. The base is comparatively broader.
3. The surfaces are flatter in comparison to those of ox.
4. Cranial border is more convex and the caudal border is nearly vertical.
5. Apex is placed on the 7th sternebra.
6. Left and right longitudinal grooves do not meet together.

Heart of dog

1. Pericardium is attached to the sternal part of diaphragm by pericardiaco phrenic ligament.
2. Apex is blunt and rounded.
3. The organ is placed obliquely at the level between the third rib to sixth interchondral space.
4. The right and the left longitudinal grooves meet together to the right of the apex.

Heart of pig

1. The organ is comparatively small.
2. It is broad and the apex is blunt.
3. The intermediate groove is small or absent.
4. Fossa ovalis is extensive.
5. Arch of aorta is strongly curved and the left subclavian artery and brachiocephalic trunk arise separately from it.

Heart of rabbit

1. It is conical in shape.
2. The sinus venosus and truncus arteriosus are not well marked.
3. Left subclavian artery arises separately.
4. Arch of aorta is strongly curved.

Heart of fowl

1. Heart is placed at the midline in the cranial part of the thoraco-abdominal cavity.

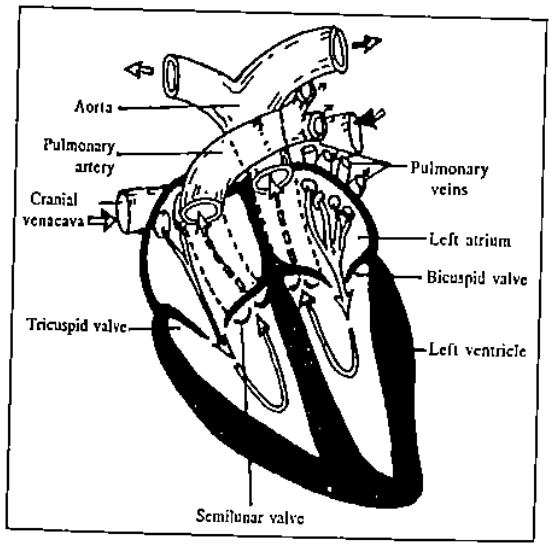


Fig. 7.11 Section of heart (Diagramatic) showing flow of blood.

2. Size is comparatively large.
3. Apex is placed between the cranial parts of the two lobes of liver.
4. Right auriculo ventricular valve is guarded by only one strong muscular leaf.
5. The AV valves are thick.

Pulmonary circulation

The branches of pulmonary artery accompany the branches of bronchial tree. Finally the capillaries derived from arterioles of the pulmonary arteries enclose the air spaces, as the bronchioles finally end as alveoli. From the capillaries venous blood returns through venous tree.

Pulmonary trunk

This is very short artery leaves the heart at the conus arteriosus at the base of the right ventricle between the appendices of right and left atria. It courses dorsally and caudally along the left side of the aorta, reaches the caudoventral aspect of descending aorta and divides into left and right branches. A little before its bifurcation into the left and right pulmonary arteries, the common pulmonary trunk is connected to the descending aorta by a fibrous cord known as **ligamentum arteriosum**, the remnant of the ductus arteriosus of foetal life.

The right pulmonary artery is longer and broader than the left. It passes caudally under the bifurcation of trachea and above the right atrium, reaches the hilum of right lung and enters it below the right bronchus. The left pulmonary artery is short, passes caudally and enters the hilum of left lung below the left bronchus.

Systemic circulation

A set of veins bring oxygenated blood to the left atrium. These are the pulmonary veins. The left ventricle receives oxygenated blood from left atrium and pumps it to the remotest capillaries through the aorta and its branches. After the exchanges of nutritive materials, oxygen, CO_2 and waste products with the tissues, finally blood returns to the right atrium of heart through venules, veins, cranial and caudal vena cava. From right atrium deoxygenated blood goes to right ventricle. The right ventricle pumps the blood to the lungs through pulmonary artery. In the lungs the blood in reoxygenated and returns to the left atrium of heart.

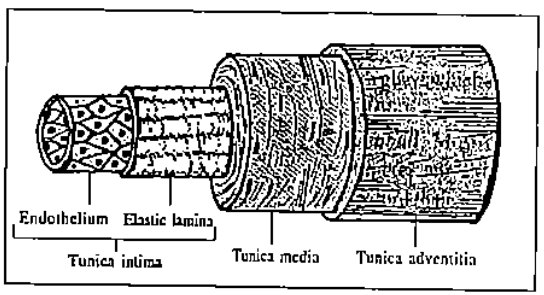


Fig. 7.12 Structure of an artery schematic.

Structure of arteries and veins

The arterial wall is composed of (1) Tunica intima, (2) Tunica media and (3) Tunica adventitia.

The **tunica intima** consists of (a) an endothelial lining of the lumen of the vessel, (b) a delicate layer of connective tissue (basal lamina) and (c) internal elastic lamina.

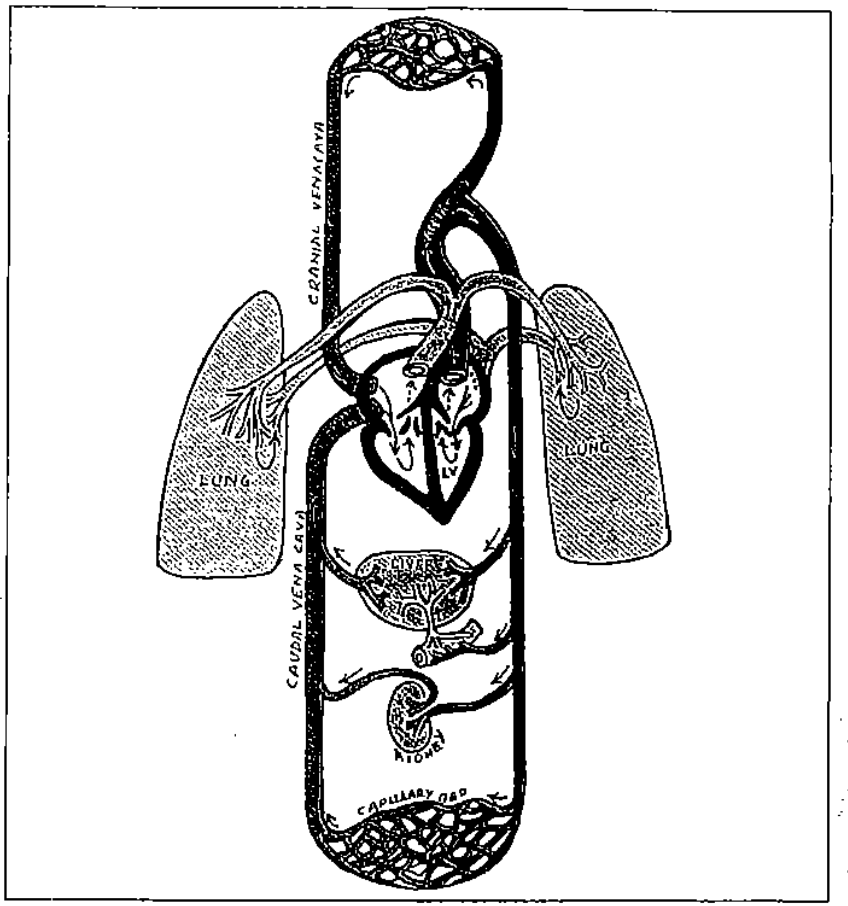


Fig. 7.13 Systemic circulation (schematic).

The **tunica media** consists of smooth muscle cells with the varying amount of collagenous and elastic tissue. The muscle fibers are arranged in circular or in spiral manner.

The **tunica adventitia** consists of (a) external elastic lamina and (b) connective tissue.

The venous wall is also composed of all the three layers but is much thiner due to reduction of muscular and elastic tissue components and lack of limiting membranes. Most of the veins excepting the trunk veins are provided with valve. These valves are formed by infolding of tunica intima.

SYSTEMIC ARTERIES

The following terms are often encountered at the time of studying this chapter.

Muscular branch—These arteries supply blood to muscles.

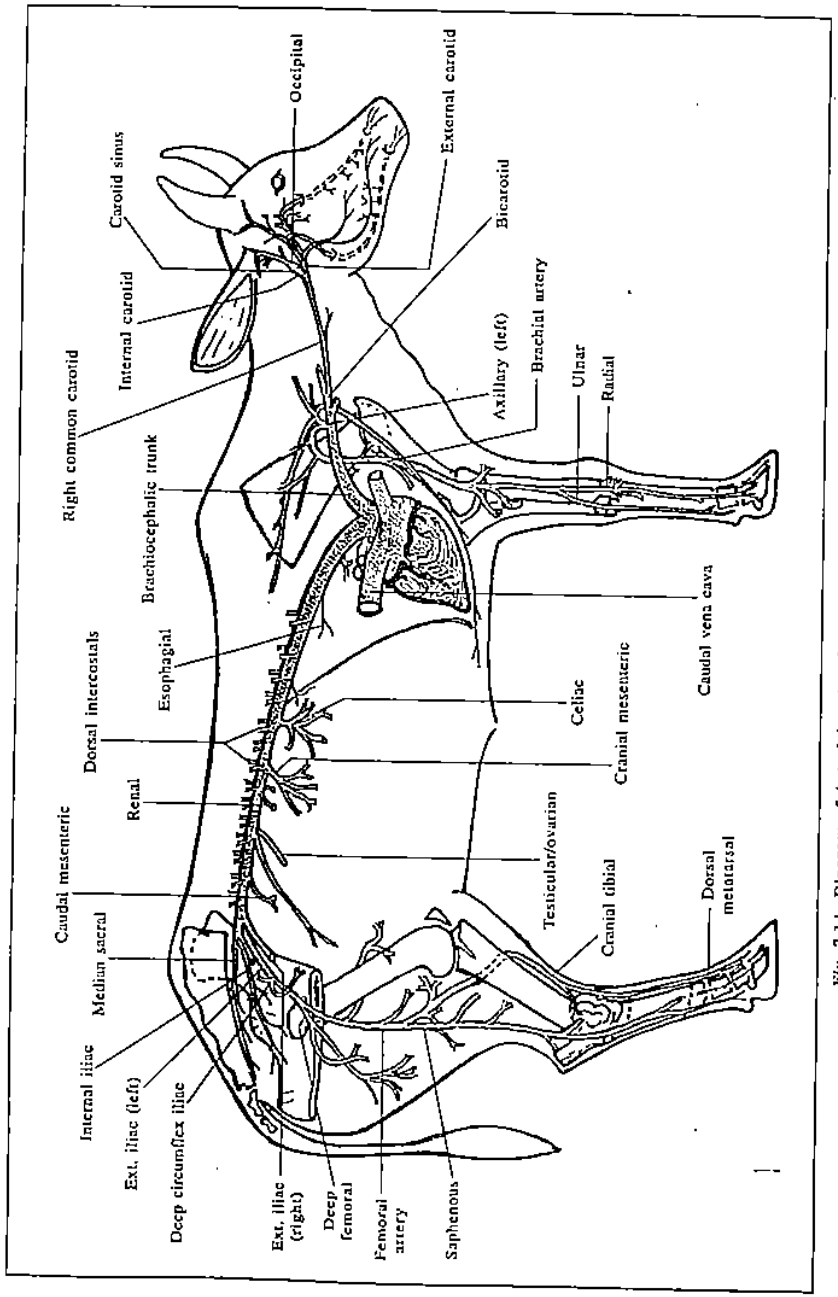


Fig. 7.14 Diagram of Arterial system in cow (only major vessels are shown).

Anastomosis—Communications between blood vessels are known as anas tonroses. They may be of following types :

a) Inter-arterial anastomosis – This is a communication between adjacent arteries.

b) Arterio-venous anastomosis (AVA) – Here the arterioles communicate with venules. They are found at the tip of nose, lips, finger tips, eye lids, etc.

Collateral branches—These are the branches which arise from any artery before its termination.

End arteries—Most of the arteries anastomose with one another at the capillary and precapillary levels. End arteries are those which do not form any pre-capillary anastomosis. An obstruction of the end artery produces local death of the tissue. End arteries are found in central artery of retina, cerebral arteries, splenic artery renal artery, etc.

Vesa vasorum—*These are the vessels for thick blood vessels.* Minute blood vessels supply nutrition to the tunica adventitia and outer part of tunica media. The arterial blood is derived from the branch of the same vessel or from neighbouring artery. The venous blood drains into the veins which accompany the artery.

AORTA

This great arterial trunk originates at the base of the left ventricle and ascends between the pulmonary artery on the left and right atrium on the right. This begining portion is called ascending aorta.

The ascending aorta inclines backward after forming a sharp curve, the aortic arch. From the arch the vessel continues caudally along the dorsal aspect of the thoracic abdominal and pelvic cavities as descending aorta. It is also sometimes called caudal aorta.

Just at the begining, *i.e.*, close to the semilunar valves, the wall of the aorta is dilated in the form of bulbus swelling, known as aortic sinus *or* bulbus aorticus. The left and right coronary arteries originate from the corresponding sides of the bulbus.

Brachiocephalic trunk

This vessels originates from the aortic arch at the level of 4th rib and proceeds cranially. As it is a very large vessel and originates in the form of bifurcation of the main aorta, sometimes referred as anterior aorta.

The brachiocephalic trunk leaves the pericardium and passes forward in the cranial mediastinum. It is related dorsally to the trachea and laterally to the vagus and phrenic nerve at the left side and anterior venacava at the right side. It detaches the left axillary (subclavian) artery at the level of second intercostal space and the right axillary artery at the level of first rib and continues as bicarotid trunk. In dogs and pigs the left axillary artery arises directly from the aortic arch and therefore not detached from brachiocephalic trunk. The right axillary artery, however, arises from the bachio cephalic trunk. [Fig. 7.15]

After a short course of about 4 cm, close to the thoracic inlet and ventral to the trachea the bicarotid trunk bifurcates into left and right common carotid arteries.

COMMON CAROTID ARTERY

The artery passes forward and upward in the neck in company with the vago-sympathetic trunk and a small internal jugular vein in a common fibrous covering, called *carotid sheath*. The right one

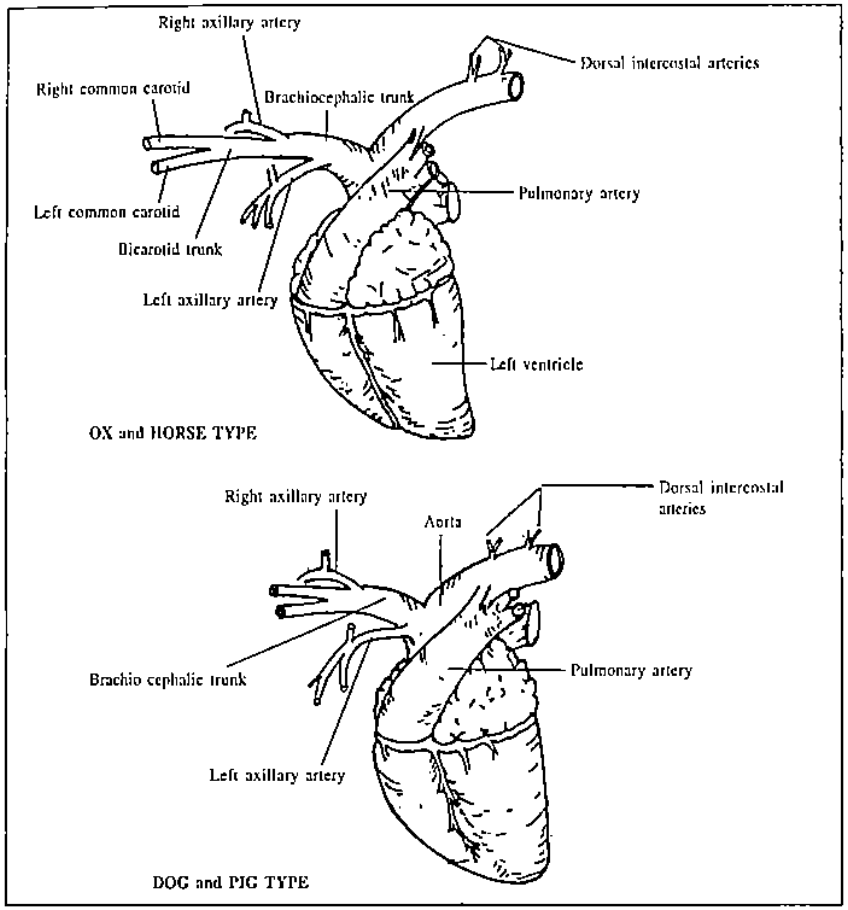


Fig. 7.15 Pattern of origin of axillary (Subclavian) arteries.

crosses the lateral aspect of the trachea and the left one passes along the lateral aspect of the oesophagus. They reach to the superior face of trachea at the corresponding side at the middle of the neck and maintain this relation up to their terminations at the level of the digastricus where each of them divides into **external carotid** and **internal carotid arteries**. At the termination it is related to parotid and mandibular gland externally and esophagus and lymph glands internally. The collateral branch are (a) trachial, (b) esophageal, (c) muscular, (d) caudal thyroid, (e) cranial thyroid, (f) laryngeal and (g) pharyngeal.

(a) Tracheal and (b) oesophagial branches are small and their origins are also variable. Cervical lymph nodes get supply from branches of these vessels.

(c) Muscular branches are few in number. These arteries are small and are distributed to the muscles of inferior cervical group.

(d) Caudal thyroid is a slender vessel and inconstant. It supplies to the caudal part of the thyroid gland.

(e) Cranial thyroid artery originates from the carotid artery close to the gland, gives two branches to it and divides into few branches to supply pharynx, cricothyroideus muscles and caudal part of the larynx.

(f) Laryngeal branch supplies the cranial part of larynx.

(g) Pharyngeal branch remifies to the pharynx.

Internal carotid artery

It is detached from the common carotid at the level of larynx. This is a slender vessel and enters the cranial cavity through jugular foramen in prenatal life. In adult life the part outside the cranium degenerates.

Just after origin it gives off its main branch – the occipital artery.

Occipital artery—It ascends towards the bula tympany and gives off the following branches.

(a) *Palatine artery*—Tis vessel goes downward and forward to supply the soft palate.

(b) *Stylomastoid artery*—It enters the stylomastoid foramen and supplies the middle ear.

(c) *Middle meningeal artery*—It enters the cranial cavity through jugular foramen.

(d) *Caudal meningeal branch*—it passes up to the occipital bone and remifies locally.

(e) *Condyloid artery*—It is a very small branch and supplies the caudal aspect of the occipital condyle.

Carotid sinus

Sometimes a little dilatation is observed at the point of common origin of internal carotid and occipital arteries from the dorsal aspect of the common carotid artery. This is the carotid sinus. The wall of the sinus is comparatively thin and contains large number of sensory nerve endings. This sinus acts as **baroreceptor.**

External carotid artery

Actually external carotid artery is the direct continuation of the common carotid artery. It courses cranio-dorsally and then along the caudal border of the ramus of the mandible, reaches below the temporo mandibular joint, detaches the superficial temporal vessel and continues as maxillary artery. On the way it gives off following branches.

1. *Linguofacial artery*—This is a large vessel gives off branches to parotid and mandibular salivary glands and divides into lingual and facial branches :

(a) *Lingual artery*—It sometimes originates separately from the carotid artery, passes forward along the extrinsic muscles of the tongue and travels along the lateral surface of the genioglossus muscle, enters the tongue and remifies within the organ.

(b) *Facial artery*—After the origin it goes little downward and forward between the mandibular gland and digastricus muscle and reaches in front of the angle of the lower jaw. Here it gets the company of the corresponding vein, duct of the parotid salivary gland, ventral buccal branch of seventh cranial nerve and courses along the cranial border of massater muscle. The artery passes to the ventral aspect of the upper jaw, continues further forward and terminates at the lateral aspect of the nose. It gives off submental artery at the ventral border of the mandible, mandibular labial

artery towards the buccinator and maxillary labial artery towards the depressor labii maxillaris muscle.

2. *Caudal auricular artery*—This vessel originates from the caudal aspect of the parent trunk, passes dorsally towards the temporal area under the parotid gland and remifies around the base of the ear.

3. *Masseteric artery*—It is a slender branch courses anteroventrally to supply the massater muscle.

4. *Superficial temporal artery*—It originates from the dorsal curvature of the external carotid, a little above the origin of the caudal auricular artery and under the cover of the parotid gland. It ascends towards the temporomandibular articulation and terminates by bifurcating into the lacrimal and cornual branches. Its collateral branches are as follows :

(a) *Transverse facial artery*—It courses anteroventrally to supply the massater.

(b) *Cranial auricular artery*—It passes backward, gives branches to parotid gland and supplies to the external ear. It also gives meningeal branches after passing through temporal canal.

(c) Palpebral arteries are two and supply the corresponding superior and inferior eyelids.

Lacrimal artery—This is one of the terminal branches passes to the lacrimal gland and anastomoses with the similar artery of the ophthalmic rete.

Cornual artery—This terminal branch courses along the lateral surface of the base of the horn, supplies the horn core and anastomoses with the artery of the opposite side behind the frontal tuberosity.

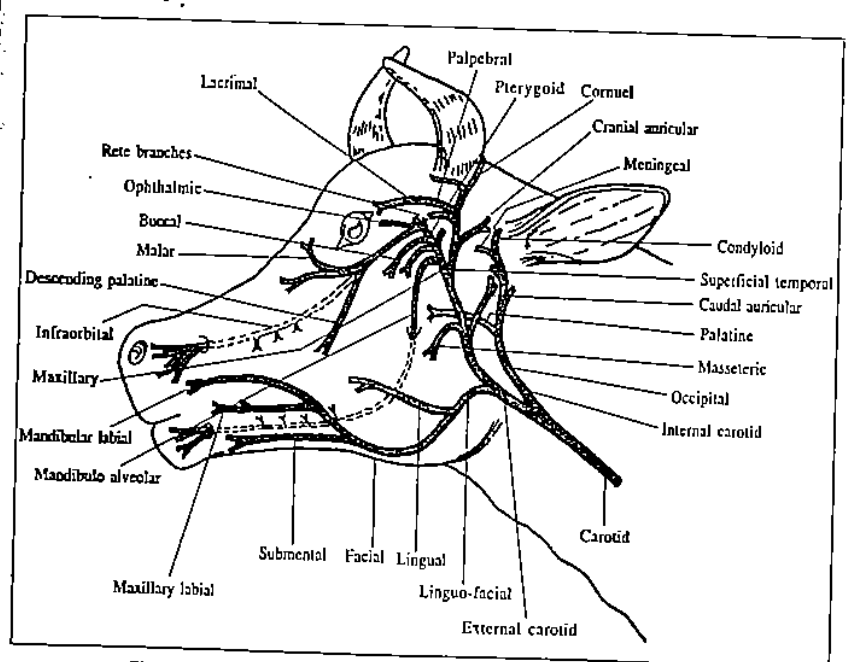


Fig. 7.16 Disposition of carotid artery with its main branches (Diagrammatic).

Maxillary artery

The external carotid artery continues as maxillary artery after the origin of superficial temporal branch. It ascends anteriorly through the pterygopalatine fossa and ultimately divides into two terminal (infra orbital and descending palatine) branches.

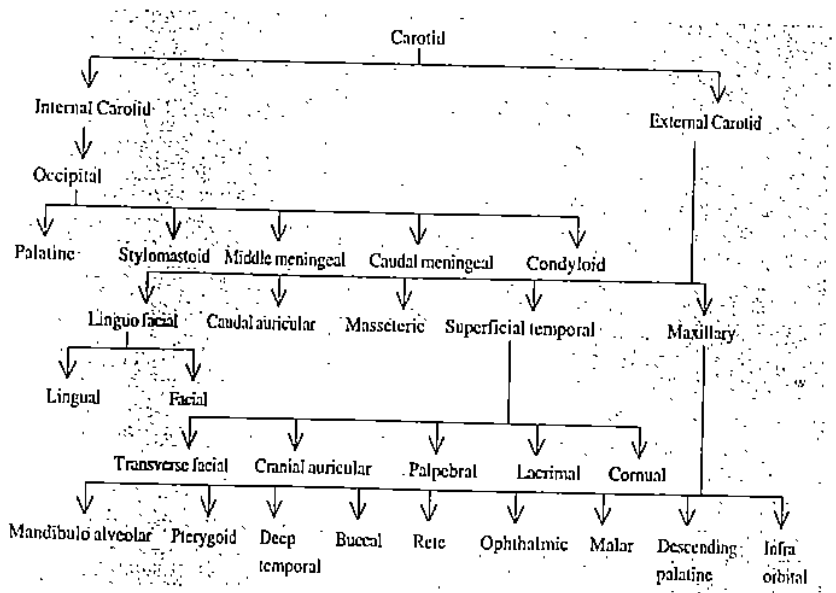
On its course the maxillary artery gives off following branches

1. *Mandibulo alveolar artery*—It originates caudal to the pterygoideus lateralis muscle, goes downward and forward detaches a small muscular branch and enters into the mandibular canal. Inside the canal it gives off inferior dental branches to the teeth and comes out of the canal as mental artery to supply the chin.

2. *Pterygoid artery*—This small vessel arises close to mandibulo alveolar artery and remifies in the pterygoidus medialis muscle.

3. *Deep temporal artery*—It ascends from the dorsal aspect of the parent vessel and becomes distributed at the temporal region. On the way it gives off masseteric branch.

4. *Buccal artery*—It originates from the anterior surface of the maxillary artery. It goes downward and forward and divides into several branches to supply buccinator, masseter, pterygoidus and depressor labii muscles.



5. *Rete arteries (rostral and distal)*—These are dorsally directed small arteries arise from the maxillary vessel a little before its division into terminal branches. There are two groups of vessels – anterior and posterior, which enter the cranial cavity through foramen orbitorotundum and foramen ovale respectively. These vessels join the epidurally situated arterial network at the base of the skull.

6. *Ophthalmic artery*—It originates at the level of foramen orbitorotundun. The vessel enters the orbit at its apex after crossing the maxillary nerve laterally and forms a vascular network – the ***ophthalmic rete mirable***, between extraocular muscles. From the rete arises one vessel which goes forward and upward and forms two terminal branches. These are **supraorbital artery** and **external ethmoidal artery**. The supraorbital branch passes through the supraorbital canal and remifies at the frontal region. After a very short course the external ethmoidal artery leaves the orbit through ethmoidal foramen and enters the cranial cavity. The collateral branches are lacrimal artery, posterior ciliary artery, central retinal artery periorbital artery and conjunctival artery.

7. *Malar artery*—It originates in common with infraorbital at the pterygopalatine fossa, reaches the medial angle of the eye after passing through the orbital fossa and passes to the lateral aspect of the face. It gives a small branch to the nictitating membrane and goes forward as dorsal nasal vessel.

Descending palatine artery is one of the terminal branches of the maxillary artery at the pterygopalatine fossa. It goes forward to supply soft and hard palates and the floor of the nasal cavity. One of its branches enters the nasal cavity through sphenopalatine foramen and applies the caudal part of the nasal cavity.

Infraorbital artery is the other terminal branch of the maxillary artery. It enters the maxillary canal along with infraorbital nerve, gives off branches of the teeth of the upper jaw and comes out through infraorbital foramen. After its exit the vessel remifies to the upper lip and the surrounding area.

AXILLARY ARTERY (SUBCLAVIAN ARTERY)

The left axillary artery arises from the brachiocephalic trunk opposite to the second intercostal space and the right one arises opposite to the first rib. Each artery gives off following intrathoracic branches at their thoracic course and then leaves the thoracic cavity through the thoracic in let to be continued as extra thoracic (axillary) artery.

Intra thoracic part

At the begining both the arteries are close to each other and pass forward at the anterior mediastinal space below the trachea. Subsequently the diverge from each other and proceed towards the thoracic inlet.

1. *Costocervical artery* — It is common trunk for dorsal, intercostal, deep cervical and vertebral arteries.

(a) *Dorsal artery*—Sometimes it originates commonly with intercostal artery. It ascends under the serratus cervices, towards the anterior angle of scapula and remify to the upper parts of trapezius and rhomboideus muscles. Frequently it detaches first intercostal artery.

(b) *Intercostal artery*—This vessel goes upward and backward and divides into few branches to form **second to fourth intercostal arteries. The first intercostal artery** also sometimes originates from this vessel.

(c) *Deep cervical artery*—It is variable in its origin. It courses upward and forward at the level of 7th cervical vertebra, reaches the dorsal and lateral aspect of the neck and provides branches to longissimus dorsi, trapizius, rhombodius, serratus cervices, splenius and complex muscles.

(d) *Vertebral artery*—As the continuation of the costocervical artery, this vessel passes forward and enters the transverse canal through the foramen transversarium of 6th cervical vertebra. At the level of each intervertebral foramen, it detaches a spinal artery for the spinal cord and meninges. The spinal branches inside the spinal canal divide and join with the adjoining vessels to form dorsal and ventral spinal arteries. The vertebral artery reaches the level between second and third cervical vertebrae gives off anastomotic branch to occipital artery and enters the vertebral canal. Here it detaches a small branch which joins with condylar artery and the main trunk continues as descending branch. On the way it supplies branches to the muscles of head and neck.

2. ***Superficial or inferior cervical artery*** — It originates from the axillary artery at the level of 1st rib. It passes downward and forward and divides into a number of branches to supply prescapular and prepectoral lymph glands and brachiocephalicus, omotransversarius and supraspinatus muscles.

3. ***Internal thoracic artery*** — It arises from the axillary artery at the level of 1st rib, goes downward and backward to the thoracic face of sternum and under the transversus thoracic muscle. Near the 8th costal cartilage it divides into (a) musculophrenic and (b) anterior abdominal (cranial epigastric) arteries. On the way this vessel detaches branches to the pericardium, thymus, pleura, diaphragm and pectoral muscles. It gives off ventral intercostal branches at each intercostal space. These arteries go upward and anastomoses with the respective dorsal intercostal arteries. Musculophrenic artery passes backward and upward, detaches ventral primary branches and supplies to the diaphragm and transversus abdominalis muscle.

The anterior abdominal artery courses along the floor of the abdominal cavity by entering in the rectus abdominalis muscle. It gives few branches to the ventral abdominal wall and ultimately its finer branches anastomose with the posterior abdominal artery.

Extra thoracic part

The axillary artery after giving off the intra-thoracic branches leaves the thoracic cavity by curving round the anterior border of the first rib. It reaches the medial aspect of the shoulder by passing between median and ulnar nerves of brachial plexus. It continues along the distal part of teres major and subscapular muscle as **brachial artery**. This artery accompanies the median nerve passes downward at the medial surface of the elbow joint under the insertion of biceps brachii and in front of pronator teres, gives off common interosseous artery at the level of proximal interosseous space between radius and ulna and continue as median artery. It gives off following branches :

1. ***External thoracic artery***

It arises from the axillary artery close to the first rib, goes downward and becomes distributed to pectoral, biceps brachii and brachiocephalicus muscles.

2. ***Suprascapular artery***

It is a small vessel goes upward and supplies supraspinatous muscle and to the medial aspect of the shoulder joint.

3. *Subscapular artery*

It is a large vessel originates from the dorsal aspect of the main artery at the angular junction between the axillary and brachial part. It goes upward and backward between subscapularis and teres major and along the posterior border of scapula. It supplies subscapular, teres major, teres minor, deltoid and infraspinatus muscles and gives off thoraco-dorsal and posterior circumflex humeral arteries. It provides a nutrient artery to scapula.

(a) Thoraco-dorsal artery accompanies thoraco-dorsal nerve and finally ramifies in the latissimus dorsi muscle. On the way it supplies teres major and subscapular muscles.

(b) *Posterior circumflex humoral*—Sometimes it directly originates from the axillary artery. This vessel passes lateral to the shoulder joint and divides into one upper and one lower branch. The upper one supplies the deltoid, triceps, brachialis, teres minor and the lower one gives nutrient artery to the humerous. This artery remifies at the lateral aspect of arm and forearm.

4. *Anterior circumflex humeral artery*

This is a small vessel arises from the anterior aspect of the brachial artery, goes forward and supplies coracobrachialis and biceps brachii muscles. It also gives branches to the medial aspect of the shoulder joint.

5. *Deep brachial artery*

It originates from the posterior aspect of the brachial artery goes backward and supplies to the triceps muscle. It sometimes anastomoses with collateral ulnar artery.

6. *Collateral ulnar artery*

At the level of the olecranon process and close to the medial condyle of humerus, this artery originates from the posterior aspect of the brachial artery. Sometimes more than one vessels are seen. It divides into an ascending and a descending branch. Ascending artery supplies the lower end of triceps, biceps brachii and upper end of flexor muscles. The descending vessel supplies pectoral muscle, skin and may anastomose with one branch of proximal interosseous artery.

7. *Transverse cubital artery*

It is a small artery arises from the anterior aspect of the brachial artery at the level of elbow joint. It divides into an ascending and a descending branch to supply biceps brachii and the upper ends of extensor muscles.

8. *Common interosseous artery*

It is a large vessel detached from the parent artery at the level of proximal interosseous space. It gives off branches to the proximal ends of flexor muscles, passes through the proximal interosseous space and continues as anterior interosseous artery along the groove between radius and ulna. On the way it gives branches to the extensor muscles of fore arm. The vessel at the level of distal interosseous space detaches a posterior branch and continues downward and helps in the formation of anterior carpal rete. The posterior branch which was given off at the level of distal interosseous space, goes backward through this space and then goes downward contributes in the formation of posterior carpal rete. This vessel then continues further downward and takes part in the formation of proximal planter arch. The planter arch is formed between the posterior surface of the metacarpal bone and anterior surface of the suspensory ligament. It then continues as *lateral volar digital artery*.

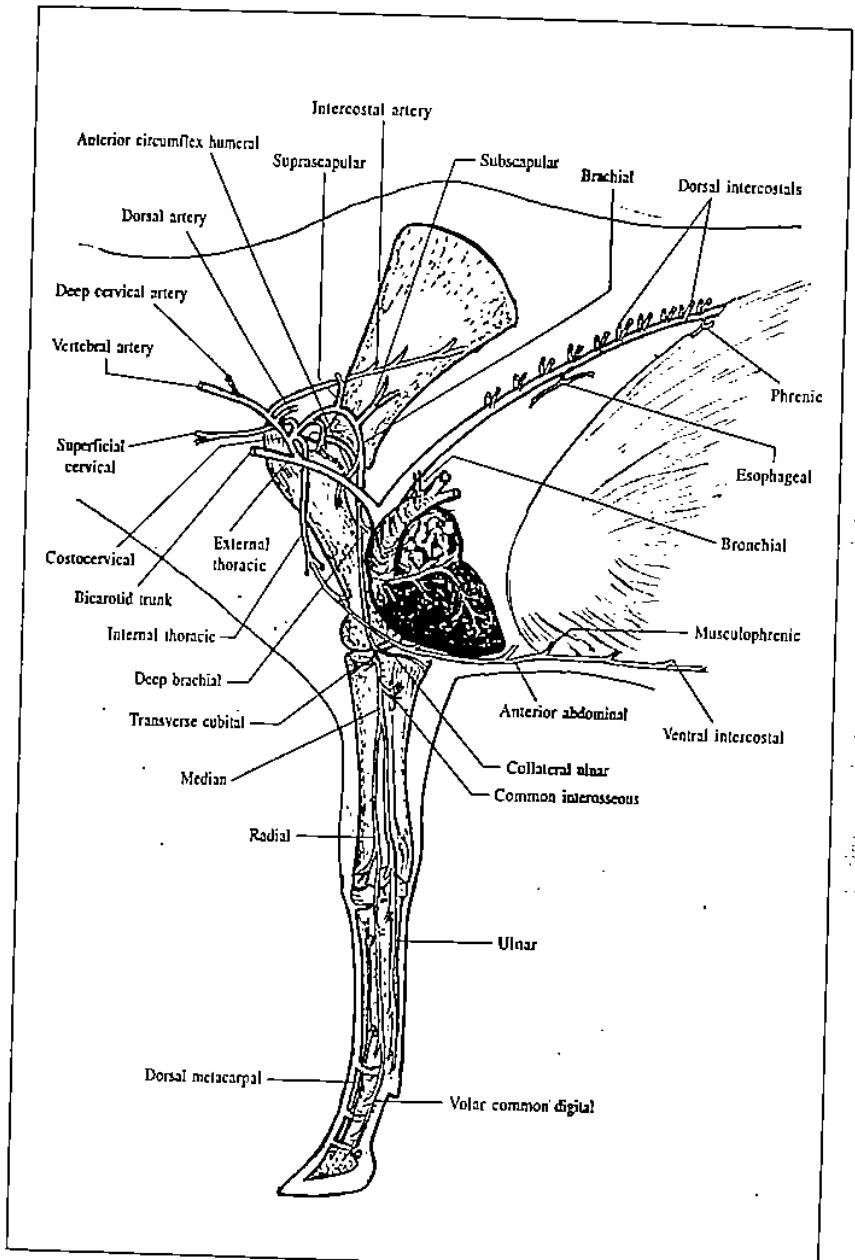


Fig. 7.17 Disposition of right axillary artery (Schematic).

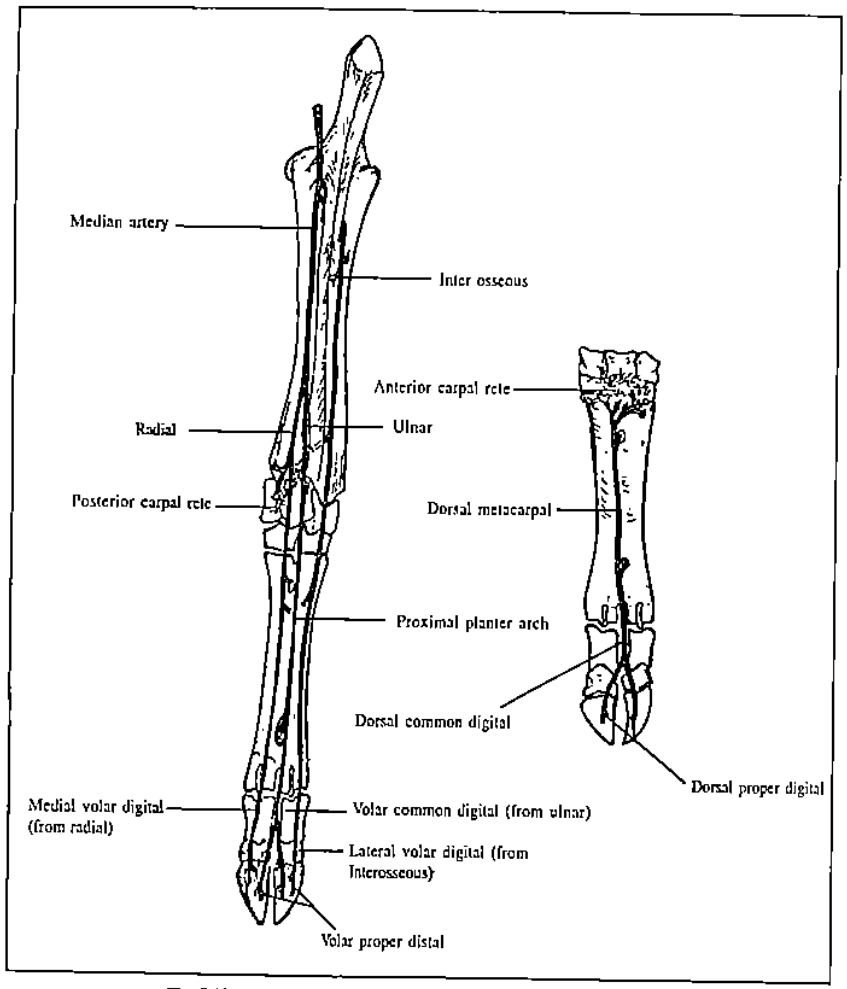


Fig. 7.18 Disposition of right axillary artery (Schematic) after elbow.

Median artery

It is the distal continuation of brachial artery after it detaches the interosseous artery. It passes downward along the posteromedial aspect of the radius along with median nerve and divides into Radial and Ulnar arteries.

Radial artery

It goes along the posteromedial aspect of the radius and reaches the posterior surface of the carpus and continues as volar medial metacarpal artery. This vessel at the distal part and posterior

surface of the metacarpal bone, forms superficial planter arch and finally continues as *medial volar digital* artery. The radial artery contributes branches to posterior and anteiror carpal rete. One branch of this artery passes through the proximal foramina of metacarpal, reaches the anterior surface of the bone and joins the anterior rete. From this area one artery originates and passes along the anterior groove and continues as ***dorsal metacarpal artery*** at the metacarpal region and as ***dorsal common digital artery*** below fetlock joint. The common digital divides into two proper digital arteries.

Ulnar artery

It is the main continuation of the median artery. It descends down under the flexor carpi radialis, crosses the posterior aspect of the carpus and then continues further down to the metacarpal region and ultimately forms ***volar common digital artery***. At the distal part of the metacarpus, it gives off a vessel which passes through the distal foramina and unite with the dorsal metacarpal artery, is known as perforating branch. The volar common digital artery divides into two ***volar proper digital arteries*** at the level of the distal part of first phalanx.

DESCENDING AORTA

This is a very large voluminous and thick walled tube which begins from the level of 4th thoracic vertebra and extends backward through the thoracic and abdominal cavities. At the begining it goes upward and backward and thereby forms the ***arch of aorta***. Here it is inclined slightly towards left, gradually becomes narrow, passes between the lungs along the ventral surface of the bodies of vertebra and reaches the median position at the hiatus aorticus and enters the abdominal cavity.

THORACIC AORTA

The thoracic portion of descending aorta is known as thoracic arota. The left surface of the aortic arch is related to left lung, pulmonary artery, left vagus and venahemiazygos. Ligamentum arteriosum, the remnent of ducts arteriosus connects the pulmonary artery and thoracic aorta just above the base of the heart at the left side. The right face of the arch is related to oesophagus and terminal part of trachea. In the posterior mediastinum it is related to both the mediastinal surfaces of lungs. Its terminal part is related to the bodies of last few thoracic vertebrae. It gives off following branches :

1. ***Bronchial artery***—It is a small vessel originates from the ventral wall of the aorta at the level of the 6th thoracic vertebra. It divides into left and right branches to enter the corresponding lung. These vessels accompany branches and sub-branches of bronchi.

2. ***Esophageal artery***—It originates from the ventral wall of the aortic arch and divides into cranial and caudal branches to supply the corresponding portions of oesophagus. It gives branches to the mediastinal lymph nodes and pericardium.

3. ***Intercostal arteries***—Out of the 12 pairs of intercostal arteries, last 9 pairs originate directly from the dorsal wall of the thoracic aorta. First three pairs arise from the corresponding costocervical (branch of axillary) arteries.

Each intercostal artery ascends dorsally, reaches the caudal border of the proximal end of the corresponding ribs, gives off a dorsal branch and continues downward along the intercostal space and ultimately anastomoses with corresponding ventral intercostal artery. On the way it supplies to the intercostal muscle pleura and ribs. The dorsal branch divides into (a) muscular branch for the local

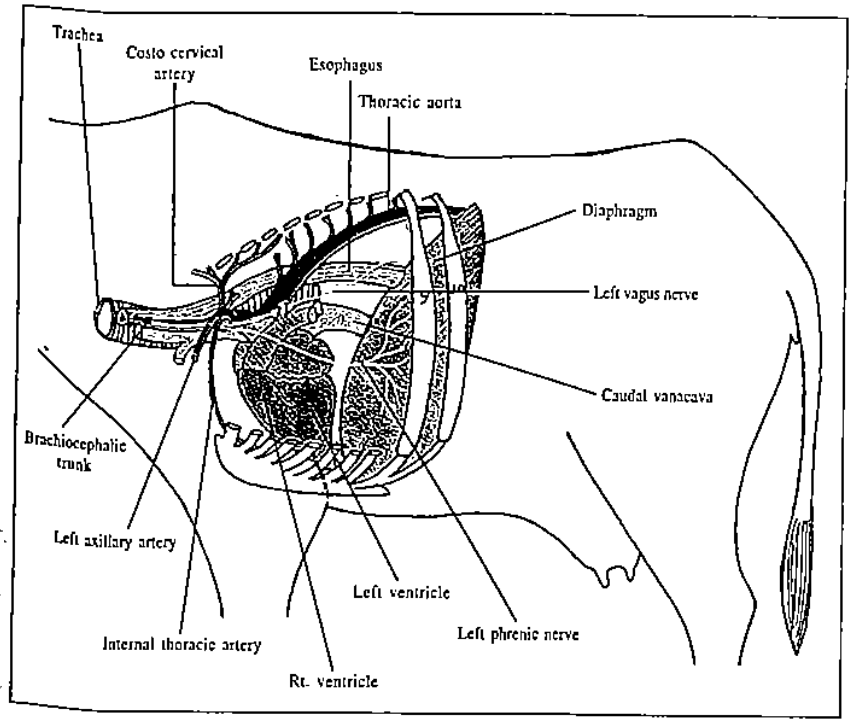


Fig. 7.19 Organs in the thorax (Lungs removed).

muscles and (b) spinal branch, which enters the spinal canal through intervertebral foramen, supplies the meninges and anastomoses with the ventral spinal artery.

4. *Phrenic arteries*—These are few small vessels originate from the ventral aspect of the aorta close to the hiatus aorticus and supply the diaphragmatic crura.

ABDOMINAL AORTA

The abdominal part of the aorta is known as abdominal aorta. It extends from hiatus aorticus, passes below the bodies of lumbar vertebrae, sublumbar muscles, ventral common vertebral ligaments and terminates below 5th or 6th lumbar vertebra by dividing into two external and two internal iliac arteries. However, this abdominal aorta continues in the sacrocaudal region as median sacral artery. It detaches the following branches :

1. *Celiac artery* — It is a short but thick vessel (6 to 10 cm) originates from the abdominal aorta just after its entry into the abdominal cavity. It is related to the pancreas and rumen at the left and the right crus of diaphragm and caudal venacava at the right side. The celiac artery gives off a number of branches for different organs. The level of origin is 1st lumbar vertebra.

(a) *Phrenic artery*—It is a small vessel originates from the celiac artery and supplies the diaphragm. Sometimes there may be two arteries one for each crus of diaphragm.

(b) *Splenic artery*—It is also a slender vessel and generally originates in common with right ruminal artery. It passes cranially, crosses the dorsal surface of rumen, reaches the left side and enters the hilus of the spleen.

(c) *Right ruminal artery*—It is a large vessel descends caudally along the right ruminal groove, traverses the caudal groove, reaches the left side of the rumen and anastomoses with the left ruminal artery. On the way it gives off branches to the dorsal and ventral sacs of the rumen and pancreas.

(d) *Left ruminal artery*—It descends cranially, passes along the right surface of the cranial part of the rumen, traverse the cranial groove and then the left longitudinal groove and anastomoses with the right ruminal artery. Its branches supply the reticulum and cranial part of the rumen.

(e) *Hepatic artery*—It is given off from the celiac artery at the right side when it passes the venacava. It gives off a number of branches as follows :

(i) **Pancreatic branch** for pancreas,

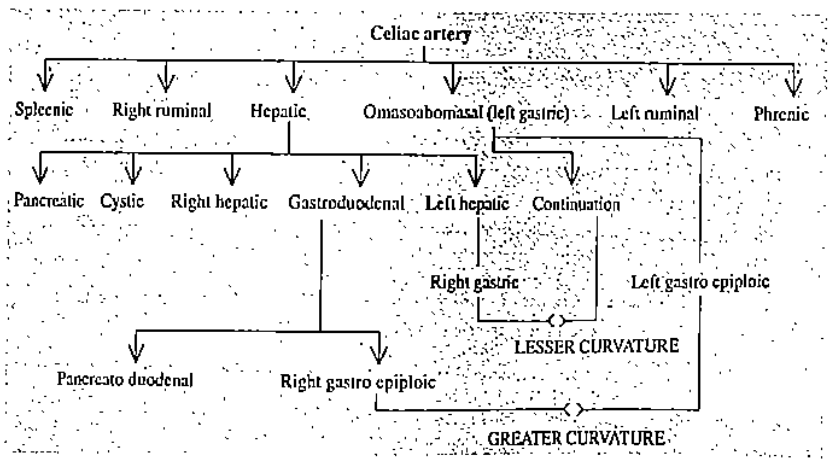
(ii) **Cystic branch** for gall bladder,

(iii) **Right hepatic** for right part of liver.

(iv) **Left hepatic branch** for left part of the liver. One vessel (right gastric) originates from the left branch which passes in the lesser omentum along the lesser curvature and anastomoses with left gastric artery.

(v) **Gastro duodenal artery**—It divides into pancreato duodenal and right gastroepiplioc branches for pancreas, duodenum and abomasum respectively. This artery passes downward and forward along the greater curvature of abomasum and anastomoses with the left gastroepiploic artery.

(f) *Left gastric/omasoabomasal artery*—It is the continuation of the celiac artery. It descends cranially to the lesser curvature of omasum and detaches the left gastro epiploic artery. The parent artery passes caudally, reaches the lesser curvature of the abomasum and anastomoses with one branch of the hepatic artery. The left gastroepiploic artery descends between omasum and rumen in front, reaches the greater curvature of the abomasum and anastomoses with right gastro epiploic artery.



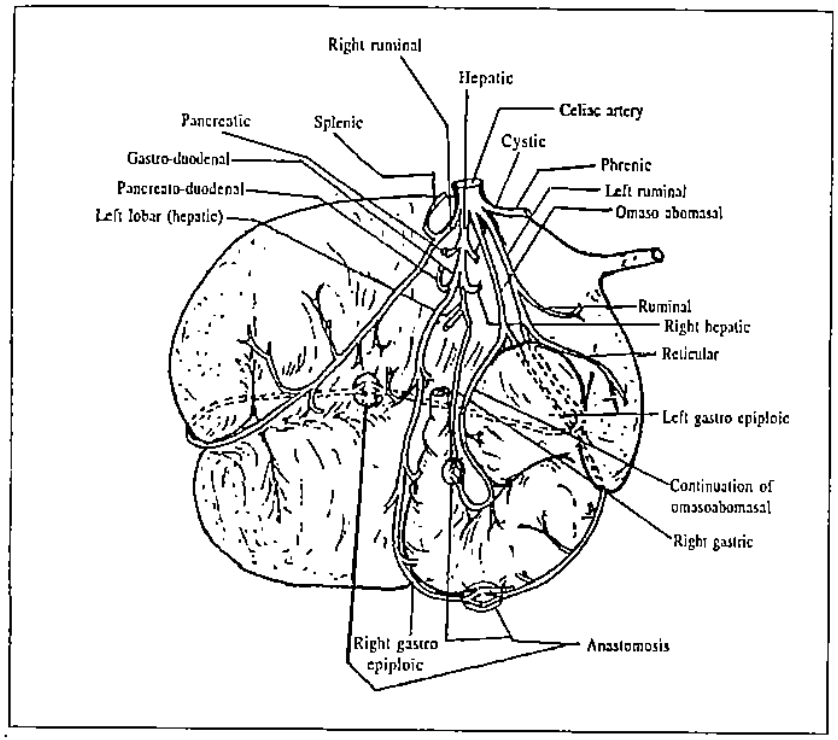


Fig. 7.20 Branches of celiac artery.

2. ***Cranial mesenteric artery*** — It originates behind celiac, descends between pancreas and caudal venacava and then passes behind transverse colon and ramifies in the mesentery to supply most of the parts of intestine. Its branches are (a) pancreatic, (b) middle colic, (c) ileocolic, (d) collateral and (e) jejunal arteries according to their area of distribution.

3. ***Renal arteries*** — These are two, one for each kidney. Right one originates at the level of 2nd lumbar vertebra, crosses the dorsal surface of the posterior venacava, passes laterally and enters the hilus of the right kidney. The left vessel is longer than right. It originates further behind, passes cranially and ventrally to enter the hilus of the left kidney.

Inside the kidneys each of the renal arteries divide into lobar, interlobar, arcuate, inter-lobular and finally affarent glomerular arteries.

4. ***Testicular/Overian arteries (right and left)*** — These vessels in the male are called testicular arteries and in the female are termed as overian arteries according to their supply.

Each testicular artery originates from the ventral aspect of the aorta close to the origin of caudal mesenteric artery. It descends downward and backward, traverses along the lateral wall of the pelvic cavity and reach the inguinal canal. Here it becomes included within the spermatic cord and supplies the tunica vaginalis, vas, epididymis and testis.

Ovarian artery (cranial uterine artery) originates in a similar manner, descends downward passes along the free border of the broad ligament and divides to supply the ovary and fallopian tube.

5. ***Lumbar arteries*** — Out of the six pairs of lumbar arteries, first five pairs originate from the abdominal aorta and the last pair from the corresponding internal iliac arteries. Their course and distribution pattern are almost similar to that of intercostal arteries. The ventral branches supply the abdominal wall.

6. ***Caudal mesenteric artery*** — It originates from the abdominal aorta at the level of 5th lumbar vertebra. It divides into a cranial colic branch and a caudal rectal branch to supply the colon and rectum respectively.

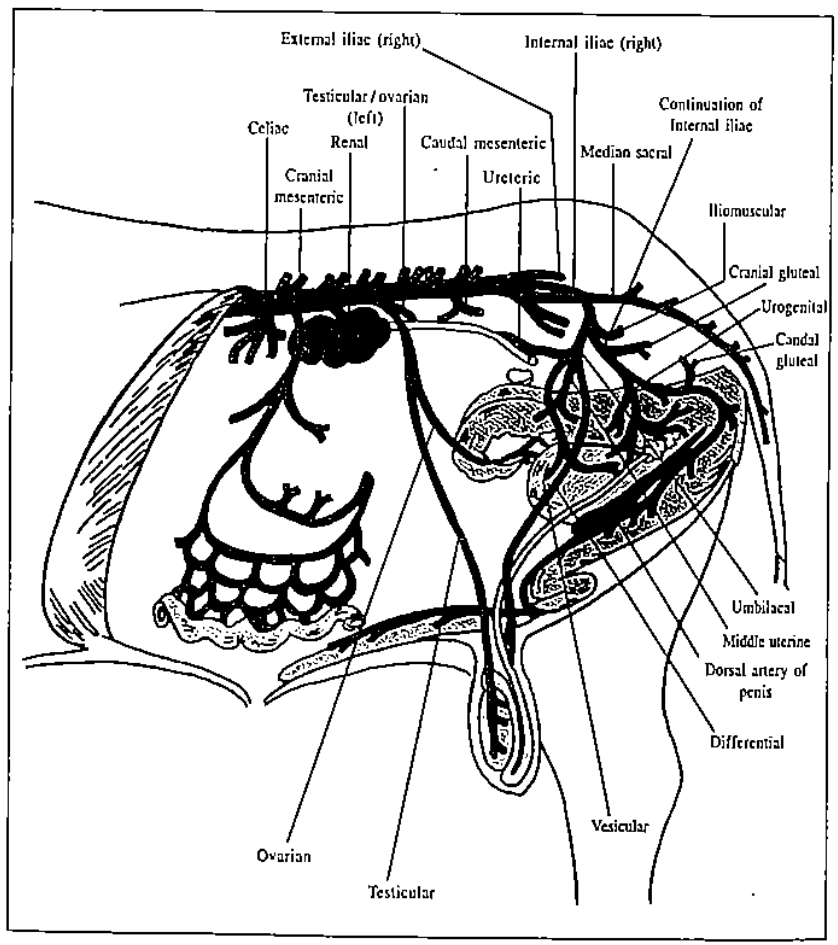


Fig. 7.21 Branches of abdominal aorta (Schematic Male and Female combined).

MEDIAN SACRAL ARTERY

It is the continuation of the abdominal aorta after the detachment of external and internal iliac arteries. It passes backward at the ventral surface of the sacrum and then along the ventral surfaces of all the caudal vertebrae. On the way it detaches paired sacral arteries. These sacral arteries pass through ventral sacral foramina and supply the meninges and then pass through dorsal sacral foramina to the muscles of the dorsal wall of the pelvic cavity. The parent artery courses the whole length of the tail along the ventral surface of the bodies of the caudal vertebrae. In between the caudal vertebrae the median sacral artery releases paired vessels on either side, each of which divides into dorsal and ventral branches and form dorsolateral caudal and ventrolateral caudal arteries. These vessels also extend along the whole length of the tail.

INTERNAL ILIAC ARTERY

These large paired arteries supply the pelvic viscera and the pelvic wall. They originate close to the external iliac arteries at the termination of the aorta below 5th or 6th lumbar vertebra. Each vessel descends in a backward direction on the internal surface of the sacrosciatic ligament and finally divides into **caudal gluteal** and **internal pudendal** arteries at the level of lesser sciatic foramen. Its collateral branches are as follows :

1. *Umbilical artery*—This is a very potent artery at the foetal stage. After birth it becomes obliterated at the end and transforms into the round ligament of bladder. It gives off

   (a) **Ureteric branch** to ureter,

   (b) **Vesicular branch** to the cranial part of bladder and

   (c) **Uterine branch (middle uterine artery)** to the horn and body of the uterus in the female and **deferential branch** to the ductus deferens in the male.

2. *Iliomuscular artery*—This small vessel supplies the iliacus and psoas major muscles. Sometimes 6th lumbar vertebral artery originates from it.

3. *Cranial gluteal artery*—Occasionally this artery originates in common with iliolumber at the level of superior ischiatic spine. It leaves the pelvic cavity through greater sciatic foramen and supplies the muscles of the hip.

4. *Urogenital artery*—It originates from the ventral aspect of the internal iliac at the level of ischiatic spine. In male its branches supply to the **bladder, vas, seminal vesicle** and **pelvic** part of **urethra**. In female its branches supply the uterus (**caudal uterine** artery), bladder urethra and vestibule.

5. *Obturator arteries*—These are small and inconstant vessels, supply the obturator externus and internus muscles.

6. *Caudal gluteal artery*—It leaves the pelvic cavity through lesser sciatic foramen after the origin and remifies in biceps femoris and middle gluteus muscles.

7. *Internal pudendal artery*—It is one of the terminal branch of the internal iliac artery. It gives branches to the muscles of perinium, rectum, obturator externus (intra pelvic part), bulb of the penis and in case of male continues as **dorsal artery of** penis after detaching deep artery of penis. The latter supplies the corpus covernosum penis. The dorsal artery of the penis passes along the dorsal aspect of the penis upto the glans.

In the female this vessel after providing muscular and rectal branches, supplies the vagina vestibule and vulva. Its terminal continuation passes beyond ischial arch and ramifies in the clitoris.

EXTERNAL ILIAC ARTERY

This large vessel supplies blood to the hind limb. Below the 5th or 6th lumber vertebra, these left and right arteries originate from the abdominal aorta. Each artery passes downward and backward upto the cranial border of pubis and then continues as **femoral artery** through the femoral canal with saphenous nerve in front and the femoral vein behind. The continuation of the same artery below stifle joint is known as **popliteal artery**. Beyond the proximal third of the tibia it is called **cranial tibial artery** and below tarsus the same vessel is known as **dorsal pedal artery**. It gives off following branches :

1. *Deep circumflex iliac artery*—This vessel is detached from the external iliac close to its origin from the abdominal aorta. It divides into a cranial and a caudal branch to supply the abdominal muscles, tensor fascia lata and craniolateral part of the quadriceps femoral muscles.

2. *Deep femoral artery*—It originates at the level of ventral margin of pelvic inlet, descends a little and divides into (a) **Pudendo epigastric and** (b) **Medial circumflex femoral arteries**. The pudendo epigastric artery again divdes into (i) **External pudendal** and (ii) **Posterior abdominal** (caudal epigastric) arteries.

The external pudendal artery passes out of the abdominal cavity through the inguinal canal and is distributed in the local lymph nodes, **scrotum and prepuce in the male**. This artery continues as **mammary artery in female**. The caudal abdominal artery courses through abdominal muscles and anastomoses with cranial abdominal artery. The **medial circumflex femoral artery** passes backward, and downward to supply the muscles of the medial and posterior aspect of thigh.

3. *Lateral circumflex femoral artery*—It is also known as anterior femoral artery. Just after the origin at the level of upper third of femur it divides into an ascending and a descending branch and supplies quadriceps femoris muscle.

4. *Saphenous artery*—This large vessel originates from the parent trunk at the middle of the thigh and courses distally along the anterior aspect of the calcaneal (Achielles) tendon. Behind the tarsus it divides into (a) medial and (b) lateral planter arteries. The **medial planter artery** passes down the posterior aspect of the tarsus, joins the proximal perforating branch of the dorsal pedal artery. It forms proximal planter arch by joining with a branch of the lateral planter artery on the proximal part of the planter surface of the metatarsus.

The **lateral planter artery** also descends down and at the distal third of the metatarsus. Both the planter arteries joint together to form distal planter arch. The distal perforating artery arises from the distal arch, passes through the distal metatarsal canal and joins with the dorsal metatarsal artery. The planter arteries continue as **digital arteries**.

5. *Genicular artery*—It arises at the distal third of thigh and supplies to sartorius, semimembranosus and distal part of quadriceps femoris muscles.

6. *Caudal femoral artery*—This vessel originates from the femoral artery, just above the stifle joint. It divides into ascending branches and supplies to adductor, vastus intermediatus, gastrocnemius and superficial digital flexor muscles.

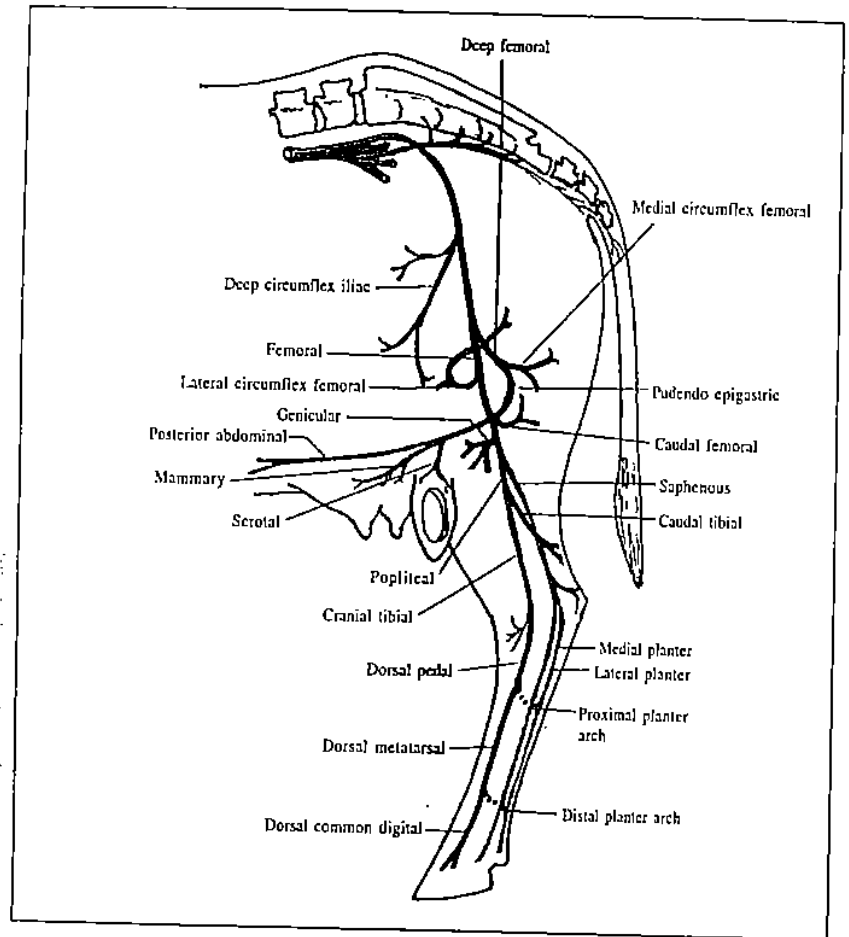


Fig. 7.22 Branches of external iliac artery (Schematic).

Popliteal artery

It is the continuation of the femoral, passes between the two heads of gastrocnemius, then through popliteal region and divides into (a) cranial and (b) caudal tibial arteries, after giving some branches to biceps femoris and gastrocnemius muscles. The **caudal tibial artery** is small and supplies the popliteus and digital flexor muscles.

The ***cranial tibial artery*** is large, passes down through the interosseous space to the anterior aspect of the tibia and tarsus and continues as **dorsal pedal artery**. It gives branches to popliteus, semimembranosus and most of the extensor muscles. The dorsal pedal artery gives few branches to form tarsal rete in front of the tarsal joint and at a little below gives one perforating branch, which communicates with the proximal planter arch. It continues down on the metatarsal groove as dorsal

metatarsal artery. This vessel gives off a distal perforating branch, which also communicates with the distal planter arch. The dorsal metatarsal artery descends down below fetlock joint as dorsal common digital artery.

BLOOD SUPPLY TO THE BRAIN

The rete branches (rostral and distal) of maxillary artery, Meningeal branch of occipital artery and cranial branches of vertebral arteries together form a fine vascular network at the floor of the cranial cavity around the sella turtica, known as ***Rete mirabile Cerebrale.*** The rostral and distal rete branches of maxillary artery and the meningeal branch of occipital artery enter the cranium through foramen orbitorotundum, foramen ovale and Jugular foramen respectively.

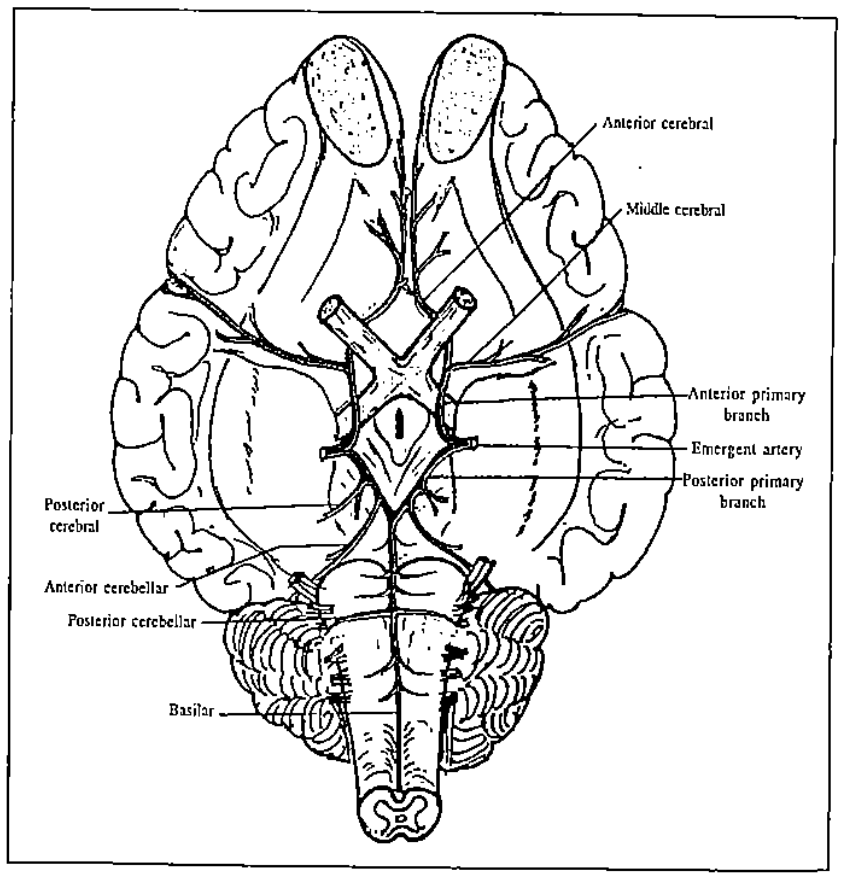


Fig. 7.23 Arterial supply to the brains.

From the superior aspect of the rete, emerge two arterial trunks (left and right) which pierce the duramater on either side of the pituitary stalk. These are known as ***emergent arteries.***

Each emergent artery immediately divides into anterior and posterior primary branches :

1. ***Anterior primary branch***—This vessel proceeds forward, crosses the optic tract detaches the middle cerebral artery and continues rostrally and medially as anterior cerebral artery :

(a) *Middle cerebral artery*—It is given off from the anterior primary branch in front of the pyriform lobe. The vessel gains the Sylvian fissure and supplies the lateral mass of cerebrum.

(b) *Anterior cerebral artery*—The anterior primary branch continues forward and inward, reaches the front of optic chiasma, come close to the similar artery of the opposite side, may communicate with it and ultimately ramifies into the anterior mass of the corresponding cerebral hemisphere.

2. ***Posterior primary branch***—It turns backward and inward, detaches two posterior cerebral arteries at the level of the origin of the 3rd cranial nerve. It passes further backward detaches anterior cerebellar artery after crossing the root of 5th cranial nerve, reaches the midline and joins with the same vessel of opposite side to form Basilar artery.

(a) *Posterior cerebral arteries*—They are two in number on each side. The vessels pass backward and upward to supply posterior part of the cerebral hemisphere.

(b) Anterior cerebellar artery goes upward to supply anterior part of cerebellum.

(c) The basilar artery is formed in front of the pons. It goes backward along the ventral median groove and gives off 4 to 5 collateral small branches at the ventral surface of pons. Just in front of corpus trapizoidum it detaches posterior cerebellar arteries on either side which supply the posterior aspect of the cerebellum. The basilar artery continues along the ventral longitudinal fissure of the medulla oblongata and spinal cord.

Circle of Wills or Circular arteriosus

The anterior cerebral arteries with their anastomosis in front and the formation of basilar artery by the union of terminal vessels of posterior primary branches behind, make a vascular circle at the interpeduncular fossa at the base of the brain in the subarachnoid space is popularly known as circle of Willis. It helps in equilising pressure in arteries of two sides. It also helps in maintaining blood supply to different parts of brain in case of obstruction of main artery of one side.

Venous drainage of brain—The veins of the brain are thin walled and devoid of valves. Most of these veins drain into dural venous sinuses after piercing the arachnoid and meningeal layer of duramater. These are three sets of veins – (a) from cerebral hemisphere, (b) from brain stem and (c) from cerebellum.

Blood brain barrier—The tight junction between the endothelial cells of capillaries and the foot processes of glial cells (astrocytes) from a barrier between the blood and brain tissue which does not allow everything in the blood to enter into the brain. This is called blood brain barrier. However, it allowes free passage to O_2, Co_2 and some drugs like sulphonamides, penicillin, erythromycin, etc.

FETAL CIRCULATION

The umbilical vein carrying placental (oxygenated) blood, enters the abdomen of the fetus at the umbilicus and enters the liver. At the early part of embryonic life two umbilical veins are present. Later only the left vein persists. It then joins the portal vein, hepatic vein and finally opens into the abdominal venacava through ductus venosus. The blood is then conveyed to the right atrium. Through the foramen ovale maximum blood passes into the left atrium and thereby to the left ventricle. The

foramen ovale closes at birth. Through the aorta most of the blood goes to the head and fore limbs and a small amount passes into the abdominal aorta. From the cranial aspect blood returns through anterior venacava to the right atrium. This blood along with a small amount of blood from the abdominal venacava passes into the right ventricle. The right ventricular blood goes *via* pulmonary trunk but instead of going to the inactive fetal lungs most of the amount passes into the descending aorta through ductus arteriosus. Ductus arteriosus is a arterial duct which connects the palmonary artery with the aorta. At birth it becomes occluded and in adult it persists as a ligament (Ligamentum arteriosum). This blood mix with a small amount of blood which is transmitted from the left ventricle through the aorta, passes backward, supplies to some extent to the viscera and hind limbs and the maximum amount finally passes out to the placenta through the umbilical arteries.

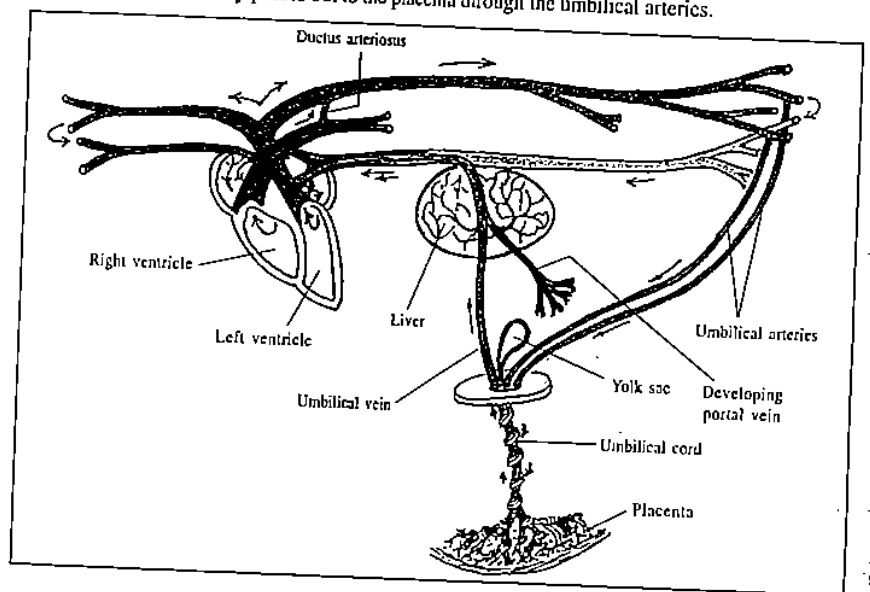


Fig. 7.24 Fetal circulation (Schematic).

VEINS

From different tissues of the body the systemic veins drain blood to the heart. Most of the veins except the cranial and caudal venacava contains a series of valves (bicuspid) which control the flow of blood in one direction, *i.e.*, towards heart. In the portal system of veins and in pulmonary veins, the valves are not present. Majority of the tributaries of veins accompany arteries. However superficial veins which make network under the skin do not accompany arteries. Therefore, only few important venous distributions which undergo independent course will be discussed here.

Cranial venous sinus

The upper edge of falx cerebri accommodates the superior sagittal sinus along its length. The lower edge accommodates the inferior sagittal sinus. The tentorium cerebelli on either side accomodates the left and right transverse sinuses. At the junction of falx cerebri and tentorium cerebelli, the straight

sinus is situated. It receives great cerebral vein at its anterior end. The cavernous sinus is situated on either side of the body of sphenoid bone. It is spongy in appearance. It is connected with the superior and inferior petrosal sinuses which are situated at the corresponding edge of the temporal bone.

Internal jugular vein

It brings blood from all the veins of the cranial cavity, extends from the jugular foramen gets included in the carotid sheath with the carotid artery and vagus nerve and finally joins the external jugular vein. However controversy is there regarding the termination of internal jugular vein.

External Jugular vein

It is a large vessel formed by the union of superficial temporal and maxillary veins below and behind the temporo-maxillary articulation. It drains blood from the superficial aspect of head and neck. At the begining it is covered by parotid gland. At the neck it is lodged in a furrow between brachiocephalicus muscle above and sternomaxillaries muscle below. In front of the thoracic inlet the internal and external jugular veins of each side join to form common jugular vein. The common jugular vein joins the axillary vein and forms the **jugular confluent** from where cranial venacava initiates.

The portal vein

The tributaries of this large vein receive the products of digestion, absorbed by the capillaries at the mucous membrane of small intestine. The intestinal villi contains large number of capillaries in the

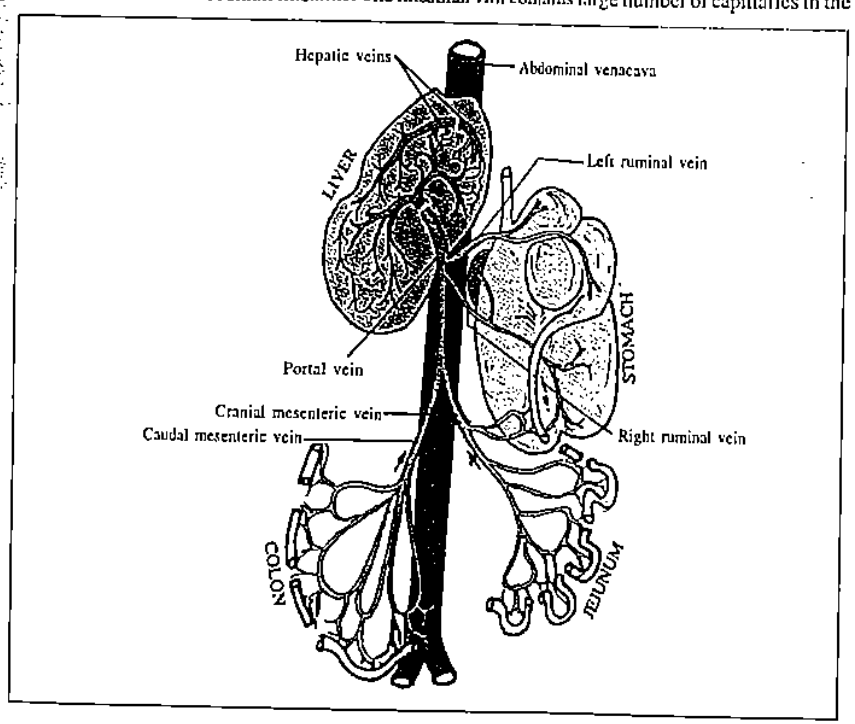


Fig. 7.25 Schematic diagram of distribution of portal vein.

form of a fine network. They join with some other veins from stomach and spleen and form the portal vein. This is a vein which begins and also ends in capillaries.

Formation—Two mesenteric (Cranial and caudal) veins join with the right ruminal and left ruminal vein to form the portal vein. Right ruminal vein is formed by union of right ruminal vein proper and splenic vein, while the left ruminal vein is formed by the union of left ruminal, reticular and omaso-abomasal veins. The veins from the jejunum and ileum join to form the cranial mesenteric vein and those of different parts of colon unite to form the caudal mesenteric vein. The portal vein passes forward below the abdominal venacava and enter the liver at the portal fissure, close to the entry of hepatic artery.

Inside the liver the portal vein divides into branches. Each finer branch accompanies a branch of hepatic artery and bile duct. These three tubes pass through triangular spaces between the lobules of liver. The portal vein thus gives rise to its terminal branches— the interlobular veins. Blood from these vessels passes through hepatic sinusoids towards the center of the lobule and enters the central vein. The hepatic cells on either side of the sinusoid absorb the glucose brought to it from digestive tract and form glycogen. The venules of the center of the lobules repeatedly unite to form large veins. These veins join to form hepatic veins which ultimately open into the caudal venacava.

VENAAZYGOS

It is a single vein drains blood from the dorsal walls of the left side of the thoracic and abdominal cavity and opens independently to the heart.

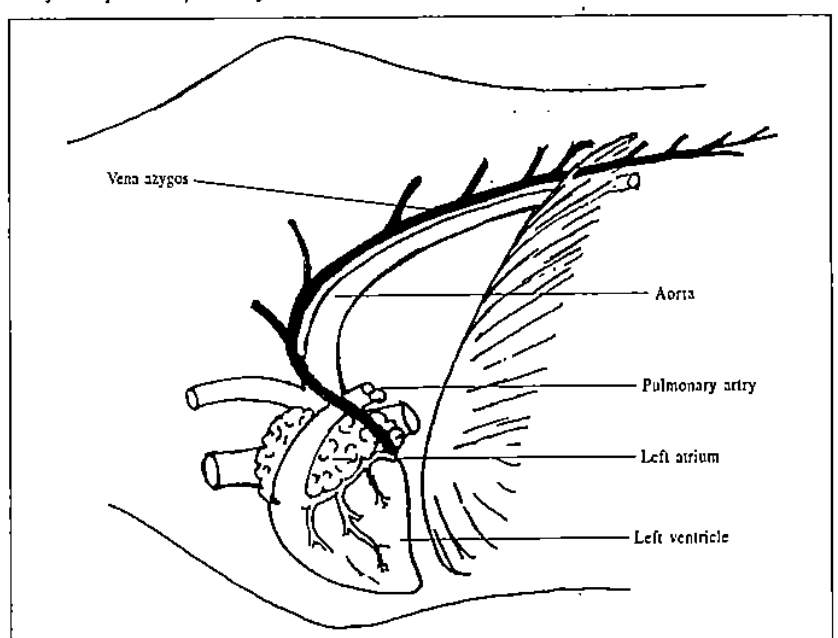


Fig. 7.26 Vena Azygos, its position and tributaries.

It starts from lumbar area gets redicles from psoas muscles, passes forward along the left ventral part of the bodies of the vertebrae and joins the veins from crura of diaphragm. It continues further forward and downward along the superior aspect of the left face of the abdominal aorta joins with the some vertebral and intercostal veins and reaches to the level of 5th intercostal space. It then crosses the left vagus nerve, joins with the some intercostal veins and esophageal vein, passes backword and downward over the left atrium obliquely, reaches at the back of the base of heart, receives the great cardiac vein and immediately opens into the right atrium, ventral to the termination of caudal venacava.

LYMPHATICS

These are the vessels other than blood vessels, which transport tissue fluid to the blood stream. Lymph is a colourless tissue fluid drained by lymphatics. These vessels are small, delicate and possess numerous valves which allow the lymph to flow in one direction. These are mainly distributed in the mucous, serous and synovial membranes, glands and in skins but not found in nervous system. The flow of the lymph is very slow. The vessels pass through lymph nodes. Finally the vessels end at the thoracic duct and right lymphatic duct which open into the venous system.

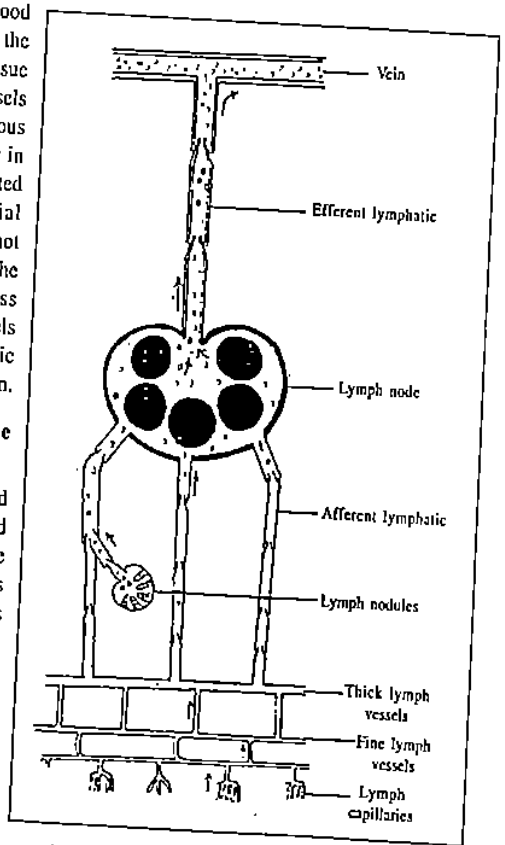


Fig. 7.27 Schematic diagram of the lymphatic

The lymphatic system may be summarised as follows

Lymph capillaries are blind ended vessels, take up excessive tissue fluid and lymphocytes to form the lymph. The lymph flows slowly through lymph vessels of increasing caliber. These lymph vessels have valves. Lymphocytes produced from the local lymph nodules are drained into these vessels. The lymph is filtered through the lymph nodes, antibodies and more lymphocytes are added and finally joins with the vein as shown in the figure. These nodules are composed of aggregated lymphocytes.

Lymph nodes

They are oval or bean shaped nodular brown or reddish black structures of variable sizes ranging from very minute bodies to the size of a lemon. The hilum is in a depressed area where

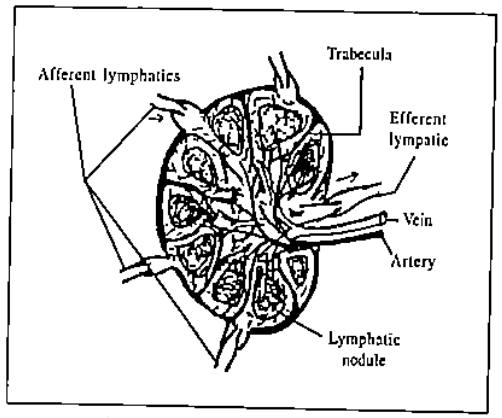


Fig. 7. 28 Lymph node (Diagramatic).

blood vessels and effarent lymph vessels enter or leave the gland. The afferent vessels are found at different points along the convex surface of the node. The nodes are covered by a connective tissue capsule. The capsule send septa or trabeculae inside the node. The trabeculae form compartments at the cortical area. The compartments accommodate cortical nodules. The central portion of a nodule is known as **germinal center**. The germinal center is lighter in colour and production of lymphocytes occures in these germinal centers. The cortical nodules are separated from the capsule as well as trabeculae by lymph sinuses. The medulla is composed of lymph cords which extend from the nodules, lymphocytes, RE cells, meshwork of trabeculae and lymph sinuses of the medulla. In ox large pigmented branching cells are found. The lymph enter the nodes through afferent lymphatics, percolate through sinusoids and the filtered lymph emerges *via* the efferent lymphatic through the hilus.

Although variable in number the lymph nodes are constantly found in certain definite areas such as axilla, inguinal region, mesentery, pre-scapuler area, supra mammary region, *etc.*

Cisterna chyli

Cisterna chyli is a dilated and elongated sac about 2-3 inches in length and 0.5 inch in thickness, placed to the right of the abdominal aorta at the level of 2nd and 3rd lumbar vertebrae and on the right face of the crus of diaphragm. It is formed by the union of lumber and gastrointestinal lymphatic trunks. It is the reservoir of lymph. From its cranial end the thoracic duct starts.

Thoracic duct

This is the main lymphatic trunk which receives lymph from all parts of the body except from right side of the head, neck, thorax and right forelimb. It enters the thorax through aortic aperture of diaphragm, passes forward along the right part of the dorsal face of the aorta and receives a large duct, coming from mediastinal lymph glands. It then crosses the dorsal face of the esophagus and aorta to reach the left of the midline and finally terminates in the cranial venacava or left common jugular vein in front of 1st rib. In the thorax the vessel may be divided into two – left and right branches which again unite at the level of 6th thoracic vertebra.

Right lymphatic duct

It receives lymph from right side of the head, neck, thorax and right forelimb and opens into right common jugular vein or in the jugular confluent.

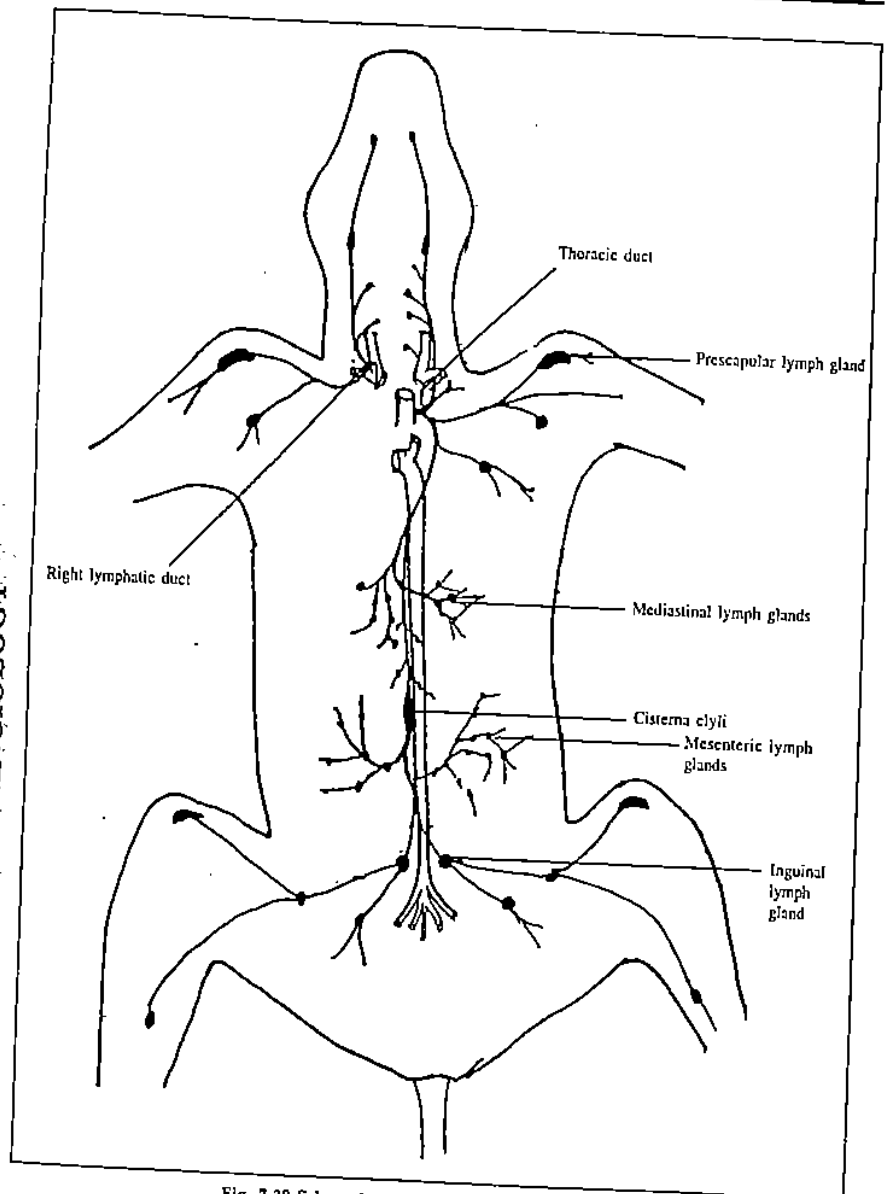


Fig. 7.29 Schematic diagram of the lymphatic system.

Major variations in the arterial distributions in other domestic animals

HORSE

Intercostal arteries—They are 18 pairs in number.

Celiac artery—It divides into (a) left gastric, (b) hepatic and (c) splenic branches.

It originates at the level of 17th to 18th thoracic vertebra and therefore intrahiatic in position.

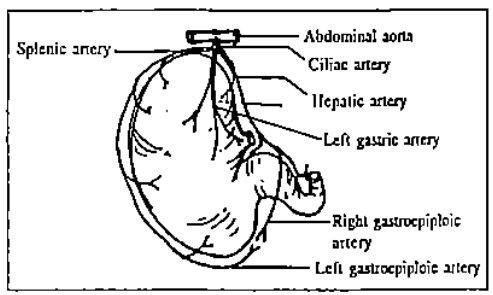


Fig. 7.30 Celiac artery of Horse.

The left gastric artery gives off pancreatic, esophagial, parietal and visceral branches. The hepatic artery divides into pancreatic, right gastric and gastroduodenal branches. The splenic artery is the largest of the three. It provides pancreatic, splenic, left gastroepiploic and short gastric arteries. The left gastroepiploic artery anastomoses with right gastroepiploic branch of hepatic artery after coursing along the greater carvature of the stomach.

Median sacral artery is absent. However, the median coccygeal artery, an unpaired vessel originates from the caudal gluteal (right or left) artery takes the position of median sacral artery of ox.

Axillary artery—As horse has only one digit, the median artery, alone continues down as a major vessel to the extreame end to supply the limb. At the posterior aspect of the distal third of the large metatarpal bone it bifurcates into lateral and medial posterior digital arteries. The terminal branches of these digital arteries finally enter the volar foramen of third phalanx. The radial artery does not continue up to the phalanges but forms proximal and distal palmar arches with the other collateral branches of median artery.

External iliac artery—In the hind limb the lateral and medial posterior digital arteries originate from the cranial tibial artery. The saphenous artery (caudal branch) joins with the caudal tibial artery in front of tuber calcis and forms double curve in most of the cases.

DOG

Celiac artery—It is very short and usually divides into (a) left gastric, (b) hepatic and (c) splenic arteries. It originates at the level of 1st lumbar vertebra.

Lumbar arteries—Out of seven pairs of lumbar arteries first six pairs arise from aorta and the last pair from internal iliac arteries.

Intercostal arteries—They are 12 pairs in number. First three pairs usually originate from thoracic vertebral artery and rest 9 pairs originate directly from the aorta.

Median sacral artery is developed.

Axillary artery—In case of dog and pig left axillary artery arises independently from the aortic arch. The right axillary, however originates from the brachiocephalic trunk but very closely associated

with the begining of left and right common carotid arteries. In the metacarpus and digital region two dorsal sets (superficial and deep) and two palmar sets (superficial and deep) arteries are present.

The dorsal common digital arteries (superficial set) are I to IV which arise from cranial superficial antibrachial artery. This vessel is a branch of superficial brachial artery which is detached from the brachial artery just above elbow joint. The **dorsal metacarpal arteries** (deep set) are II to IV and are the branches of radial and caudal interosseous arteries.

The palmar common digital I to IV (superficial set) **arteries** are the branches of median and caudal interosseous arteries. The **palmar metacarpal** II to IV, (deep set) **arteries** originate from radial and caudal interosseous arteries.

The dorsal and palmar vessels communicate within themselves at the distal portion of metacarpus and finally divides into digital arteries.

External iliac artery—In the hind limb also two dorsal sets and two palmar sets of vessels are present.

Dorsal common digital arteries (superficial set) are the branches of saphenous artery and the **dorsal metatarsal** (deep set) **arteries** are the branches of dorsal pedal artery. The dorsal pedal artery is the continuation of cranial tibial artery.

Planter common digital arteries (superficial set) originate from the medial planter branch of the caudal division of saphenous artery. The **planter metatarsal arteries** (deep set) are branched from lateral planter artery which is a branch of the caudal division of saphenous artery.

The pattern of distribution of these vessels are mostly similar to those of fore limb.

TYPES OF ARTERIES

There are two types of arteries—(a) Elastic artery, (b) Muscular artery.

(a) Large arterial trunks, such as Aorta, Brachiocephatic trunk, Pulmonary trunk contains more elastic tissue in the tunica media and therefore these are **Elastic arteries.**

(b) Most of the other arteries contain more muscle tissue in their tunica media and therefore called **Muscular arteries. The muscles are mainly circular and can respond to nerve stimuli.**

Capillaries

These are the network of fine blood vessels remain distributed in the tissues between arterioles and venules. Each capillary has a length of about 1 mm and diameter of about 8 microns.

The wall of a capillary is very thin and composed of single layer of flattened endothelium and a basal lamina. At some places the basal lamina is splitted to enclose some polygonal cells with long cytoplasmic processes called **pericytes.** The capillary endothelium may be fenestrated in some organs like kidney (renal corpuscle), endocrine glands etc.

Cavernous tissues

In some tissues blood filled spaces are seen. They are lined by endothelium and generally remain surrounded by trabeculae and the arterises and venules directly open into these spaces. These type of tissue are found in erectile tissue of penis and in the mucous membrane of nasal cavity.

Sinusoids

These are spaces within the parenchyma of some organs like liver, spleen, pituitary, adrenal etc. They are more dilated and tortuous than capillaries and lined by flattened endothelium or by other variety of cell type. They may be fenestrated or closed type.

Portal system

When two sets of capillaries are connected with a blood vessel, for the purpose of collection and distribution of materials through blood, the arrangement is called portal system. Four such portal systems are available in the body.

1. *Hepatic portal system*

   Here the capillaries of the gut are connected to hepatic sinusoids by the portal vein.

   It collects absorbed food materials from the gut and transport to liver.

2. *Renal portal system*

   Efferent glomerular arterioles connect glomerular plexus with peritubular plexus of blood vessels. This mechanism helps in reabsorption of essential elements of glomerular filtrate back to the blood.

3. *Hypophyseal portal system*

   Here short portal vessels connect the capillaries of infundibulum to those of Adenohypophysis. Through this portal system hypothalamus controls/regulates the activities of adenohypophysis.

4. *Supra renal portal system*

   Some small portal vessels connect the cortical sinusoids with those of medullary sinusoids. This arrangement is said to help transportation of some chemicals directly to medulla.

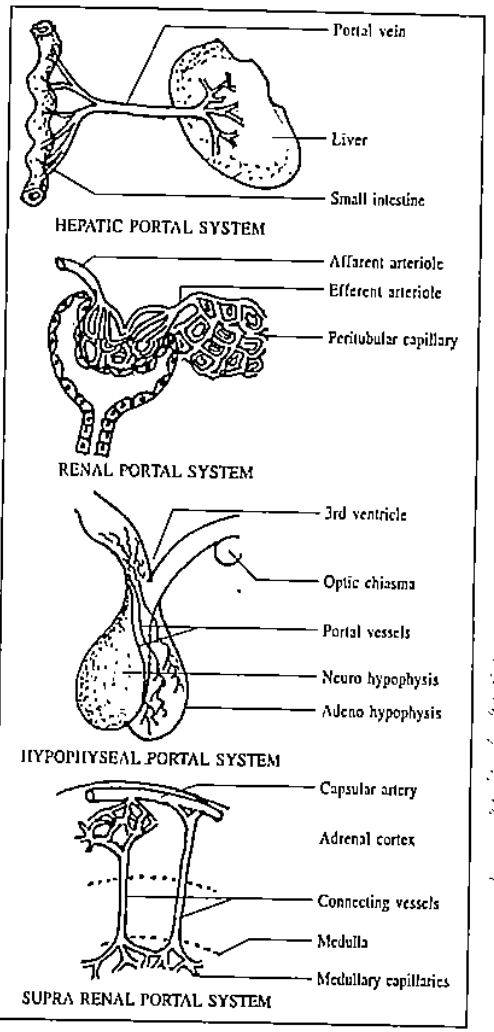


Fig. 7.31

8 NEUROLOGY

Nervous system

It is the system that receives the information with regard to the changes in the environment (external and internal) of the body and in response regulates appropriate function.

Neurons

The unit of the nervous system is the neuron. A nerve cell with all its processes or parts is called a neuron. The nerve cells have two types of processes. A long process which carries the impulse away from the cell body is known as axon. One or more short and branched processes which carry impulses towards the cell body is knows as dendrons. Axon is always single and dendrons may be numerous. These processes are also called fibers. The motor neurons are generally multipolar and the sensory neurons are bipolar or unipolar in nature.

The cell body generally contains a large nucleus, neuroplasm, neurofibrils, *Nissl bodies* (angular granules), mitochondria, Golgi apparatus, endoplasmic reticulum, ribosomes, inclusions, neurosecretary materials and cell membrane. *Centrioles* are absent in nerve cells and therefore incapable of reproduction in post-natal life. The *Nissl bodies* are composed of rough surfaced endoplasmic reticulum, surrounded by closely packed ribosome granules combined with iron. These bodies are associated with synthesis of new proteins and enzymes. They disappear when a nerve cell is injured or fatigued. Nissle bodies extend into the dendrites but do not do so in the axons because they cannot percolate through the crowded neuro fibrils at the axon hillock. The cells are classified according to their number of processes, such as **Apolar, Unipolar, Bipolar, Multipolar**, *etc*. Neurons can be classified according to relative lengths of axons and dendrons. (a) ***Golgi type-I*** – Here the dendrites are short and numerous. The axons are long. Peripheral neurons and those forming tracts in CNS belong to this category. (b) ***Golgi type-II*** – In these cells, axons are short and morpholigacally similar to those of dendrites. They are confined within grey matter and establish synaptic connections with other neurons. ***Amacrine neurons*** – These are unusual neurons of retina and possess numerous *neurites* (terminal fibers of axon and dendrons) without axons. The Axons or nerve fibers which carry impulses from the central nervous system (CNS) to periphery are termed ***efferent or motor fibers*** and those carry impulses to the CNS are known as ***affarent or sensory fibers***.

Nerve trunk—A number of fibers group together to form a fasciculus. Each fascicle contains a number of myelonated nerve fibers of different diameters. Generally the diameters vary from 2 to 20 microns (Fig. 8.3). Each fasciculus is enclosed by a connective tissue membrane known as **perineurium. Endoneurium** is the connective tissue present in the spaces between the nerve fibers. A nerve trunk is composed of a number of fasciculi of different sizes which are enclosed together by a dense irregular connective tissue sheath—the **Epineurium**.

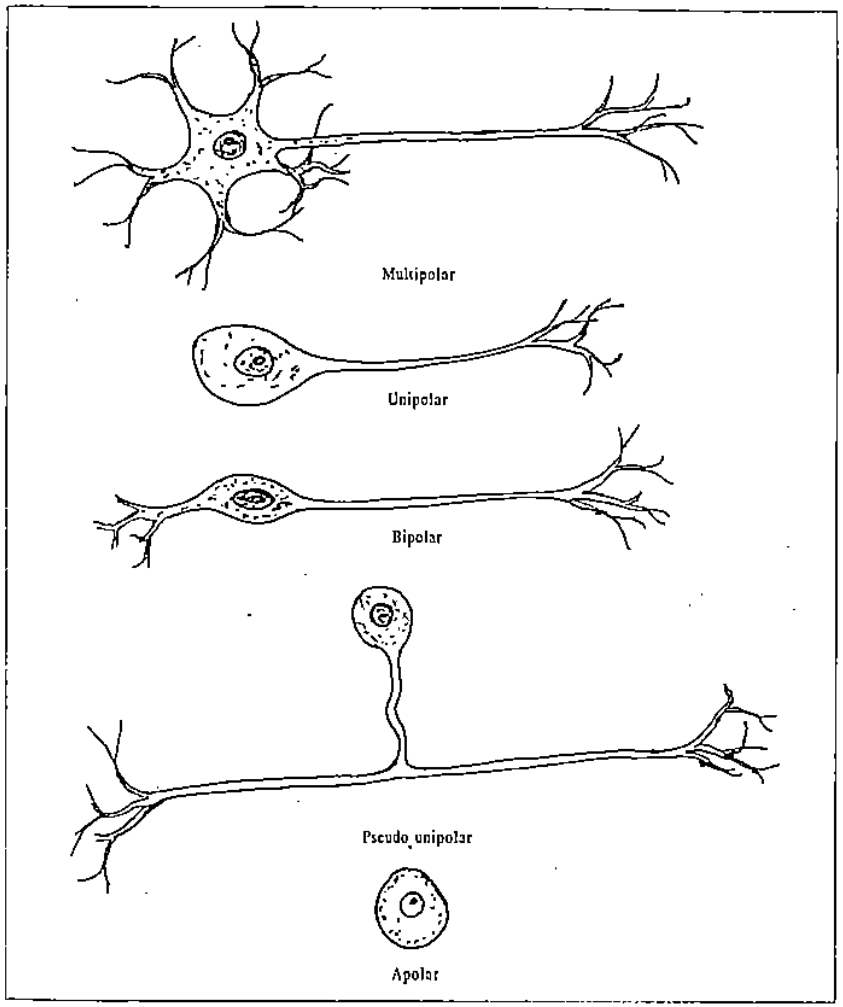


Fig. 8.1

Myelin sheath—The nerve fibers with in the grey matter of brain and spinal cord are devoid of any covering. These are **naked fibers**. The fibers get their first covering, *i.e.*, the **myelin sheath**, when they enter into white matter and get second covering, *i.e.*, **neurolemma**, when they come out of the CNS. At the termination the fibers loose the neurolemma first, then the myelin sheath. The axis cylinder ends as naked processes without any covering. Myelin sheath imparts white colour of nerves. All post ganglionic fibers of autonomic nervous system and somatic fibers less than 1 micron diameter are unmyelinated. The Myelin sheath is formed by a set of Schwann cells which are arranged along the length of axon.

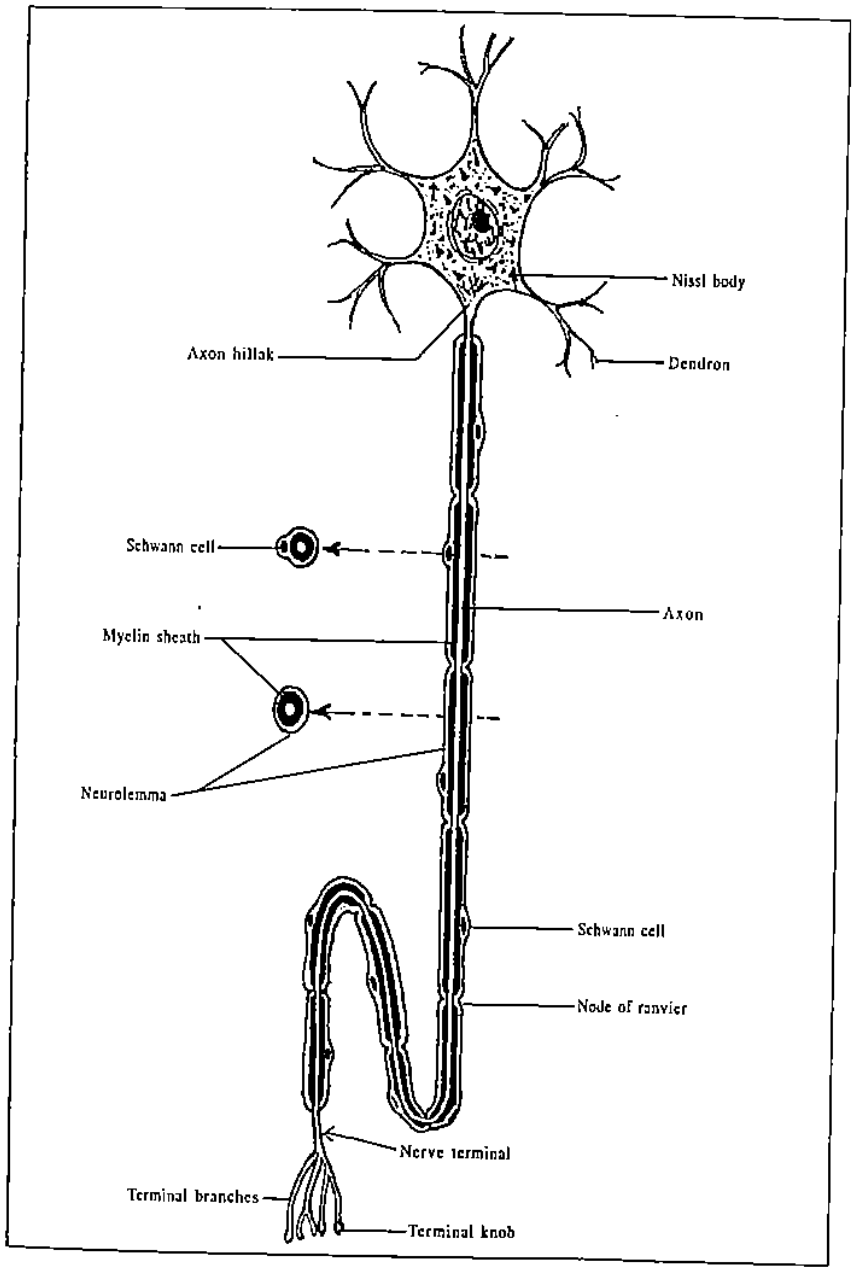


Fig. 8.2 Structure of a neuron.

Peripheral nerves if damaged, may regenerate, but the nerves within the CNS cannot. This is due to absence of neurolemma in the central nervous system. These damaged nerves of the CNS lead to degeneration of the cell bodies and their processes, which is followed by replacement by neuroglial tissue. This process in known as gliosis.

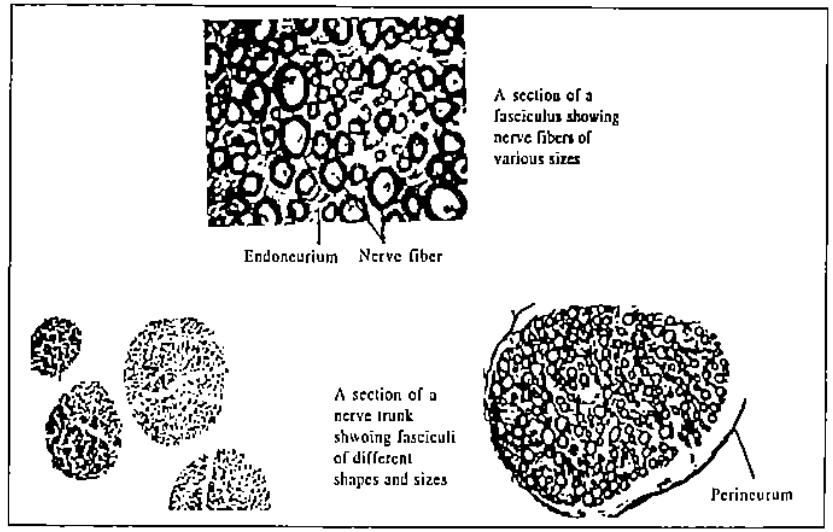


Fig. 8.3 Section of a nerve trunk and its fibers.

The axon is filled up by axoplasm – a intracellular fluid. The axon is surrounded by a myelin sheath. The schwann cells undergo spiralling around the axon and deposit concentric layers of lipids and proteins to form myelin sheath. In the somatic nerves the myelin sheath is covered by neurolemma – formed by the body of Schwann cell. Post ganglionic autonomic fibers have no myelin sheath. The preganglionic autonomic fibers are medullated. In the CNS the myelin sheath is derived from oligodendrocytes. In the myelinated nerve collateral branches arise at right angles from the side of the axon at the nodes of Ranvier. The terminal branches of the axon or its collaterals are known as telodendria. These terminals from bulbus swelling at their ends known as terminal knobs or boutons. A special form of termination of axon in a skeletal muscle is known as motor end-plate. The distance between nodes varies between 150 and 1500 microns.

Nodes of Ranvier—At the myelinated nerve fibers, gaps occur at the junction between Schawann cells where the axon cylinder is exposed. These gaps are known as nodes of Ranvier.

Neurolemma—This sheath is formed by the body of the Schwann cells, *i.e.* the cell membrane, cytoplasm and nucleus. This sheath is absent in CNS. *Due to presence of neurolemma the peripheral nerve may re-generate if damaged but that of CNS cannot.*

Effects of Nerve injuries

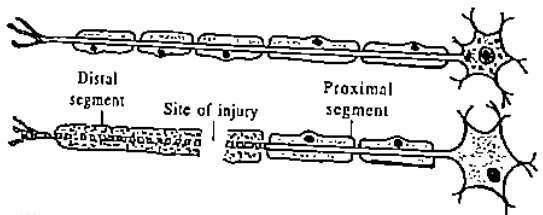
Nerve fibers may be damaged due to various reasons. In case of minor injuries like pressure or pull or moderate crushing, complete healing takes place. However, in the event of cutting and severe

crushing, the following changes occur :

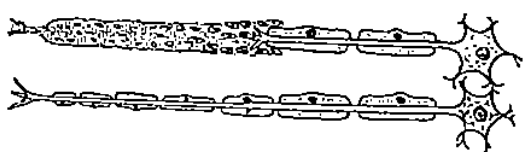
In the cell body—If the injury is close to the cell body, chromatolysis starts within 48 hours, Nissl bodies disappear, Neurofibrils breakup into small fragments, Golgi bodies decrease in number, Cell bodies increase in size and Nucleus become eccentric. In severe cases the cell dies. But in less severe cases repair begins within 40 days and may be completed by 80 days. Nissl granules re-appear and re-growth of axon in the proximal segments starts.

In the proximal segment—Proximal segment is the part of the axon between the cell body and the site of injury. In this segment degeneration occurs up to the first node of Ranvier, next to the site of Injury. The axis cylinder breaks up into fragments and the Myelin sheath is converted into droplets. This is called ***Retrograde degeneration***.

In the distal segment—This is the part of the axon, distal to the site of injury. This whole part of the axon degenerates completely in the same procedure. This is called ***Antegrade degeneration*** or ***Wallarian degeneration*** (in the name of the scientist Waller).



Regeneration—With the recovery of the cell body, the proximal part regenerates. At the begining few fine branches appear at the endoneural tube in the form of sproutings and explore the distal segment. When one of these branches can find the degenerated distal segment by the guidance of the strands of Schwann cells, it starts growing quickly and the other branches disappear. At first the regrown fiber is thin and unmyelinated. Subsequently it becomes thicker and very slowly become myelinated. However, sometimes the regrown fiber (axon) may end at a wrong destination and lead to complications.



Summary on Nerve injuries

1. In case of minor injuries (pressure, pull, crushing) regeneration is complete.
2. In cut injuries, complete regeneration may occur, but functionally it does not become perfect.
3. When graft is applied to bridge the gap between cut ends, satisfactory result is not always achieved because the regenerating axon may encounter obstacles frequently.

Injury in CNS

Degeneration in CNS, following injury occurs as in peripheral nervous system. However, it becomes more extensive and spreads beyond the site of injury. This is called Trans-synaptic degeneration. In

CNS, re-generation does not take place which may be due to lack of endoneuronal tube. The degenerated area is filled by growth of neuroglia.

Neuroglia—These are the supporting interstitial cells of nervous tissue. Unlike nerve cells, the glial cells are non-exitable and undergo mitotic division and that is why the brain tumors are mostly neuroglial, meningeal or vascular in origin. These cells take active part in the ionic transport and metabolism of the brain. The number of neuroglial cells is several times more than that of nerve cells. They may be of following varieties :

(a) *Astrocytes*—Stellate shaped cells with many cytoplasmic processes.

In some astrocytes, there are some microfilaments around the nucleus and in the processes. The cells with fibrils are called *fibrous astrocytes* and those without fibrils are known as *protoplasmic astrocytes*. The fibrous astrocytes are having longer processes and are situated in the white matter. The protoplasmic astrocytes have thick and short processes and are mostly situated in the grey matter. Astrocytes helps (i) in the formation of Blood Brain barrier, (ii) synaptic contact between cells, (iii) pump potassium in to capillaries and (iv) store glycogen.

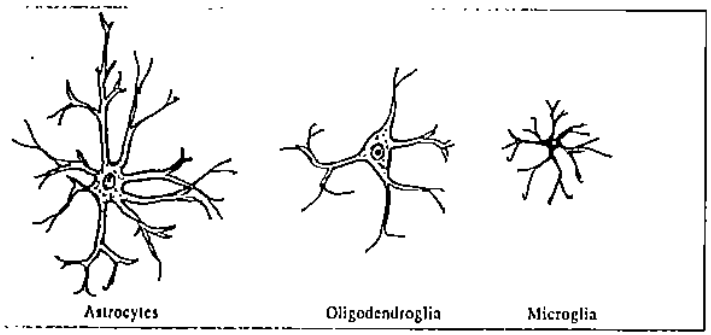


Fig. 8.4

(b) *Oligodendroglia*—These cells have few processes.

They are found in both white and grey matter. They are smaller than astrocytes and help in the formation and maintenance of myelin sheath around the nerves of CNS.

(c) *Microglia*—They are very small in size. They possess amoeboid movement and act as macrophage cells of CNS.

The astrocytes and oligodendroglia are ectodermal in origin but the microglia originate from mesoderm. Most of these neuroglial cells are smaller in size and also take part in phagocytosis, formation of myelin sheath and blood brain barrier.

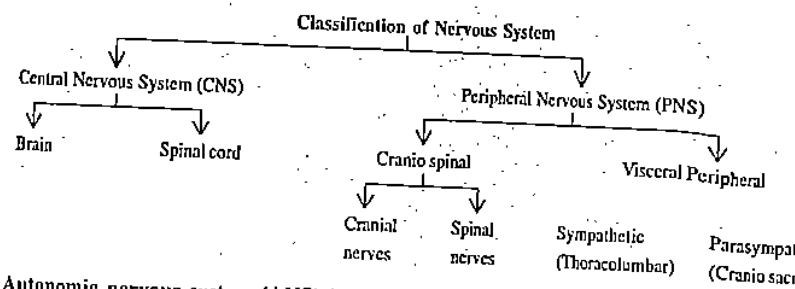
Ependyma—The lining membrane of ventricles of brain and central canal of spinal cord are formed by a layer of simple ciliated columnar cells and called ependyma. The cilia resemble microvilli and help exchange of substances between brain and CSF. Some cells of the ventricular lining send long cytoplasmic processes deep towards the neurons and other glial cells called *tanycytes*. These layer of cells, lining the choroid plexus helps actively in the formation of CSF. The ependymal cells form germinal layer of primitive neural tube and give rise to the development of Neuroblasts and Spongioblasts.

NEUROLOGY

Synapse—This is the junction where one neuron ends and other neuron begins. Here the terminal branches of one axon come in contact with the cell body or dendrites of other neuron.

Ganglion—This may be defined as a nerve tissue where a number of nerve cell bodies are aggregated in the peripheral nervous system.

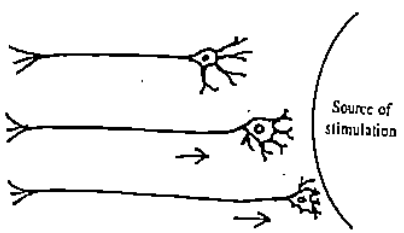
Nucleus—When a group of cell bodies of neurons are embedded in the substance of central nervous system, the collection is called nucleus.



Autonomic nervous system (ANS) is the visceral part of the nervous system. Its peripheral components are theracolumber and craniosacral outflows and central components of this system are placed within the CNS.

Neurobiotaxis

It is a process in which the cell bodies of the motor and connector neurons move, as a result of



some attractive force, towards their chief source of stimulation. Therefore the dendrites of motor and connector neurons tend to be short and their axons lengthen in opposit direction.

Sensory neurons are not involved in this process, because in them the urge for centralisation is more important than neurobiotaxis.

MENINGES

The brain and spinal cord are enclosed by three membranous coverings for their protection. These are known as meninges. They are Duramater, Arachnoid and Piamater from outside inward.

Duramater

This is the outermost strong and tough fibrous covering. For description this can be divided into *cranial duramater and spinal duramater.*

Cranial duramater not only acts as a covering of the brain but also lines the inner surface of the cranial cavity and serves the purpose of periosteum. Folds of duramater form partitions which project between major divisions of the brain and divide the cranial cavity into incomplete compartments. **Falx cerebri** is a sickle shaped vertical fold situated at the midline in between two cerebral hemispheres. The superior border of this fold is attached to the internal occipital protuberance, interparietal and frontal crests and crista galli. The anterior portion of the inferior border of falx cerebri is thin and free but the posterior portion meets with the tentorium cerebelli at right angles. **Tentorium cerebelli** is another infolding of duramater and forms a partial transverse partition between the cerebral hemispheres and cerebellum. Out of the two borders the upper border is attached to internal occipital protuberance and petrosal crest. The lower border is concave and free. The duramater contains large venous channels along certain lines in association with falx cerebri and tentorium cerebelli. These are known as **cranial venous sinuses. Diaphragm sellae** is a fold of duramater extending transversely across the *sella turcica* (**pituitary fossa**) and makes the roof over the pituitary body. It is perforated at the middle for the infundibulum of the pituitary gland and laterally for the emergent arteries and 3rd cranial nerve respectively.

Spinal duramater starts from the foramen magnum and terminates at the middle of the sacrum. Unlike cranial duramater, its external surface is separated from the wall of the spinal canal and the space between the spinal canal and the duramater, which remains filled with areolar and adipose tissue is known as **epidural space**. At the cranial part of the vertebral column the epidural space is very less and gradually increases towards caudal portion. This membrane is pierced by roots of spinal

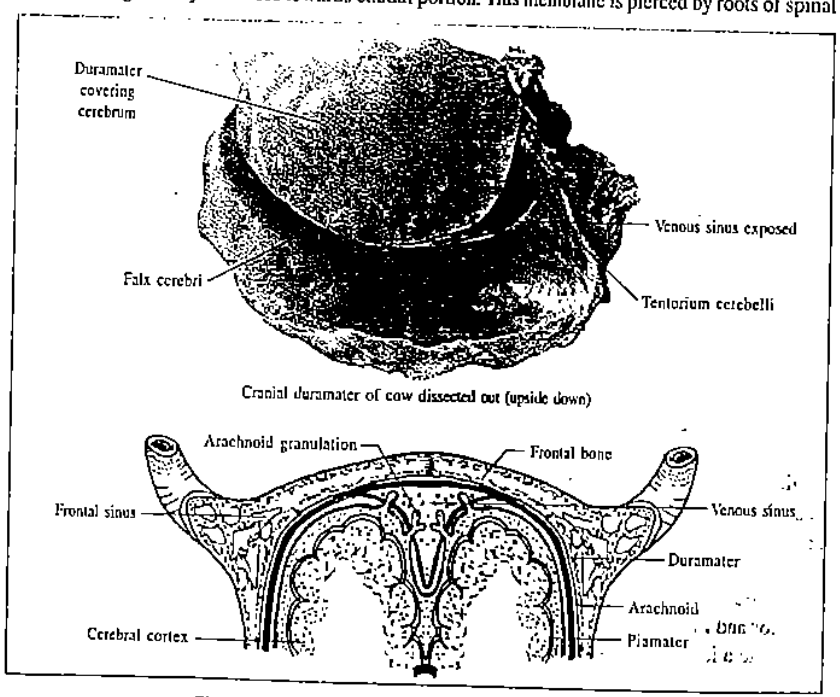


Fig. 8.5 Duramater and scheme of meninges of cranium.

nerves. However, the roots of the nerves are surrounded by special sheaths send off by the duramater. Internally the duramater is lined by arachnoid. The potential space in between the duramater and arachnoid which contains a small amount of fluid is known as **subdural** space.

Arachnoid

It is a very thin delicate membrane covers the brain and spinal cord. It remains in between the duramater externally and piamater internally. The space between the arachnoid and piamater is known as **subarachnoid** space. It remains filled up by cerebro spinal fluid (CSF). The arachnoid is thick at the base of the brain and in different points it is widely separated from piamater by large subarachnoid spaces or cisterns. Small buds of arachnoid sometimes invaginate inside the venous sinuses of duramater. These are called **arachnoid granulations.**

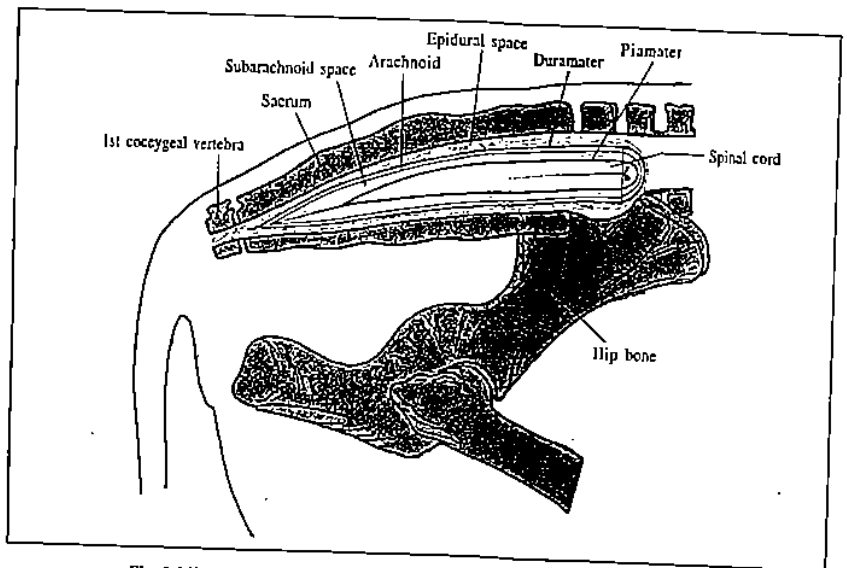


Fig. 8.6 Terminal part of spinal cord showing disposition of epidural space.

Piamater

This is a more delicate membrane, closely invests the brain and spinal cord. This is composed of very minute blood vessels and fine areolar tissue. The cranial part dips between cerebral gyri, cerebellar lamina and invaginates to form **tela choroida** and **choroid plexuses** of ventricles. The tela choroida is a bilamilar fold of piamater situated along the roof of 3rd ventricle as well as of 4th ventricle. In both occasions the tela provides vascular tuft of choroid plexuses which project into adjacent ventricles. The spinal part is less vascular and thicker. **Lamina splendens** is a thickening of piamater lie along the inferior median line of spinal cord through which inferior spinal artery passes. In between the superior and inferior roots of spinal nerves the piamater produces series of pointed processes which constitute a longitudinal band, known as **denticulate ligament.**

Cerebrospinal fluid — Tufts of capillaries inside the ventricles are covered by ependyma to form chroidal plexus. CSF is mainly formed by the choroid plexuses of lateral ventricles. CSF

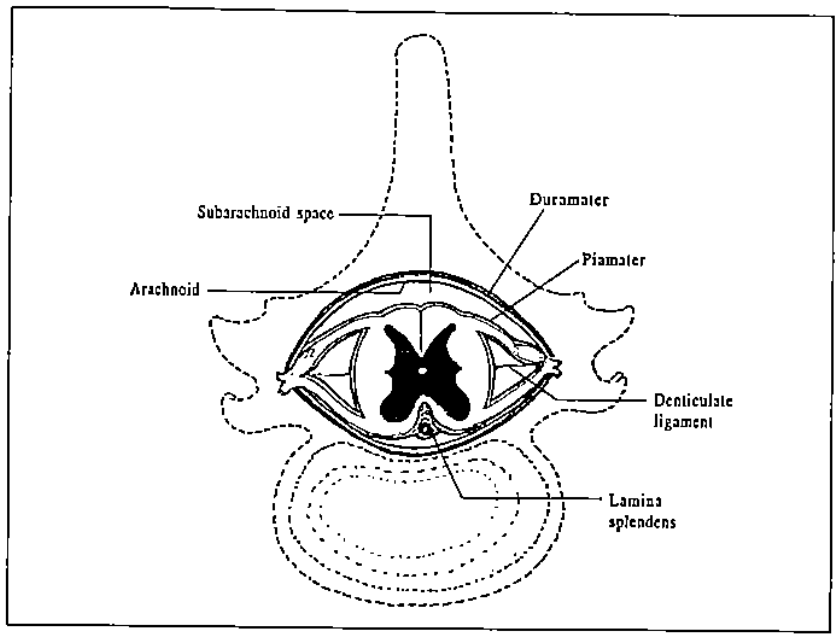


Fig. 8.7 Scheme of spinal meninges.

thus formed passes to the 3rd ventricle through the two foramen of Monro. From 3rd ventricle it passes to the 4th ventricle through aquiduct of Sylvius. From the 4th ventricle a small amount of fluid passes through the central canal of spinal cord and the major portion escapes to the subarachnoid space through **Foramina Magendie and Luschka.** The foramina Luschka are the two laterally placed apertures and foramen of Magendie is the centrally placed aperture at the roof of 4th ventricle. The fluid is drained into the venous system mainly through arachnoid granulations.

Excess accumulation of CSF due to difficulty in the circulation of the fluid may lead to *hydrocephalus.*

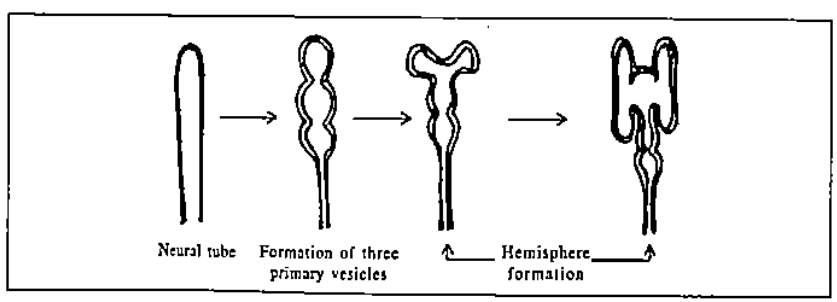
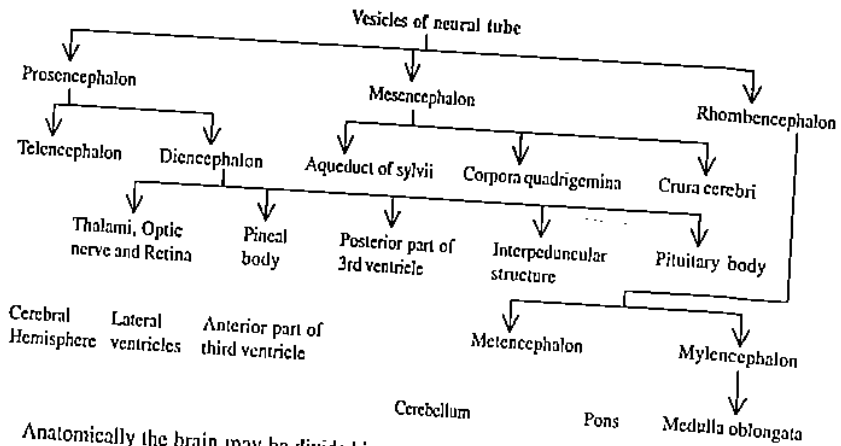


Fig. 8.8 Schematic diagram of early development of brain.

THE BRAIN

In the developmental stage the upper end of the neural tube takes the form of three round swellings marked from one another by constrictions. These three vesicles give rise to fore brain (prosencephalon), mid brain (mesencephalon) and hind brain (rhombencephalon).

The derivatives of the three vesicles are as follows :



Anatomically the brain may be divided into cerebrum, cerebellum, pons and medulla oblongata. For description five divisions may be considered. These are (a) Cerebral hemispheres, (b) Inter brain, (c) Mid brain, (d) Hind brain and (d) Medulla oblongata.

CEREBRAL HEMISPHERES

The cerebrum is a ovoid mass and the largest part of the brain. It is incompletely divided into two symmetrical halves by a deep median longitudinal cerebral fissure. Each half presents similar structures and components and therefore called hemispheres. Each cerebral hemisphere has three surfaces (superolateral, medial and ventral).

Basal ganglia

These are masses of grey matter embedded in the white matter of the base of each cerebral hemisphere. These are associated with controlling the voluntary reflex and automatic movement of the body by acting as subcortical cell station for the extra-pyramidal motor pathway which influences the lower motor neurons of the brains stem and the spinal cord through various tracts like rubro-spinal tract, reticulo spinal tract, olivo-spinal tract, vestibulo-spinal tract, etc. The ganglia are (i) corpus striatum (ii) claustrum and (iii) amygdaloid nucleus.

The *corpus striatum* is a mass of gray matter placed at the anterolateral aspect of thalamus. It is divided into two parts by anterior limb of internal capsule. These are caudate nucleus (medial) and lenticular nucleus (lateral). The lenticular nucleus is subdivided into an external part the putamen and an internal part the globus pellidus. External capsule is a layer of tissue situated on the outer side of the lenticular nucleus.

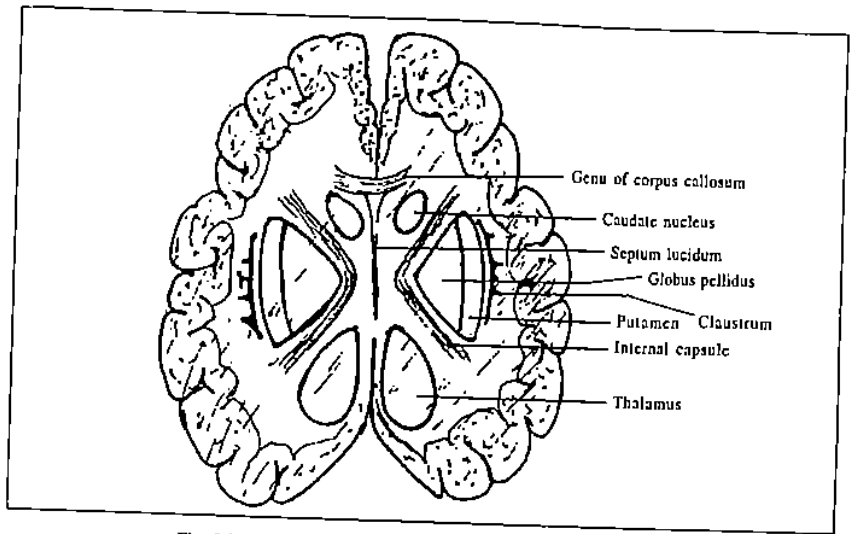


Fig. 8.9 Horizontal section of the brain showing basal ganglia.

The claustrum is a thin layer of grey matter placed on the outer surface of external capsule. This structure is also belongs to corpus striatum. Its specific function is still not well explained.

The amygdaloid nucleus is an almond shaped thickening of the cortex at the apex of the temporal lobe placed on the roof of the descending cornu of the lateral ventricle.

Surfaces of cerebral hemispheres

The great longitudinal fissure, which lodges the falx cerebri divides the cerebrum into two equal halves incompletely. Centrally the fissure extend up to the corpus callosum. The corpus callosum is the connection between the two hemispheres at the median plane.

Each hemisphere has three surfaces and two ends. The supero lateral surface is convex. The inferior surface is irregular and the medial surface is flat and forms the lateral boundary of the longitudinal fissure. The surfaces of the hemisphere presents a number of irrigular convolutions, known as Gyri. These gyri are separated by depressions or furrows known as sulci. In each of the cerebral hemisphere five lobes may be considered—(a) **Parietal lobe** (upper middle), (b) **Frontal lobe** (anterior), (c) **Temporal lobe** (below middle), (d) **Occipital** (posterior) and (e) **Limbic area** (at the base).

The lobes have been named according the overlying bones of the skull.

Parietal lobe occupies the upper middle part of the cerebral cortex. It co-ordinates audito, visual, motor and somato-sensory function. It is responsible for planned movement and also accommodates taste sensation.

Frontal lobe is the anterior part of the hemisphere. It is associated with the motor system. This part is responsible for performing sequential jobs, two work at a time, storing programmes, etc.

Temporal lobe is situated at the lower middle part of the cerebral hemisphere. It accommodates auditory area and auditory association area. It is also involved in olfaction and equilibrium.

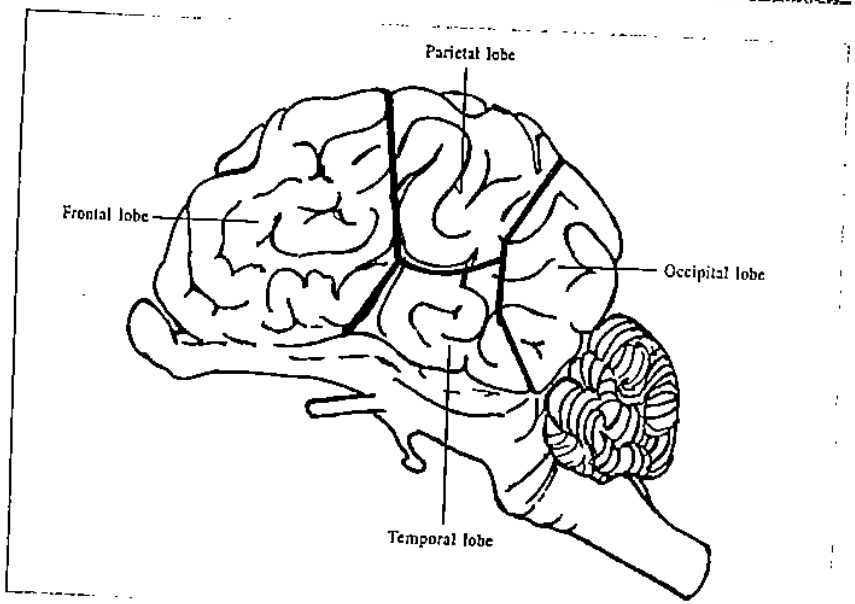


Fig. 8.10 Lobes of the cerebral hemisphere.

Occipital lobe occupies the posterior part of the cerebral hemisphere and is the primary visual area of brain.

Limbic area is situated at the base of the brain and is the seat of emotion. It has been discussed in the limbic system.

Functional areas of cerebral cortex

Broadly the cerebral cortex is subdivided into (a) Motor area, (b) Sensory area and (c) Psychical area on the basis of functional analysis.

Motor area — The primary motor area (area 4) is situated at the pre-central gyrus and extends on to the medial surface. It controls movement of voluntary muscle of the contralateral side of the body.

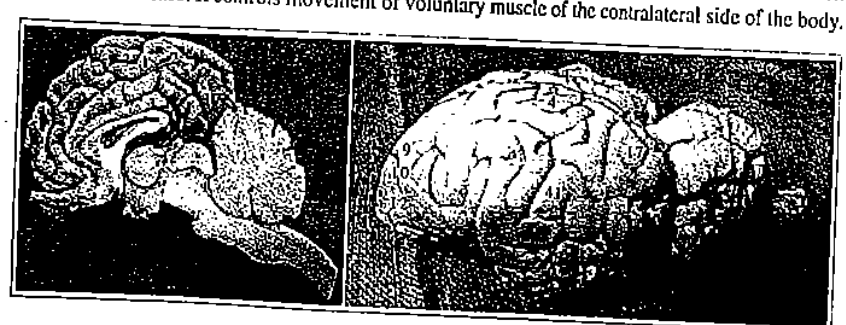


Fig. 8.11

However the pre-central area (area 9-12) located at the anterior most part of frontal lobe is associated with the depth of feelings and is responsible for mature judgment, foresight and tactfulness.

Sensory area — Somesthetic (analysis, discrimination and differentiation of cutaneous and proprioceptive senses) sensory area are located at the medial aspect of post-central gyrus (area 1, 2 and 3). Visual area is situated at the extreme caudal aspect of the occipital lobe (area 17). It receives inputs of optic radiation from the lateral geniculate body.

Psychical cortex (area) — It is located at the anterior part of the temporal lobe and Associated with the memories of past experience.

Beside the sulci there are some longer depressions on the surface of the hemispheres. These are known as fissures. The fissures are as follows :

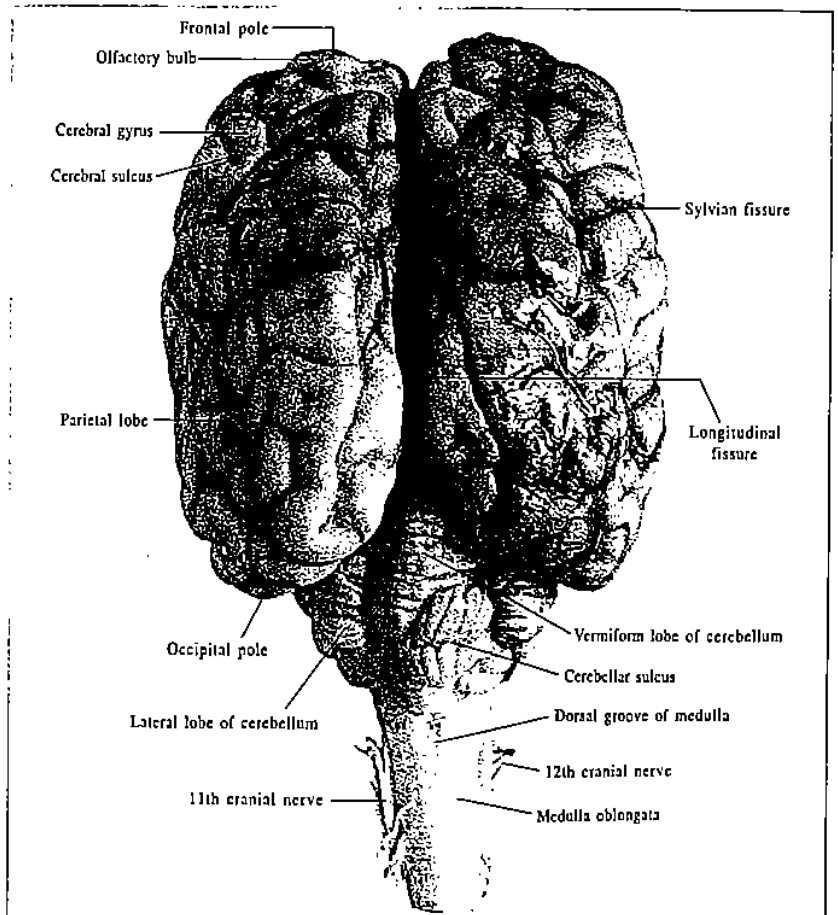


Fig. 8.12 Dorsal surface of the brain of ox.

Sylvian fissure—It originates from the middle of base, goes outward and gains the lateral aspect. It accommodates the middle cerebral artery.

Suprasylvian fissure is placed longitudinally on the sylvian fissure in an oblique manner.

Transverse fissure is short and situated at the middle in a transverse manner.

The **posterosuperior fissures** are three in number.

(a) *Posterosuperior central,*

(b) *Posterosuperior medial* and

(c) *Posterosuperior lateral.*

Antero superior fissure is deep and placed at the dorsal aspect of the anterior part. **Rhinal sulcus** is an extended groove which passes along the inferolateral aspect of the hemisphere in a longitudinal manner. **Callosal fissure** is the furrow, situated between corpus callosum and callosal

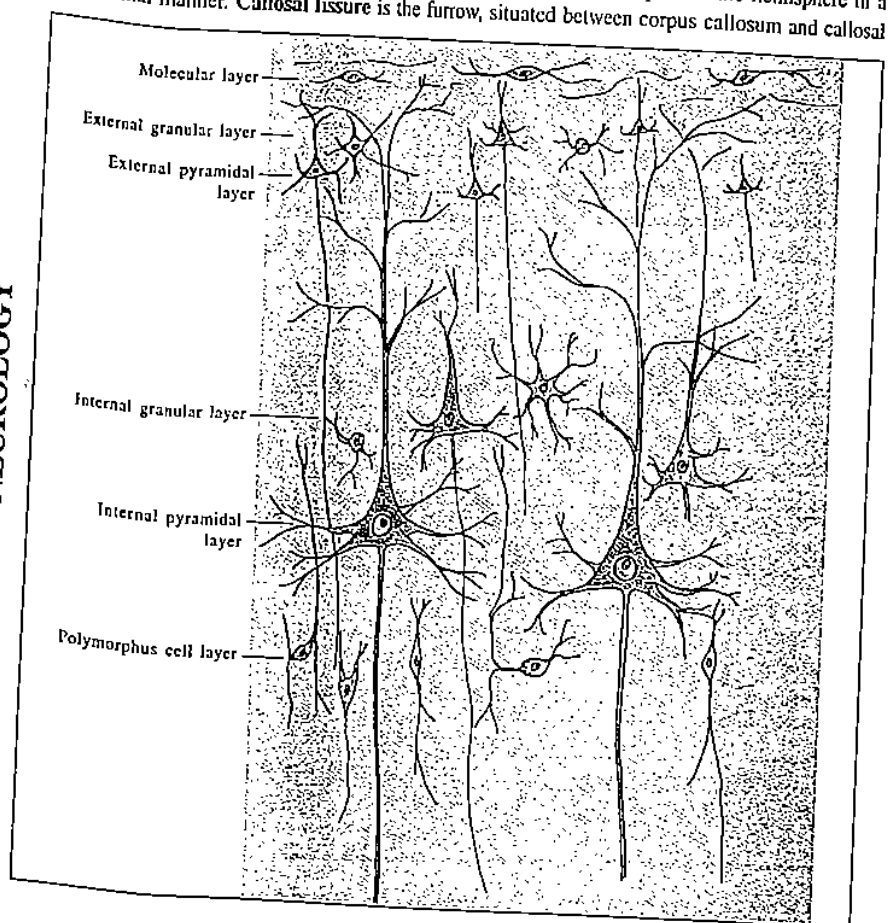


Fig. 8.13

convolution at the medial surface. **Callosomarginal fissure** is a long curved depression at the medial surface between callosal convolution and the convolutions at the dorsomedial border of the hemisphere. At the posterior part of the medial surface there is a short linear depression, known as **calcarine sulcus.**

Grey matter

It is the outer layer of the cerebral mass composed of nerve cells, nerve fibers and neuroglia. This is also called the cerebral cortex. The grey matter is subdivided into 6 layers. These are as follows :

(a) **Molecular layer** — Composed of horizontal cells and their processes, axon terminals and synapses.

(b) **External granular layer** — Consists of tightly packed granule cells and small pyramidal cells.

(c) **External pyramidal layer** — Contains small and medium sized pyramidal and granule (stellate) cells.

(d) **Internal granular layer** — Composed of closely packed granule cells and some medium sized pyramidal cells. It also accommodates some fibers which are derived from association or projection fibers.

(e) **Internal pyramidal layer** — Contains medium and large pyramidal cells and fibers at its outer part. The large neurons are called giant pyramidal cells of **Betz.**

(f) **Polymorphus cell layer** — This layer is composed of fusiform multipolar cells and cell of Mortinotti. Axons of these Mortinotti cells project vertically upwards to ramify in the molecular layer and tranversed by plenty of corticopetal and corticofugal fibers.

White matter

It is remaining below the grey matter and composed of three groups of medullated fibers. These are (a) Projection fibers, (b) Association fibers, and (c) Commissural fibers.

(a) The **projection fibers** are projected out from or into the cerebral cortex, assemble to a narrower bundle to enter at the narrow zone of the brain stem and in each hemisphere they appear as a spray of fibers, known as **Corona radiata.** The corona radiata passes through the fibers of corpus striatum, reaches the base of the hemisphere, splits the corpus striatum into lateral and medial parts (lateral – lenticular and medial – caudate) and forms internal and external capsules. These fibers are mostly intersected by the commissural fibers at the corpus callosum.

(b) **Association fibers** connect the different parts of same hemisphere. The short fibers connect one gyrus to next gyrus near the cortex and take a U shaped course. The long fibers in a bundle pass from one region to a distant region of the cortex.

(c) **Commissural fibers** pass transversely along the midline from one hemisphere to the other hemisphere and form a compact plate of structure, known as **corpus callosum.** These fibers connect wide areas of cerebral cortex of two hemisphers across the midline. Most of these fibers connect identical areas of two hemispheres but some fibers do not. These fibers are mostly derived from the axons of Pyramidal cells.

Due to lack of pores and presence of tight junctions in the wall of the capillaries of the central Nervous system, diffusion of materials to the parenchyma is either stopped or restricted. This so called obstruction between the blood and CNS parenchyma is known as **blood brain barrier.**

Olfactory bulbs

These are oval elongated structures one for each hemisphere, situated at the anteroventral aspect of the frontal pole and are lodged in the olfactory fossae. Each bulb receives olfactory nerves coming from nasal mucosa through the perforations of the cribriform plate of ethmoid bone. The olfactory tract is a thick short bundle of fibers which extends backward and divides into inner and outer olfactory striae. The **olfactory trigone** is a triangular area placed between the two striae. The outer striae is longer, passes backward and outward along the medial aspect of Rhinal sulcus and enters the inferior part of the hippocampal convolutions. The inner one passes backward and inward and goes to the internal aspect of cerebral hemisphere. The fore part of the hippocampal gyrus is the cortical center for smell.

Limbic system

In macrosmatic vertebrates (Dog, Cat etc), the sense of smell or olfaction is highly developed and the fore brain was termed rhinencephalon. The olfactory system not only receives smell but activates the emotional behaviour in the form of increase salivation, aggression for self defence, sex urge and searching of food, etc. With profuse growth of neocortex in human the rhiencephalon become rudimentary. Therefore man become microsmatic and its emotional behaviour becomes dependent on other sensory modalities like vision, hearing, taste and on the influence of psychic cortex. Broca (1878) introduced the name **Limbic system** which includes (a) **Olfactory pathway**, (b) **Pyriform lobe**, (c) **Amygdaloid body**, (d) **Hippocampal formation**, (e) **Limbic lobe** (Cingulate gyrus, parahippocampal gyrus and (f) **Hypothalamus**. All these components of limbic system are associated with the emotional integration. As the motor system expresses the motor programme of brain, the limbic system is responsible for outward expression of internal state.

Lateral ventricles

These are two irregular elongated cavities situated within each cerebral hemisphere and remain separated from each other by a thin vertical partition, the **septum pellucidum**. These cavities communicate with each other and with 3rd ventricle by a Y shaped opening, the **foramen of Monro**. The roof and lateral walls are formed by corpus callosum, medial wall by *septum pellucidum* and the floor is formed by caudate nucleus, thalamus, choroid plexus and hippocampus from before backward.

Corpus callosum

It is formed by the largest band of commissural fibers which connect wide areas of cerebral cortices of two hemisphers.

It is a transverse commissure between the cerebral hemispheres, lying at the bottom of the longitudinal fissure and is formed by commissural fibers. It is arched longitudinally and thick at the anterior (**Genu**) and posterior (**splenium**) extremities. The central portion (**truncus**) is thinner. Few hundred million finely myelinated fibers pass through corpus callosum and keep the two hemispheres of brain working together.

Fornix

This is a curved structure, made up chiefly of longitudinally directed white fibers, placed below the corpus callosum and just above the telachoroidea of 3rd ventricle. The anterior end is separated by septum pellucidum and the posterior end is continuous with the corpus callosum. The anterior pillars are two cords starts from the anterior ends of fornix, curve downward to the base of the brain from the mammilary body (corpora albicans) and terminate in the thalami. The posterior pillars pass

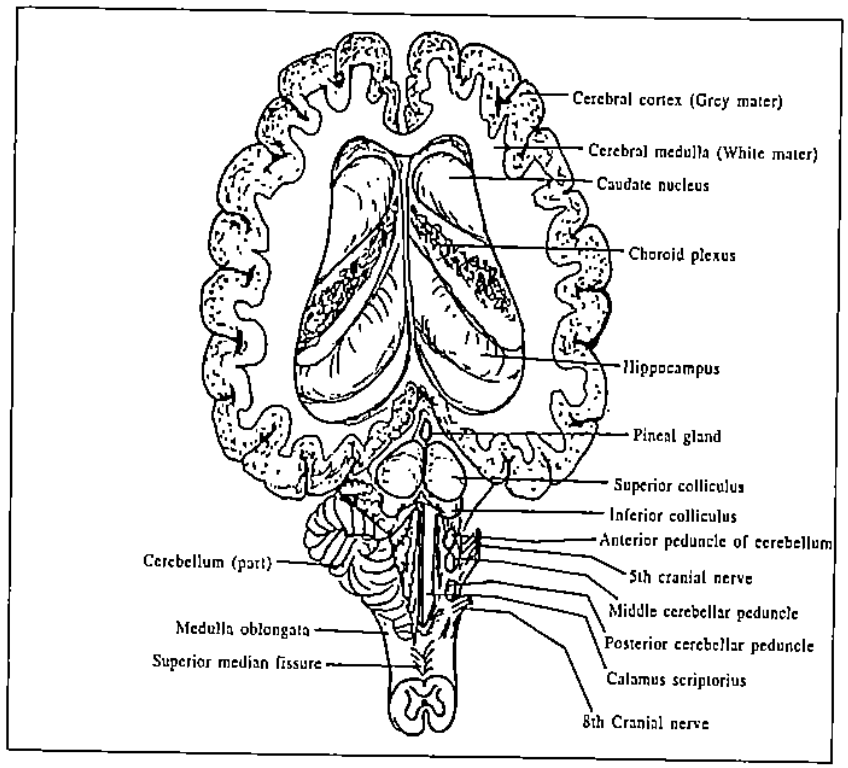


Fig. 8.14 Frontal section of the brain of ox.

down the posterior horns of lateral ventricles along the concavities of hippocampus major and continue as corpus fimbriatum into the hook of hippocampal convolutions.

Septum pellucidum

This bilamilar partition extends from the under surface of corpus callosum to the upper surface of the body of fornix. It consists of both grey and white matter. A very thin slit like cavity exists between two layers. When the septum is removed, the lateral ventricle is exposed.

Hippocampus

It is an invagination of the cerebral cortex at the lateral ventricle through the hippocampal sulcus. The convex ventricular surface has a layer of white matter below the ependyma known as Alveus. Fimbria of the fornix is formed by the convergence of the fibers of alveus at the mid-longitudinal aspect. Dentate gyrus is a small band of gray matter placed between the hippocampus and para hippocampal gyrus.

Grossly this component of brain is a curved structures occupies the posterior parts of lateral ventricles and made up of two curved horns which meet at the midline. The horns are broader at the begining at the midline and gradually become curved dorsally, laterally and ventrally and anteriorly

into the pyriform lobe. Such curvature of the structure looks like the horns of ram and that is why called hippocampus.

INTER BRAIN

It comprises of the region of 3rd ventricle and also the thalami and pineal body.

Third ventricle

It is a fissure like space situated in the midline between the thalami. Its roof is formed by the tela choroida, a membranous fold of piamater. From the tela choroida, two choroid plexus of third ventricle project downward. The lateral walls are formed by the thalami and hypothalami from above downward. The floor is formed by infundibulum, tuber cinerium, optic chiasma, etc. Anteriorly it is bounded by lamina cineria and posteriorly by pineal gland. The cavity is communicated antero-superiorly with lateral ventricles by interventricular foramen (**foramen of Monro**) and posteriorly with the fourth ventricle by cerebral aqueduct (**aqueduct of Sylvius**).

Thalami

They are two oval structures of grey matter placed at the top of the midbrain and form the medial boundary of internal capsule and lateral boundary of third ventricle. Each thalamus consists of five main nuclear masses. Their anterior ends are narrow and are placed close with each other on either side of median plane. The posterior ends are wide, placed apart and the superior Colliculi (anterior quadrigeminal bodies) are situated between them. The dorsal surface of each thalamus is convex and free. A groove on this surface separates the thalamus from the caudate nucleus.

Thalamus is a great sensory center and relays sensory impulses to cortex. Each thalamus represents the contralateral side of the body. It acts as a link between basal ganglia and cerebellum with the cortex. It is responsible for alertness of brain as a whole. It serves as the perception center for some sensations.

Geniculate bodies

These are ill defined elevations situated at the posterior aspect of the thalami. There are two lateral geniculate bodies and two medial geniculate bodies. The Lateral geniculate bodies (LGB) are placed laterally and anteriorly. They are connected to the concerned superior colliculi and are involved with vision. The medial genicalate bodies (MGB) are placed posteriorly and medially. They are connected with the inferior colliculi and are associated with audition.

Pineal gland (Epiphysis cerebri)

It is a cone shaped grey body situated between the superior colliculi and is attached by a hollow stalk to the roof of the third ventricle. This gland by its inhibitory action regulates the activity of some other glands like adenohypophysis, neurohypophysis, parathyroid, *etc.* The gland is composed of pinealocytes, neuroglial cells and blood vessels and covered by piamater. It gets blood supply from choroidal branches of posterior cerebral artery. Some trabeculae extend from the capsule invade the parenchyma and divide it into a number of lobules. In birds it is placed superficially just under the skull between cerebrum and cerebellum and is attached to the roof of the 3rd ventricle by a long stalk. Lobulations are very clear in birds.

MID BRAIN

This portion comprises of Cerebral aqueduct, Corpora quadrigemina and Crura cerebri.

Cerebral aqueduct

This is a narrow passage through the mesencephalon and connects the third and fourth ventricles. It is situated at the median plane. The shape of the lumen is variable at different places. It is lined by ciliated columnar epithelium. Surrounding it is a layer of gray matter which is continuous anteriorly with that of 3rd ventricle and caudally with the grey matter of fourth ventricle. This grey matter accommodates the nuclei of third, fourth and fifth cranial nerves.

Corpora quadrigemina

These are two pairs of rounded bodies at the dorsal aspect of mid brain. They are also called superior and inferior colliculi. The superior colliculi are called nates and the inferior colliculi are known as testis for their likeness of hips and testicles of man. The pineal body is situated in the space between the anterior parts of superior colliculi. These coliculi contain nuclei, associated with sight and hearing. [See Fig. 8.14]

The *superior colliculi* receive input from (a) retina, (b) cerebral cortex, (c) inferior colliculi, (d) spinal cord and send efferent fibers to (a) spinal cord, (b) nuclei of III, IV and VI cranial nerves, (c) pontine nucleus, (d) thalamus and (e) LGB. Superior colliculi act as reflex and intergrading centers of the visual system. Superior colliculi are enlarged to form the optic lobe in submammalian vertebrates. The inferior colliculi receive fibers from (a) MGB, (b) inferior colliculi of other side and (c) lateral laminiscus. They transmit fibers to (a) MGB, (b) opposit inferior colliculi and (c) superior colliculi of the same side, (d) cerebellum and (e) superior olivary nucleus. They act as relay center of auditory pathway and are concerned with auditory reflexes.

Crura cerebri (Cerebral peduncles)

These are two broad bundles situated at the ventral surface of the mid brain. Caudally the bundles approach one another and disappear into the pons. Cranially the peduncles diverge as they pass forward and sink into the corresponding cerebral hemisphere. At this point the inferior and lateral surfaces of each peduncle is crossed by optic tract. The medial surfaces form the lateral boundary of interpeduncular fossa. Third cranial nerve originates from this surface. Each peduncle consists of a dorsal part, the tegmentum, middle part, the **substantia niagra** and the ventral part, the **crus cerebri**. The crus cerebri consists of cortico-spinal, cortico-nuclear and cortico-pontine fibers. Substantia niagra is a layer of grey matter and composed of numerous deeply pigmented nerve cells. These neurons are multipolar. The tegmentum is continuous with that of pons and contains some fiber tracts. At the dorsomedial aspect of each substantia niagra, remains an ovoid mass of nerve cells with pinkish tinge. This is known as **Red nucleus**. The red nucleus is an important motor component and contributor to the extra pyramidal system.

Inter peduncular fossa

It is a space, formed by the cerebral peduncles and optic tracts and chiasma. It accommodates a hollow tubercle known as **Tuber cinerium** and a small nodule like structure situated behind the tuber, known as **Mamillary body** or **Corpus albicans**. Dorsally the tuber cinerium is connected with the 3rd ventricle and ventrally with a conical tube, the infundibulum. The Infundibulum is attached to the pituitary gland.

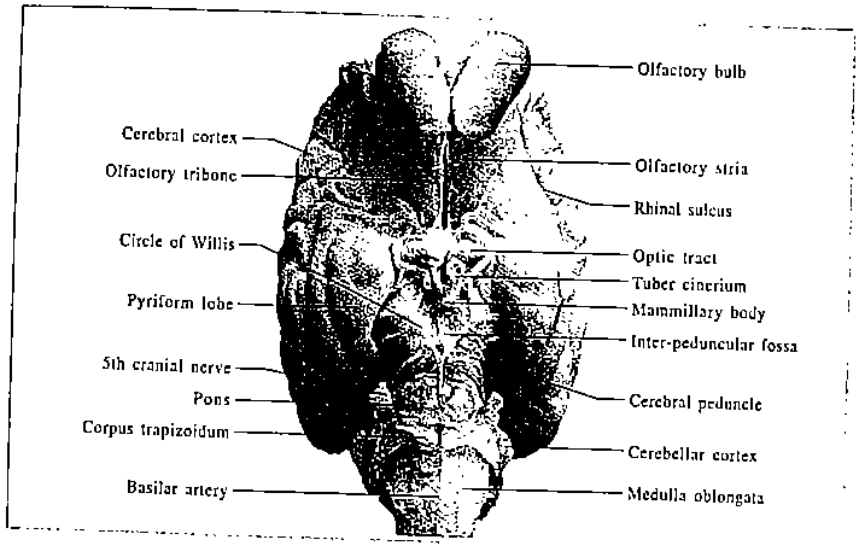


Fig. 8.15B Ventral surface of brain of ox.

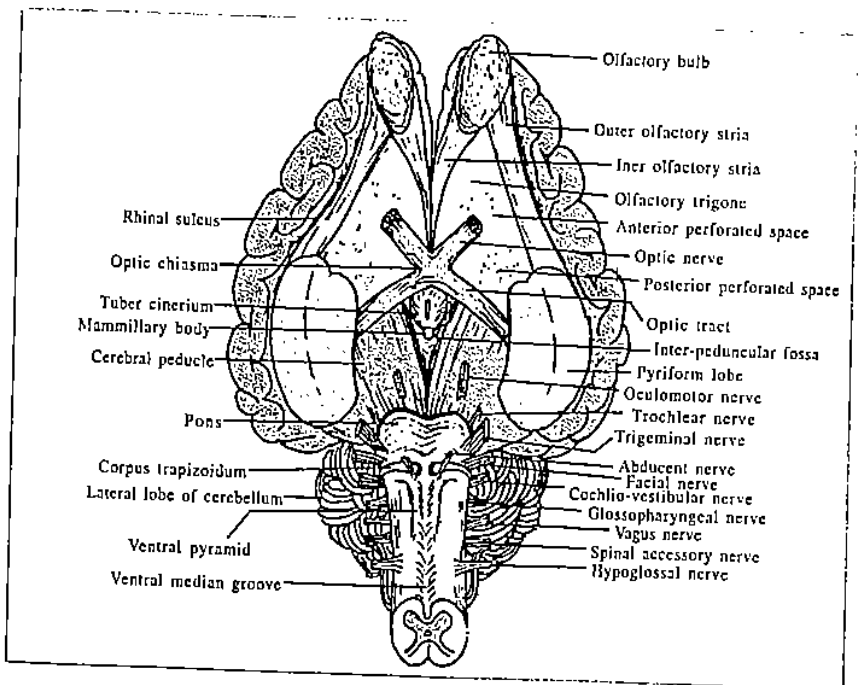


Fig. 8.15D Ventral surface of brain of ox (line diagram).

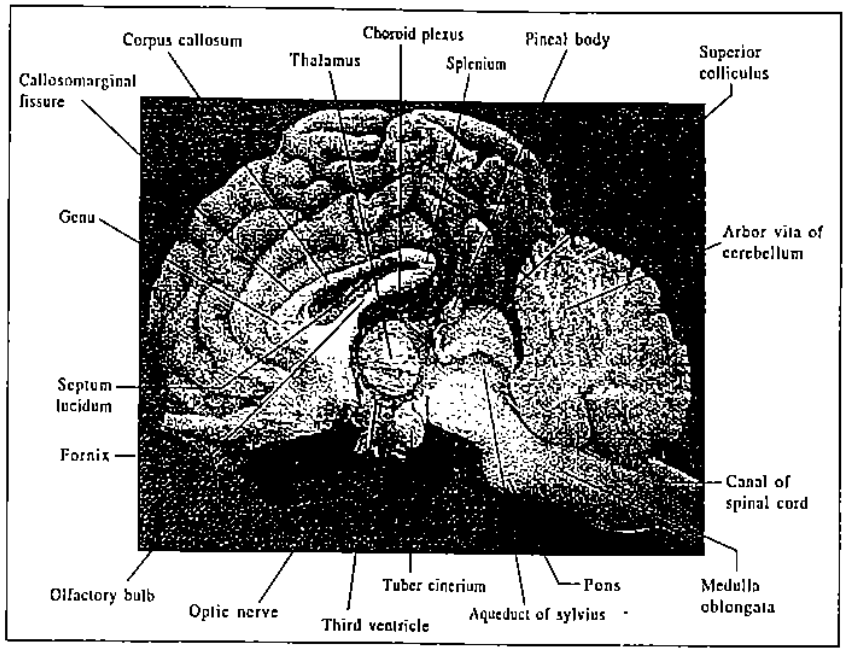


Fig. 8.16 Medial surface of brain of ox.

HIND BRAIN

Hind brain consists of cerebellum, pons and medulla oblongata.

Cerebellum

This is the largest part of the hind brain and situated above the pons and medulla oblongata. It is separated from its underlying structures by the 4th ventricle. It is median in position and irregularly divided into three lobes by two longitudinal fissures. The middle lobe is known as vermis for its likeness to that of a worm. The lateral lobes are irregular in shape. The surface presents numerous transverse but curved fissures of varying depth and thereby form the folds or folia. The surface of vermiform lobe presents ten such folia and according to Larsell, they are called **Lingula, Central lobule, Culumen, Declive, Folium vermis, Tuber vermis, Pyramid, Uvula** and **Nodule** from front to back (see figure 8.16 and 8.17). These folds give off secondary or tertiary laminae and thus appear as a branching pattern in sagittal section and hence popularly known as **Arbor vitae**. In birds, however the secondary or tertiary lamination are not found and only the vermiform lobe is wall developed. The vermiform lobe presents all the 10 folia as found in mammals.

The cerebellar cortex is made up of a layer of grey matter which covers the white matter. It is composed of three distinct layers of cells. The outer molecular layer contains **Molecular cells, Stellate cells** and **Basket cells**; the middle layer comprises of a single layer of large flask shaped **Purkinje cells** and the inner layer contains small **Granule cells** and **Golgi cells.**

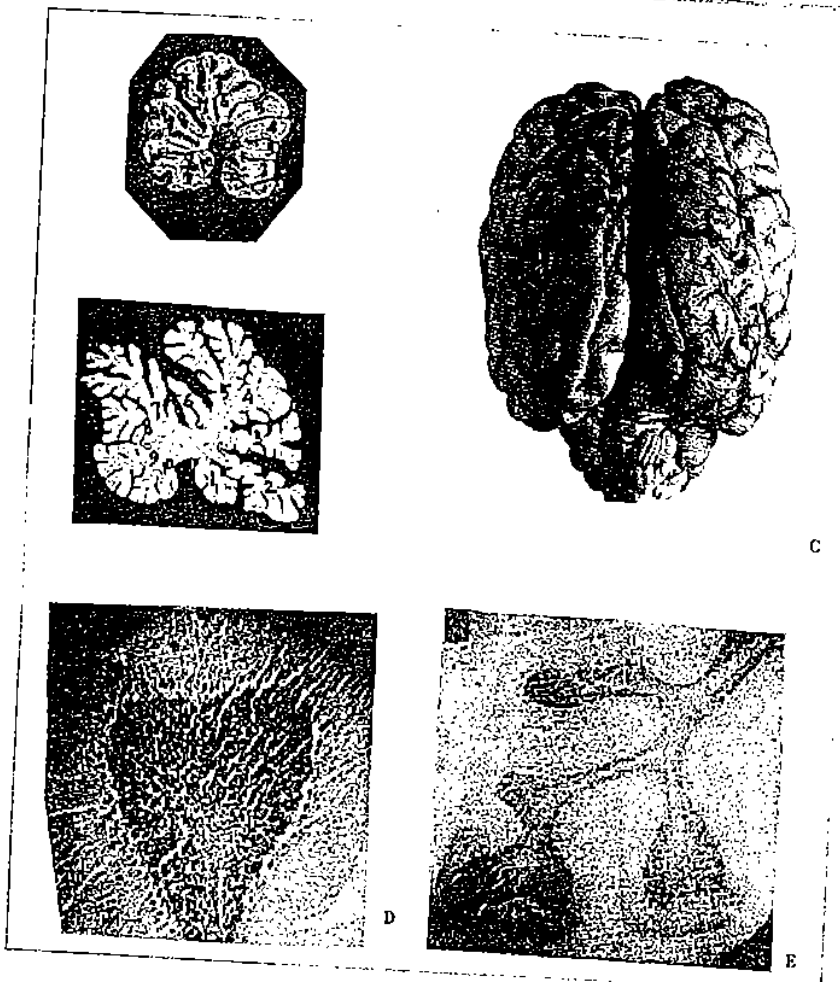


Fig. 8.17
A. Sagittal section of cerebellum of bird, showing various folia B. Sagittal section of cerebellum of goat, showing various folia C. Dorsal surface of cerebrum and cerebellum D. Cerebellar cortex showing and layers of cells E. Cerebellar cortex showing secondary laminations (By Courtesy Dr. R. K. Mondal).

The white matter is composed of (a) Intrinsic fibers, confined within the cerebellum, (b) Projection fibers (peduncles), (c) Axons of Purkinje cells (d) Mossy fibers and (e) Climbing fibers.

In higher vertebrates the cerebellum consists of 4 pairs of nuclei. These are Nucleus fastigii, **Nucleus globosus**, Nucleus emboliformis (situated at the roof of vermis) and Nucleus Dentate (situated at the lateral lobes).

The cerebellum has three pairs of peduncles. The middle peduncle originates from the pons and known as **brachium pontis**. The anterior peduncle is known as **brachium conjunctivum**, which

runs forward to connect the cerebellum with the mid-brain. The posterior peduncle is called **corpus restiforme**, which runs from the medulla oblongata, in forward and upward direction and enters the cerebellum.

Functions of cerebellum — (i) It maintains equilibrium, muscle tone, posture and skilful movement of the body, (ii) it receives inputs from vestibular, auditory and visual systems, (iii) the sensations received by it are processed in the circuits of cerebellum and integrated in to motor system through cerebral motor cortex, red nucleus, vestibular nucleus and brain stem reticular formation. These motor sensations are conveyed through vestibulo spinal, rubro spinal, cortico spinal and reticulo spinal tracts.

The cavity of the **fourth ventricle** is formed dorsally by cerebellum and valve of Vieussens, laterally by the cerebeller peduncles and ventrally by pons and medulla. This is a diamond shaped space anteriorly continuous with the third ventricle by aqueduct of Sylvius and posteriorly with the central canal of the spinal cord. Beside this the fourth ventricle communicates with the sub-arachnoid space by two lateral foramina (**foramina of Luschka**) and one middle foramen (**foramen of Magendie**), at the caudo-dorsal aspect.

Pons

It is a pair of tranverse prominences situated in front and ventral to medulla oblongata. Ventrally it appears as a bulging mass of transverse fibers and is separated from the cerebellum dorsally by fourth ventricle. It is demarcated from the crus cerebri and from ventral surface of the medulla by sulci. The transverse fibers are disposed in a arched manner across the median plane and converge on each side into a compact mass and form the middle cerebellar peduncle. The trigeminal nerve originates from the antero lateral aspect of the pons.

Pons accommodates various nuclei and tracts and takes part in the control of respiration and other vital regulations.

Medulla oblongata

It is the cranial continuation of the spinal cord and extends from the foramen magnum to the caudal margin of pons. It is a part of brain stem, wide cranially and correspond to the spinal cord caudally. It rests on the cranial face of basioccipital bone. The posterior third is the closed part and contains the central canal. The anterior two third is the open part and contains the posterior two third of the fourth ventricle. This ventricle is roofed by a very thin membrane known as inferior velum. The grey matter at the floor of the cavity accommodates very important centers for the regulation of respiration, body temperature and heart rate. The superior and inferior median fissures of the spinal cord are continued cranially in the median line of the corresponding surfaces of the medulla oblongata. At the ventral surface, immediately behind the pons, there is a transverse band, known as **Corpus trapezoidum**. On this surface a pair of elongated rounded mass – the **pyramids**, each of which is placed on either side of the median groove. They carry major efferent pathways of the central nervous system. On the lateral side of the each pyramid there is a rounded mass called olive or olivary body. The filaments of 12th cranial nerve arise from the depression between the pyramid and olive. Lateral to the olive there is the restiform body, fibers from which pass forward into the cerebellum to form the posterior peduncle.

Since the medulla contains vital centers (respiratory, cardiac and vasomotor), lesions in the medulla will lead to failure of vital functions, especially, respiratory failure.

SPINAL CORD

This is a thick cylindrical structure situated in the vertebral column and lies loosely by its coverings. It extends from the foramen magnum to the middle of the sacrum. This cord is not uniform in its thickness throughout the length. As it is continuous with the medulla oblongata, the begining is dilated. There are other two dilatations at the level of the origin of the nerves for brachial plexus and lumbo-sacral plexus. These are known as cervical and lumbar enlargements respectively. The caudal end gradually diminishes in volume from the lumbar region and it terminates in a tapering and pointed manner at about the level of 2nd sacral vertebra. This pointed terminal portion is known as conus **medullaris**. A very thin cord which extends from the conus medularies to the first coccygeal vertebra is known as **filum terminale**. It is not a nervous element but a filament of piamater. The roots of spinal nerves which pass directly and laterally towards the intervertebral foramen, do not do so at the terminal part. Here the roots increase in length and travel a considerable distance caudally within the vertebral canal. Thus at the termination, the vertebral canal occupies a lash of long nerve roots of some sacral and coccygeal spinal nerves which are attached to the spinal cord and as a whole looks like the tail of a horse, termed **cauda equina**.

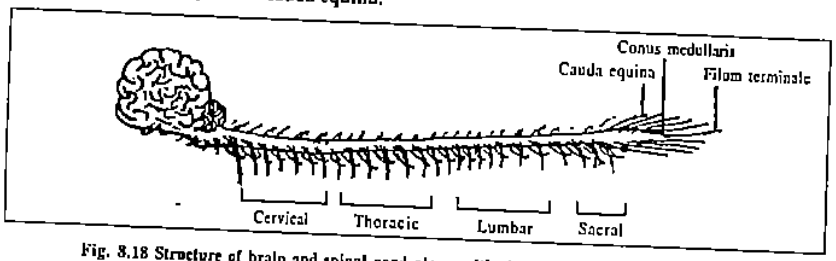


Fig. 8.18 Structure of brain and spinal cord along with the attachments of spinal nerves.

The body of the cord although cylindrical, is slightly dorsoventrally compressed and is partially divided into two symmetrical halves by dorsal and ventral longitudinal median fissures. The dorsal fissure is shallow and the ventral one is deep. The ventral fissure accommodates the ventral spinal artery. At the entrance of the dorsal root at the dorso-lateral aspect of the cord, there is a faint groove along the length known as dorso lateral groove. About 37 pairs of spinal nerves are attached to the lateral aspect of the spinal cord and they can be grouped with the concerned vertebrae such as cervical, thoracic, lumbar, sacral and coccygeal. Each nerve is attached to the cord by a dorsal root and a ventral root. Each root is in the form of several nerve filaments (root-lets) attached to the corresponding aspect of the spinal cord. The dorsal roots are affarent and thereby sensory in nature and the ventral roots are efferent and motor in function.

STRUCTURE

The spinal cord is composed of a central grey matter which is surrounded by a thick layer of white matter. In a typical cross section of the spinal cord the grey matter appears in the shape of the letter H.

At the center of the cord and within the grey matter, there is a minute canal known as central canal of the cord. It is lined by cubical ciliated epithelium – the ependyma.

Grey matter

There are three important aggregations of nerve cells in the grey matter. The ventral horn of the grey matter has a collection of the bodies of multipolar cells whose axons make the ventral root. They

are known as ventral horn (**motor**) cells. The dorsal horn cells (**sensory**) are placed in the dorsal horn of the grey matter which are the relay stations for dorsal nerve roots. The cell bodies of the nerve fibers which are making the dorsal root are situated outside the cord in the dorsal root ganglia. Lateral horn cells (**autonomic**) are placed at the lateral aspect of the horn and are found only in the thoracic and in the cranial portion of the lumbar regions. This is the relay station for autonomic sensations. The connection between the two lateral masses of grey matter are known as Grey commissures. The pointed end of the dorsal horn is translucent in appearance and called **substantia gelatinosa**.

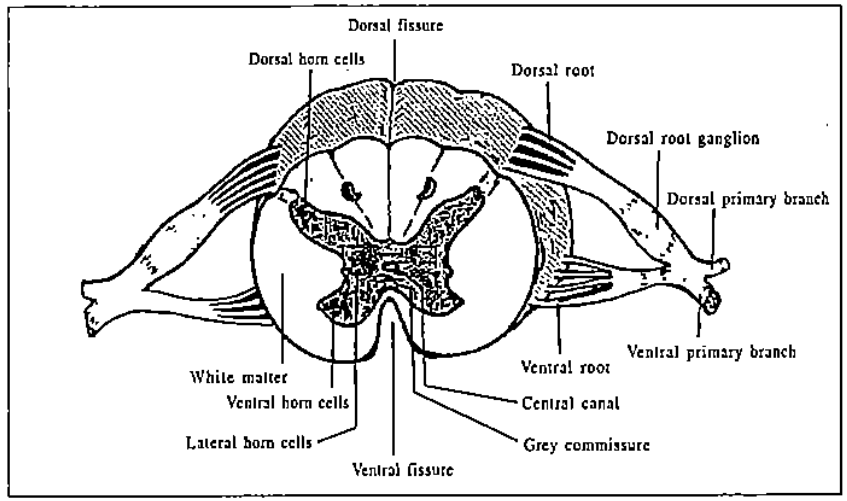


Fig. 8.19 Transverse section of spinal cord.

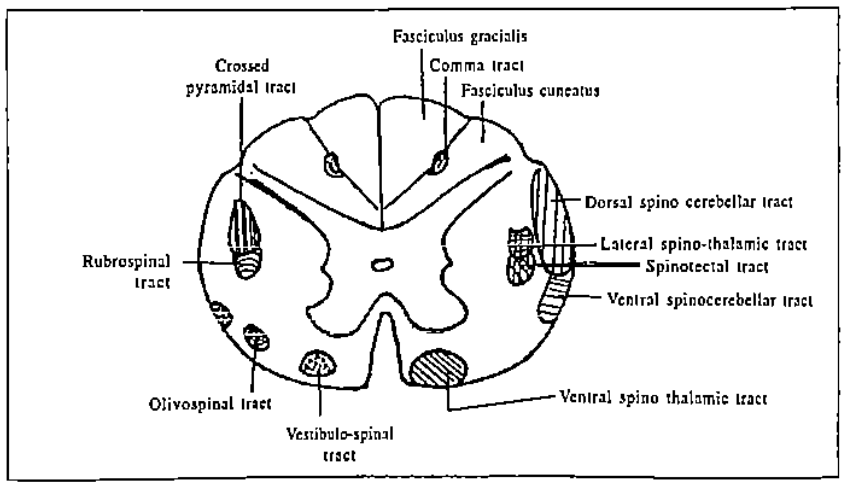


Fig. 8.20 General pattern of distribution of some ascending and descending tracts in the spinal cord.

White matter

The white matter of the spinal cord on each side is divided into three columns of nerve fibers, termed funiculi. They are known as ventral, dorsal and lateral white columns respectively according to their positions in the spinal cord. The white commissures are situated outside the grey commissures. The white matter is composed of nerve fibers. A bundle of fibers carrying one or more sensory or motor impulses in the CNS is known as **tract**. There are two types of tracts in the spinal cord (a) ascending (sensory) and (b) descending (motor). Some important tracts are presented in the table below :

Ascending tracts		*Descending tracts*	
Dorsal column	Fasciculus Gracialis Fasciculus Cuneatus Comma tract	Pyramidal tract	Crossed pyramidal tract Direct pyramidal tract Uncrossed cerebrospinal fasciculus
Lateral column	Spino thalamic tract (Lateral) Spino tectal tract Dorsal Spinocerebellar tract Ventral Spinocerebellar tract	Extra pyramidal tract	Rubro spinal tract Tecto spinal tract Vestibulo spinal tract Olivo spinal tract Ponto spinal tract (reticulo spinal)
Ventral column	Ventral Spinothalamic tract	Descending autonomic fibers	Pupil dilating fibers Vesomotor fibers

To understand the functional aspect, some important pathways are described here in short.

AFFERENT OR SENSORY PATHWAYS

Pain and temperature pathway (Fig. 8.21)

These impulses are carried by sensory neurons whose cell bodies are placed in the dorsal root ganglion. The axons enter the cord *via* dorsal root, turn forward, proceed cranially for a short distance and turn into Grey matter. They make synapse with dorsal horn cells. The axons of these cells cross to the other side of the spinal cord along the ventral aspect of the central canal and form the Lateral Spinothalamic tract. After traversing the cord, they pass through the medulla, pons and terminate in the thalamus. Thereafter the fibers are finally projected to the sensory cortex of cerebral hemisphere.

Touch and pressure pathways (Fig. 8.22)

These fibers enter the cord *via* dorsal root and travel through two different paths.

(a) Some fibers run cranially along the dorsal funiculus for a short distance and then turns into grey matter, synapse with the dorsal horn cells. The axons of these cells cross along the ventral aspect of the central canal to the other side and run along the ventral spino-thalamic tract.

(b) Other fibers traverse the whole length of the cord in the same side at the dorsal funiculus, synapse with the cells of nucleus gracialis or cuneatus, cross the other side and proceeds to thalamus. From thalamus fibers proceed towards the cerebral cortex.

Referred pain

This pain is felt at some other region having same segmental innervation. Example – In case of acute cholecystitis, the abdominal surface of diaphragm is also inflammed. The pain sensation from

the diaphragm is carried by phrenic nerve via C_4 spinal segment in human and the person feels pain at the right shoulder region in this condition because the skin over the shoulder is also innervated by branches of C_4 spinal nerve.

EFFERENT OR MOTOR PATHWAYS

These efferent pathways from higher centers pass down to influence the motor cells in the brain stem and spinal cord. They originate either in the cerebral cortex or in various reflex centers in the brain stem.

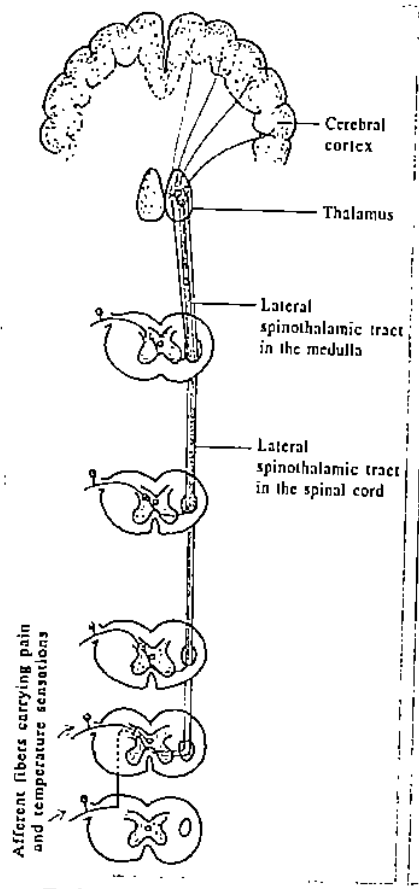


Fig. 8.21 Pain and temperature pathway.

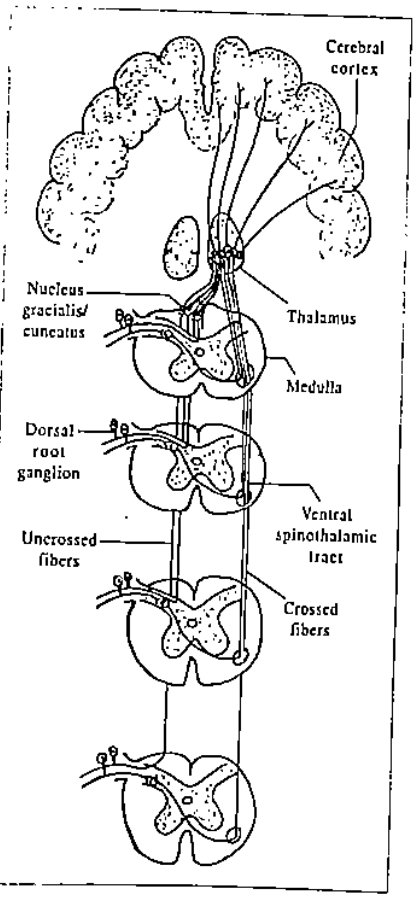


Fig. 8.22 Touch and pressure pathways.

Pyramidal tracts (Cortico spinal tract) [Fig. 8.23]

The fibers originate at the precentral gyrus from the giant (large) pyramidal cells. This tract is concerned mainly with the movement of flexor muscles of fore limb and hind limb. They pass

through corona radiata and then posterior limb of internal capsule. Now they traverse the cerebral peduncle, pons and the most ventral surface of the medulla oblongata in the form of a rounded column, known as pyramid. In the lower part of the medulla most of the fibers cross to the other side. The crossed (about 90%) fibers decend in the lateral funiculus, as lateral cortico spinal tract, extend along the length of the cord and in each segment some fibers leave the tract, turn inward and end round the ventral horn cells. The uncrossed fibers extend along the ventral white column close to the ventral median fissure as ventral cortico spinal tract. However, the fibers of the tract cross the middle line in the ventral white commisure to terminate at the spinal gray matter of the other side.

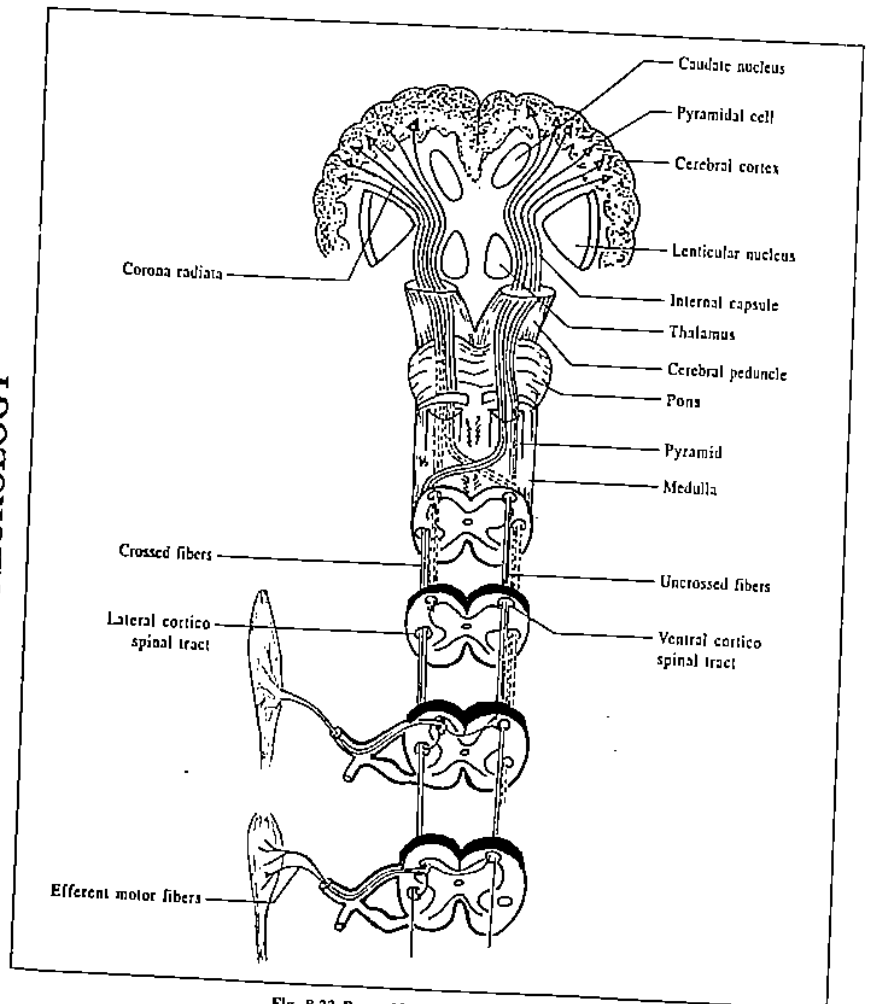


Fig. 8.23 Pyramidal tract (diagramatic).

Extra pyramidal system

The cell bodies of the first order neurons are situated at the gyri in front of the motor area and in some parts of parietal and temporal region. Axons pass through corona radiata, internal capsule, cerebral peduncle and reach the pontine nucleus. The axons of these second order neurons pass through the middle cerebellar peduncle to opposite cerebellar cortex. From this place fibers of 3rd order neurons (Purkinge cells) go to dentate nucleus of the cerebellum. Axons of the 4th order neurons leave the dentate nucleus as well as the cerebellum through the anterior peduncle, cross the midbrain, go to the opposite side and reach the red nucleus. The fibers of these 5th order neurons cross immediately again to the opposite side and extend through the cord as rubro spinal tract at the lateral funiculus. These axons also terminate at the ventral horn cells. (Fig. 8.24).

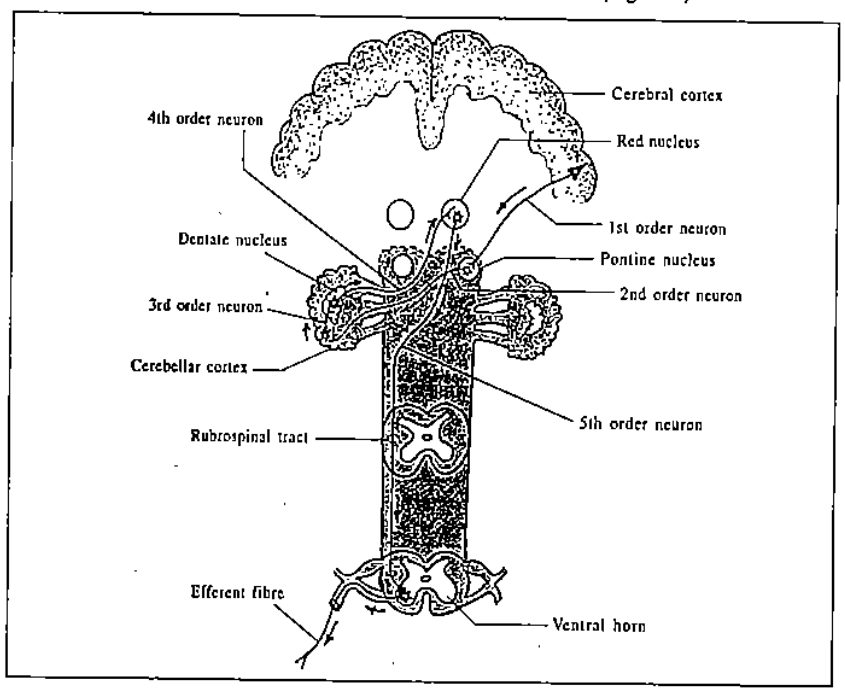
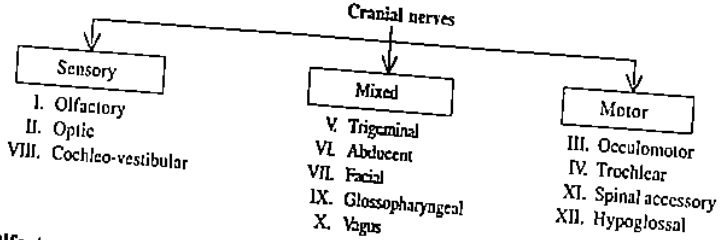


Fig. 8.24 Extra pyramidal system.

CRANIAL NERVES

There are 12 pairs of cranial nerves connected to the base of the brain and traverse through different foramina of the skull. The nerve trunks carry motor fibers or the sensory fibers or both types of fibers. The motor fibers originate from the concerned nuclei in the brain and the sensory fibers arise from the neurons outside the brain. So functionally the cranial nerves may be grouped under three heads.



I. Olfactory nerve (*sensory*)

The mucous membrane of the posterior part of the nasal cavity contains the olfactory cells. These are the cell bodies of the first order neurons. Their axons are collected in bundles, run in different directions, form a network and pass through the cribriform plate of the ethmoid bone, pierce the meninges, enter the olfactory bulb and join the glomeruli of olfactory bulb. Axons of second order neurons run backwards through olfactory tracts. This tract goes backward and divides into 1) medial and 2) lateral olfactory striae. The medial stria cross to the opposite side via anterior olfactory nucleus for co-ordination of sensations between two sides. Lateral stria distribute fibers to amygdala for emotional response and periamygdaloid and pyriform cortex for olfactory perception.

Loss of sensation of smell is called *Anosmia* and excess sensitiveness to smell is known as *Hyperosmia*. *Caeosmia* is a condition in which a person imagines non existant odours.

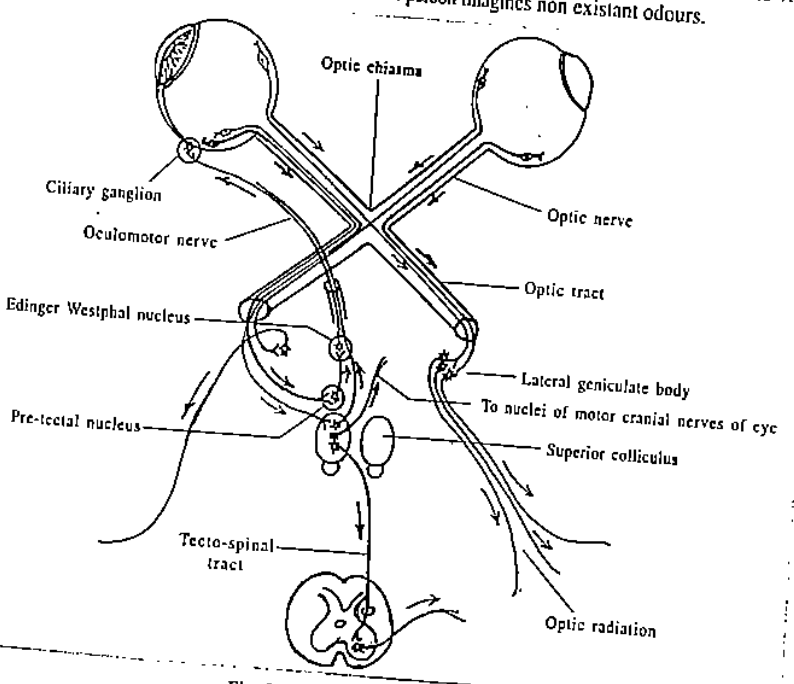


Fig. 8.25 Pathway in the optic nerve.

II. Optic nerve (*sensory*)

The neurons of the retina are rods and cones, bipolar cells and ganglionic cells. The rods and cones are sensitive to light. The axons of ganglion cells constitute the fibers of the optic nerve which leave the eye ball through blind spot. It is situated a little medial to the posterior pole of the eye ball. The nerve enters the cranial cavity through optic foramen and joins the nerve of other side to form optic chiasma. From the chiasma the optic tracts diverge and each of them winds round the concerned crus cerebri and enters the lateral geniculate body.

An object is seen by the retina of lateral (temporal) half of one eye and by the medial (nasal) half of the other eye. The fibers of nasal half of each retina cross at the optic chiasma and run along the optic tract of the other side. The fibers of temporal half of the retina do not cross. Thus fibers carrying impulse from a visual field reach together to the same cortical center. Each optic tract winds round the respective cerebral peduncle and the fibers terminate in different areas according to the function.

(a) Visual path—Only for recognisation of the object, the fibers end in the lateral geniculate body. The axons of the neurons of the LGB pass backward as optic radiation to the cortical center (visual area) situated at the occipital pole.

(b) Light reflex—Fibers concerned with the quantity of light, end at the ***pre-tectal nucleus*** near the superior colliculus. Axons of the pre-tectal neurons pass to the accessory motor nucleus which is situated further forward. This is known as ***Edinger – Westphal nucleus***. The axons of the cells of this nucleus go out of the brain with oculomotor nerve to the ciliary ganglion which is situated at the back of the eye ball. From ciliary ganglion post ganglionic fibers enter the eyeball and constrict the pupil and increase the convexity of lens according to the magnitude of the impulse.

(c) Somatic reflex—The concerned fibers end at the superior colliculus. From the cell bodies, the axons may pass cranially as the tectobulbar tract to the cells of the motor cranial nerves of the eye (oculomotor, trochlear abducent) or may go caudally as fibers of tecto-spinal tract to the ventral horn cells. Generalised motor response can occur by this path in response to light.

III. Oculomotor nerve (*motor*)

This nerve originates from the medial aspect of the cerebral peduncle, leaves the cranial cavity through foramen orbitorotundum and supplies **all the extraocular muscles except superior oblique and lateral rectus**. This nerve, however, carries preganglionic parasympathetic efferent fibers to the ciliary ganglion for the supply of the sphincter muscles of iris and ciliary muscles. Lesion on the nucleus of this nerve may lead to *Ptosis* (drooping of upper eye lid), *Proptosis* (abnormal protrusion of eye ball) and *Diplopia* (double vision).

IV. Trochlear nerve (*motor*)

This is the slenderest of all the cranial nerves. It originates from the anterior part of the superior medullary velum behind the inferior colliculus. The nerve passes through foramen orbitorotundum, enters the orbit and supplies the **superior oblique muscle**. It is also called **pathetic nerve**.

V. Trigeminal nerve (*mixed*)

It is the largest cranial nerve but not the longest. It carries sensory fibers from face, teeth, oral and nasal cavities and motor fibers to the muscles of mastication. It is attached to the anterolateral aspect

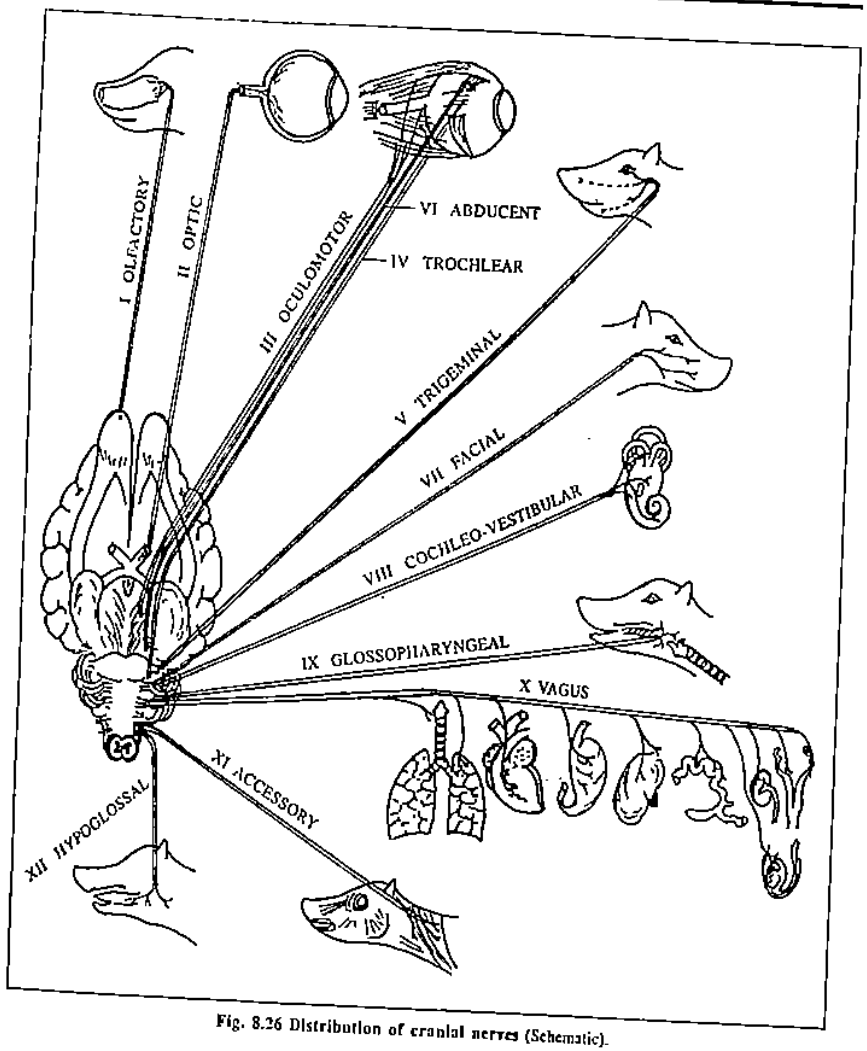


Fig. 8.26 Distribution of cranial nerves (Schematic).

of pons by a large sensory and a small motor root. The sensory root presents a **trigeminal ganglion (Gasserian/Semilunar)** at the apex of the petrous temporal bone and the motor root passes beneath it without any connection. The ganglion represents the dorsal (spinal) root ganglion for all sensory fibers. Three main nerve trunks – ophthalmic, maxillary and mandibular are attached to this ganglion in a radiating manner.

1. *Ophthalmic nerve (sensory)*—It passes through foramen orbitorotundum, enters the orbit through superior orbital fissure and divides into Zygomaticotemporal, Lacrimal, Frontal and Nasociliary branches.

(a) The zygomaticotemporal branch courses dorsolaterally to the ventral border of lacrimal gland, gives off some branches to the skin of temporal region and orbital margin, traverses caudally, exchanges twigs with the zygomatic branch of 7th and finally becomes distributed to the base of the horn as **cornual branch.**

(b) The lacrimal branch originates along with zygomaticotemporal nerve, reaches the gland at the medial surface along with lacrimal artery and is distributed within the lacrimal gland.

(c) The frontal nerve is slender and originates from the ophthalmic nerve, medial to the origin of lacrimal nerve. It extends dorsally enters the supraorbital canal through its orbital opening and emerges through supraorbital foramen. Here it remifies in the skin of forehead and upper eyelid.

(d) The nasociliary branch is the continuation of the ophthalmic nerve in the orbit. It runs forward between the extraocular muscles and divides into ethmoid and infratrochlear nerves.

(i) The ethmoid nerve re-enters the cranial cavity through ethmoid foramen and leaves it through a slit in the dorsomedial aspect of the cribriform plate and enters the nasal cavity to supply the mucosa of the nasal septum and dorsal turbinate.

(ii) The infratrochlear nerve courses anterodorsally, below the trochlea, reaches the medial canthus and remifies in the surrounding skin, conjunctiva, lacrimal sac and caruncle.

The nasociliary nerve communicate with the ciliary ganglion from where fibers enter the sclera and finally remify in the ciliary body, iris and cornea.

2. *Maxillary nerve (sensory)*—It is the largest of the three divisions. It passes through foramen orbitorotundum and enters the pterygopalatine fossa. It reaches the maxillary hiatus and enters the infraorbital canal. The trunk continues as infraorbital nerve inside the canal and comes out of the canal through infraorbital foramen. It passes downward and divides into a number of branches to ramify in the nostril and upper lip. In the pterygopalatine fossa it gives off the following branches.

(a) *Zygometico facial*—It enters the orbit, passes along the lateral wall and becomes distributed to the lower eye lid and skin.

(b) *Caudal nasal*—It is a small branch, passes through pterygopalatine foramen and innervates the nasal mucous membrane.

(c) *Posterior palatine*—It sometimes originates with anterior palatine. It goes forward and downward to innervate the soft palate.

(d) *Anterior palatine*—This is a trunk of moderate thickness, passes through posterior palatine foramen and supplies the hard palate and gum of upper jaw.

Inside the infraorbital canal, this division gives off **alveolar branches** which supply the upper cheek teeth.

3. *Mandibular nerve (mixed)*—This is the caudal and ventral branch of trigeminal nerve and contains both motor and sensory fibers. It exits through oval foramen, courses ventrally and laterally under pterygoideus lateralis muscle gives off the following branches on its way and finally divides into **lingual** and **mandibulo alveolar** nerves.

(a) *Pterygoid nerve*—It originates from the ventromedial side of the mandibular nerve and innervates the pterygoid muscle.

(b) *Buccal nerve*—It is detached from the mandibular nerve close to the foramen ovale. It passes downward and forward across the superficial surface of the lateral pterygoid muscle, gives few fibers to temporalis muscle, crosses the maxillary artery and innervates buccal glands,

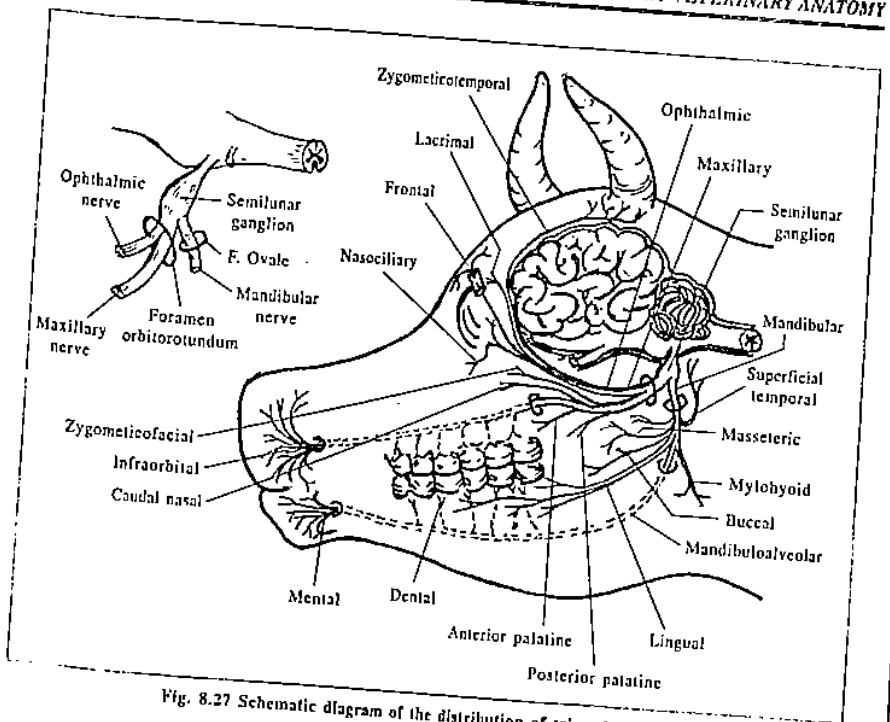


Fig. 8.27 Schematic diagram of the distribution of trigeminal nerve.

parotid gland and mucosa of cheek. It communicates with dorsal buccal branch of facial nerve.

(c) Masseteric branch is small and supplies the massater muscle after passing through mandibular notch.

(d) *Superficial temporal nerve*—It originates from the caudal border of the parent trunk, winds round the neck of mandible, comes under parotid and divides into transverse facial and anterior auricular branches. The transverse facial nerve joins the dorsal buccal branch of 7th cranial nerve and supplies the skin of masseteric area. The anterior auricular branch supplies the parotid gland.

Lingual nerve—This terminal branch joins with the corda tympani, and passes in the lingual groove between the medial pterygoid and ramus of the mandible and finally ramifies on the mucous membrane of anterior two third of the tongue.

Mandibular alveolar nerve—This nerve extends caudoventrally detaches mylohyoid branch to supply mylohyoid and digastricus muscles and enters the mandibular canal. The terminal filaments come out through mental foramen and supply the lower lip. In the mandibular canal it gives off alveolar branches to the teeth of the lower jaw.

Trigeminal neuralgia—It is a disease of unknown etiology in which there is sudden severe pain in the area of distribution of trigeminal nerve.

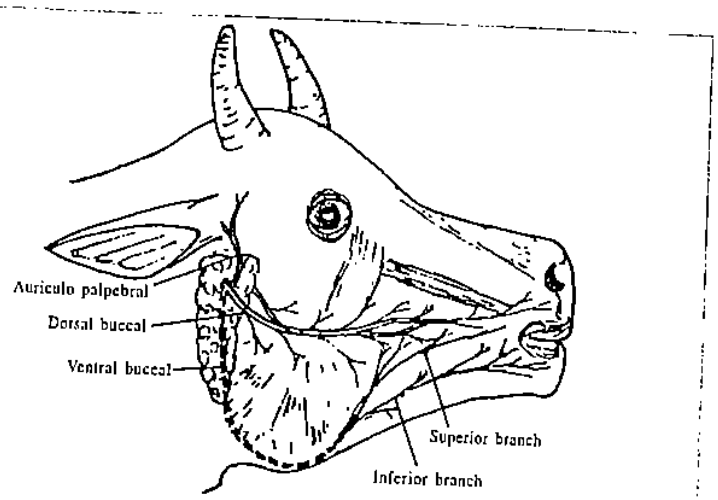


Fig. 8.28 Facial nerve, outside facial canal.

VI. **Abducent nerve** *(mixed)*

It originates from the corpus trapezoideum, leaves the cranial cavity through foramen orbitorotundum reaches the orbital cavity and supplies to the **retractor oculi** and **lateral rectus** muscles. Lateral rectus muscle acts as abductor of eye and therefore this nerve is called abducent. It also carry some sensory proprioceptive fibers from muscles.

Paralysis of abducent nerve lead to Diplopia (double vision).

VII. **Facial nerve** *(mixed)*

This nerve originates from the lateral aspect of medulla oblongata in front of auditory nerve. Both the 7th and 8th cranial nerves enter the internal auditory meatus. The facial nerve alone enters the facial canal and forms the **geniculate ganglion** and comes out through stylomastoid foramen. Facial canal is an irregular canular space between the internal auditory meatus and stylomastoid foramen. Here it reaches under the parotid gland and divides into three terminal branches. These are **auriculo palpebral, dorsal buccal** and **ventral buccal.**

Within the facial canal it gives off three branches as follows :

(a) **Great petrosal nerve**—It starts from the geniculate ganglion, contributes some fibers to tympanic plexus, receives the deep petrosal nerve from the carotid plexus of sympathetic and emerges from the foramen lacerum. Here it is known as the nerve of the pterygoid canal. It terminates in the pterygopalatine ganglia. From here post-ganglion parasympathetic fibers go to lacrimal gland. This nerve carries taste fibers from the palate.

(b) **Stapedial branch**—It is a very small branch supplies to the stapedius muscle.

(c) **Chorda tympani**—Just after the origin from the facial nerve in the facial canal it enters the tympanic cavity, passes across it and exits through petro tympanic fissure and then passes down the lateral wall of the bulla tympany below the maxillary artery and mandibular nerve and finally joins with the lingual branch of 5th cranial nerve and remifies as gustatory fibers to the anterior two third of the tongue.

Just at the exit at the stylomastoid foramen and before dividing into terminal branches, the facial nerve gives some small branches. These are (i) Caudal auricular, (ii) Middle or internal auricular, (iii) Stylomastoid and (iv) Digastricus. They innervate the local muscles and skin.

Terminal branches

1. **Auriculopalpebral nerve**—This nerve proceeds dorsally with the superficial temporal vessels and supplies branches to cranial auricular, orbicularis oculi and levator anguli muscles.

2. **Dorsal buccal nerve**—It is the largest of all the terminal branches. It crosses the posterior border of the ramus of the mandible appears on the rostral margin of parotid gland, reaches the lateral aspect of massater muscle and join the buccal nerve of 5th cranial nerve.

It crosses the parotid duct, passes along the facial vein as a single nerve and divides into two branches. Shortly these branches reunite to form a single trunk. The branches of this trunk innervate malaries, buccinator, orbicularis oris and muscles of the lateral aspect of nose.

3. **Ventral buccal nerve**—It passes ventrally through the parotid gland parallel to the posterior border of the ramus of the mandible. The nerve then courses forward, crosses the parotid duct, external maxillary vessels and gives off communicating branches to the dorsal buccal nerve. The inferior branch enters the depressor labii mandibularis and ramifies there. Few of its branches proceed further forward and join terminal mental filaments to supply the lower lip.

VIII. Cochleo-vestibulr nerve *(sensory)*

Cochlear part (hearing)

The axons of the cell bodies of spiral ganglion of the organ of Corti come out of the petrous bone through the internal acoustic meatus in company with the vestibular division to form cochlear nerve. It enters the brain stem at the caudal border of pons and the fibers end at the cochlear nuclei, situated deep at the site of entrance. The axons of second order neurons cross to the opposite side in the pons, passes cranially through lateral laminiscus and end at the medial geniculate body. From medial

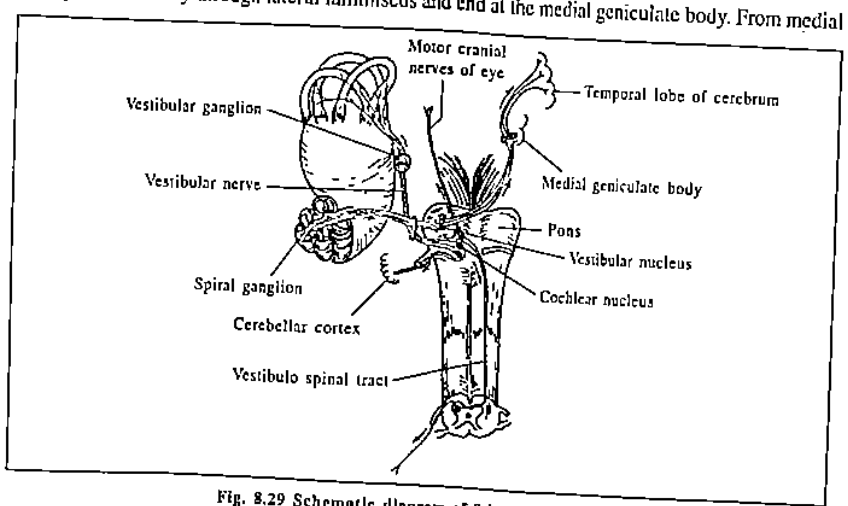


Fig. 8.29 Schematic diagram of 8th cranial nerve.

geniculate body the axons of 3rd order neurons pass below the lenticular nucleus to the hearing center at the temporal lobe.

Vestibular part (equilibrium)

The axons of the vestibular ganglionic cells situated within the petrous bone, pass through the internal auditory meatus in company with the cochlear division. These neurons carry impulses from the semicircular canals of the internal ear. They end at the vestibular nucleus in the medulla oblongata, deep at the floor of the 4th ventricle. From this place impulse may go in different ways by the axons of the cells of vestibular nucleus. Impulse may go (a) directly to the cerebellar cortex *via* posterior cerebellar peduncle; (b) cranially to the motor cranial nerves of the eye and (c) caudally as the vestibulo spinal tract to the ventral horn cells.

Lesion on vestibular nerve may lead to ***vertigo*** (sensation of whirling motion), *Ataxia* (loss of muscular co-ordination) and *Nystagmus* (spasmodic movement of eye balls).

IX. Glosso pharyngeal nerve *(mixed)*

It is attached to the lateral aspect of the medulla oblongata, just ventral to the posterior cerebellar peduncle. The rootlets converge to form a single nerve which emerges through the Jugular foramen in company with 10th and 11th cranial nerves and presents one proximal and one distal ganglion.These two ganglia often remain fused with each other.

The nerve passes forward and downward behind the great cornu of the hyoid bone and divides into pharyngeal and lingual branches. Before dividing into terminal branches the trunk detaches the following nerves :

(a) **Tympanic nerve**—It originates from the distal ganglion, passes dorsally, enters the tympanic cavity by passing through the tympanic and petrous part of the temporal bone and joins with the branches of carotid plexus of sympathetic to form the tympanic plexus. The lesser petrosal nerve arises from the tympanic plexus, leaves the tympanic cavity after passing over the tensor tympani muscle and joins the otic ganglion. From this ganglion post ganglinic fibers arise and provide secretomotor fibers to parotid gland.

(b) **Carotid sinus branch**—Being detached at the ventral margin of the tympanic bulla, this nerves runs caudally and terminates around the carotid sinus to act as chemo and baro receptors.

Terminal branches

1. The pharyngeal branch forms pharyngeal plexus with the branches of vagus and sympathetic. The fibers of this plexus innervate the mucous membrane and muscle of pharynx.

2. The lingual branch carries taste fibers and ramifies into the posterior third of the tongue, soft palate and isthmus faucium.

X. Vagus nerve *(mixed)*

It is the longest of all the cranial nerves. It is attached at the lateral aspect of the medulla oblongata and with the fibers of 9th and 11th nerves it leaves the cranial cavity through jugular foramen. In the foramen it presents the jugular ganglion which is having communication with the 11th and 12th nerves and the ganglion of 9th nerve. For a short distance this nerve goes downward and backward along with the 11th nerve. Then the two nerves separate and the 12th nerve passes in between these two nerves. It passes further ventrally and caudally with the cervical sympathetic nerve and forms the vago-sympathetic trunk. The sympathetic fibers come from cranial cervical ganglion. The common

trunk passes through the carotid sheath, descends deeply into the jugular furrow and enters the thorax. Just before entering the thorax, the nerve separates itself from sympathetic cord. In the thoracic cavity the right vagus passes under the right axillary artery and right face of trachea and divides into superior and inferior branches behind the aortic arch. The left vagus passes under the left axillary artery, crosses the aorta at its origin, reaches the root of the left lung and divides into superior and inferior branches at the upper face of the esophagus. The superior as well as inferior branches of left and right nerves join separately at the concerned aspect of the esophagus, pass caudally along the caudal mediastinum and enter the abdomen through esophageal aperture as superior and inferior continuations of vagi.

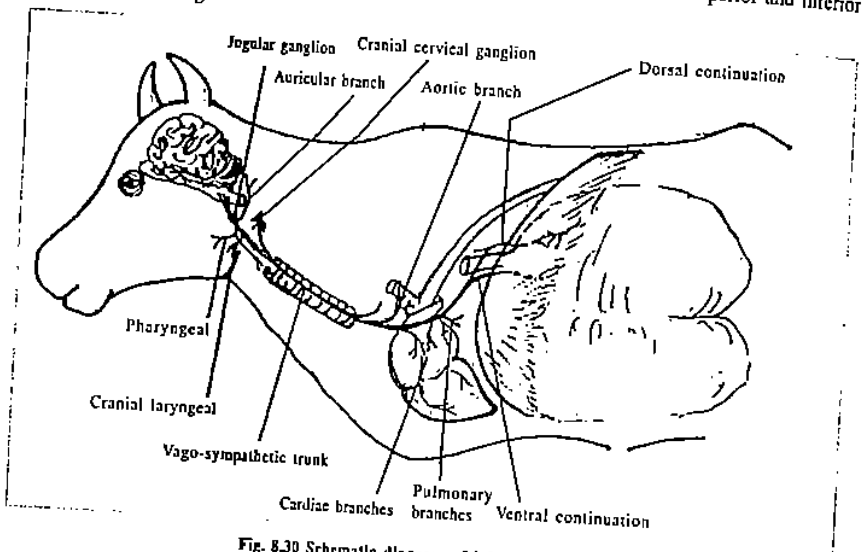


Fig. 8.30 Schematic diagram of left vagus nerve.

Branches at the cervical course

(a) *Auricular nerve*—The fibers of this branch are detached from the jugular ganglion. It joins the facial nerve and supplies the skin at the back of the ear and external auditory meatus.

(b) *Pharyngeal and esophagial branches*—They originate close to the origin of auricular nerve. With the sympathetic fibers they form pharyngeal plexus to supply pharynx and cranial part of the esophagus.

(c) *Cranial or superior laryngeal nerve*—It is detached a little behind the origin of preceding nerves. It courses along the lateral wall of pharynx with the glossopharyngeal nerve and enters the larynx through thyroid foramen.

(d) *Aortic nerve*—Just in front of the thoracic inlet the left vagus detaches this branch which runs parallel to the parent trunk and supplies the aorta. However, the right aortic nerve originates from the right vagus at the level of 2nd rib.

Branches at the thoracic course

(a) *Recurrent laryngeal nerve*—The right recurrent laryngeal nerve arises behind the level of first rib. This branch winds round a small artery, detaches sensory branches to trachea and esophagus, passes cranially, and reaches the ventral surface of the trachea by crossing the dorsal surface of the common carotid artery. At the level of the 8th tracheal ring it reaches the dorsal surface of the trachea, goes further cranially and supplies the larynx. The left nerve is detached at the level of 4th intercostal space. It winds round the aortic arch and runs cranially along the ventral surface of the esophagus. Further cranially it courses between the trachea and esophagus and splits into 2-3 branches at the level of 3rd tracheal ring under the thyroid gland to supply the pharyngeal muscles and larynx.

(b) *Cardiac nerves*—Right vagus detaches right cardiac nerves at the level of 3rd rib. The left cardiac branches are detached at the level of 5th rib from the left vagus nerve. Nerves of both sides contribute fibers along with the fibers of sympathetic for the formation of **cardiac plexus**.

(c) *Pulmonary branches*—They are detached by each vagus at the level of tracheal bifurcation. They join with the sympathetic nerves and form **pulmonary plexus** to innervate the lungs.

Abdominal course

The superior esophageal continuation of vagi goes caudally, communicates with splanchnic nerve, forms **hepatic** and **reticulo-omasal plexuses** and remifies to the right surface of all compartments of stomach. It also contributes fibers to the celiac plexus.

The inferior esophageal continuation also contributes to the hepatic and reticulo-omasal plexuses and supplies the stomach.

Fibers of the vagus nerve also innervate the mucous membrane of intestine and other viscera like kidneys, adrenal gland etc.

Effect of lesion on vagus nerve are *Dysphagia* (difficulty in swallowing), change of voice and absence of certain movement of palate.

XI. Accessory nerve *(motor)*

This nerve has two roots of origin—*cranial* and *spinal*. The cranial root arise from the dorsolateral aspect of the medulla oblongata. Spinal root comprises of nerve fibers from five cranial cervical

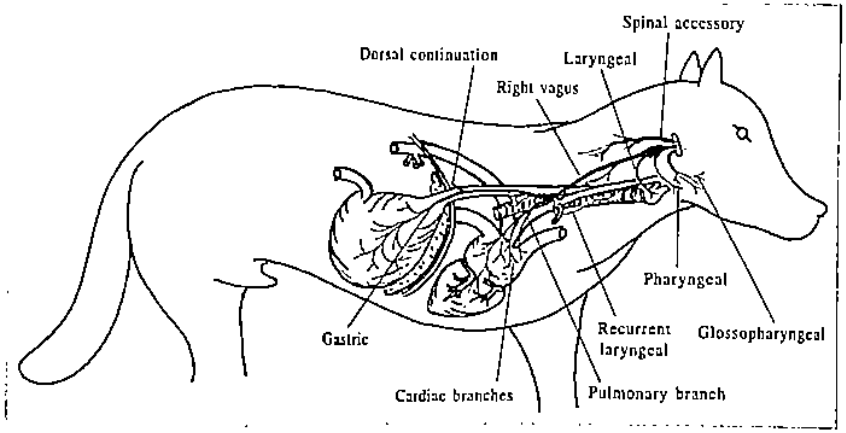


Fig. 8.31 9th, 10th and 11th cranial nerves in dog (Schematic).

NEUROLOGY

A table of cranial nerve

Nerve	*Functional component*	*Attachment with brain*	*Cells of origin*	*Passage*	*Ganglion*	*Distribution*
I. OLFACTORY (Sensory)	Afferent fibers for sensation of smell	Olfactory bulb	Olfactory cells of nasal mucosa	Cribriform plate of ethmoid bone	—	Olfactory area at pyriform cortex and hippocampal gyrus.
II. OPTIC (Sensory)	(i) Afferent fibers for sensation of vision (ii) Afferents for pupillary light reflex.	Optic chiasma	Neurons of ganglionic layer of retina	Optic foramen	—	Visual cortex at the occipital pole
III. OCULOMOTOR (Motor)	Efferent fibers for movement of eye ball	Medial aspect of cerebral peduncle	Edinger-Westphal Nucleus (accessory oculomotor nucleus)	Foramen orbitorotundum	—	All extra ocular muscle except superior oblique and lateral rectus
IV. TROCHLEAR (Motor) Pathetic nerve slenderest cranial nerve	Efferent fibers for movement of eye ball.	Behind the inferior colliculus	Nucleus is situated at the ventral wall of aqueduct of mid brain	Foramen orbitorotundum	—	Superior oblique muscle of eye
V. TRIGEMINAL (Mixed) Largest cranial nerve	Afferent fibers for pain, touch and temperature sensation of skin, face, teeth, gum. Afferent fibers of proprioceptive sensation from muscles of mastication extra-ocular	Antero-lateral aspect of pons by a large sensory and a small motor root.	(i) Sensory nucleus in pons. Mesencephalic nucleus in the mid brain, spinal nucleus at 2nd or 3rd cervical segment of spinal cord from trigeminal ganglion	Ophthalmic and maxillary branch pass through foramen orbitorotundum and the mandibular branch passes through foramen ovale.	Trigeminal ganglion (Gasserian/ semilunar)	Face teeth, gum, muscle of mastication and skin of face, horn, lacrimal gland and nasal cavity, tongue, palate, eye lids.

A table of cranial nerve *Contd.....*

Nerve	*Functional component*	*Attachment with brain*	*Cells of origin*	*Passage*	*Ganglion*	*Distribution*
V. *Contd.*	muscles etc. Efferent fibers for the muscles related to movements of lower jaw.		(ii) Motor nucleus in pons.			
VI. ABDUCENT (Mixed)	(i) Efferent fibers for movement of eye ball (ii) Some proprioceptive fibers from lateral rectus muscle	Close to corpus trapizoidum	Nucleus is situated beneath the 4th ventricle	Foramen orbitorotumdum	—	(i) To lateral rectus of eye (ii) From -do-
VII. FACIAL (Mixed)	(i) Efferent fibers for muscles of ear and face. (ii) Secreto-motor fibers to mandibular, sub lingual and lacrimal glands. (iii) Taste fibers (afferent) from anterior two-third of tongue	Lateral aspect of medulla oblongata	(i) Nucleus of facial nerve is placed at the floor of 4th ventricle. (ii) Superior salivary Nucleus (iii) Geniculate ganglion.	Internal autitory meatus→ facial canal →stylomastoid foramem	Geniculate ganglion	(i) Facial muscles (ii) Pterygopalatine and submandibular ganglion. (iii) Anterior two-third of tongue. (iv) Mucous membrane of nose and palate.

A table of cranial nerve *Contd.....*

Nerve	*Functional component*	*Attachment with brain*	*Cells of origin*	*Passage*	*Ganglion*	*Distribution*
VIII. Cochleo vestibular (Sensory)	(i) Afferent fibers from hair cells for hearing sensation (ii) Afferent fibers from semicircular canal for equilibrium	Close to the junction of pons and medulla oblongata	(i) Cells of spiral ganglion (ii) Cells of vestibular ganglion	Internal auditory meatus	Spiral and vestibular	Cochlea vestibule semicircular canal
IX. GLOSSOPHARYNGEAL (Mixed)	(i) Efferent fibers to parotid salivary gland (ii) Efferent fibers for movement of pharynx. (iii) Afferent fibers from carotid sinus (iv) Afferent fibers for taste.	Lateral aspect of medulla oblongata	(i) Inferior salivary Nucleus in medulla oblongata (ii) Cells of Nucleus ambiguus in the medulla. (iii) Cells of carotid body (iv) Cells of taste buds (v) Ganglionic cells	Jugular foramen.	Proximal ganglion Distal ganglion	Parotid gland carotid sinus Muscles of pharynx posterior third of tongue.
X. Vagus (Mixed) Longest cranial nerve	(i) Efferent fibers for movement of pharynx and larynx. (ii) Efferent fibers to involuntary	Lateral aspect of medulla oblongata.	(i) Cells of nucleus ambiguus (ii) Dorsal nucleus in the medulla (iii) Jugular ganglion	Jugular foramen	Jugular ganglion	Pharynx, larynx, Esophagus, Stomach, Intestine, trachea, lungs, liver, pancreas, Heart, spleen, kidneys.

A table of cranial nerve *Contd.....*

Nerve	*Functional component*	*Attachment with brain*	*Cells of origin*	*Passage*	*Ganglion*	*Distribution*
X. *Contd.*	muscles of G. I. tract, bronchial tree and heart. (ii) Afferent fibers of visceral sensibility					
XI. Accessory (Motor)	Efferent fibers to neck and shoulder muscles	(i) Cranial root is attached to the dorsolateral aspect of medulla oblongata (ii) Spinal root is attached to the first five cervical segment of spinal cord.	(i) Nucleus ambiguus (ii) Cells of the later part ventral grey column of spinal cord.	Jugular foramen	—	Muscles of neck and shoulder, larynx, soft palate
XII. Hypoglossal (Motor)	Efferent fibers for movement of tongue	Ventro lateral aspect of medulla oblongata	Cells of Hypoglossal nucleus at the floor of 4th ventricle	Hypoglossal foramen	—	Tongue

segments, enters the foramen magnum and joins the cranial root. The combined trunk leaves the cranial cavity through jugular foramen behind 10th cranial nerve. Outside the cranial cavity the cranial fibers join branches of the vagus and ramify chiefly to the voluntary muscles of larynx, soft palate and pharynx.

The spinal portion passes caudally to the neck region receives twigs from 2nd and 3rd cervical nerves and divides into several branches to innervate the sterno mastoid and Trapezius muscles.

Since it is having a spinal root, it is also called spinal accessory nerve.

XII. Hypoglossal nerve *(motor)*

It originates by several rootlets from the ventrolateral aspect of the medulla oblongata. The united trunk exits through the hypoglossal foramen, gives a twig to the first cervical nerve, crosses the external carotid artery and swings forward to supply all the extrinsic and intrinsic muscles of the tongue.

SPINAL NERVES

There are generally 37 pairs of spinal nerves in ox, 42 pairs in horse, 35 pairs in dog, 39 pairs in pig, 37 pairs in rabbit and 36 pairs in fowl (*vide* table).

	Cervical	*Thoracic*	*Lumbar*	*Sacral*	*Coccygeal*
Ox	8	13	6	5	5
Horse	8	18	6	5	5
Dog	8	13	7	3	4
Pig	8	15	6-7	4	5
Rabbit	8	12	7	4	6
Fowl	15	7	(L+S=14)		

There is a general pattern of arrangement in the origin and distribution of all the spinal nerves in the body. However, variation are there in the distribution part in different regions of the body.

Each spinal nerve is formed by the union of dorsal and ventral roots just outside the intervertebral foramen. Then and there it divides again into a dorsal and a ventral ramus. The roots are formed by the union of several rootlets arising from the corresponding aspect of the spinal cord. The dorsal root is sensory in function and presents a spinal ganglion which is known as **dorsal root ganglion.** These ganglia contain unipolar neurons. Generally the ganglions are encapsulated by connective tissues. The constituent neurons are arranged in groups and are separated by bundles of nerve fibers and intraganglionic connective tissue. The neurons are round or oval in shape (Fig. 8.33). Each of these neurons has a single dendro-axonal process which is divided into a peripheral affarent part and a central part. The peripheral process is very long and conducts sensation fowards the cell body and therefore considered functionally as an elongated **dendron.** But this peripheral process has all the structural characteristics of an axon. The ventral roots of the spinal nerves are motor in function. These are formed by the axons of the neurons whose cell bodies are generally situated at the ventral horn of the spinal grey matter. Each ramus (primary branch of a spinal nerve), consists of fibers from both dorsal and ventral roots.

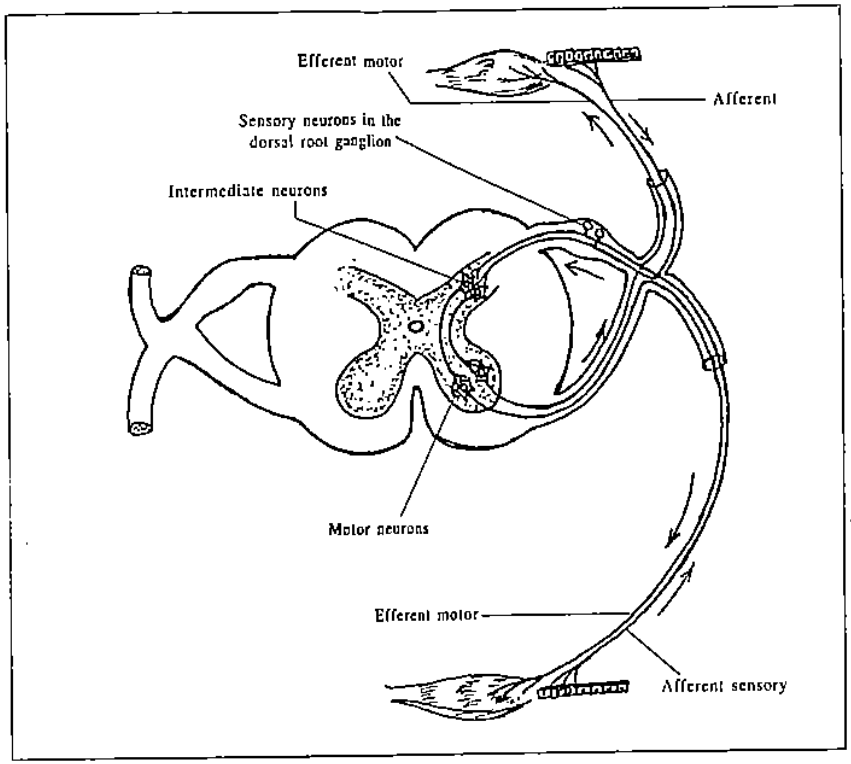


Fig. 8.32 Simplest form of a spinal nerve.

Dorsal ramus—It passes upward between the transverse processes, reaches the muscles of the back and divides into lateral and medial branches to innervate the muscles and skin of the dorsal aspect of the body. These rami are segmentally disposed and are smaller than ventral rami.

Ventral ramus—It is larger than the dorsal. It divides to innervate skin and muscles of trunk as well as those of limbs by forming plexuses with similar branches of other spinal nerves. The ventral branches of thoracic and lumbar spinal nerves are connected with the fibers of autonomic nervous system.

The spinal nerves which join to form plexuses to supply different body parts will only be discussed in details.

Cervical spinal nerves

The first cervical spinal nerve leaves the spinal canal through the lateral vertebral foramen of Atlas. The second nerve emerges through the lateral vertebral foramen of axis. Other nerves pass as usual through corresponding intervertebral foramen.

Phrenic nerve

The ventral primary branches of 5th, 6th and 7th cervical spinal nerves unite together to form this nerve. Sometimes 4th nerve also contribute to the formation of this nerve. At first 6th & 7th unite to form a trunk and then the 5th join it in the thoracic cavity at the level of 1st intercostal space. It travels caudally and ventrally over the scalenus muscle and enters the thoracic cavity between the axillary and inferior cervical arteries. The right phrenic nerve passes backward along the right face of the cranial venacava and then acrosses the base of the heart over pericardium. It now passes along the right face of caudal venacava and reaches the center of diaphragm. The left phrenic nerve travels in company with the vagus at the cranial mediastinum. The nerve separates itself from the company of vagus at the base of the heart and goes along the upper part of pericardium and passes further backward to innervate the diaphragm. It is a motor nerve to the diaphragm.

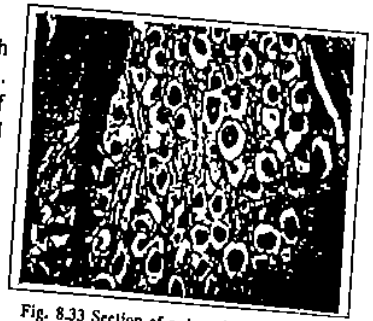


Fig. 8.33 Section of a dorsal root ganglion showing clusters of neurons.

BRACHIAL PLEXUS

Formation—The plexus is formed by convergence of ventral rami of 6th, 7th and 8th cervical and 1st and 2nd thoracic spinal nerves.

Position—This is placed between the thoracic wall and medial surface of shoulder and specifically between two branches of scalenus muscle.

Distribution—Its branches supply to the muscles and skin of forelimb and certain parts of thorax and neck. The nerves originating from the brachial plexus are as follows :

(a) **External (lateral) thoracic nerve**—It is formed by the fibers 8th cervical and 1st and 2nd thoracic nerves. It descends downward under the triceps, sends some branches to the pectoral muscles, passes caudally and supplies to the skin of the abdominal area. Some of the branches join with few perforating branches of intercostal nerves, wind round the latissimus dorsi and supply the scapulo humeral region.

(b) **Thoraco dorsal nerve**—It is formed by last cervical and first thoracic spinal nerves. It passes caudally along the axillary nerve and passes backward and upward to ramify in the latissimus dorsi.

(c) **Pectoral nerves**—They are formed by 7th and 8th cervical and first thoracic spinal nerves. All these branches (3 to 4) pass downward and backward to supply the pectoral muscles. Few cranial branches sometimes form a loop around axillary artery.

(d) **Long thoracic nerve**—This is a long trunk formed by 7th and 8th cervical spinal nerves. It passes backward to innervate serratus cervicis and further backward to supply serratus thoracis muscle.

(e) **Sub-scapular nerve**—It is usually formed by 6th and 7th cervical components. It innervates the subscapular muscle.

(f) **Supra scapular nerve**—It is derived from 6th and 7th cervical spinal nerve. It arises from the cranial part of the plexus, passes between the subscapular and suprascapular muscles, winds round the distal part of the scapula below acromion process and divides into several branches to be distributed to the supraspinatous and infraspinatous muscles.

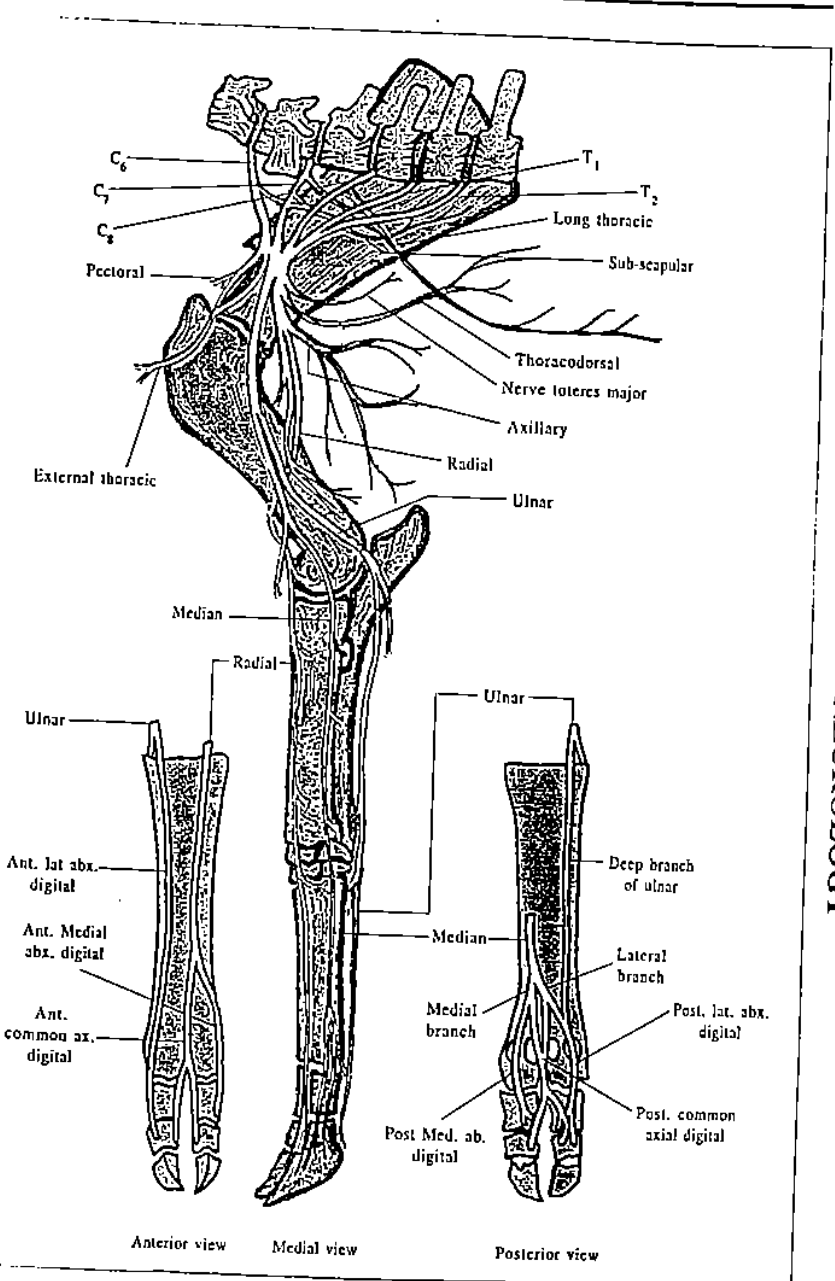


Fig. 8.34 Brachial plexus and its branches in the right fore limb (Semi schematic).

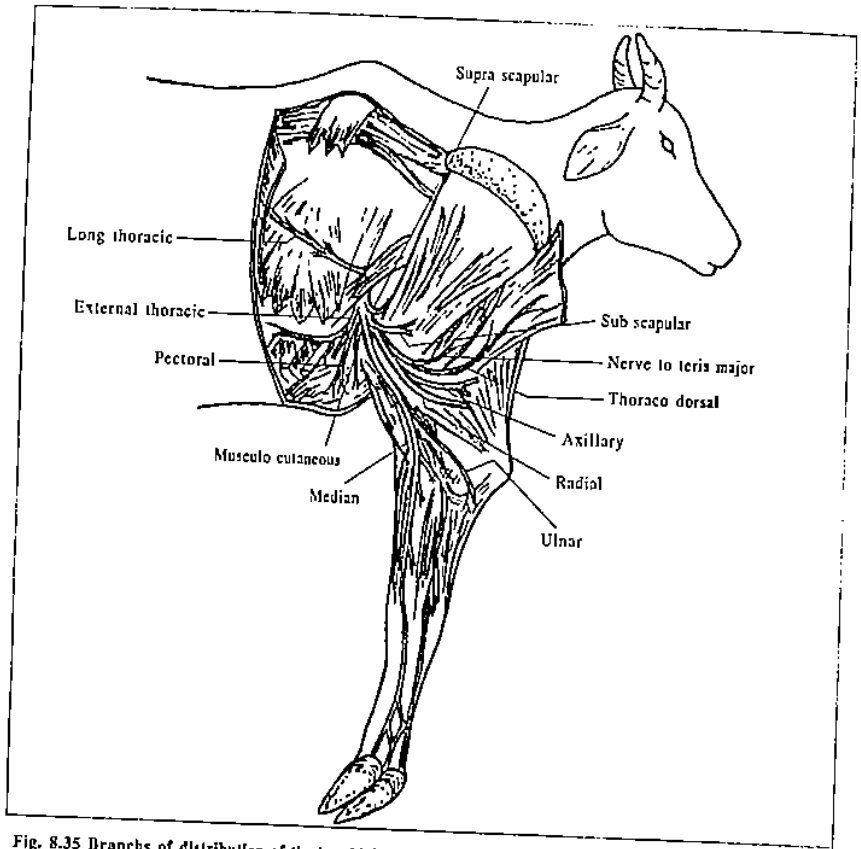


Fig. 8.35 Branchs of distribution of the brachial plexus as appeared in the dissection of a buffalo calf. The right forelimb is overturned to expose the medial aspect.

(g) **Axillary nerve**—This branch appears to be considerably thick and remain in close association with the radial nerve. Its fibers are derived from 7th and 8th cervical spinal nerves. It passes downward caudal to the shoulder joint and supplies branches to the deltoids, teres major, teres minor and subscapular muscles. It also detaches cranial cutaneous antibrachial nerve. It innervates lateral aspect of arm and craniomedial aspect of fore arm.

(h) **Nerve to teres major**—It is a small nerve arises from the caudal aspect of the brachial plexus, passes backward and supplies the teres major muscle.

(i) **Musculo cutaneous branch**—It starts from the cranial aspect of the plexus, descends to the medial aspect of the shoulder joint along with the median nerve and forms a loop with it. It goes further downward and innervates coraco brachialis, biceps brachii muscles and skin at the craniomedial aspect of the forearm.

(j) **Radial nerve**—This is the thickest of all the branches. It descends caudally, reaches the musculo spiral groove of humerus along with the collateral radial artery by passing between

the anterior border of triceps and posterior border of humerus. It gives off few cutaneous branches and divides into superficial and deep trunks. On the way it gives off few muscular branches to triceps, tensor fascia antibrachi and anconeous muscles. The deep trunk emerges between the brachialis and extensor carpi radialis and innervates all extensor muscles and ulnaris lateralis of the forearm. The superficial trunk also emerges along with the deep branch and reaches the antero-lateral aspect of the forearm. It joins with a branch of median nerve above the carpus, passes down to the middle of the metacarpus and finally divides to form **anterior common axial digital** and **anterior medial abaxial digital** nerve to supply the corresponding aspect of the digit.

(k) **Ulnar nerve**—It accompanies median nerve at its origin, reaches the middle of the arm and gives a small cutaneous branch at that region. The nerve then reaches the space between the medial condyle of the humerus and olecranon process of ulna and detaches an articular branch to the elbow. It then passes between the heads of flexor carpi ulnaris, detaches few muscular branches, passes below the flexor muscles, goes externally inclines further outward, reaches the tendon of ulnaris lateralis and divides into superficial and deep branches just above the carpus. The superficial branch descends down to continue as **anterior lateral abaxial digital nerve**. The deep branch descends along the carpus, gives few fibers to the suspensory ligament, joins with a branch of median nerve and continues downward as **posterior lateral abaxial digital nerve**.

(l) **Median nerve**—This large nerve forms a loop with the musculocutaneous nerve at the origin through which axillary artery passes. It runs downward along the medial aspect of the arm, crosses the elbow and reaches beneath the pronator teres muscle. It passes between the radius and flexor carpi radialis, descends further down through carpal sheath, reaches the lower third of the metacarpus and divides into lateral and medial branches. Each of these branches are subdivided into axial and abaxial branches as shown in the diagram. The abaxial branch of the medial branch continues downward as **posterior medial abaxial digitial nerve**. The abaxial division of the lateral branch joins with a branch of ulnar nerve and continues downward as **posterior lateral abaxial digital** nerve. The axial branches of both the lateral and medial branches of median nerve unite again to form a single trunk. It continues down in between of the digits as **posterior common axial digital nerve**.

LUMBO-SACRAL PLEXUS

Formation—The ventral rami of 4th, 5th and 6th lumbar along with those of first and second sacral spinal nerves converge to form this plexus.

Position—The plexus comprises of a cranial (lumbar) and a caudal (sacral) part. The lumbar plexus is situated at the ventro-lateral aspect of lumber transverse processes of 5th and 6th vertebra and the sacral plexus is placed below and lateral to the cranial aspect of the wings of sacrum.

Distribution—Branches from these plexuses innervate muscles and skin of caudal lumbar region, hip, thigh and hind limb.

Lumbar plexus

The nerves emerging from lumbar plexus are as follows :

(a) **Lateral cutaneous femoral nerve**—Its fibers are derived from 4th lumbar with occasional contribution from 3rd and 5th. It passes caudally towards the cranial aspect of tuber coxae, innervates psoas and iliacus muscles and ramifies to the skin.

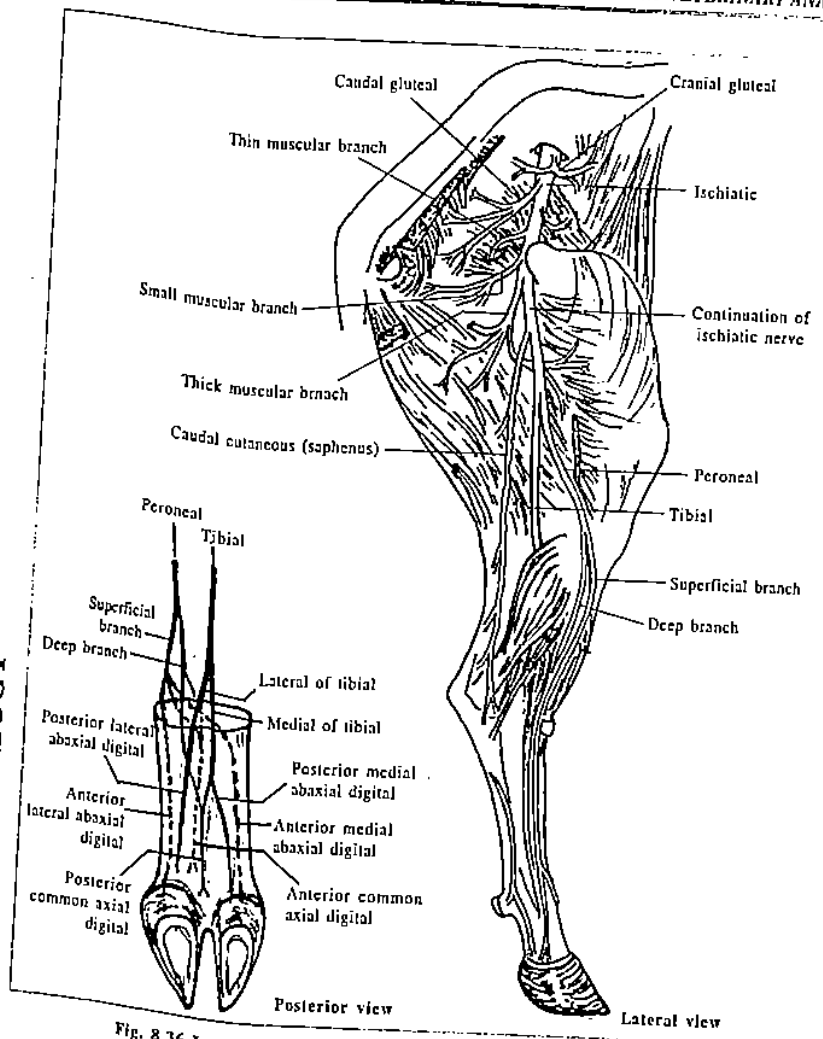


Fig. 8.36 Lumbo-sacral plexus and its branches of left hind limb (Lateral view).

(b) **Femoral nerve**—It is formed by the fibers from 4th, 5th and 6th lumbar nerves. It is the largest branch of the lumbar part. It goes downward and backward between the psoas muscles and detaches the internal saphena nerve a little above the pelvic brim and terminates in the quadriceps muscles. The **internal saphena nerve** passes down through the femoral canal, emerges between the sartorius and gracilis and becomes distributed at the fascia and skin at the medial aspect of the stifle joint. On the way it gives variable branches to the thigh muscles.

(c) **Obturator nerve**—It gets fibers from 4th, 5th and 6th lumbar nerves, goes downward and backward under the peritonium and reaches the obturator foramen. It supplies the obturator

internus, passes out of the pelvic cavity through the anterior part of the obturator foramen and ramifies to the muscles at the medial aspect of thigh.

Sacral plexus

The following main nerves arise from sacral part of this plexus :

(a) ***Cranial gluteal***—It starts from the cranial aspect of the sacral part of the plexus. The fibers are derived from last lumbar and first sacral spinal nerves. It exits through the greater ischiatic foramen and innervates the middle and deep gluteal muscles. A long branch extends forward to supplies tensor fascia lata.

(b) ***Ischiatic nerve***—It is the largest nerve in the body. The fibers are derived from last lumbar and 1st and 2nd sacral nerves. It comes out through the greater ischiatic foramen passes caudoventrally between the trochanter major and tuber ischi, runs along the gamellus and quadratus femoris muscles and enters into the muscular canal formed laterally by semitendinosus and biceps femoris and medially by adductor and semimembranosus muscles. It then comes downward and dips in between the two heads of gastrocnemius and continues as **tibial** nerve. On the way it gives off following important branches :

(i) A **thin muscular branch** passes along the deep face and re-enters the pelvic cavity through the lesser ischiatic foramen to supply obturator internus.

(ii) A **small muscular branch** originates from the caudal aspect of the ischiatic nerve at the lateral aspect of the pelvic cavity, passes backward and supply the gamellus and quadratus femoris muscles.

(iii) A **thick muscular branch** is given off at the level of hip to innervate part of biceps femoris, semitendinosus and semimembranosus muscles.

(iv) **Caudal cutaneous (external saphenus) nerve**—It originates close to the hip joint, courses downward, communicates with peroneal and passes over the lateral head of gastrocnemius towards the lower third of the leg. It finally ramifies to the skin and lateral aspect of the tarsal and metatarsal area.

(v) **Peroneal (external popleteal) nerve**—It is a large trunk, originates from the ischiatic nerve at the middle of the thigh, descends along the lateral aspect of the gastrocnemius and divides into superficial and deep branches at the level of the origin of the extensor muscles.

The *superficial branch* goes down between the extensor muscles at the middle of the metatarsal region and divides into three branches. The lateral one continues down as **anterior lateral abaxial digital** nerve; the medial branch descends down as **anterior medial abaxial digital** nerve and the middle one joins with the lateral branch of the deep part of this peroneal nerve and continues down as **anterior common axial digital nerve.** The *deep part* divides into two branches – the lateral branch joins with the middle branch of superficial trunk as stated above and the medial one joins with the axial branch of medial division of tibial nerve to form posterior common axial digital.

Tibial nerve—It is the continuation of the ischiatic nerve which passes between the two heads of gastrocnemius and descends down behind the superficial digital flexor and gastrocnemius muscles, becomes superficial, passes along the front of Achilles tendon and divides into lateral and medial branches at the level of the hock. The medial one goes between the tendons of muscles and suspensory ligament, reaches

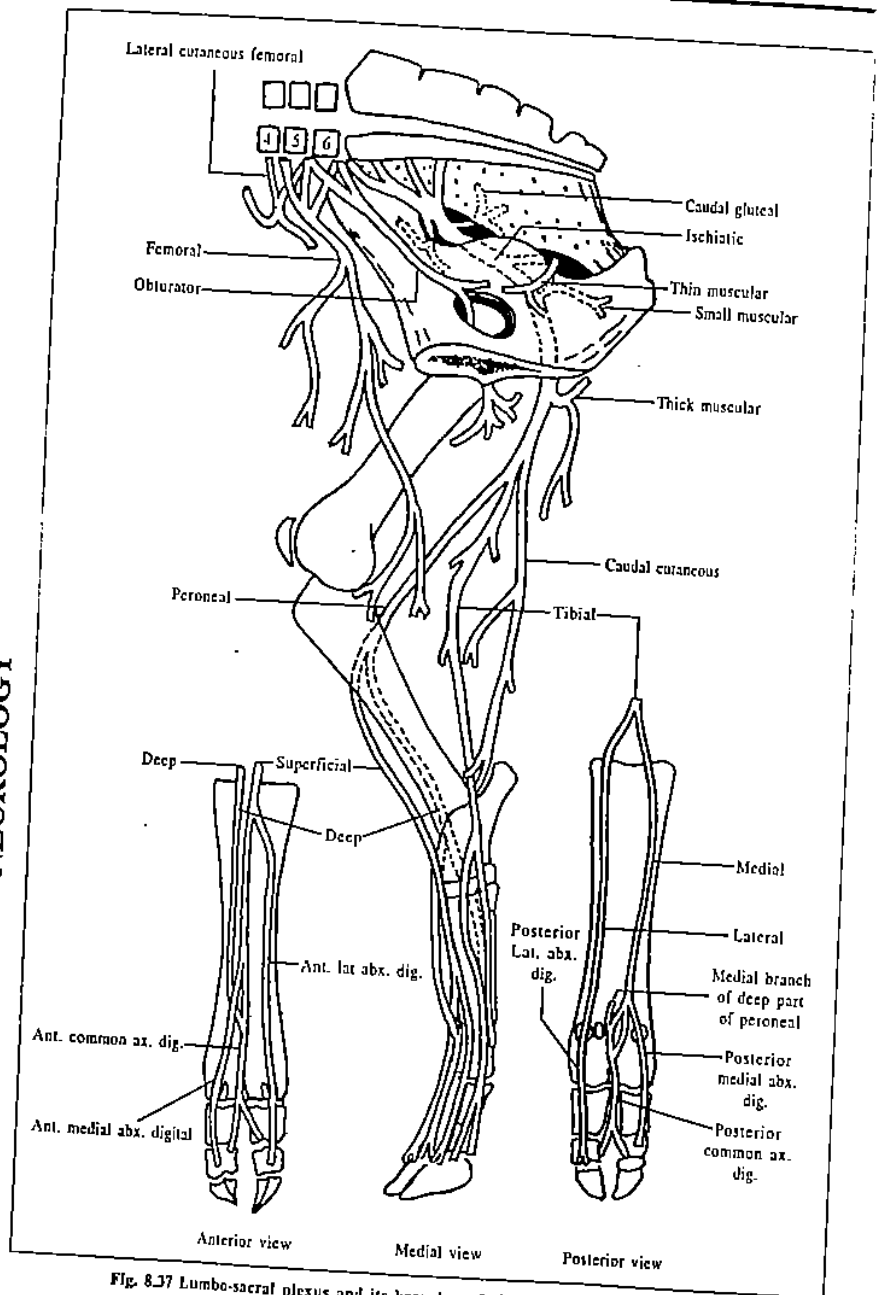


Fig. 8.37 Lumbo-sacral plexus and its branches of right hind Limb (Medial view).

the fetlock joint and divides into two branches. Its axial branch joins with the axial branch of the deep part of the peroneal nerve and forms **posterior common axial digital** nerve and the abaxial branch continues downward as posterior **medial abaxial digital** nerve. The lateral branch descends down and continues as **posterior lateral abaxial digital** nerve.

(c) ***Caudal gluteal***—It arises from the caudal aspect of the ischiatic nerve. Its fibers are derived from 1st and 2nd sacral spinal nerves. It exits through the greater ischiatic foramen along with the ischiatic nerve, passes along the middle gluteus and divides into superficial and deep branches to supply gluteals, biceps femoris and semitendinosus muscles and skin of the area.

Pudendal nerve

It is formed by the union of the ventral primary branches of 2nd, 3rd and 4th sacral spinal nerves. It passes caudoventrally along the medial surface of sacrosciatic ligament, crosses the lesser ischiatic foramen and leaves the pelvic cavity at the ischial arch. It bends downward and divides in case of males into dorsal nerve of penis and superficial perineal nerve. The latter innervates the scrotum and prepuce. In the female it divides into dorsal nerve of the clitoris and the nerve of mammary gland. The pudendal nerve gives off following branches :

(a) While passing in the pelvic cavity, from its medial aspect it detaches a large **pelvic nerve.** It provides branches to sphincter ani externus.

(b) **Proximal cutaneous** nerve—After the origin, the nerve emerges through lesser ischiatic foramen. It passes caudally and supply the skin over semitendinosus muscle.

(c) **Distal cutaneous nerve**—It arises just distal to the preceding nerve, passes through the ischiorectal fossa emerges superficially and divides into two branches to supply the skin of perineal region and medial aspect of the thigh.

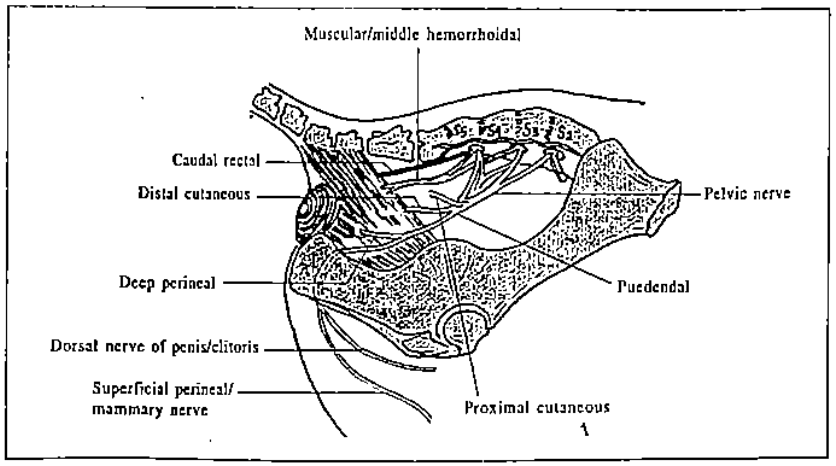
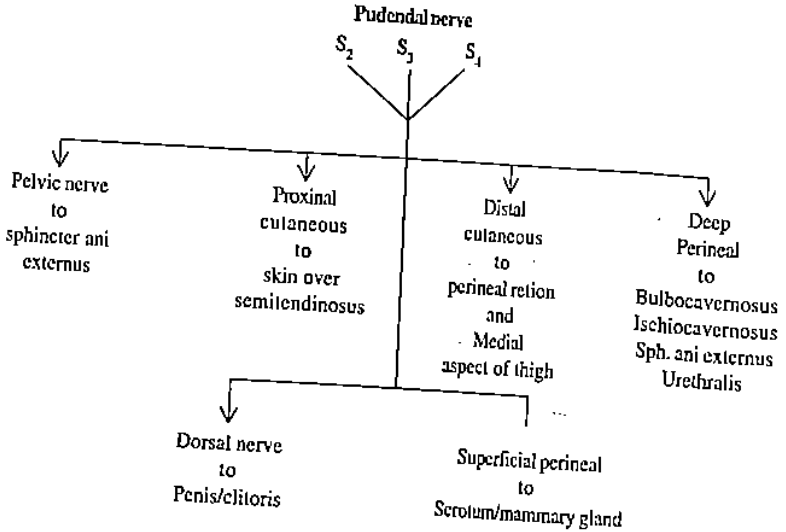


Fig. 8.38 Nerve supply to the pelvic and perineal region (Schematic).



(d) **Deep perineal**—It arises at the caudal border of coccygeus and runs along the ventral border of levator ani. It divides into a number of fine rami to supply bulbo cavernosus, ischio cavernosus, sphincter ani externus and urethralis muscles.

Muscular/Middle hemorrhoidal nerve

This nerve gets fibers from 3rd and 4th sacral nerve, combines with pudendal or caudal rectal nerve and ramifies in the coccygeus and levator ani muscles.

Caudal rectal nerve

It is derived from the ventral primary branches of 4th and occasionally from the 5th sacral nerves. It passes caudally between the rectum and coccygeus muscles and supplies branches to rectum, coccygeus and levator ani muscles.

AUTONOMIC NERVOUS SYSTEM

This is the visceral component of the nervous system. The nerve fibers are distributed to the viscera, blood vessels, glands and unstriped muscles.

The sensations of autonomic nervous system usually are not brought into consciousness. They work at subconscious or unconscious level. ANS is not absolute autonomus because it is partially regulated by CNS and they also use somatic system as their afferent path.

On structural and functional ground the efferent component of the ANS can be divided into parasympathetic and sympathetic systems. The sympathetic system comprises of ganglia and branches of distribution. The parasympathetic system utilise some cranial and spinal nerves as their pathway.

However, most of the viscera of the body recieve nerve supply from both systems and these two systems are antagonistic to each other in function.

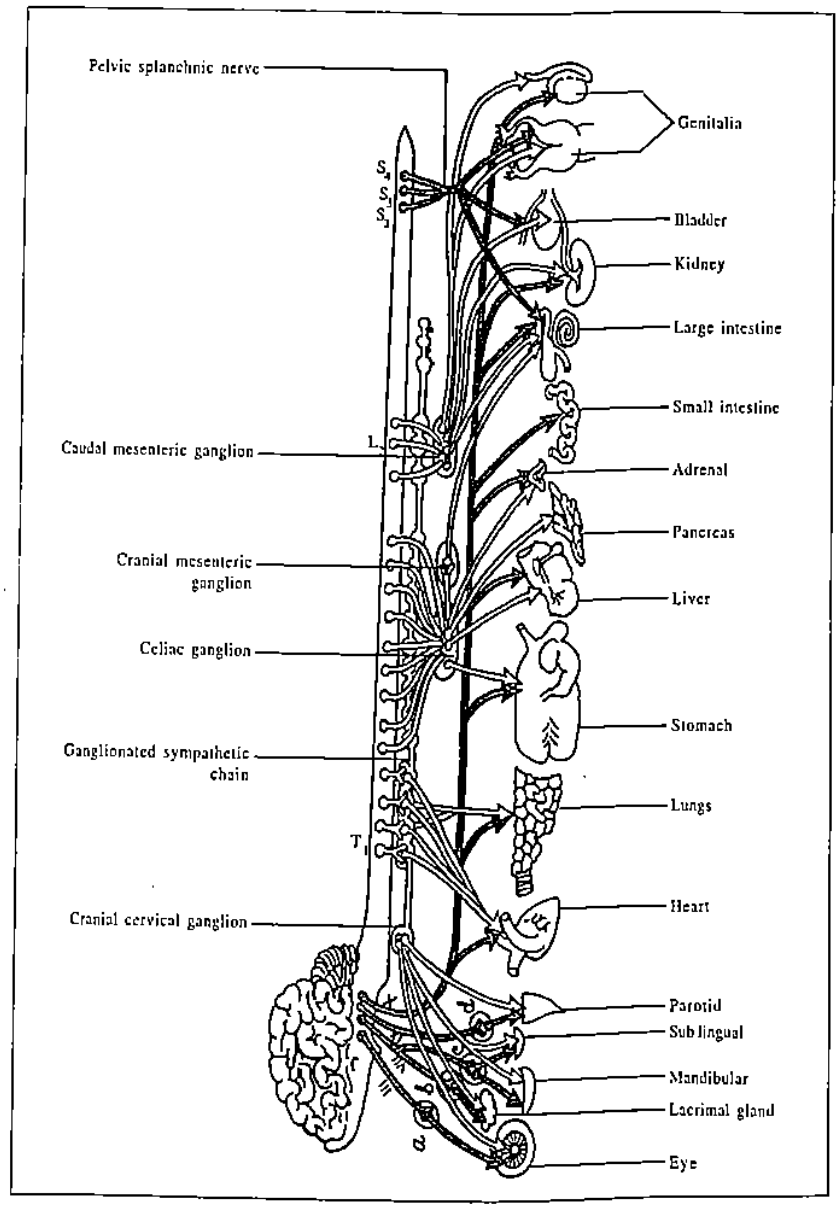


Fig. 8.39 Efferent parts of autonomic nervous system (Diagramatic).
(a) Ciliary ganglion (b) Pterygopalatine ganglion
(c) Submandibular ganglion (d) Otic ganglion.

The primary neurons of visceral efferent components are situated in the cranial nerve nuclei and in the lateral grey columns of the spinal cord. The axons of these primary neurons traverse the corresponding cranial and spinal nerves enter the ganglia and synapse with the secondary neurons. The axons of the secondary or effector neurons are distributed to the structures innervated (muscle or gland cells). So in the peripheral efferent pathway, there are two principal sets of neurons—*Pre-ganglionic neurons* and *Post-ganglionic neurons*.

In the parasympathetic system, the pre-ganglionic efferent fibers emerge through some cranial and some sacral spinal nerves and form **cranio-sacral outflow**; whereas in the sympathetic system the same fibers emerge through the thoracic and lumber spinal nerves and form the **thoraco-lumber outflow.**

The cell bodies of the secondary (post ganglionic) neurons in the para-sympathetic system are situated in the structures, they innervate, *i.e.*, peripherally. On the other hand, the same cell bodies in the sympathetic system are situated in the ganglia of the sympathetic trunk.

PARASYMPATHETIC SYSTEM

The cranial nerves which transmit the pre-ganglionic para-sympathetic efferent fibers are (a) Oculomotor, (b) Facial, (c) Glossopharyngeal and (d) Vagus. There are four peripheral ganglia in this part of ANS. These are (a) **Ciliary ganglion of oculomotor**, (b) **Pterygo palatine ganglion of facial**, (c) **Sub-mandibular ganglion of facial** and (d) **Otic ganglion of glossopharyngeal**. In case of vagus nerve the ganglia are situated at SA and AV nodes of heart, around the roots of lungs and at the wall of the gut.

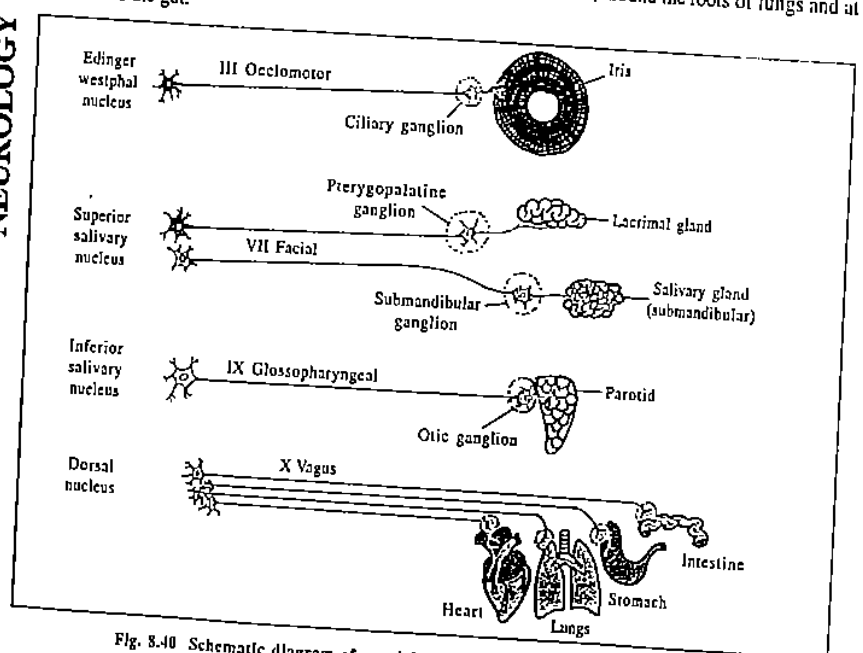


Fig. 8.40 Schematic diagram of cranial nerves carrying parasympathetic fibers.

The preganglionic parasympathetic efferent fibers of the **oculomotor nerve** originate from the Edinger Westphal nucleus and ultimately enter the **ciliary ganglion** after travelling through the nerve. The postganglionic fibers leave the ganglion pass through short **ciliary** nerves and are distributed to the circular ciliary muscles of the eye.

The preganglionic parasympathetic efferent fibers of **facial nerve** originate from superior salivary nucleus, travel through corda tympani, travers the tympanic cavity, reaches the lingual nerve and enter in the **sub-mandibular ganglion**. From here secretomotor post ganglionic fibers arise for submandibular salivary gland. It is said that facial nerve also contains efferent parasympathetic fibers which travel through great petrosal branch, reaches the **pterygopalatine** ganglion from where postganglionic secretomotor fibers arise for lacrimal gland.

The glossopharyngeal efferent parasympathetic fibers are derived from the inferior salivary nucleus. They reach the **otic ganglion** after travelling through tympanic **plexus** and lesser petrosal nerve. From the otic ganglion the post ganglionic fibers travel *via* auriculo temporal branch and reach the parotid gland.

The preganglionic parasympathetic efferent fibers of the **vagus** nerve are derived from dorsal nucleus and travel through the main trunk and its different branches like cardiac, pulmonary, oesophagial, gastric, intestinal branch, *etc.* They reach the **minute ganglia** situated in the walls of individual viscera in which these fibers are relayed.

The ventral rami of 2nd, 3rd and 4th sacral spinal nerves transmit the preganglionic parasympathetic efferent fibers to constitute the **pelvic splanchnic nerve.** It is distributed to the structures of the pelvic cavity such as rectum, bladder, penis/clitoris, testis/ovary, uterine tube and uterus. In most of the cases the post ganglionic fibers are relayed from the small ganglia placed in the walls of the individual viscera.

IMPORTANCE OF PARASYMPATHETIC SYSTEM

One pre-ganglionic parasympathetic fiber synapses with only one post-ganglionic fiber and therefore, its actions are accurate and localised. On stimulation this system produces following effects :

1. Inhibition of heart rate.
2. Fall of blood pressure.
3. Constriction of pupil.
4. Constriction of bronchi and bronchioles.
5. Promotion of secretomotor and peristaltic activity of gut.
6. Relaxation of sphincters of the gut.
7. Evacuation of bladder and rectum.

SYMPATHETIC SYSTEM

This system is composed of two ganglionated sympathetic trunks extending along each side of the vertebral column, some ganglionated plexuses and a number of communicating and distributing fibers. The ganglia of the sympathetic trunk are connected with the central nervous system by white and grey rami communicans.

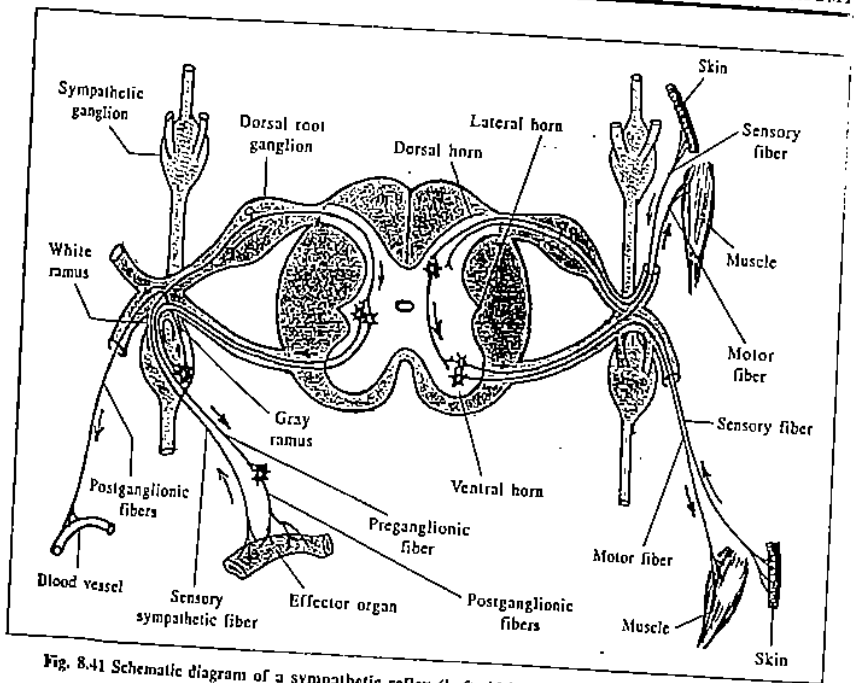


Fig. 8.41 Schematic diagram of a sympathetic reflex (Left side) and a simple reflex are (Right side).

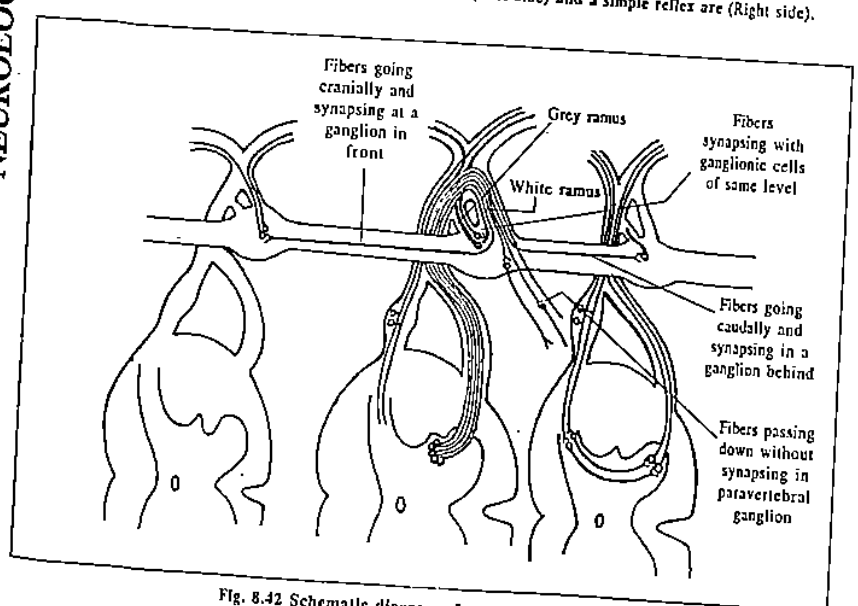


Fig. 8.42 Schematic diagram of sympathetic system.

The cell bodies of first order neurons (present only between 1st thoracic to 2nd lumbar segments of the spinal cord) are situated at the lateral horn. Their **myelinated pre-ganglionic** fibers pass out of the cord *via* ventral roof of the spinal nerve and enter the paravertebral ganglion (as shown in the figure 8.41 and 8.42) *via* **white rami communicans**. These pre-ganglionic fibers may terminate in the following ways :

(a) Some fibers synapse with the cells of the ganglia at the same level.

(b) Some fibers go cranially through the chain and synapse with the cells in cranially placed ganglia.

(c) Other fibers go caudally and synapse with the cell bodies of caudally placed ganglia.

(d) Some other fibers pass down without synapsing in any ganglia of the paravertebral chain and form splanchnic nerves. These nerve fibers synapse on the cell bodies at the pre-aortic ganglia (ganglia around the roots of main branches of aorta).

(e) Few fibers go directly to the terminal organs such as chromaffin cells of adrenal medulla.

The post-ganglionic fibers going to the peripheral blood vessels, swate and sebacious glands, hair follicles, *etc.* run in the spinal nerves. These post ganglionic fibers pass through **grey rami communicans** and thus make connection with the sympathetic chain in each level. The post-ganglionic fibers are very less **myelinated** and that's why grey.

The smooth muscle and glands of the head region get post-ganglionic fibers from cranial cervical ganglion.

The pre-ganglionic fibers going to the abdominal organs synapse with the cell bodies in the pre-aortic ganglia, placed in irregular series around the roots of the main branches of the aorta. The paired celiac ganglia are important amongst them. To the abdominal organs the post-ganglionic fibers travel along the main blood vessels of the organ. To the thoracic organs, these fibers run as discrete nerves to the roots of the great vessels to form cardiac and pulmonary plexuses.

IMPORTANCE OF SYMPATHETIC SYSTEM

One pre-ganglionic neuron of sympathetic system usually makes synapse with 20 or more post-ganglionic sympathetic neurons and thereby makes **wide spread** response and produce the following effects :

1. (a) Vasoconstriction of cutaneous vessels.
   (b) Vaso dilatation of coronary and skeletal muscles providing more blood to the heart muscles and brain and increases heart rate, blood sugar and blood pressure.
2. Dilate the pupil, bronchi and bronchioles.
3. Decrease peristalsis, glandular secretion and absorption of gut.
4. Sphincter muscles of the gut is stimulated.
5. Swate glands are stimulated and perspiration is increased. This leads to fall of body temperature and produce goose flesh appearance.

OVERALL CONSIDERATION OF ANS

1. The connector neurons of somatic system are equivalent to pre-ganglionic motor neurons of autonomic system and the effector neurons of somatic system are equivalent to post-ganglionic neurons of autonomic system.

2. Reflex of ANS may be (a) Viscero-visceral, (b) Somato-visceral (example – Light from external source would lead to constriction of Pupil), and (c) Viscero – somatic (example – If the lung alveoli are inflated with air, the afferent sensation will be transmitted *via* vagus and the motor response to arrest the action of inflatory skeletal muscles, would be relayed *via* phrenic and thoracic spinal nerve).

3. Sympathetic system works for energy mobilisation and therefore, **catablic**. It works in emergency and may be considered as a **nerve for to-day**. This is best explained by WB. Cannon in his *'fight* **and flight'** mechanism. In the face of sudden emergency the whole body is put in to alert and prepared to fight or flee keeping other bodily functions depressed. The parasympathetic system works for energy storage and therefore, **anabolic**. It works for tranquility and considered as a **nerve for to-marrow.**

4. The sympathetic and parasympathetic components are antagonistic but complementary to each other. Sometimes they work synergestically. Example – Salivary secretion (mucous component is regulated by sympathetic and the serous component by parasympathetic system).

5. Some of the tissues are provided with only sympathetic fibers alone. *e.g.*, Follicular cells of thyroid, Juxtaglomerular cells of nephrons, pineal gland and eccrine type of sweat gland.

Difference between sympathetic and parasympathetic system

Sympathetic	*Parasympathetic*
1. It consists of a pair of ganglionated sympathetic trunks, their communications, branches, plexuses and subsidiary ganglia and therefore presents definite Anatomical entity.	1. Fibers of this system use certain cranial and spinal nerves for their passage and hence presents no definite Anatomical entity.
2. The pre-ganglionic motor neurons are located in the lateral horn cells of all thoracic and few cranial lumbar segments of the spinal cord and hence known as thoraco-lumbar out flow.	2. Since its fibers pass through some cranial and some sacral spinal nerves, it is known as cranio-sacral out flow.
3. Pre-ganglionic fibers are shorter than post ganglionic fibers.	3. Pre-ganglionic fibers are longer than post-ganglionic fibers.
4. Except in Sweat glands and in most of the blood vessels of skeletal muscles, the post-ganglionic nerve endings liberate nor-adrenaline.	4. The post-ganglionic nerve endings libarate acetylcholine.
5. One pre-ganglionic neurone synapses with about 20 post-ganglionic neurons and therefore produce on wide spread but diffuse response.	5. One pre-ganglionic neuron synapses with only a few post-ganglionic neuron and therefore produced localised response.
6. Afferent fibers convey mostly visceral pain sensation.	6. Affarent fibers convay general visceral sensations and pain from pelvic viscera.
7. Controlled by posterior part of hypothalamus.	7. Controlled by anterior part of hypothalamus.
8. Works in emergency.	8. Works during tranquillity.

Major differences in the organs of nervous system in other animals

HORSE

Brain—The brain is elongated and comparatively depressed from above downwards. Medulla oblongata is longer. Avarage weight is about 600 gm. Fourth ventricle is elongated. Pons is comparatively larger. Olfactory bulb is also larger.

Spinal nerves—They are 42 pairs in number. (C_8, T_{18}, L_6, S_5 and Cy_5)

Nerves at the distal end of the limbs

Out of the two proper digital nerves of the fore limb the *lateral palmar* nerve is formed by the fibers of ulnar nerve with a small contribution of median nerve. The *medial palmar* nerve is the main continuation of the median nerve.

The distal part of the hind limb is supplied by the medial and lateral planter nerves. Both the nerves are branched from the tibial nerve.

DOG

Brain—The size is highly variable according to the breed. In general the brain is wider and thicker in comparison to other domestic mammals. The sulci and gyri are less complicated. The gyri are comparatively thick. The olfactory bulbs are well demarcated and elongated.

Spinal nerves—They are 36 to 38 pairs in number. (C_8, T_{13}, L_7, S_3 and Cy_{5-7})

Neves at the distal end of the limbs

The superficial nerves of the metacarpal/metatarsal regions are designated as common digital nerves and the deep nerves of these areas are designated as metacarpal/metatarsal nerves.

In the fore limbe, the dorsal common digital nerves are detached from radial and ulnar nerves and the palmar nerves (dorsal and metacarpal) are derived from median and ulnar nerve. Dorsal I is derived from medial branch of Radial and dorsal II, III and IV are derived from lateral branch of Radial nerve. Dorsal V is a branch of Ulnar nerve. The medial branch of Median gives rise to palmar-I and the lateral branch of Median forms palmar II and III. Palmar branch of ulnar form palmar IV and V.

In the hind limb, the dorsal common and metacarpal nerves are formed by the common fibular nerve (peroneal) which is a branch of ischiatic nerve, detached above the stifle joint. The planter digital nerves are the branches of the lateral and medial divisions of tibial nerve.

PIG

The whole brain is comparatively elongated. Olfactory bulbs are well developed. Cerebellum is broad and the lateral lobes are large. Medulla oblongata is wide. Rhinal sulcus is more laterally placed.

The spinal nerves are usually 39 pairs in number.

RABBIT

The cerebral hemispheres are narrow in front and more wide behind. The gyri and sulci are very ill developed. Olfactory bulbs are club-shaped, projecting in front of the hemispheres. Cerebellum is wide and well developed with prominent laminae. Medulla oblongata is broad. The spinal nerves are 37 pairs.

Since the number of digits in pigs and rabbits are more, there are variations in branching pattern in radial, ulnar and median nerves in the fore limb and peroneal and tibial nerves in hind limb.

FOWL

The cerebral hemispheres are pear shaped and devoid of gyri and sulci. The cerebellum has a single well organised lobe. The number of spinal nerves is 40 to 41 pairs. Optic nerve is very thick.

FUNCTIONAL DOMINANCE BETWEEN HEMISPHERES

If both the hemispheres become equaly active, there is a chance of confusion to perform a job, because both the motor and sensory pathways cross with each other. Therefore one hemisphere is dominant in function than the other. This is better understood in higher vertebrates like man. Generally the **left hemisphere is dominant** and therefore most of the people use their right hands or right legs for performing a work. This is due to the fact that the right side is under the control of left hemisphere.

However, the dominant hemisphere is concerned with linguistic expression, arithmetical and software related problems; where as the non-dominant hemisphere is concerned with geometrical arrangements and artistic thoughts including sense of music in human and proportionately in domestic pets, wild animals and birds.

9 ORGANS OF

EYE

Eye balls are the chief apparatus for vision. Each eye ball is housed comfortably in the orbit within a soft atmosphere of surrounding fat and maintained in position by the action of extra ocular muscles.

Eye lids—These are two fibrous sheets, attached to the periphery of the orbital margin which cover the anterior portion of the eye ball when it is closed. The slit between them is known as **palpebral fissure.** External angle of the fissure is thick and the inner angle is rounded. At the margin of the lids there are stiff hairs, termed cilia or eye lashes. There is a number of ciliary glands close to the margin of the lids. The ducts of these glands open near the attachments of the cilia. The eye lids are composed of skin, subcutaneous areolar tissue, fibers from orbicularis oculi muscle, tarsus (a dense plate of fibrous tissue which forms the bulk of the lid) and conjunctiva.

Conjunctiva—This is a thin transparent membrane which covers the front portion of sclera and cornea and is reflected to the inner surface of palpebra at the palpebral fissure. The palpebral conjunctiva is highly vascular. The membrane is loosely connected over the sclera and continues as corneal epithelium over the cornea.

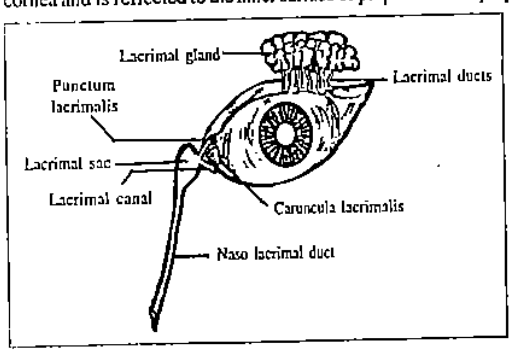


Fig. 9.1 Lacrimal apparatus.

Orbit—The bony cavity which accommodates the eye ball is known as orbit. It is roughly conical in shape with the apex inward and the base downward at the orbital margin. The cavity is formed by lacrimal, frontal, malar and sphenoid bones. The rim of the cavity is formed by frontal, lacrimal and malar bones. The supra orbital process is prominent. The whole margin is roughly serrated. The optic foramen is placed at the apex. At the ventro lateral aspect of the apex, foramen orbitorotundum is placed. Orbital opening of the supraorbital canal is situated at the dorsal wall and the ethmoid canal is situated at the medial wall.

Lacrimal apparatus

This is composed of lacrimal gland, caruncula lacrimalis, puncta lacrimalis, lacrimal canals, lacrimal sac and nasolacrimal duct. The gland is situated below supraorbital process and inside of the upper lateral margin of the orbital cavity. The gland is lobulated and tubulo-acinar in structure. The secretion (tear) is conveyed through excratory ducts (about 12 in number) to the superior conjunctival fornix. There is a triangular space at the medial angle of the eye known as **lacus lacrimalis.** Caruncula

lacrimalis is a small rounded body situated in this lacus and helps in the flow of tears in proper direction. **Puncta lacrimalis** are minute orifices of the lacrimal canal at the lacrimal papilla, situated on the margin of each lid and close to the lacus lacrimalis. The **lacrimal canals** are two in number — superior and inferior. They connect the lacus lacrimalis to the **lacrimal sac**. The sac is lodged in a fossa at the front end of the medial wall or the orbit. The **nasolacrimal duct** starts from the sac, passes through the nasolacrimal canal and opens on the external wall of the nostril.

Ocular muscles

There are seven muscles — **four recti, two oblique** and one **retractor**. The **recti** muscles are **superior, inferior, lateral** and **medial**. They help in the axial movement of the eyeball. These muscles originate around the optic foramen, proceed forward in a diverging manner and end at the corresponding area of sclera in the form of thin flat tendons. The **oblique muscles** are **superior** and **inferior**. These muscles are responsible for rotatory move-ment of the eye.

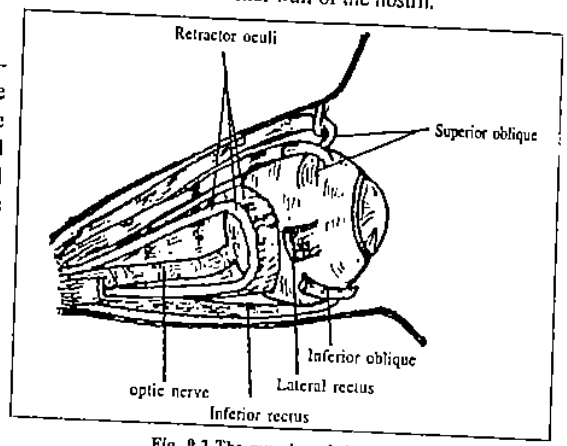


Fig. 9.2 The muscles of the orbit.

The superior oblique muscle runs along the angle between medial and dorsal walls of the orbit and lies above medial rectus. It rotates the visual axis downward. The inferior oblique arises from the floor, runs posterolaterally below inferior rectus and inserts close to that of superior oblique at the back of sclera. It rotates the visual axis upward. **Retractor oculi** originates around the optic foramen, encloses the optic nerve and inserts at the posterior wall of the sclera.

Eye ball

It is spherical in shape with a transverse diameter of about 3-4 cm. The axial diameter is slightly larger due to forward bulging of cornea. The eye ball is composed of three coats – fibrous, vascular and nervous and its contents are aqueous humour, vitreous body and lens. However, there is great variations in the shape and size of the eye ball amongst various breeds of different domestic animals and birds.

Fibrous coat

This is the outer protective and hard coat of the ball. The opaque posterior fifth sixth part is called sclera and the anterior transparent one sixth is known as cornea. The junction between the two portions is known as sclerocorneal junction.

The **sclera** is composed of white fibrous tissue intermixed with elastic fibers. Externally it is white in colour and covered in front by conjunctival mucous membrane. The internal surface is brown and has grooves. Posteriorly it is pierced by optic nerve, ciliary vessels and ciliary nerves. The optic nerve pierces the sclera just medial to the posterior pole at the **optic disc** or **blind spot** of the eye. The area has an appearance of a cribriform plate known as **lamina cribrosa sclerae**. The lamina transmits central retinal vessels along with nerve bundles. **Suprachoroid lamina**, a delicate layer occupies the

perichoroidal space between the sclera and choroid. Within the sclerocorneal junction an encircling canal or *sinus* is situated, known as **canal of Schlemm** or **Sinus Venosus sclerae**. Internally there is a projected rim of scleral tissue behind the canal known as **scleral spur**. The aqueous humour can pass from the anterior chamber to the canal through its wall and ultimately go to the venous system through the anterior ciliary veins.

The **Cornea** is a transparent membrane, convex in front, concave behind and is 1.5 mm in thickness. The central part is little thinner than the peripheral part. From before backward, it is composed of corneal epithelium, anterior limiting membrane, substantia propria, posterior limiting membrane and endothelium of the anterior chamber. It is one of the refracting media of the eye.

Vascular coat

This tunic remians between the sclera and retina and consists of choroid, ciliary body and iris.

The **Choroid** is a dark coloured thin vascular membrane composed of capillary plexuses, small blood vessels and loose connective tissue, which contains pigment cells. The choroid of animals, specially those of nocturnal habit, presents a reflecting structure, the *tapetum*, which gives a greenish glare at night.

The **ciliary body** is the anterior thickened part of choroid. This thickening is due to the presence of 70 to 80 raised ridges – the **ciliary processes**. Groups of fine fibers which originate from the grooves in between the ciliary processes and extend up to the capsule of the lens are the **suspensory ligaments of lens**. These ligaments maintain the position of the lens. The involuntary ciliary muscle lies in the depth of the ciliary body and are attached to the scleral spur. Contraction of these muscle fibers loosen the suspensory ligaments and allow the lens to become more convex and helps in accommodation.

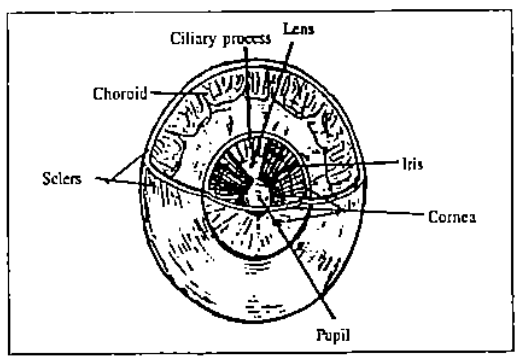


Fig. 9.3 Front view of eye ball.
(Portions of sclera cornea and iris removed)

The **iris** is the anterior continuation of the vascular tunic, which remains suspended in the aqueous humour behind cornea and infront of the lens. It is composed of fibrous stroma which contains radiating and circular muscle fibers, pigment cells, vessels and a layer of endothelial covering. The central aperture of iris is known as **pupil**. The size of the pupil is regulated by the contraction of these muscle fibers. The pigment cells which are present in the iris are responsible for the colour of the eye.

Nervous coat

This is the innermost tunic of the eye ball. This very thin and delicate membrane is called Retina. The Retina is actually a membranous expansion of the optic nerve elements. The optical part of the retina ends behind the ciliary body in a serrated border, known as **ora serrata**. It further prolongs forward as a thin membrane up to the back of the ciliary process and iris known as ciliary and iridial part of the retina. At the center of the posterior pole of the eyeball the retina presents an oval yellow

spot, termed **macula lutea**. At the middle of the macula lutea there is a depressed area named **fovea centralis** in which the sense of vision is most actue. At this point the retina is very thin due to absence of some layers of cells.

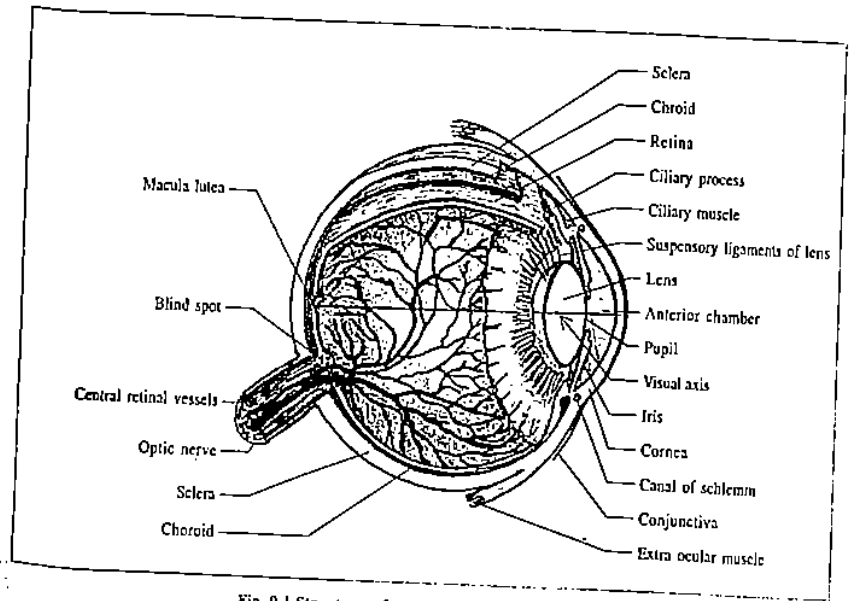


Fig. 9.4 Structure of a eye ball (Partially opened).

The **retina** is composed of nervous elements, blood vessels, pigment cells and modified connective tissue. These are arranged in 10 conventional layers – (i) Pigment cell layer, (ii) Layer of rods and cones, (iii) External limiting membrane, (iv) External nuclear layer, (v) External plexiform layer, (vi) Internal nuclear layer, (vii) Internal plexiform layer, (viii) Ganglionic cell layer, (ix) Layer of nerve fibers and (x) Internal limiting membrane. The pigment cell layer is attached to choroid and the internal limiting membrane is in contact with the hyaloid membrane. However, in these layers, the retina contains many chains of three microscopic neurons – (a) Rods and cones, (b) Bipolar cells and (c) Ganglion cells. The number of rods are three times more than cones and are also more sensitive to light. These are the end organs.

Aqueous humour

This is a clear fluid occupies both anterior and posterior chambers. The space in front of iris is the anterior chamber and the room in between iris and lens is the posterior chamber of the eye ball. The aqueous humour is secreted by the ciliary body and deposited in the posterior chamber. The fluid passes to the anterior chamber through the pupil and escapes from the iridocorneal angle to the anterior ciliary veins *via* sinus venosus sclerae and hence not a stagnant fluid. It is composed of water glucose, amino acids, ascorbic acid, *etc.*, and mediates metabolites and respiratory gases to the avascular tissue like lens and cornea. It also serves as a refractive medium. Interference in the circulation of this fluid may increase intraocular pressure and leads to glaucoma.

Vitreous body

It is a poorly set jelly like substance occupies the posterior compartment (vitreous chamber) of the eye ball and covered by hyaloid membrane. A canal is found within the vitreous body for the passage of the hyaloid artery in embryonic life roughly along the long axis of the eye is known as **hyaloid canal**. Anteriorly there is a depression for the accommodation of lense, termed hyaloid fossa. The vitreous is composed of water, salts, glycoprotein, hyaluronates and very fine fibrils. It acts as a refractive medium and helps to maintain shape and pressure of the eye ball.

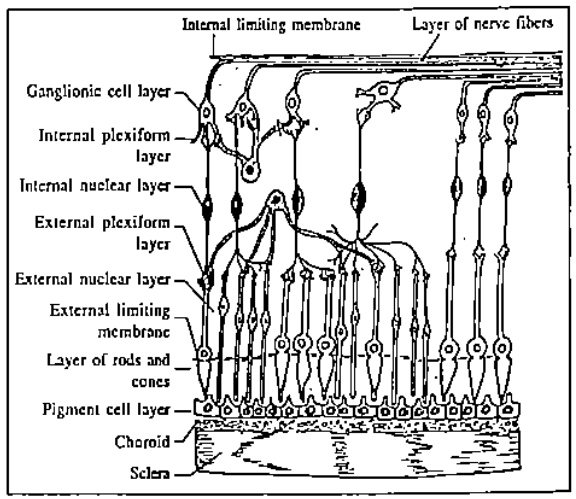


Fig. 9.5 Layers of retina.
(Retina is magnified many times in comparison to sclera and choroid)

Lens

It is a biconvex transparent disc enclosed in a capsule and is the chief refractory medium of the eye ball. It is situated behind the pupil and in front of vitreous body and held in position by fibers of the suspensory ligament. The posterior surface is more convex. It is made up of concentric layers of modified cells, which are elongated in structure. At old age the lens may become opaque and cataract occurs.

Third eye lid or Nictitating membrane

It is a piece of thin T-shaped cartilage enveloped by a fold of conjunctiva. It is situated at the medial angle of the eye. The free end is pigmented and partially moves over the anteromedial aspect of the eye ball. Palpebral surface is convex and the bulbar surface is concave. The base of the third eyelid remains surrounded by glandular tissue. This is called **Harder's gland** or **Nictitating gland** and the secretion of this gland is similar to that of Lacrimal gland.

In birds this membrane is thin, semi-transparent, elastic and without any cartilage. It is attached to the inner angle of the eye and is highly movable across the surface of the eye. The movement is controlled by muscles.

EAR

This is an organ associated with hearing and equilibrium and may be considered as vestibulocochlear organ. It comprises of three parts – External ear, Middle ear and Internal ear.

External ear

It can be divided again into two portions. (i) Auricle or Pinna and (ii) External acoustic meatus.

The **Auricle**, unlike that of human, can be moved in desired position by muscles. It is roughly an elongated funnel shaped structure, having two surfaces, two borders, a base and an apex. The anterior surface is concave, ridged and possesses the opening of external ear. Posterior surface is convex and covered by hairy skin. Upper and lower borders are thick and the apex is blunt. Base is broad and attached to the external auditory process of petrous temporal bone. There are three cartilages in the external ear. **Conchal cartilage** is large and actually forms the shape of the ear. **Scutiform cartilage** is small quadrilateral in shape. It is attached to the anterior aspect of the base of conchal cartilage. **Annular cartilage** is in the form of a small incomplete ring. It is attached to the osseous external acoustic meatus. With the help of other cartilages it forms the cartilagenous portion of the meatus.

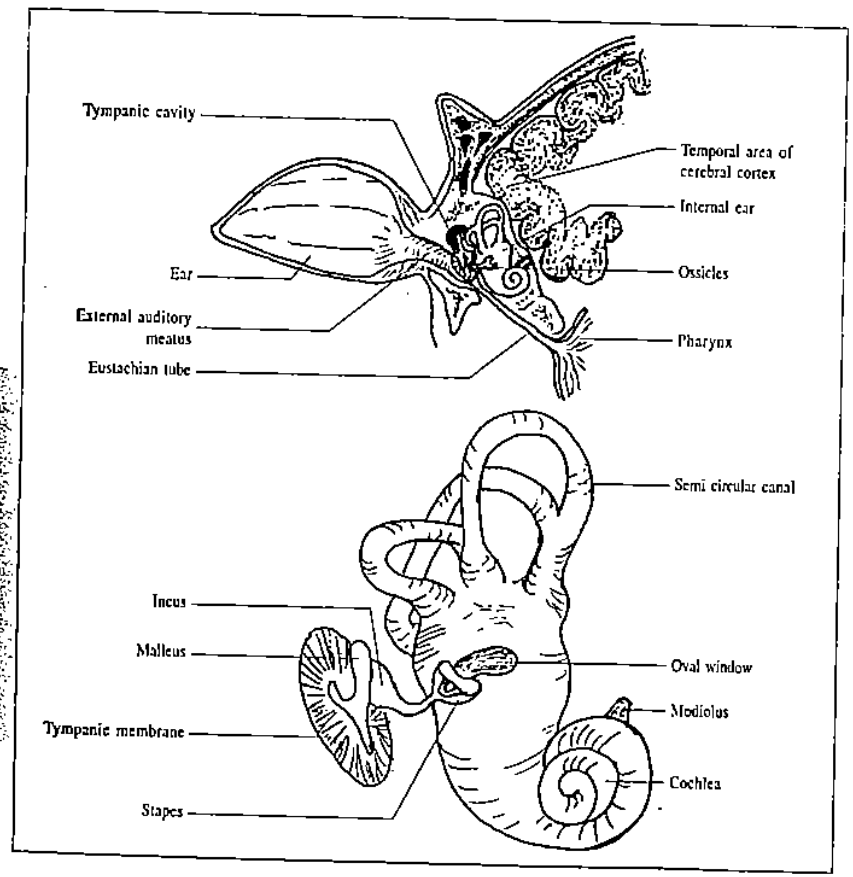


Fig. 9.6 Scheme of ear passages.

The **external acoustic meatus** is a canal which leads medially towards the middle ear. It is slightly curved ventrally and cranially. Its lateral one third is cartilagenous and medial two third is osseous. The lining epithelium of the meatus accomodates some sebaceous and sweat glands which

secret *cerumen* or ear wax. Infections of external ear is generally very painful because the skin is firmly adherent to the underlying bone and cartilage. so a little swalling due to infection causes pain.

Tympanic membrane (eardrum)

This is a thin membranous oval structure situated at the junction between the external acoustic meatus and tympanic cavity in a tilted manner and separates the two. Its diameter is about 8 to 10 mm. This membrane is composed of external cuticular, middle fibrous and internal mucous layers. It is believed that these three layers are derived from ectoderm, mesoderm and endoderm respectively. Its margin is thick and is attached to the tympanic sulcus at the end of the meatus. The lateral surface is concave and the medial surface is convex. The handle of the malleus is attached to the medial surface.

Middle ear (tympanic cavity)

It is an irregularly biconcave small space within the petrous temporal bone placed between the tympanic membrane and the internal ear. This space is also called the tympanic cavity. It contains ear ossicles, part of the chorda tympani, muscles and air. The outer wall is formed by the tympanic membrane, inner wall is formed by the lateral wall of internal ear which presents (a) **oval window** – fitted with the foot plate of stapes and (b) **round window** – closed by a membrane. The posterior wall presents opening of mastoid antrum, the air cavity in the mastoid process. The anterior wall presents the opening of a canal which lodges the tensor tympani muscle and another opening of the Eustachian or **auditory tube**. The auditory tube maintains atmospheric pressure in the middle ear by its communication with the pharynx and for the same reasons throat infection occasionally spread to middle ear.

Tympanic ossicles are three in number. They are very small bones (Malleus, Incus and Stapes) arranged in a chain to connect the tympanic membrane with oval window of internal ear. These are the smallest variety of bones in the body.

Malleus—It is a hammer shaped bone which presents a head, neck, a short process and a long process or the handle. The long process is attached to the tympanic membrane and the head articulates with incus.

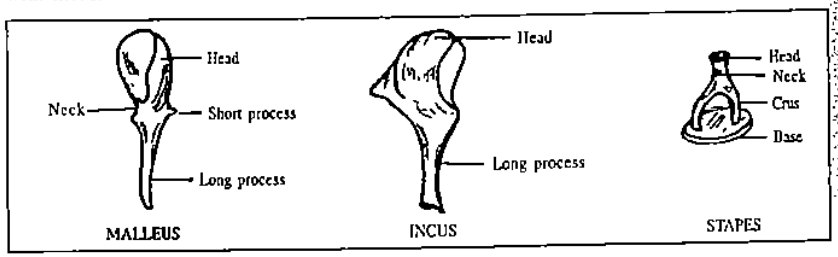


Fig. 9.7 Auditory ossicles.

Incus—It is an anvil shaped structure, presents a head and a long process. The head articulates with that of malleus. The long process articulates with the head of the stapes with the help of lenticular process.

Stapes—This stirrup shaped bone has a head, neck, two crura and a base. The base is fitted at the oval window at the lateral wall of internal ear. The bones articulate together with the help of ligaments.

The muscles of the tympanic cavity are tensor tympani and stapedius. The tensor tympani originates from the petrous temporal bone and inserts to the head of the malleus. It keeps the tympanic membrane tense and curved inwards. Stapedius originates from the posterior wall of the tympanic cavity and is inserted to the neck of the stapes.

Chorda tympani is a branch of facial nerve which enters the middle ear through the posterior canaliculus, crosses the cavity between the malleus and incus, reaches the anterior wall and makes its exit by anterior canaliculus.

Internal ear

It is the main portion of the organ of hearing and situated within the petrous temporal bone. It consists of a osseous **labyrinth** (excavation) which accommodates almost similar shaped membranous structure – the membranous labyrinth. The space between the two Labyrinths are filled with a fluid, known as **perilymph** which resembles cerebrospinal fluid.

The bony labyrinth comprises of (a) vestibule, (b) cochlea and (c) semicircular canals.

Vestibule

It is a bony cavity placed medial to the tympanic cavity. It is continuous with the cochlea in front and semicircular canals behind. The oval window (fenestra vestibuli) is situated at the lateral wall. The medial wall is perforated for the passage of the filaments of vestibulocochlear nerve and aqueduct of vestibule. This aqueduct is extended through the petrous part of temporal bone. Three semicircular canals are attached by five orifices at the posterior part of the vestibule. The cavity of the vestibule lodges the utricle and saccule of membranous labyrinth.

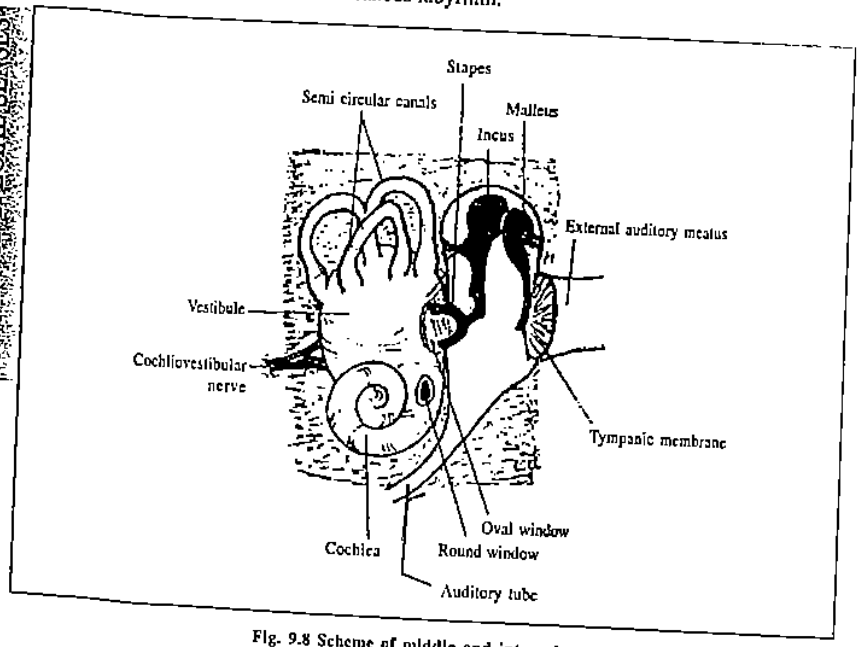


Fig. 9.8 Scheme of middle and internal ear.

Cochlea

It is a bony spiral canal winds two and a half turn around a osseous *modiolus* and has a appearance of a shell of a snail. A bony spiral lamina projects from the modiolus makes an incomplete partition within the canal which is completed by the basilar membrane. The modiolus along with its lamina looks like a threaded screw. The basilar membrane extends from the edge of the lamina to the outer wall of the canal and thus divides the canal into scala vestibuli and **scala tympani**. These two scalae are continuous at the apex of the cochlea, termed **Helicotrema**. **Aqueduct of cochlea** is a minute duct extends from the scala tympani towards the jugular foramen below internal acoustic meatus through the petrous temporal bone which brings the perilymph within the bony Labyrinth. The perilymph is probably originating from three sources : (a) From surrounding blood vessels as a transudate, (b) From cerebro spinal fluid, (c) From fluids surrounding 8th cranial nerve.

Semicircular canals

These are three in number – (a) Superior or anterior, (b) Posterior and (c) Lateral. They are curved tubes placed at right angles to each other. These canals are about 25 to 30 mm long and join with the vestibule by five openings. The anterior and posterior canals have a common opening. The terminal parts of the tubes at their junctions with the vestibule are dilated to form ampullae.

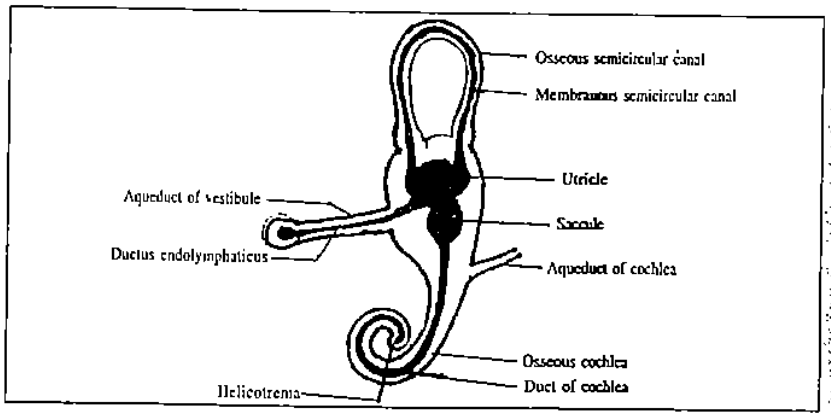


Fig. 9.9 Scheme of ducts in the internal ear.

Membranous Labyrinth

It includes (a) Cochlear duct, (b) Saccule and utricle and (c) Three ducts of semicircular canals. **Ductus endolymphaticus** extends from saccule and utricle through aqueduct of vestibule and terminate in a cavity which acts as a safety expansion sac. The sac of this endolymphatic duct lies under duramater. The cavity of the membranous labyrinth is filled with endolymph. Utricle is larger than saccule. They communicate with each other by utriculosaccular duct. The membranous semicircular canals have same shape as the osseous canals. The membranous cochlea is the scala media which is formed by the basilar membrane, Reissners (vestibular) membrane and periosteum of bony cochlear wall. This spiral tube contains endo lymph and the organ of Corti, the sense organ of hearing.

Organ of Corti

This organ is situated on the basilar membrane. It contains hair cells, tunnel of corti, tectorial membrane and spiral ganglion. The organ is winded spirally throughout the length of the membranous cochlear duct.

The **hair cells** are placed on the basilar membrane in an outer and an inner row. The inner cells are arranged in a single line and the outer cells are arranged in four lines. The outer and inner *rods of corti* unite at the upper ends and thereby enclose the **tunnel of corti.** The hair cells are situated on either side of the corresponding rods. The hairs of the hair cells project through the perforations of a reticular lamina formed by the processes of the supporting cells which remains in between the hair cells. The **tectorial membrane** is attached to the outer border of spiral lamina. It is made up of gelatinous substance and overhangs the hair cells.

Spiral ganglions are situated on the bony spiral lamina. Its bipolar cells receive fibers from the bases of inner and outer hair cells. The axons of these spiral ganglionic nerve cells constitute the cochlear division of the auditory nerve.

Formation of Impulse

The sound waves recived by the external ear is propagated to the perilymph of internal ear by the tympanic membrane and ossicles of middle ear.

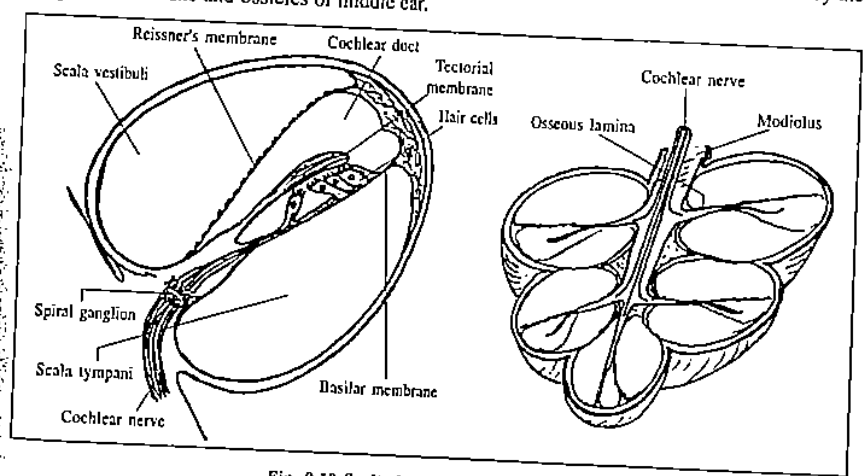


Fig. 9.10 Sagittal section through cochlea.

As the hair cells are placed on the basilar membrane, a part of it will vibrate accordingly on receiving stimulus by different sounds. Apex will respond to lower and the base will respond to higher tones. This vibration of hair cells will result in bending of the hairs due to shearing motion between reticular membrane and tectorial membrane. This will produce stimulus to the nerve endings of the spiral ganglionic nerve cells whose axons form the cochlear nerve.

NOSE

It is the peripheral organ of smell which comprises of the outer nose and nasal cavaties. The outer nose is situated at the midline of face and composed of a bony and cartilagenous framework.

Externally it is covered by skin and internally lined by mucous membrane. The nasal cavaties left and right are irregular and separated by septum nasi, open in front by **anterior nares** and behind by **posterior nares. The olfactory epithelium** is that part of the nasal epithelium which is sensitive to smell and is limited to the ethmoturbinates, adjacent part of the dorsal nasal concha and nasal septum. Dog being a macrosmatic (having acute smell sensations) animal has a large olfactory area.

The olfactory area contains rod shaped receptor (bipolar) cells. The dendrites of the olfactory rods again form projecting cilia. When the particles of odoriferous substances come in contact with the cilia of receptor cells, generator potentials are developed. When sufficient potentials are developed, it is propagated to the olfactory bulb through the axons of these receptor cells.

INTEGUMENT

Skin

The skin of cow is about 3 to 4 mm thick. The thickness varies from region to region. The colour, size and thickness of the hairs are highly variable. The mane is absent. The end of the tail presents long hairs in the form of brush. The sweat and sebaceous glands are less in number. Below the mazzle there is a layer of nasolabial glands. Tactile hairs are found on the lips, nostrils, eye lids and on the external ear. In this animal the subcutis contains some striated muscle fibers which are attached to the skin but not with the skeleton. Contraction of these muscles cause twitching of the skin.

Structure of skin

The skin consists of a superficial layer — the Epidermis and a deep layer — the **Dermis.**

The **Epidermis** is composed of the following layers of alls from outside inwards :

I. Stratum corneum—This is the surface most layer and continuously shed off. It is composed of dead cells without nuclei and contain keratin. Thickness varies from region to region.

II. **Stratum lucidum**—This layer is thin and not always evident. It appears as a thin translucent layer. It is composed of flattened cells containing **Eleidin,** the precursor of keratin.

III. **Stratum granulosum**—It is composed of several layers of rhomboidal cells which contain many **keratohyaline** granules.

IV. **Stratum spinosum**—This layer is thick and composed of multiple layers of polyhedral cells. The cells have spine like process on their surfaces and therefore called **prickle** cells. The peripheral cells divide to form the cells of stratum granulosum.

V. **Stratum basale (Germinativum)**—A single layer of cuboidal or columnar cells on a basement membrane form this layer. There cells divide to produce new generation of cells and pushed towards the surface giving rise to stratum spinosum. **Malanocytes,** the melanin pigment containing cells are present in this layer.

This lalyer along with same **prickle cells** invaginale in the form of blunt projections in the dermis.

The **Dermis** is the true skin and composed of a superficial papillary layer and a deep reticular layer.

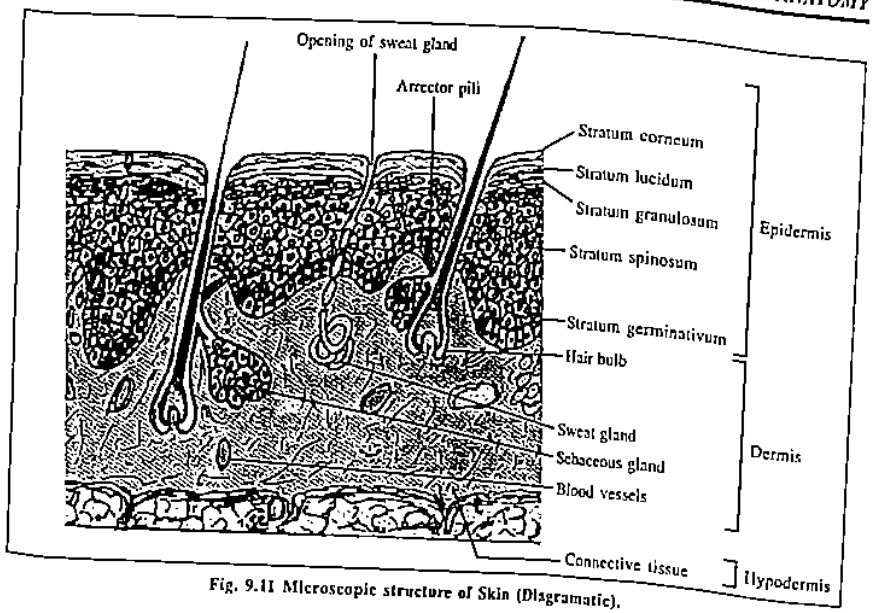


Fig. 9.11 Microscopic structure of Skin (Diagramatic).

I. The **Papillary layer** is compact and project in the form of blunt finger like papillae into the epidermis. This layer contains blood vessels, nerve endings and lymphatic.

II. The **Reticular layer** binds the skin with deeper structures and composed of reticular and elastic fibers impregnated with fat and loose areolar tissue. This layer accommodates hair follicles, glands, some smooth muscles and cells like fibroblasts and histiocytes.

Hair—Hairs are thread like structures, developed from epidermis. They are keratinised appendages of the skin and has a shafts and a root. Since the hairs are developed from the epidermis, the down growths expand to form **hair bulbs.**

Erection of hairs occur due to contraction of some very small smooth muscles — the *arrectors pilorum.* These muscles are situated in the dermis and are attached to the hair follicles of long tactile hairs.

Each bulb is invaginated by a condensed mesoderm in the form of projection, called papilla. **Root sheath** is formed by the cells which are remaining at the parietal layer around the bulb and is the continuation of surface epidermal layer. The shaft has a central cornified part the medulla and a cortex.

Glands

Sweat glands—These are present all over the skin except in some places like glans penis, tympanic membrane, etc. These are of two types—(a) Merocrine and (b) Apocrine.

Merocrines are long tubular coiled glands and produce sweat. Apocrines are modified sweat glands situated at the axilla, ext-anditory meatus, mammary gland, etc. and start functioning after puberty.

Sebacous glands are small alveolar glands which open at the hair follicle. These glands produce sebum. These are pear shaped glands and remain close to the bulbs of hair.

Hoof

The hoofs are the hard and horny coverings of the ends of the digits. There are two chief and two accessory hoofs on each limb. The chief hoof comprises of three parts—(a) Periople, (b) Wall and (c) Sole. This hard covering is the modification of the epidermis of that region.

The periople is a soft, flat, light coloured band which surrounds the coronary (upper) border of the hoof. This is about 1 cm thick. In the heels the band widens to cover the large convexity of the bulb.

The wall presents two surfaces. The abaxial surface is convex and presents transverse ridges. The axial surface is slightly concave. These two surfaces join at the toe. Towards the bulb the walls become thin.

The sole is slightly concave and placed at the ground surface of the hoof. Caudally the sole is continuous with the periople of the bulb.

Nails, claws and hoofs, etc. consist of hardest keratin. Keratin is synthesized primarily by stratified squamous epithelia. It is a fibrous albuminoid protein and relatively hard, elastic and resistant to friction.

Corium of foot

The corium or dermis of the foot is highly modified and vascular tissue which addopt the shape of the corresponding outer coviring. Accordingly its different part are called perioplic corium, Coronary corium, Laminar corium, Solar corium, etc. The laminar corium receive the horny lamellae of the wall. As the hoof is not a vascular structure, it derives nutrition from corium.

The **digital cuslion** is a modified subcutaneous tissue which helps in minimising concussion. It remains in the form of a fatty elastic tissue in between the corium of bulb and the flexor tendon.

The two *accessory digits* are placed a little above and behind the corresponding the chief hoofs. Each of them comprises of a conical horny covering and a corium. The corium covers a nodular vestigial phalanx which is connected to the third phalanx and sesamoid bones and the elastic pad of the heel by some fibers.

Horns

The cornual processes of the frontal bones are enclosed by a horny covering. The horns as a whole form various curvatures and shape. Sometimes the shape and size are specific to the breeds. The horny cover is thin at the base and thickest at the apex. At the base, it presents a soft horn which is identical to that of perioplic band of hoof. The corium of horn is remaining in between the horn and the periosteum. It presents papillae of variable sizes. In some breed of animals the horns are absent.

Nerve supply—Cornual nerve, a branche of ophthalmic of 5th cranial nerve.

Blood supply—Cornual artery, a branch of superficial temporal artery of external carotid.

HORSE

Skin

1. It is far thiner than that of cow.
2. Sweat and sebaceous glands are well developed.

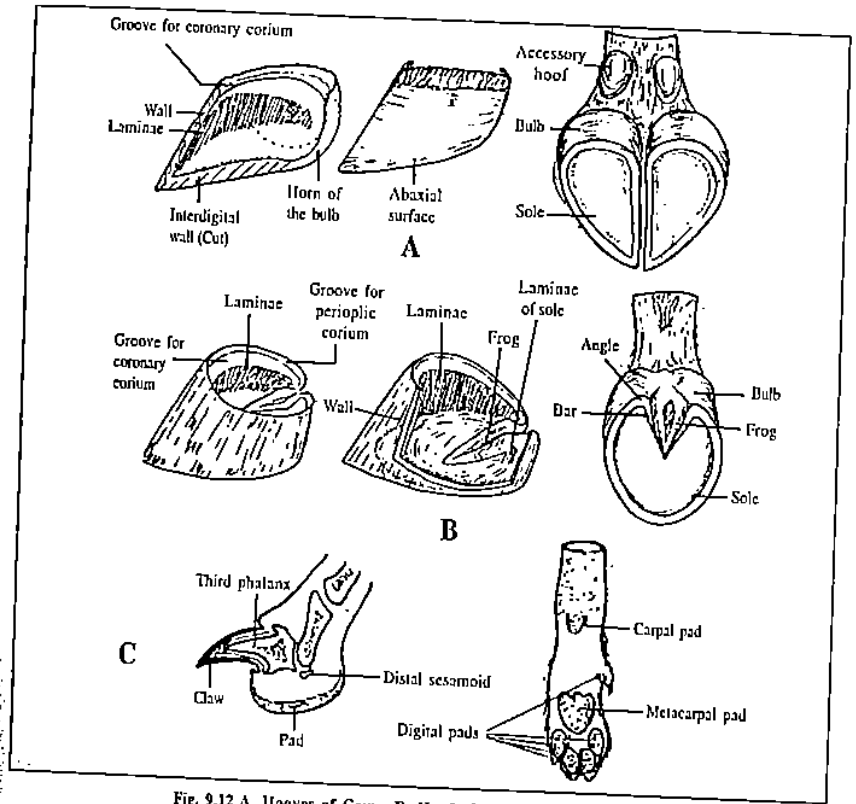


Fig. 9.12 A. Hooves of Cow, B. Hoof of horse, C. Claw of dog.

3. The dorsal border of wither, neck and forehead presents long hairs. This is the mane of the horse.

4. The tail bears long hairs, typical to the species.

Hoof

1. There is only one hoof for each limb.
2. The hoof is well built and presents the wall, sole and frog.
3. The lamina and corium are well developed.
4. The wall is reflected at the back on either side at acute angles to form bars.
5. In between the bars a wedge shaped structure is present. This is known as frog. It presents two surfaces, a base and an apex.

Ergots—Small horny areas placed at the postero-medial surfaces of all the four fetlock joints are known as ergots. They are considered as vestiges of second and fourth digits.

Chestnuts—These are masses of horns situated a little above on the medial surfaces of carpus and tarsus in all the four legs. These are considered as vestiges of the first digit.

DOG

Skin

1. The skin is loose with the variable thickness.
2. Sebaceous glands are well developed.
3. The palmar surfaces of carpus, metacarpus and digits are hareless and bear pads. The pads are composed of fibroclastic tissue, fat and a thick keratinized epidermal covering.
4. The sizes of the hairs are highly variable from breed to breed.

Claws

1. There are five claws in a limb, one for each digit.
2. The horn of each claw covers the concerned third phalanx and presents a body and a sole.
3. They are curved downward.

PIG

Skin

1. The skin of pig is thick due to accumulation of subcutaneous fat, the panniculus adiposus.
2. The hairs on the skin is sparse.
3. The epidermis of snout is very thick.
4. Subcutaneous glands are less in number.

Hoof

1. They resemble the hooves of cow.
2. Hooves of accessory digits are well developed.
3. Digit 4th is larger then digit 3rd.
4. Bulb of hoof is larger in size.

RABBIT

Skin

1. It is very soft due to presence of moderate amount of subcutaneous fat.
2. The hairs are long and soft and cover most of the skin except the muzzle.
3. The tail is covered by thick soft hairs.
4. Sebaceous and swate glands are moderate in number.
5. Palmar surface of foot bears pads.

Claws

1. They are elongated and curved downwards.
2. The tips are blunt.
3. The claws are five in number, one for each digit.

FOWL

Skin

1. The appandages of the epidermis of fowl are—comb, wattles, ear lobes, feathers, scales and claws.
2. Beaks are the horny covering of upper and lower jaws.
3. The distal end of metatarsus presents the metatarsal spur. It is capped by horny covering.

10 ENDOCRINE GLANDS

These are ductless glands or glands of internal secretion. The glands contain epithelial cells supported by reticular fibers and plenty of capillary plexus. These glands secrete hormons and some useful chemical substance into the blood capillaries. These glands may be of (a) cord and clump type or (b) follicular type. In cord or clump type of glands, the cells are arranged in the form of cords or clumps. The secretions are directly delivered to capillaries. In follicular type of glands, the secretions are stored in follicles and subsequently absorbed into the blood.

HYPOPHYSIS CEREBRI (PITUITARY GLAND)

This is an oval reddish grey coloured body about the size of a large pea situated in the sella turcica of sphenoid bone, connected at the base of the brain with a stalk and enclosed by duramater. Actually an extension of duramater while enclosing the gland, roofs the sella turcica is known as diaphragm sellae. The pituitary stalk passes through a small aperture in the diaphragm. It consists of two lobes – anterior lobe and posterior lobe. The gland is developed from Rathke's pouch, as a glandular up-growth of premitive buccal ectoderm and a neural down growth from third ventricle. The stalk of Rathke's pouch disappears and the stalk of neural downgrowth persists as infundibulum (pituitary stalk).

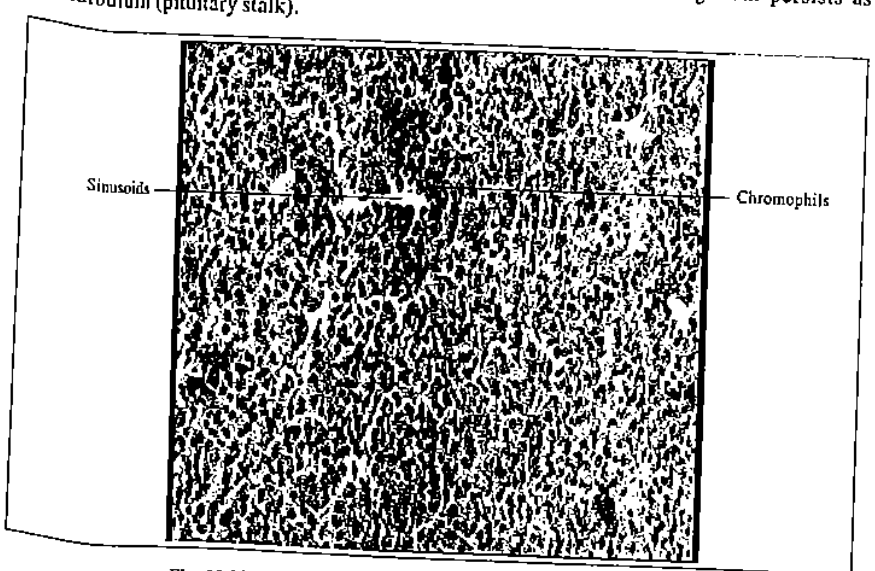


Fig. 10.1A Histological section of anterior pituitary (Pars anterior).

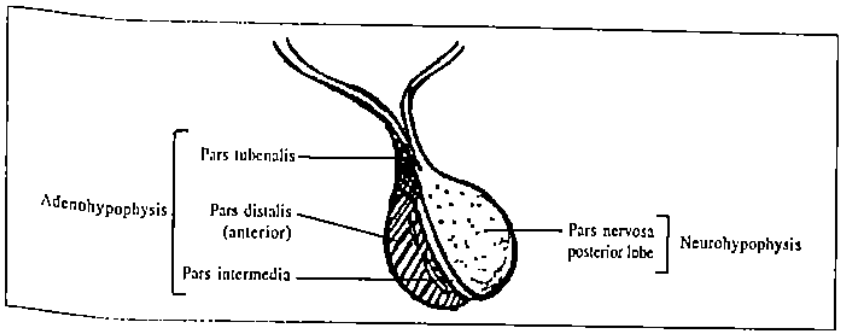


Fig. 10.1B Different portions of Pitultary gland.

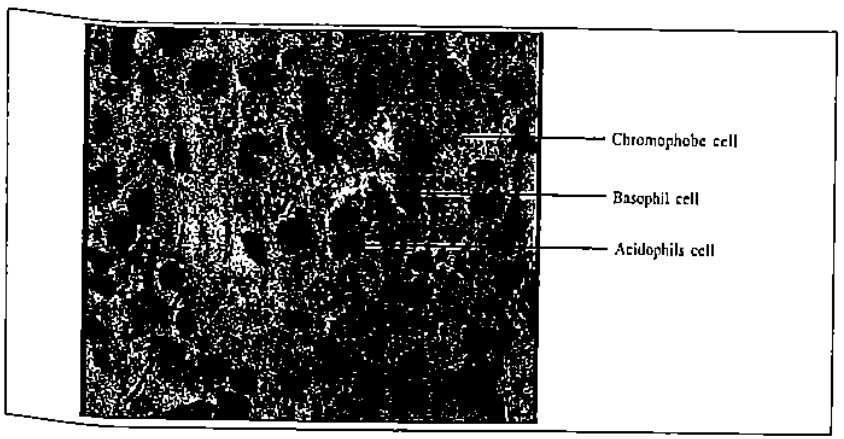


Fig. 10.2 Histological section of pituitary gland (Higher magnification).

The portions which are developed from the Rathke's pouch are included under the term **Adenohypophysis**. These are (a) Pars distalis or Pars anterior, (b) Pars tuberalis and (c) Pars intermedia. These parts constitute the major and important portion of the gland.

The **Neurohypophysis** includes (a) Pars nervosa (posterior lobe) and (b) Infundibulum. However, pars anterior and pars tuberalis constitute anterior lobe and pars nervosa and pars inter media constitute posterior lobe of the gland.

Pars anterior is composed numerous cells arranged in interlacing cords or clusters with some connective tissue stroma mainly of reticular fibers and abundant blood vessels.

Depending upon the staining reactions these cells have been classified into two types. The cells which have very little affinity for stain are called **chromophobes**. They form 50% of the total population. They are mostly devoid of secretery granules. These cells are smaller in size. The other cells have the property of staining with acid or basic dyes and called **chromophils**. The chromophil cells which take acidic stains are known as **acidophils**. In hematoxylin and eosin, these cells appear pink. They secret Gwoth hormone (GH) and prolactin (PRL). Basophil cells take basic stain. They stain darker than acidophils with hemotoxylin and eosin. The basophil cells secret Adrenocorticotrophic hormone

(ACTH), Thyroid stimulating hormone (TSH), Follicle stimulating hormone (FSH), and Luteinising (LH)/Interstitial cell stimulating hormone (ICSH).

Pars tuberalis is composed of cuboidal cells and exhibit similar histological features to that of pars anterior.

Pars Intermedia is separated from pars anterior by a cleft, the remnants of Rathke's pouch. It contains small basophil cells of polyhedral shape. They secret Malanocyte stimulating hormone (MSH).

Pars Nervosa is the main component of posterior pituitary have the appearance of nerve tissue. The cells (pituicytes) look like glial cells. They are elongated in shape and possess long processes. This neurohypophysis also contains the dilated ends of the axons of hypothalamo-hypophyseal tract. These nerve terminals are known as **Herring bodies.**

Blood supply—Branches from left and right carotid arteries and circle of Willis supply this gland. A second set of blood circulation in the organ occurs *via* portal system of veins. It convays the releasing factors from hypothalamus to influence the secretory activities of adenohypophysis.

Nerve supply—The anterior lobe is controlled by neurohumoral mechanism and the posterior lobe is communicated by hypothelamo hypophyseal tract.

In other domestic animals and birds no much appreciable difference is observed other than size.

ADRENAL (SUPRA RENAL) GLANDS

These are two in number. Each one is situated close to the cranial aspect of corresponding kidney. In the ruminents the right one is V shaped and the left one is C shaped. The right one is placed at the medial aspect of the cranial end of the right kidney and lodged in the renal impression of liver. The left one is placed on the midline about 6 cm anterior to the cranial end of left kidney and behind the cranial mesenteric artery. Average weight of these glands is about 10 gm. Whole gland is covered by a capsule.

The gland comprises of an outer cortical part and an inner medullary part. The cortex is derived from mesoderm and comprises of three histological zones – (i) zona glomerulosa (outer), (ii) zona fasciculata (middle) and (iii) zona reticularis (inner). Medulla is ectodermal in origin. It is composed of irregularly arranged masses of polyhedral cells. These cells are granular and surrounded by blood sinuses.

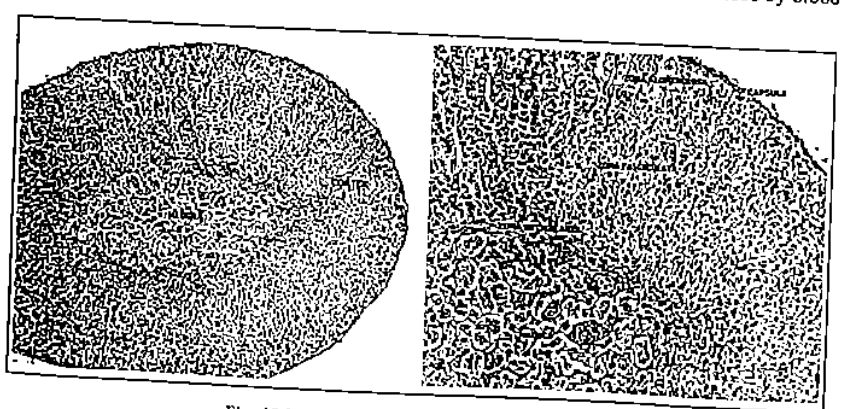


Fig. 10.3 Histological section of Adrenal Cortex.

Blood supply—Branches of renal artery and lumbar artery.

Nerve supply—From adrenal plexus.

In the horse both the glands are situated at the medial aspect of the cranial pole of the corresponding kidneys. Right gland is comma shaped and the left gland is little shorter. In dog the right adrenal gland is triangular with the base directed cranially. The left gland is elongated and in the form of the figure eight. In the fowl these glands are placed cranial to the corresponding kidneys. They are roughly oval or triangular in outline.

THYROID GLAND

These are two triangular dark brown coloured glands situated at the ventrolateral aspect of the junction of larynx and trachea. Both the gland are connected ventrally by isthmus which traverses the ventral aspect of the trachea at the level of 2nd ring. Medial surface is related to cricoid cartilage and first one or two tracheal rings. Laterally it is related to muscles, carotid artery, internal jugular vein, vagus nerve and esophagus.

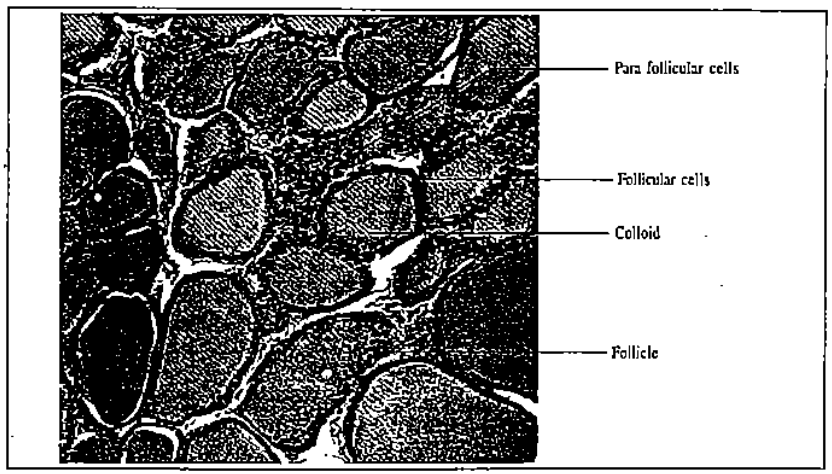


Fig. 10.4A Histological section of Thyroid gland.

Each glands is encapsulated by connective tissue covering with rich plexus of capillaries. The gland is composed of large number of follicles of various sizes. In between the follicles there are para follicular cells. The follicles are spherical in shape and lined by a single layer of glandular epithelium. These cells are simple cuboidal or short columnar depending upon their content—a colloid substance called thyroglobulin. The cells have micro villi and pinocytic vesicle on the luminal surface. The parafollicular cells are arranged in single or in cluster form but are found within basement membrane but outside the follicular cells.

Blood supply—Cranial and caudal thyroid arteries.

Nerve supply—Sympathetic fibers from cervical ganglion and parasympathetic fibers from recurrent laryngeal nerve.

In the horse these glands are situated on either side of the trachea and just behind the larynx. They are oval in shape and connected by isthmus. In dog they are oval-elongated and flat structures situated at the lateral aspect of first six tracheal cartilages. Caudal ends are generally connected by glandular isthmus. The isthmus is inconstant.

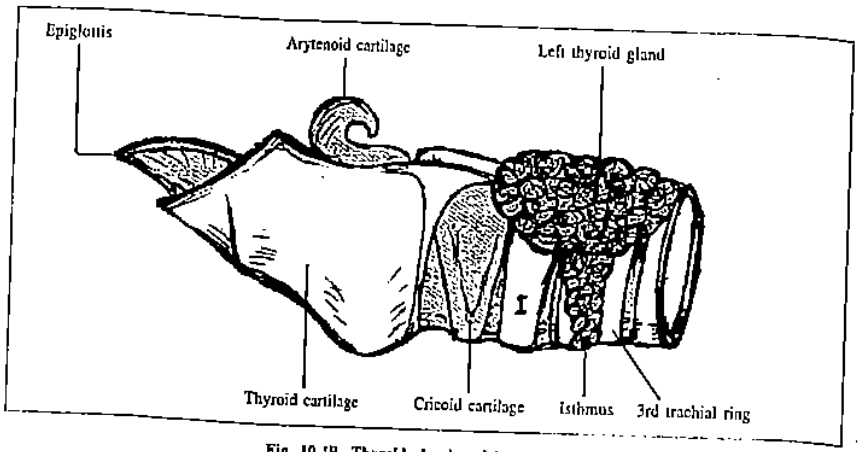


Fig. 10.4B Thyroid gland and its relation.

In the fowl these are two reddish-dark coloured round small bodies situated at the ventral aspect of the common carotid artery close to the thoracic inlet.

PARATHYROID GLANDS

These are four (2 cranial and 2 caudal) reddish yellow coloured small bodies situated at variable positions, close to the thyroid gland. They may be closely associated with the thyroids. Generally cranial glands are located cranial to the thyroid glands and the caudal glands are located at the caudal edges of the corresponding thyroid gland.

Blood supply—Similar to that of thyroid glands.

Nerve supply—Sympathetic fibers from cervical ganglia.

Pancreas
Ovary
Testis
Pineal gland
} Described in the Concerned chapters

11 WILD ANIMALS
(A Brief Anatomical Note)

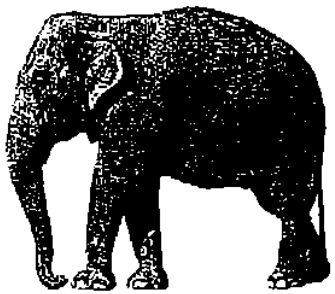
In this chapter some informtaion on the gross anatomy of few common wild animals has been presented. The idea behind such presentation is to help field veterinary doctors to provide some basic anatomical knowledge who have to encounter wild animals for the purpose of treatment including surgery or for performing post-mortem. So far I understand, in most of the circumstances the veterinary doctors have to perform such jobs by using only philosophical knowledge on the subject because such references are not available in the standard text book of veterinary anatomy.

However, this chapter does not include every details of various organ systems but only some important comparative points which were searched from existing literature, books, some museum specimens and from internet. So the information provided here may not be exact but very closed to it and I am sure, it will serve some purpose as stated above. Moreover, the wild animals are numerous and all could not be accommodated here and only few selected animals (**Elephant, Tiger, Deer, Camel, Monkey, Rhinoceros** and **Crocodile**) have been chosen which are commonly found in the country.

Some species specific structures like *Tusk* and *Trunk* of elephants, *Horns* of rhinoceros, *Antlers* of deer, *Hump* of camel, *Canine tooth* of tiger, *Foramen of Panizza* in crocodile, etc. are important and interesting subject to the anatomists. In this chapter only the special anatomical features have been mentioned while describing an organs or a body part.

It may also be noted that structural variations do exist amongst the animals of same species and threfore data which have been provided in this chapter are on the basis of average findings and has been described as per zoological anatomy rather than Medical / Veterinary Anatomy.

Suggestions for improvement and corrections in this regard will be highly appreciated.



ELEPHANT

Skeletal System

Vertebral Formula

African elephant : Cervical - 7, Thoracic - 20-21, Lumbar - 3, Sacral - 5, Coccygeal - 19-21.

Asian elephant : Cervical - 7, Thoracic - 19-20, Lumbar - 4-5, Sacral - 4-5, Coccygeal - 24-33.

Ribs

They are 20-21 pairs in African elephant and 19-20 pairs in Asian elephant. The first rib is very wide at the distal part.

Sternum

It is composed of 5 sternebrae arranged in three segments.

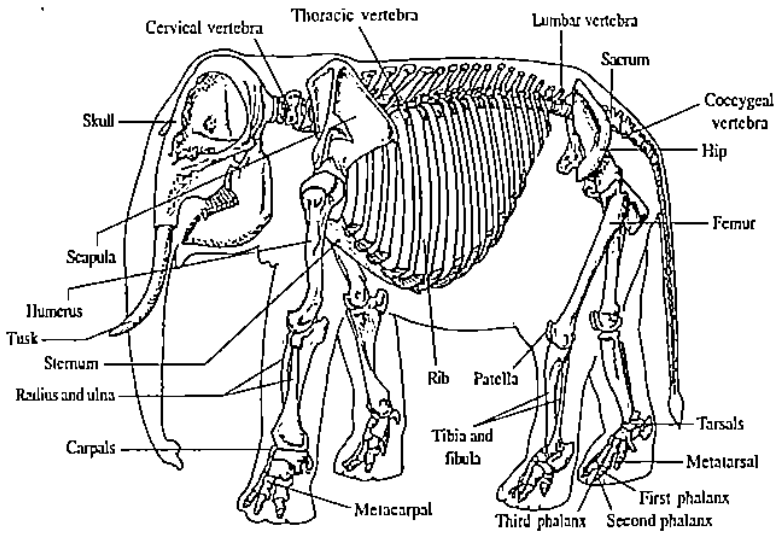
1	2-4	5

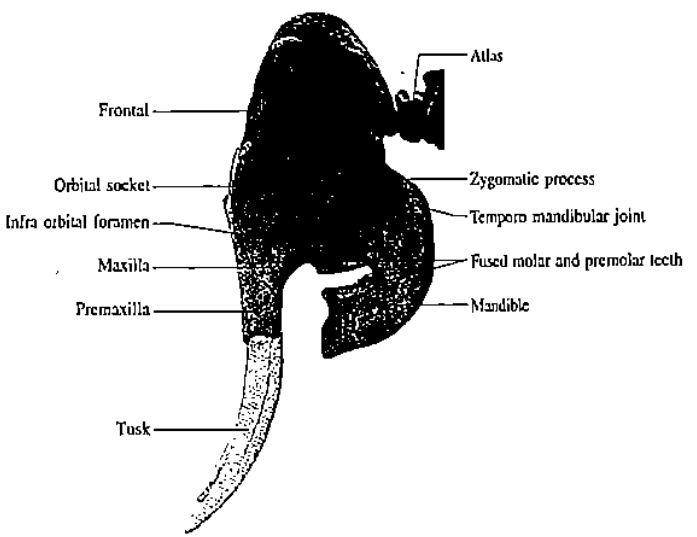
Skull

It is volumnus. Cranial cavity is small and situated at the back of the skull, well away from the forehead. Most of the bulk of the forehead is formed by numerous large hony comb like spaces. Orbital rim is incomplete and continuous with temporal fossa. Coronoid process of mandibul is small and does not insert much into the temporal fossa.

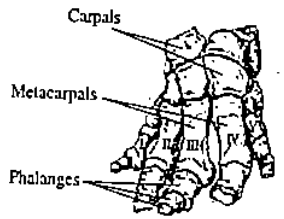
Limbs

Scapula presents well developed spine which is extended backward. Radius and Ulna are almost separated but remain in close contact. Ulna is massive. Number of carpal bones is eight and that of





Metacarpal bones are five. There are four bones at the proximal row and four bones at the distal row in carpus. Tarsal bones are tibial tarsal, fibular tarsal, central tarsal at the proximal row and 1st, 2nd, 3rd and 4th tarsal at the distal row. Number of tarsal bones is seven and that of Metatarsal bones is five. Each digit have three phalanges. Tibia and fibula are separate and interosseous space is wide. Tibial tuberosity is bifid like that of horse.



Dental formula

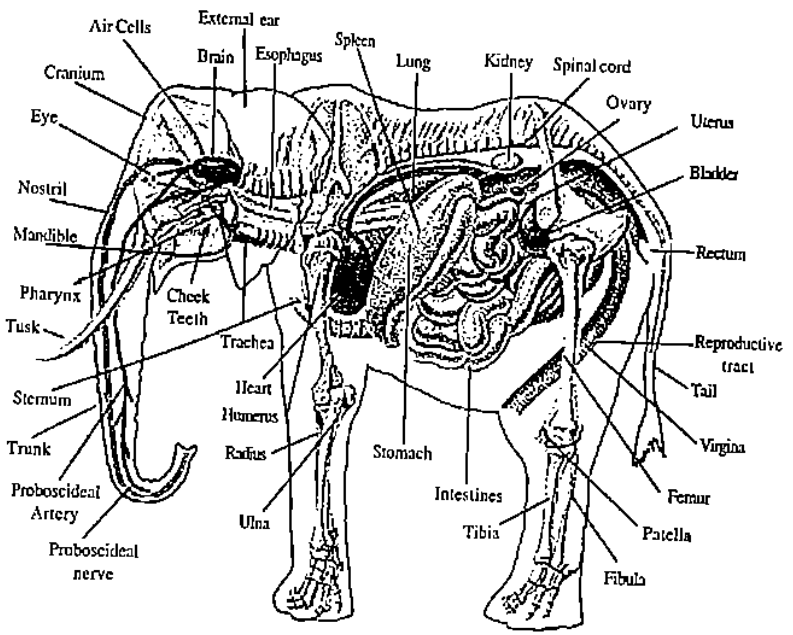
$$I\frac{1}{0}\quad C\frac{0}{0}\quad P\frac{3}{3}\quad M\frac{3}{3}$$

The cheek teeth are generally fused. The enamel and dentin of these teeth are intricately interfolded. The enamel is disposed on ridges on enormous plateaus of naked dentin. These teeth are termed *Lophodont*.


Cheek Teeth

Tusks

These are the extended and elongated incisor teeth. The tusks are found in both male and female African elephants. In Asian elephants only the males have tusks. In some breeds tusks are absent both in male and female. The tusks grow throughout the life. Ivory is the dentin of the tooth.



Trunk

It is an extension of the nose with two nostrils running through the whole length along with the upper lip. It is made up of skin, muscles and lining mucous membrane. A good number of muscles form the bulk of the thick wall of the trunk.

Heart

Heart is a large apple shaped structure with double ventricular apices. The weight ranges from 12-21 kg.

Stomach

It is simple but cylindrical in shape. The average capacity is 30-70 liters. The fundus is dilated. The whole of the structure is situated at the left side of the abdomen and closely applied to the diaphragm.

Intestine

It is composed of Duodenum (1.5 ft.), Jejunum (11 ft.), Cecum (5-7 ft.), Colon (20-22 ft.) and Rectum (12-14 ft.).

Liver

Liver is volumnus and ***devoid of Gall bladder***. There are multiple bile ducts. It is placed at the right cranial part of the abdomen.

Kidneys

Kidneys are multilobar. Each kidney is composed of 5-7 lobes and situated at the sublumbar region.

Testes

Testes are tennis ball shaped in structure and **intra-abdominal** in position. They are situated behind the corresponding kidney.

Penis

It is elongated, without sigmoid flexure and about 2 meter in length.

Uterus

Uterus is bicornuate. *Vulva* is situated in the inguinal region.

Mammary glands

The glands are two in number and located pectorally like primates.



RHINOCEROS

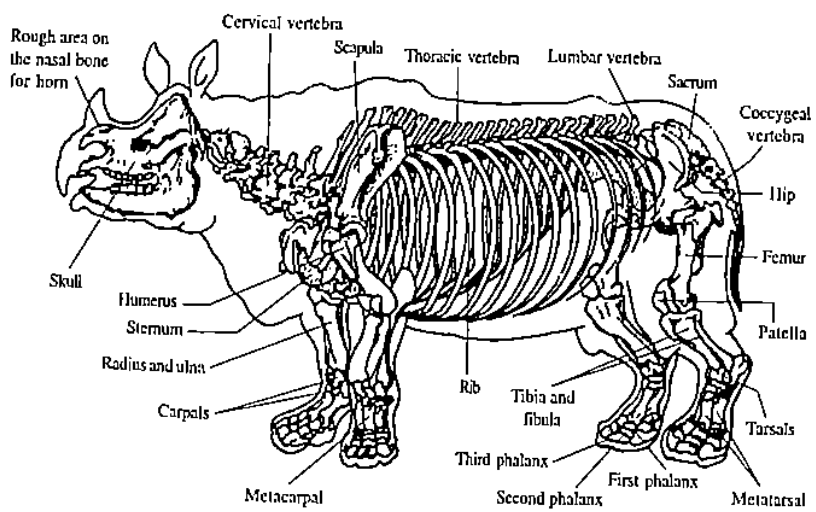
Skeletal System

Vertebral Formula

Cervical - 7, Thoracic - 18-19, Lumbar - 4, Sacral - 5, Coccygeal - 5-10.

Ribs

They are 18-19 pairs in number. The bodies are mostly rounded in shape. They are extended along the major part of the body barrel and cover a considerable part of abdomen.

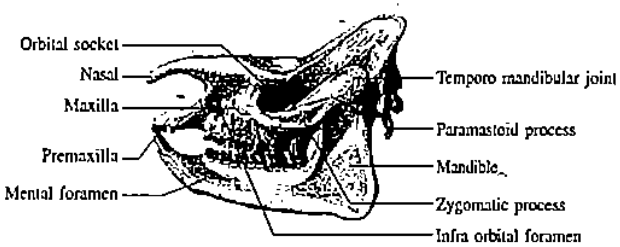


Sternum

It is boat shaped and laterally compressed. All sternebrae are fused.

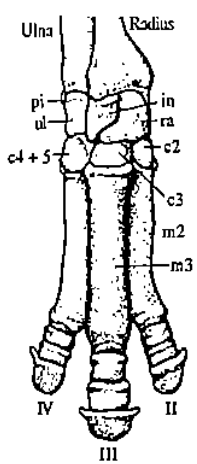
Skull

It is compact and very hard. Nasal bones are fused and extended over the pre-maxilla. Cranially the nasal bone bears roughness which marks the position of the horn. Orbital rim is incomplete and the orbit is continuous with the temporal fossa. Both the upper and lower jaws bear teeth.

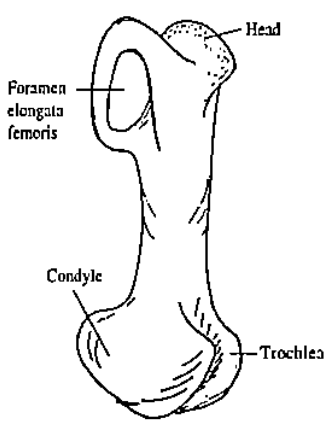


Limbs

Scapula is flat club shaped rather than triangular. The scapular spine is large but blunt. Deltoid tuberosity of humerus is well developed and sharp. Radius and ulna are separate. Ulna is well developed and massive. Olecranon process is broad. Carpal bones are 7 in number, 4 at the proximal row and 3 at the distal row. There are 3 metacarpal bones and each metacarpal bears three phalanges. Middle digit is massive and strong. The Ilium of hip bone is very large. The femur is massive. In one horn Indian rhino, the trochanter major and 3rd trochanter have joined together and thereby formed an oval elongated space which may be termed as *foramen elongata femoris*. Tibia and fibula are separate. Fibula is ill developed. Tarsal bones are tibial tarsal, fibular tarsal, central tarsal, 2nd, 3rd and 4th tarsals. Metatarsals and phalanges are similar to those of fore limb.



Carpals and digits of rhino.
ra – Radial Carpal, pi – Pisiform, in – Intermediate Carpal, ul – Ulnar Carpal, c2-c4 – Carpals of distal row m2-m4 – Metacarpals



Femur of one horn Indian rhino.

Horn

Horn of this animal is made up of keratin and grows continuously. It is fixed firmly at the rough area on the fused nasal bones which over hangs premaxilla. Unlike other animals the horn does not have a bone core. Since this structure is composed of agglutinated keratinized hair like epidermal fibers and form a solid man, it is called *Hair horn*. Horns are found in both males and females and are not shed. Some African rhinoceroses have two horns and placed one behind other.



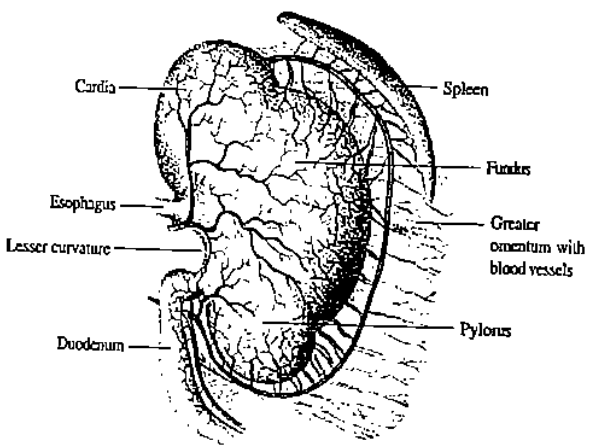
Hair Horn

Dental formula

$$I\frac{1}{1}\ C\frac{0}{1}\ P\frac{3}{3}\ M\frac{3}{3}$$

Stomach

Stomach is simple but the cardia, fundus and pylorus are demarcated by grooves. Lesser curvature is short and therefore the esophagus and the pyloric end are closely situated. The pylorus is smaller in comparison to that of other herbivores.



Stomach of Rhinoceros

Spleen

It is elongated in shape. The organ is broad above and narrow below. It is situated close to the cardia along the greater curvature.

Liver

It has four distinct lobes and a papillary process. ***Gall bladder is absent.***

Kidneys

Kidneys are lobulated. Each kidney possesses about 80 lobules. Renal papillae are absent.

Testes

Testes are ellipse shaped structures placed at the inguinal region. Average weight is about 1.3 kg.

Penis

It is less elongated and about 15 cm in length.

Uterus

Uterus is bicornuate.

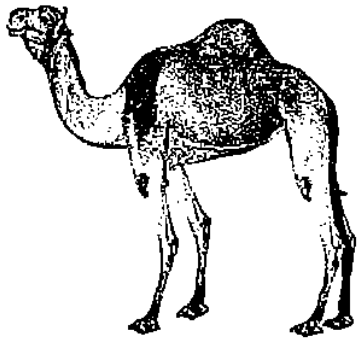
Heart

The shape resembles to that of buffalo and the weight is about 9.5 kg.

Mammary gland

The paired glands are inguinal in position.

WILD ANIMALS



CAMEL

Skeletal System

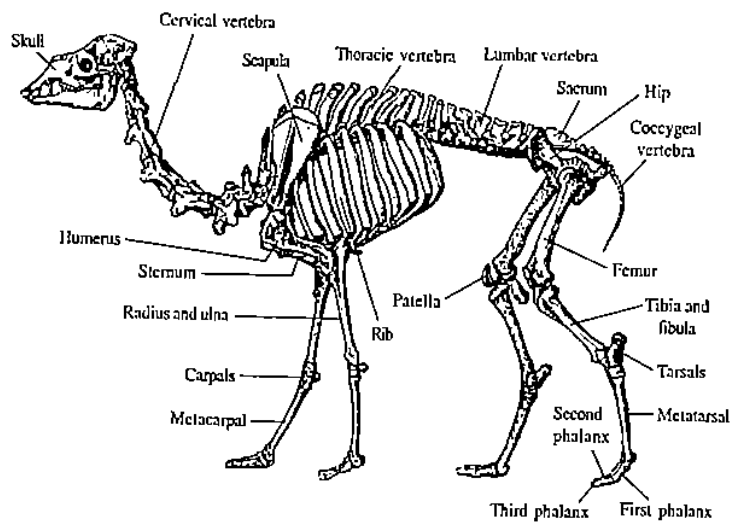
Vertebral Formula

Cervical - 7, Thoracic - 13, Lumbar - 6, Sacral - 5, Coccygeal - 10-15.

Cervical bones are elongated.

Ribs

Eleven pair of ribs are found. They are mostly flat. Last two are floating. Thoracic cage is small in comparison to other mammals.

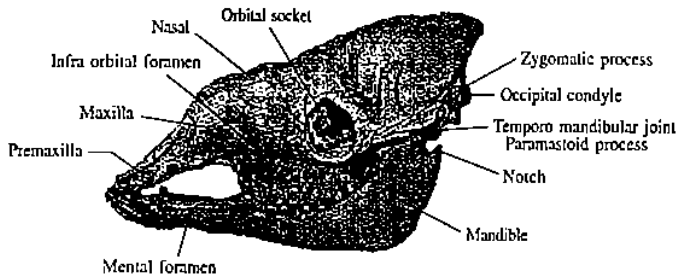


Sternum

It is laterally compressed backward and dorsoventrally compressed (flat) in front.

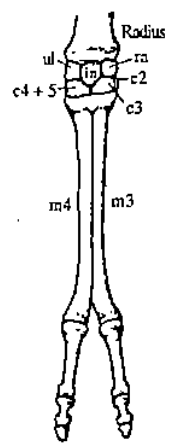
Skull

It is anteriorly tapered and triangular in front. Orbital margin is complete. Nasal bones are short. Maxilla is upwardly placed and thereby the gap with the mandible in this place is more. Zygomatic process is prominent. Frontal bone is short. Interparietal bone is extended backward. Temporal fossa is not deep. Maxilla and pre-maxilla are long. Ventral turbinates are well developed. Mandible is massive and rami are fused rostrally. Parietal crest is prominent. Hamulus is developed. Mandible presents a deep notch below and behind the condyle.



Limbs

Limbs are almost similar to those of cow. Radius and Ulna are totally fused without having any interosseous space. Sometimes, proximal interosseous space is found in the form of a large foramina. Carpal bones are seven in number, four at the proximal row and three at the distal row. Proximal bones are radial carpal, intermediate carpal, ulnar carpal and accessory carpal. Distal row bones are 2nd, 3rd and 4th. There is only one large and long metacarpal bone which bears two condyles at the distal end. Functional digits are two representing 3rd and 4th. Phalanges are three for each digit. Tarsal bones are six in number. They are tibial tarsal, fibular tarsal, central tarsal, 1st tarsal, 2nd and 3rd fused tarsal and 4th tarsal. Fibula is rudimentary. There are two proximal sesamoid bones in each digit. Inter condyloid clefts both in metacarpal and metatarsal are deep and extended upward.



Carpals and digits of camel.
ra – Radial Carpal, in – Intermediate Carpal, ul – Ulnar Carpal, m3-m4 – Fused metacarpals 3rd and 4th, c2-c5 – Distal row carpals.

Dental formula

$$I\frac{1}{3}\ C\frac{1}{1}\ P\frac{2\text{-}3}{1\text{-}2}\ M\frac{3}{3}$$

Hump

Hump is situated on the back *i.e.* over the thoraco-lumbar region. It is composed of masses of fat without any corresponding curvature at the vertebral column. The bulk of the hump serve the purpose of reserver of nourishment.

Stomach

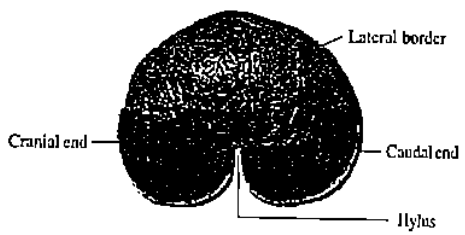
Camels possess ruminant stomach. Although 4 compartments are present but from out side 3 comparments are visible. The internal structures differs from those of ox and sheep. The wall of the first compartment (rumen) accommodates a number of little pouches which store water, called water cells.

Liver

It is composed of five lobes – left lateral lobe, left medial lobe, right lobe, caudate lobe and quadrate lobe. ***Gall bladder is absent.***

Kidneys

They are bean shaped and smooth surfaced. Hylus is situated deep at the medial border. Both the dorsal and ventral surfaces are convex. Lateral border is more convex.



Ventral surface of the kidney of camel.

Testes

Oval elongated testes with large sized epididymis are placed within the scrotal sac which are situated at the inguinal region.

Penis

The penis is long and presents a sigmoid flexure maintained by retractor penis muscle. The tip is hook shaped. The orifice of prepuce is directed caudally and for this reason camels urinate backward.

Ovaries

They are flattened and lobulated.

Uterus

Uterus is bicornuate. The shape is like the letter 'T' than classical 'Y' shape as found in other bicornuate mammals.

Mammary gland

The udder of camel cow has four quarters with its own teat. They are situated in the inguinal region. Each teat contains two streak canals.



MONKEY (Chimpanjee)

Skeletal System

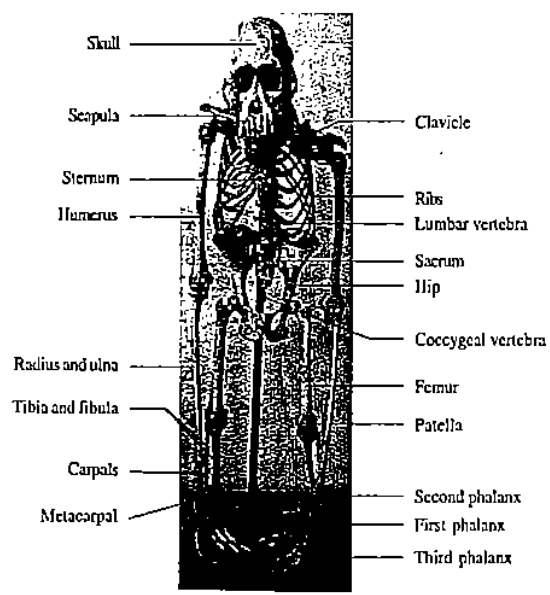
Vertebral Formula

Cervical - 7, Thoracic - 11-12, Lumbar - 5, Sacral - 5, Coccygeal - 4-40.

Thoraco-cervical region of the vertebral column is bent forward. Sacrum is almost vertical in position. Due to change of pelvic diaphragm, the pelvic inlet is directed upward.

Ribs

There are eleven to twelve pairs of ribs. Sometimes one or two floating ribs are found. Clavicles are well developed and extend from shoulder to first sternebra.

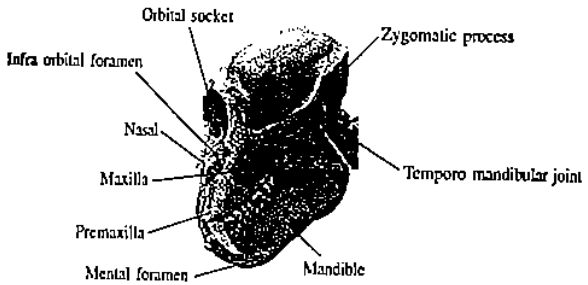


Sternum

Sternum is flat and expanded at the upper part to articulate with first pair of ribs and clavicle.

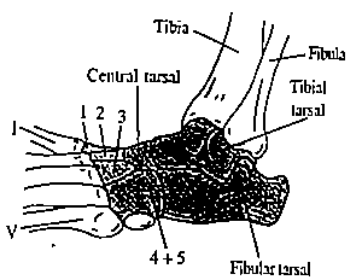
Skull

Cranial cavity is large. Foramen magnum is ventrally placed. Maxilla and Mandible are extended forward. Nasal bones are short. Parietal bone is extensive. Frontal bone is dome shaped. Orbital rim is complete. Rami of the mandible are fused.



Limbs

Fore limbs are comparatively long and free from the body at the level of shoulder joint. Coracoid and acromion processes are developed. Radius and Ulna are separate. Number of crpal bones is eight, four at the proximal row and four at the distal row. Digits are five. Excepting 1st, all digits possess three phalanges each. First digit have two phalanges. Hind limbs are free from the body at the level of hip joint. Natural swing of the limbs are increased. Hip bone and hip joints are larger and provide partial support to the trunk. Tibia and fibula are separate. Tarsal bones are seven in number. Tarsals metatarsals and phalanges together partially support body weight and at the same time remain partially opposable.



Tarsus of monkey
1-5 – Distal row tarsal bones
I-V – Meta tarsals

Dental formula

$$I\frac{2}{2}\ C\frac{1}{1}\ P\frac{3}{3}\ M\frac{3}{3}$$

Structure of canine teeth varies from breed to breed.

Stomach

Stomach is simple and without any proventicular or non glandular part. Pylorus is little elongated. Shape is almost identical to that of human.

Liver

There are four lobes in the liver. These are Median (largest), Right lateral, Left lateral and Caudate. Gall bladder is present.

Kidneys

Kidneys are smooth surfaced and bean shaped.

Testes

They are ovoid in shape and situated in the pendulus scrotal sac at the inguinal region. Seminal vesicles are pyramidal and the prostate is conical in shape.

Penis

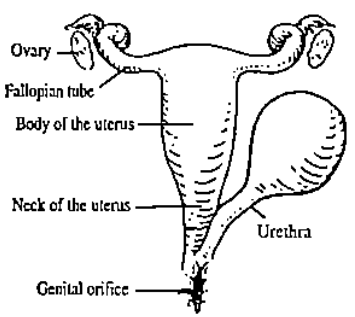
It is elongated and prismatic in appearance.

Ovaries

These are oval elongated structures, smooth surfaced in young and rough surfaced in adults.

Uterus

It is a pear shaped sac like structure, identical to that of human and situated in the pelvic cavity. Due to maximum fusion of muellerian ducts in monkey and human the oviducts become short, horns are not developed and thus simplex uterus is formed.



The uterus and bladder of monkey.

Mammary gland

One pair of pectoral mammary glands are present. Structures are identical to those of human or bitch.



DEER

Skeletal System

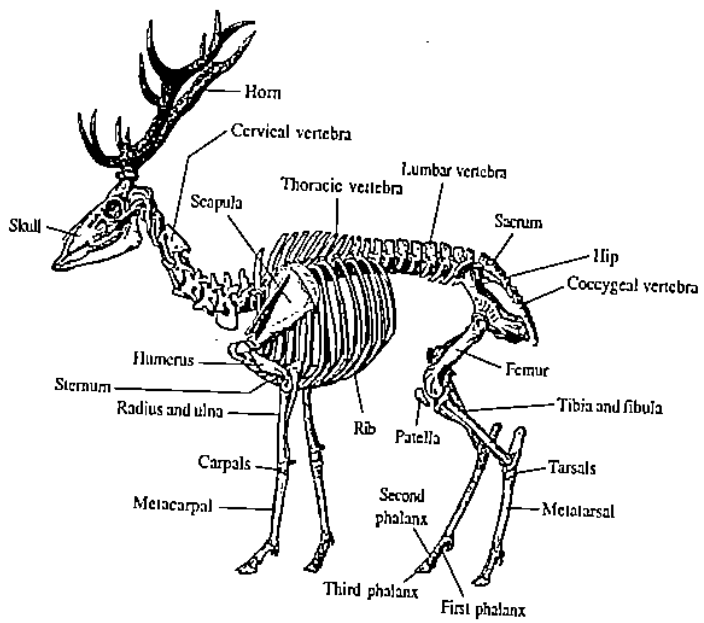
The whole of the skeleton is identical to that of large goats, but some variations are found.

Vertebral formula

Cervical - 7, Thoracic - 12-13, Lumbar - 7, Sacral - 4-5, Coccygeal - 5-15.

Ribs

Ribs are twelve to thirteen pairs in number. They are mostly flat. Floating ribs are also found.

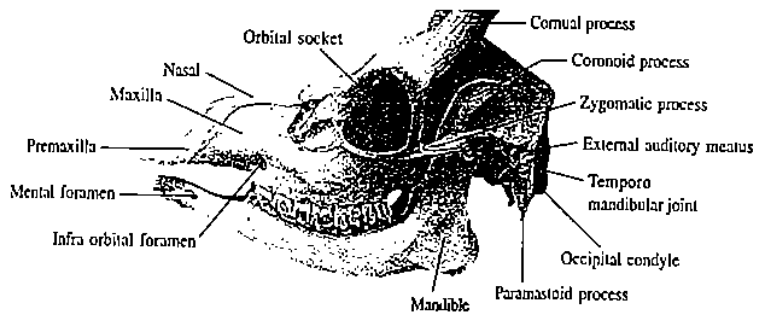


Sternum

Sternum is boat shaped and laterally compressed. All sternebrae are fused.

Skull

Nasal bones are short. Orbital margin is complete, round and wide. No alveolar socket at the premaxilla. Zygomatic process is prominent. Maxilla is well built. Infraorbital foramen is prominent. Cornual processes are present in males and extend from frontal bones. Premaxilla is extended forward. In some breeds, the beginning of the naso-lacremal canal is exposed. Angle of the jaw is extended backward. Horizontal part of ramus of mandible is long and the coronoid process is extended upwards.



Horns (Antlers)

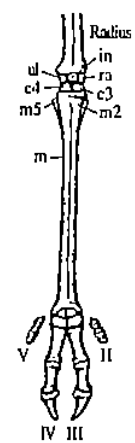
They are present in male animals and are often branched. These are the bony projections from the frontal bone and remain covered by a sheve of keration. However, new growing horns are covered with soft vascular skin and velvety hair. The antelars generally shed annually which is dependent on androgenic concentration of the body. The branching pattern as well as curvatures are highly variable from breed to breed.

Limbs

Radius and ulna are fused. Interosseous space is present. There are six carpal bones arranged in two rows. The large metacarpal bone has been formed by the fusion of 3rd and 4th. Two small vestigial metacarpals are present representing 2nd and 5th. There are two main digits having three phalanges each and two vestigial digits. Tarsal bones are six in number. Lateral malleolus is present. Metatarsals and digits are structurally similar to those of fore limb.

Dental formula

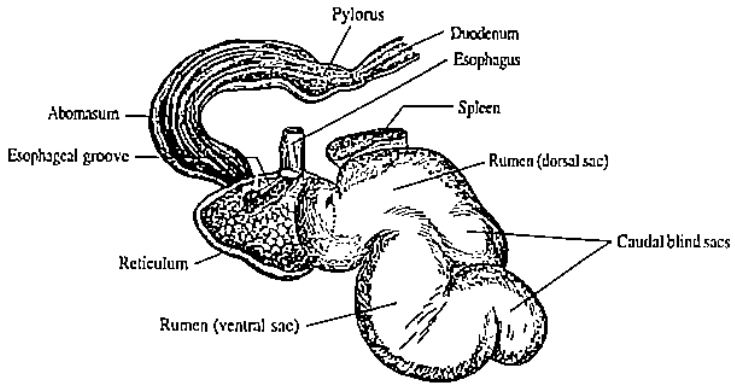
$I\frac{0}{3}\ C\frac{1}{1}\ P\frac{3}{3}\ M\frac{3}{3}$ Canine teeth are ill developed.



Carpals and digits of deer.
ra – Radial Carpal, in – Intermediate Carpal, ul – Ulnar Carpal, m – Large metacarpal (3rd and 4th fused), m2 and m5 – Small metacarpals, c3 and c4 – Distal row carpals, II and V – Vestigeal digits, III and IV – Developed digits.

Stomach

It is identical to that of small ruminants, *i.e.* sheep and goat. Rumen, reticulum, omasum and abomasum are ill defined from outside. Abomasum is in the form of a elongated and expanded tube. Ventral sac of rumen is larger than dorsal sac.



Liver

Gross structure of liver is identical to that of ruminants but no gall bladder is found in most of the breeds.

Kidneys

Kidneys are smooth surfaced and bean shaped.

Testes

They are vertically placed within the scrotal sac which is situated at the inguinal region between thighs.

Penis

This is in the form of a cylindrical fibro-muscular structure like small ruminants but without any sigmoid flexure.

Uterus

Deers have bicornuate uterus. Uterine caruncles are very less in number. Sub-urethral diverticulum is absent.

Mammary gland

Mammary glands are two in number and identical to those of sheep and goat. However they are comparatively smaller in size.



TIGER (BIG CAT)

Skeletal System

The whole of the skeleton is identical to that of cat, but some variations are found.

Vertebral formula

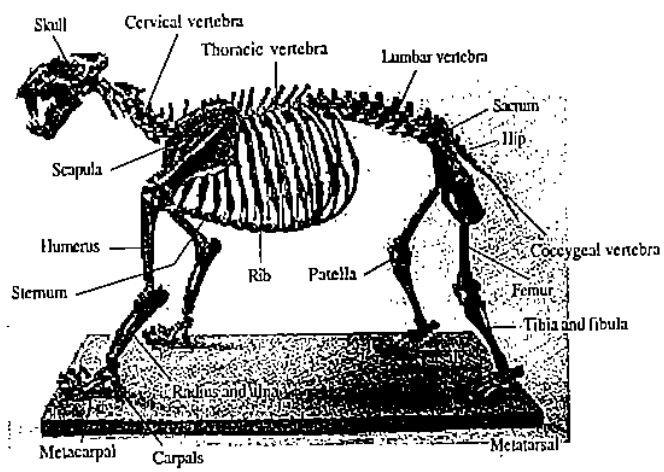
Cervical - 7, Thoracic - 13, Lumbar - 7, Sacral - 3, Coccygeal - 10-30.

Ribs

There are thirteen pairs of ribs. The bodies of the ribs are round and not flat as found in other animals.

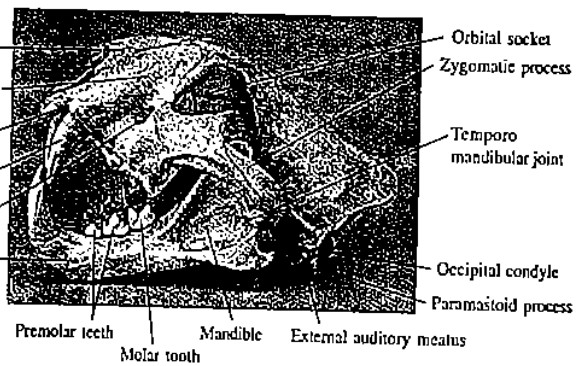
Sternum

Rod shaped sternebrae, numbering eight to ten form the sternum. The sternebrae are not completely fused with each other.



Skull

Frontal bone is short and diamond shaped. Parietal bone is large. Maxilla is well built. Zygomatic process is curved and strong. Orbital ring is incomplete. Nasal bones have extended process anterolaterally at the margin of the nasal opening. Infra orbital foramen is large. Mandible bears a fossa at the lateral aspect and a hook like projection at the angle of jaw. Bulla tympani is oval and strong. Paramastoid processes are short. Interparietal bones are fused each other and has formed a dorsal projection.



Limbs

Scapular spine is blunt. Radius and ulna are separate. Carpal bones are seven in number. There are five digits having three phalanges each except the 1st. The third phalanx (claw) is in the form of a laterally compressed cup with a central hook. Tibia and fibula are also separate. Number of tarsal bones is also seven. 4th tarsal is long. Metatarsals and digits are similar to those of fore limb.

Dental formula

$$I\frac{3}{3}\ \ C\frac{1}{1}\ \ P\frac{3}{2}\ \ M\frac{1}{1}$$

Upper molar and last premolar are peg shaped with a broad base. Lower molar is boat shaped and premolars are crown shaped. Canine teeth are very strong and look like a curved spear. Upper jaw canines are longer than those of lower jaw.

Stomach

The shape of the stomach is identical to those of cat and dog and possesses all the features – cardiac, fundic and pyloric parts. It is pyriform in appearance. Greater curvature and lesser curvature are prominent. Constriction between fundic part and pyloric part is absent. The interior presents numerous longitudinal as well as some irregular folds.

Liver

Liver consisted of five lobes – right lateral, right central, left lateral, left central and caudate. The gall bladder is situated in the right central lobe.

Kidneys

Kidneys are bean shaped but surface is marked with faint grooves arranged in a diverging manner from hilus to periphery. Colour of the organ is comparatively reddish.

Testes

These oval shaped structures situated obliquely behind the inguinal region and below the anus. The scrotal sac is little blackish in colour.

Penis

This is in the form of a cylindrical fibro-muscular structure and contains os-penis. Bulbus glandis is not developed. Sigmoid flexor is absent.

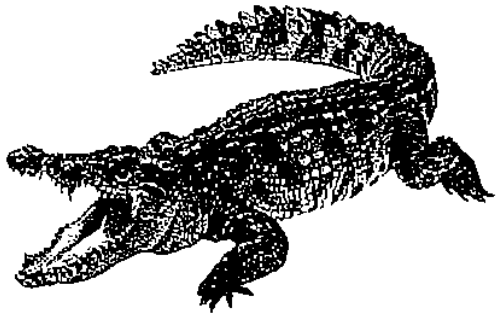
Uterus

Tigress has bicornuate uterus. Ovaries are not lobulated. The horns are long and extended forward in the form of a structure 'V'.

Mammary gland

Mammary glands are five pairs, two pectoral, two abdominal and one inguinal.

WILD ANIMALS



CROCODILE

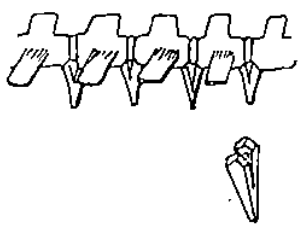
Skeletal System

The skeleton of this reptile is an elongated structure with flat and broad skull and extended tail. The thoracic cage is dorso-ventrally compressed. The limbs are short in comparison to trunk.

Vertebral Formula

Cervical - 6-7, Thoracic - 11-15, Lumbar - 3, Sacral - 2, Coccygeal - 30-35.

The bodies of the vertebrae are convex caudally unlike those of mammals. At the tail 'V' shaped ventral spines are attached with the concerned facets of the two consequtive coccygeal vertebrae at the ventral aspect of the bodies. Supra spinous processes of most of the vertebrae excepting those of cervical and coccygeal groups are quadrilateral in shape.

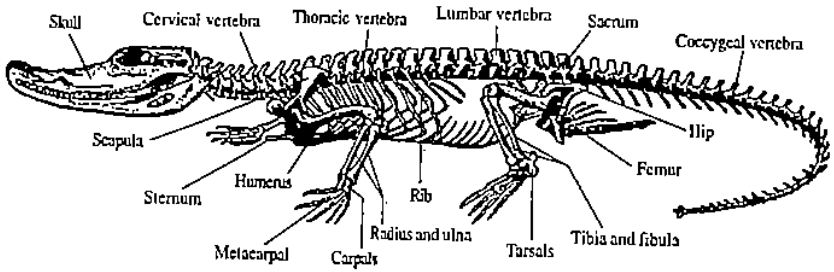


Ribs

The number of ribs is normally 14 pairs. Presence of few cervical ribs and few floating ribs are found. Clavicles are developed and flat at the ends.

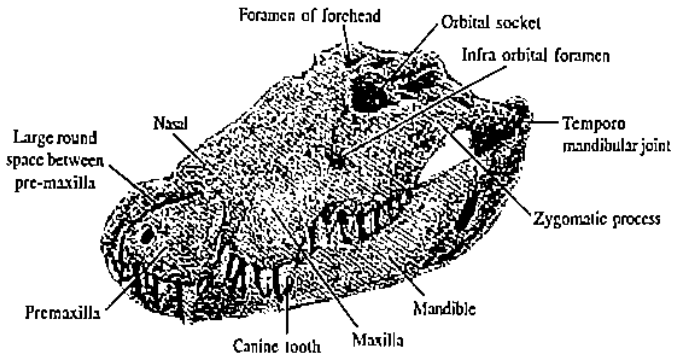
Sternum

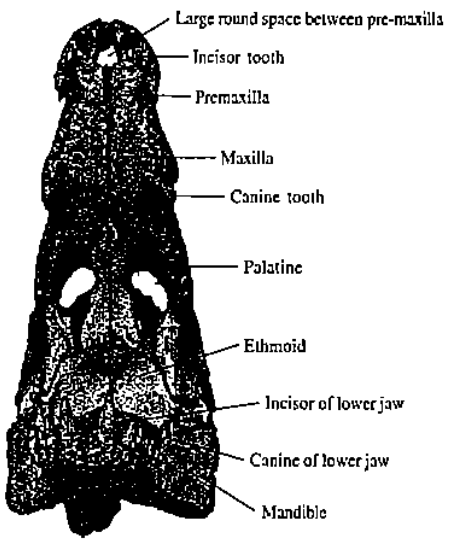
It is flat. 8-9 segments fused to form this structure. Costal cartilages are flat and extensive. First sternebra is long and extended forward.



Skull

The skull has a well ossified neurocranium, a single occipital condyle and a large number of membrane bones. Frontal bone is small and elongated. Maxilla and pre-maxilla are also elongated. Palate is smooth and spacious due to close fusion of pre-maxilla, maxilla and ethmoid. In between the two premaxilla bones there is a large round space which communicate ventrally. Mandible is longer than skull. Coronoid process is extended backward and upward and remains free. The condyle of mandible articulates with parietal bone. Lateral to the frontal bones at the supra-orbital fossa there is a pair of large oval foramina on the forehead.





Limbs

Limbs are in general short. Forelimbs are shorter than hind limbs. Radius and ulna are separate. Carpals are small rod shaped structures. Digits are five. Excepting the first, all bears three phalanges each. Ilium, ischium and pubis are not completely fused. Pubis is extended forward and keeps a wide gap from ischium and therefore obturator foramen is absent. Tibia and fibula are separate. Tarsals bones are irregular, voluminus and 4-5 in number. Metatarsal bones are larger than metacarpals.

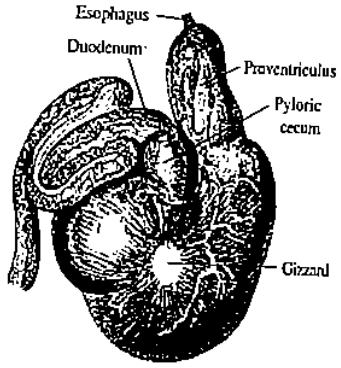
Dental formula (Highly variable amongst different breeds)

$$I\frac{4}{4}\ C\frac{6}{6}\ P\frac{4}{2}\ M\frac{4}{2}$$

Last canine is the largest. Molars are ill developed.

Stomach

Like that of birds, the stomach is divided into two parts – proventriculus and gizzard. However, the proventricular part in some breeds are not developed. Proventriculus is the glandular part and gizzard is the grinding part. The gizzard is lined by a horny mucous membrane. Between the pyloric end of stomach and begining of duodenum a diverticulum is found called pyloric cecum.



Stomach of Crocodile.

Liver

It is bi-lobed and situated in the coelomic cavity at the level of 3rd to 9th ribs and below the heart. Right lobe is larger and a pouch like gall bladder is attached with it. The diaphragm is not fully developed.

Kidneys

Metanephric kidneys are bilaterally placed in the dorsal aspect of abdomen. They are oval-elongated in shape and presents lobulations on the surface. Ureters open in the cloaca.

Respiratory organs

To prevent entry of water into the respiratory passage, the crocodiles have a fleshy valve, the *palatine velum*, which consists of two large transverse folds suspended from caudal end of the long palate, just anterior to the internal nares.

Each lung is in the form of a elongated sac and divided into numerous chambers. Small out pockets from each lung with traped air are sometimes found.

Testes

Testes are narrow and elongated structures situated at the medial aspect of the corresponding kidney within the abdomino-pelvic cavity.

Penis

It is short, conical structure with a pointed end. It bears a urogenital groove. Normally, the phallus is not visible from outside as it remains enclosed within the cloacal pouch in non-erectile state.

Ovary

Two ovaries are attached to the dorsal wall of the body.

Uterus

The horns of the uterus have infundibulum, magnum or albumin secreting portion and the shell gland secreting part just prior to cloaca. In some variety of crocodiles, only one of the two embryonic muellerian ducts differentiates.

Heart

Heart is conical and have four chambers. However, the ventricles are connected above by the foramen of Panizza, which occured due to incomplete development of interventricular septum.

Nabeela Chande

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