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Ministry of Labor and Skills

Animal Health

Level-II

Based on March 2022, Version 4 Occupational standard



Module Title: - Identifying basic Anatomy and Physiology of Animals

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Ministry of Labor and Skills

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Introduction to the Module

This module covers the knowledge, skills and attitude required to identify basic anatomy and physiology of animal and their clinical applicability at work place. It includes knowledge of understanding of normal structures and functions of different organs and systems, and also skills to locate organs in different body systems as well as their clinical application at work place.

LG #1	LO #1-Identify the structures and function of main body systems

Instruction sheet 1

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Introduction to veterinary anatomy and physiology
- Planes of reference and directional terms
- Structure and function of integumentary system
- Anatomy and physiology of muscular-skeletal system
- Anatomy and physiology of the digestive system and accessory digestive organs
- Anatomy and physiology respiratory system
- Anatomy and physiology circulatory system
- Anatomy and physiology of uro-genital system
- Anatomy and physiology of the endocrinal system
- Anatomy and physiology nervous system

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Define and describe the science of veterinary anatomy and physiology.
- Identify the different Planes of reference of the body
- Use appropriate directional terms in the description of locations of body parts.
- Identify and recognize structure and function of the integumentary system in different animal species
- Recognize structure and function of musculo-skeletal system with their respective locations in different animal species.
- Identify structure and function of the digestive system, the accessory digestive organs in both simple stomach and complex stomach animal with their respective locations
- Identify structure and function of the respiratory system with their respective locations in

different species.

- Identify structure and function of the circulatory system with their respective locations in different species of animals.
- Identify structure and function of the uro-genital system including mammary gland with their respective locations.
- Identify and describe structure and function of the endocrinal system for different animal species.
- Identify and recognize structure and function of the nervous system in different animal species

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below and try to understand what are being discussed. Ask your teacher for assistance if you have hard time understanding them.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet 1

1.1.Introduction to veterinary anatomy and physiology

Anatomy: - it is one of the oldest branches of biological sciences, which deals with the form and structure of the tissues and organs that compose the body and the relation of its parts. Literally speaking the word 'anatomy' comes from two Greek words Ana-apart; Tomy-cut, Hence anatomy means to cut apart. The subject anatomy is usually studied by dissection and observation. The subject Anatomy has the following subdivisions:

- **Gross (Macroscopic) Anatomy-** is the study of those structures which are visible with unaided eyes.
- **Microscopic anatomy (Histology)** - deals with those structures which are only visible with the aid of a microscope.
- **Developmental anatomy (Embryology)** - is the study of stages that an individual passes from conception through birth, youth, and maturity to an old age.
- **Comparative anatomy-** is the description and comparison of the structure of various species of animals with particular emphasis on those characteristics that aid in classification.

Methods of study of anatomy:

The mammalian body is a complex structure composed of a number of interrelated systems Combined into an integrated whole. To break the body down into parts that can be studied individually has been a difficult task and which cannot be perfect since the body is an integrated unit and each structure is related to the others. A number of methods have been developed for the study of anatomy. Among these the following are in use.

- **Systemic Anatomy (Descriptive anatomy)-**is the study of various groups of organs that are so closely related in their activities with evident common functions. e.g. Digestive system
- **Topographic anatomy** - is the study of parts or systems in relation to their surrounding parts.

- **Regional anatomy-** is the study of limited portions or regions of the body, under this method the body is normally broken down into four arbitrary regions, which are studied topographically. These regions consist of the head and neck, thorax and forelimb, abdomen, and the pelvic region and hind limb.
- **Special anatomy-** is the study of certain limited regions of the body in detailed

Physiology

The word physiology comes from Greek word meaning **Physis**-nature, **Logy**-study of, so it is the study of nature or normal functioning of the body and its constituent parts. Therefore, when Anatomy and physiology are studied together we study the forms and structures with the functions of the animal body or any of its parts.

1.2.Planes of reference and directional terms

Definition

- **Planes of references** are imaginary planes which pass through the body or its part. They used to determine the relationship (relative position) between structures and their parts. It is to be assumed that the terms listed below apply to a quadruped (four-legged) animal in an ordinary standing position.

  In general there are **four planes** of reference:

a) **Median plane: -** An imaginary plane is passing through the body craniocaudally, which divides the body into equal right and left halves. Sometimes called the midsagital plane. All the other planes are constructed in relationship to this plane.

b) **Saggital planes-** are those planes parallel to the median plane. They do not pass through the median axis so they never divide the animal body into two equal halves.

c) **Transverse planes-** are located at right angles to the median plane. All transverse planes cross the long axis of the body and divide the animal body into cranial (anterior) and caudal (posterior) portions. The transverse plane can also be said to be perpendicular to the sagital plane and frontal or coronal plane. Both of these planes run with the longitudinal axis of the body, while the transverse plane runs perpendicular to the longitudinal axis.

d) **Frontal planes-** are those which are located at right angles to both the median and transverse planes. They divide the body into dorsal (Superior or back) and ventral (Inferior or belly) portions.

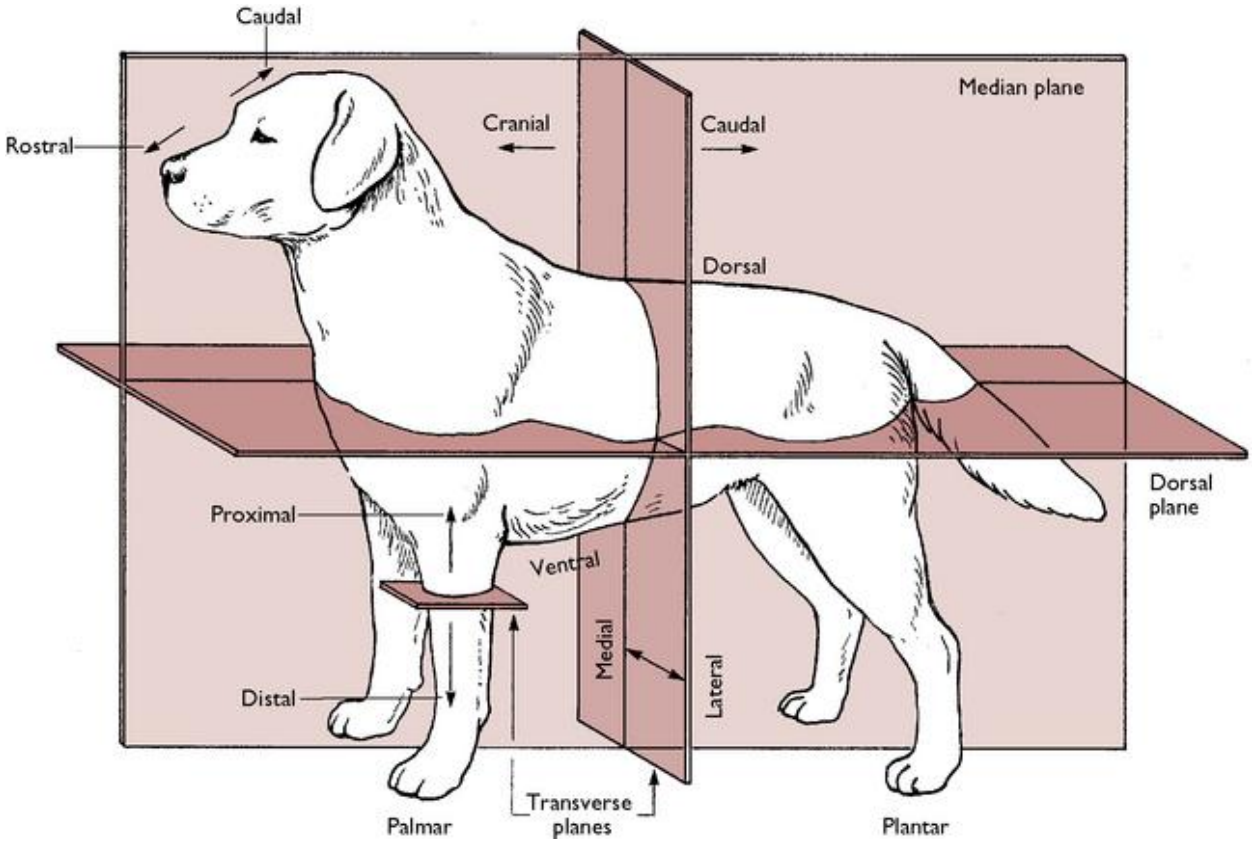


Figure 1.1:- Veterinary plane of reference (**Source**: - Colville and Bassett (2001)

- **Directional terminology**

Directional terms come in opposing pairs (like East/West & North/South). Anatomical directional terms are used to describe relative position consistently within a cadaver, independent of how the cadaver is oriented. In order to indicate the position and direction of parts of the body correctly, certain descriptive terms are employed. Some of these terms are:

- ✓ **Cranial**- means toward the head (cranium). The shoulder is cranial to the hip. It is closer to the head than is the hip, also called anterior.
- ✓ **Caudal Posterior** - mean toward the tail.
- ✓ **Medial:** - towards the median plane. The heart is medial to the lungs.
- ✓ **Rostral:** - used within the head to mean towards the nose.

- ✓ **Dorsal: -** towards the back or upper part of the body. The kidneys are dorsal to the intestines.
- ✓ **Ventral**: - towards the underside of the body. The udder is the most ventral part of the body of a cow.

Importance of knowing anatomical and directional terminology in veterinary medicine is to insure doctors and technicians have a shared method of communicating, which helps to avoid confusion when pinpointing structures and describing locations of lesions and Knowing the directional terms makes things clear and save time.

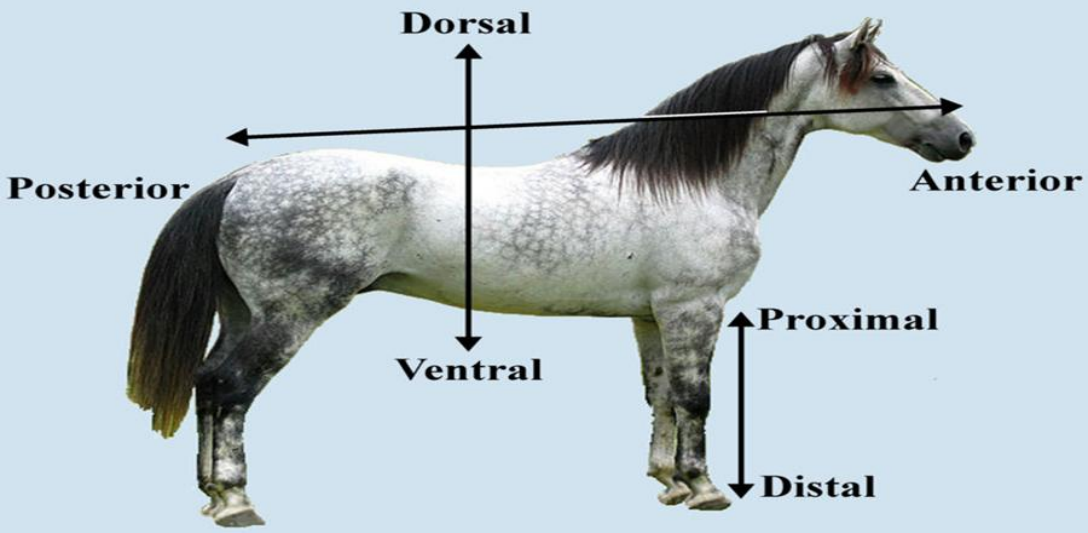


Figure1. 2: Directional terms in the description of quadruped animals body parts **(source: -** Leach, D. (2013))

- ✓ **Lateral: - away from the median plane or towards the ribs. The ribs are lateral to the lungs.**
- ✓ **Proximal- means relatively close to a given part, usually the vertebral column or center of gravity. The knee is proximal to the hoof.**
- ✓ **Distal- mean relatively farther from the vertebral column. The hoof is distal to the knee.**
- ✓ **Volar - refers to the flexion or caudal surface to the forelimbs distal to (Below) the elbow.**
- ✓ **Plantar- refers to the caudal surface of the hind limbs below the hock.**
- ✓ **Prone- refers to the position in which the dorsal aspect (dorsum) of the body is uppermost.**

- ✓ **Supine- is a position in which the ventral aspects of the body or extremity are uppermost.**
- ✓ **Supination- refers to the act of turning towards the supine position.**

1.3. Structure and function of integumentary system

Introduction

The term integument is a general term referring to the ordinary skin with its covering of hair, variety of skin glands (sweat and sebaceous glands) and more specialized structures such as claws, hooves, horns, feather, nail and mammary glands. It is continuous with mucus membrane at natural openings.

- Continuous with the digestive tract as mucus membrane of oral cavity and rectum.
- Continuous with respiratory system as mucus membrane of nasal cavity.
- Continuous with uro-genital tract as mucus membrane of vagina in female and as mucus membrane of urethra in male.

1.3.1. Skin

The skin is the largest single sense organ and protective covering of the body. It rests up on looser connective tissue variously known as **sub cutis, hypodermis or superficial fascia**.

The skin is composed of two parts

a. **Epidermis**

- Superficial epithelium, which is continuously, renewed
- Epidermis does not have vessels and lymphatic. It is nourished through diffusion from subjacent dermis.

Cells in the basal layer (stratum germinativum) always undergo active mitotic division pushing the superficial layer further outward from the dermis from where it get nourishment. As the cells move away from the basal layer, the cell dye and hardened. This dying and hardening of the epidermal cells is named **keratinization** or **cornification**. The thickness of the skin varies with species and within the same species with different parts of the body.

b. Dermis

- Dermis is largely composed of collagen bundles. It has also elastic fibers, which make the skin pliable (flexible). It is highly vascularized & innervated.
- It contains hair follicles, sebaceous & sweat glands growing from the epidermis and erector pili muscle, which help to erect the hair.

c. Hypodermis sometimes called sub cutis /superficial fascia

- It separates the dermis from the underlying structures. It consists of loose connective tissue interspersed with fat. Hypodermis varies in amount according to situation.
  - ➢ It is thin or absent where skin movement is undesirable e.g. lip, eyelid, teat
  - ➢ It is ample where movement of skin is needed.

1.3.2. Appendages of the skin

These are modifications of epidermis. These include **hairs, hooves, claws, horns** and even **mammary glands**, which is enlarged sweat gland. Mammary gland is the only gland which is structurally related to the common integument and functionally associated with genital organs.

Anatomy of the hooves in different domestic animals

Hooves are formed from closely packed epidermal cells, which have undergone cornification. It is insensitive cornified layer of epidermis. Its color varies depending on the color of the skin found at the upper part of the skin. It is composed of; tubular horns, intertubular horns and laminar horns.

1.3.3 The wall of the hooves:

- The wall is the part, which is visible when the animal is in standing position. It is divided in to: Toe region, quarters (Medial and lateral) and heels (Medial and lateral).



Figure 1.3: Anatomy of the hoof (source: - https://extension.tennessee.edu/publications/Documents/W785.pdf Accessed on 26/08/2022

- ✓ **Sole**

The sole is the palmar surface of the hoof found between the wall and the frog. In the area where the sole meets the internal margin of the walls, there is a narrow **white line /zone**. It is also called **zona alba** to avoid confusion with linea alba. The white line is a useful landmark for driving nails during shoeing. Properly directed nail should start outside the white line so as not to touch any sensitive structure of the hoof.

- ✓ **Frog:**

The frog is a wedge of soft, elastic horn situated between the hoof bars. It blends with the bulbs of heels on each side. The frog has a central groove dividing it into two crura.

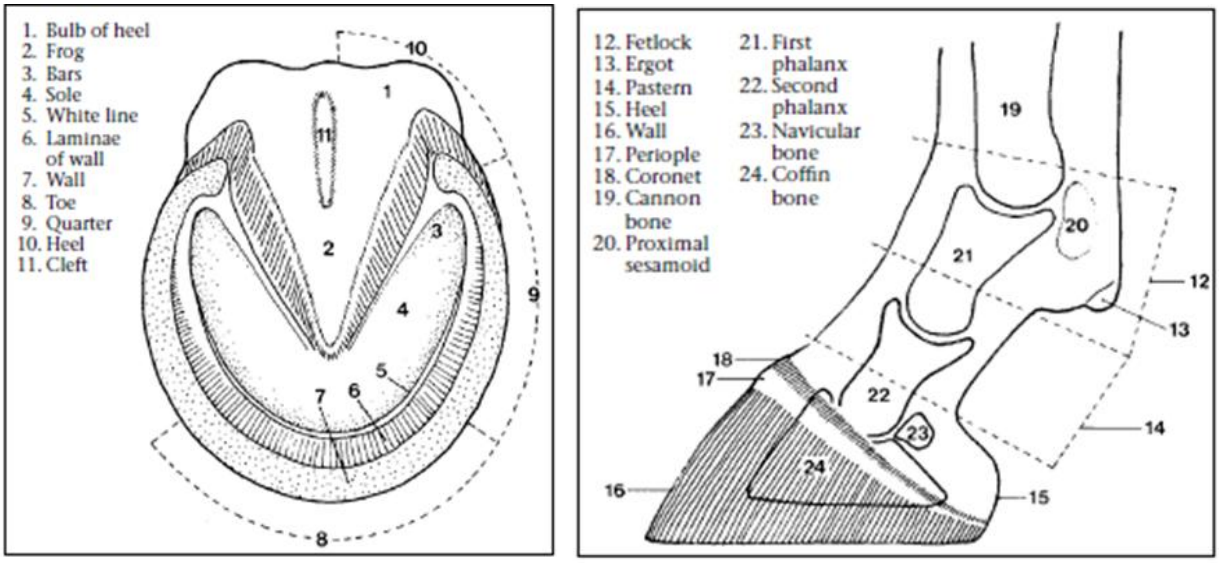


Figure 1.4: Structural anatomy and parts of the hoof

(**Source: -** https://extension.tennessee.edu/publications/Documents/W785.pdf Accessed on 26/08/2022

- **Hoof of the ruminants and pig**

In ruminants and pigs the individual digits are called **claw**. Generally the hoof is similar to the hoof of horse except for the absence of frog and bar. Cranially the wall of the hoof makes a sharp bend. In ruminants especially in cattle the caudal end of the claw is somehow sensitive and is thin layered and softer when pressed. This part is called the bulb.

✓ **Dewclaws**

Dewclaws are reduced digits. They represent 2^{nd} (medial) and 5^{th} (lateral) digits of ruminants and swine. In dog dewclaw represent digit N^{o} 1 in the thoracic limb, but no dewclaw in hind limb.

✓ **Chestnuts**

Chestnuts are horn like growth on the medial side of the leg of horse. They are considered as vestiges of 1^{st} digit by some authors. Front chestnuts are found above the carpus on the medial side of the forearm. Hind chestnut (torus tarsal is) is located on the medial side of the hock.

- ✓ **Ergots**

Ergots are small projections of cornified epithelium in the center of the caudal part of the fetlock joint. They are considered as vestiges of 2nd and 4th digits. In most instances they are found covered by tufts of hair (feather).

1.3.4. Horn

Horn is formed on the bony core/corneal process, which is the process of frontal bone. The corium of horn is very thick where it joins the skin proper and has many long cylinder papillae. The corium of the horn completely surrounds the corneal process and fuses with periosteum of the bone. Horn tubules extend from the base towards the apex of the horn to form the horn proper. Soft and somewhat transparent type of horn called **epiceras** that resembles the periople of the hoof covers the surface of the horn core at the base.

Seasonal variation in the body metabolism resulted in variation in the growth of horn expressed in the appearance of a serious of grooves and ridges. The grooves are resulted from slowed growth of the horn near the end of gestation and during lactation. Sometimes these grooves are named as pregnancy grooves. The grooves help to estimate the age of cows. The number of such grooves plus the age at first calving gives the current age.

1.3.5. Skin glands

Two basic types of skin glands are distinguished; these are:-

I. Sudoriferous (sweat) glands

Sweat glands are scattered over the entire body. They are sparsely distributed in carnivore's pigs**.** They are divided in to two types:

a. Apocrine sweat glands: Discharge an aibuminious (viscous/ sticky) sweat in to hair follicles over meat of the body

b. Eccrine glands: secrete a more watery sweat directly on to certain naked or nearly naked regions of the skin (e.g. nasolabial plate of cattle and foot pads of dogs)**.** Most mammals possess fewer glands and sweat less profusely than man. The horse is an exception to this general

statement as it sweat profusely and produces especially an aluminous sweat that froths by the movement of skin and coat.

II. Sebaceous (oil) glands

These glands produce a (an oily) fatty secretion called sebum**. Ceruminous glands:** occur in all domestic animals. They are located in the wall of external auditory canal. They help in preventing foreign bodies from entering the ear. They are especially well developed in pigs and carnivores.

1.3.6. Basic function of integumentary system

The integumentary system protects the body from infection and injuries that could get from the external environment. It's the body's coat of armor and the first line of defense against viruses, bacteria and other microbes. It shields the body from harmful light and helps regulate your body temperature.

a. Physical protection.

- Keratin and acidic oily secretions (pH 4.0-6.8) on the surface of the skin of mammals provides protection from water and microorganisms.
- Cornification protects against abrasion.
- Pigmentation (i.e., melanin) protects the germinal layers against the damaging effects of UV light.

b. **Hydro regulation** - fluid loss is minimal as a result of keratinization and cornification.

c. Temperature regulation.

- Body heat is generated from cellular metabolism, particularly in muscle cells.
- Normal body temperature is maintained in 3 ways:
  - ✓ Radiant heat loss from dilated blood vessels.
  - ✓ Evaporation of respiration.
  - ✓ Retention of heat from constricted blood vessels.
- A serious danger of continued exposure to heat and excessive water and salt loss is heat exhaustion.

- Heat stroke is similar to heat exhaustion, except that in heat stroke sweating is prevented and body temperature rises.
- Hairs have an insulating effect when dense enough, and are also sensitive tactile organs.

d. Synthesis.

- Skin permits UV light absorption used in the synthesis of vitamin D.
- Skin also absorbs respiratory gases, steroids, fat-soluble vitamins, and certain toxins and pesticides.

e. Sensory reception.

- Highly specialized sensory receptors that respond to the precise stimuli of heat, cold, pressure, touch, vibration, and pain are located throughout the dermis.
- These cutaneous receptors are especially abundant in the skin of the face and palms, the fingers, the soles of the feet, and the genitalia.

f. Communication.

- Various emotions, such as anger or embarrassment, may be reflected in changes in skin color.
- The contraction of various facial muscles produces facial expressions that convey an array of emotions in mammals, especially primates

1.4. Anatomy and physiology of muscular-skeletal system

The musculoskeletal system consists of bones, cartilage, muscles, ligaments, and tendons. Primary functions of the musculoskeletal system include support of the body, provision of motion, and protection of vital organs.

1.4.1 The skeletal system

The term skeleton is applied to the framework of hard structures, which supports and protects the soft tissue of the animals, whereas the skeletal system includes the bones, cartilage, teeth and joints.

- The specific studies are **Osteology** (the study of bone), **chondrology** (the study of cartilage), **deontology** (the study of tooth) & **arthrology** (study joints).

- Logically, it is the first system to be studied, for the skeleton forms the foundation upon which all the other systems are laid or built.

The **skeletal system** is divided into three parts:

- The appendicular (bones of the limb) skeleton
- The axial skeleton
- The visceral (splanchink) skeleton.

Terms used in osteology:

- Bone consists of a number of modifications such as enlargements, depressions, holes, projections, indentations and protrusions, which have got specific purposes.
- Specific terms are used to identify these features.
- The most important ones are depressions and projections. Both of them can be articular or non-articular.

✓ **Articular Depressions**

- **Gelnoid cavity** - is a shallow articular cone-cavity (depression). E.g. the articular cavity found at the distal end of the scapula.
- **Condyloid cavity**- is a deep articular cone cavity e.g. Acetabullum of hip joint.
- **Notch**- is an articular indentation ex. Semillumar notch of the ulna.

✓ **Non-articular depression**

- **Fossa**- a large non- articular depression located outside the joint. E.g. Atlantal Fossa, prescapular fossa.
- **Fovea**- is a small non-articular depression. E.g. Fovea capities the femur (on the head of the femur)
- **Foramen**- is a circumscribed hole in the bone e.g. the foramen magnum at the base of the skull through which the spinal cord passes.
- **Canal**- is a tunnel through one or more bones. E.g. Vertebral canal

✓ **Articular Projections**

These projections from an integrated part of a joint.

- **Head**- is a spherical articular projection E.g. Head of the femur.
- **Condoyle**- is more or less a cylindrical articular mass usually located at the distal end of the femur and humorous.

- **Trochlea-** is a pulley like articular mass at the distal end of the femur.
- **Facet-** is a relatively flat articular surface. E.g. the articular surface of the carpal bone.

✓ **Non-articular projections**

- **Process-** is a general term for a bone projections E.g. Transverse process of the vertebrae
- **Tuberosity-** is a large non-articular projection. E.g. The major tuberosity of the humorous.
- **Tubercle-** is a smaller projection of a bone.
- **Spine-** is a point of projection. E.g. Spinous process of the vertebrae

Classification of Bones Based on physical Appearance

According to their shape and size even sometimes by their internal morphological structures bones are classified in to **six** classes.

a. Long bones:

- Are elongated cylindrical types of bones.
- They are found exclusively in the extremities (fore and hind limbs)

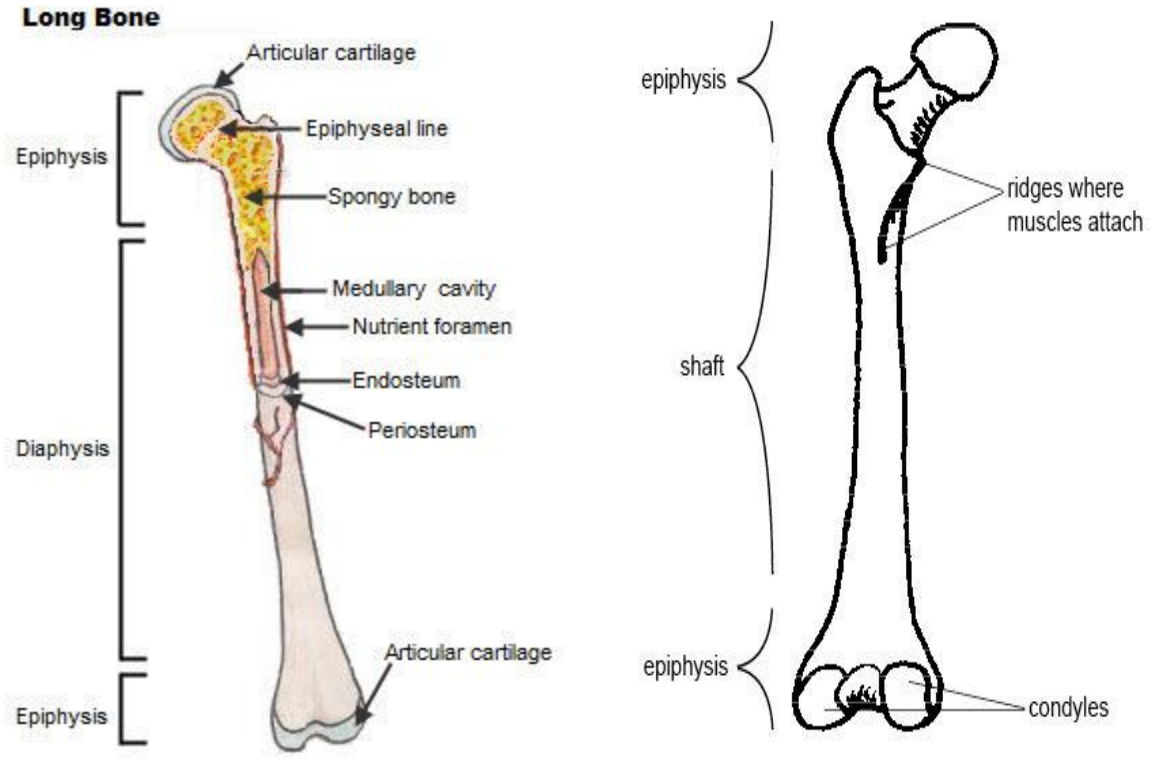


Figure 1.5:- physical structure of long bone

https://training.seer.cancer.gov/anatomy/skeletal/classification.html accessed on 26/08/22)

b. Short bones:

- Short bones, such as those of the carpus and tarsus, present (somewhat similar dimensions) in length, breadth and thickness.
- Their chef function appears to be that of diffusing concussion.

c. Flat bones-

- Are relatively thin and expanded in two dimensions.
- They furnish sufficient area for the attachment of muscles and afford protection to the organs which they cover. E.g. scapula & many boned of the skull.

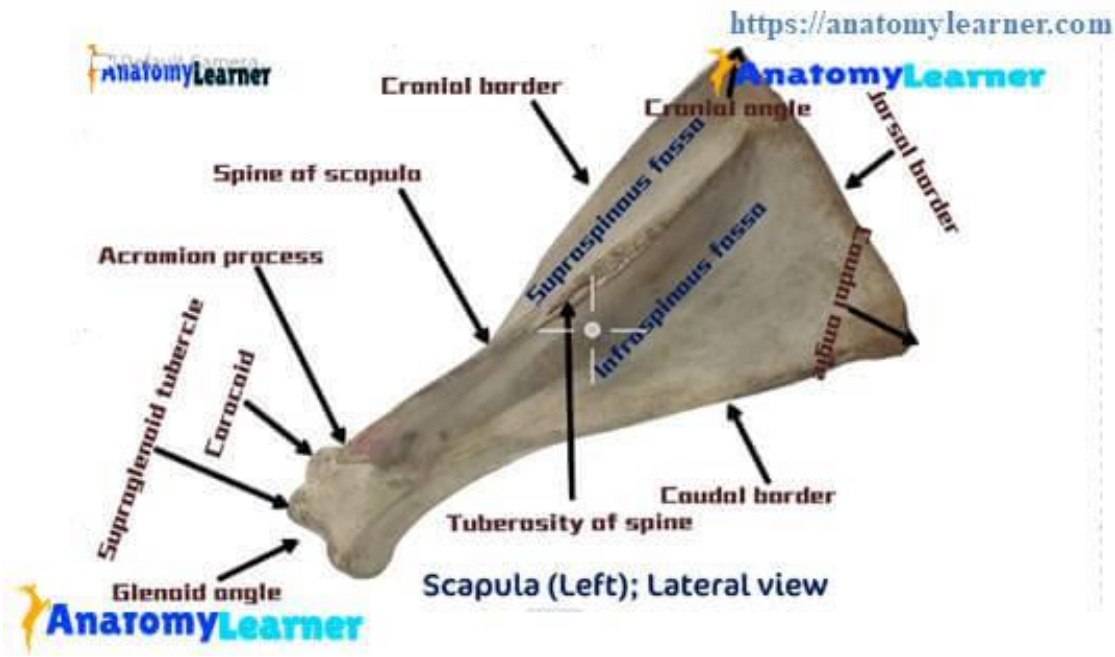


Figure 1.6 Structure of flat bone

https://anatomylearner.com/scapula-of-ox/ accessed on 26/08/2022

d. Irregular bones

- Are unpaired bones located on the median plane and include the vertebrae and some of the unpaired bones of the skull.

e. Sesamoid bones-

- As the name implies, they resemble a sesame seed and are developed along the course of tendons to reduce friction or change the course of tendon.
- The patella (Knee cap) is the largest sesamoid bone in the body.

f. Pneumatic bones-

- Contain air spaces or sinuses that communicate with the exterior.
- The frontal & maxillary bones of the skull are e.g. of this type of bone.

Classification of skeletal system

a). Axial skeleton

- The axial skeleton includes practically all bones except those of the limbs or appendages and visceral bones.

- The bones comprising the axial skeleton are either on the midline, such as the vertebrae and skull, or attached to midline bones, as ribs (as are the ribs)

The skull

- That part of the skeleton which forms the basis of the head is called the skull.
- It formed of a group of flat and irregular bones.
- The skull is divided into two parts, the **cranium** and the **face**.
- The cranium is composed of the bones of the skull which immediately surround the brain and which are incorporated into the floor and vault of the brain cavity.
- Whereas the face consists of the bones of the skull which are not part of the cranium.

Note- Much of the observable species difference, as far as the head is concerned depends on variations in the facial parts of the skull.

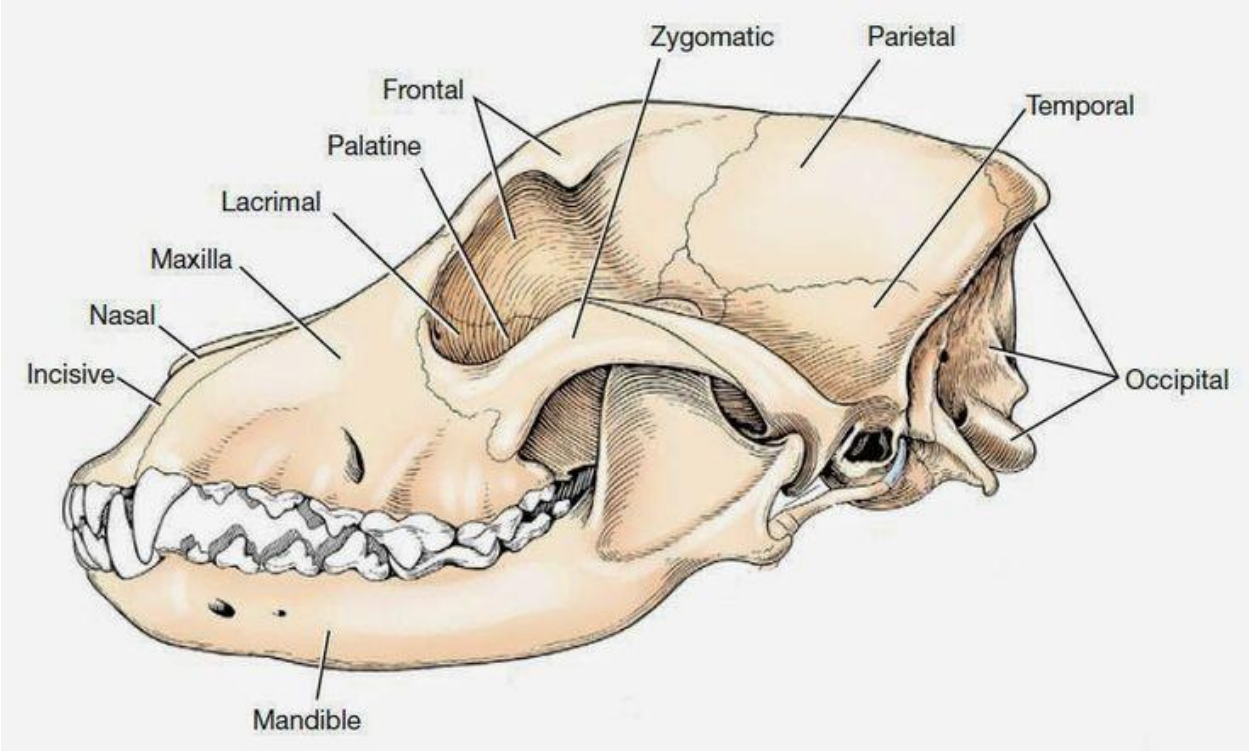


Figure 1.7:- structure of skull bone

The posterior and dorsal wall of the cranium are formed by the occipital, parietal, inter parietal and frontal bones.

- The horn cores (corneal process) develop on the dorsolateral angle of the frontal bones.

Laterally and ventrally the walls of the cranium are formed by the temporal bones, which contain the middle and inner ears and the sphenoid bone, which supports the brain and pituitary gland.

- Anteriorly the ethmoid bone presents numerous openings for a passage of the olfactory nerves associated with the sense of smell.
- The facial portion can be divided into orbital, nasal and oral regions orbit refers to the bony socket that protects the eye.
- The orbit is formed by portions of the frontal, lacrimal & zeugmatic.
- Molar bones.
- The air passages through the nasal part of the skull are bounded dorsally by the nasal bones, laterally by the maxillac and pre-maxillae and ventrally by the palatine processes of the maxillae, pre maxillae and palatine bones. The nasal passages are separated longitudinally by the vomer.

The Oral (mouth) portion is roofed by the maxillae and pre maxillae, which contain teeth, and by palatine bone.Ventrolaterally, the mandible completes the oral portion.

The vertebrae

- The vertebrae form a chain or column of dorsal, median, unpaired & irregular bones extending from the skull to the tail. The column is divided into five regions: **Cervical (C), thoracic (T**), Lumbar **(L)**, **Sacral (S)** and **coccygeal** (Cy).
- The number of vertebrae in each region for a given species is quite constant except for the coccygeal. However, except for the cervical, there is a variation in number of vertebrae between species. The vertebrae in the sacral region are fused together more or less completely into a solid mass. These are called fixed (false) vertebrae in contrast to the movable (true) vertebrae comprising the reminder of the vertebral column. The vertebrae in each region have certain character tics which serve to distinguish them from those of other regions. The vertebral formula for a given species consists of the letter symbol for each region followed by the number of vertebrae in the region in the given species.

Vertebral formulas of common animals and man are as follows:

Horse: $C_7\ T_{18}\ L_6\ S_5\ Cy_{15-20}$ Hog (pig): $C_7\ T_{145}\ L_{6-7}\ S_4\ Cy_{20-23}$

Cow: $C_7\ T_{13}\ L_6\ S_5\ Cy_{18-20}$ Man: $C_7\ T_{12}\ L_5\ S_5\ Cy_4$

Sheep: $C_7\ T_{13}\ L_{6-7}\ S_4\ Cy_{16-18}$ Dog: $C_7\ T_{13}\ L_7\ S_3\ Cy_{20-23}$

Goat: $C_7\ T_{13}\ L_7\ S_4\ Cy_{12}$ Cat: C_7 T13 $L_7\ S_3\ Cy_{5-23}$

- A typical vertebra has **a body, arch and processes**.
- The body is a cylindrical mass, oriented craniocaudally, upon which the other parts are built. The body connects cranially and caudally with the bodies of adjacent vertebrae. The arch is composed of two lateral halves and is constructed dorsally to the body. The halves meet medially to form a bony ring called the vertebral foramen. Successive foramina, together with the soft tissue which unite them form the vertebral canal which contains the spinal cord. The arches are notched before and behind, and the unions of adjacent vertebral notches form the intervertebral foramina through which the spinal nerves and vessels pass. The process can be divided into articular processes, spinous processes, which are located dorsally and ventrally along the median plane; transverse processes, which projects laterally from the arch.

Note:

- The first cervical vertebrae is called **Atlas**, here the spinousproces is absent
- **Axis** is the second cervical vertebrae; here spinous process is very broad not very high.
- The thoracic vertebrae are marked by well-developed spinous processes in the shoulder region these spinous processes form the basis for a dorsal prominence known as **withers.**
- The lumbar vertebrae have large, flat transverse processes which project laterally.
- Coccygeal vertebrae form the long basis for the tail.

The Ribs (costae)

- The ribs form the lateral walls of the bony thorax located between the thoracic vertebrae and sternum.
- Each rib articulates dorsally with the bodies of two vertebrae and is continued ventrally by a costal cartilage which may or may not attach directly to the sternum.
- **The proximal extremity consists** of a head, neck and tubercle.
- The head articulate with the bodies of two adjacent thoracic vertebrae.
- The neck is the bony junction of head and shaft.

- The tubercle projects backward at the junction of neck and shaft and bears a small facet of its dorsomedial surface for articulation with the transverse process of its thoracic vertebrae.

Types of Ribs

i. **Sternal (true) ribs**
   - ✓ They extend form their respective thoracic vertebrae to the sternum, where they are connected directly by costal cartilage.

ii. **A sterna (False) ribs**
   - ✓ They are found caudal to the Sternal ribs and are not directly connected with the sternum.
   - ✓ The costal cartilage at ventral extremity of most of the astral ribs overlaps & thus indirectly connects the sternum.

iii. **Floating ribs**
   - ✓ These are ribs at the caudal end of the thorax which have their ventral ends free or embedded in the soft tissues of the abdomen.

Note: The spaces between adjacent ribs are called **intercostals spaces.**

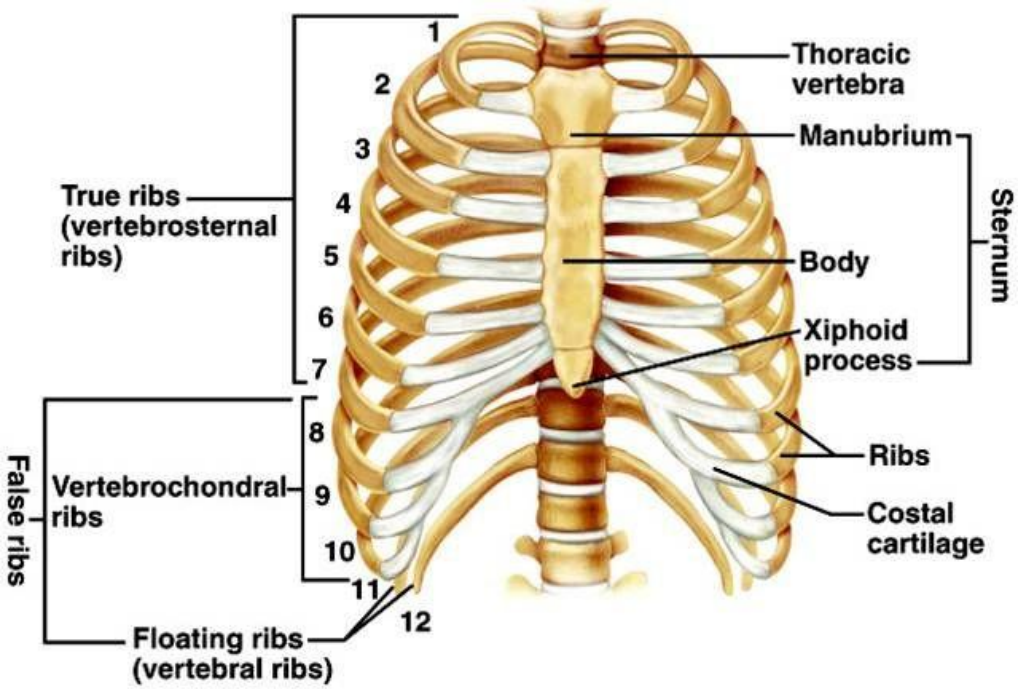
The Sternum

The sternum is formed by a group of medial, ventral, segmental unpaired bones, which complete the bony thorax ventrally and gives attachment to the costal cartilages of the Sternal (true) ribs as well as a place of origin for pectoral muscle.

The sternum is composed of 3 parts

i. **The pre sternum** (manubrium sterni) and carini form cartilage.
ii. **The meso sternum (body)** consists of segments called sternebrae which tend to fuse together as the age advances.
iii. **Meta sternum and xiphoid cartilage**. As part of the skeletal system the ribs & sternum protect and support the vital organs found in the thoracic cavity.

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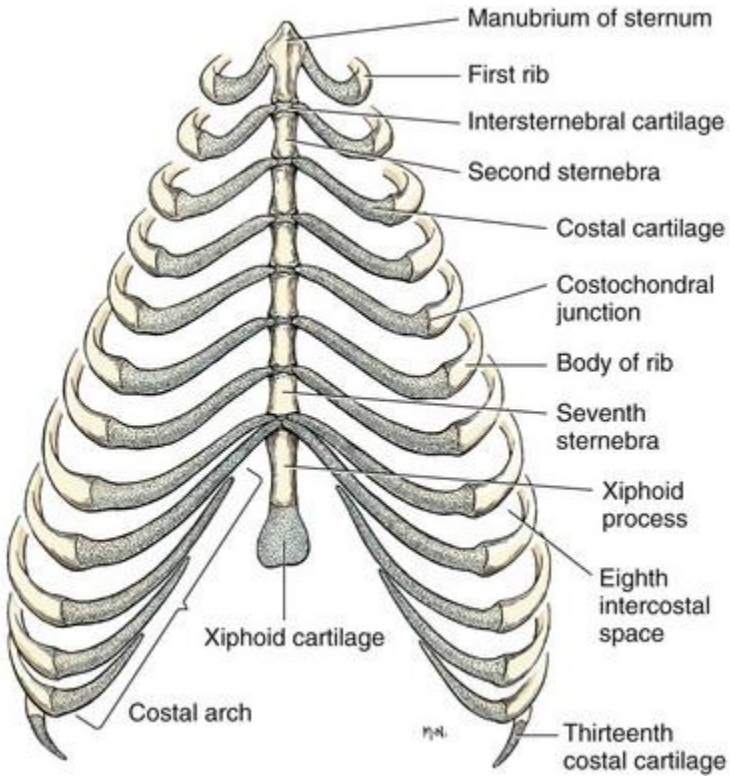


Figure 1.8 anatomical structures of ribs and sternum

b) The Appendicular skeleton

- The Appendicular skeleton is made up of the bones of the limbs.
- It is attached to the axial skeleton by means of two bony structures, the **pectoral (shoulder) girdle** and **pelvic (hip) girdle.**
- The pectoral girdle attaches the forelimbs to the body and is incomplete in domestic animals.
- A complete pectoral girdle consists of **six bones**, the right & left scapula, coracoids and clavicles which is found in birds.
- One or more of these pairs is usually is missing in mammals.
- In animals which possess only scapula, the attachments of the forelimb to the body is by means of flesh and tedious structures.
- This type of attachment is called **synosarcosis.**
- A bony attachment of the forelimb to the body is found in animals which possess two or more pairs of functional bones in the pectoral girdle. The thoracic limb is composed of four chief segments: the thoracic girdle, the arm (humorous), the forearm (radius and ulna) and the manus (carpus, metacarpus and digits (phalanges & sesamoid bones)).

I. **The thoracic girdle-**

It consists of the scapula in higher animals. The scapula (shoulder blade) in all animals is a rather flat, triangular bone. It is situated at the cranio-lateral aspects of the thorax. It is directed downward and forward. It possesses two surfaces, three angles & three borders. The distal portion, forming a joint with the humerus is known as the ventral (articulea) angle and forms the only true joint between the scapula and another bone in most domestic animals. The lateral face of the scapula has a ridge extending from the ventral angle to the dorsal (vertebral) border. This ridge is called the spine and divides the lateral side of the scapula into tow depressions. One is the **supraspinatous fossa**, which is cranial and above the spine, and the other is the **infraspinous fossa**, which is caudal and below the spine.

The Humerus-

- Is a long bone situated obliquely downward and backward, forms shoulder joint above with the scapula and elbow joint below with radius & ulna.
- It has a shaft and two extremities (Proximal and distal).

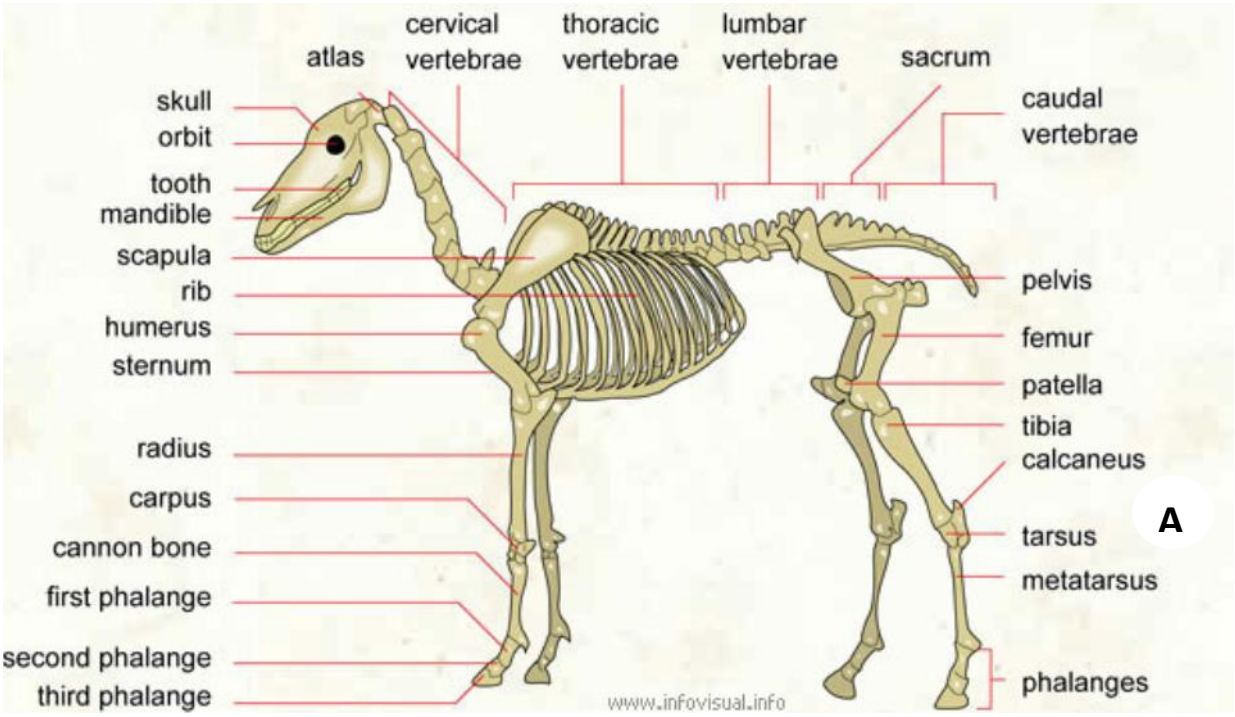
The radius and ulna-

- The radius is the larger of two forearm bones, and the ulna is the smaller in mammals but not in birds.
- The radius is well developed in all species.
- It enters into the elbow joint proximally and the carpus (knee joint) distal.
- The ulna varies in the amount of development from species to species.

Manus/carpal the carpus in all animals is a very complex region made up of two rows of small bones. Those in the proximal rows are called (from medial to lateral) radial, intermediate, ulnar and accessory.

Metacarpals-

Classified as long bone and located between the distal row of the carpals and the proximal phalanx. The numbers of these bones vary considerably in the different species. Their number conforms to the number of functional or visible digits. In cloven-hoofed ruminants the third and fourth metacarpals are functional but are fused together to form a single bone. Three bones are present in the horse: the 2^{nd}, 3^{rd} and 4^{th} (II, III, and IV). The 1^{st} and 5^{th} are absent of the three, the 3^{rd} is fully developed, articulation with the carpus and digit. In dogs there are five metacarpal bones.



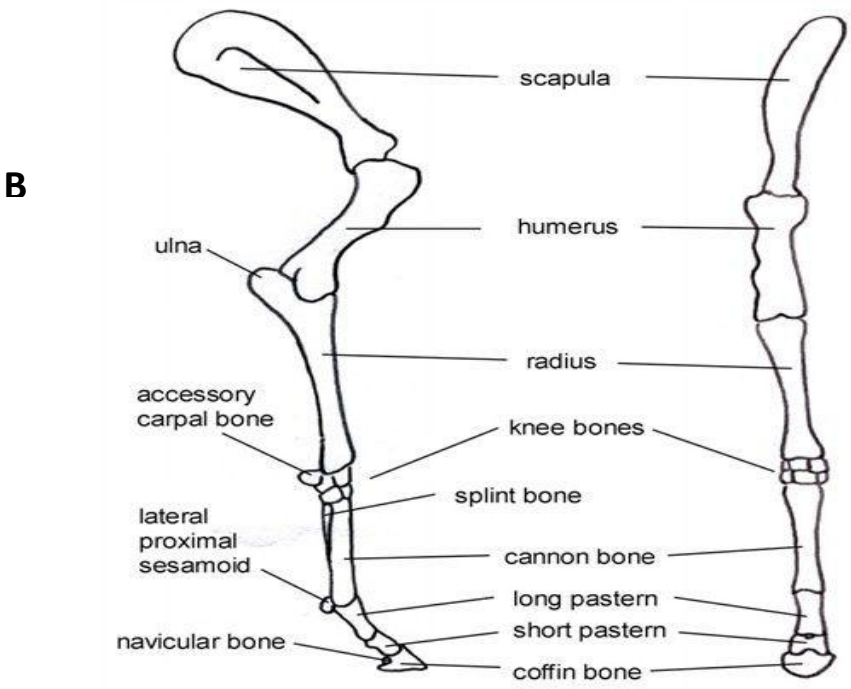


Figure 1.9:- skeleton of horse (A) and forelimb (B) (**Source**: - Hanot, *et al.*, (2017).

The digits and phalanges

These are group of bones analogues to the fingers and toes of man animals. The digits have great variation in number and composition among the various species of domestic animals. With the exception of slight modifications in size and shape, the digits of the front and hind limbs are the same in large domestic animals. Two fully developed digits (3^{rd} and 4^{th}) are present in the ox, 2^{nd} and 5^{th} digits are rudimentary and remains as dew claws or false digits at the posterior aspects of the metacarpo-phalangial joint without forming any articulation with any bone. In those species, each of the developed digits has three phalanges (first or proximal; second or middle (intermediate; third or distal phalanx) and three sesamoid bones (two proximal and distal sesamoid).Since there is only one digit in horse, the manus consists of one proximal, one intermediate and one distal phalanx; and three sesamoid bones (tow proximal and one distal). In domestic animals the horny structures like claw, nail or hoofs are developed over the 3^{rd} phalanx (distal phalanx).

II. Pelvic girdle

The bony pelvis (pelvic girdle) is formed by the right and left hip bones (so coxae), sacrum and one or tows coccygeal vertebrae. Each hip bone (Os coxae) consists of three hones on each side, which are fused to form tow irregular bones. The bones entering into the formation of the Os coxae are the **ileum**, **Ischium** and **pubis**. The right and left Os coxae join together at the **pelvic symphysis** ventrally to form the Ossa Cox arum (pelvis) and is joined to the axial skeleton dorsally by a very strong joint on each side, the right and left **sacra-iliac articulation.** The bones of Os coxae join together to form a large **acetabular cavity** which articulates with the head of femur (hip joint). The bony pelvis plus the soft tissues of the rectum, anus & reproductive system form the pelvic cavity. This structure is relatively smaller and narrower in males than in females.

The ilium

Is the largest and most dorsal of the bones. It is irregularly triangular in shape with the apex at the acetabulum and the base projecting craniocaudally. The medial angle is called the tuber sacral and lateral angle is tuber coxae (point of the hip). The broad, flat portion between the tubercoxae and tuber sacral is called the wing of the ilium

The pubis

- Is the smallest of the three bones and forms the cranial part of the floor of the pelvis.
- The pubis and ischium forms the boundaries of the largest foramen in the body called the **obturator foramen.**
- The ischium projects backward and ventrally form the acetabulum, forming much of the floor of the pelvis.

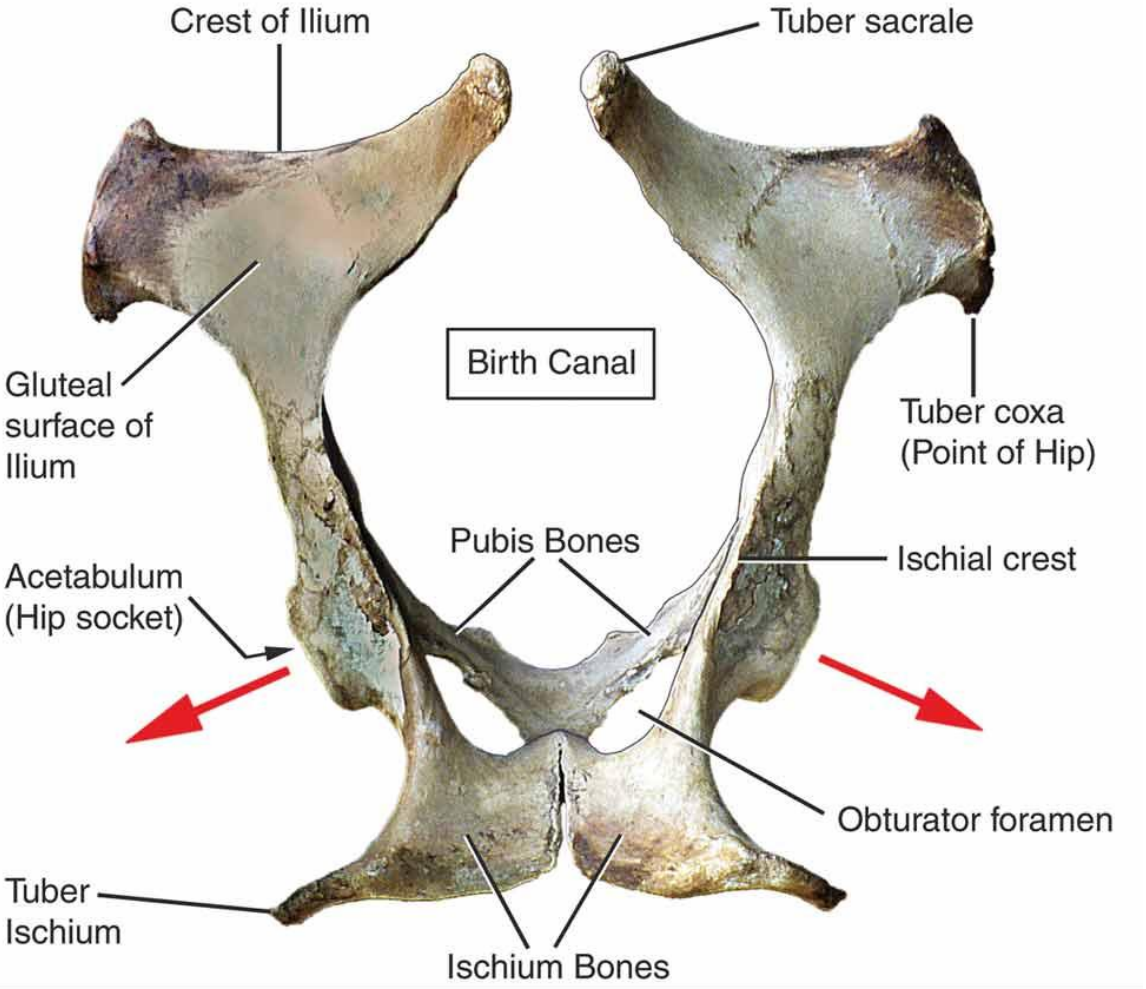


Figure 7

Figure 1.10: Structure of hip bone source: - https://www.pinterest.ph/calmie_143/bovine-bones/ accessed on 27/08/2022

The femur (thigh bone)

- It is a cylindrical and largest long bone in the skeleton and extends from the hip joint to the stifle (the joint corresponding to human knee).
- The distal end has two condoles for articulation with the tibia and a trochlea for articulation with the patella (the largest sesamoid bone in the body).
- There are also several roughened prominences known as trochnaters for the attachment of heavy thigh and hip muscles.

The tibia and fibula

- **The tibia**
  - ✓ Strong and massive long bone extends obliquely downward and backward from the stifle to the hock joint.
  - ✓ Tibia is the largest of the two bones and located medially.
  - ✓ The tibia has a shaft and two extremities.
  - ✓ The shaft is large and three-sided proximally, becoming smaller and flatter in the middle portion and widened and rectangular at the distal extremity.
- **The fibula**
  - ✓ Much smaller and is located on the lateral side of the tibia.
  - ✓ This bone is highly rudimentary in ox.
  - ✓ The proximal end (head) is fused with the lateral condoyle of tibia.
  - ✓ The body and the distal end remain as a blunt projection.
- **The fibula of horse**
  - ✓ Is to some extent better developed as compared to ox and generally terminated in the middle third of the tibia.
  - ✓ Both ends are fused with the tibia.
  - ✓ In dogs and cat this bone is a long and thin bone and extends the whole length of tibia.

The tarsus (Hock)

- **The tarsus**
  - ✓ Composed of short bones much like the **corpus** (knee) in the front limb.
  - ✓ The proximal row of tarsal bones consists of two large bones.

- ✓ The tibia tarsal bone (talus) - which articulate with the tibia.
- ✓ The fibular tarsal bone (calcareous) -project upward and backward to form the point of the hock.
- ✓ In the horse the central row of tarsal bones is represented by one the central tarsal
- ✓ The bones of the distal row are again numbered form medial to lateral-first, second, third, and fourth.
- ✓ The Fourth tarsal and central bones are fused in ruminants and swine

- **The metatarsals**

They are classified as long bone and located between the distal row of tarsal and there proximal phalanx. Generally they are similar to the metacarpals of the forelimb.

Digits, Phalanges and Sesamoid

- They are almost similar in both fore and hind legs in cow, horse and dog and are not described separately.

c). Visceral skeleton

The bones of the visceral skeleton are formed in soft organs. They are not present in all species of animals. Examples of visceral skeleton bones include. os penis - bone in the penis of dogs. Os cordis - bone in the heart of cattle.

1.4.2. **Joints**

Joints are the structures in the skeleton where 2 or more bones meet. There are several different types of joints.

- Some are **immovable** once the animal has reached maturity. Examples: skull and the midline joint of the pelvic girdle. Some are **slightly moveable** like the joints between the vertebrae but most joints allow free movement and have a typical structure with a fluid filled cavity separating the articulating surfaces (surfaces that move against each other) of the two bones. This kind of joint is called a **synovial joint.**
- The joint is held together by bundles of white fibrous tissue called **ligaments** and a fibrous **capsule** encloses the joint. The inner layers of this capsule secrete the **synovial fluid** that acts as a lubricant. The articulating surfaces of the bones are covered with **cartilage** that also reduces friction and some joints, e.g. the knee, have a pad of cartilage between the

surfaces that articulate with each other. The shape of the articulating bones in a joint and the arrangement of ligaments determine the kind of movement made by the joint. Some joints only allow a to and from **gliding movement** e.g. between the ankle and wrist bones; the joints at the elbow, knee and fingers are **hinge joints** and allow movement in two dimensions and the axis vertebra **pivots** on the atlas vertebra.

- **Ball and socket joints**, like those at the shoulder and hip, allow the greatest range of movement.

Common Names of Joints

Some joints in animals are given common names that tend to be confusing. For example:

- The joint between the femur and the tibia on the hind leg is our knee but the **stifle** in animals.
- Our **ankle** joint (between the tarsals and metatarsals) is the **hock** in animals
- Our **knuckle** joint (between the metacarpals or metatarsals and the phalanges) is the **fetlock** in the horse.
- The **"knee"** on the horse is equivalent to our **wrist** (i.e. on the front limb between the radius and metacarpals)

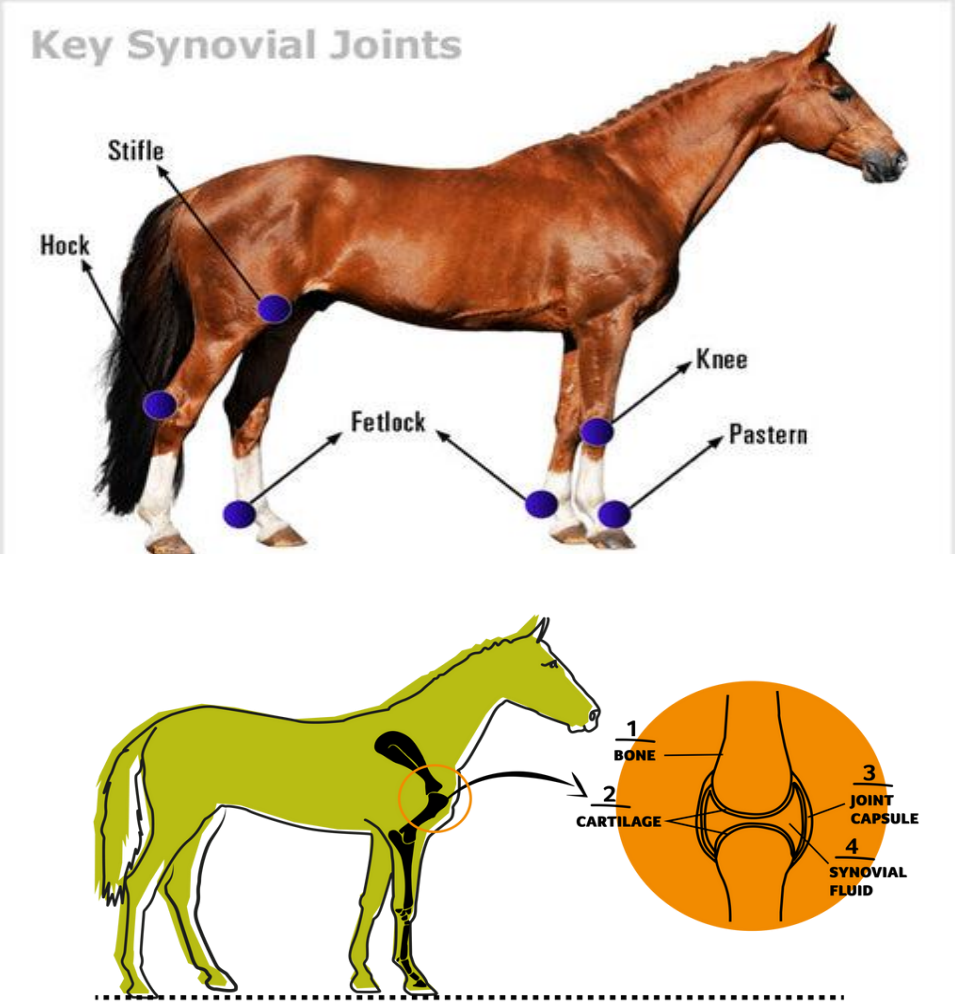


Figure 1.11: The names of common joints in horse

1.4.3. Myology

Definition

Myology is the study of the structural and functional organization of muscles in multicellular organisms: Muscle cells possess the properties of contractility and conductivity. Their arrangement suggests that they may be called fibers instead of cells. Embryologically muscles of all types originate from the mesoderm**. Muscle**: Tissues that can undergo repeated contraction and relaxation, so that it is able to produce movement of body parts, maintain tension, or pump fluids within the body.

Types of muscle tissue

The three types of muscle are skeletal, smooth, and cardiac. The bulk of the muscle in the body is **skeletal muscle**, and it is responsible for producing the voluntary movements of the limbs, trunk, and head. It is also the muscle tissue with which we are most familiar as the meat of our domestic animals. The muscle cells (fibers) of skeletal muscle tissue are grouped into distinct organs of variable size identified as individual **muscles**. These are usually attached to the bones of the skeleton (hence the term skeletal muscle) and are under voluntary control of the animal. Skeletal muscle is also called **striated muscle**.

a) Smooth (**involuntary** or **unstriated**) **muscle**

It composed of muscle cells that have no striations visible with a microscope. Smooth muscle is found in systems of the body with autonomic function. Thus, smooth muscle is a major component of the wall of organs of the digestive and urogenital systems and most blood vessels. Contraction of smooth muscle is an intrinsic property of the fibers themselves, which means that contraction does not generally require stimulation by a nerve; however, the contractility of smooth muscle is regulated and coordinated by the autonomic nervous system.

b) Cardiac muscle

This characterized by fibers with visible striations, so it is considered a type of striated muscle. However, cardiac muscle, like smooth muscle, contracts intrinsically and is not under voluntary control. Cardiac muscle is restricted to the heart, where it constitutes most of the thickness of the wall. Its rhythmic contraction is responsible for the circulation of blood.

c) Skeletal muscle organization

Muscle fibers are arranged in **bundles** surrounded by fibrous connective tissue. The connective tissue between individual muscle fibers is called **endomysium**. The sheath surrounding bundles of muscle fibers is called **perimysium** and the connective tissue around an entire muscle is known as **epimysium.** The epimysium is the deep fascia of the muscle. Muscle fibers may be arranged in parallel sheets, as in the abdominal muscles, or narrower bands, as in the sartorius muscle on the medial side of the thigh; the muscle fibers in these **strap muscles** are parallel to one another. Other arrangements of muscle fibers include **fusiform** muscles and various **pennate**, or **penniform** (feather like), arrangements. In the penniform arrangements, a tendon represents the quill and the muscle fibers attaching to the tendon at an angle represent the vane of

the feather. If the fibers come from only one side, the arrangement is called **unipennate**; from two sides, **bipennate**; and from three or more sides, **multipennate**.

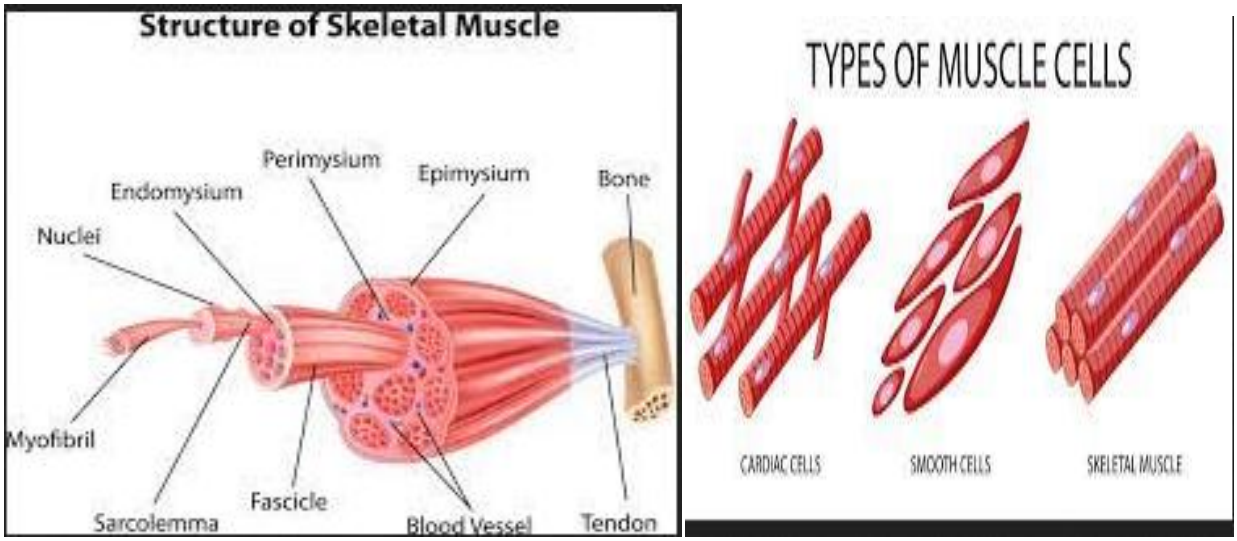


Figure 1.12 types and structure of muscle cells (**Source:-** https://www.google.com/search?q=muscles+cells&hl=en&sxsrf=ALiCzsZVErnagpN17nzKHNpAbHVfPYMPYA:1661512947910&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjb4rKIsuT5AhUIGuwKHU3GCAsQ_AUoAXoECAEQAw&biw=1366&bih=615&dpr=1 accessed on 26/08/2022

Muscles of the trunk, head, neck and abdomen

- **Sacrospiralis** or **erector spinae**- is especial muscles located dorsal to the transverse processes of the vertebrae on either side of the spinous processes.
- These muscles make up the loin muscles (Longissimus muscle) & continue forward to the head. The large extensor muscles of the head take **origin** form the vertebrae in the region of the wither and **insert** on the occipital bone of the skull. In addition to many other muscles, a heavy elastic band the ligamentum niche, reaches from the withers to the skull & gives considerable aid to the muscles, which extend the head and neck.

Abdominal Muscles

- **Abdominal muscles** are arranged in layers much like plywood with the muscle fiber running in different directions.

- Most of these muscles have broad aponeurotic insertions that meet at the mid-ventral line at an area known as **linea alba** (white line). The abdominal muscles help in defecation, micturation, rumination, coughing, respiration, parturition, etc.

i. The external abdominal oblique muscle

- Is the most superficial.
- The fibers of this muscle are directed obliquely downward and backward.
- Its origin is from the last few ribs & thoraco-lumbar fascia over the back & loins.
- The insertion is by means of a broad flat tendon (aponeurosis) that meets the insertion of the muscle form the opposite side at the linea alba.

ii. The internal abdominal oblique muscle

- Immediately deep to the external abdominal oblique.
- It takes origin from a deeper layer of the thoraco lumbar fascia and inguinal ligament.
- The fibers pass obliquely downward & forward, and this muscle also inserts on the linea alba by means of aponeurosis.

iii. The transverses abdominal muscle

- Thin and innermost of the abdominal muscles.
- It takes origin from the deepest layer of thoraco lumbar fascia, and the fibers are directed straight downward to insert on the linea alba.

iv. The rectus abdomen

- A form the muscular floor of the abdomen.
- It takes origin from the cartilages of the ribs & the sternum.
- The fibers run directly caudally in a frontal plane (horizontally) to attach to the pubis by means of a strong tendon, the prepubic tendon.

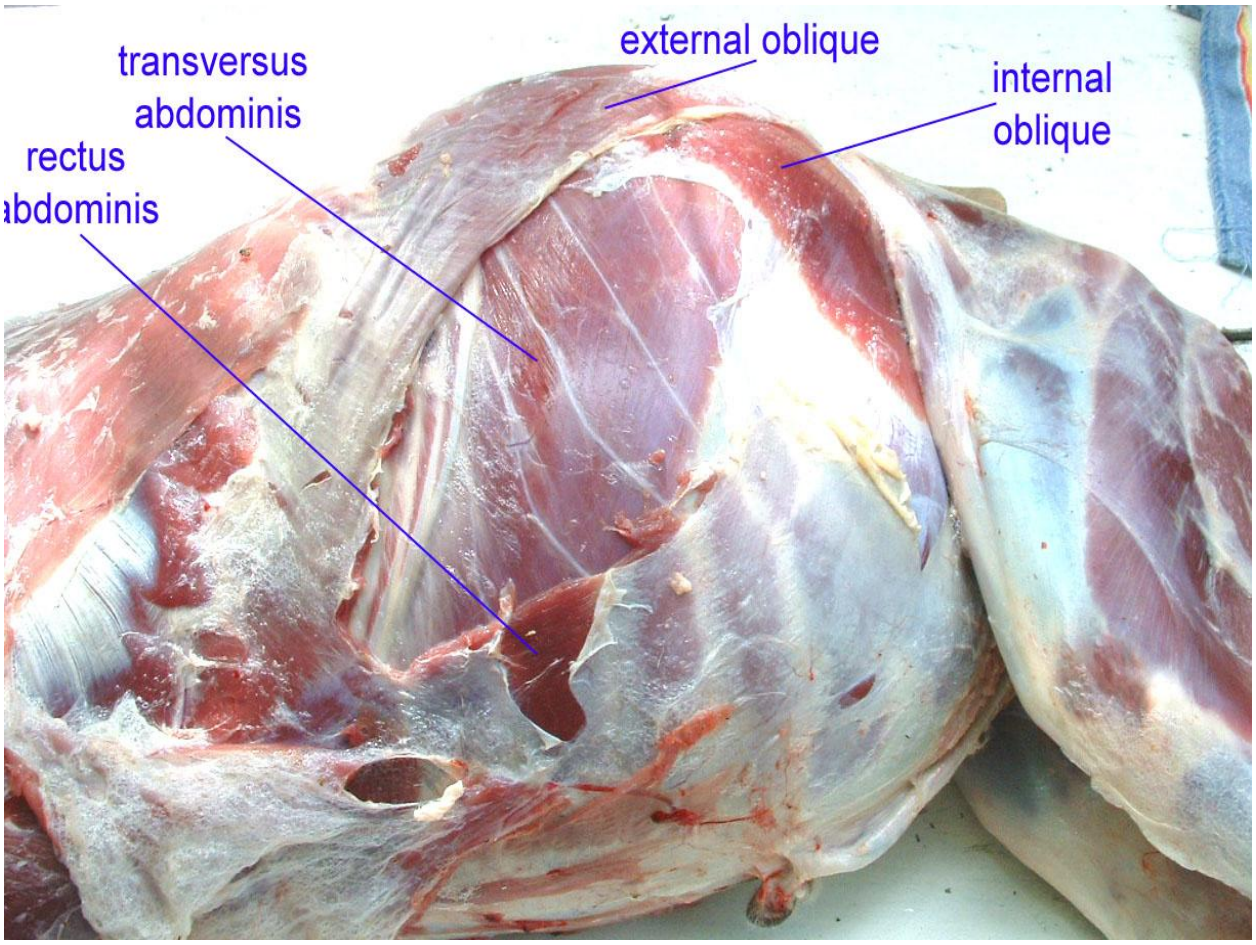


Figure 1:13 types of abdominal skeletal muscles (source: -
http://bio.sunyorange.edu/updated2/comparative_anatomy/anat.html2/M_ABDOMINAL.htm
Accessed on 27/08/2022

Muscles of the Hind limb

Hamstring muscles-

- The chief extensors of the hip.
- **Origin-**behind the hip joint from tuber ischia or pin bones.
- **Insertion**- Proximal end of the tibia or fibula.
- These muscles include Biceps femoris (extensive and flat muscle which covers most of the lateral aspect of hip and thigh), Semitendinosus (long muscle (tendon like) extend form ischium to tibia along the caudal aspect of the hip and thigh), and Semimembranosus muscles (wide & flat muscle placed at the caudal aspect of hip and thigh).

Middle gluteal muscle

- A very fleshy muscle covers an extensive part of the gluteal surface of ilium.

- It is partially covered by biceps femoris.
- It helps to abduct the limb and extend hip.
- **Origin-** the wing of ilium.
- **Insertion-** trochanter major of the femur.

Flexors of the Hip

- Located cranial to femur.
- **Origin** for **iliacus**-the ventral surface of the wing of ilium.
- **Insertion-** trochanter minor of femur.

Sartorius

- It is a thin flat muscle of the superficial layer placed cranial to gracialis.
- This muscle diagonally across the medial surface of the thigh.
- **Origin**-tuber coxae.
- **Insertion**-tibia (medial aspect of proximal)
- The deep gluteus, middle gluteal, superficial gluteus and tensor fascia lata are abductors of the hip.
- The pectineus, gracialis, adductor muscle & quadratus femoris are the major adductors of the hip.

Regional classification of skeletal muscles:

- **Muscles of head region**
  - ✓ These muscles are classified as muscles of f**ace** (caninus muscle, buccinators, lavator naso labialis) **eye** (malaris, orbicularis occuli) and mandibular (massetor muscle) muscles.
- **Muscles of neck region**
  - ✓ They are classified into two- ventro cervical muscles consisting of Bracheocephalicus and sterno cephalicus. And the second is dorso lateral cervical muscles which are found in layers named- trapezius, Rhomboidus, splenius, and the Longissimus muscles. The dorsolateral muscles of the neck region are important of intramuscular injection in bovines and equines.
- **Muscles of the back and loin**
  - ✓ These muscles are extended from the sacrum and ileum up to the head.

- ✓ The important muscle is Longissimus muscles which powerful extensor of back and loin.

- **Muscles of thorax**

This region consists of 3 muscles, Internal and external intercostals muscles and diaphragm. These muscles are important for inspiration and expiration, so they are referred as respiratory muscles.

- **Muscles of abdominal region**
  - ✓ These muscles are important for defecation, micturation, and parturition by compression of abdomen. These muscles are oblique externus and internus abdominus muscle, the transverse abdominus muscle and rectus abdominus muscle. The junction of these muscles form linea alba at the ventral region.

- **Muscles of thoracic limb**
  - ✓ They are generally originated dorsally and inserted ventrally.
  - ✓ This consists of 4 parts. Muscles of shoulder girdle (Dorsal divisiontrapezius, latismus dorsi muscles & ventral division- ascending and descending pectoral muscles, serratus ventralis muscle), muscle of shoulder (supra, and infra spinatus muscles, teres major muscle), muscle of Humorus (Triceps and biceps brachii muscles) and muscles of fore arm and manus (extensor- common digital extensor and raial extensor muscle) flexor of carpus- ulnar flexor muscle).

- **Muscles of pelvic limb**
  - ✓ These muscles are divided into three

a. sub lumbar (iliacus and psoas majora muscles),

b. muscles of hip and thigh- these are grouped into lateral (semitendinous, semi membranous, gluteus medius and gluteus biceps), cranial (one large muscle namely quadriceps femoris muscle) and medial (Sartorius and gracialis muscles) groups.

c. muscles of leg (extensor- long digital & lateral extensor muscle and flexor- deep digital and gastrocnemius muscle. The gluteal muscles are used for intramuscular injections in bovines but not in equines.

1.4.4. Connective tissue structures

Connective tissue structures identifiable in gross anatomy:

Tendon - attaches muscle to bone (called **aponeurosis** when sheet-like).

Ligament - attaches bone to bone (usually thickenings of fibrous joint capsules). Sheet of strong fibrous connective tissue connecting the articular ends of bones, binding them together and facilitating or limiting motion.

Cartilage- is the 'gristle' of the meat. It consists of a tough jelly-like matrix with cells suspended in it. It may contain collagen and elastic fibers. It is a flexible but tough tissue and is found at the ends of bones, in the nose, ear and trachea and between the vertebrae

Note: visceral ligaments located in body cavities are entirely different structures

Fascia - collagenous fibrous tissue that hold the body together

1.4.5. Basic functions of the bone, joints and muscles

I. Basic functions of the bone

- Protect the brain form physical injuries
- Supports many of the sense organs
- Forms passages for the beginning of the digestive & respiratory systems.
- They **furnish attachments** for the origin and insertion of the major muscles that control motion.
- They act as a **shock-absorbing device** to cushion the impact of the limbs against the ground.

Functional sesamoid bones allow muscles to exert greater pull on the movable bones distal to the sesamoid.

They give the tendons, which ride over the sesamoid, a greater amount of angular pull & consequently, a greater leverage. Since the **central opening** of the pelvis forms the birth canal in the female, the factors of reproduction enters into its structures

- It is the framework of the body.
- Protection of vital organs. E.g. the central nervous system is protected by the skull and vertebral column.
- In vertebrates, locomotion, defense, offense, grasping and other activities of this type depends largely upon the action of muscles that attached to the bones.
- The entire skeleton serves as a dynamic storage area for minerals, particularly calcium & phosphorus.

- These minerals are deposited and withdrawn as needed in the ongoing home kinetic processes.
- Blood cell formation- the red marrow is responsible for formation blood.

II. Basic functions of the Joints

- Serve as functional junctions between bones.
- Bind bones, strokes, and other related tissues together.
- Allow bone growth to occur.
- Permit certain structures to change shape during childbirth (i.e. pubic symphysis).
- Enable the body to have movements, lever actions, and body posture.

Table 1.1. Type and function of major joints

Type	Description	Function	Example
Fibrous	Bones connected by fibrous connective tissue • **Syndesmosis** Uses interosseous ligaments; • **Suture** (immovable joint) uses sutural ligaments;	Stability	Tibia/fibula Skull
Cartilaginous	Bone connected by cartilage • **Synchondrosis** uses hyaline cartilage • **Symphysis** uses hyaline cartilage	Bending	Sterno costalis Connection Spinal vertebrae
Synovial	Bone connected by ligaments (gliding, hinge, pivot)	Movement	Knee Hip

III. Basic functions of the muscle

Vertebrate muscle has only one function: **contraction**. “Relaxation” is a passive process, a lack of contraction. Thus, the varied functions of the muscular system are all based on contraction (or shortening) of muscle fibers. Layers of smooth muscle in the walls of the stomach and intestines

contract to mix and propel food along the gastrointestinal tract; smooth muscle layers in the walls of blood vessels control the distribution of blood, which is propelled by the contraction of the cardiac muscle of the heart. In the eye, smooth muscle fibers adjust the diameter of the pupil and thickness of the lens for optimal vision, while in the skin, contraction of smooth muscles causes the hair to stand up. Skeletal muscles permit locomotion by contracting to change the relative positions of bones during movement and by maintaining joint angles against the pull of gravity during support. The skeletal muscles of respiration move air into and out of the lungs by contracting to change the volume of the thoracic cavity. In addition, heat production through shivering is the result of brief repetitive contractions of skeletal muscle throughout the body. The remainder of this chapter describes the locations, attachments, and actions of the major skeletal muscles.

1.5. Anatomy and physiology of the digestive system and accessory digestive organs

Introduction to anatomy and physiology digestive system

The digestive system is a tube running from mouth to anus. The breakdown of food stuffs is accomplished through a combination of mechanical and enzymatic processes. To accomplish this breakdown, the digestive tube requires considerable assistance from accessory digestive organs such as the salivary glands, liver and pancreas, which dump their secretions into the tube. Remarkably diverse and specialized processes take place in different sections of the digestive tract, but there is a fundamental consistency in the architecture of the tubular digestive tract.

The Gut

The **digestive tract, alimentary canal** or **gut** is a hollow tube stretching from the mouth to the anus. It is the organ system concerned with the treatment of foods. At the mouth the large food molecules are taken into the gut - this is called **ingestion**. They must then be broken down into smaller ones by digestive enzymes - **digestion**, before they can be taken from the gut into the blood stream - **absorption**. The cells of the body can then use these small molecules - **assimilation**. The indigestible waste products are eliminated from the body by the act of **egestion.**

The food that enters the **mouth** passes to the **esophagus**, then to the **stomach**, **small intestine**, **cecum**, **large intestine**, **rectum** and finally undigested material exits at the **anus**. The **liver** and **pancreas** produce secretions that aid digestion and the **gall bladder** stores **bile**. Animals do not have an appendix.

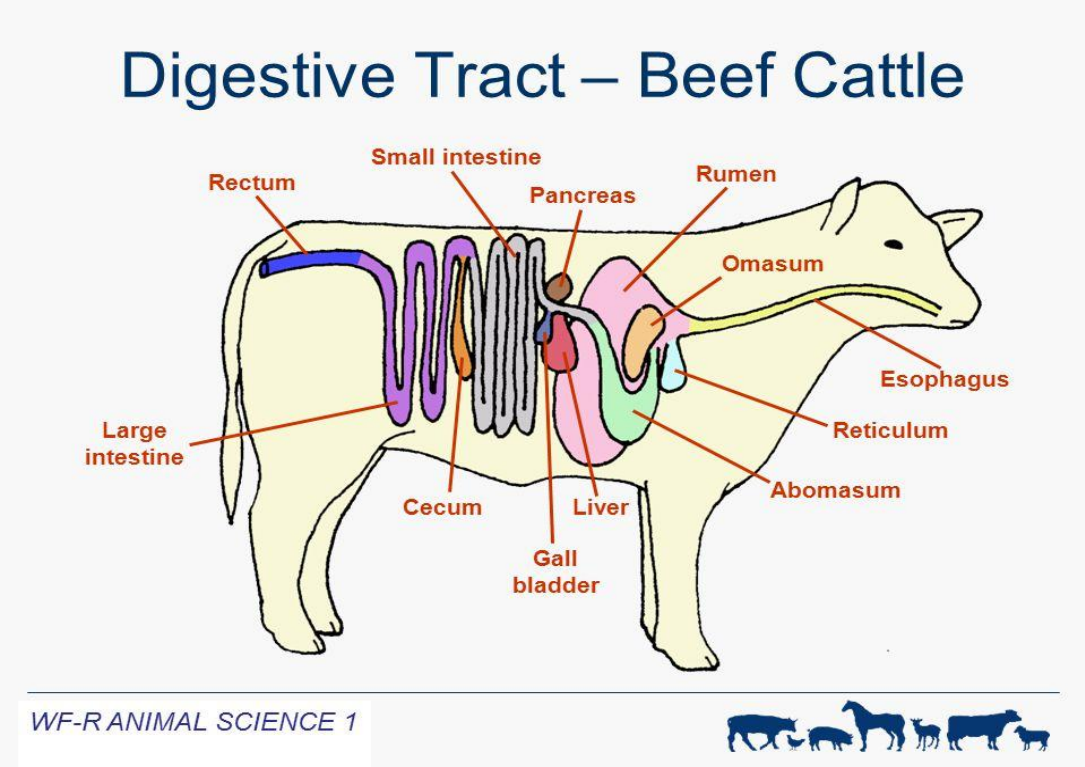


Figure 1.14: A typical ruminant gut (**source**: https://www.dreamstime.com/illustration/ruminant-digestive-system.html Accessed on 29/08/2022

1.5.1. Components of the digestive system

- The digestive system consists of:
    a) **Alimentary tract:**
    b) **Accessory glands:** - closely related with digestion function (Salivary gland, Liver and Pancreas).

a) Alimentary tract: - that extends from mouth to anus (mouth, oesophagus, stomach, small and large intestine).

I. Mouth (Oral cavity)

The mouth takes food into the body. The lips hold the food inside the mouth during chewing and allow the baby animal to suck on its mother's teat. In elephants the lips (and nose) have developed into the trunk which is the main food collecting tool. The mouth is bounded by Cheeks laterally, Soft palate and hard palate dorsally and Body of the mandible ventrally. Hard palate is the dorsal wall of the oral cavity and it continuous with soft palate caudally without any external demarcation. In equine, soft palate is well developed in length and makes contact with epiglottis that may prevent mouth breathing and Introduction of stomach tube through the mouth. Hence during vomiting the ejected matter will escape usually through the nasal cavity since it will be prevented by this long curtain like soft palate from going to the oral cavity. So, vomiting is fatal for horse and interobation is possible only using the nostril.

The sight or smell of food and its presence in the mouth stimulates the **salivary glands** to secrete **saliva**. There are four pairs of these glands in cats and dogs. The fluid they produce moistens and softens the food making it easier to swallow. It also contains the enzyme, **salivary amylase**, which starts the digestion of starch. The **tongue** moves food around the mouth and rolls it into a ball for swallowing. **Taste buds** are located on the tongue and in dogs and cats it is covered with spiny projections used for grooming and lapping. The cow's tongue is prehensile and wraps around grass to graze it. Swallowing is a complex reflex involving 25 different muscles. It pushes food into the **esophagus** and at the same time a small flap of tissue called the **epiglottis** closes off the windpipe so food doesn't go 'down the wrong way' and choke the animal.

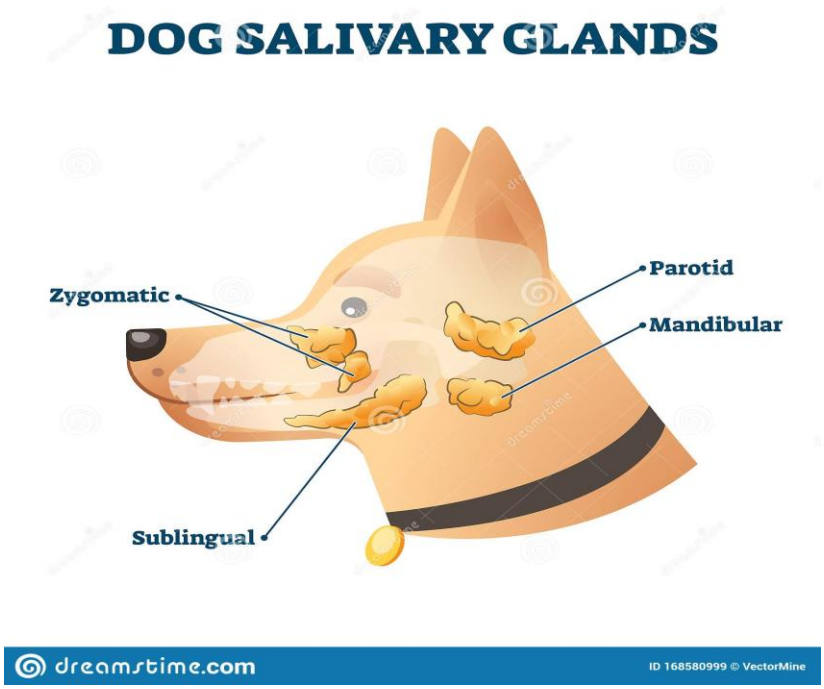


Figure 1:15: Mouth cavity with its associated structures salivary glands (**Source**: - https://www.dreamstime.com/dog-salivary-glands-vector-illustration-animal-anatomy-educational-scheme-zoological-diagram-inner-organs-location-image168580999 Accessed on 29/08/2022

II. Teeth

Teeth seize, tear and grind food. They are inserted into sockets in the bone and consist of a crown above the gum and root below. The crown is covered with a layer of **enamel**, the hardest substance in the body. Below this is the **dentine**, a softer but tough and shock resistant material. At the centre of the tooth is a space filled with **pulp** which contains blood vessels and nerves. The tooth is cemented into the **socket** and in most teeth the tip of the root is quite narrow with a small opening for the blood vessels and nerves. In teeth that grow continuously, like the incisors of rodents, the opening remains large and these teeth are called open rooted teeth. Mammals have 2 distinct sets of teeth. The first the milk teeth are replaced by the permanent teeth.

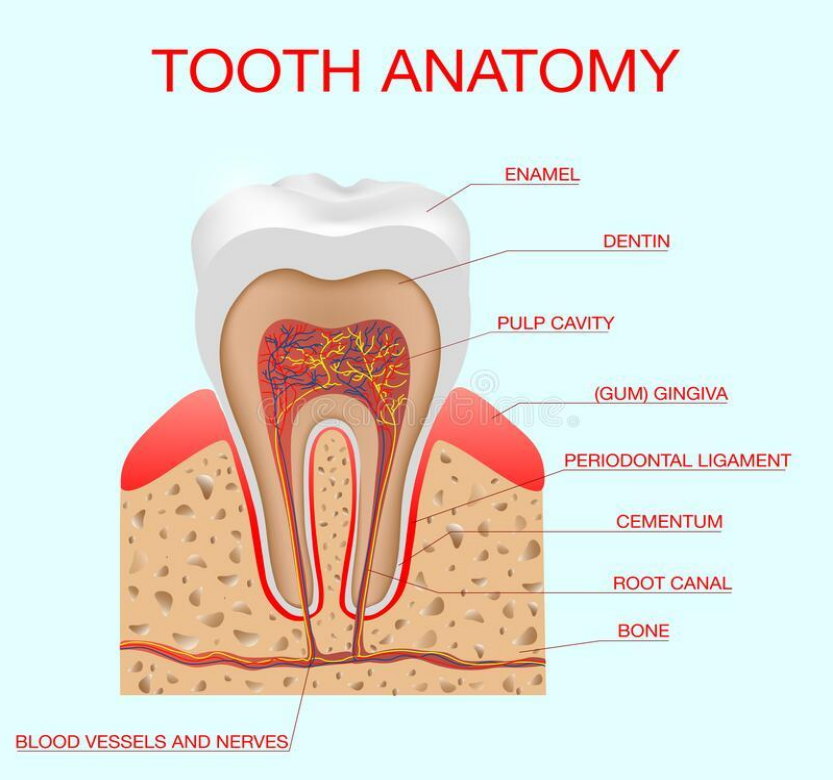


Figure 1:16: Structure of a tooth source: - https://www.dreamstime.com/root-canal-dental-infographic-structure-inside-tooth-diagram-chart-illustration-vector-llustration-concept-education-image189185411 Accessed on 28/08/2022

Types of Teeth

All the teeth of fish and reptiles are similar but mammals usually have four different types of teeth. The **incisors** are the chisel-shaped 'biting off' teeth at the front of the mouth. In rodents and rabbits the incisors never stop growing (open-rooted teeth). They must be worn or ground down continuously by gnawing. They have hard enamel on one surface only so they wear unevenly and maintain their sharp cutting edge. The largest **incisors** in the animal kingdom are found in elephants, for tusks are actually giant incisors. Sloths have no incisors at all, and sheep have no incisors in the upper jaw. Instead there is a horny pad against which the bottom incisors cut.

The **canines** or 'wolf-teeth' are long, cone-shaped teeth situated just behind the incisors. They are particularly well developed in the dog and cat families where they are used to hold, stab and kill the prey. The tusks of boars and walruses are large canines while rodents and herbivores like

sheep have no (or reduced) canines. In these animals the space where the canines would normally be is called the **diastema**. In rodents like the rat and beaver it allows the debris from gnawing to be expelled easily. The cheek teeth or **premolars** and **molars** crush and grind the food. They are particularly well developed in herbivores where they have complex ridges that form broad grinding surfaces. These are created from alternating bands of hard enamel and softer dentine that wear at different rates. In carnivores the premolars and molars slice against each other like scissors and are called carnassials.

- **Table 1.2** Dental formal for each spp of domestic animals

	Dental formula for different species	
Species	Temporary teeth	Permanent teeth
Ruminants	$2(I^0_4\ C^0_0 P^3_3)=20$	$2(I^0_4\ C^0_0 P^3_3\ M^3_3)=32$
Horse	$2(I^3_3\ C^0_0 P^3_3)=24$	$2(I^3_3\ C^1_1\ P^{3/4}_3\ M^3_3)= 40/42$
Dog	$2(I^3_3\ C^1_1 P^3_3)=28$	$2(I^3_3\ C^1_1 P^4_4\ M^2_3)=42$
Pigs	$2(I^3_3\ C^1_1 P^3_3)=28$	$2(I^3_3\ C^1_1 P^4_4\ M^3_3)=44$
Camel	$2(I^1_3\ C^1_1\ P^3_3)=22$	$2(I^1_3\ C^1_1 P^3_2\ M^3_3)=34$
Human	$2(I^2_2\ C^1_1\ P^3_3)=24$	$2(I^2_2 2C^1_1 P^2_2\ M^3_3)=32$

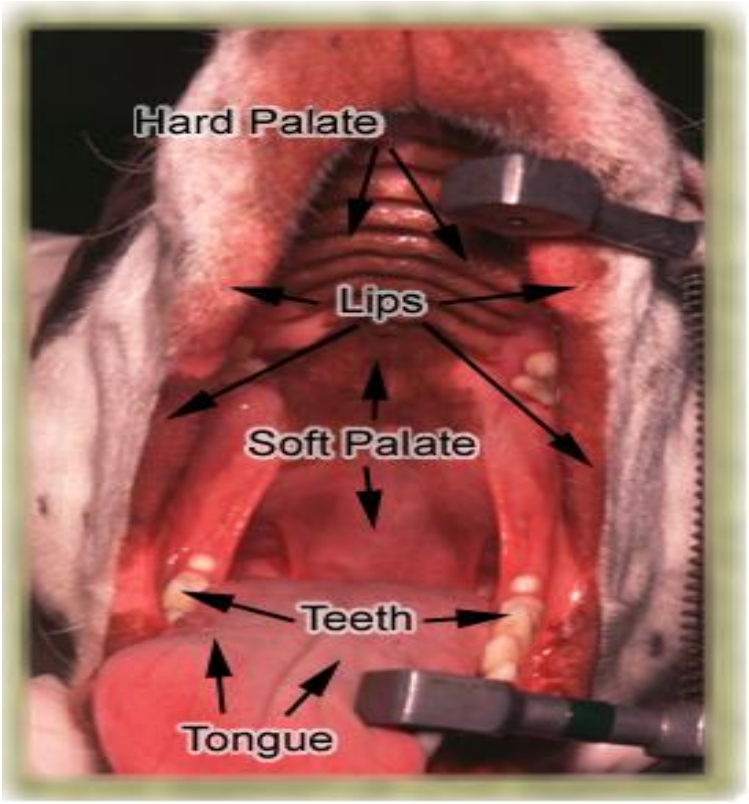


Figure1.17:-Anatomy of oral cavity in animals. Source**:-** https://www.drvet.in/2019/05/the-digestive-apparatus-of-animals.html Accessed on 31/08/2022

III. Oesophagus

The **esophagus** transports food to the stomach. Food is moved along the esophagus, as it is along the small and large intestines, by contraction of the smooth muscles in the walls that push the food along rather like toothpaste along a tube. This movement is called **peristalsis.**

IV. Stomach

The **stomach** stores and mixes the food. Glands in the wall secrete **gastric juice** that contains enzymes to digest protein and fats as well as **hydrochloric acid** to make the contents very acidic. The walls of the stomach are very muscular and churn and mix the food with the gastric juice to form a watery mixture called **chyme** (pronounced kime). Rings of muscle called **sphincters** at the entrance and exit to the stomach control the movement of food into and out of it.

- **Stomach types**

a) **Monogastric animals:-** are stomach of monogastric animals

- Horses, Donkey, swine, poultry

b) Poly gastric animals

- Ruminants (cattle, sheep and goats) and camels **(Psuedoruminant** lack of Omasum)

Stomach of ruminants

Contain four champers

- ✓ Rumen
- ✓ Reticulum
- ✓ Omasum
- ✓ Abomasum

- ✓ **The Rumen**

In ruminant **herbivores** like cows, sheep and antelopes the stomach is highly modified to act as a "fermentation vat". It is divided into four parts. The largest part is called the **rumen**. In the cow it occupies the entire left half of the abdominal cavity and can hold up to 270 liters.

- ✓ **The reticulum**

It is much smaller and has a **honeycomb** of raised folds on its inner surface. In the camel the reticulum is further modified to store water.

- ✓ **The omasum** with a folded inner surface. Camels have no omasum.
- ✓ The final compartment is called the **abomasum**.

This is the **'true' stomach** where muscular walls churn the food and gastric juice is secreted. The rumen (on the left flank), reticulum and abomasums (on the right ventral abdomen). The omasum lies in the lower part of the right anterior abdomen between the reticulum and anterior rumen to the left. The gastrointestinal system within the abdomen is composed of the fore stomachs, the small intestine and the large intestine. The fore stomachs are composed of the reticulum, rumen, omasum and abomasum.

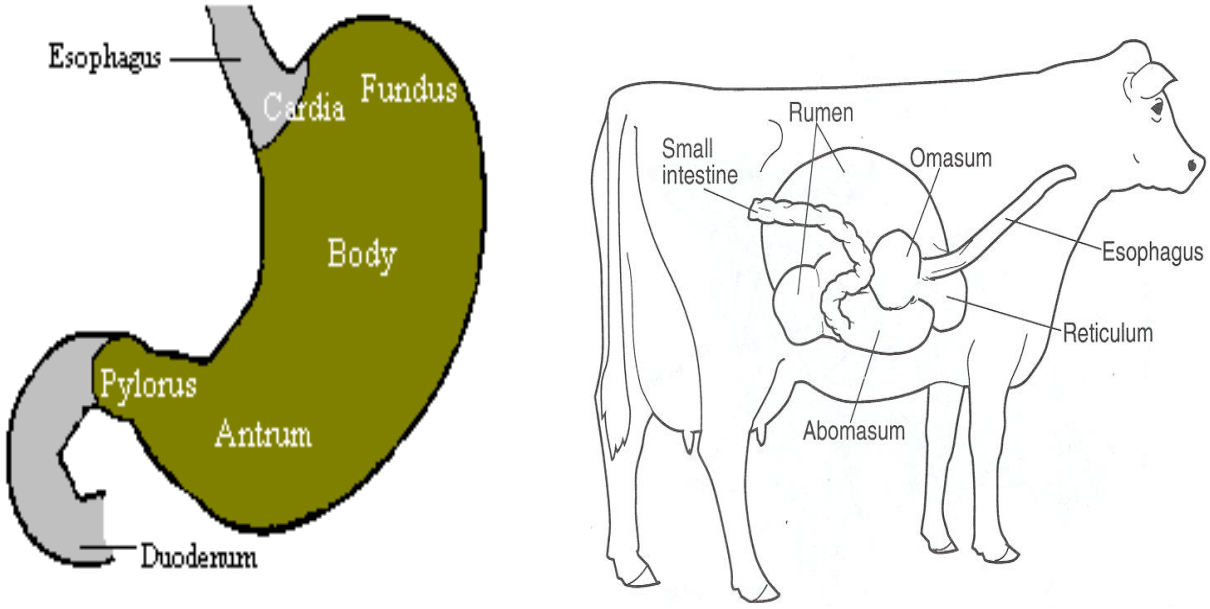


Figure 1:18: The Stomach of monogastric and ruminants animals from left to right

https://www.chegg.com/flashcards/chap-21-digestive-system-17fd0c01-7f53-4959-8642-05d93c8ee27d/deck Accessed on 29/08/2022

Ruminants swallow the grass they graze almost without chewing and it passes down the esophagus to the rumen and reticulum. Here liquid is added and the muscular walls churn the food. These chambers provide the main fermentation vat of the ruminant stomach. Here bacteria and single-celled animals start to act on the cellulose plant cell walls. These organisms break down the cellulose to smaller molecules that are absorbed to provide the cow or sheep with energy. In the process, the gases methane and carbon dioxide are produced. These causes the "burps" you may hear cows and sheep making. Not only do the micro-organisms break down the cellulose but they also produce the **vitamins E, B and K** for use by the animal. Their digested bodies provide the ruminant with the majority of its protein requirements. In the wild grazing is a dangerous activity as it exposes the herbivore to predators. They crop the grass as quickly as possible and then when the animal is in a safer place the food in the rumen can be regurgitated to be chewed at the animal's leisure. This is 'chewing the cud' or **rumination**. The finely ground food may be returned to the rumen for further work by the microorganisms or, if the particles are small enough, it will pass down a special groove in the wall of the esophagus straight into the

omasum. Here the contents are kneaded and water is absorbed before they pass to the abomasum. The abomasum acts as a **"proper" stomach** and gastric juice is secreted to digest the protein

V. Small Intestine

Most of the breakdown of the large food molecules and absorption of the smaller molecules take place in the long and narrow small intestine. The total length varies but it is about 6.5 meters in humans, 21 meters in the horse, 40 meters in the ox and over 150 meters in the blue whale. These complete the digestion of starch, fats and protein. The products of digestion are absorbed into the blood and lymphatic system through the wall of the intestine, which is lined with tiny finger-like projections called **villi** that increase the surface area for more efficient absorption.

It is divided into 3 sections:

- The duodenum the duodenum receives 3 different secretions:
  - ✓ **Bile** from the liver;
  - ✓ **Pancreatic juice** from the pancreas and
  - ✓ **Intestinal juice** from glands in the intestinal wall.
- Jejunum and
- Ileum.

VI. Large Intestine

The **large intestine** consists of the **caecum**, **colon** and **rectum**. The chyme from the small intestine that enters the colon consists mainly of water and undigested material such as cellulose (fiber or roughage). In **omnivores** like the pig and humans the main function of the colon is absorption of water to give solid faces. Bacteria in this part of the gut produce vitamins B and K. The caecum, which forms a **dead-end pouch** where the small intestine joins the large intestine, is small in pigs and humans and helps water absorption. However, in rabbits, rodents and horses, the caecum is very large and called the **functional caecum**. It is here that cellulose is digested by micro-organisms. The **appendix**, a narrow dead end tube at the end of the caecum, is particularly large in primates but seems to have no digestive function.

Functional Caecum

The caecum in the rabbit, rat and guinea pig is greatly enlarged to provide a **"fermentation vat"** for micro-organisms to break down the cellulose plant cell walls. This is called a **functional caecum.** In the horse both the caecum and the colon are enlarged. As in the rumen, the large cellulose molecules are broken down to smaller molecules that can be absorbed. However, the position of the functional caecum after the main areas of digestion and absorption means it is potentially less effective than the rumen. This means that the small molecules that are produced there cannot be absorbed by the gut but pass out in the faces. The rabbit and rodents (and foals) solve this problem by eating their own faces so that they pass through the gut a second time and the products of cellulose digestion can be absorbed in the small intestine. Rabbits produce two kinds of faces. Softer night-time faces are eaten directly from the anus and the harder pellets you are probably familiar with, that have passed through the gut twice.

b) Accessory digestive organs: closely related with digestion function (Salivary gland, Liver and Pancreas). These secrete enzymes and fluid that facilitate the digestive process in addition to the numerous glands located in the wall of the stomach and intestine.

The Gut of Birds

Birds' guts have important differences from mammals' guts. Most obviously, birds have a **beak** instead of teeth. Beaks are much lighter than teeth and are an adaptation for flight. Imagine a bird trying to take off and fly with a whole set of teeth in its head! At the base of the esophagus birds have a bag-like structure called a **crop**. In many birds the crop stores food before it enters the stomach, while in pigeons and doves glands in the crop secretes a special fluid called **crop-milk** which parent birds regurgitate to feed their young. The stomach is also modified and consists of two compartments. The first is the **true stomach** with muscular walls and enzyme secreting glands. The second compartment is the **gizzard**. In seed eating birds this has very muscular walls and contains pebbles swallowed by the bird to help grind the food. This is the reason why you must always supply a caged bird with grit. In birds of prey like the falcon the walls of the gizzard are much thinner and expand to accommodate large meals.

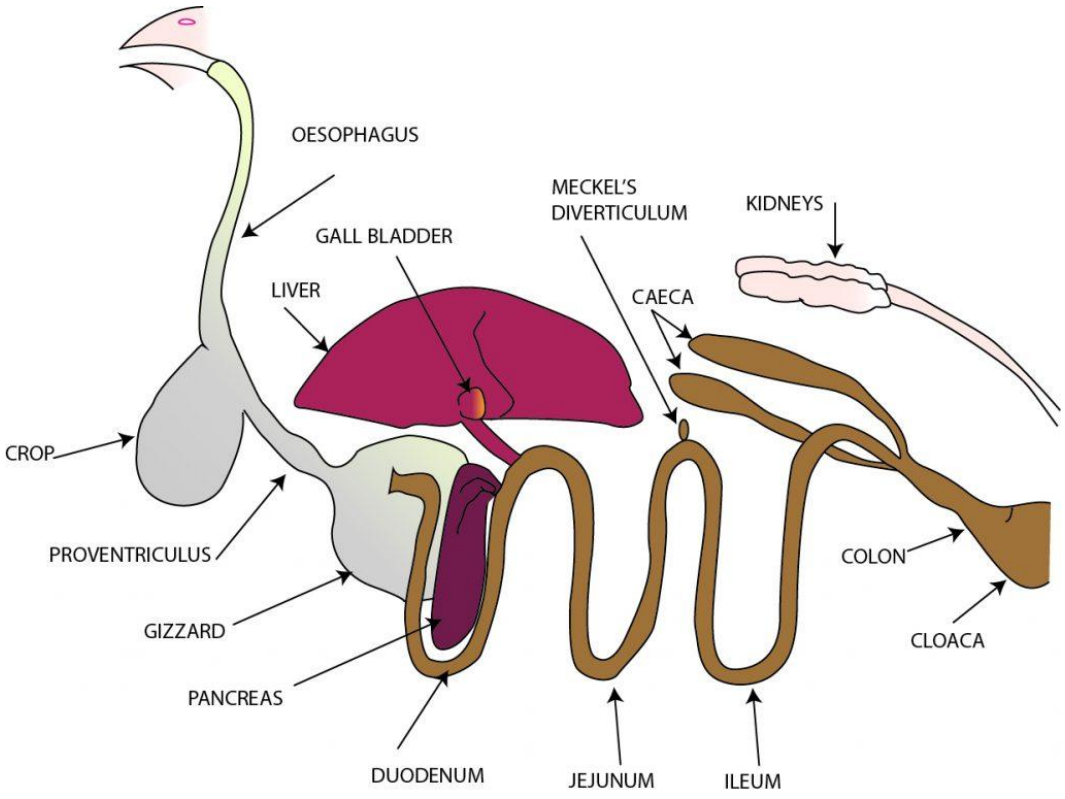


Figure 1:19:- digestive system of avian (**source**: - https://www.poultryhub.org/anatomy-and-physiology/body-systems/digestive-system Accessed on 26/08/2022.

1.5.2 Basic functions of the digestive system

Digestion is defined as a process of breakdown of complex macro molecules into simple, micro molecule which can be easily absorbed and assimilated in cells.

The factors of digestion:

- **Mechanical factors:** Mastication, Deglutition, Regurgitation, vomiting, gastric & intestinal motility, & defecation
- **Secretary factors:** Secretions of digestive glands
- **Chemical factors:** action of enzymes, action of Hcl.
- **Microbiological factors:** Bacteria

Prehension of Food:

- Prehension means seizing and conveying of food to mouth.
- In all domestic animals lips, teeth, tongue are principal organs of Prehension.

I. Digestion in Mouth:

- Breakdown large pieces into small pieces, resulting in a massive increase in surface area, which is where digestive enzymes work.
- Softening of food and transformation into a size conductive to swallowing.
- Lubrication of food by impregnating it with saliva.
- Chewing is, to a large extent, a reflex, although you can voluntarily masticate as well.
- During mastication, the tongue and, to a lesser extent, the lips and cheeks acts to keep food between the grinding surfaces of the teeth.
- The final step in pregastric digestion is swallowing, also known as deglutition.

Function of saliva:

- Saliva serves many roles, some of which are important to all species and others to only a few.
- Saliva functions are
  - Lubrication and binding,
  - Solubilizes dry food,
  - Oral hygiene,
  - Initiates starch digestion,
  - Provides alkaline buffering and fluid, and
  - Evaporative cooling:

Mastication:

- Mastication or chewing is the mechanical reduction of food which takes place in Mouth.
- The grinding of food takes place by molar teeth.

Importance of Mastication:

- Finely divided food provides greater surface area for action of digestive juice.
- Food well mixed with saliva is more easily swallowed.

II. Digestion in Simple stomach animals (Horse, Donkey, Swine, Poultry) or monogastric animals

a. Stomach secretions:

- Mucus protects the stomach lining.
- Pepsinogen is converted to pepsin, which digests proteins.
- Hydrochloric acid promotes pepsin activity and kills microorganisms.
- Intrinsic factor is necessary for vitamin B12 absorption.

b. Movement in the stomach:

- The stomach stretches and relaxes to increase volume.
- Mixing waves mix the stomach contents with stomach secretion to form chyme.
- Peristaltic waves move the chyme into the duodenum.
- The stomach wall is made up of 4 layers.
- They are Serous, muscular, sub mucosal & mucosal layers.
- **It possesses 3 glandular Zones**- cardiac, Fundic, Pyloric.
- The esophageal part is glandless.
- In **horse**- esophageal part is large, in pig it is limited & in dog it is lacking.

Gastric Secretion:

- There is a constant gastric secretion flow into stomach. At least of 50 ml secretion is always present which is called residium.
- Based on location 3 kinds of glands present.

Gastric Juice:

- Thin, transparent fluid. PH – 0.9 – 1.8. It contains 99% water, Salts-Na, Cl, Po4, Mucin and enzymes like Pepsin, rennin, gastric lipase.

Action of Gastric Juice:

- Secreted by oxyntic / parietal cells of pyloric glands.
    - The Hcl performs the following functions.
        - ✓ It Kills/ destroys bacteria which is taken along with food.
        - ✓ It provides optimum PH condition for enzymes to act on food.

- ✓ It dissolves the material & make readily available for enzyme action. HCl to liberate hormone secretion from intestinal mucosa which helps in stimulates the pancreatic secretion.
- ✓ It is believed to control the opening & closing of pyloric aperture.

III. Digestion in ruminant stomach (Cattle, sheep, goat)

a. Rumen & reticulum:

- Any food taken in normal manner, in adult ruminants goes to anterior dorsal sac of rumen.
- Some heavier food soon finds its way into reticulum.
- Usually there is a collection of gas above the food mass.
- The reticulum is an anterior continuation of rumen with which it freely communicates over the rumino reticular fold.
- The reticular content consists of liquids and suspended solids.
- The more solid ingesta of rumen are kept from entering and choking up the reticulum by rumino reticular fold which acts as bridge between 2 regions of stomach.
- At fairly regular intervals, the portions of the ruminal and reticular contents are returned to mouth for remastication & rein salivation.
- During their movements, the ingesta are subjected to energetic mixing, churning because of rumen and reticular motility.
- The contraction & relaxation of rumen forces ingesta forward & upward into anterior dorsal region of the rumen.
- The contractions begin at anterior pillar proceeds backwards towards longitudinal posterior & dorsal coronary pillars.
- As these contractions relax, the ventral coronary pillars & musculature of ventral sac stars contractions.
- Following this primary wave, secondary wave proceeds in the same way as primary wave.
- The pump like action of reticulum causes a flow of liquid in to & out of rumen. The significance of the flow being-
  - ➢ To direct ingesta in to rumen.

- To regulate passage of ingesta from rumen to omasum or abomasums.
- To supply moisture to rumen content,
- To assist on regurgitation.

b. Omasum:

- The omasum shows peristaltic contractions.
- The contractions were found to be slow, sluggish and often super imposed on strong dry tonus waves.
- As a result of contractions of omasum, its contents are subjected to considerable pressure and some of them are passed on to abomasums.
- The more fluid portion directly passes in to abomasums.
- But the solids are held back.
- The function of omasum is to grind food materials entered in to it.
- The omasum is drier than rumen & reticulum.
- It contains 50 – 60 % water and PH is 7.2.
- These conditions are unfavorable for chemical digestion.
- It was observed in young goats the food passes from rumen, reticulum and then directly in to abomasums without entering in to omasum.

c. Abomasum:

- It is the glandular portion of ruminant stomach, presents Fundic & pyloric zones with respective digestive glands.
- Their secretion is gastric juice, so the function of the abomasums is essentially the same as that of simple stomach.
- The gastric content PH is 2.0 – 4.0. The contractions are similar to simple stomach.
- The true stomach fundus is normally quite.
- The body shows numerous contractions & relaxations.
- The pyloric part shows peristaltic waves.

Rumination and eructation:

- Ruminants are well known for “cud chewing”.
- Rumination is regurgitation of ingesta from the reticulum, followed by remastication and reswallowing.

- It provides for effective mechanical breakdown of roughage and thereby increases substrate surface area to fermentative microbes.
- Regurgitation is initiated with a reticular contraction distinct from the primary contraction.
- This contraction, in conjunction with relaxation of the distal esophageal, sphincter, allows a bolus of ingesta to enter the esophagus.
- The bolus is carried into the mouth by reverse peristalsis.
- The fluid in the bolus is squeezed out with the tongue and reswallowed, and the bolus itself is remasticated, then reswallowed.
- Eructation or belching is how ruminants continually get rid of fermentation gases.
- As mentioned above, an eructation is associated with almost every secondary ruminal contraction.
- Anything that interferes with eructation is life threatening to the ruminant because the expanding rumen rapidly interferes with breathing.
- Animals suffering ruminal tympani (bloat) die from asphyxiation.

Nutrient absorption and utilization in ruminants:

- Volatile fatty acids (VFA's) are produced in large amounts through ruminal fermentation and are of paramount importance in that they provide greater than 70% of the ruminant's energy supply.
- Virtually all of the acetic, proprionic acid and butyric acids formed in the rumen are absorbed across the ruminal epithelium, from which they are carried by ruminal veins to the portal vein and hence through the liver.

Absorption in ruminant stomach:

- The capillaries of rumen mucosa come in to intimate relation with deep epithelial cells.
- The omasal epithelium is similar to that of rumen.
- Evidence of absorption was obtained from all 4 compartments, but in the first compartments absorption is more rapid than in abomasums.
- The amount absorbed from the omasum is less than the rumen. Absorption of glucose and fatty acids are absorbed in rumen.
- The partially digested food in stomach is called chyme.

- It contains water, Hcl, Inorganic salts, Meta proteins, proteases, peptones, starch, dextrin's and maltose, cellulose, fats & others depending on diet & feeding habits of the animal.
- The chyme enters in to small intestine for further digestion.

IV. Digestion in small intestine:

- It is within the small intestine that the final stages of enzymatic digestion occur, liberating small molecules capable of being absorbed.
- The small intestine is also the sole site in the digestive tube for absorption of amino acids and monosaccharide.
- Most lipids are also absorbed in this organ.
- The small intestine incorporates three features which account for its huge absorptive surface area:

Bile juice: Bile is produced by the parenchymal cells of the liver and stored in the gall bladder.

Role of bile:

- Bile creates alkaline medium in intestine in order to activate pancreatic lipase.
- The acids of augment the action of proteolytic and aminolytic enzymes.
- It is capable to dissolve a large amount of Fatty acids.
- Emulsifies fats and lowers surface tension make accessible for lipase action
- Essential for absorption of products of fat digestion.

Pancreatic Juice:

- The pancreas is one of the most important digestive glands.
- The exocrine part consists of acinar cells which secrete pancreatic juice.
- The important feature of pancreatic juice is high concentration of bicarbonate & several enzymes hydrolysis any food.

Mechanical Factors of Digestion in small intestine:

- The Chyme enters the intestine by peristaltic waves through pylorus where greater part of digestion & absorption takes place.
- The purpose of this movement is to mix & churn the intestinal contents and propel towards large intestine.

- The mechanical digestion occurs by the following movements:
  - ✓ Tonus changes,
  - ✓ Pendular movements,
  - ✓ Segmenting movements.
- The basic purpose of these movements is to mechanical breakup the intestinal contents & mixes them with various digestive juices.

Peristaltic movements:

- These are meant to propel the intestinal contents.
- The wave propelling the contents down wards or posterior end is called diastalsis.
- In some cases large intestine (descending colon) consists of wave of contraction which moves up wards called anastalisis or anti peristalsis.

V. Digestion in large intestine:

- The large intestine is the last attraction in digestive tube and the location of the terminal phases of digestion. In comparison to other regions of the tube, there are huge differences among species in the relative size and complexity of the large intestine.
- Nonetheless, in all species it functions in three processes.
  - ✓ Absorption of water and electrolytes from ingesta
  - ✓ Formation and storage of feces and
  - ✓ Microbial fermentation.

1.6. Anatomy and physiology of respiratory system

1.6.1. Introduction to respiratory system

Animals require a supply of energy to survive. This energy is needed to build large molecules like proteins and glycogen, make the structures in cells, move chemicals through membranes and around cells, contract muscles, transmit nerve impulses and keep the body warm. Animals get their energy from the large molecules that they eat as food. Glucose is often the energy source but it may also come from other carbohydrates, as well as fats and protein. The energy is made by the biochemical process known as **cellular respiration** that takes place in the **mitochondria**

inside every living cell. The overall reaction can be summarized by the word equation given below.

Carbohydrate Food (glucose) + Oxygen = Carbon Dioxide + Water + energy

Oxygen enters the body from the air (or water in fish) and carbon dioxide is usually eliminated from the same part of the body. This process is called **gas exchange**. In fish gas exchange occurs in the gills, in land dwelling vertebrates lungs are the gas exchange organs and frogs use gills when they are tadpoles and lungs, the mouth and the skin when adults.

Mammals (and birds) are active and have relatively high body temperatures so they require large amounts of oxygen to provide sufficient energy through cellular respiration. In order to take in enough oxygen and release all the carbon dioxide produced they need a very large surface area over which gas exchange can take place. The many minute air sacs or **alveoli** of the lungs provide this. When you look at these under the microscope they appear rather like bunches of grapes covered with a dense network of fine capillaries. A thin layer of water covers the inner surface of each alveolus. There is only a very small distance -just 2 layers of thin cells - between the air in the alveoli and the blood in the capillaries. The gases pass across this gap by **diffusion**.

- Two kinds of respiration are constantly going on in the body:
  - ✓ **External respiration**
  - ✓ **Internal respiration**

External respiration:

- Occurs in the lungs.
- It is the exchange of oxygen and carbon dioxide that takes place between the air inhaled into the lungs and the blood flowing through the pulmonary (lung) capillaries.

Internal respiration:

- Occurs all over the body.
- It is the exchange of oxygen and carbon dioxide between the blood in the capillaries all over the body (the systemic capillaries) and all of the cells and tissues of the body.

1.6.2. Components of respiratory tract

a. Upper respiratory tract

- Nostril
- Nasal passages
- Pharynx
- Larynx
- Trachea

b. Lower respiratory tract

- Bronchi
- Bronchioles
- Alveolar ducts
- Alveoli

Anatomy of the respiratory system

- Structurally, the respiratory system consists of the lungs and a system tubes that connects them with the external environment. All the respiratory structures outside the lungs are part of upper respiratory tract and all the structures within the lungs are part of lower respiratory tract.

a. Upper Respiratory Tract

- The upper portion of respiratory tract includes the nose, the pharynx, the larynx, and the trachea.
- All the air that enters and leaves the lungs does so through the upper respiratory structures.

Nostrils (Nose)

The nostrils are the external openings of the air passages. They vary in size and shape from the soft, pliable, easily dilated nostrils of the horse to the rigid opening in the snout of a pig. The skin surrounding the nostril is continuous with and forms part of the muzzle. The muzzle of the horse, one of the chief organs of touch, may be used by the horse in the investigation of strange. The muzzle is covered with hair and contains both sebaceous and tubular (sweat) glands. The non-haired areas (plenum nasal) of the cow, Sheep, and

pig muzzle contain no sebaceous glands. Long-standing fever in the cow may cause this area to become dry and scabby.

Nasal Cavities (Nasal passages)

- The nasal cavity is separated from the mouth by the hard and soft palates and separated into two halves by a median cartilaginous septum. Each half of the nasal cavity communicates with the nostril of the same side Rostral and with the pharynx caudally by way of the posterior nacres. The nasal cavity is lined with **mucous membrane** which covers a number of scroll-like **turbinate bones** located on the lateral wall of the nasal cavity. There are two major turbinate bones (**dorsal turbinate** and **ventral turbinate**) and a series of small **ethmoturbinate bones**. The vascular mucous membrane covering these turbinates helps warm the inspired air. The mucous membrane in the caudal part of the nasal cavity contains the sensory ending of the olfactory nerve, which mediates the sense of small. The actual space of the nasal cavity is subdivided in part by the dorsal and ventral turbinate bones into **nasal meatuses**. The word meatus means **passageway.** The dorsal nasal meatus is located between the dorsal turbinate and the roof of the nasal cavity. The middle nasal meatus is between the two turbinates. The ventral turbinate meatus is between the ventral turbinate and the floor of the nasal cavity. The common nasal meatus is common to the first three meatuses. It is located between the nasal septum and the structures and spaces on the lateral side of the nasal cavity. Aside from housing the receptors for the sense of smell, the main function of the nasal passages is to condition the inhaled air that passes through them to protect the lungs. The three main conditioning roles performed by the nasal lining are **warming, humidifying, and filtering the inhaled air.** The scroll-like twists and turns of the turbinates tremendously increase the surface area of the nasal lining.

Sinuses

- Passages from the sinuses (air-filled cavities) in certain cranial bones open into the nasal cavity. All farm animals have maxillary, frontal, sphenoidal, and palatine sinuses excavated in the bones of the same name. In the horse the sphenoidal and palatine sinuses are fused to form one sinus, the sphenopalatine sinus. The cow and sheep have an additional sinus, the lacrimal sinus, excavated in each lacrimal bone.

- Several upper cheek teeth project into the maxillary sinus.
- It may become infected due to diseased teeth, particularly in the horse.
- Dehorning mature cattle usually opens the frontal sinus, since it is continued into the horn core of cattle.
- The opened sinus is susceptible to infection if foreign material gets into opening. This infection is called sinusitis.

Pharynx

- The pharynx is the crossroads of the upper respiratory and digestive tracts, that is to say, is a common passage for food and air. These two paths cross so that air cannot be inspired at the same time food is being swallowed.
- Openings into the pharynx include the two posterior nares (openings from the nasal cavity), two Eustachian tubes from the middle ears, the mouth, the larynx, and the esophagus. Each Eustachian tube of the horse has a large ventral diverticulum known as the guttural pouch, which is located just lateral to the pharynx. For purposes of description it can be divided into an oropharynx ventrally and a nasopharynx dorsally.
- In the normal breathing condition these two divisions are separated by the soft palate, a cartilaginous extension of the hard bony palate, and the epiglottis of the larynx. During breathing the epiglottis overlaps the soft palate, and the opening to the esophagus is closed by tonic muscular constriction. Thus, air directly crosses the nasopharanyx from the nasal passages to the larynx.

Larynx

- The larynx (voice box) control inspiration and expiration of air, prevents inhalation of foreign objects, and is essential for voice production. Five large cartilages form the basis of the larynx in the horse and cow. Additional small cartilages may be found in other animals. The somewhat leaf-shaped **epiglottic cartilage** is located just behind the base of the tongue. The **thyroid cartilage** consists of a body and two laminae. The body of the thyroid cartilage is the projection from the ventral of the neck and in the human is known as the Adam's apple. The laminae or wings of the thyroid cartilage project backward and laterally, giving attachment to a number of muscles associated with swallowing and phonation. The two **arytenoids cartilages** are irregular in shape and serve to close the glottis (opening into the larynx) and also act as levers for tightening or loosening the

vocal cords, thus controlling the pitch of the voice. The **cricoids cartilage** is shaped like a signet ring, with the expanded portion located dorsally. The cricoids cartilage aids in maintaining the shape of the larynx so air may pass through, gives attachment to many of the intrinsic laryngeal muscle, and also attaches to the first ring of the trachea.

Trachea

- The larynx is continued by the trachea, which consists of a noncollapsible tube formed by a series of adjacent cartilage rings which are incomplete dorsally. The tracheas passes caudally to the base of the heart, where it divides into two chief bronchi, one for each lung, **(bifurcation of the trachea)** these bronchi branch into smaller bronchi and finally form even smaller branches called bronchioles. The several orders of bronchioles are intralobular bronchioles, terminal bronchioles, and respiratory bronchioles. Each respiratory bronchiole branches into several alveolar ducts which terminate as alveolar sacs consisting of numerous alveoli, which are the final and smallest subdivisions of the air passages. The general arrangement of air passages can be compared to a bunch of grapes, with the alveoli represented by the grapes and the larger air passage represented by the various orders of branches from the grape stem. Structurally, the trachea is a tube of fibrous tissue and smooth muscle held open by hyaline cartilage rings and lined by the same kind of ciliated epithelium that is present in the nasal passages. It is shaped like an upside-down Y.
- Incomplete rings of hyaline cartilage spaced along the length of the trachea prevent this collapse.
- Each tracheal ring is C shaped with the open part of the C face dorsally.

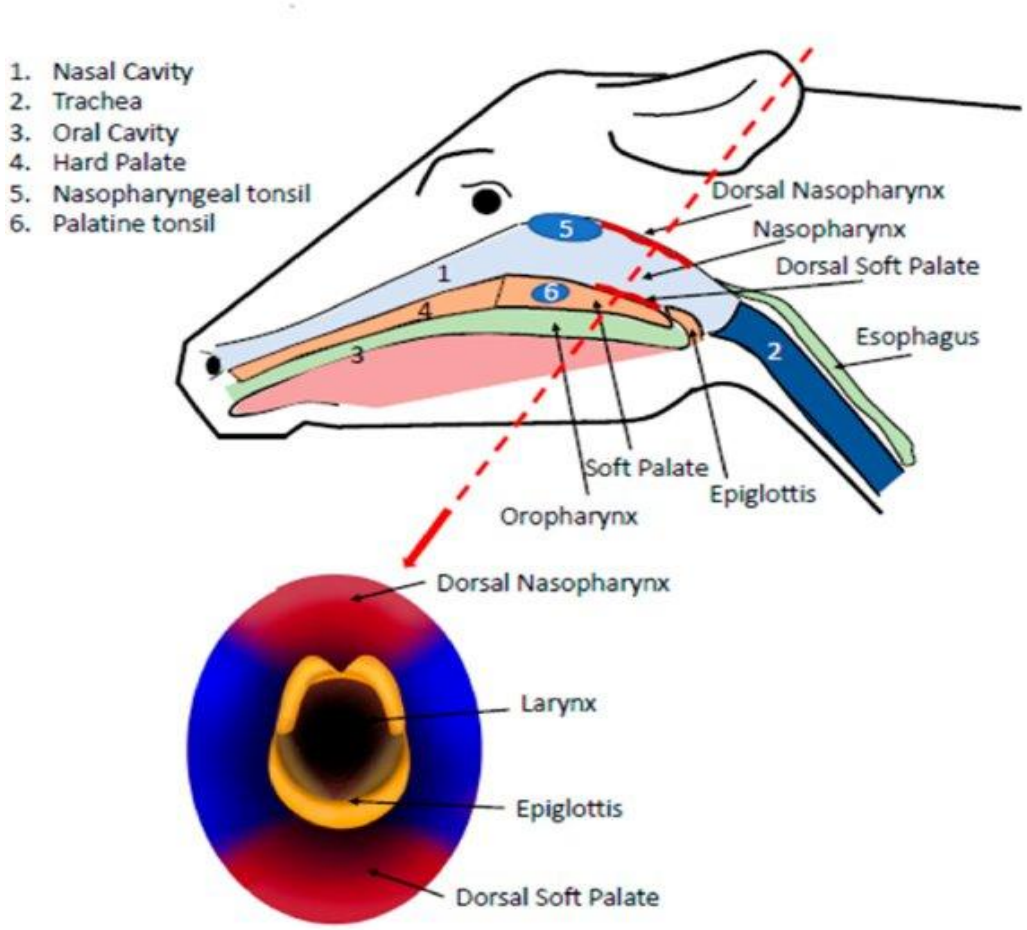


Figure 1.20:- Anatomy of bovine upper reparatory tract (Source: - Andrea. H 2019)

b. Lower respiratory tract

- The lower respiratory tract starts with the bronchi, ends with the alveoli, and includes all the air passages in between. Except for the two main bronchi that are formed by the bifurcation of the trachea, all the structures of the lower portion of the respiratory tract are located within the lungs.

Bronchial tree

- The air passages that lead from the bronchi to the alveoli are often called the bronchial tree because they divide into smaller and smaller passageways much like branching of a tree. After it enters the lungs, each main bronchus divides into smaller bronchi, which divide into even smaller bronchi and finally, the tiny bronchioles. The bronchioles continue to subdivide down to the smallest air passageways-the microscopic alveolar

ducts. The alveolar ducts end in groups of alveoli arranged like bunches of grapes. The groups of alveoli are called alveolar sacs

Alveoli

- The alveoli are the “business end” of the respiratory system.
- They are where external respiration takes place that is where oxygen and carbon dioxide are exchanged between the blood and the air.
- The rest of respiratory structures exist just to move air in and out of the alveoli.
- Structurally, the alveoli are tiny-walled sacs that are surrounded by network of capillaries.
- The wall of each alveolus is composed of the thinnest epithelium in the body-simple squamous epithelium.
- The capillaries that surround the alveoli are also composed of simple squamous epithelium.

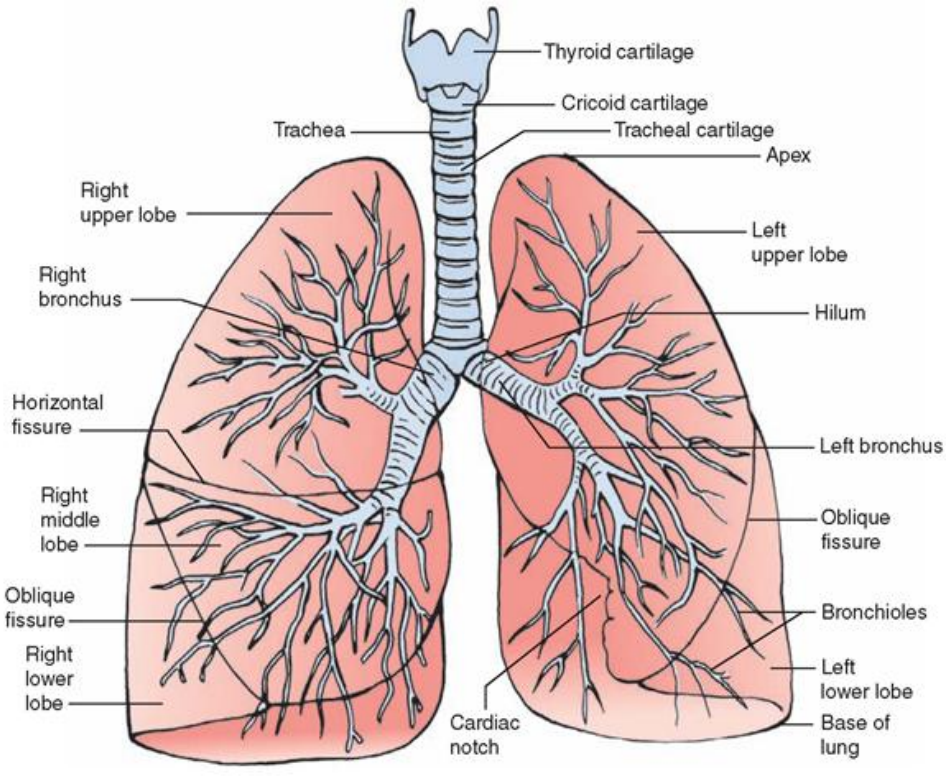


Figure1.21:- structure and animal lungs (**Source**:-
https://www.google.com/search?q=infographics+of+lower+respiratory+tract+of+animal++&tbm=isch&ved=2ahUKEwjL97fc2eT5AhUITRoKHc5ZBeQQ2-

cCegQIABAA&oq=infographics+of+lower+respiratory+tract+of+animal++&gs_lcp=CgNpbWcQAzIECCMQJ1CbH1ibH2C9K2gAcAB4AIABwwOIAdIGkgEFMy0xLjGYAQCgAQGqAQtnd3Mtd2l6LWltZ8ABAQ&sclient=img&ei=idYIY4uPCIiaac6zlaAO&bih=615&biw=1366&client=firefox-b-d#imgrc=SjkEXTjd0USm_M&imgdii=_v69cU-uQyhOCM. Accessed on 26/08/2022

1.6.3. Regional anatomy of lung

The lungs are located in the triangle formed by the points on the external angle of scapula, the 2nd from the last intercostals space and olecranun process. The left lung is smaller in size to accommodate the heart.

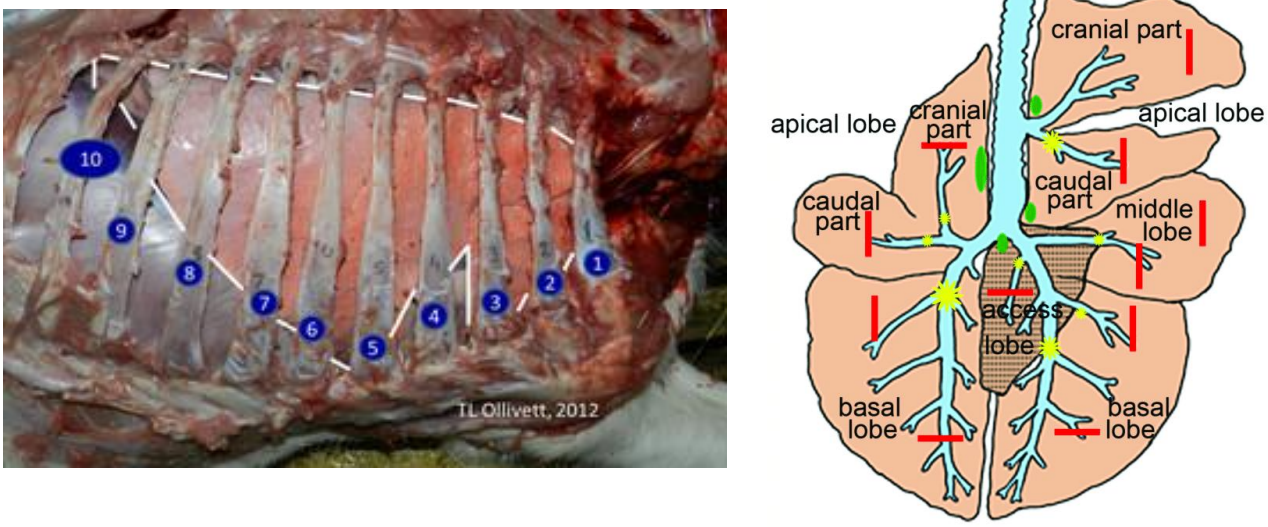


Figure 1.22 obes of bovine lung and regional location of it.
https://www.researchgate.net/figure/Schematic-drawing-of-bovine-lung-Inoculation-sites-are-indicated-as-yellow-stars_fig9_340833242 Accessed on: - 30/08/2018

The lung

- Lungs are:
  - ✓ Paired organs
  - ✓ Principal organ of respiration
  - ✓ Conical in shape

- The lung tissues are soft and spongy and crepitate upon squeezing b/c of the residual air they contain and float in water.
- But lungs that are filled with fluid in case of disease process will not float in water.
- Each lung has two ends. These are: the base and the apex

a) **The base:** Oval in outline

Resting against the cranial side of the diaphragm

b) **The apex**: Narrow and flattened laterally

➢ Resting in or closer to the thoracic inlet

- The hilum is a region on the medial surface of the lung where structures, such as the primary bronchi, blood vessels, nerves, and lymphatic vessels enter/ exit the lung.
- All structures passing through the hilum are referred to as the root of the lung.
- A healthy lung from a normal animal, particularly from a rural area is **pale-pink** in colour.

- The lungs are sometimes called “lights”, indicating their low specific gravity, which is less than of water. Each lung is a **cone-shaped** structure, with the base resting against the cranial side of the diaphragm and the apex within or close to the thoracic inlet. Because of the elasticity of the spongy, air-filled lung substance, the lungs completely fill the available space in the thoracic cavity regardless of whether the thorax in contracted in expiration or enlarged in inspiration. The lungs may be incompletely divided into lobes by deep fissures in the ventral part of the lung. In the cow, sheep, and pig the left lung is divided into apical cardiac and diaphragmatic lobes. The right lung in these animals has an intermediate lobe in addition to the other three. The lungs of the horse have no subdivisions, except for the presence of an intermediate lobe of the right lung. The lateral side of each lung is in contact with the thoracic wall, except at the cardiac notch, where the heart is against the thoracic wall instead. After an animal has taken one breath the lungs will never completely collapse even is air is permitted to enter the pleural cavity, a condition known as pneumothorax. In the fetus, however, the lungs are nearly the consistency of liver, contain no air, and will sink in water. Whether the lungs will sink or float in water is a standard test to determine if a newborn animal was born dead, in which case the lings will sink, or if it drew at least one breath, the lungs will float.

The Fetal Lungs

- The fetal lung seems it contains no air and has a relatively small blood supply.
- A fetal lung differs from that of an animal w/c has breathed in the following aspects:
  - ✓ It is much smaller
  - ✓ It is firm and doesn't crepitate upon squeezing
  - ✓ It sinks in water
  - ✓ It is pale-gray in color

Different and similarities of lungs in animals

- In most species of animals the lungs are divided into lobes by deep fissures in the ventral part of the lung.
- In the left lung, there are:
  - ✓ Apical (cranial) lobe and
  - ✓ Diaphragmatic (caudal) lobe.
- In the right lung, there are:
  - ✓ apical (cranial) lobe
  - ✓ Intermediate (accessory) lobe
  - ✓ Diaphragmatic (caudal) lobe and
  - ✓ Cardiac (middle) lobe
- The right lung is almost twice as large as the left lung b/c of the number of lobes present in it.
- In ruminants and pigs the lungs are clearly subdivided by deep inter-lobal fissures into lobes, but in the case of horse the lungs are not clearly divided in to lobes except for the presence of intermediate lobe of the right lung.
- Cardiac (middle) lobe is not present in horse.

Pleura:

- The pleura is a continuous, thin, double serous membrane that is firmly attached to the walls of thorax and its contents, except for the heart w/c has its own serous covering- the **pericardium**.
- The lungs are contained within the thoracic cavity, but each lung is surrounded by a separate pleural serious membrane.
- The free surface of pleura is very smooth & glistering in appearance.

- The pleura are divided into various parts. Such as:
  - ✓ The **visceral pleura-** cover the lungs, except at the hilums where the bronchi, blood vessels, and nerves enter the lungs.
  - ✓ The **parietal pleura**- cover the wall of the thorax, the anterior surface of diaphragm and the mediastinum.
- The part attached to the thoracic surface of the diaphragm is called **diaphragmatic pleura**.
  - ✓ The **mediastinal pleura**- cover the blood vessels, the esophagus, the lymph nodes, etc. in the mediastinal space.
  - ✓ The **pericardiac pleura**- the part that is attached to the pericardium.

The Pleura cavity

- The pleura cavity (pleural sac) is a potential space b/n pariental and visceral pleura and b/n mediastinum and visceral pleura.
- The pleura cavities are separated by the mediastinum, a middle portion formed by the heart, trachea, and esophagus and associated structures.
- The pleural cavity contains a small amount of serous fluid, w/c acts as a lubricant to reduce friction b/n the lungs and other structures of the thorax

Muscles of Respiration:

- The diaphragm and muscles associated with the thoracic cage are responsible for respiration.
- The muscles of **inspiration** (breathing in) include:
  - ✓ The diaphragm
  - ✓ Muscles that elevate the ribs and sternum such as- the external intercostals, pectoralis minor, and scalenes.
- The muscles of **expiration** consist of muscles that depress the ribs and sternum, such as internal **intercostals** and **abdominal muscles**.

Avian lung design:

- Although the mass of an avian lung is comparable to that of a mammal of similar size, the volume is only about **one-tenth**. Considering the relatively **high oxygen requirements of birds**, this means that the lung design must be **more efficient**. The greater efficiency of the avian lung is due to **a one-way air flow** and a **fairly constant shape** to the lung.

Avian lungs are positioned dorsally, tucked well up under the ribs and vertebrae. Although they may move with movements of the ribs, they do not appreciably expand and contract like mammalian lungs. Expansion and contraction on breathing is instead a function of **air sacs** attached to the lung. Embryologic ally there are **six pairs of air sacs**, some of which may fuse in the adult. The air sacs of a chicken can be divided into two groups:

- ✓ **cranial air sacs :-** cervical, clavicular, cranial thoracic (paired);
- ✓ **Caudal air sacs: -** caudal thoracic (paired), abdominal (paired).

- The functional units for gaseous exchange in the avian lung are the **air capillaries**. These small tubules branch and anastomose. They have a small internal diameter and are far more delicate than the alveoli of mammalian lungs. This is possible since the lung does not need to stretch with each inspiration. The air capillary network connects by funnel-shaped openings to parabrochi or tertiary bronchi. Each parabronchus forms the center of a histologically recognizable lobule in the chicken lung. Like the air capillaries, the parabronchi form a network facilitating the continuous and unidirectional flow of air. Birds do not have fibro muscular diaphragms as seen in mammals. Separation between the thoracic and abdominal viscera is provided by **fusions of the serous membrane** of the abdominal air sacs with pleura cranially and peritoneum caudally. These fused serous membranes are called the **Sacco-pleural and saccoperitoneal membranes** respectively. The medullary cavities of some of the avian bones contain diverticulae from the air sacs, e.g. in the domestic fowl, the cervical and thoracic vertebrae, sternum, humerus and pelvis. In some birds more bones have air sac diverticulae, in others less. Although the presence of air in their medullary cavities would make bones lighter, there is no phylogenetic correlation between flight ability and the number or volume of such diverticulae. The purpose of aerating bones remains open to speculation.

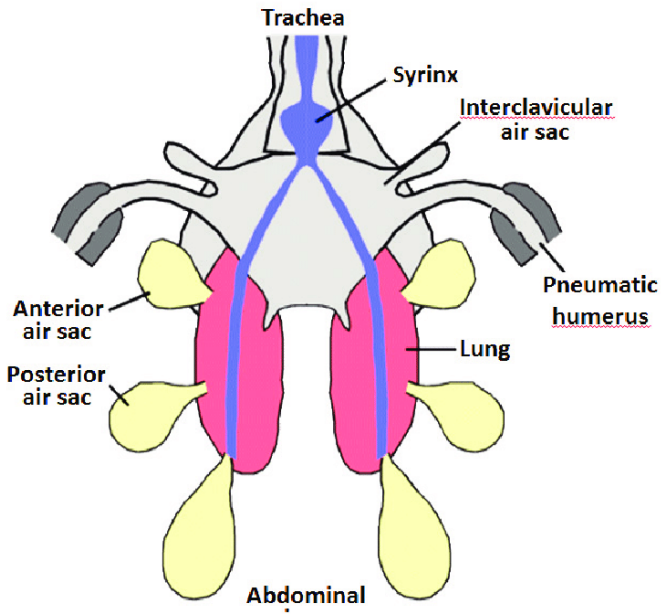


Figure 1.23:- reparatory system of birds (source https://www.google.com/search?q=avian+lung+anatomy&client=firefox-b-d&sxsrf=ALiCzsbaLMUbQXSgtEZY0LAmbNLvy8vCyA:1661524907591&source=lnms&tbm=isch&sa=X&ved=2ahUKEwi5jJvP3uT5AhU5nf0HHc1tBaEQ_AUoAXoECAEQAw&biw=1366&bih=615&dpr=1#imgrc=u5Ur5crOZJ0_IM accessed on 26/08/2022

The rate of respiration

The speed of the respirations varies with many internal and external factors. It is faster during fever, after exercise, during powerful emotions, such as fear, anger, sexual excitement, etc.; during very cold or very hot weather, when the body condition is very fat, or when radiation is obstructed through too thick a covering of wool, fur etc., or too much clothing. It is slower than normal during resting, either when lying or when sleeping.

Table 1.3. Normal rates in adult domesticated animals are as follows:

Species of animal	Breath/minute
Horse	8-12 per minute
Ox	12-16 per minute
Sheep and goat	12-20 per minute
Pig	10-16 per minute
Dog	15-30 er minute

Identified type of respiration in different species

Respiration process

- This is the process of breathing. Air is inspired through the nasal passages, via the wind pipe on trachea, into the lungs, and later expired. There is a general rhythm to respiration.
- All domestic animals have a pair of lungs suspended in the thoracic body cavity one on either side of the chest. They are extremely elastic and spongy. The heart is considerably smaller and lies between the lungs. Atmospheric air inspired through the larynx and long cartilaginous tube called trachea and then through the two major bronchi (bronchial tube), one going to each lung; smaller bronchioles; until the terminal, dead end, sac like structures, the alveoli are reached. The actual exchange of the respiratory gases takes place between the alveoli and the blood which flows through very fine neighboring capillaries.

Regulation of breathing

- The normal rhythmicity of breathing is controlled by a physionerological reflex mechanism, while depth and rate of breathing are influenced by chemical stimuli again mediated neurologically.

Mode of Respiration

- Based on the muscles involved during respiration, there are two main types of respiration
- These are:
  - Costal breathing eg. in dogs and cats
  - Abdominal breathing eg. in cattle, sheep and goats
  - Costo-abdominal, breathing eg. in equine

1.6.4. Basic functions of the respiratory system

- Supplying oxygen to the tissues and removing carbon dioxide from the tissues are the two major functions of the respiratory system.
- Secondary functions include temperature control, elimination of water, and phonation (voice production).
- The respiratory system consists essentially of the lungs and the passages with enable air to get into and out of the lungs.
- These passages include the nostrils, nasal cavity, pharynx, larynx, and trachea.

- The respiratory apparatus provides an open passageway for air from the exterior to reach the smallest subdivisions of the lung (the alveoli).
- The thin membranes of the alveolar wall and capillaries facilitate movement of oxygen into the blood and movement of carbon dioxide into the alveolar air.
- This exchange constitutes external respiration, in which oxygen from the blood is given to the tissues for cellular oxidation and the resulting carbon dioxide is picked up by the blood.

Nostrils

- Are important inlets for air during breathing they serve to humidify incoming air and for communication.
- Humidification of air is of importance to the sense of smell or olfaction, a function of the caudal-most nasal passages.
- Air is moved forcefully through a proportionally small opening, the nostril, into a larger space, the nasal passages, by inhalation.)

Nasal cavity

- Is lined with mucous membrane.
- The vascular mucous membrane helps warm the inspired air.
- Nasal passage can adjust the air temperature to the body temperature, cleaning moistening air.

Sinuses

- (air-filled cavities) in certain cranial bones open into the nasal cavity.
- The opened sinus is susceptible to infection if foreign material gets into opening.

Pharynx

- Is a common passage for food and air.
- These two paths cross so that air cannot be inspired at the same time food is being swallowed.

Larynx: (voice box)

- Control inspiration and expiration of air, prevents inhalation of foreign objects, and is essential for voice production.

Trachea: cleaning and passage of air.

Alveoli: exchange of gases between blood and lungs.

Lungs: loss of body heat, moisture and exchange of air

1.7. Anatomy and physiology circulatory system

17.1 Introduction circulatory system

The vascular system includes all the duct systems of the body that carries blood or lymph. The **Cardiovascular System** consists of the heart and all the blood vessels; and its function is transportation of blood to all parts of the body.

Heart

- Heart is a cone-shaped hallow muscular organ.
- The blunt, rounded point of the cone is the apex; and the larger part at the opposite end of the cone is the base.

Location of heart and pericardial membranes:

The heart is situated in the thoracic cavity between the lungs. This area is called the mediastinum. The heart stands obliquely, with its base directed cranio-dorsal and the apex directed caudo-ventral, between the 3rd and 6th intercostals spaces. The apex is also directed to the left so that approximately two-thirds of the heart's mass lies to the left of the midline of the sternum. This is why we may think of the heart as being on the left side, because the strongest beat can be heard or felt here. The heart is enclosed in the **pericardial membranes**, which has three layers. The outermost is the **fibrous pericardium**, a loose fitting sac of strong fibrous connective tissue. The serous pericardium is a folded membrane; the fold gives it two layers, parietal and visceral. Lining the fibrous pericardium is the **parietal pericardium**. On the surface of the heart muscle is the **visceral pericardium**, often called the **epicardium**. Between the parietal and visceral pericardial membranes there is a serious fluid, which prevents friction as the heart beats.

- **Heart wall:** The heart wall is composed of three layers of tissue.
  - ✓ The most external layer is known as the epicardium, the thick muscular middle layer is known as the myocardium and the most inner layer of the heart is known as endocardium.

- **Heart chambers:**

The heart is divided into left and right sides, and each side has an atrium and ventricle, i.e. the heart consists of four chambers: two atria and two ventricles. The thin-walled atria form the base of the heart, and the thick-walled ventricles form the apex of the heart.

✓ **Right and left atria:**

- The right atrium has three major openings that receive blood vessels from the body: the superior vena cava, the inferior vena cava, and the coronary sinus.
- The left atrium has four relatively uniform openings that receive the four pulmonary veins.
- The two atria are separated from each other by the inter-atrial septum.

✓ **Right and Left Ventricles:** The atria open into the ventricles through atrioventricular canals.

- Each ventricle has one large, superiorly placed outflow route near the midline of the heart. The right ventricle pumps blood to the lung through the pulmonary artery, and the left ventricle pumps blood to the whole body through the aorta. The two ventricles are separated from each other by the interventricular septum, which has a thick muscular part toward the apex and a thin membranous part toward the atria. Since the right ventricle do not reach to the end of apex, the apex is entirely formed by the muscular wall of the left ventricle.

- **Heart Valves**

✓ **Atrioventricular Valves:**

- An atrioventricular valve is present in each atrioventricular canal and is composed of cusps, or flaps. The free margins of the cusps are connected to the inner surface of ventricle by means of fibrous cords called chordae tendineae. These valves allow blood to flow from the atria into the ventricles but prevent blood from flowing back into the atria. The atrioventricular valve between the right atrium and the right ventricle has three cusps called tricuspid valve. The atrioventricular valve between the left atrium and left ventricle has two cusps, thus called the bicuspid or mitral valve.

✓ **Semilunar Valves:**

- The valve which blocks return of blood from Aorta to the left ventricle is called Aortic Semilunar valve, and the valve which blocks the return of blood from pulmonary artery

into the right ventricle is called Pulmonary Semilunar valve. Each valve consists of three pocket-like semilunar cusps, the free inner borders of which meet in the center of the artery to block back blood flow.

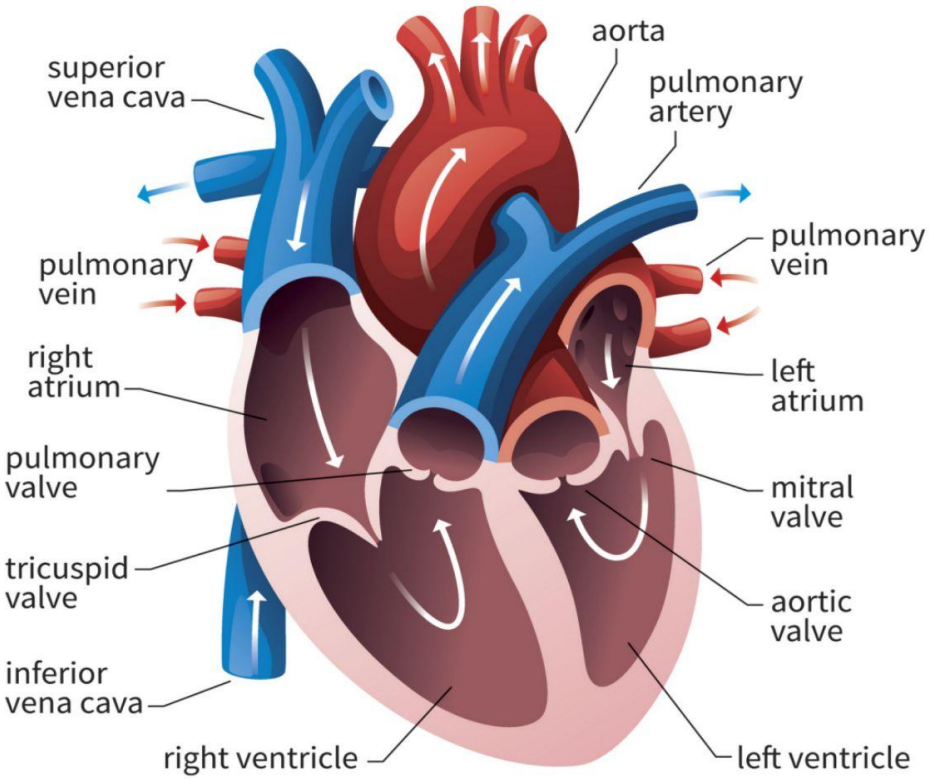


Figure 1.24:- Internal structure of mammalian heart

1.7.2 Differentiating location of arteries and veins

Blood Vessels

a. Arteries:

- Arteries are tubular structures that convey blood from the heart to tissues.
- They act as pressure reservoirs because the elastic walls collapse inward during ventricular diastole (when there is less blood in the arteries.
- All arteries of the systemic circulation are derived either directly or indirectly from the **aorta**; **Coronary arteries** are the first branch of aorta immediate distal to aortic valve.

b. Arterioles:

- The arterioles transport blood from small arteries to capillaries and are the smallest arteries in which the three tunics can be identified.
- The arterioles, like the small arteries, are capable of vasodilation and vasoconstriction.

c. Capillaries:

- Are tiny vessels composed of only the endothelium and they is the site of exchange of materials between blood & tissues. Exchange may occur by simple diffusion.

d. Veins:

- Veins are larger than arteries and have much thinner wall with less amount of muscle tissue. Unlike to arteries, they have valves at irregular interval. Three major veins return blood from the body to the right atrium; these are (1) **the coronary sinus** – returning blood from the walls of the heart; (2) **the cranial vena cava** – returning blood from the head, neck, thorax, and upper limbs; and (3) **the caudal vena cava** – returning blood from the abdomen, pelvis, and lower limbs.
- **The cardiac veins,** which transport blood from the walls of the heart and return it through the coronary sinus to the right atrium.
- The two pairs of major veins that drain blood from the head and neck are the external and internal jugular veins.
- The **hepatic portal vein,** the largest vein of the system, is formed by the union of the superior mesenteric vein, which drains the small intestine, and the splenic vein, which drains the spleen. The splenic vein receives the caudal mesenteric and pancreatic veins, which drain the large intestine and pancreas, respectively. The hepatic portal vein also receives gastric veins before entering the liver.
- **Venules and Small Veins:** The venules collect blood from the capillaries and transport it to the small veins, which in turn collect it to the medium-sized veins & finally to heart.

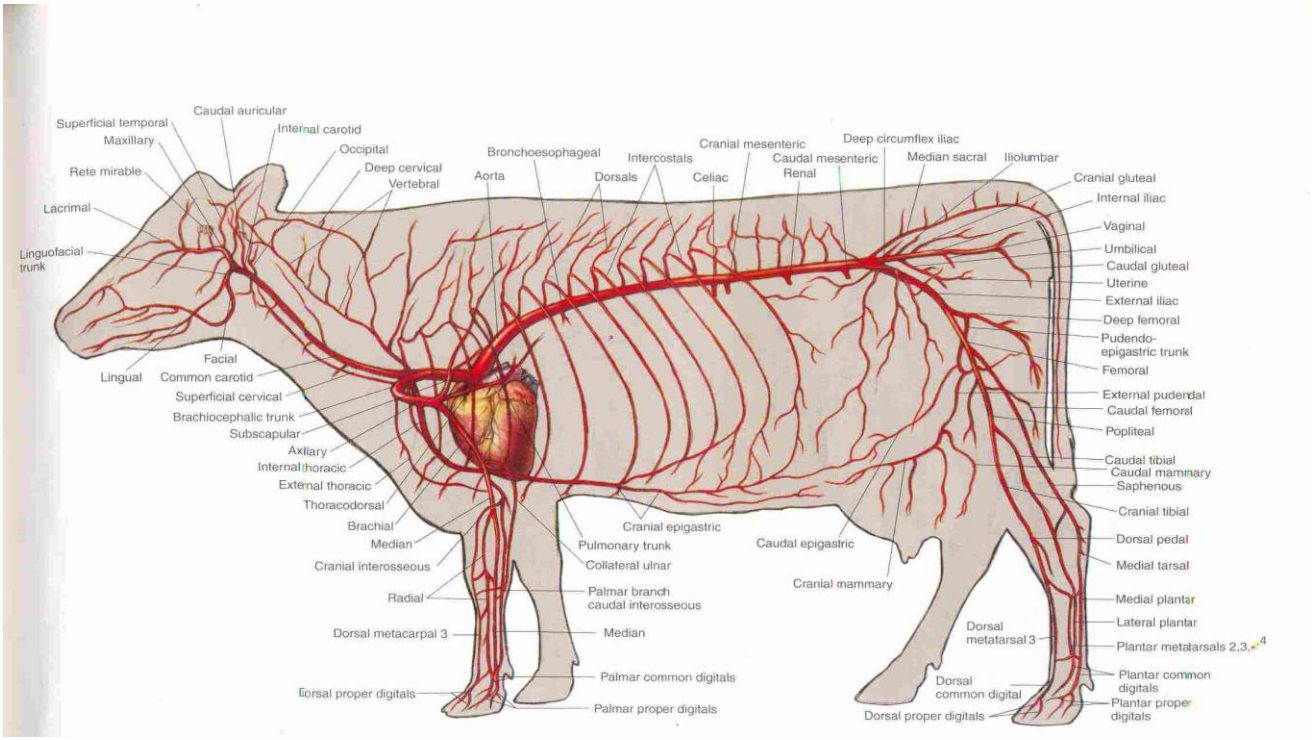


Figure 1:25: Major arteries of the cow source: - Markovitz, Letal. 2012)

1.7.3 Types of circulation

Obviously there are two types of circulation **open circulatory system**, the blood vessels open into spaces and not into capillaries, so that blood comes in direct contact with tissues. Whereas; in **closed circulatory system**, blood flows through capillaries connected by arteries and veins. Hence this closed circulation subdivide in to the following

II. **Pulmonary Circulation:** it is the circulation of blood between heat and lung.

Contraction of the right ventricle pushes Un-oxygenated blood against the tricuspid valve, forcing it closed, and against the pulmonary semi lunar valve, forcing it open, thus allowing blood to enter the pulmonary trunk. The pulmonary trunk branches to form the pulmonary arteries, which carry blood to the lungs, where carbon dioxide is released and oxygen is picked up. Oxygenated blood returning from the lungs enters the left atrium through the four pulmonary veins. The blood passing from the left atrium to the left ventricle opens the bicuspid valve, and contraction of the left atrium completes left ventricular filling.

III. Systemic circulation:

It is the circulation of blood between the heart and the rest of the body. It starts from left ventricle after the oxygenated blood returned from the lung. Contraction of the left ventricle pushes blood against the bicuspid valve, closing it, and against the aortic semi lunar valve, opening it and allowing blood to enter the aorta. Blood flowing through the aorta is distributed to all parts of the body by the smaller arterial branches indifferent regions of the body and reaches to the arterioles and capillaries of different organs(except to the parts of the lungs supplied by the pulmonary blood vessels). Then the blood will be collected by venules into larger veins, then to largest veins (cranial and caudal venacava) and finally collected into the right atrium, where the systemic circulation ends.

IV. Hepatic portal circulation:

It is a subdivision of systemic circulation in which blood from the abdominal digestive organs and spleen circulates through the liver before returning to the heart. Blood from the capillaries of the stomach, small intestine, colon, pancreas, and spleen flows into two large veins, the superior mesenteric vein and the splenic vein, which unite to form the portal vein. The portal vein takes blood into the liver, where it branches extensively and empties blood into the sinusoids, the capillaries of the liver. From the sinusoids, blood flows into hepatic veins, to the inferior vena cava and back to the right atrium. This portal circulation enables the liver to modify the blood from the digestive organs and spleen. Some nutrients may be stored or changed, bilirubin from the spleen is excreted into bile, and potential poisons are detoxified before the blood returns to the heart and the rest of the body.

IV. Fetal Circulation:

The fetus depends upon the mother for oxygen and nutrients and for the removal of carbon dioxide and other waste products. The site of exchange between fetus and mother is the placenta, which contains fetal and maternal blood vessels that are very close to one another. The blood of the fetus does not mix with the blood of the mother; substances are exchanged by diffusion and active transport mechanisms. The fetus is connected to the placenta by the umbilical cord, which contains two umbilical arteries and one umbilical vein. The umbilical arteries are branches of the fetal internal iliac arteries; they carry blood from the fetus to the placenta. In the placenta, carbon

dioxide and waste products in the fetal blood enter maternal circulation, and oxygen and nutrients from the mother's blood enter fetal circulation. The umbilical vein carries this oxygenated blood from the placenta to the fetus. Within the body of the fetus, the umbilical vein branches: One branch takes some blood to the fetal liver, but most of the blood passes through the ductus venous to the caudal vena cava, to the right atrium. After birth, when the umbilical cord is cut, the remnants of these fetal vessels constrict and become nonfunctional. The other modifications of fetal circulation concern the fetal heart and large arteries. Because the fetal lungs are deflated and do not provide for gas exchange, blood is shunted away from the lungs and to the body. The foramen ovale is an opening in the interatrial septum that permits some blood to flow from the right atrium to the left atrium, not, as usual, to the right ventricle.

The blood that does enter the right ventricle is pumped into the pulmonary artery. The ductus arteriosus is a short vessel that diverts most of the blood in the pulmonary artery to the aorta, then to the body. Both the foramen ovale and the ductus arteriosus permit blood to bypass the fetal lungs. Just after birth, the newborn breathes and expands its lungs, which pulls more blood into the pulmonary circulation. More blood then returns to the left atrium, and a flap on the left side of the foramen ovale is closed. The ductus arteriosus constricts, probably in response to the higher oxygen content of the blood and pulmonary circulation becomes fully functional within a few days.

1.7.4. Function of the circulatory system

Cardiac Cycle:

- The term cardiac cycle refers to the repetitive pumping process that begins with the onset of cardiac muscle contraction and ends with the beginning of the next contraction. Pressure changes produced within the heart chambers as a result of cardiac muscle contraction are responsible for blood movement because blood moves from areas of higher pressure to areas of lower pressure.
- One complete heartbeat is known as Cardiac cycle. Each cardiac cycle consists of 3 phases. (1) Atrial Systole (contraction of both atria occurs); (2) Ventricular systole (contraction phase of ventricles); and (3) Atrio-Ventricular diastole- both auricles and ventricles dilate. The duration of one cardiac cycle is 0.8 sec and the number of cardiac cycles per minute is called the cardiac rate.

Rhythmicity and conduction in heart:

- A specialized nervous tissue called the sino-atrial (SA) node is present near the roof of atrium. This SA-node is known as pace maker of heart, because the heart beat initiates from this area. The impulses generated from pace maker spread to atrial muscle. In the floor of the right atrium there is an Atrio-ventricular node. This receives the impulses from atria and passed it to the ventricles to initiate contraction.

Blood

- Blood is a fluid connective Tissue. It is the extra cellular fluid. Arterial blood has bright red color because of its high oxygen content; venous blood has less oxygen and is dark red. It is alkaline in reaction; venous blood has more CO2 and a lower pH than arterial blood. Blood consists of **cellular components** (about 45%) and **noncellular fluid portion/plasma** (about 55%). **The fluid part** is the matrix of blood and is called **plasma**. It consists of about 90% water and 10% solids. The solids include 7% proteins, 1% inorganic matter and 2% is non-protein organic matter. Organic components are Albumins, Globulins, Fibrinogen, and Heparin. The inorganic components of plasma include chlorides, bicarbonates, phosphates, sulphates, sodium, potassium, calcium, magnesium, iron and iodine. It has yellow color due to the pigment bilirubin.
- **The Cellular elements** (formed elements) of the blood are Red Blood Cells (RBC/Erythrocytes), White Blood Cells (WBC/Leukocytes), and platelets (Thrombocytes).
- About 95% of the volume of the cellular component is erythrocytes.
- The remaining 5% is leukocytes, and cell fragments called thrombocytes.
- Leukocytes are the only formed elements possessing nuclei, whereas erythrocytes and platelets have few organelles and lack nuclei.
- All of the functions of blood can be grouped as (1) **Transportation** of Oxygen and carbon dioxide, chemical, hormones, nutrients antibodies and wastes; (2) **Regulation** of body temperature and electrolyte equilibrium (acid- base balance); and (3) **Protection** of the body from diseases and controlling bleeding by clot formation.

Functions of circulatory system

The circulatory system may differ in various animals but carries out the same basic functions.

a. Transport of nutrients. It transports all soluble food compounds from the area of absorption to different parts of the body for storage, assimilation or synthesis of new components.

b. Transport of waste products: it transports all the excretory products produced as a result of cellular activities from all over the body to the organs of excretion (like kidney in man)

c. Transport of intermediate metabolites: it transports all the byproducts or intermediate products from the tissues they are produced to the organs where they can be metabolized (like lactic acid produced in muscles is transported to the live for oxidation.

d. Transport of hormones: since hormones are produced by ductless glands, they are transported through the circulatory fluid to their target organs.

e. Uniform distribution of heat: since circulatory fluid connects to all parts of the body it picks up heat from one part and dissipates it on the surface bringing about the uniform distribution.

f. Transport of water, inorganic ions and various chemicals is also done by the circulatory fluid so as to maintain a uniform distribution

g. Defense against diseases: the circulating fluid contains blood cells responsible for body defense

h. Transport of respiratory gases: in some animals the circulatory fluid contains respiratory pigments which may be dissolved in plasma like in snails, crustaceans or cephalopods or present in cells like in all vertebrates including man. The oxygen is transported from respiratory organs to respiring tissues while carbon dioxide is carried from tissues to respiratory organs. Some animals like insects have tracheal system for respiration and circulatory system is not directly associated with respiration. More so it lacks any respiratory pigment.

1.8. Anatomy and physiology of uro-genital system

Introduction

The **kidneys** in mammals are bean-shaped and loblated organs that lie in the abdominal cavity attached to the dorsal wall on either side of the spine. An artery from the dorsal aorta called the **renal artery** supplies blood to them and the **renal vein** drains them.

Regional anatomy

The urinary system is predominantly located in the pelvic cavity of the body. The left kidney of bovine lies under the transverse process of 3^{rd} -5^{th} lumbar vertebrae. Right kidney lies dorsally to

the last rib and transverse process of the 1st, 2nd or 3rd lumbar vertebrae. In equine right kidney is located ventral to the upper parts of the last 3rd ribs and transverse process of 1st lumbar vertebrae. The left one is situated more caudally than the right one, the posterior pole corresponding to the transverse process of 3rd lumbar vertebrae. In large animals only the left kidney can be palpated by rectal palpation and the right is not accessible.

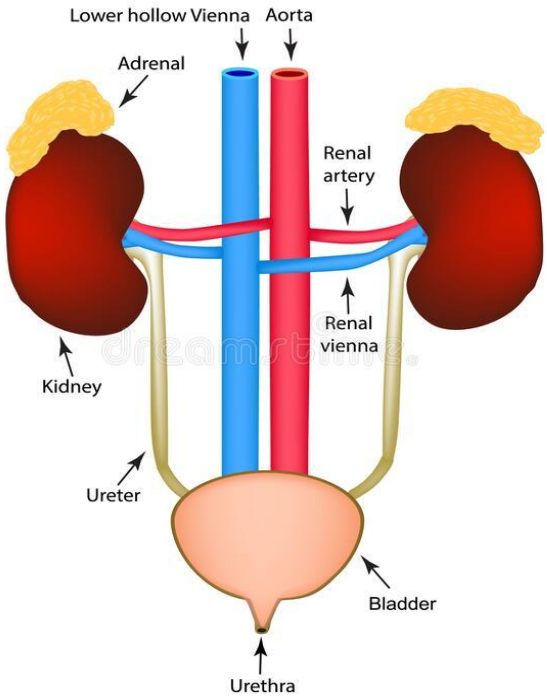


Figure 1.26: The urinary system

https://www.dreamstime.com/structure-kidneys-bladder-excretory-system-infographics-vector-illustration-isolated-background-structure-image175039462 Accessed on 29/08/2022

1.8.5. Components of urinary system

- Paired kidneys- form urine from blood
- Paired ureters- tubes that convey urine from kidneys to bladder
- Urinary bladder- where urine is briefly stored before flowing in to the urethra
- Urethra- opening through which urine passes to exterior

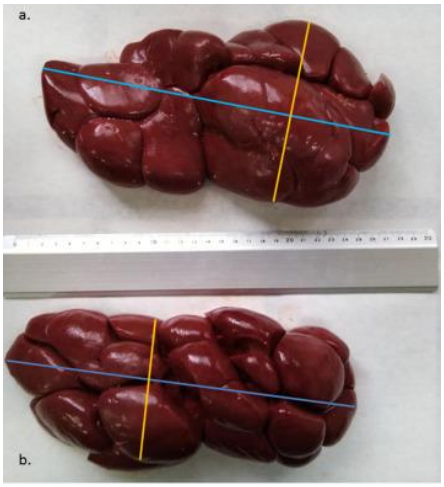
a. The kidneys

- Grossly the kidneys of most animals are bean shaped organs.

- They are held in position by renal fascia and by pressure of surrounding organs. The renal fascia contains peritoneal fat. The kidneys are located pressed against the roof of abdomen and are retroperitoneal (outside the membranous lining of the abdominal cavity). In most animals they lie on either side of vertebral column in the lumbar region. Kidneys have smooth surface except for bovine, which is loblated. They are covered by a thin transparent membrane called renal capsule (loosely attached and easily removed).

Types of kidney

a) lobulated kidney (cattle)



b) Bean shaped kidney (small ruminats and human)

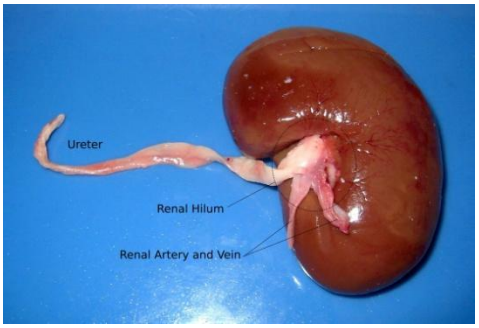


Figure 1.27:- Kidney types of animals https://alevelbiologystudent.weebly.com/155-mammalian-kidneys.html Accessed on 30/08/2022

Kidney has:

- Anterior curvature (anterior pole)
- Posterior curvature (posterior pole)
- Hilus (external depressed portion)

The parenchyma of the kidney is divided into:

- **Medulla- inner zone**
  - ✓ Characterized by radial striations and divided into outer medullary zone (dark red) and inner medullary zone (pinkish-yellow to red)
- **Cortex- outer zone**
  - ✓ Has reddish brown color
  - ✓ Granular in appearance
  - ✓ Lies between the outer medullary zone and capsule

b. Ureter

- The ureters are tubes that convey urine from kidneys to the urinary bladder.
- Each ureter begins at the renal pelvis and ends by opening into neck of the bladder.

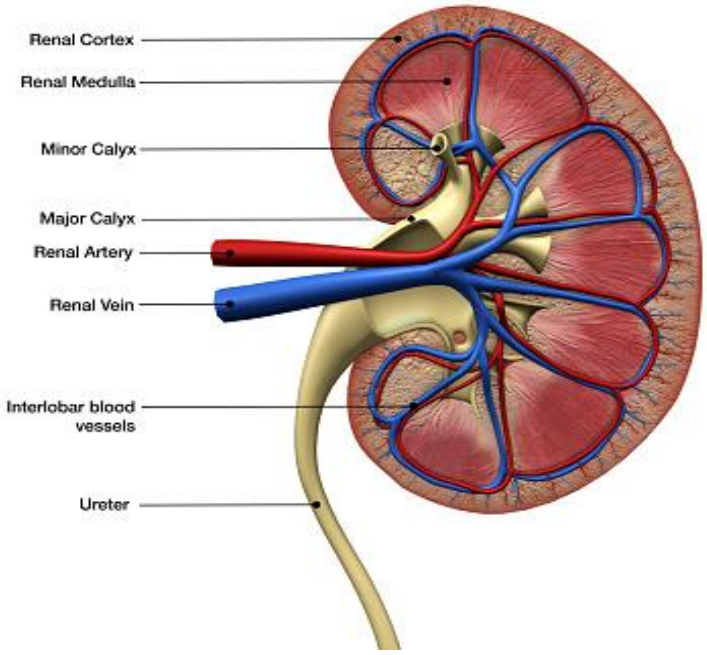


Figure 1.28: The dissected kidney **source**: - https://www.istockphoto.com/photo/kidney-anatomy-labeled-cross-section-view-on-white-gm929720296-254932932 Accessed on 28/08/2022

c. Urinary bladder

- Urinary bladder is distensible storage organ of urine.
- In some animals, the bladder is situated in the pelvis, but in dog and cat it is placed farther forward in the abdomen.

- In the pig and ox it is almost entirely abdominal.
- The constricted portion from which the urethra takes its origin is called the neck of the bladder.

d. Urethra

- The male urethra extends from the neck of bladder to external orifice at the free extremity of penis. The pelvic part of urethra is joined by different duct a short distance from its origin from bladder. The greater part of urethra serves of urethra is related to rectum and semen. The dorsal surface of urethra is related to rectum and to various accessory reproductive glands. The urethra can be palpated through rectum.

The nephron can be divided into three main regions:

- **Proximal nephron**- consists of Bowman's capsule, proximal convulted tubule and proximal straight tubule
- **Loop of Henle**- Hair pin shaped and comprises descending limb and ascending limb
- **Distal nephron**- comprises distal convulted tubule and collecting duct. Cllecting ducts run through the medulla to join renal pelvis.

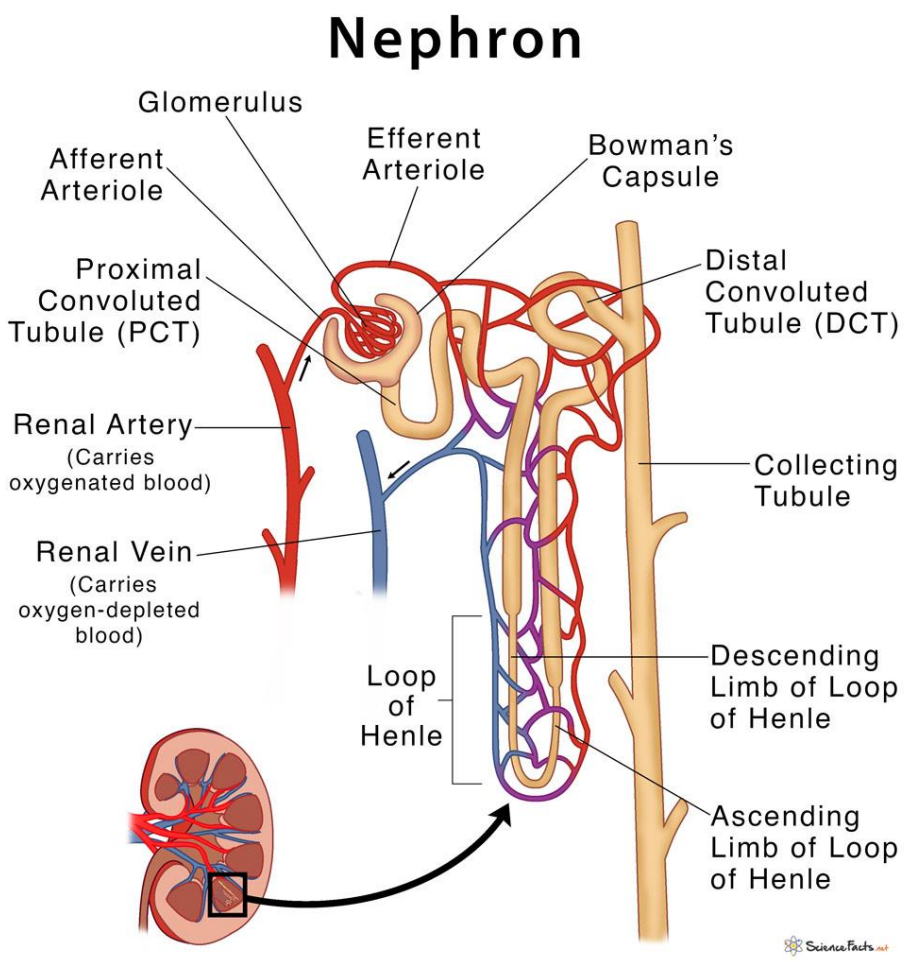


Figure 1.29: A kidney tubule or nephron **source**: - Bentley, M *et al.*, (2007).

1.8.6. Reproductive System

In biological terms sexual reproduction involves the union of **gametes** - the sperm and the ovum produced by two parents. Each gamete is formed by **meiosis**. This means each contains only half the chromosomes of the body cells (**haploid**). Fertilization results in the joining of the male and female gametes to form a **zygote** which contains the full number of chromosomes (**diploid**). The zygote then starts to divide by **mitosis** to form a new animal with all its body cells containing chromosomes that are identical to those of the original zygote.

- **Component and location of reproductive system**

In both male and female, the reproductive system is a pair of primary reproductive organs or gonads

I. **The male gonads (testes), produce sperm in males,**
II. **The female gonads (ovaries) produce eggs in females.**

Both also secrete sex hormones that influence reproductive function as well as the development of secondary sexual traits (characters). Such traits are features associated with maleness and femaleness.

I. Anatomy of the male reproductive organs

The male reproductive organs include:

- Primary sex organs (Paired gonads), testes, which produce both male gametes (sperm)
- Paired duct system, consisting of an epididymus and deferent duct (ductus deferens
- Accessory glands (prostate, bulbouretheral and seminal vesicles
- The male urethra
- The penis, the male copulatory organ
- The scrotum and the prepuce

Testicles (testes)

Testicles (the left and right) are the essential male generative glands or gonads, which along with the epididymus and its associated structures lie in the scrotum in each of the domestic animals. In some cases the testes are retained in the abdominal cavity, they don't descend at all. The testis is solid ellipsoidal (egg shaped) organ. Among domestic species, conspicuously small in cats and impressively large in sheep and goats. Their orientation also varies. They are carried with their long axes vertical in ruminants, horizontal in horses and dogs tilted toward the anus in pigs and cats.These differences are broadly correlated with the position of the scrotum, which is below the caudal part of the abdomen in ruminants, perennial in pigs and cats, and inter mediate in position dogs and horses

Structure of testicles

- Externally most part of the testicular surface except the caudal border is covered with peritoneal serous membrane- **Tunica Vaginal Propria.**

- Internally covered by whitish connective tissue (and sometimes including fiber of smooth muscles) - **Tunica Albugenea**, which has radiation (trabecuclar septa) in to testicular tissue, and divide the parenchyma into pyramid shaped lobules (which appear much like connective tissue of orange).
- These lobules or small chambers are many in number, contain:
- Interstitial tissue, which consists of interstitial (Leydig) cells, which are the producers of androgenic hormones (the male sexual hormone, testosterone).
- **Sertoli cells-** known as sperm mother cells, which provide nutrient to sperm cells for maturation.

Epididymis:

- It is a long convoluted tubule that connects vas- efference of testes with vasdeferens, lies up on the surface of the testicles, and is composed of three parts:

The head:

- The upper enlarged part, which occupies the upper end of the testes.
- It is firmly attached to the testicular capsule.
- It receives the efferent ductless, which immediately or after some coiling join to form the wider epididymal duct.

The body (caput epididymus)

- Parallel with the long axis of testes, closely attached to testes proper.

The tail (caudal epididymus)

- Bends sharply backwards at the ventral pole of the testicle and becomes the relatively straight vas-deferens.
- Provided spermatozoa with nutrition, storage, concentration and maturation, length of epididymis varies in different species of animals (Bull – 30m, Boar 50 m, stallion 20m

Vas deferens (ductus deferens)

- Thin tube, which starts from the tail of epididymis, passes upward along the caudal border of the testicle in slight tortuous manner and gets incorporated in to the caudal bundle of the spermatic cord.
- After they pass through the inguinal canal, the terminal portions of the tubes are little dilated, known as ampullae's.

- The ampullae are placed side by side under the bodies of seminal Vesicles before their disappearance under the prostate, at the neck of bladder.
- Ductus deferens conveys spermatozoa from epididymis to urethra.

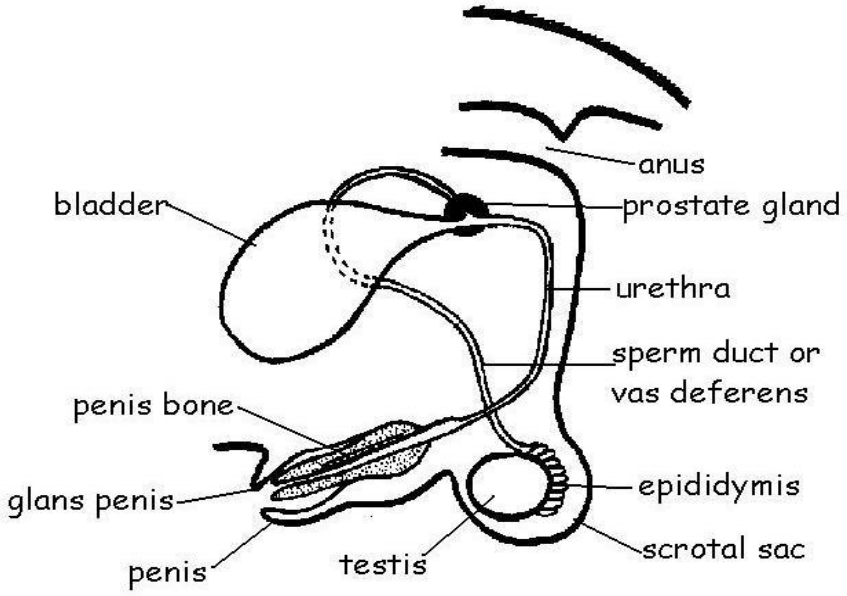


Figure 1.30: The reproductive organs of a male dog **source**: - https://commons.wikimedia.org/wiki/File:Male_repro_system_labelled.jpg Accessed on 29/08/2022

The accessory reproductive glands

- Comprises ampulla, vesicular, prostate and bulbouretheral glands, although not all of these are present in every species.
- These glands empty in to the urethra and their secretion form semen, with the spermatozoa released from the ampullae.

A. Seminal vesicles (Vesicular glands) –

- Are paired glands that secrete a clear seminal fluid that contain nutrients and buffers for semen.
- They are located posterior to neck of bladder and lateral to ampullae. Present in all species except the dog and cat.

B. Prostate gland:-

- Located on or around neck of bladder and variable in size and shape for different species. Present in all domestic species.

C. Bulbouretheral gland (Cowper's gland): -

- Paired gland which is located on either side of pelvic urethra anterior to ischial arch. They are found in all species except dog.

The spermatic cord

- The testicle is fixed in scrotum by the spermatic cord and scrotal ligament.
- This cord starts from internal abdominal ring of inguinal canal to testis.
- The spermatic cord is composed of: -
  - ✓ Testicular (spermatic) artery
  - ✓ Testicular (spermatic) vein- constitutes close-meshed pampiniform plexus in which the arteries are embedded. The plexus reduces to a single vein and joins the caudal venacava
  - ✓ Cremaster muscle
  - ✓ Lymphatic vessels
  - ✓ Nerves
  - ✓ Vaginal tunic
  - ✓ Vas deferens.

The scrotum

- The testicles are enclosed in a sac called scrotum present in all domestic animals:
- It is located below the caudal part of the abdomen in ruminants, perinea in pigs and cats, and intermediate in position in dogs and horses.

Structure of the Scrotum

- Externally covered by skin, which is thin, elastic relatively hair less, lack sub cutaneous fat and is supplied with sweat and sebaceous glands. At the median plane there is longitudinal raphe which marks the septum scroti (externally, a median groove marks the division into right and left compartments).Tunica dartos- a tough fibro muscular layer attached to the skin.
- Composed under skin muscle and fibro-elastic tissue that divides the scrotum in to two halves or sacs which contracts during cold weather and relaxes in hot weather (temperature regulation). Scrotal (spermatic) Fascia- has many layers
- External Cremaster muscle

- Tunica vaginal communis (Parietal layer of the vaginal tunic)
- Tunica vaginal propria (visceral layer of vaginal tunic that covers the outer portion of testicles and epididymis. The scrotum provides testicular temperature from 4-7^{0}C cooler than the general body temperature under normal.

The penis

The penis is the copulatory organ. There are two different types of penis:

- **Fibroelastic type:**
  - ✓ Found in ruminants and boar (pig).
  - ✓ Sigmoid flexure (S- Shaped curve) – Present in bull, ram and boar.
  - ✓ The retractor muscle, which is attached on anterior part of the flexure, help in pulling back the elongated penis in to the prepuce.
  - ✓ In the above mentioned species, the distribution of erectile tissue is smaller in relation to the stallion.
  - ✓ It is relatively rigid even when none erect.
  - ✓ Erection involves only slight increase in diameter and length (the penis straightens by protruding 25-40 cm from the prepuce)
- **Musculocavernous (Vascular) type:**
  - ✓ Found in horse dog and man.
  - ✓ Erection is by filling of blood in the cavernous spaces, which increase the diameter, and length of the organ.

The penis is divided in to three general areas:

- **Glans penis:** - is a free conical end of the penis, which varies anatomically with species.
  - ✓ Sheep have free urethral process
  - ✓ Bull and ram have helmete shaped gland
  - ✓ In boar it is spiral twist counter clockwise.
- **Body**
  - ✓ Main portion (corpus penis) composed of corpus spongiosum, corpus cavernosum, smooth muscle and urethra.
  - ✓ Corpus spongiosum constitutes the erectile tissue filled with blood, large amount in stallion (no sigmoid flexure)

- **Root**
  - ✓ Begins at the ischial arch.
  - ✓ Here the urethra is enclosed between the two crura.

Urethra

- It is a tube, which extends from the neck of the bladder to the glans penis.
- It has two parts: the pelvic part and penile for both urine and semen.
- The pelvic part arrives at the ischial arch, bends down ward and becomes continuous as the penile part.
- The penile part proceeds forward along the groove on the inferior surface of the corpus cavernosum penis surrounded by corpus cavernosum urethra up to the glans penis.

Prepuce (Sheath)

- A long and narrow cavity in larger animals (relatively short in smaller animals).
- Only a retracted penis occupies the deepest part.
- Externally the cranial part of the prepuce is caudal to the umbilicus.
- A tuft of long coarse hairs marks the orifice.

II. The female reproductive system

- The female reproductive organs include: paired ovaries, paired uterine tubes, the uterus, the vagina and the vestibule.
- The structures inside the abdomen are hanged commonly by paired sheet of broad ligaments, which suspend from the roof of the abdomen.
- The broad ligament not only fixes these structures, also have ovary arteries and veins to support them.

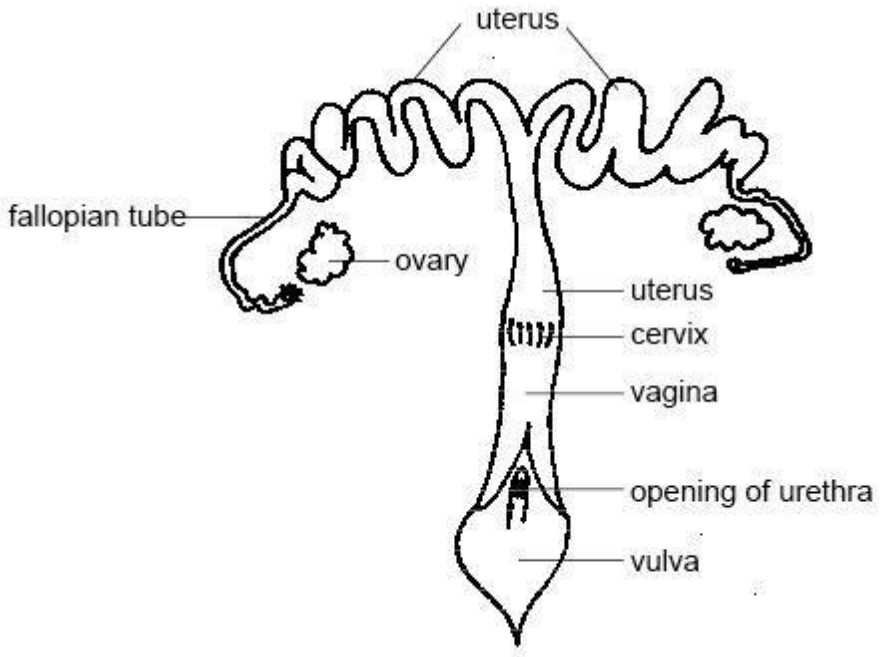


Figure 1.31:- Female Reproductive structures in section source: - https://veteriankey.com/reproductive-system-2/ Accessed on: - 29/08/2022

The ovaries:

- Ovaries are usually found in the caudo-dorsal part of the abdomen, close to the tips of the horns of the uterus.
- They are suspended in the cranial part (mesovarium) of the broad ligaments.
- Each ovary is a solid, basically ellipsoidal body and its surface is commonly irregular due to projection of large follicles and corpora.
- The ruptured follicle then passes through three stages.
  - **I. Corpus haemoragicum (filled with blood)**
  - **II. Corpus luteum (yellow body)**
  - **III. Corpus albicans nonfunctional connective tissue scar or white bodies.**

The oviduct (fallopian tube):

- The oviducts are narrow and convoluted (zigzag) tubes. They capture the ova released from the ovaries and convey them toward the uterus. The ovarian end of the tube dilated

into a funnel shaped infundibulum, whose free cranial extremity possesses a finger like projection or fimbriae. The caudal ends of the oviducts open into the tip of the uterine horns. The oviducts also facilitate upward movement of the sperm, so the fertilization normally occurs within the tubes.

Generally, the oviducts divided into three parts:

a) **Isthmus:** is a narrow, convoluted and thick part, which connects the fallopian tube with the tip of uterus horns.

b) **Ampullae**: the middle wider (dilated) portion of the oviduct. It is longer and thin walled.

c) **Infundibulum**: The ovarian end of the tube, which is dilated into a funnel shaped, lies over the lateral part of the ovary. There is no anatomical continuity between the infundibulum and the ovary.

Uterus:

- Uterus (the womb) is a thick walled muscular organ, which is cranially continuous with the oviducts and caudally with the vagina. It is attached to the lateral walls of the pelvic and abdominal cavities by broad ligament. It is located in pelvic cavity in non-pregnant animals and in abdominal cavity in pregnant animals.

The uterus has got three main parts:

a). Horns

- They are two (the left and right).
- Each horn is a spinal muscular tube tapered cranially to join the oviduct and broad caudally to form the body of the uterus.

b). Body

- It is a very small in its size whose wall is thicker than that of the horns.
- Cranially it bifurcates to form two horns and caudally continue with the cervix.
- The wall of the uterus is made of three layers:
  - ✓ **Perimetrium** (the outer layer).
  - ✓ **Myometrium:** middle muscular layer.
  - ✓ **Endometrium:** the inner layer, which is covered with mucous membrane on which presents large number of caruncles in all ruminants. Caruncles serve as part of placental attachment. Uterine vessels enter the caruncles through the uterine wall and the crypts of cotyledons receive chorionic villi of the placenta.

c) Cervix

- It is the caudal part of the uterus.
- The wall is very thick.
- The canal is narrow and filled with spinal folds of mucus membrane and muscles.
- Bovine cervix has 3-5 internal folds.
- The cervix is open during oestrus and parturition.
- But it is sealed due to increased goblet cell secretion during pregnancy, preventing uterine infection.

Vagina

- Vagina is a highly elastic musculo-membranous tube, which extends from the cervix to the vestibule.
- It has got dual function in that it serves as a birth canal and a copulatory organ.

Vaginal vestibule

- It is the caudal most part of the birth canal.
- Extends from external urethral orifice to the vulva cleft.
- On the ventral wall of the vestibule there is a small mass of erectile tissue called clitoris, which is homologues to the male penis.
- On the ventral surface of vulva opens the female urethra.

1.8.7. Structure of the mammary gland

The mammary gland (udder)

- Mammary glands are specialized secreting glands that identify the class mammalian.
- The glandular epithelium is composed of true secretary cells which utilizes the bloodstream as a substrate.
- The activity of milk gland is periodic and normally is related to parturition. They are located outside the abdominal cavity. The number of glands varies in different species.

Bovine mammary gland

- The hair except the teat covers udder of cow, which is hairless.
- The udder has got four glands or quarters.

- A strong septum (intramammary grove) divides the two right side glands from the left side.
- The udder is produced with an individual duct system and teat.
- The udder is located in the pelvis (inguinal) region and suspended medially between the hind limbs by the medial and lateral ligament of the udder.

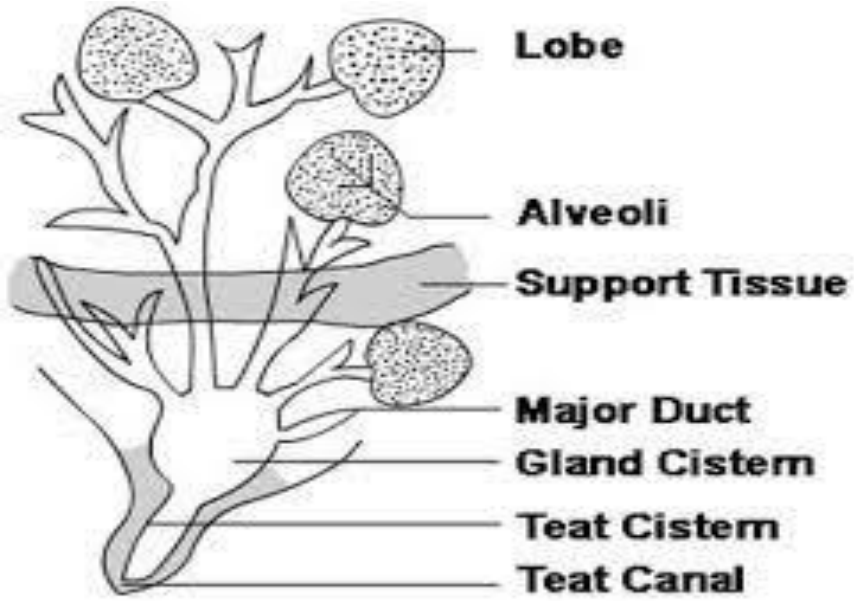


Figure 1.32:- A mammary gland of bovine source: https://www.google.com/search?q=bovine+mammary+gland&tbm=isch&ved=2ahUKEwjU3pyJ9eT5AhVEzaQKHbEODfUQ2-cCegQIABAA&oq=bovine+mammary+gland&gs_lcp=CgNpbWcQAzIFCAAQgAQyBQgAEIAEMgQIABAYOgQIABBDOggIABCABBCxAzoLCAAQgAQQsQMQgwE6CAgAELEDEIMBOgYIABAeEAhQiQpY-kZg6k5oAHAAeACAAZAEiAHJLpIBCjItMTguMi4wLjGYAQCgAQGqAQtnd3Mtd2l6LWltZ8ABAQ&sclient=img&ei=NvMIY9TrMcSakwWxnbSoDw&bih=615&biw=1366&client=firefox-b-d#imgrc=8ZMVI_RtGF0JgM&imgdii=yVikf5hbxwEzfM Accessed on 29/08/2022

1.8.4. Function of the urinary and reproductive systems

I. Function of urinary system

Functions of the kidney

- The primary function of kidney is urine formation.

- While doing so, it also performs numerous functions. These include:
  - ✓ **Regulation of plasma ionic composition:** ions such as sodium, potassium, calcium, magnesium, chloride, bicarbonate, and phosphates are regulated by the kidney.
  - ✓ **Regulation of plasma osmolarity (osmotic pressure):** the kidneys regulate osmolarity because they have direct control over how many ions and how much water to be excreted.
  - ✓ **Regulation of plasma volume:** the kidneys control plasma volume by controlling how much water a person excretes.
  - ✓ **Regulation of plasma hydrogen ion concentration (pH):** the kidneys help maintain the blood pH mainly by excreting hydrogen ions and reabsorbing bicarbonate ions as needed.
  - ✓ **Removal of metabolic waste products and foreign substances from the plasma:** the kidneys excrete most nitrogenous wastes such as urea, ammonia, and creatinine.
  - ✓ **Secretion of Hormones:** Rennin is released by the kidneys. Rennin leads to the secretion of aldosterone which is released from the adrenal cortex. Aldosterone promotes the kidneys to reabsorb the sodium (Na+) ions. The kidneys also secrete erythropoietin when the blood

II. Function of reproductive systems

a. Function of male reproductive system

Each part has a specific function in the reproductive system. If any of the parts do not function correctly, the animal may have difficulty with reproduction or be unable to reproduce. Following is a description of the functions of each of the reproductive parts of the bull.

- **Epididymis** – The epididymis is a tube with three parts: a head, body, and tail. Sperm is stored in the epididymis for maturation. It also concentrates the sperm and transports it from the testicles to the vas deferens.
- **Vas deferens** – The vas deferens is a tube that transports sperm from the epididymis to the urethra.
- **Urethra** – The urethra carries sperm and urine to the penis.

- **Seminal vesicles** – The seminal vesicles produce the seminal fluid that transports and protects the sperm.
- **Prostate gland** – The prostate gland releases fluid that mixes with the seminal fluid and nourishes the sperm. The combination of the sperm with the fluids from the seminal vesicles and prostate gland is referred to as semen.
- **Cowper's (bulbouretheral) gland** – This gland releases a fluid into the urethra that cleanses and neutralizes it to allow the sperm to survive the passage to the penis. The secretions pass through the urethra prior to the semen.
- **Sigmoid flexure** – This S-curved muscle extends the penis outside the body during mating.
- **Retractor muscle** – This muscle pulls the penis back into the body.
- **Penis** – The penis is an organ that deposits semen into the female reproductive tract. It also excretes urine from the body.
- **Sheath** – The sheath is a fold of skin that covers and protects the penis when it is relaxed.

The reproductive parts found in the boar, stallion, dog, and buck have functions similar to those of the bull. The filiform appendage found in the ram is actually the opening of the urethra, which extends beyond the head of the penis. It rotates and sprays semen during mating. The reproductive system of the fowl, however, differs in form and function from the other domestic animals.

- **Testicles** – As in the other animals, sperm and hormones are produced in the testicles. In fowl, they also secrete the seminal fluid.
- **Vas deferens** – Sperm and seminal fluid are transferred from the testicles to the cloacae through the vas deferens.
- **Cloacae** – The reproductive and digestive systems meet at the cloacae. The male cloacae join the female cloacae in the mating process.
- **Papillae** – Attached to the inside wall of the cloacae, the papillae transport the sperm to the female reproductive tract during mating.
- **Vent** – The vent is connected to the cloacae. It releases the reproductive and digestive products.

b. Function of female reproductive system

The principal functions of female reproductive system are:

- Production of ova and
- Production of sex hormone that maintains the development of genital tract
- Facilitates the successful implantation and development of the embryo in the uterus.

Function of fallopian tube (oviduct)

- Facilitate transportation of ova, sperm and zygote to their respective site.
- Serves as a site of fertilization.
- It produces a fluid that capacitate and hyperactivate the sperm for fertilization.

Function of uterus

Its function involves:

- The endometrium and its fluid facilitate transportation of sperm from site of ejaculation to site of fertilization.
- It regulates function of CL.
- Initiation of implantation of zygote.
- Serves as a site for the development of embryo during pregnancy.

Function of cervix includes:

- It facilitates the passage of sperm to the uterine tubes.
- It may serves as a reservoir of sperm.
- It produce viscous mucous that seals the cervix opening and prevent infection during the pregnancy.
- It plays a role in selection of viable sperm, preventing the non-viable and defective.

Function of vagina

- Serves as copulatory organ and birth canal.
- It also serves as excretory duct for secretions from endometrium, cervix, and oviducts.

c. Function and mechanism of milk synthesis and secretion

Milk synthesis

- Milk synthesis takes place inside the epithelial cells lining the alveoli.

- Some milk components like vitamins; minerals and some proteins are not synthesized in the epithelial cells but are rather filtered from the blood from epithelial cells and forms components of milk.
- However others such as lactose, fat, and most of milk proteins are synthesized inside the epithelial cells from blood precursors.

Hormones responsible for milk secretion

Prolactin: -Functions to stimulate increased enzyme activity, which in turn stimulates milk secretion.

Oxytocin: -Is secreted from posterior pituitary gland and is responsible for the ejection of milk (milk letdown).

Thyroid stimulating hormone (TSH): -

- Regulates the vital metabolic process of body and influence the general wellbeingness of animals. In increases appetite, flow of blood to udder and rate of milk secretions.

1.9. Anatomy and physiology of the endocrinal system

1.9.1 **Definition**

Endocrine glands are ductless glands of the endocrine system that secrete their products, hormones, directly into the blood. The major glands of the endocrine system include the pineal gland, pituitary gland, pancreas, ovaries, testes, thyroid gland, parathyroid gland, hypothalamus and adrenal glands. The pancreas is also a part of this system; it has a role in hormone production as well as in digestion. Endocrine system hormones work even if the target cells are distant from the endocrine glands. Through these actions, the endocrine system regulates nearly every metabolic activity of the body to produce an integrated response. The endocrine system can release hormones to induce the stress response, regulate the heartbeat or blood pressure, and generally directs how your cells grow and develop.

Endocrine glands are usually heavily vascularized, containing a dense network of blood vessels. Cells within these organs produce and contain hormones in intracellular granules or vesicles that

fuse with the plasma membrane in response to the appropriate signal. This action releases the hormones into the extracellular space, or into the bloodstream. The endocrine system can be activated by many different inputs, allowing for responses to many different internal and external stimuli.

1.9.2. Types of glands in animal body

I. Exocrine glands and integral components

Exocrine glands are the glands of external secretion. These are those that secrete substances on the body surface through a duct. Salivary glands, mammary glands, sweat glands, are some of the exocrine glands.

Salivary glands: - It is a tissue in the mouths of animals including human that expels saliva. Saliva is a mixture of water, mucus, antibacterial substances, and digestive enzymes. One of the most recognizable digestive enzymes in saliva is amylase. This enzyme is able to break down the starch in our food to simpler and more easily digestible sugars like glucose and maltose. Salivary glands come in three types: the parotid**,** sublingual**,** and submandibular glands**.** Each is aptly named after the area in the oral cavity in which it is located.

Sweat gland: - are secretary skin glands occurring only in mammals. The sweat gland, which is controlled by the sympathetic nervous system, regulates body temperature. When internal temperature rises, the sweat glands secrete water to the skin surface, where heat is removed by evaporation.

Sebaceous gland: - is small oil-producing gland present in the skin of mammals. It usually attached to hair follicles and releases a fatty substance, sebum, into the follicular duct and thence to the surface of the skin.

Liver: - The liver has both exocrine and endocrine glands; they are exocrine glands because they secrete products bile into the gastrointestinal tract through a series of ducts, and endocrine because they secrete other substances directly into the bloodstream.

II. Endocrine glands and integral components

a. Pituitary gland

The pituitary gland is located near the center and bottom of the brain. It produces a number of critical hormones that control many parts of the body, including several other endocrine glands. Because of its central role, the pituitary gland is often referred to as the "master gland. The pituitary gland or **hypophysis** is a small round gland located ventrally to the brain. Embryologically, the pituitary is formed from the conjunction of an outgrowth from the floor of the brain (**neurohypophysis** or posterior pituitary) and a detached up growth from the roof of the mouth (**adenohypophysis** or anterior pituitary).

The **hypothalamus** releases corticotropin releasing hormone (**CRH)** which releases adrenocorticotropic hormone, and gonadotropin releasing hormone which releases **LTH, FSH and LH**, and **TRH** which **TSH**. The **neurohypophysis** releases **ADH** which causes water retention by the kidney, and **Oxytocin** which causes uterine contraction during parturition, then milk release. The **adenohypophysis** produces **STH** which stimulates body growth, **LTH** which stimulates mammary glands, **ACTH** which stimulates the adrenal cortex, **TSH** which activates the thyroid glands and adipose tissue lipase, **FSH** which activates the testes or prepares the ovarian follicles, and **LH** which completes spermatogenesis and stimulates androgen secretion which depending on the sex of the animal and stimulates ovarian follicle growth, estrogen secretion, ovulation, formation of the corpus luteum, and progesterone secretion. Clinically, the most important of these hormones include growth hormone (GH), adrenocorticotropic (ACTH), thyroid-stimulating hormone (TSH), and antidiuretic hormone (ADH). Because the pituitary gland produces so many hormones, pituitary disease, most commonly pituitary tumors, may result in a variety of different conditions.

b. Thyroid gland

The thyroid is located around the trachea, near to the larynx in mammals. Left and right thyroid glands are joined ventrally in pigs; in cattle and sheep the junction is restricted to a narrow connecting isthmus. In poultry, left and right thyroid glands are deep red in color instead of pale brown, and they are completely separated at the base of the neck. The thyroid glands receive an

abundant supply of blood from which they are able to capture iodine. Iodine is used for the synthesis of hormones which contain three or four iodine atoms; **triiodothyronine** and **thyroxine**. Thyroid hormones regulate oxidative metabolism and heat production in the body. Some cells in the thyroid also produce the hormone calcitonin.

C. Parathyroid gland

The parathyroid glands are four small glands located adjacent or within the thyroid gland. These glands secrete parathyroid hormone (PTH). PTH helps maintain normal calcium and phosphorous levels in the body and is necessary for proper bone development.

If the parathyroids are removed during a thyroid operation, the blood PTH will fall (hyperparathyroidism). The blood calcium will then become dangerously low (hypocalcemia), causing neuromuscular signs of muscle spasms or twitches, tetany, or seizures. A tumor of one of the parathyroid glands may cause the secretion or release too much PTH (hyperparathyroidism). The blood calcium will then become too high (hypercalcemia), causing increased thirst and urination, muscle weakness, and fatigue.

d. Adrenal glands

The two adrenal glands are located on the top of each kidney. The adrenal glands essentially contain two separate endocrine organs. The outer portion or core of the adrenal gland is called the adrenal cortex. The inner portion of the gland is called the adrenal medulla. The hormones of the adrenal cortex are essential for life and the hormones of the adrenal medulla are not.

The adrenal cortex produces glucocorticoids (e.g., cortisol) that help the body control blood sugar, increase the burning of protein and fat, and respond to stressful stimuli, such as fever, major illness, and injury. The mineralocorticoids (e.g., aldosterone) control blood volume and help to regulate blood pressure by helping the kidneys hold on to sodium and water. Cushing's syndrome (too much cortisol) and Addison's disease (too little cortisol) are the two most common adrenal cortex disorders. Symptoms of Cushing's syndrome generally include an increase in thirst and urination, enlarged abdomen, and hair loss on the trunk. Symptoms of Addison's disease include poor appetite, weight loss, weakness, and vomiting.

The adrenal medulla produces epinephrine (adrenaline), which increases heart rate, opens airways to improve oxygen intake, and increases blood flow to muscles. The adrenal medulla usually secretes epinephrine when one is scared, excited, or under stress. The adrenal medulla also secretes norepinephrine, but this hormone is more related to maintaining normal activities as opposed to emergency reactions. Tumors of the adrenal medulla (called pheochromocytoma) may produce increased thirst and urination, increased heart rate, and restlessness.

e. Pancreas

The pancreas is an oblong, flattened gland located in the abdomen, adjacent to the stomach and small intestine. While it secretes digestive juices to aid in digestion, its endocrine function is to maintain healthy glucose (blood sugar) levels. If blood sugar is too high, such as after a meal, the pancreas secretes insulin. Insulin moves the sugar from the blood into the cells of the body, where it is used for energy. If blood sugar is too low, the pancreas releases glucagon. Glucagon releases sugar, stored in the liver as glycogen, back into the bloodstream.

Diabetes, an imbalance of blood sugar levels, is the major disorder of the pancreas. Diabetes occurs when the pancreas does not produce enough insulin or the body is resistant to the insulin in the blood. Without enough insulin to keep glucose moving through the metabolic process, the blood glucose level rises too high. Most dogs and cats with diabetes require insulin shots to do well, although some can be managed by a combination of diet or oral drugs.

A condition called hyperinsulinism is caused by too much insulin and leads to hypoglycemia (low blood sugar). This is most commonly seen when owners inadvertently overdose their diabetic dogs or cats with insulin. Less commonly, an insulinoma (insulin-secreting pancreatic tumor) will cause hypoglycemia. Symptoms of low blood sugar include anxiety, weakness, and seizures.

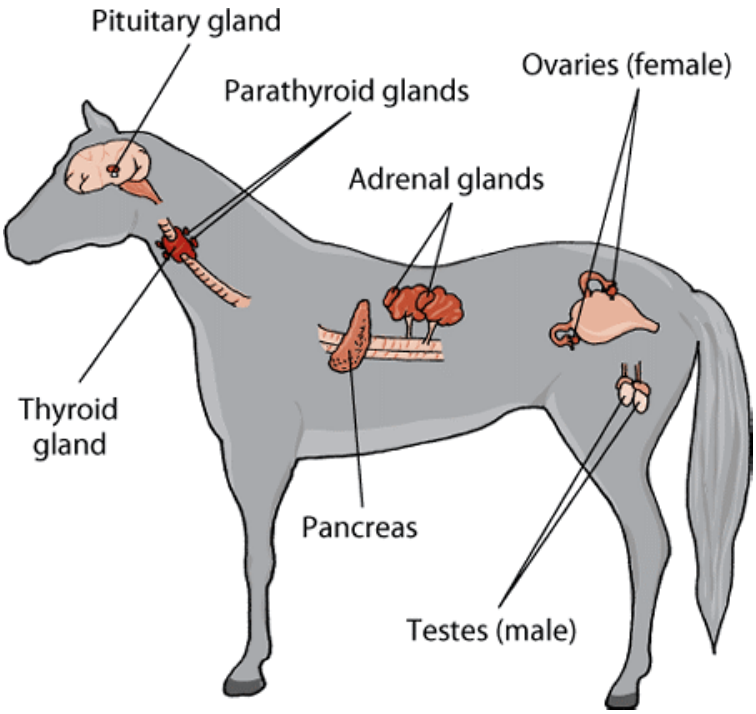


Figure 1.33:- Major endocrine glands in horse **source:-** https://www.google.com/search?q=types+of+endocrine+glands+in+animals&client=firefox-b-d&hl=en&sxsrf=ALiCzsZy3VqmPYrv-52JeOnSmy9TPzHGMQ:1661586049662&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiApoOywub5AhXZ8rsIHdHFCcYQ_AUoAXoECAEQAw&biw=1366&bih=615&dpr=1 Accessed on 27/08/2022

1.10. Anatomy and physiology nervous system

1.10.1. Introduction to the nervous system

The adjustment of an animal's response to changes in the environment and the complex linking of the various processes in the body that this response involves are called **co-ordination.** Two systems are involved in co-ordination in animals. These are the nervous and endocrine systems. The first operates via **electrical impulses** along nerve fibers and the second by releasing special chemicals or hormones into the bloodstream from glands. All nervous tissue is made up of nerve cells or neurons. These transmit high-speed signals called **nerve impulses**. Nerve impulses can be thought of as being similar to an electric current.

The Neuron

Neurons are cells that have been adapted to carry nerve impulses. A typical neuron has a cell body containing a nucleus, one or more branching filaments called dendrites which conduct nerve impulses towards the cell body and one long fiber, an axon, that carries the impulses away from it. Many axons have a sheath of fatty material called myelin surrounding them. This speeds up the rate at which the nerve impulses travel along the nerve.

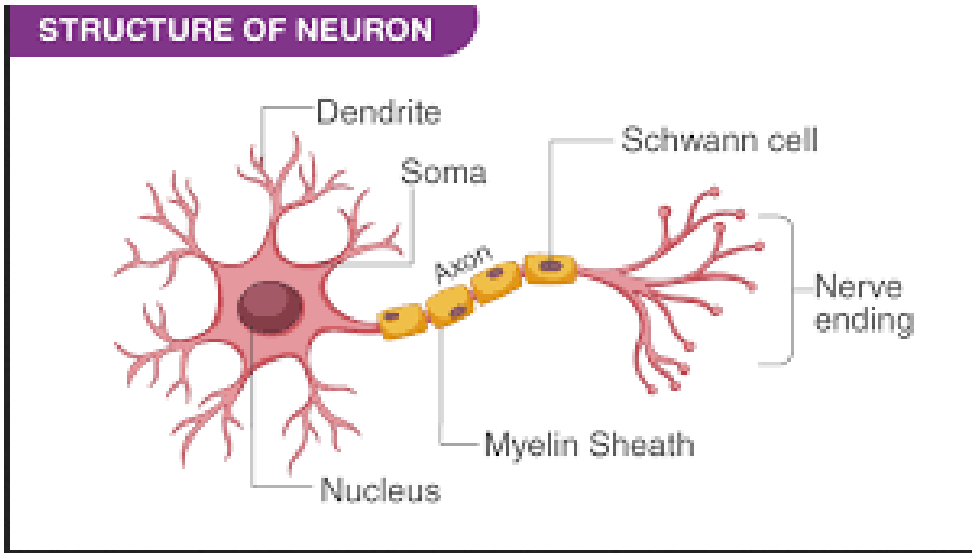


Figure 1.34: A motor neuron **source:-**
https://www.google.com/search?q=images+of+neuron&client=firefox-b-d&sxsrf=ALiCzsZOqdbBYhDza83oEV92WiBpCwHsvQ:1661535437036&source=lnms&tbm=isch&sa=X&ved=2ahUKEwic-4XsheX5AhW_h_0HHWArCmMQ_AUoAXoECAEQAw&biw=1366&bih=615&dpr=1
Accessed on 28/08/2022

The cell body of neurons is usually located in the brain or spinal cord while the axon extends the whole distance to the organ that it supplies. The neuron carrying impulses from the spinal cord to the hind leg or tail of a horse, for example, can be several feet long. A **nerve** is a bundle of axons. A **sensory neuron** is a nerve cell that transmits impulses from a sense receptor such as those in the eye or ear to the brain or spinal cord. A **motor neuron** is a nerve cell that transmits

impulses from the brain or spinal cord to a muscle or gland. A **relay neuron** connects sensory and motor neurons and is found in the brain or spinal cord.

Connections between Neurons

The connection between adjacent neurons is called a **synapse**. The two nerve cells do not actually touch here for there is a microscopic space between them. The electrical impulse in the neuron before the synapse stimulates the production of chemicals called **neurotransmitters** (such as **acetylcholine**), which are secreted into the gap. The neurotransmitter chemicals diffuse across the gap and when they contact the membrane of the next nerve cell they stimulate a new nervous impulse. After the impulse has passed the chemical is destroyed and the synapse is ready to receive the next nerve impulse.

Reflexes

A **reflex** is a rapid automatic response to a stimulus. When you accidentally touch a hot object and automatically jerk your hand away, this is a reflex action. It happens without you having to think about it. Animals automatically blink when an object approaches the eye and cats twist their bodies in the air when falling so they land on their paws.

2.10.2. Classification of the nervous system

When we describe the nervous system of vertebrates we usually divide it into two parts

I. The central nervous system (**CNS**) which consists of the brain and spinal cord.

II. The peripheral nervous system (**PNS**) which consists of the nerves that connect to the brain and spinal cord (cranial and spinal nerves) as well as the **autonomic** (or involuntary) nervous system.

III. Autonomic nervous system sympathetic (thoracolumbar) and parasympathetic (craniosacral) division

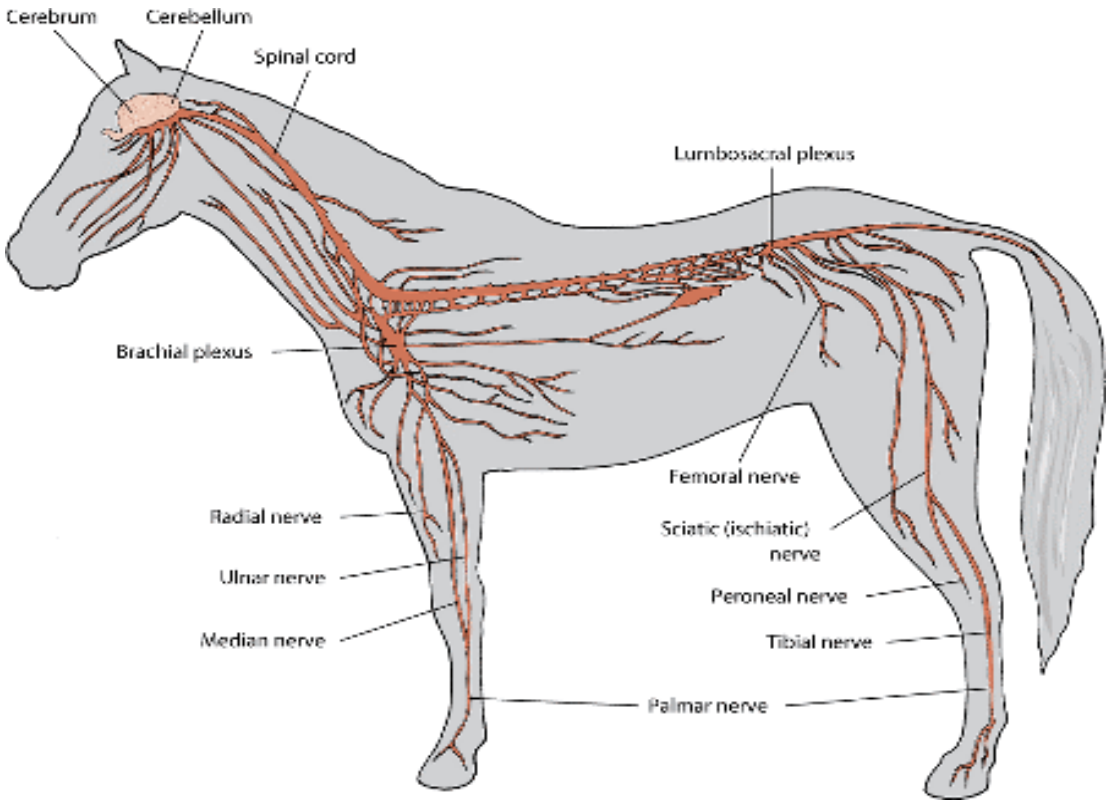


Figure 1.35: The nervous system of a horse Source: - https://www.msdvetmanual.com/horse-owners/brain,-spinal-cord,-and-nerve-disorders-of-horses/parts-of-the-nervous-system-in-horses Accessed on 29/08/2022

I. The Central Nervous System

The **central nervous system** consists of the brain and spinal cord. It acts as a kind of 'telephone exchange' where a vast number of cross connections are made. When you look at the brain or spinal cord some regions appear creamy white (**white matter**) and others appear grey (**grey matter**). White matter consists of masses of nerve axons and the grey matter consists of the nerve cells. In the brain the grey matter is on the outside and in the spinal cord it is on the inside

The Brain

The major part of the brain lies protected within the sturdy "box" of skull called the **cranium**. Surrounding the fragile brain tissue (and spinal cord) are protective membranes called the **meninges** and a crystal-clear fluid called **cerebrospinal fluid**, which protects and nourishes the

brain tissue. This fluid also fills four cavities or **ventricles** that lie within the brain. Brain tissue is extremely active and, even when an animal is resting; it uses up to 20% of the oxygen taken into the body by the lungs. The **carotid artery**, a branch off the dorsal aorta, supplies it with the oxygen and nutrients it requires. Brain damage occurs if brain tissue is deprived of oxygen for only 4-8 minutes.

The brain consists of three major regions:

a. The **fore brain** which includes the **cerebral hemispheres**, **hypothalamus** and **pituitary gland**

b. The **hind brain** or **brain stem**, contains the **medulla oblongata** and **pons** and

c. The **cerebellum** or "little brain"

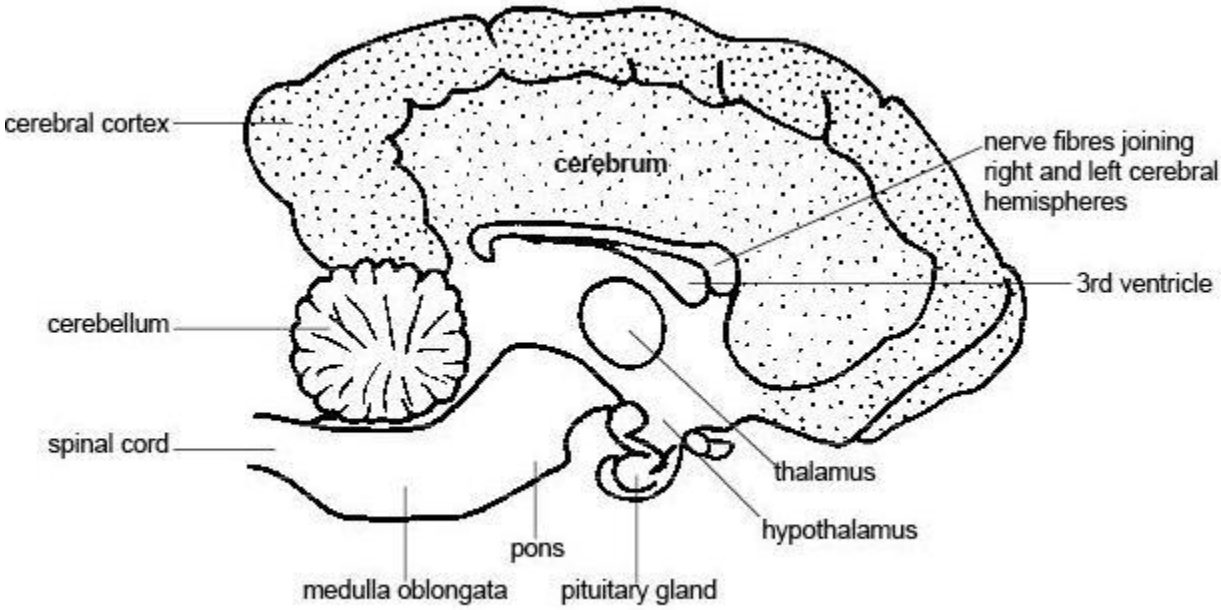


Figure 1.36: Longitudinal section through the brain **Source**: - https://en.wikipedia.org/wiki/File:Anatomy_and_physiology_LS_dog%27s_brain.JPG Accessed on 28/08/2022

a. The Forebrain

The **cerebral hemispheres** are the masses of brain tissue that sit on the top of the brain. The surface is folded into ridges and furrows called **sulci** (singular sulcus). They make this part of the brain look rather like a very large walnut kernel. The two hemispheres are separated by a deep groove although they are connected internally by a thick bundle of nerve fibers. The outer layer of each hemisphere is called the **cerebral cortex** and this is where the main functions of the cerebral hemispheres are carried out. The cerebral cortex is large and convoluted in mammals compared to other vertebrates and largest of all in humans because this is where the so-called **"higher centers"** concerned with memory, learning, reasoning and intelligence are situated.

The **hypothalamus** is situated at the base of the brain and is connected by a "stalk" to the pituitary gland, the "master" hormone-producing gland. The hypothalamus can be thought of as the bridge between the nervous and endocrine (hormone producing) systems. It produces some of the hormones that are released from the pituitary gland and controls the release of others from it.

B.The Hindbrain

The **medulla oblongata** is at the base of the brain and is a continuation of the spinal cord. It carries all signals between the spinal cord and the brain and contains centers that control vital body functions like the basic rhythm of breathing, the rate of the heartbeat and the activities of the gut. The medulla oblongata also co-ordinates swallowing, vomiting, coughing and sneezing.

C. The Cerebellum

The **cerebellum** (little brain) looks rather like a smaller version of the cerebral hemispheres attached to the back of the brain. It receives impulses from the organ of balance (vestibular organ) in the inner ear and from stretch receptors in the muscles and tendons. By co-coordinating these it regulates muscle contraction during walking and running and helps maintain the posture and balance of the animal. When the cerebellum malfunctions it causes a tremor and uncoordinated movement.

The Spinal Cord

The spinal cord is a cable of nerve tissue that passes down the channel in the vertebrae from the hindbrain to the end of the tail. It becomes progressively smaller as paired **spinal nerves** pass out

of the cord to parts of the body. Protective membranes or meninges cover the cord and these enclose cerebral spinal fluid.

II. The Peripheral Nervous System

The peripheral nervous system consists of nerves that are connected to the brain (**cranial nerves**), and nerves that are connected to the spinal cord (**spinal nerves**). The **autonomic nervous** system **is also** part of the peripheral nervous system.

- **Cranial Nerves**

There are twelve pairs of cranial nerves that come from the brain. Each passes through a hole in the cranium (brain case). The most important of these are the olfactory, optic, acoustic and vagus nerves.

- The **olfactory nerves** - (smell) carry impulses from the olfactory organ of the nose to the brain.
- The **optic nerves** - (sight) carry impulses from the retina of the eye to the brain.
- The **auditory (acoustic) nerves** - (hearing) carry impulses from the cochlear of the inner ear to the brain.
- The **vagus nerve** - controls the muscles that bring about swallowing. It also controls the muscles of the heart, airways, lungs, stomach and intestines.

- **Spinal Nerves**

Spinal nerves connect the spinal cord to sense organs, muscles and glands in the body. Pairs of spinal nerves leave the spinal cord and emerge between each pair of adjacent vertebrae.

The **sciatic nerve** is the largest spinal nerve in the body. It leaves the spinal cord as several nerves that join to form a flat band of nervous tissue. It passes down the thigh towards the hind leg where it gives off branches to the various muscles of this limb.

III. The autonomic Nervous System

The **autonomic nervous system** controls internal body functions that are not under conscious control. For example when a prey animal is chased by a predator the autonomic nervous system automatically increases the rate of breathing and the heartbeat. It dilates the blood vessels that

carry blood to the muscles, releases glucose from the liver, and makes other adjustments to provide for the sudden increase in activity. When the animal has escaped and is safe once again the nervous system slows down all these processes and resumes all the normal body activities like the digestion of food. The nerves of the autonomic nervous system originate in the spinal cord and pass out between the vertebrae to serve the various organs (There are two main parts to the autonomic nervous system the **sympathetic system** and the **parasympathetic system**.

The **sympathetic system** stimulates the **"flight, fright, figh**t" response that allows an animal to face up to an attacker or make a rapid departure. It increases the heart and respiratory rates, as well as the amount of blood flowing to the skeletal muscles while blood flow to less critical regions like the gut and skin is reduced. It also causes the pupils of the eyes to dilate. Note that the effects of the sympathetic system are similar to the effects of the hormone adrenaline. The **parasympathetic system** does the opposite to the sympathetic system. It maintains the normal functions of the relaxed body. These are sometimes known as the **"housekeeping"** functions. It promotes effective digestion, stimulates defecation and urination and maintains a regular heartbeat and rate of breathing.

Organs of special sense

In order to survive, an animal must constantly check its environment. It must see its obstacles, hear predators, and smell other animals to identify outsiders from the member of its group, taste in order to discard harmful substances in its feed. These interactions with the environment are possible by special sense organs (organs of vision, hearing, equilibrium, taste smell and cutaneous sense).

Eye

Organ of vision, which receives stimuli in the form of light→ the retina changes the stimuli into nerve impulse → goes to the brain along optic nerve → interpreted as a picture. It includes the eyeball and accessory organs of vision (eyelid, conjunctiva, lachrymal apparatus, ocular muscle and orbital fascia).

Ear

Organ of hearing and equilibrium, which is a highly developed sense organ like the eye. Two ears are present in normal mammals each consisting: external ear, middle ear and inner ear.

Nose

The organ of smell is situated in the nose. In animals with well-developed sense of smell, it consists of large area of olfactory mucosa covering the lateral wall and the ethimoidal conchae in the caudal part of nasal cavity.

Tongue

The organ of taste, which contains taste buds (fungiform, filiform, vallaten or circumvallate and foliate)

The cutaneous sense

The animal through the skin experiences much of the most immediate environment. The cutaneous sensations are touch, pressure, pain, temperature (heat or cold). For these there are sensory receptors of the skin. A special sense of cutaneous sense is mediated by tactile hairs (long hairs thicker than other hairs and are mostly found on the muzzle and eye regions).

1.10.3 Physiology of the nervous system

- Controls functions and movement of
  - ✓ Organs
  - ✓ Muscles
  - ✓ Sensory organs
- Neurons relay and receive information
- Neurons conduct electrochemical signals

The functional unit of the nervous system is neuron (nerve cell), which has four different regions:

I. **Dendrite-** information receiving area from the neighboring neurons
II. **Cell body-** integrates signals

III. **Axon-** transmits action potential along the cell

IV. **Presynaptic terminal-** send signals to the adjacent cells

Functions of the brain and spinal cord

- **The Brain-** The central information processing organ of the body
- **Spinal cord-** Long, thin tubular bundle of nerve connected to the brain. It communicating lead between the body and spinal cord.
- **Cerebrum-** all sensations take place in the CNS primarily in the sensory portions of the cerebral cortex, also responsible to learning, intelligence, awareness, smell.
- **Cerebellum-** responsible for maintaining posture, orientation of the animal in space and for accurate limb movements.
- **Medulla oblongata** - center for respiration and cardiovascular reflexes and other reflexes like locomotion, visceral functions like bladder control, erection of the penis and clitoris.

The peripheral nervous system: - Control voluntary muscles that provide movement

Autonomic nerves system: - Control involuntary responses (smooth muscles, cardiac muscle, glands and organs)

Special sense organ functions

- The eye – sight
- The ear – hearing and balance
- The tongue – taste
- The nasal cavity - smell

Self-check 1	

Name_____ ID_____signature_____ date_____

Directions: Answer all the questions below accordingly.

Test I: Choose the best answer (11 point)

1. Among the following which one is different from other
   a. Cranial
   b. Caudal
   c. Dorsal
   d. Medial plane
2. Which one is not appendages of the skin the:
   a. Hairs
   b. Hooves
   c. Claws and horns
   d. mammary gland
   e. None of the above
3. Hoof is composed of:
   a. Perioplic (a band of soft horns) epidermis
   b. Coronary epidermis and
   c. Laminar epidermis
   d. All of the above

4._____is a shallow articular cone-cavity (depression).
   a. Gelnoid cavity
   b. Fossa
   c. Fovea
   d. Condyloid cavity

5. Are unpaired bones located on the median plane and include the vertebrae and some of the unpaired bones of the skull.
   a. Seasamoid bones
   b. Pnuematic bones

c. Irregular bones

d. Short bones:

6. The sternum is composed of:

a. The pre sternum (manubrium sterni) and carini form cartilage.

b. The meso sternum (body) consists of segments called sternebrae

c. Meta sternum and xiphoid cartilage.

d. All of the above

7. Composed of muscle cells that have no striations visible with a microscope.

a. Cardiac muscle

b. Skeletal muscle

c. Smooth muscle

d. None of the above

8. Which one of the following is not part of ruminant stomach?

a. Rumen

b. Reticulum

c. Omasum

d. Abomasum

9. The three main conditioning roles performed by the nasal lining are:

a. Warming

b. Humidifying

c. Filtering the inhaled air

d. All of the above

10. The valve which blocks return of blood from Aorta to the left ventricle is called:

a. Atrioventricular valve

b. Semilunar valve

c. Tricuspid valve

d. Mitral valve

11. Which one is not the region or parts of nephron:

a. Proximal nephron

a. Distal nephron

b. Loop of henle

c. None of the above

Test II: Short Answer Questions (2pts each)

1. Define the term myology.
2. What is the difference between exocrine and endocrine glands?
3. Write the components of nervous system and briefly discuss them.

Note: Satisfactory rating – 8.5 points **Unsatisfactory - below 8.5 points**

LG #2	LO #2- Identify clinically important structure of animal body

Instruction sheet 2

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Muscles for meat inspection, respiration and drug administration
- Organs used for external clinical diagnosis
- Blood vessels used for sample collection and drug administration
- Location of clinically important arteries, veins, nerves, muscles and lymph nodes
- Sites for trocarization, castration, shoeing, hoof trimming and dehorning
- Location and importance of sciatic nerve, spermatic cord and lymph nodes

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify muscles involved on meat inspection and administration of drugs in different animal species
- Identify muscles involved in respiration.
- Identify the relative locations of organs used for external clinical diagnosis and application of treatment during ill health.
- Identify the locations of blood vessels used in blood sample collection and drug administration; for different animal species.
- Identify the clinical importance and locations of lymph nodes.
- Identify appropriate sites for shoeing, hoof trimming and dehorning
- Identify the location of sciatic nerve is and recognize its importance during drug administration.
- Recognize the location of the spermatic cord and its importance during castration is minimizing damage to self and the material according to the organizational guidelines.

Learning Instructions:
1. Read the specific objectives of this Learning Guide. 2. Follow the instructions described below. 3. Read the information written in the information Sheets 4. Accomplish the Self-checks 5. Perform Operation Sheets 6. Do the “LAP test”

Information Sheet 2

2.1. Muscles for meat inspection, respiration and drug administration

2.1.1. Muscles involved on meat inspection

Postmortem Inspection Process

The postmortem inspection process for livestock involves the following steps:

- **Head part inspection**

There are four steps in head inspection.

Step 1: observe the outer surface of the head and eyes.

Step 2: incise and observe the four pairs of lymph nodes – mandibular, parotid, lateral retropharyngeal, and medial retropharyngeal.

Step 3: incise and observe the **masticatory or cheek muscles**.

Step 4: observe and palpate the **tongue**.

Viscera inspection

Viscera inspection includes the following steps:

The following steps are performed in viscera inspection.

a) Observe cranial and caudal mesenteric (mesenteric) lymph nodes, and abdominal viscera.
b) Observe and palpate rumeno-reticular junction.
c) Observe esophagus and spleen.
d) Incise and observe lungs lymph nodes - mediastinal [caudal (posterior), middle, cranial (anterior)], and tracheobronchial (bronchial) right and left.
e) Observe and palpate costal (curved) surfaces of lungs.
f) Incise heart, from base to apex or vice versa, through the interventricular septum, and observe cut and inner surfaces.
g) Turn lungs over; observe ventral (flat) surfaces and heart's outer surface.
h) Incise and observe hepatic (portal) lymph nodes.
i) Open the bile duct (both directions) and observe its contents for flukes.
j) Observe and palpate liver's ventral surface.

k) Turn liver over, palpate renal impression, observe and palpate parietal (dorsal) surface.

Carcass inspection

i. Palpate superficial inguinal, or supramammary, and internal iliac lymph nodes.
ii. Observe lumbar region.
iii. Observe and palpate kidneys.
iv. Observe diaphragm's pillars and peritoneum.
v. Observe and palpate **diaphragm muscle**.
vi. Observe pleura, cut surfaces of muscles and bones, neck, and carcass exterior.
vii. Briceps brachii muscle

- Triceps brachii muscle
- Massetor muscle
- Biceps femori
- Diaphragm muscle

2.1.2. Muscles involved for respiration

Muscles of inspiration

Diaphragm the most important respiratory muscle, a membranous dome shaped muscle which separates the abdominal and chest cavities. When it contracts at the start of inspiration, the diaphragm flattens down to increase intrathoracic volume. This creates a negative intrathoracic pressure relative to atmospheric pressure, favouring the movement of air from the mouth down into the lungs

- **External intercostals**
  - ✓ Join adjacent ribs and contract at the start of inspiration to pull the ribs upward and outwards, supplementing the role of the diaphragm in increasing the intrathoracic volume.
- **Accessory muscles**
  - ✓ **Scalenes –** anterior, middle, posterior. Pull the first two ribs upwards.
  - ✓ **Sternoclidomastoid** – pulls the sternum upwards

- ✓ **Pectoralis minor -** vertebral extensors, serratus anterior

Muscles of expiration

- During quiet breathing expiration is passive, using the elastic recoil of the lungs and chest wall to move gas out of the mouth. In active breathing, muscles used include:
- **Anterior abdominal wall muscles**
  - ✓ Rectus abdominus, internal and external oblique and transverses abdominus. Contract on expiration and increase intra abdominal pressure, pushing the diaphragm up and increasing intrathoracic pressure to favor air movement out of the lungs
- **Internal intercostals** join adjacent ribs.
  - ✓ Oppose the external intercostals by moving ribs downwards and inwards, enhancing the effects of the abdominal muscles.

2.1.3. Muscles involved on administration of drugs

All injections carry a risk of infection and can cause pain, fear and distress to some extent. They should never be given unnecessarily. The following rules apply for all injections:

Always use a sterile syringe and needle to avoid creating an injection site abscess. Wipe the top of the medicine bottle with surgical spirit if it is dirty. Always use the narrowest gauge (g) that allows smooth injection of the drug, i.e. 20g or 21g for watery drugs and vaccines, 16g or 18g for oily drugs or suspensions. Always ensure the injection site is clean and free from mud or dirt.

I. **Neck** – in the **triangle of muscle** demarcated by the nuchal ligament, the dorsal border of the cervical spine and the cranial border of the scapula. Alternatively a hand can be placed on the neck with the base at the junction of the neck and the shoulder, half-way between the crest and the ventral side of the neck: the hand will be covering the area suitable for injection.



Figure 2.1: Site of injection of drug **source**: - https://m.facebook.com/trainingpakistan/photos/following-are-the-common-sites-of-injection-in-cow1-intravenous-iv-2-intramuscul/1104023186407159/ Accessed on 29/08/2022

II. **Gluteal muscles** – in the centre of the muscular square bordered by the tuber coxae, tuber ischia, sacrum and base of tail. Do not inject caudal to the femur as this may damage the **sciatic nerve**.

III. **Pectoral muscle (horses only)** – in thickest part. Maximum volume is 5 ml per site and do not inject potentially irritating drugs in this area as it will affect movement.

IV. Semimembranosus/Semitendinosus muscles

V. Triceps muscle

VI. Subcutaneous

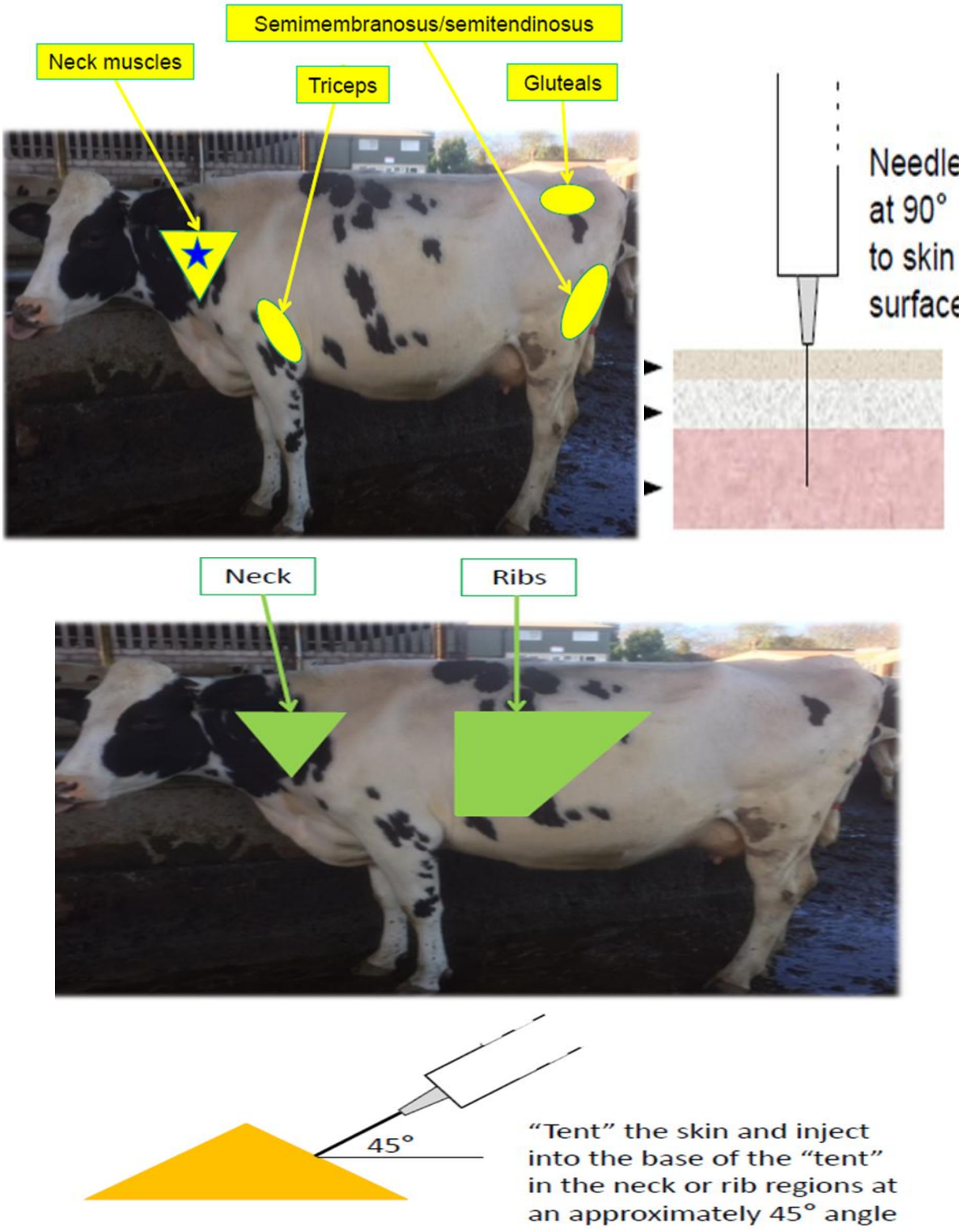


Figure 2.2: Site of injection of drug at triceps muscle and subcutaneous **source: -** https://www.facebook.com/349414388835448/posts/how-to-administer-medicine-to-your-cattle/944761299300751/ Accessed on 28/08/2022

2.2. Organs used for external clinical diagnosis

Veterinary clinical diagnosis defines as the process or activity of identifying the nature and cause of a disease or injury by various mechanisms. The following are parts external organs of animals that are used to detect and diagnose up on the manifestation of any diseases.

a) **The skin**
b) **The head and the neck area**
   - Eye
   - Ear
   - Mucus membrane of the eye
c) **Oral cavity**
   - Tongue
   - Teeth
   - Tongue
   - Mucus membrane of oral cavity
d) **Nasal cavity**

2.2.1. Clinical conditions regarding digestive system

a. Bloat

Ruminant animals carry an active population of micro-organisms (bacteria, fungi, and protozoa) in the forestomach of their digestive system. Without these organisms, the animal would be unable to digest fibrous feeds, such as grasses and legumes. In the process of digesting these materials, the micro-organisms produce large quantities of gas that must be expelled. When steers are fed fresh alfalfa, they produce up to 2 L of gas per minute. Under normal conditions, the gas produced in the rumen separates from the solid and liquid contents and then rises to the top of the rumen, where it collects as a free bubble. Eructation, or belching, is initiated by increasing gas pressure in the rumen. When an animal belches, the rumen contracts and pushes the free gas toward the front of the rumen, where it collects around the esophageal opening.

The opening of the esophagus is controlled by receptors in the rumen wall that can sense when the area is exposed to liquid or to free gas. If the area is covered by liquid or foam, the esophagus remains tightly closed, preventing belching. This trait apparently has evolved in ruminant animals to prevent rumen fluid or foam from accidentally entering the lungs, which would cause aspiration pneumonia.

Types of bloat

I. Frothy bloat

Although frothy rumen contents are characteristic of both legume pasture bloat and feedlot bloat, the physical and chemical explanations for the two conditions were quite different until recently. According to the traditional theory of legume pasture bloat, froth was attributed to soluble proteins in the rumen fluid, which were produced by legume forages. The foaming properties of all soluble proteins are well known, so it was reasonable to suspect them as the cause of pasture bloat. Current theories place more emphasis on the involvement of small particles and microbial activity. Alfalfa, which is rapidly digested, provides for bacterial blooms, producing large quantities of both gas and slime.

Frothy feedlot bloat has been attributed to small feed particles in grain rations that cause slime to form in rumen contents. The slime is made up primarily of polysaccharides secreted by rumen bacteria and released from ruptured bacterial cells. The bacterial polysaccharides increase the viscosity of rumen fluid and subsequently trap small gas bubbles in the rumen fluid, leading to frothy rumen contents and bloat.

II. Free-gas bloat

Free-gas bloat in feedlot animals is more sporadic than frothy bloat, usually affecting a few animals rather than a large number. Free-gas bloat generally occurs very rapidly and provides little warning for treatment. Free-gas bloat accounts for approximately 10 per cent of the cases of feedlot bloat. Irregular feed intake, inhibition of the nerves controlling the contractions of the rumen walls, and physical obstruction of the esophagus may cause free-gas bloat.

b. Carbohydrate engorgement

It is a condition in which large amounts of highly fermentable carbohydrate rich feeds causes an acute disease due to the excessive production of lactic acid in the rumen. It is characterize by ruminal stasis, severe toxemia, diarrhea, weakness and recumbency, and dehydration. Etiology: sudden ingestion of toxic doses of carbohydrate rich feeds especially grain.

2.2.2. Clinical conditions of urogenital system

I. Uterine infection

The two main postpartum clinical conditions are metritis and endometritis. Metritis is most common within 10 days of parturition, and is characterized by an enlarged uterus containing a watery red-brown fluid to viscous off-white purulent uterine discharge, which often has a fetid odor. The severity of metritis is categorized by the signs of the animal's health, from mild disease to toxemia. The incidence of metritis varies between breed, country and herd. Clinical endometritis is defined as the presence of a purulent discharge detectable in the vagina 21 days or more post partum, or mucopurulent discharge detectable in the vagina after 26 days post partum. One of the determinants of the likelihood of uterine disease is the incidence of risk factors. These risk factors can be divided into factors that are associated with damage to the uterus, metabolic stress, or deficits in hygiene. Interestingly, the latter is the least important in the majority of epidemiological models that quantify the risk factors for uterine disease. The risk factors most frequently associated with uterine infection are those that likely lead to some trauma to the endometrium, including stillbirth, twins, male and beef-sire calves, dystocia, caesarean section operation, and retained placenta. The diagnosis of metritis and clinical endometritis should include an inspection of the contents of the female genital tract by speculum or insertion of a clean-gloved-hand into the vagina

II. Dystocia

Literally means difficult labor and it is characterized by abnormally slow progress of labor **abnormal labor:** disproportion between the presenting part of the fetus and the birth canal. It is the consequence of four distinct abnormalities existing singly or in combination.

Common clinical findings in female animals with ineffective labor

- **Inadequate cervical dilation or fetal descen**t
  - ✓ Protracted labor (slow progress)
  - ✓ Arrested labor (no progress)
  - ✓ Inadequate expulsive effort (ineffective pushing
- **Fetopelvic disproportion**
  - ✓ Excessive fetal size
  - ✓ Inadequate pelvic capacity
  - ✓ Malpresentation or position of the fetus
- **Ruptured membranes without labor**

III. Prolapse of uterine

A uterine Prolapse is usually seen immediately following or within a few hours of calving. Compared to the vaginal Prolapse, the uterine Prolapse is larger, longer (usually hanging down to the hocks when standing), deep red in color and covered with the “buttons” where the placenta was attached. A uterine Prolapse is considered a medical emergency. This condition is life-threatening. If the affected cow is not treated quickly, she could go into shock or die from blood loss. Contact your veterinarian for assist trance with this procedure. If the uterus is pushed back improperly, it could result in internal bleeding and death of the animal. Uterine prolapses are not heritable like vaginal prolapses. If the uterine Prolapse is repaired properly, the cow may maintain a normal reproductive existence.



Figure 2.3:- Black Angus cow with a uterine prolapsed

https://www.uaex.uada.edu/publications/pdf/FSA-3102.pdf Accessed on 29/08/2022

IV. Vaginal Prolapse

A vaginal Prolapse occurs due to increased pressure in the abdominal cavity during the latter stages of pregnancy. This type of pro-lapse is more common than a uterine Prolapse and typically looks like a pink bulge of tissue ranging in size from a large grapefruit to a soccer ball. The bulge often retracts when the cow gets up and pressure is reduced. Once this tissue becomes prolapsed, it is exposed to environmental elements (e.g. dust, sun or manure) and to potential infectious organisms.Vaginal prolapses are recurring problems. Vaginal Prolapse can be an inherited trait, making the daughter of a cow that experienced this problem likely to also suffer a vaginal Prolapse in her lifetime. For this reason, cattle that have had a vaginal Prolapse should be culled, and their offspring should not be used for breeding purposes.

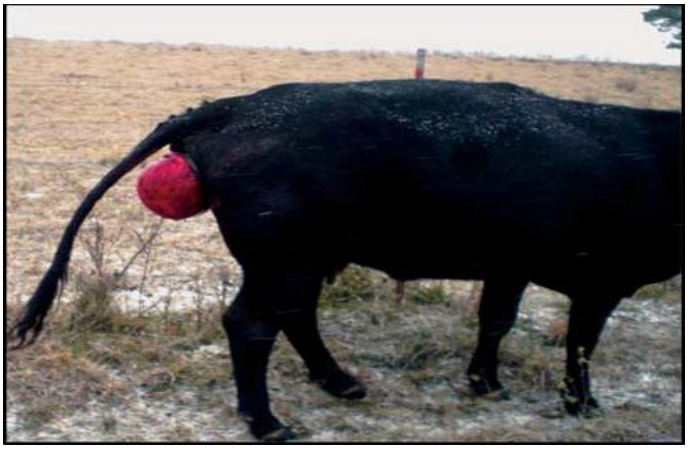


Figure 2.4:- Black Angus cow with a vaginal prolapsed **Source**: - https://www.researchgate.net/figure/Grade-3-vaginal-prolapse-in-a-crossbred-HF-cow_fig1_236983750 Accessed on 28/08/2022

V. Phymosis: is a condition in which the prepuce cannot be retracted over the glans penis.

VI. Paraphymosis: is a condition in which the foreskin is left retracted because of entrapment of the tight prepuce proximal to the corona. The glans engorges and the prepuce becomes edematous because of lymphatic and venous congestion

VII. Urinary calculi: refers to deposits in the urinary tract. These deposits may block the flow of urine, particularly in male cattle and sheep. Prolonged blockage generally results in the rupture of urinary bladder or urethra, releasing urine into the surrounding tissue.

2.3. Blood vessels used for sample collection and drug administration

2.3.1. Sites of blood vessels used in blood sample collection



Figure 2.5:- Location of jugular vein and blood sample collection **Source**: - https://www.alamy.com/stock-photo/jugular.html Accessed on 29/08/2022

Blood collection (venipuncture, phlebotomy) is a common and important specimen collection procedure in the conduct of research. In many protocols, multiple blood draws are an important part of collecting and analyzing data.

Table 2.1. Blood vessels used for blood sample collection

No	Species of animal	Blood vessels used for blood sample collection
1	Dog	Cephalic vein, Jugular vein. Lateral saphenous vein Femoral vessels
2	Cat	Cephalic vein, Jugular vein, Medial saphenous vein Femoral vessels
3	Sheep	Jugular vein
4	Goat	Jugular vein, Cephalic vein, ear vein
5	Cattle	Jugular vein, ear vein, tail vein
6	Horse and Donkey	Jugular vein, Cephalic vein
7	Swine	Cranial vena cava, Jugular vein, Lateral saphenous vein, ear vein
8	Birds	Brachial vein, Jugular vein, Femoral veins, wing vein

2.3.2. Locations of blood vessels used in drug administration

Table 2.2. Blood vessels used for drug administration

No	**Species of animal**	**Blood vessels used for drug administration**
1	Dog	Jugular vein
2	Cat	Jugular vein
3	Sheep	Jugular vein
	Goat	Jugular vein
4	Cattle	Jugular vein,
5	Horse and Donkey	Jugular vein
6	Swine	Jugular vein
7	Birds	Jugular vein

2.4. Location of clinically important arteries, veins, nerves, muscles and lymph nodes

I. **Clinically important veins: - Jugular vein** located on both side of the neck, **ear vein** on ear, **tail vein** on tip of tail, **cephalic vein** located on the upper limb and it's one of the two main veins of the forelimb.

II. **Clinically important arteries**:- The **carotid arteries** are major blood vessels in the neck that supply blood to the brain, neck, and face

III. **Clinically important nerves**:- **sciatic nerve** located on the gluteal or rump area, **radial nerve** on the radial surface of the forelimb, **cranial nerves** including vagus nerves

IV. **Clinically important muscles:-** trapezius muscle located upper tip of scapula, brachiocephalicus muscle from temporal bone to glonoid tuberosity of humers, gluteal muscle on back loin, semimebranius and semitendinous muscles, tongue muscle, maseter muscle on chicks, buccinators muscle

V. **Clinically important lymph nodes**:- Submandibular lymph nodes located under mandible, Parotid lymph nodes located cranio caudally, retropharyngeal lymph nodes, Prescapular lymph nodes located cranial to scapula and Prefemoral lymph nodes located located to cranial to femur bone.

2.5.Sites for trocarization, castration, shoeing, hoof trimming and dehorning

2.5.1 Trocarization

Trocarization is a procedure whereby a trocar and cannula are inserted through the abdominal wall and into the rumen. Trocarization entails preparing a small area on the left side of the abdomen and then inserting a large needle directly into the stomach to allow an avenue for air to escape. Trocarization is done to provide brief relief and improve circulation. This producer is majorly done in the condition of free gas bloat. It is possible to see the steps and producers of trocarization on YouTube link https://www.youtube.com/watch?v=d_jFKoU4XJw accessed on 28/08/2022.



Figure2.6:- Trocarization of cattle during free gas bloat

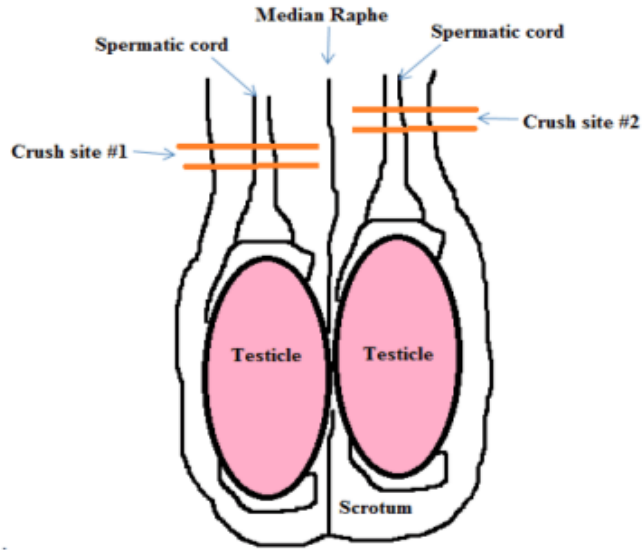
2.5.2. Castration

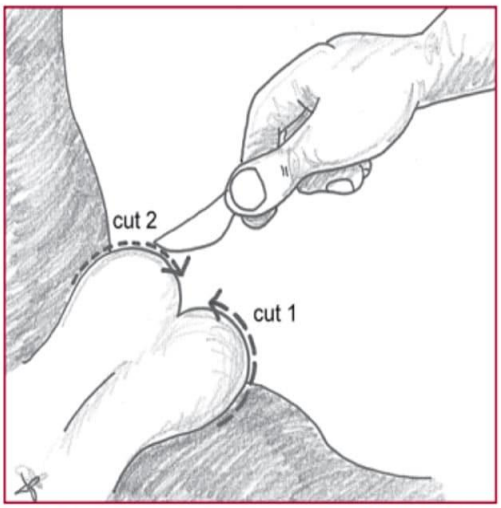
It the removal or inactivation of the testicles of a male animal. Castration is a common management tool in the beef cattle sector for many reasons, including to: Stop the production of male hormones. Prevent unplanned mating. Decrease aggression to enhance on-farm safety for handlers and animals

Methods of castration

Castration can be performed surgically or non-surgically. Surgical castration is performed by making an opening in the scrotum and removing the testicles. In baby calves, the bottom 1/3 of the scrotum is removed by a horizontal incision with a sharp blade or scalpel. Once exposed, grasp each testicle individually, isolate the spermatic cord and cut or apply even tension on the cord until it breaks free. This procedure can often be done by one person with the rear legs and one front leg of the calf tied, and results in the least amount of stress to the animal. For older males, either a horizontal incision or a vertical incision can be made. The key is to make a large enough incision to allow drainage. Extreme care must be taken not to cut the inside of the calf's leg, or the handler. A newberry knife is the safest method of making two vertical incisions, one on each side of the scrotum, for testicle removal. Once the scrotal sac is opened, grasp each

testicle individually, isolate the spermatic cord and apply tension on the cord. An emasculator is then applied as high as possible to crimp and cut the cord. The testicle can also be removed by applying tension as described in younger animals, but there are greater risks of bleeding and internal injury when this is done in older animals. The emasculator should be left on the cord for 15-20 seconds to help control bleeding.





Make the cuts long enough for easy removal of the testicle and to allow good drainage.

Figure 2.7:- Crush sites for non-surgical castration **Figure 2.8**:- Horizontal incision site for surgical castration in younger calves

http://omafra.gov.on.ca/english/livestock/beef/facts/07-029.htm Accessed on 29/08/2022

2.5.3. Shoe placement

When a shoe is placed on an animal's foot, the animal no longer stands on its feet but on its shoes instead. Therefore, the shoe is placed with biomechanical congruency so that it considers the same biomechanical landmarks used for the trim and essentially forms an extension of the trim. The shoe should be placed central to the widest part of the foot. The distance between break over (the dorsal point of the shoe's contact with the ground) and the widest part of the foot should equal the distance from the widest part of the foot to the heel end of the shoe (Figure 2.10). Break over in the toe of the shoe can be altered when necessary by forging or by using a hand grinder. Using this technique also provides a basis in which to evaluate the existing farriery.

- **7 Steps to fix a block**

i. Hoof trimming
ii. Clean whole hoof and check health of the claw on which you plan to fix the block
iii. Grind smoothly the surface of horn
iv. Degreasing with alcohol
v. Find block who fits to the claw
vi. Prepare glue (2-component glue) and put it on block
vii. Adjust block on the hoof and wait until it gets hard



Figure 2.9: Plastic and wood block used for shoeing Source: - https://www.americanfarriers.com/articles/11658-formahoof-ltd-formahoof-podiatry Accessed on 28/08/2022

2.5.4. Hoof trimming

Five step method of foot trimming

A wooden block 7.5 cm long and 7 mm deep is used as a guide to the measurements used in this method.

(1a) Cut the medial hoof wall to the correct length of 7.5 cm at the toe, ensuring the cut at the toe is perpendicular to the sole and is square across the toe.

(1b) Reduce the horn of the medial sole to the correct depth of approximately 7mm

- The cut edge at the toe should be 7mm
- The white line will reappear as an ellipse around the toe when sole is correct depth
- If the sole is pinking it is getting too thin.

- Using the handle of the knife check to ensure that the paring is producing a flat sole.

(2) Using the medial claw as a template cut the toe of the lateral claw to the correct length and pares the sole to the correct depth.

(3) Hollow out the non-weight bearing axial surfaces between the white line and the heels of both claws.

(4) Investigate any problems on the sole.

(5) Trim the heels if necessary. Be careful because the heels are sensitive. Do not be too aggressive:

- Remove any loose tags of horn
- Reshape the heel
- Reduce any deep furrows.
- Rasp the edges of the claws to prevent trauma.

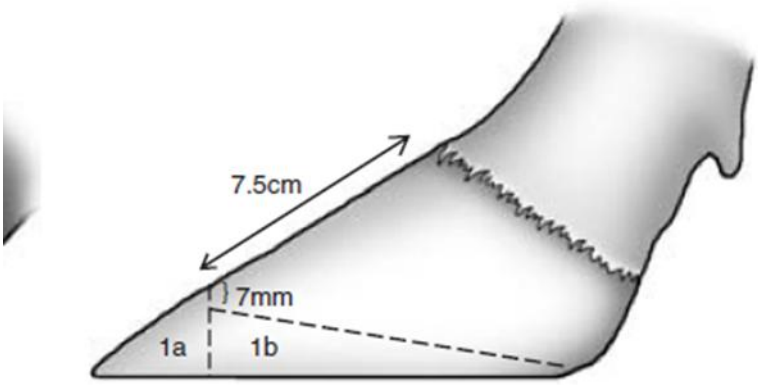


Figure 2.10: Five step' method of foot trimming: steps 1a and 1b.

https://www.pinterest.ca/pin/293296994453322316/ Accessed on 28/08/2022

2.5.5. **Dehorning**

Horns are special adaptations of the integument (skin). The corium (the area of cells located at the junction of the horn and skin) is the site of horn production. If the horn but not the corium is removed, horns will resume growing. Horns begin as buds within the skin of the poll. At approximately 2 months of age, the horn buds become attached to the periosteum of the frontal

bone overlying the frontal sinus. As the horns grow, the corneal diverticulum of the caudal portion of the frontal sinus extends into the most proximal portion of the horn. The corneal nerve, a branch of the Trigeminal nerve (cranial nerve V), provides sensation to the skin of the horn/horn bud region. Injection of a local anesthetic around the corneal nerve as it traverses the frontal crest desensitizes the area.

Dehorning is removal of the horns after they have formed from the horn bud. Physical methods of dehorning (gouge dehorning) include the use of embryotomy wire, guillotine shears, or dehorning knives, saws, spoons, cups, tubes, or high tension rubber bands. The Barnes-type scoop dehorner is commonly used for physical dehorning. When cattle have large horns they are sometimes “tipped”, a procedure that removes the sharp end of the horn but leaves the base.

Dehorning with Wire

For very large horns

- Properly restrain the animal’s head and follow pain management practices
- Cut an arm’s length piece of obstetrical wire and attach to wire handles
- Place the wire on the back side or caudal aspect of the horn flush with the scalp.
- Saw back and forth making sure to stay as close to the scalp as possible.
- Cauterize the blood vessels with a hot iron and apply blood stop powder.
- Apply fly spray if the procedure was done during the fly season or if flies are present.
- Repeat steps 4-7 to the other horn.

Disbudding

Disbudding involves destroying the horn-producing cells (corium) of the horn bud.5 Horn buds are removed without opening the frontal sinus. Chemical and hot-iron disbudding methods destroy the horn-producing cells, whereas physical methods of disbudding excise them.

Benefits of disbudding and dehorning

Dehorning cattle conveys advantages. Horns are the single major cause of carcass wastage due to bruising, and trim associated with bruising for carcasses from horned cattle is approximately twice that for carcasses from hornless cattle. Dehorned cattle require less feeding trough space; are easier and less dangerous to handle and transport; present a lower risk of interference from dominant animals at feeding time; pose a reduced risk of injury to udders, flanks, and eyes of

other cattle; present a lower injury risk for handlers, horses, and dogs; exhibit fewer aggressive behaviors associated with individual dominance; and may incur fewer financial penalties on sale

2.6. Location and importance of sciatic nerve, spermatic cord and lymph nodes

2.6.1. Sciatic nerve and its importance

Sciatic nerve (spinal nerve roots L6, S1 and S2). The sciatic nerve bifurcates to form the peroneal nerve and tibial nerve. The nerve roots of the sciatic nerve can be damaged together with the nerve roots of the obturator nerve by pressure during parturition and may contribute to calving paralysis. Sciatic nerve paralysis is most commonly seen in a young animal following incorrectly placed intramuscular injection into the gluteal or biceps femoris. Complete paralysis is rare. At rest there may be knuckling, and as the animal walks the limb is dragged forward along the dorsal surface of the fetlock by flexion of the hip only. The position of the hock is dropped with increased flexion when compared with the normal hind limb. The sciatic nerve is responsible for skin sensation with the exception of the medial aspect (saphenous branch of the femoral nerve).

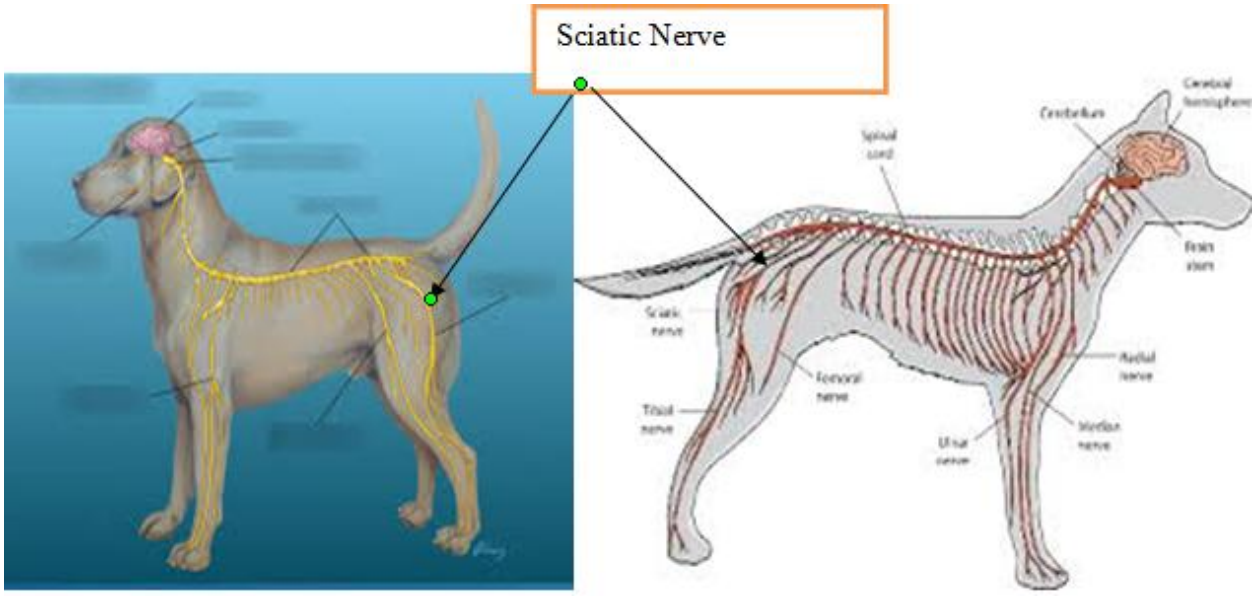


Figure 2.11: Anatomy of sciatic nerve in dog

2.6.2. Spermatic cord and its importance

Spermatic cords: are readily palpable as they run dorsally from each testis towards the inguinal canal. The cords should be approximately equal in size, consistency and compressibility. The cords may become thickened, less mobile and painful to the touch when inflamed. They contain the spermatic artery, veins (including the pampiniform plexus), lymphatics, nerves and the vas deferens. The contents of the cord can be gently compressed, allowing them to be identified and compared. The vas deferens is readily identified as it runs dorsally in the medial part of the spermatic cord. It is approximately 3mm in diameter and less compressible than surrounding tissues

Importance of spermatic cord

- Suspends the test is in the scrotum
- Provides pathway to and from the body for the testicular vasculature, lymphatics, and nerves
- Thermoregulation Mechanism
  - **Pampiniform plexus:** Provides a countercurrent heat exchange mechanism and act as a pulse pressure eliminator
- Houses the Cremaster muscle
  - Primary muscle supporting the testis
  - Coursing the length of spermatic cords
  - Involves with testicular temperature regulation
  - Striated muscle, short-term elevation of testes (Not capable of sustained contraction like the tunica dartos in the scrotum)
- Houses the ductus deferens
  - Responsible for sperm transport from epididymis to the urethra

2.6.3. Importance and locations of lymph nodes

Lymphatic system

The lymphatic system consists of the carcase lymph nodes, the network of lymph vessels which connect them and the lymphatic parts of the spleen. Many of the nodes are readily palpable in the

healthy animal. Others can be palpated only when enlarged. Details of the location of the individual nodes and their ease of palpation are given below. The lymph vessels are normally palpable only if they are enlarged. Some vessels may be seen and palpated as they run subcutaneously towards the regional lymph nodes.

Clinical examination of the lymphatic system

Grossly enlarged lymph nodes may have been seen during observation of the patient before it is handled. Further observation and palpation is possible when the animal is restrained. The lymph nodes can be examined as a separate system or checked during the examination of the skin when the clinician's hands run over the whole body surface. Each paired node should be compared for size and consistency with the contra lateral node.

Lymph node enlargement

This may occur for two main reasons. (1) Enlargement of one or more lymph nodes may occur in cases of infection of the lymphatic system. This can occur in a number of diseases including bovine tuberculosis, actinobacillosis and a number of other bacterial infections. (2) Lymph node enlargement in response to local infection or inflammation in the region of the body drained by the lymph node involved. In these circumstances the lymph node is acting as a sentinel of local disease. The enlarged node may be warm and inflamed, and sensitive to the touch.

Location of the carcass lymph nodes

Many of the nodes are paired and should be compared for size and consistency. Lymph nodes are normally firmer than adjacent muscle and other soft tissues. Locations of the readily palpable lymph nodes in cattle showing placement of the clinician's hand. See text for details.

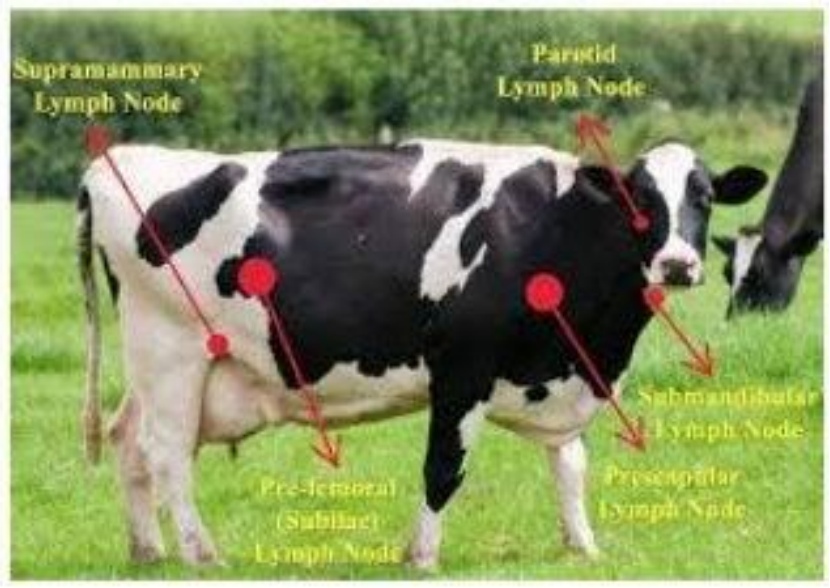


Figure 2.12: Locations of the readily palpable lymph nodes in cattle showing placement of the clinician's hand.

https://www.google.com/search?q=palpable+lymph+nodes+in+cattle++infographics&tbm=isch&ved=2ahUKEwikt-fks-v5AhUa4RoKHZNhCzgQ2-cCegQIABAA&oq=palpable+lymph+nodes+in+cattle++infographics&gs_lcp=CgNpbWcQDFAAWABgAGgAcAB4AIABAIgBAJIBAJgBAKoBC2d3cy13aXotaW1n&sclient=img&ei=SFoMY6TzEprCa5PDrcAD&bih=598&biw=1349&client=firefox-b-d&hl=en Accessed on:-29/08/22

- **Submandibular lymph nodes**

These are situated and are palpable on the medial aspect of the 'angle of the jaw' where the horizontal and vertical rami of the mandible meet. Normal size is 1.5 to 2cm at maximum diameter.

- **Parotid lymph nodes**

Often these are not palpable unless they are enlarged through local infection or tumor formation. These small nodes lie subcutaneously just below the temporomandibular joint. Normal size is 0.5cm.

- **Retropharyngeal lymph nodes**

These nodes lie in the midline dorsal to the pharynx. If enlarged they can be palpated by placing two fingers of one hand on either side of the larynx. The fingers of the two hands are advanced

towards each other just dorsal to the larynx. In normal animals the retropharyngeal nodes are rarely palpable and it is possible to advance the fingers (as described above) towards each other until they are separated only by the compressed pharynx.

- **Prescapular lymph nodes**

These nodes lie subcutaneously and underneath the cutaneous muscle just anterior to the shoulder joint. It is often possible to palpate them directly in front of the shoulder. They may also be reliably located by extending the fingers and pressing them forward from the shoulder joint onto the neck. The prescapular nodes vary in size and may be small and round or elongated in a dorsoventral direction. Normal size in adult is 1cm - 3.5cm.

- **Inguinal lymph nodes**

These are usually palpable as a small group of fairly mobile and firm structures adjacent to the inguinal canal. In the male they are found just anterior to the scrotum and in the female just anterior and lateral to the udder. Normal maximum diameter is 0.5cm**.**

- **Spleen**

In cattle the spleen is flat, 40 cm in length, 9cm in width and 2 to 3 cm thick. It lies on the left side of the body with its visceral surface in contact with the dorsolateral walls of the rumen and reticulum. The parietal surface is in contact with the diaphragm. The upper extremity is level with the dorsal parts of the 12th and 13th ribs, and the lower extremity is level with the costochondral junction of the 7th rib. It is normally not palpable, but if grossly enlarged it may be palpated just caudal to left rib cage. The spleen can be palpated at laparotomy either directly or through the wall of the opened rumen. It is seldom involved in disease, although its lymphoid tissue may be involved as part of the bovine leucosis complex.

Self-Check – 2	

Name_____ ID_____signature_____ date_____

Directions: Answer all the questions up on the instruction

Test I: Multiple choice (1pt each)

a. Muscles involved on administration of drugs are:

a) Semimembranosus
b) Triceps muscle
c) Gluteal muscle
d) All of the above

2. One of the following is not the muscles of expiration.

a) Rectus abdominus
b) Internal and external oblique
c) Transversus abdominus.
d) External intercostals muscles

3. Which one is the common clinical finding in female animals with ineffective labor?

a. Inadequate cervical dilation or fetal descent
b. Fetopelvic disproportion
c. Ruptured membranes without labor
d. All of the above

4. Which of the following lymph node is situated and are palpable on the medial aspect of the 'angle of the jaw' where the horizontal and vertical rami of the mandible meet?

a. Precrural lymph nodes
b. Popliteal lymph nodes
c. Submandibular lymph nodes
d. Parotid lymph nodes

5. Lymph node enlargement may occur due to:

a. Infection of the lymphatic system.
b. Local infection

c. Inflammation in the region of the body drained by the lymph node involved

d. All of the above

Test II: Short Answer Questions (2pts each)

1. Describe and discuss the difference between frothy bloat and free gas bloat.
2. List blood vessels used in drug administration
3. Describe the importance of dehorning.
4. Write the location and importance of ischiatic nerve.
5. Write the function of spermatic cord.

Note: Satisfactory rating – 7.5 points **Unsatisfactory - below 7.5 points**
You can ask you teacher for the copy of the correct answers.

Operation Sheet -2

2.1 Procedures of locating of clinically important , veins and lymph nodes in domestic animals

A. Tools and equipments

I. PPE (gown, boots, gloves, head cover, apron.
II. Required animals (shoats, cattle, equine, cat, dog, or any lab animals…)
III. Restraining equipments and chemicals (eg. Rope, povidone iodine, alcohol, detergents, crush, pole, bull holder…)
IV. Surgical equipments (like blade with handle, scissors, forceps, clamps and drapes)

B. Steps

- Wear PPE
- Restrain the animals with rope
- Disinfect the area of the target skin with alcohol or iodine
- Cut the hair with scissors
- Shave with blade
- Finally locate the vein and lymph nodes,

NB: - To visualize muscle, nerves and arteries it need opening of the body after killing of the animal /birds/.

2.2. Procedures of locating of clinically important arteries, veins, nerves, muscles and lymph nodes of sheep in post-mortemly

a) Tools and equipments

I. PPE (gown, boots, gloves, head cover, apron.
II. Required animals (shoats, cattle, equine, cat, dog, or any lab animals…)
III. Restraining equipments and chemicals (eg. Rope, povidone iodine, alcohol, detergents)
IV. Post mortem kits (like blade with handle, curved and straight scissors, needle, forceps, clamps and drapes)

b) Steps

- Wear PPE

- Restrain the animals with appropriate restraining equipment depending up on the behavior of animals.
- Cut the hair with scissors directly to the area of jugular vein.
- Shave with blade
- Disinfect with alcohol or povidone iodine
- Inject the 10 ml of Savlon with jugular vein a
- After death of the sheep
- Skinning with surgical blade and appreciate muscle and blood vessels by using forceps to stop bleeding.
- Expose the thorax and abdomen appreciate the lymph node and muscles, veins and artery

2.3. Procedures of locating of clinically important arteries, veins, nerves, muscles and lymph nodes of post-mortemly in avian

A. Tools and equipments

i. Appropriate PPE (gown, latex glove, apron…)
ii. hen
iii. post mortem kit (scissors, blade with handle, towel)
iv. Detergents, alcohol, bucket, surgical table, water

B. Steps

- Wear appropriate PPE
- Restrain the birds with manually
- Kill the hen with back of scissors by suffocation
- Recumbent the died bird dorsally and incisive from the kill bone
- Carefully skinning and open the visceral organ accordingly
- Inspect and visualize the vein, artery, nerves, lymph nodes, muscles and all visceral organs

2.4. Procedure of hoof trimming

A. Tools and equipments

I. Appropriate PPE (gown, boots, gloves, head cover, apron…)
II. Required animals (shoats, cattle, horse, donkey, mule)

III. Restraining equipments and chemicals (eg. Rope, mesh wire, anesthetic chemicals, povidone iodine, alcohol, detergents, crush, pole...)

IV. Available equipments (a hoof jack or chisel, pincers or hoof knife)

B. Steps

- Secure the animal with the help of casting rope and throw it on the soft ground by Ruff's method.
- Tie the animal's feet.
- Keep feet resting on a portable stock or a solid board for convenience in trimming hooves.
- Cut and trim the hoof from the bottom to the medial hoof wall to the correct length of 7.5 cm at the toe, ensuring the cut at the toe is perpendicular to the sole and is square across the toe using a chisel, pincers or hoof knife.
  - ✓ Reduce the horn of the medial sole to the correct depth of approximately 7mm
  - ✓ The cut edge at the toe should be 7mm;
  - ✓ The white line will reappear as an ellipse around the toe when sole is correct depth
  - ✓ If the sole is pinking it is getting too thin.
  - ✓ Using the handle of the knife check to ensure that the paring is producing a flat sole. Be careful because the heels are sensitive and give attention during:-
    - Remove any loose tags of horn;
    - Reshape the heel;
    - Reduce any deep furrows.
    - Rasp the edges of the claws to prevent trauma.

2.5. Techniques for dehorning with wire

A. Tools and equipments

I. PPE

II. Animal (cow, oxen, buffalo)

III. Restraining equipments (crush, ropes, pole, nose ring)

IV. Disinfectants and antiseptics, detergents, fly spray, blood stop powder

V. Equipments (Giggly wire with hands, hot iron)

B. Procedures

- Properly restrain the animal's head and follow pain management practices
- Cut an arm's length piece of obstetrical wire and attach to wire handles
- Place the wire on the back side or caudal aspect of the horn flush with the scalp.
- Saw back and forth making sure to stay as close to the scalp as possible.
- Cauterize the blood vessels with a hot iron and apply blood stop powder.
- Apply fly spray if the procedure was done during the fly season or if flies are present.
- Repeat steps 4-7 to the other horn.

2.6. Procedure of shoeing of animals

A. Tools and equipments

2. PPE
3. Animal (horse, mule, donkey)
4. Restraining equipments (crush, ropes, pole, halter)
5. Disinfectants and antiseptics, detergents)
6. Equipments (plastic or wooden block, glue, hoof knife)

B. Steps for shoeing

- Hoof trimming
- Clean whole hoof and check health of the claw on which you plan to fix the block
- Grind smoothly the surface of horn
- Degreasing with alcohol
- Find block that fits to the claw
- Prepare glue (2-component glue) and put it on block

- Adjust block on the hoof and wait until it gets hard

2.7. Techniques of closed castration

A. Tools and equipments

I. PPE
II. Animal (male shoats, bull)
III. Restraining equipments (ropes, pole, nose ring, crsuh)
IV. Disinfectants and antiseptics, detergents)
V. Equipments (burdizzo)

B. Procedures

- Preparation of material
- Restrain the animal to be castrated
- Hold the neck of scrotum in one hand and push the spermatic cord to the opposite side
- Apply the burdizzo to the spermatic cord and crush it. Close tightly about 2 inches above the testicle
- Left the burdizzo in place for approximately 2-3 minutes.
- Each cord should be crushed separately. Repeat the same procedure for the other testicle

LAP TEST-2	Performance Test

Name_____ ID_____ Signature_____-Date_____

Time started: 2:30 Time finished: 6:30 local time

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **4 hours**. The project is expected from each student to do it.

Task-1:-

1.1. Locate clinically important arteries, veins, muscles and lymph nodes of the required domestic animals

1.2. Locate clinically important arteries, veins, muscles and lymph nodes of the bird

Task 1:- Performe hoof trimming using correct technique of trimming.

Task 2:- Apply dehorning activity using giggly wire technique.

Task 3:- Fix wooden or plastic block to the given horse.

Task 4:- Perform closed castration technique**.**

LG #3	LO3 # Identify the structures and function of main body systems in avian

Instruction sheet 3

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Anatomy and physiology of integumentary system
- Anatomy and physiology of musculo-skeletal system
- Anatomy and physiology of digestive system and accessory organs
- Anatomy and physiology of circulatory system
- Anatomy and physiology of uro-genital system

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify and recognize structure and function of the integumentary system in avian species.
- Recognize structure and function of musculo-skeletal system with their respective locations in avian species.
- Identify structure and function of the digestive system, the accessory digestive organs in avian.
- Identify structure and function of the circulatory system with their respective locations in avian species.
- Identify structure and function of the uro-genital system with their respective locations in avian.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet 3

3.1. Anatomy and physiology of integumentary system

The **integumentary system** consists of the skin, the feathers and the appendages (claws and beak). The skin covers the majority of the body and contains glands in the outer ear canal and the preen gland at the base of the tail, that the bird uses to preen its feathers. The integumentary system is very important in providing protection to the bird from a number of potentially dangerous situations. The functions provided by the integumentary system include:

- A barrier between the external environment and the internal systems and organs thus provides support and protection from infection by microorganisms and from physical injury.
- Numerous nerve endings for the senses to enable the bird to be aware of potentially harmful situations.
- No sweat glands evaporative cooling through respiratory tract regulates temperature
- The compounds capable of conversion into vitamin D when exposed to sunlight.
- Uropygial gland/oil gland is located near tip of the tail. It is the principal cutaneous gland secreting lipoid sebaceous material to moisten the skin and lubricate the feather.
- Skin is very thin and covered by feathers
- Horny structures include claws, spur, scales, comb wattle and beak

The avian skin is divided into a number of separate areas where the skin has been modified to some extent to be able to carry out special functions. These areas are:

- The feathered skin.
- The scale covered skin on the lower legs and feet.
- The hard, horny areas of the beak and toenails.
- The pad of the foot (or plantar).
- The skin of the comb and wattles.

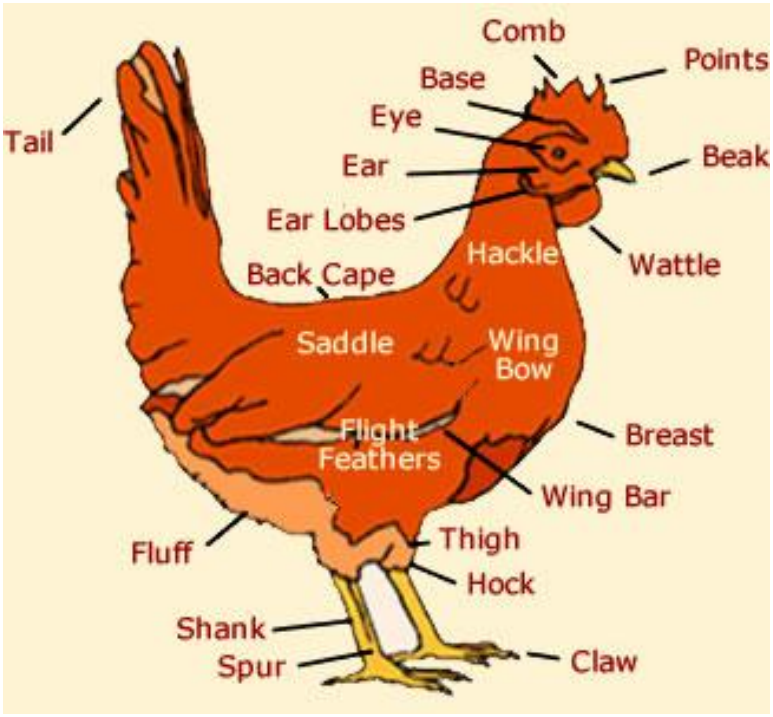


Figure 3.1:- Integumentary system of avian **source: -** https://slideplayer.com/slide/6225086/ accessed on 29/08/2022

3.2. Anatomy and physiology of musculo-skeletal system

The difference in the anatomy of birds from the mammalian anatomy is related to

- Relatively recent decent of birds from their reptilian ancestors
- The adaptation of birds to flight

General characteristics of the skeletal system of avian

a. Skeleton

- The skeleton constitute 9 –12% of the body weight. The bones are highly mineralized than other animals. The composition of the skeleton is 33% organic matter and 67% mineral mater. Majority of the mineral mater is phosphate and organic group salts.
- Modified for flight
- Reduced mass

- Pneumatic bones- major bones hollow with struts, air spaces connected to respiratory system
  - Fused bones- adds rigidity
  - Lack teeth- lightweight beak

b. Lightness of the bones as a result of pneumatization of many bones. These aerated parts of the bones communicate with the air sacs. Pneumatic bones include humerus, vertebral bones, sternum and costal bones. Scapula and femur are not aerated.

c. Strong tendency toward fusion:

Ex. Synsacrum: bone formed by fusion of last 1 or 2 thoracic, lumbar, sacral and first caudal vertebrae. Furucula (wishbone): fused clavicles. Carpometacarpus: fused bones of distal carpus with metacarpal bones. Tibiotarsal: fused bone formed from tibia and proximal tarsal bones. Tarsometatarsal: bone formed by fusion of distal rows of tarsal bones and fused bones of metatarsal I, II and III.

d. **Great mobility of the cervical vertebrae and head**.

This is due to

- Large number of cervical vertebrae
- Lightness of the skull as most of the bones of the skull are membranous, thin and carrying no teeth.
- The occipital bone has a single condoyle enabling the formation of mobile occipitoatlantal joint.

e. **Sternum** is well developed with a large ventral process called keel. Based on the size and development of keel birds can be classified in to

- Carinates are birds with massive keel and good fliers
- Ratites are birds with poorly developed keel

Pneumatic Bone

- Not completely hollow
- Connected to respiratory system
- Major bones of body pneumatic

Forelimb:

- It is modified to wing
- Ulna is more massive than radius
- There are only two free carpal bones related two ulna and radius
- Distal rows of carpal bones are fused with the metacarpal bones to form carpo-metacarpus
- There are only digits number II, III and IV. Digits II and IV have only one digit each while Digit III has two digits

Hind limb

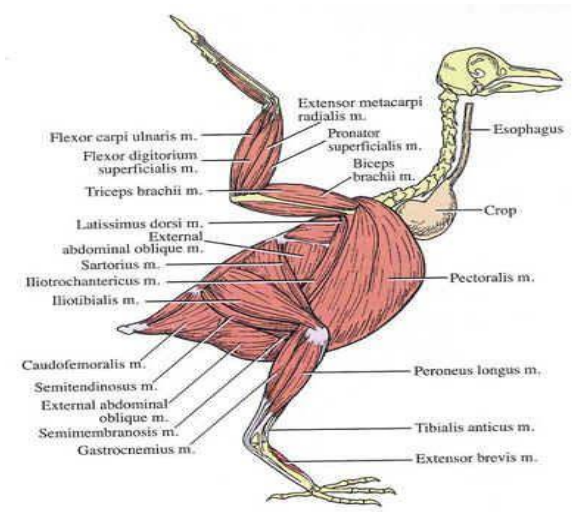
Tibia is fused with proximal rows of tarsal bone and formed a single bone named tibiotarsus. Distal rows of tarsal bones are fused with metatarsals, which are fused themselves together, and formed a single bone named tarsometatarsus. The I, II, III and IV digits exist and have II, III, IV and V digits respectively. The I digit is directed caudal and the rest are directed forward.

Vertebrae

The total number of vertebrae is 42 in many birds. The vertebral formula is C14T7L-S14Cd6. The number of cervical vertebrae may be more in long necked birds. Most of the cervical vertebrae are fused. The scapula articulates with coracoids and clavicle bone forming foramen triosseous through which tendon of supracoracoideus muscle pass to attach to dorsal part of humerus.

Ribs

The ribs have vertebral part and Sternal/costal part. There are small caudally projected processes from the ribs and termed **uncinate** process.



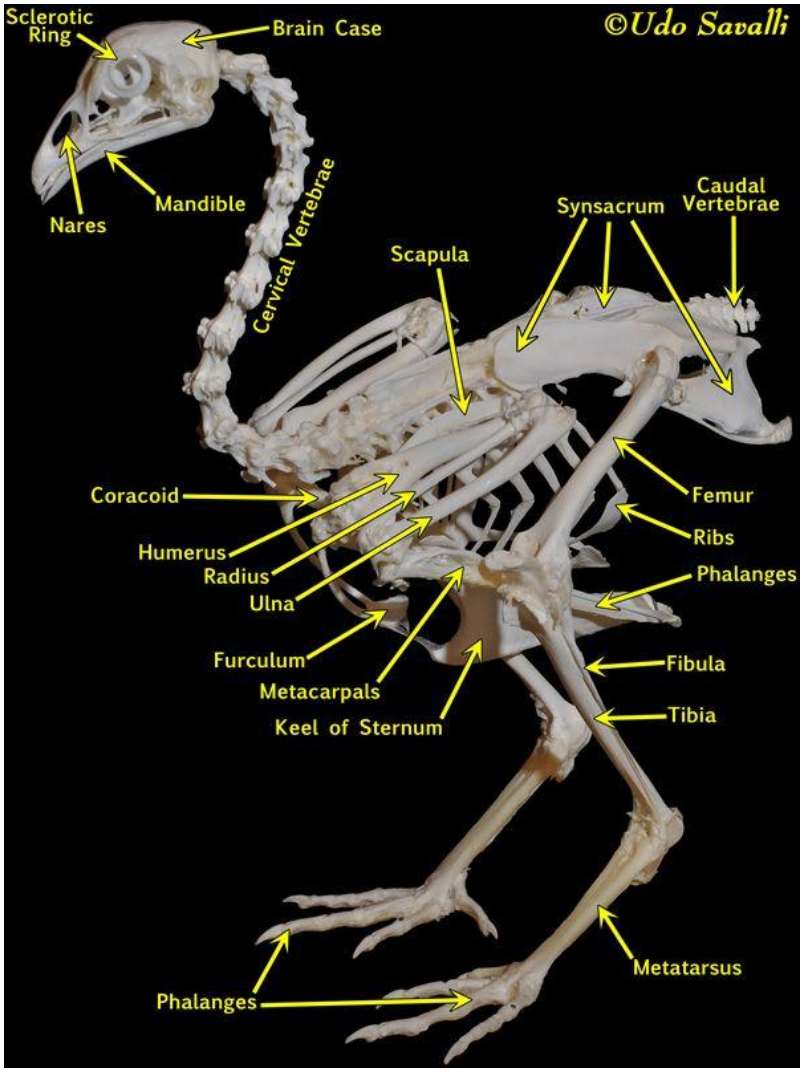


Figure 3.2:- Avian skeletal bone and muscle.

Muscles

In all birds pectoral muscles (deep pectoral/supracoracoideus and superficial pectoral/ pectoralis thoracicus) are well developed. These muscles are important muscle for flight. Supracoracoideus provides the upstroke of the wings for flight while pectoralis thoracicus provides down stroke of wings for flight. These muscles are used for intramuscular injection. However care must be taken during using these muscles as intramuscular injection sites not to enter the body cavity. It is wise to avoid the cranial part of the muscles not to severe the larger blood vessels that enter through the cranial part.

3.3. Anatomy and physiology of digestive system and accessory organs

The digestive system extends from the mouth to the vent. The teeth, lips and gum are absent, instead they have strong beak for pickling of grains and food particles and to offend and defend. The upper beak (maxilla) is with sharp end. The lower beak is composed of two bones cranially fused and termed mandible.

a. Beak

- Excellent example of adaptation to diet
- Prepare food for swallowing
- Remove poorly digested portions (e.g. seed hulls, snail shells, bones)

b. Tongue

Is very thin and movable covered by horny epithelium. Has 3 primary roles

- Collecting food sticky tongue of woodpeckers, long thin tongue hummingbirds
- Manipulating food in mouth
- Swallowing – may have papilla to direct food items toward the back of the mouth. There is no soft palate and epiglottis

c. Esophagus

- Thin walled, highly folded tube, larger (long) than in mammals
- mucus glands
- Foods often in large pieces

- May serve as storage organ
- Has a diverticulum, which is called crop**.**

d. Crop (ingluvies)

It is variable in size and shape. The crop "milk" The crop functions as temporary storage of food (Storage enables birds to consume a large amount of food and process later).

e. Stomach is divided in to two parts:

I. **Proventriculus**:- Glandular, produces acids and enzymes

II. **Ventriculus**

- Muscular part of stomach (Gizzard)
- Powerful mechanical digestion occurs in the gizzard
- Grinds food into small particles (teeth)
- Large in herbivores
- Two pairs of muscles: thin and thick
- Koilin - protein lining color related to bile pigments
- Mechanical digestion
- Special digestive functions: Grit - small bits of stone retained in the gizzard

f. **Small intestine**

Is long tube almost with the same diameter up to the end. Duodenum forms a tight U shaped loop around the pancreas. Jejunum and ileum are continuous without demarcation. Jejunum forms loose coils along the edge of the mesentery and is so thin walled that appears greenish due to its content.

- Generally shorter than mammals
- Primary site for chemical digestion and absorption

g. Large intestine: - Comprises ceca and colon rectum and cloacae

- **Ceca: -** arise at the iliocolic junction (junction of ileum and colon) and accompany ileum to which they are attached by iliocecal folds (blind pouches at junction of small and large intestine).

Generally paired but may be rudimentary, single or absent. The wall of ceca contains lymphoid tissue, which is called **cecal tonsil.** Site for Fermentation and fiber digestion

- **Colon or rectum** is short (about 10 cm long) and ends by a slight enlargement at the cloacae (iliocecal junction to cloacae). It is important for Water balance. In general large intestine absorbs water and stores feces.
- **Cloacae**, which is common to the digestive and urogenital system, opens to the exterior at the vent. It is site for excretion, mineral and water balance. The vent is a horizontal slit and bears non protractible phallus on its internal surface. The phallus protrudes when they swell in response to sexual stimulation and form a groove that receives the ejaculate from the deferent duct. During insemination the vent is evested and the phallus pressed against the cloaca mucasa of the female. This is termed **cloaca kiss.**

Accessory glands of digestive system of poultry

- **Pancreas -** consists of 2-3 lobes located at the duodenal loop.
- **Liver** is well-developed **(**relatively large) dark reddish organ and located investing the heart. Gall bladder is well developed with paired bile duct. Gall bladder may or may not be present

- **Salivary glands**: - Lubricate food for swallowing, Larger in birds that eat dry foods, Amylase activity not significant, Other functions:

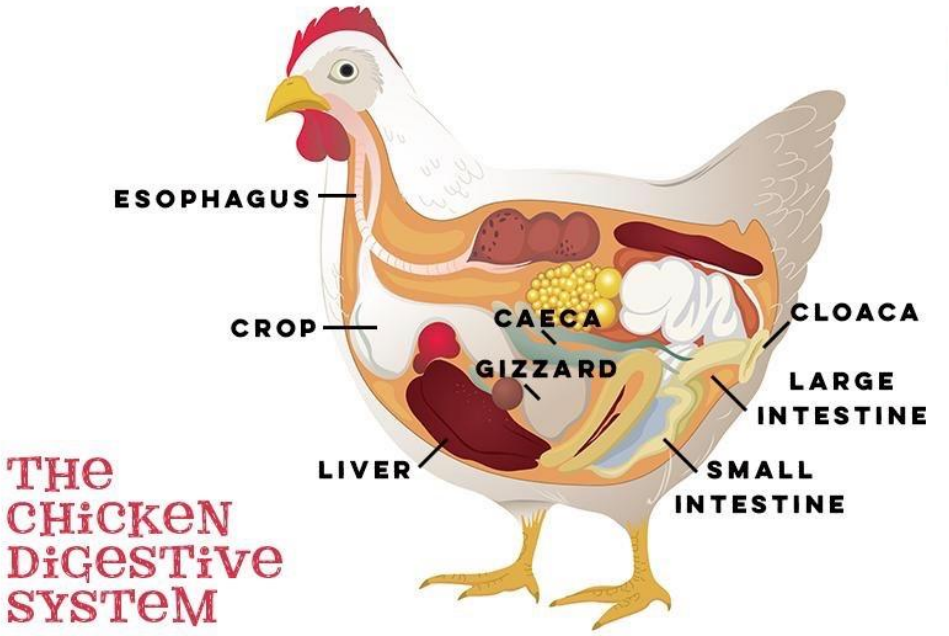


Figure 3.3:- avian digestive systems **source**: - https://www.slideshare.net/ramsawroop1/avian-digestive-system-243049403 Accessed on 28/08/2022

3.4. Anatomy and physiology of circulatory system

3.4.1. Circulatory system

Heart is located between and in front of the two lobes of the liver. The hart is large relative to body weight. The right AV valve is made of a single muscular flap unprovided with chordae tendineae. The left AV valve has 3 cusps, which are membranous and provided with chordae tendineae. The right ventricle envelops the left one.

3.4.2. Lymphatic system

Lymph vessels are fewer than in mammals. Lymph nodes are absent except in duck and goose where a pair of cervicothoracic nodes in the thoracic inlet and a pair of lumbar nodes close to the kidneys exists. Lymph nodules are found in all parenchymatous organs. Patches of

aggregate lymph nodules are found in oropharynx and cecum (cecal tonsil). Thymus consists of several separate lobs that accompany the jugular veins. It is best developed in the young and regresses with the onset of sexual maturity. The lobes are divided in to lobules each of which has distinct cortex & medulla. It has a decisive role in cellular immunity.

- **Cloacal bursa (fabricators bursa)** is 1-2 cm in diameter consisting loblated wall located dorsal to cloacae and the organ is typical to bird. It has decisive role in humeral immunity.
- **Spleen** is brownish red sphere located medial to the proventriculus. It contacts the liver cranioventrally. The distinction between red and white pulp is less marked.

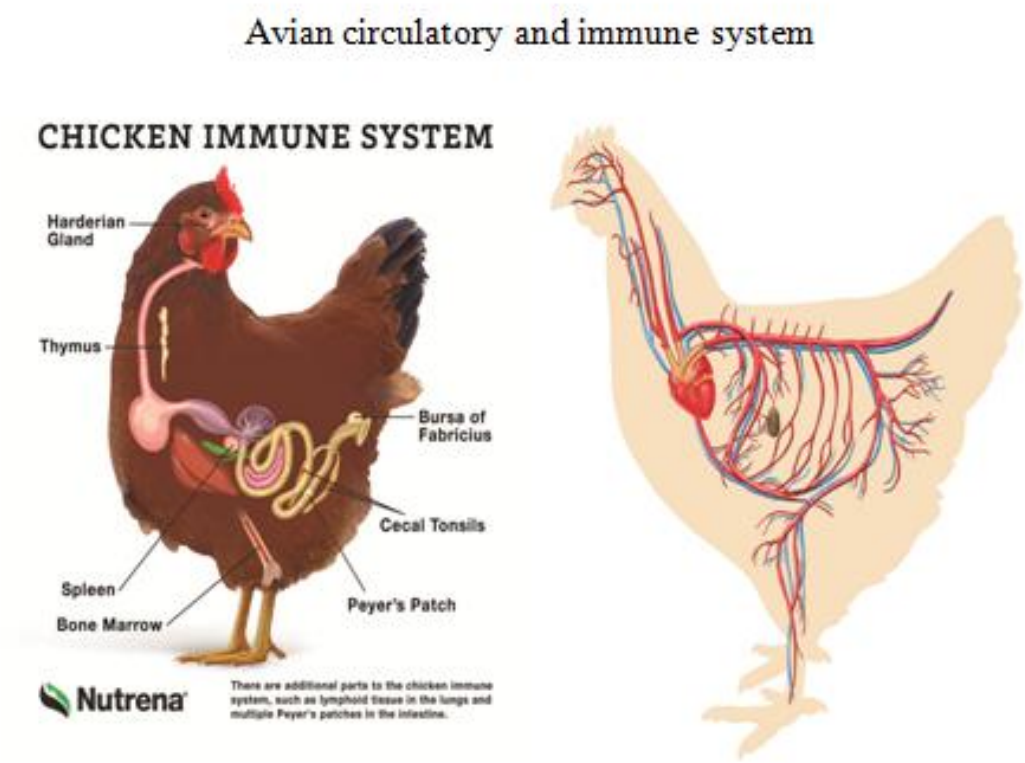


Figure 3.4:- Circulatory and immune system of avian Geese

3.5. Anatomy and physiology of uro-genital system

3.5.1. Urinary system

Kidneys are elongated paired organs located deep in the fossa renalis of the pelvis. It is composed of 3 lobes cranial, middle and caudal. The kidney is transfixed by arteries veins and sacral plexus. There is one ureter which has no renal pelvis per kidney there is no urinary bladder, the ureter opens directly in to the urodeum.

3.5.2. Genital system of avian

i. Male genital system

Testes are bean shaped

- White & about 5 cm long large during breeding season
- Yellow & reduced by half size from their size at non breeding season.

Two testicles are located internally at the level of cranial renal lobes. No spermatic cord and scrotum. Epididymis attached to dorsomedial border of the testis. Accessory sex glands are poorly developed. Ductus deferens is coiled and open at the cloacae. Copulatory apparatus consists of only folds of **cloaca mucosa (phallus)** at the vent.

ii. Female Genital Organ

At embryo stage there are symmetrical gonads and oviduct. In the adult the right one regress and only the left side remain functional. Rudiments of the right oviduct might persist in adults.

- **Ovary** resembles a bunch of grape containing several thousand follicles attached to the cranial pole of the kidney.
- The left **oviduct c**onsists of infundibulum, magnum, isthmus, uterus and vigina.
  - **a) Infundibulum** is a funnel shaped expanded part, which receive the egg and convey it to the magnum. Its glands secrete chalaziferous layer.
  - **b) Magnum** is highly coiled longest segment of the oviduct. Its mucosa bears folds and thickened by glands that secret albumin (about half of the total volume of albumin)

c) **Isthmus** is about 8cm demarcated from magnum by a narrow a glandular (translucent) zone. It has lower mucosal folds than magnum. Its glands secrete albumin and shell membrane.

- **Uterus (shell gland)** is thinner walled, about 8 cm slightly enlarged chamber. Its mucosal glands secrete shell.
- **Vagina** is a muscular S – shaped tube. Its junction from uterus is marked by a sphincter. It ends as a slit like opening in the lateral wall of urodeum. There are glandular crypts at the region of sphincter, which store sperm. One insemination is sufficient to fertilize the ova released during the following few days or so.

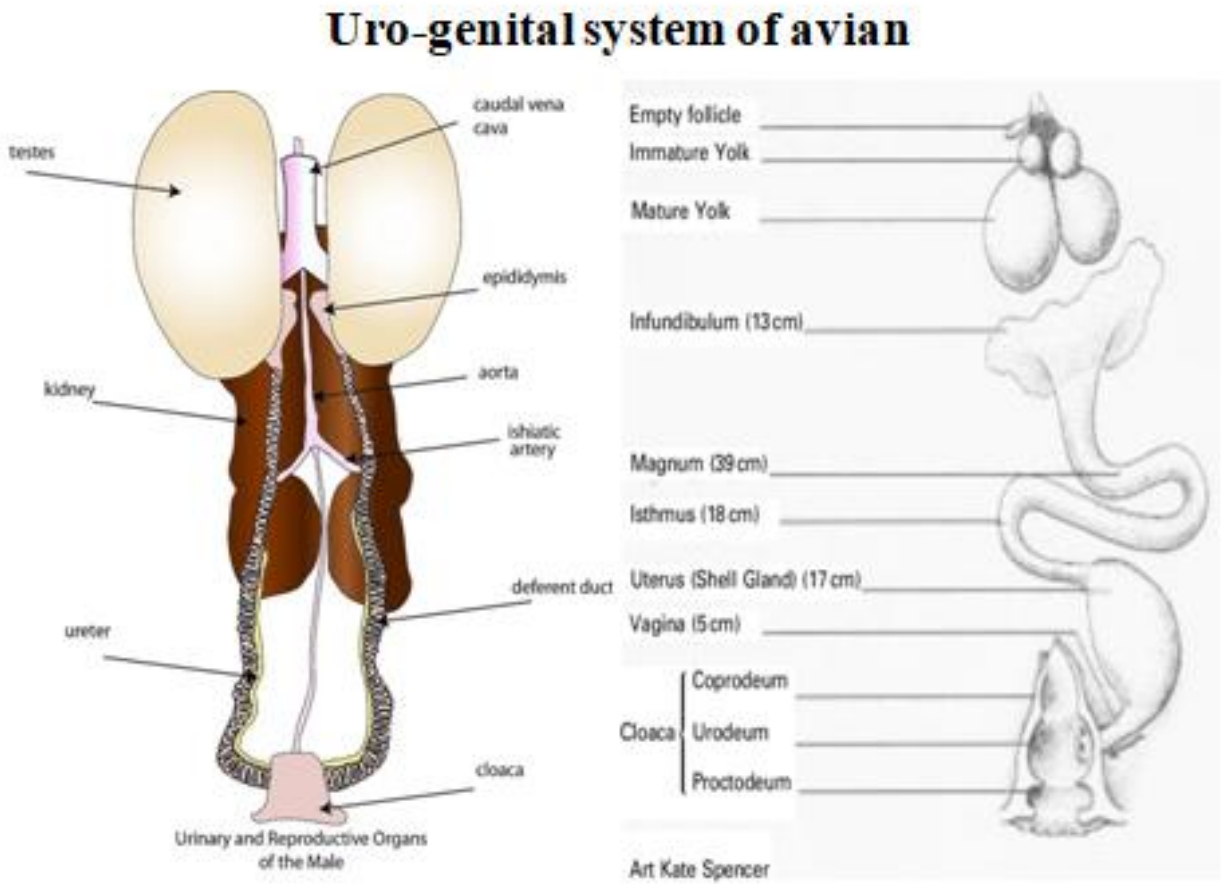


Figure 3.5:- Uro genital system of avian

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Self-Check – 3	Written test

Name_____ ID_____signature_____ date_____

Directions: Answer all the questions below according to the instruction

Test I: Multiple choice (1pt each)

a. Which one of the following is highly coiled and longest segment of the oviduct:

a) Isthmus
b) Magnum
c) Infundibulum
d) All of the above

2. One of the following is not true about pneumonic bone

a) Not completely hollow, has struts
b) Connected to respiratory system
c) Major bones of body pneumatic
d) None of the above

3. Which one is the shell gland of female reproductive organ of avian?

a) Uterus
b) Vagina
c) Ovary
d) All of the above

4. Which of the following lymph node is situated on the cloacae of birds.

a) Bursa fabricators
b) Submandibular node
c) Prescapular lymph node
d) Parotid lymph nodes

5. Of the following one is site for fermentation and fiber digestion.

a) Ceca
b) Colon
c) Cloacae d) none of the above

Test II: Short Answer Questions (2pts each)

1. What is the name of copulatory organ of male bird?
2. List down accessory glands of avian used for digestion?
3. Write down the vertebral formal for birds?

Note: Satisfactory rating - 8 points **Unsatisfactory - below 8 points**

You can ask you teacher for the copy of the correct answers.

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