9. ANATOMY AND PHYSIOLOGY OF LIVESTOCK

Can you recall ?

1. **Body structure of cow, buffalo, sheep and goat?**
2. **What are the different body systems?**

9.1 SKELETAL SYSTEM

The skeleton is composed of bones, cartilages and ligaments. Bones are the principal components of skeleton.

Do you know ?

- **Bones are living tissues as they can grow and are supplied with nerves and blood vessels.**
- **Bone is a mineralized connective tissue**

9.1.1 Structure of bones

1. Bones are composed of two types of substances –compact and spongy.

a. ***Compact bone :*** It is hard layer of bone that covers most bones and forms almost entire shaft of long bones.

b. ***Spongy bone :*** It is composed of small bony plates arranged to form a porous or spongy structure.

2. An outer surface of bone is covered by a fibrous membrane known as ***periosteum*** whereas thin membrane which lines the medullar cavity and various marrow spaces is known as ***endosteum***.

3. The cartilage which covers the articular surface of a bone is called as ***articular cartilage***.

4. A hollow cavity in the middle of long bone filled with bone marrow is called as ***medullary cavity***. Bone marrow is a soft pulpy tissue which feels marrow cavity of long bones and marrow spaces of all the bones.

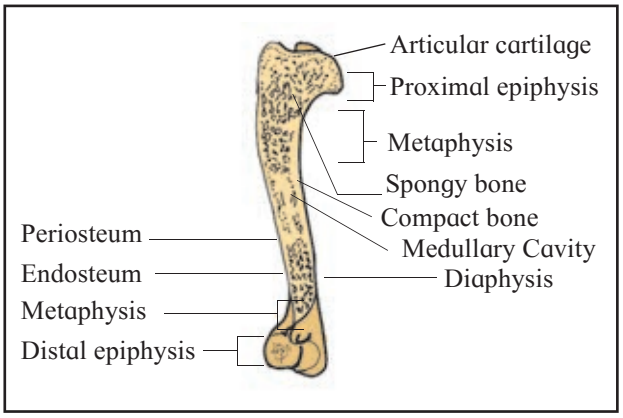


Fig. 9.1 Structure of Bone

9.1.2 Composition of bones

1. ***Fresh or wet bone*** is composed of water (25%), ash or mineral matter (45%) and organic matter (30%).
2. ***Dried bone*** consists of organic and inorganic matter in the ratio of 1: 2.
3. The ***organic matter*** mainly consists of collagen (major), mucopolysacharides, fatty acids, glyco-proteins, phospholipids (minor). The organic matter gives toughness and elasticity to bone.
4. The ***inorganic or mineral*** matter includes calcium, phosphorus, carbonates, citrates, sodium, potassium, magnesium, chlorides etc. The mineral matter gives hardness and rigidity to the bones.

9.1.3 Functions of bones

1. They give definite shape to the body.
2. They offer support to the body.

3. They help in locomotion.
4. They protect the vital organs such as brain, lungs and heart.
5. They provide minerals like calcium and phosphorus to the body.

9.1.4 Classification of bones

According to the gross appearance, the bones are classified into seven groups as long, short, flat, irregular, sesamoid, pneumatic and visceral.

Can you tell ?

1. **What are the different types of bones**
2. **Total number of bones in forelimb of cattle**
3. **In which species you will find pneumatic bones.**

1. Long bones

1. These are greater in length than any other dimension.
2. They contain marrow/medullary cavity.
3. They are located mostly in the region of the limbs.
4. ***Functions:*** They aid in support and locomotion.
5. Examples are Humerus, Radius-ulna, Metacarpal, Femur, Tibia-fibula, Metatarsal.

Do you know ?

- **Femur is the largest long bone in the animal body.**

Elongated bones - These are the diminutive forms of long bones. These are slender, long bones without medullary cavity. e.g. Ribs.

2. Short bones

1. These are small bones of uniform dimensions.
2. There do not contain marrow cavity.
3. They are mainly found in joints between two large bones.
4. **Function :** They increase the mobility of the joints and distribute pressure.
5. Examples are Carpal and Tarsal bones.

3. Flat bones

1. They are relatively thin and expanded in two dimensions.
2. **Functions :** They protect the vital organs and provide large area for muscle attachment.
3. Examples are Scapula and Pelvic bones.

Try this...

Enlist names of short and long bones

4. Irregular bones

1. These are irregular in shape.
2. They are generally unpaired and located on the median plane.
3. **Functions :** They serve for protection, support and muscle attachment.
4. Examples are Vertebrae.

5. Sesamoid bones

1. These are small, sesame seed like short bones.
2. These are placed between the bones and tendons.
3. ***Function :*** They work as pully to avoid friction.
4. Example is Patella.

Remember...

Patella is the largest sesamoid bone in the animal body.

6. Pneumatic bones

1. They contain air spaces or sinuses which communicate with the exterior.
2. The bones of bird are light in weight due to presence of air sacs.
3. Examples are long bones of birds.

Internet my friend

Search number of bones in different species of livestock

7. Visceral Skeleton

1. These are the bones developed in visceral organs.
2. They give support and rigidity to the organ.
3. Examples are os cardis (Heart of ox), os penis (Penis of dog) and os opticus (Eye of birds).

9.1.5 Skeleton

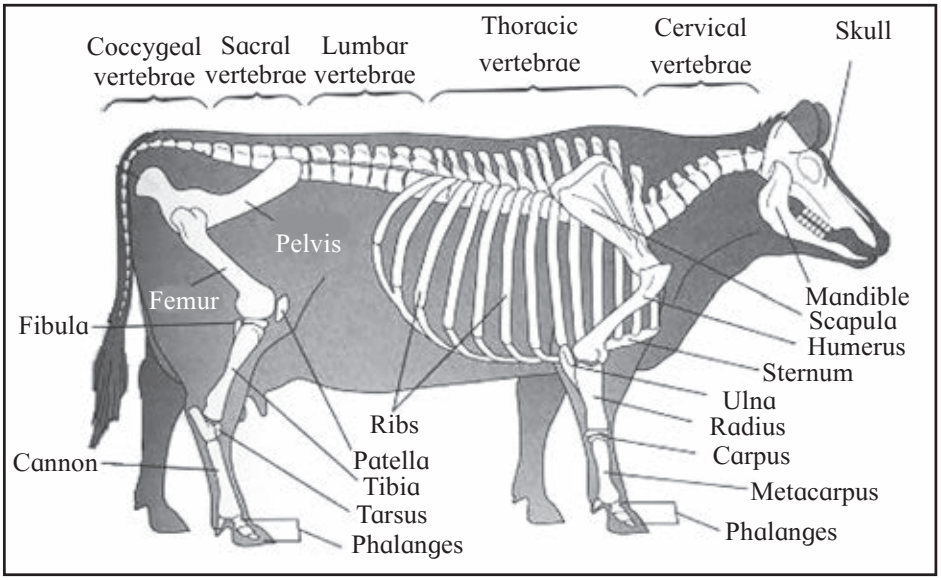
Skeleton can be defined as a hard framework of the body which supports soft structures.

The skeleton is divided into two parts as- axial and appendicular.

1. **Axial Skeleton:** It consists of bones of skull, vertebral column, ribs, and sternum.
2. **Appendicular Skeleton:** It consists of the bones of fore limbs and hind limbs.

Table 9.1 Bones - their location and classification.

Bone	Location	Classi-fication	No. in body
Appendicular Skeleton			
A) Forelimb/ Pectoral limb			
1) Scapula	Shoulder	Flat	2
2) Humerus	Arm	Long	2
3) Radius	Forearm	Long	2
4) Ulna		Long	2
5) Carpus	Knee joint	Short	12
6) Metacarpus	Manus	Long	4
7) Phalanges		Long	12
8) Sesamoids		Sesamoid	12
			48



9.2 Skeleton of Cow

B) Hind limb/			
Pelvic limb			
1) Pelvic bones	Rump/Hip	Flat	2
2) Femur	Thigh	Long	2
3) Patella	Stiflejoint	Sesamoid	2
4)Tibia- Fibula	Leg	Long	4
5) Tarsus	Hock joint	Short	10
6) Metatarsus	Pes	Long	4
7) Phalanges		Long	12
8) Sesamoids		Sesamoid	12
			48
Axial Skeleton			
1) Skull	Head	Flat	32
2) Cervical Vertebrae	Neck	Irregular	7
3) Thoracic Vertebrae	Chest	Irregular	13
4) Lumbar Vertebrae	Loin	Irregular	6
5) Sacral Vertebrae	Croup	Irregular	5
6) Coccygeal Vertebrae	Tail	Irregular	20
7) Ribs	Chest	Elongated	13 Pairs
8) Sternum	Floor of Chest	- - - -	1
			110
Visceral Skeleton			
Os cordis	Heart	Visceral bone	**2**
Total Number of bones in cattle			**208**

9.1.6 Joints

Joints are the structures formed by the union of two or more articular ends of the bones or cartilages.

Do you know ?

1. **The functions of joints**
2. **What are the different types of joints?**

Study of structure and functions of various joints is called as ***arthrology*** or ***syndesmology***.

Classification of Joints : On the basis of structure and degree of mobility, joints are classified into following three groups.

1. *Fibrous joints*

1. They do not contain joint cavity.
2. These are immovable joints.
3. The bones are united by fibrous tissues.
4. Example - Skull joints.

2. *Cartilagenous joints*

1. They do not contain joint cavity.
2. They permit limited movements.
3. The bones are united by cartilage.
4. Example - Pelvic symphysis.

3. *Synovial joints*

1. These are true joints.
2. These are movable joints.
3. These contains joint cavity or articular cavity.

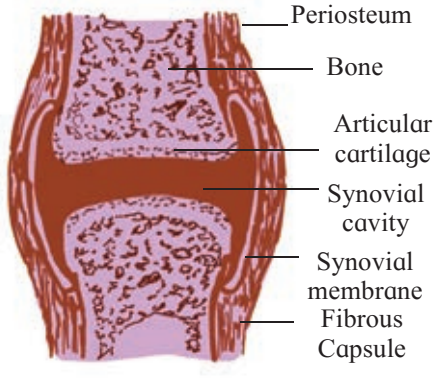


Fig. 9.3 Typical synovial joints

4. Joint cavity is surrounded by the *joint capsule* which consists of an external fibrous layer and internal synovial membrane.
5. The *synovial membrane* secretes a lubricant fluid known as *synovial fluid*.
6. The *articular cartilage* covers the surface of the bone over joint and lessens the concussion and friction.
7. Ligaments bind the bones. These are placed around the joints.
8. Examples : Knee joint, Hock joint.

Table 9.2 : Joints of forelimb and Hind limbs

Joint	Bones involved
Forelimb	
1. Shoulder joint	Scapula and humerus
2. Elbow joint	Humerus and radio-ulna
3. Knee joint	Radius-ulna, carpals and metacarpals
4. Fetlock joint	Metacarpal and first pair of phalanges
5. Pastern joint	First and second phalanx
6. Coffin joint	Second and third phalanx
Hindlimb	
1. Hip joint	Pelvic bone and femur
2. Stifle joint	Femur and tibia
3. Hock joint	Tibia, tarsal and metatarsal bones.
4. Fetlock joint	Metatarsal and first pair of phalanges.
5. Pastern joint	First and second phalanx
6. Coffin joint	Second and third phalanx.

9.2 CIRCULATORY SYSTEM

The circulatory system includes heart, blood vessels and blood.

9.2.1 Heart

Do you know ?
Heart is situated in the chest/ thoracic cavity between 3rd and 6th rib

1. The heart is a cone shaped, hollow, muscular organ having broad base and pointed apex.
2. It is reddish brown in colour and weighs about 2.23 kg i.e.0.4-0.5% of the body weight.
3. It is enclosed in membranous sac called **pericardium.**
4. The heart wall consists of three layers viz. ***epicardium*** (outer), ***myocardium*** (middle) and ***endocardium*** (inner).
5. The heart consists of 4 chambers i.e. two ***auricles*** (upper) and two ***ventricles*** (lower).
6. The two auricles are separated from one another by ***inter-auricular septum.***
7. The right auricle (RA) receives impure blood from the body through anterior and posterior vena cavae.

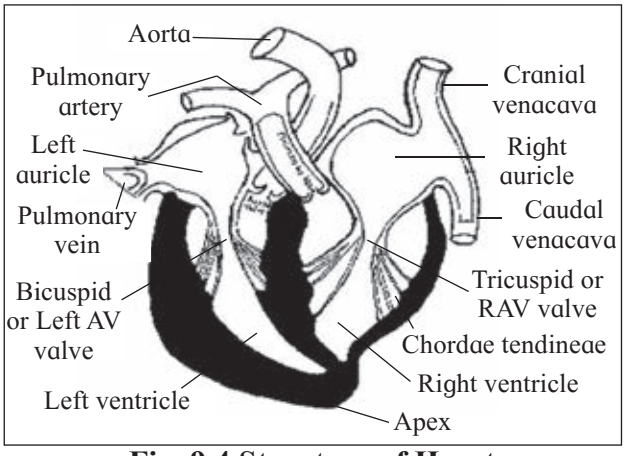


Fig. 9.4 Structure of Heart

8. The right auricle communicates with right ventricle (RV) through right auriculo - ventricular opening guarded by ***tricuspid valve.***

9. The left auricle receives pure blood from the lungs through right and left pulmonary veins.

10. The left auricle communicates with left ventricle through left auriculo-ventricular opening guarded by ***bicuspid or mitral valves.***

Internet my friend

- **Search number of chambers in heart of different livestock species.**
- **Heart beats in different species.**

11. The ventricles are thick walled and muscular.

12. The ventricles are separated from each other by ***inter-ventricular septum.***

13. Pulmonary artery originates from right ventricle which carries impure blood to the lungs for oxygenation.

14. The left ventricle discharges pure blood into aorta through aortic orifice guarded by **aortic valve.**

15. The free margins of bicuspid and tricuspid valves are indirectly attached to the ventricular wall by means of fibrous cords called as **chordae tendineae.**

Remember...

Pumping of blood is the main function of heart.

9.2.2 Blood Vessels

Blood vessels that carry blood away from the heart are called ***arteries*** while those which carry the blood towards the heart are called ***veins***. The fine blood vessels which connect arteries and veins are called **capillaries**.

Do you know ?

Aorta is the largest artery whereas Venacava is the largest vein.

9.2.3 Blood

Blood is defined as liquid connective tissue composed of blood cells and plasma.

Properties of blood

1. Blood is red in colour and viscous in nature.
2. The pH of blood is slightly alkaline i.e. 7.4.
3. Its average specific gravity is 1.043 in cattle.
4. Blood clotting time in cattle is 6.5 minutes.
5. The average blood volume in cattle is 7.7% of the total body weight.

Use your brain power !

Blood volume of different species.

Functions of Blood

1. Transport of nutrients from digestive tract to the tissues.
2. Transport of waste products from tissues to the organs of excretion.
3. Transport of O_2 from lungs to tissues.
4. Transport of CO_2 from tissues to lungs.
5. Transport of hormones from the site of production to the site of action.
6. Regulation of body temperature.
7. Maintenance of body pH i.e. acid - base balance.
8. Maintenance of water balance.
9. Protection of body from disease-producing organisms.
10. Its clotting ability prevents excess loss of blood from injuries.

Table 9.1 : Difference between Arteries and Veins

Arteries		Veins	
1)	They carry blood away from the heart.	1)	They carry blood towards the heart
2)	They carry pure blood except pulmonary artery	2)	They collect impure blood from various tissues except pulmonaryvein.
3)	The arterial blood is bright red in colour	3)	The venous blood is purplish red in in colour.
4)	They have thick, muscular and elastic wall.	4)	They have thin, less muscular and less elastic wall.
5)	They do not collapse when empty.	5)	They collapse when empty
6)	They donot have valves	6)	They have valves.
7)	They are pulsatile	7)	They are non-pulsatile
8)	Blood flow is rapid and under pressure	8)	Blood flow is slow and under low pressure
9)	They are always smaller than their respective veins	9)	They are always larger than their respective arteries
10)	They are deeply situated in the body i.e. well protected.	10)	They are generally superficial

Composition of blood

Do you know ?

Why the colour of blood is red?

Blood is composed of - (a) Plasma - 66% and (b) Blood cells - 34%

A. Plasma : It is fluid portion of the blood. It is straw coloured. It consists of 90 - 92 % water and 8 - 10 % other substances (solids). The other substances include inorganic matter and organic matter.

a. ***Organic constituents:*** They constitute about 7-9% of plasma.

1. Proteins (6-8%) : Albumin, Globulin, Fibrinogen and Prothrombin
2. Carbohydrates : Glucose, Fructose.
3. Lipids : Neutral fats, Triglycerides, Cholesterol, Phospholipids.
4. Non-Protein Nitrogenous Substances (NPN) : Urea, Uric acid, Creatinine, Ammonia.
5. Other Substances : Hormones, Enzymes, Vitamins, Pigments like bilirubin and carotene

b. ***Inorganic constituents :*** They form about 1% of plasma.These include calcium, phosphorus, magnesium,chlorides, bicarbonates, sulphates, phosphates, potassium, sodium, iron, iodine, copper, zinc etc.

B. Blood Cells : They are of three types-

1. Red blood cells
2. White blood cells
3. Platelets

1. Red Blood Cells (RBC)

1. They are also called as ***erythrocytes.***
2. They are red in colour due to ***haemoglobin.***
3. These are non-nucleated cells.
4. These are circular biconcave discs having thick margin and a thin centre.

5. They measure about 5 - 7 µ in diameter.
6. Their life span is 160 days in cattle.
7. The normal RBC count is 6 - 8 millions / µl of blood.
8. They are formed in the red bone marrow.
9. They are composed of water (65%) and solids (35%). The solid part constitutes haemoglobin (95%) and other substances like proteins, lipids (5%)
10. ***Function :*** They help in transport of respiratory gases i.e. O_2 and CO_2.

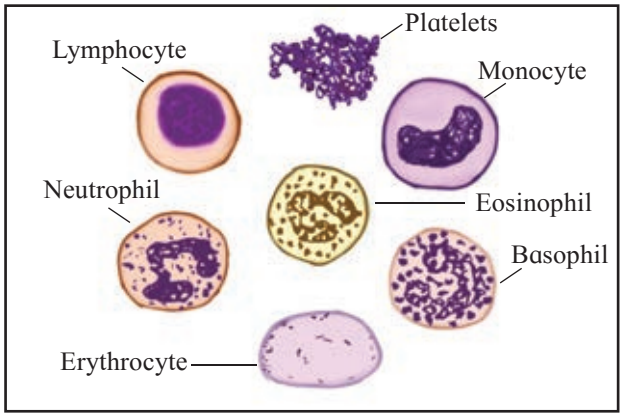


Fig. 9.5 Blood cells

Internet my friend

- **Life span of RBC's in different animal species.**

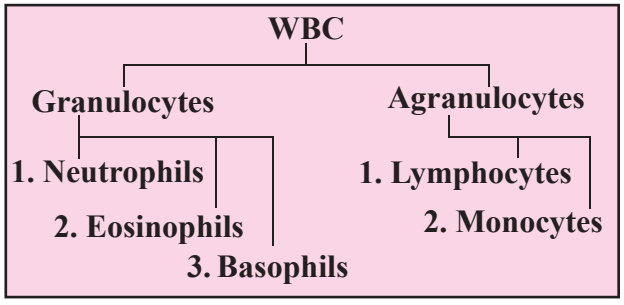
2. White Blood Cells (WBC)

1. These are also called as ***leucocytes.***
2. They are white in colour.
3. These are nucleated cells.
4. These are capable of independent movement.
5. They are circular in shape.
6. They are about 8 to 25 µ in diameter.
7. The life span varies from few hours to few years.
8. There are about 9-12 thousand / µ *l* of blood in healthy animal.
9. They are formed in bone marrow and lymphoid organs.
10. ***Function :*** These are involved in defense mechanism of body.

Do you know ?

Phagocytosis is the process of engulfing and destroying foreign material like microorganisms.

Classification of leucocytes (WBC):



These are classified as A) Granulocytes and B) Agranulocytes.

A. Granulocytes : They contain granules within the cytoplasm. On the basis of the shape of nuclei and staining reaction of their granules, they are classified as – Neutrophils, Eosinophils and Basophils.

B. Agranulocytes : They usually do not contain granules and their nuclei are non-lobulated. They are classified as Lymphocytes and Monocytes.

Remember...

Monocytes are the largest leucocytes.

3. Platelets

1. These are also called as ***thrombocytes.***
2. These are colourless and non-nucleated cells.
3. They are oval or irregular in shape.

4. These are the smallest blood cells and measure about 2-5 m in diameter.
5. Their life span is 8 - 11 days.
6. Their number varies from 3.5 to 5 lakhs / μl of blood.
7. They are formed in bone marrow.
8. ***Function :*** They help in clotting of blood.

Internet my friend !

- **In which disorders of human and livestock platelet count is lower than normal ?**

9.2.4 Blood circulation

The blood circulation in animals is carried out by two pathways-

A) Pulmonary circulation

B) Systemic circulation

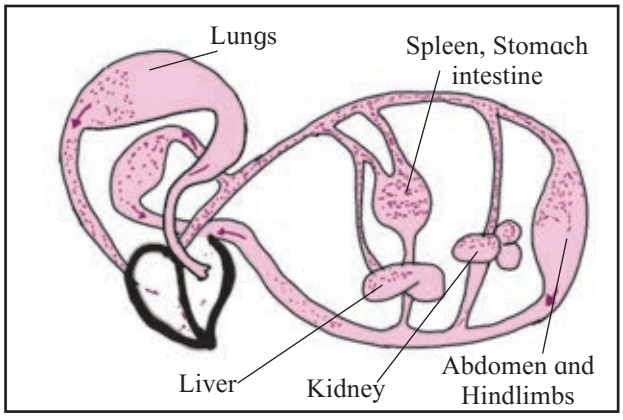


Fig. 9.6 Schematic diagram of blood circulation

A. ***Pulmonary circulation :*** It is that part of vascular system which circulates all the blood through the lungs. The impure or deoxygenated blood from right auricle passes through the right ventricle and from right ventricle to lungs for oxygenation via pulmonary arteries. The pulmonary veins bring oxygenated or pure blood from lungs to the left auricle of the heart.

B. ***Systemic circulation :*** It refers to the movement of oxygenated blood to all areas of the body and the subsequent return of deoxygenated blood to the heart. The pure or oxygenated blood from the left ventricle passes to all parts of the body through the aorta and its branches. The deoxygenated blood from different parts of the body is brought to the right auricle by the vena cavae and their branches.

Try this...

1. **Collect information about various blood groups in animals & human being.**

9.2.5 Lymphatic System

1. It serves as system for draining tissue fluid.

Can you tell ?

The functions of lymphatic system

2. It includes lymph, lymph vessels and lymphnodes.
3. **Lymph :** It is colourless tissue fluid drained by lymphatics.
4. **Lymph vessels :**These are the vessels which carry tissue fluid i.e. lymph to the blood stream.
5. **Lymph nodes :**. They are spherical, oval or bean shaped. Grey rosy structures of variable sizes. They serve as filters for the lymph and act as one of the first body defence against infection.

9.3 RESPIRATORY SYSTEM

Oxygen is a vital requirement of animals. An animal may survive for few days without water or for weeks without food but cannot survive for few minutes without oxygen. Supply of oxygen to blood and removal of carbon

dioxide from blood are the two important functions of respiratory system. In addition respiratory system also helps in the regulation of body temperature, pH of body fluid and voice production.

9.3.1 Respiratory organs

The respiratory system of cattle comprises of nasal cavity, pharynx, larynx, trachea, bronchi and lungs.

Can you recall ?

Differents parts /organs of respiratory system.

1. Nasal cavity

1. It is the first part of the respiratory passage which extends from exterior to pharynx.
2. It is cylindrical or tubular passage enclosed by facial bones and cartilages.
3. It is separated into two compartments by ***nasal septum.***
4. It opens externally by ***nostrils*** and internally by two ***posterior nares***.
5. It is located above the mouth cavity.
6. ***Functions :*** It is a passage for air. It gives sensation of smell.

2. Pharynx

1. It is funnel shaped musculo-membranous sac common for both digestive and respiratory system.
2. There are ***seven*** openings in pharynx viz. mouth (1), posterior nares (2), eustachian tubes (2), larynx (1) and oesophagus (1).
3. It is located just behind the mouth cavity.
4. ***Function :*** It is common passage for food, water and air.

3. Larynx

Remember...

Larynx is also known as 'Sound box' *or* 'Voice box'.

1. It is elongated cartilaginous structure.
2. It is made up of five cartilages namely ***epiglottis (1), cricoid (1), thyroid (1) and arytenoids (2).***
3. There are vocal cords on internal surface of the wall of the larynx.
4. It is located between pharynx and trachea.
5. **Functions :** It regulates the air flow to and from the lungs. *Epiglottis* prevents inhalation of foreign bodies.

Remember...

The vocal cords produce voice (phonation).

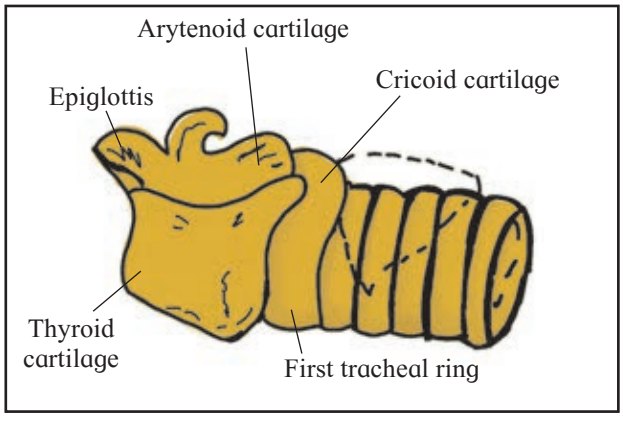


Fig. 9.7 Larynx of Cattle

4. Trachea

Do you know ?

Trachea is also known as **'Wind Pipe'**

1. It is cartilagenous tube which extends from larynx to lungs.
2. It is made up of 50 - 60 incomplete 'C' shaped cartilagenous rings.

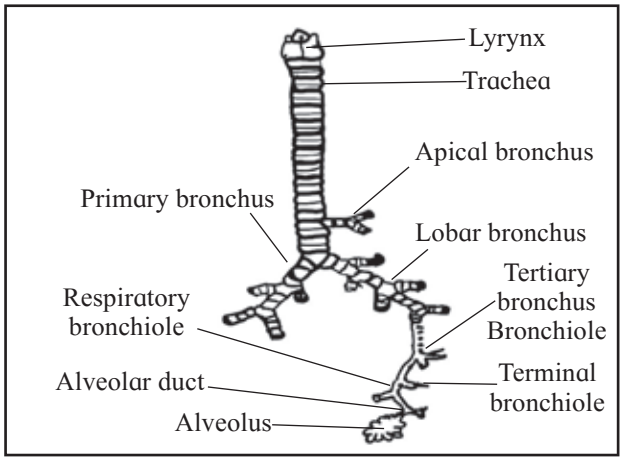


Fig 9.8 Trachea & branches of bronchi

3. It is located on the ventral side of neck and passes into thoracic cavity and divides into bronchi.
4. **Functions :** It is a passage for air. It filters the air, removes dirt and dust. It secretes mucin which moistens the dry air.

5. Bronchi

1. The trachea is divided into three bronchi in cattle viz. ***- left, right*** and ***apical.***
2. The right branch supplies to right lobes, left to left lobes and apical to the right apical lobe of lung.
3. Each bronchus divides and subdivides into small fine tubes as primary, secondary and tertiary bronchi.
4. The tertiary bronchi divides into minute ***bronchioles.***
5. The bronchioles ends into minute compartments known as ***alveoli.***
6. ***Function :*** It is passage for air.

6. Lungs

1. They are two in number i.e. left and right.
2. They are enclosed in a serous membrane called ***pleura.***
3. They are soft, spongy and highly elastic.

Do you know ?

- **Lungs are the main organs of respiration.**
- **Alveolus is the structural and functional unit of lungs.**

4. They are brownish grey in colour, conical in shape and light in weight.
5. They crepitate on pressure and floats on water.

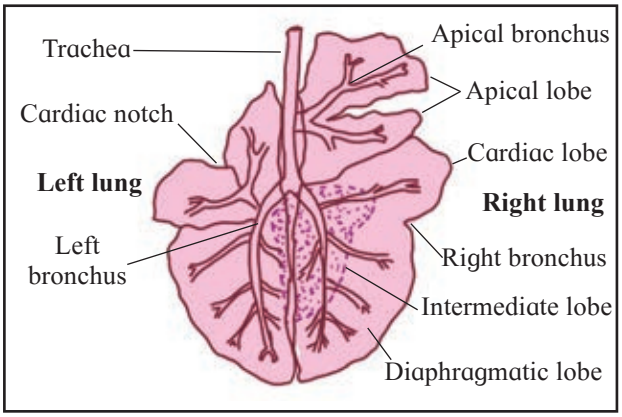


Fig. 9.9 Lungs of cattle

6. Right lung is larger than the left and average weight is 3.5kg.
7. Right lung consists of 4 lobes namely apical, cardiac, intermediate and diaphragmatic.
8. Left lung is divided into 3 lobes namely apical, cardiac and diaphragmatic.
9. Cardiac notch is larger in left lung than in right one.
10. *Functions :*
    i. The main function of lung is exchange of gases. viz. supply of oxygen to blood and removal of carbon dioxide from blood.
    ii. It also helps in regulation of body temperature by eliminating heat through breath.
    iii. It helps in elimination of water.

Remember...

Lungs are located in thoracic cavity

Internet my friend

Find the difference between human and cattle lungs.

9.3.2 Mechanism of Respiration

Respiration is defined as exchange of gases between the organism and the environment. It includes breathing and external, internal as well as cellular respiration.

1. **Breathing :** It involves inspiration and expiration. During inspiration, air rich in oxygen is taken into lungs, whereas during expiration air containing more carbon di-oxide and water vapours is given out of the lungs.

   a) **Inspiration :** It means inflow of air into lungs. It results whenever the volume of thorax is increased. During inspiration, intercostal muscles contracts and draw ribs forward and outward. This increases the volume of the thoracic cavity. It leads to lowering of air pressure in the lungs and thereby air gets entry into lungs.

Do you know ?

Diaphragm is muscular, dome shaped partition between the thoracic and abdominal cavities. It is the chief inspiratory muscle.

   b) **Expiration :** It means outflow of air from lungs. It results whenever the volume of thorax is decreased. The decrease in volume of thorax is largely passive because of the tendency of elastic structures like intercostal muscles, diaphragm, lungs and abdominal wall. The decrease in volume results in contraction of lungs which results in outflow of air from lungs.

2. ***External respiration :*** This constitutes movement of O_2 from the alveolar air into the blood and release of CO_2 from the blood into the alveolar air.

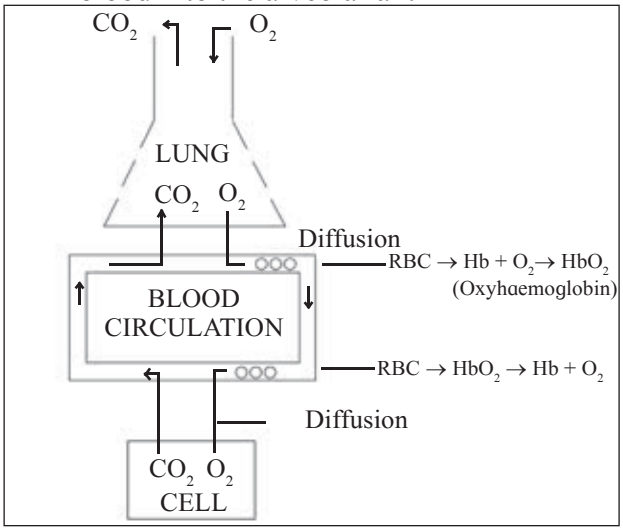


Fig. 9.10 Mechanism of Respiration

3. **Internal respiration :** This involves transfer of O_2 from the blood to the tissues and CO_2 from tissues to the blood.

4. **Cellular Respiration :** During the process of oxidation of glucose in tissues, CO_2, water and energy is produced. The CO_2 and water vapour thus produced are transported by blood to the lungs for expulsion.

Internet my friend

Respiration rate in difference livestock species.

9.4 DIGESTIVE SYSTEM

Can you tell ?

1. **Different organs of digestive system in ruminants**
2. **Differentiate between ruminants and non-ruminants system.**

The primary functions of digestive system are prehension, mastication, digestion and absorption of food and elimination of faeces. The digestive system converts the major nutrients viz. carbohydrates, proteins and lipids of food to their simplest form. These simple form of nutrients are then absorbed and utilized by the body for energy production and building other compounds to be incorporated into body tissues.

The digestive system is composed of alimentary canal and its accessory glands.

9.4.1 Organs of Alimentary Canal

The alimentary canal consists of mouth cavity, pharynx, oesophagus, stomach, small and large intestines. The accessory glands include salivary glands, liver and pancreas.

1. Mouth cavity /oral cavity

1. It is an elongated cavity which consists of lips, cheeks, palate, tongue and teeth.
2. Lips are thick musculo-membranous structures externally lined by skin which are situated at the opening of mouth. They close the mouth cavity anteriorly.
3. Cheeks are muscular structures externally covered by skin and forms lateral wall of mouth cavity.

Use your brain power !

Number of teeth in different adult animal species and human being.

4. Palate is divided into-hard palate (anterior) and soft palate (posterior).
5. Hard palate is comprised of dense connective tissue, internally lined by mucous membrane and attached to the bony plate. It forms roof of mouth cavity.
6. Soft palate is musculo-membranous mass present behind hard palate in the roof of mouth cavity which acts as a partition between the mouth and pharynx.
7. Teeth are hard, dense whitish structures embedded in gum and project into mouth. They help in chewing of food material. There are four types of teeth namely incisors (front teeth), canines (corner teeth), premolars and molars.
8. Tongue is muscular organ situated on the floor of mouth cavity. It is the chief organ of prehension and taste of food in cattle.
9. Gums/gingiva is composed of thick layer of dense layer of fibrous tissue in which teeth are embedded.
10. **Functions** : The mouth cavity helps in taking food into the mouth, chewing and mixing of food with saliva, swallowing of food, and rumination.

Remember...

Incisors are absent in upper jaw and canines are absent in either jaw in ruminants.

2. Pharynx

1. It is conical or funnel shaped musulo-membranous sac.
2. It is common cavity for both digestive and respiratory system.
3. It is located just behind mouth cavity.
4. There are seven openings in pharynx viz. Mouth cavity (1) , posterior nares (1), Eustachian tubes (2) ,Oesophagus (2) and Larynx (1).
5. ***Function*** **:** It is a common passage for food, water and air.

3. Oesophagus

1. It is a musculo-membranous tube extending from pharynx to the stomach.
2. ***Function :*** It is a passage for food.

4. Ruminant Stomach

1. It is also called as ***compound stomach.***

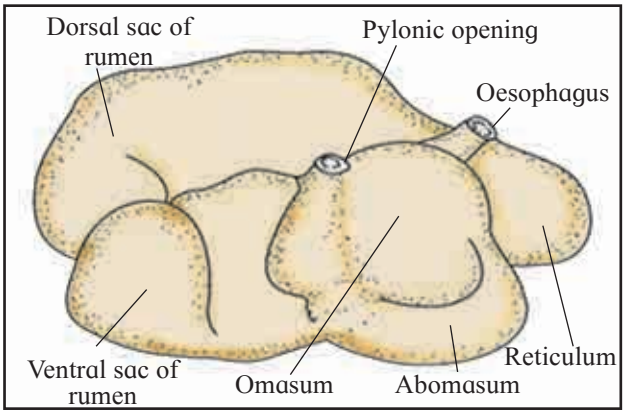


Fig. 9.11 : Ruminant stomach

2. It is made up of four compartments viz. rumen, reticulum, omasum and abomasum .
3. The first 3 compartments are collectively called as ***forestomach*** while the fourth compartment, abomasum, is called as ***true stomach.***
4. The average capacity of the stomach in adult cattle ranges from 100 - 230 liters depending upon the size of animal.

Do you know ?

Different parts of ruminant stomach.

Remember...

Rumen is the largest fermentation chamber of ruminant stomach.

The pH of rumen fluid is 6.4 to 7

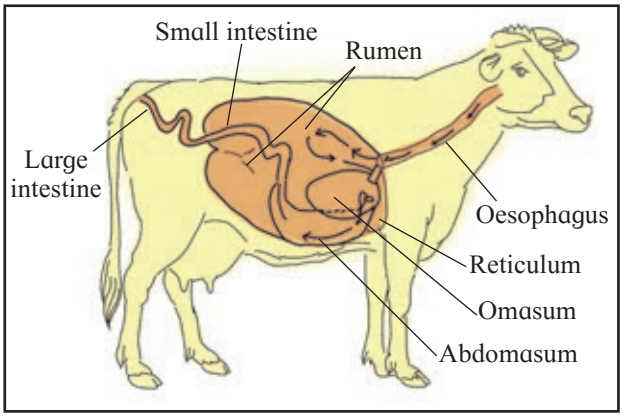


Fig. 9.12 : Digestive system of ruminants

a) Rumen

1. It is the first and the largest compartment of ruminant stomach.
2. It forms about 70-80% portion of ruminant stomach.
3. It is located in the left side of abdominal cavity from diaphragm to pelvis.
4. The rumen is subdivided into dorsal and ventral sacs by muscular pillars.
5. It is ***turkish towel*** like in appearance on its inner side.
6. It communicates with oesphagus and reticulum by means of cardiac

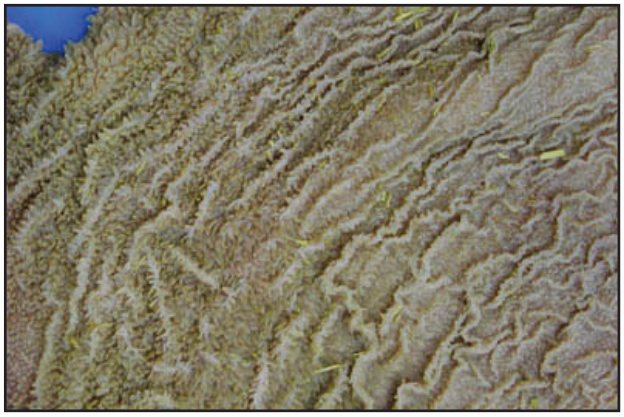


Fig. 9.13 Internal structure of Rumen

Can you tell ?

1. The function of reticulum.

2. True stomach in ruminants.

and rumino-reticular openings, respectively.

7. ***Functions :*** It stores food and helps in churning and proper mixing of ingesta (food). It helps in microbial digestion of proteins, fats and carbohydrates, synthesis of vitamins of B-complex, absorption of volatile fatty acids and expulsion of gases like CO_2 and methane.

b) Reticulum

1. It is the second and smallest compartment of ruminant stomach.
2. It forms approximately 5% portion of stomach.
3. It has ***honeycomb*** like structure on its inner side.

Fig. 9.14 Internal structure of Reticulum

4. It is located behind diaphragm and opposite to heart.
5. It communicates with rumen and omasum by rumino-reticular and reticulo-omasal orifices, respectively.
6. ***Functions :*** It acts as a filter for food material and helps in regurgitation of food while rumination.

3) Omasum

1. It is third compartment of ruminant stomach.
2. It is spherical or elliptical in shape.

Fig.9.15 Internal structure of Omasum

3. It forms approximately 7-8% portion of ruminant stomach.
4. It is located on right side of the abdominal cavity just behind reticulum.
5. It contains 100 folds in its inner side called ***'laminae'.***
6. It communicates anteriorly with reticulum and posteriorly with abomasum by means of reticulo-omasal and omaso-abomasal orifices, respectively.
7. ***Functions :*** It removes about 50% of water from ingested food material and also grinds coarse food particles. It absorbs volatile fatty acids.

4) Abomasum

1. It is fourth compartment of ruminant stomach.
2. It is elongated, saccular in shape.
3. It forms approximately 7-8% portion of ruminant stomach.
4. It is situated on the floor of abdominal

Remember...

Abomasum is called as *true stomach* of ruminants as it resembles the simple stomach in form and structure.

cavity, ventral to the omasum on right side of the rumen.

5. The anterior part of abomasum is known as ***'fundus'*** while the terminal part is known as ***'pylorus'.***

6. There are about 12 oblique folds in its inner side.

7. It communicates anteriorly with omasum and posteriorly with duodenum by means of omaso-abomasal and pyloric openings, respectively.

8. ***Functions :*** It helps in digestion of microbial proteins and absorption of volatile fatty acids to some extent. It secretes gastric juice which contains hydrochloric acid and enzymes like *pepsin* and *rennin*.

Use your brain power

Why ruminants digest more cellulose than non ruminants?

5. Small intestine

1. It extends from abomasum to caecum.

2. Its average length is about 50-52 meters and diameter is 5-6 cm in cattle.

3. The innermost lining of small intestine has long finger like projections called ***villi.***

4. The villi increases the surface area for absorption of food nurients.

5. It is divided into 3 parts viz. duodenum, jejunum and ileum.

6. ***Duodenum :*** It is the first part of small intestine located in sublumbar region. It forms 'S' shaped loop and is approximately 1 metre in length. The bile and pancreatic ducts open into duodenum.

7. ***Jejunum :*** It is indistinctly separated from duodenum and is located on the floor of abdominal cavity on right side. It is approximately 48-50 meters in length (longest)

8. ***Ileum :*** It is the terminal part of small intestine extends up to ileo-caecal junction. It is approximately 1 meter in length.

9. ***Functions :*** It secretes digestive juices. It helps in digestion and absorption of food .

6. Large intestine

1. It extends from ileum to the anus.

2. It is about 11 - 12 meters in length.

3. Its diameter varies from 5-15 cm.

4. Villi are absent.

5. It is divided into 3 parts viz. caecum, colon and rectum.

6. ***Caecum :*** It is a blind sac situated between ileum and the large colon. It is located on right side of the abdominal cavity. It is about 0.8 meter in length and 5″ in diameter.

7. ***Colon :*** It is the second portion of large intestine which is located on the right dorsal part of the abdomen. It is arranged in coils and is approximately 10 meters in length and 5″ in diameter.

8. ***Rectum :*** It is the terminal part of large intestine located in the pelvic cavity. It is little less than 30 cm in length. Its wall is more thick and dilated than caecum and colon. It is closed posteriorly by sphincter muscles called ***anal sphincter.***

9. ***Functions :*** It helps in microbial digestion and absorption of food nutrients to some extent. It helps in

absorption of water from ingesta and stores food residue temporarily in rectum.

9.4.2 Accessory glands

Accessory glands of digestive system include salivary glands, pancreas and liver.

1. Salivary Glands

1. They include parotid, mandibular and sublingual glands.
2. ***Parotid glands :*** These are paired, triangular, and reddish brown glands situated at the base of ear.The secretion of these glands is carried by ***stenson's duct*** into mouth cavity.
3. ***Mandibular or Submaxillary glands:*** These are paired, elongated, pale yellow, lobulated glands situated along the medial border of the angle of mandible. They open on the floor of mandible as mandibular or submaxillary duct.
4. ***Sublingual glands :*** These are two glands situated under tongue. Their secretions are transported to mouth cavity by small ducts.
5. ***Functions:*** They secrete saliva which acts as lubricant and helps in chewing and swallowing of food. Saliva maintains pH and fluidity of ruminal contents. The saliva of domestic animals contains little or no amylase.

Do you know ?

An adult cattle may secrete up to 200 liters of saliva per day.

2. Pancreas

1. It is flat and irregularly quadrilateral in shape.
2. It is located in the duodenal loop.
3. It is reddish yellow in colour and weighs about 300-500 gm.
4. ***Pancreatic duct*** carries secretion of pancreas to duodenum

Remember...

Pancreas is *endocrine* as well as *exocrine* gland

5. ***Functions :*** The endocrine portion contains ***Islets of Langerhans*** which produces hormones like ***insulin*** and ***glucagon.*** The exocrine portion secretes ***pancreatic juice.*** The pancreatic juice contains three digestive enzymes namely trypsin, lipase and amylase which helps in digestion of proteins, fats and carbohydrates respectively.

3. Liver

Do you know ?

Liver is the largest gland in the body.

1. It is situated on right side of the abdominal cavity near diaphragm.
2. It is irregularly rectangular with rounded corners.
3. It is reddish brown in colour, soft and pliable.
4. It weighs about 3 - 5 kg in adult animals and consists of a body and two small lobes.
5. A pear shaped sac attached to liver is called as ***gall bladder*** which stores ***bile*** and ***bile duct*** carries bile from gall bladder to duodenum.

Internet my friend

Search in which animal species gall bladder is absent.

Functions

1. It secretes bile which helps in emulsification and absorption of fats.
2. It helps in synthesis of plasma and tissue proteins.
3. It converts highly toxic ammonium salts into less toxic urea.
4. It helps in the synthesis and storage of glycogen.
5. It helps in the synthesis of fats from fatty acids and glycerols.
6. It stores minerals like Fe, Cu and Co.
7. It detoxifies toxins present in blood circulation.
8. It stores fat soluble vitamins like Vit. A, D. E & K.

9.4.3 Ruminant Digestion

Remember...

Digestion is the process of conversion of complex food material into its simpler form.

The organ wise process of digestion of food material and absorption of food nutrients in ruminants is as follows.

1. **Mouth :** The feed is taken up by the animal with the help of tongue and lips and is partially chewed and swallowed. The swallowed food reaches rumen. Animal during rest brings back the food into mouth by regurgitation. In mouth this food is again chewed and swallowed. This process is called as ***rumination*** which is the typical feature of ruminant animals. After rumination, food reaches the rumen where major digestion takes place.
2. **Ruminant stomach :** In rumen, the carbohydrate components of the diet like cellulose, hemicellulose, starches, sugars are converted to volatile fatty acids i.e. ***Acetic acid, Propionic acid and Butyric acid*** along with production of gases viz. methane and carbon dioxide. These volatile fatty acids are absorbed through ruminal wall and the gases are eructed through mouth during rumination.

The feed proteins are hydrolysed to amino acids and peptides by the proteolytic enzymes produced by ruminal microbes, while small portion of dietary proteins escape ruminal action which are called as ***bypass proteins***. Some amount of amino acids formed are used by microbes for their body protein synthesis. The remaining amino acids are then deaminated to produce ammonia, CO_2 and short chain fatty acids. Further the non protein nitrogenous(NPN) substances from the food are also converted to ammonia in rumen. The ammonia thus formed in the rumen is mostly utilized by rumen micro-organisms to synthesize their body proteins.

Fats/Triglycerides are converted to glycerol and galactose which are then converted to volatile fatty acids (VFA) by microbial enzymes.

The heavier food components settles down in the reticulum, thus reticulum acts as a filter for food material. The food then reaches the omasum where about 50% of water from food material is removed. The omasum also helps in fine grinding of food material.

The food then reaches abomasum where the gastric juice containing hydrochloric acid, mucin and enzymes (pepsin, rennin and lipase) acts on food and helps in digestion.

a. ***Hydrochloric acid*** provides suitable pH for enzymatic action of pepsin.

b. ***Rennin*** is present only in calves and which coagulates milk proteins.

c. ***Pepsin*** hydrolyses small amount of microbial body proteins and bypass dietary proteins into peptones / polypeptides.

3. Small intestine : The partially digested food then reaches to small intestine where the action of bile, pancreatic juice and intestinal juice complete the remaining digestion.

The bile salts help in the emulsification of the fats.

The pancreatic juice contains three enzymes namely ***trypsin, lipase and amylopsin*** which helps in digestion of microbial proteins, fats and carbohydrates.

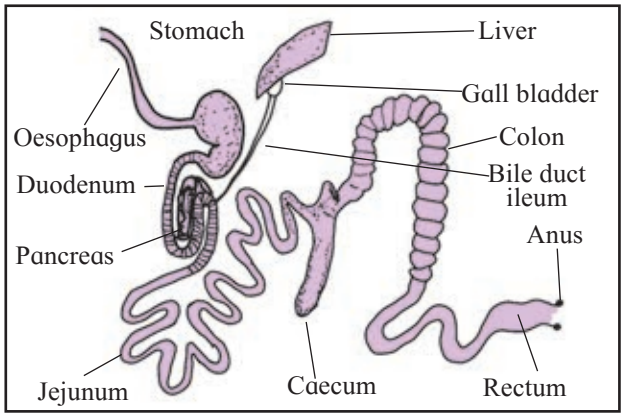


Fig. 9.16 Digestive system of non ruminants

Table 9.4 : Difference between ruminants and non – ruminant animals

	Ruminants		Non-ruminants
1.	They possess ruminant or compound stomach.	1.	They possess simple stomach
2.	Stomach is four chambered	2.	Stomach is single chambered
3.	Capacity of stomach is high	3.	Capacity of stomach is less
4.	Rumination takes place	4.	No rumination
5.	They ingest large quantity of feed	5.	They ingest small quantity of food
6.	Microbial digestion is major	6.	Microbial digestion is minor
7.	Enzymatic digestion is minor	7.	Enzymatic digestion is major
8.	Maximum digestion of feed takes place in rumen.	8.	Maximum digestion of food takes place in intestine.
9.	They can synthesize high quality proteins with the help of rumen microbes.	9.	They can not
10.	They can utilise non-protein nitrogenous (NPN) substances for protein synthesis.	10.	They can not
11.	They can digest cellulose.	11.	They can not
12.	End product of carbohydrate digestion is volatile fatty acids (VFA)	12.	End product is glucose
13.	Major carbohydrate digestion takeplace in rumen	13.	Carbohydrate digestion takes place in intestine.
14.	Major lipid digestion takes place in rumen	14.	Lipid digestion takes place in intestine.
15.	***e.g.***: Cattle, Buffalo, Sheep, Goat.	15.	***e.g.:*** Dog, Pig, Man, Horse.

The intestinal juice contains enzymes like ***enterokinase, peptidase and invertase*** which helps in digestion of amino acids and diasaccharides

The end products of nutrient digestion are then absorbed through villi of small intestine into blood and lymph circulation.

4. **Large intestine :** The digested but unabsorbed food components and water are absorbed through large intestine. While the undigested and unabsorbed portion mixes with the mucous secreted by large intestine and also with the glycerols and soluble soaps to form ***faeces.*** The peristaltic movement of large intestine expels out the faeces through anus via rectum.

9.5 URINARY SYSTEM

Metabolic activities taking place in the animal body produce a variety of waste products such as nitrogenous substances and carbon dioxide. These waste products are not only useless but also toxic and their accumulation in the animal body is harmful. These toxic nitrogenous substances are eliminated by the urinary system.

Can you tell ?

Which are the nitrogenous waste products excreted through urine in cattle ?

Excretion means elimination of liquid metabolic waste from the animal body.

9.5.1 Organs of Urinary System

The urinary system of cattle consists of two kidneys, two ureters , an urinary bladder and an urethra.

1. Kidneys

Remember...

Kidneys are the main excretory organs, although liver, lungs and skin serve as part time workers in the process.

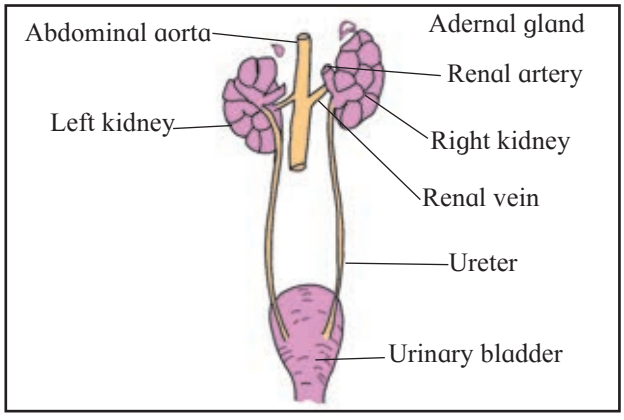


Fig. 9.17 Urinary system of cattle

1. They are two in number i.e. right and left.
2. They are situated on dorsal aspect of abdominal cavity just below lumbar vertebrae.
3. They are oval to elliptical in shape and dark brown in colour.
4. They possess 20-25 lobes in cattle.
5. They weigh about 600-700 gms .Left kidney is heavier than right.
6. The right kidney is ***fixed*** in position while left one is ***floating*** or movable.
7. Kidneys are covered by thin fibrous membrane called as ***renal capsule.***
8. The outer portion of kidney is called as ***cortex*** which is dark brown in colour.
9. The inner portion of kidney is called as ***medulla*** which is pale yellow or light brown in colour.
10. The kidneys are made up of large number of ***nephrons***.

Functions

1. The main function of kidney is formation of urine.
2. They excrete nitrogenous waste products.
3. They maintain the normal pH of body fluids.
4. They help to maintain the water balance of the body.
5. They eliminate drugs and various toxic substances from the body.
6. They help to maintain the osmotic pressure in blood and tissues.
7. They help in the maintenance of electrolyte balance.

Internet my friend

Composition of urine of indigenous and cross breed cow.

2. Ureter

1. These are two (i.e. right and left) excretory ducts extend from kidneys to urinarybladder.
2. They are 50-60 cm in length and 6-8 mm in diameter.
3. ***Function :*** They carry urine from the kidneys to urinary bladder.

3. Urinary bladder

1. It is a hollow, muscular oval sac.
2. It is situated on the floor of the pelvic cavity.
3. It conists of a vertex, body and neck.
4. ***Function :*** It stores urine.

4. Urethra

1. It is a single musculo-membranous tube.
2. It extends from neck of the bladder to tip of glans penis in male and up to vagina in female.
3. Female urethra is shorter than male urethra.
4. ***Functions:*** It acts as a passage for urine in female and for the urine and semen in male.

9.5.2 Structure of Nephron

Kidneys are made up of large number of nephrons. Each nephron consists of glomerulus, Bowman's capsule, proximal convoluted tubule, Loop of Henle and distal convoluted tubule

Use your brain power

Which is the structural and functional unit of kidney ?

1. **Glomerulus** : It is the network of capillaries formed on the course of an arteriole.
2. **Bowman's capsule :** It is an expanded blind end of proximal convoluted tubule which almost entirely surrounds glomerulus.

   The complex of glomerulus and Bowman's capsule is called as ***Malpighian corpuscle*** or ***renal corpuscle***.
3. **Proximal Convoluted Tubule (PCT):** It is connected directly with outer layer of the glomerular capsule. It is the longest and most winding portion of nephron. It forms much of the tissue of renal cortex. It reabsorbs most of the constituents of glomerular filtrate.
4. **Henle's loop** : It is located between the proximal and distal convoluted tubule. It is U-shaped. It reabsorbs Na^+, Cl^- and water.
5. **Distal Convoluted Tubule (DCT)** : It is shorter and less twisted than proximal convoluted tubule. It extends from the termination of ascending limb of Henle's loop to the collecting tubule. It secretes few substances like potassium ions, dyes etc. in urine.

6. **Collecting Tubule :** The DCT opens in collecting tubule which in turn opens in the renal pelvis.

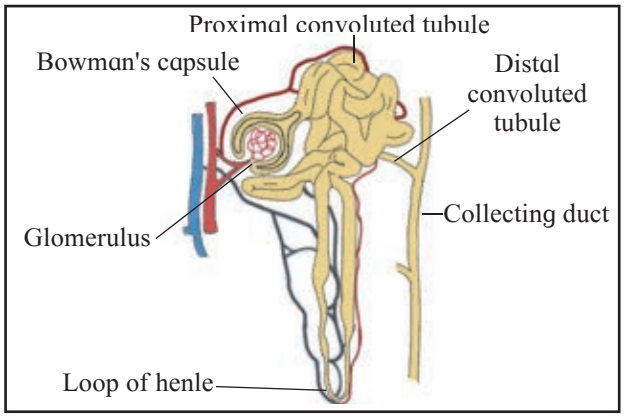


Fig. 9.18 Structure of Nephron

9.5.3 Mechanism of formation of urine

Formation of urine takes place in three steps-

1) Ultrafiltration
2) Selective reabsorption
3) Tubular Secretion

1. **Ultrafiltration**

It takes place in Malpighian corpuscle. The blood in the glomerulus is under great pressure because the diameter of the efferent arteriole is smaller than that of afferent arteriole. Therefore all the constituents of blood except blood corpuscles/cells and few plasma proteins are filtered into the Bowman's capsule. This filtrate is called as ***glomerular filtrate.***

Remember...

Renal corpuscle is the major site for filtration of fluid from the blood.

2. **Selective reabsorption**

It takes place in the tubular region. When the glomerular filtrate reaches the tubule, the cells of the tubule reabsorb useful substances like glucose, amino acids, some salts and requisite quantity of water from filtrate and give it to blood separating out urea, surplus salt and water.

3. **Tubular secretion**

This takes place in distal convoluted tubule. The substances which escapes the ultrafiltration in Bowman's capsule passes into the blood capillaries surrounding the tubular region. The cells of tubules separate the substances like ammonia, potassium ions, hydrogen ion, creatinine and put them back into the filtrate. The resulting fluid is the urine.

Do you know ?

Urine is watery solution, pale yellow in colour. Its pH is alkaline i.e. 7.4 to 8.4 and its specific gravity is 1.032 in cattle. The smell of urine is due to presence of volatile organic acids.

9.6 REPRODUCTIVE SYSTEM

Reproduction is a process by which living organisms produce new generations of individuals similar to themselves. Reproduction is one of the fundamental characteristic of living organism. It is an essential life process which helps in continuity of the species. Reproduction is of two types viz. asexual and sexual. In mammals it is sexual reproduction which involves male and female animals of same species as parents.

9.6.1 Male Reproductive System

The male reproductive system of cattle consists of a pair of testes in the scrotum, epididymis ,vas deferens, penis and accessory sex glands viz. seminal vesicles, prostate and bulbo-urethral glands.

1. **Testes**

1. Testes are suspended in the scrotum by ***spermatic cord.***

2. They are two in number, oval in shape.
3. The average weight of adult testis is 300 - 500 gms.
4. Each testes consist of a mass of ***seminiferous tubules***
5. Seminiferous tubule is made up of two types of cells i.e. ***Germ cells*** and ***Sertoli cells*** .

Remember...

Testes are the primary sex organs in male.

6 ***Functions :***They produce sperms i.e. male gametes and male sex hormone i.e. androgen which promotes development of secondary sexual characters in males.

2. Scrotum

1. It is a cutaneous pouch in which testicles are located.
2. The scrotal skin is thin, pliable and relatively hairless.
3. It is divided into two chambers by central membrane called ***'scrotal septa'.***
4. ***Functions :*** It holds the testes and located external to the body.

Do you know ?

- **Scrotum regulates the temperature of testes by contractions, relaxations and through sweating.**
- **Temperature of testes is less by 1-2^{0}c than body temperature.**

3. Epididymis

1. It is coiled tube originating at dorsal part of the testes.
2. It is approximately 30-35 meters long.
3. It consists of head ***(caput)***, body ***(corpus)*** and tail ***(cauda)***.

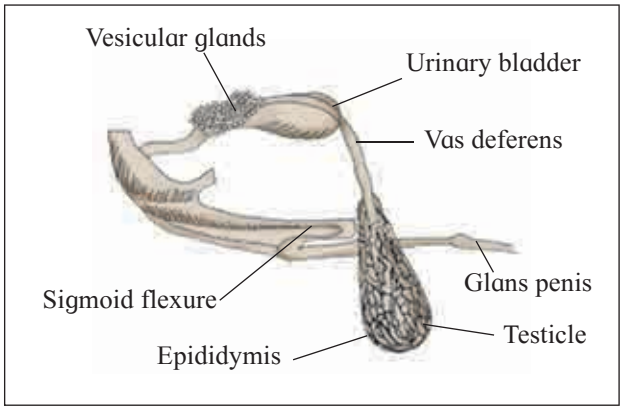


Fig. 9.19 Urogenital organs of cattle

Functions

1. It helps in migration of spermatozoa from testes to vas deferens.
2. It concentrates diluted sperm suspension.
3. It helps in maturation of sperms.

Remember...

The tail (cauda) of epididymis is store house of sperms.

4. Vas deferens

1. These are two slender tubes extending from tail of epididymis to urethra.
2. Spermatic arteries, veins, nerves, muscles and vas deferens forms ***spermatic cord.***
3. Each vas deferens goes through the ***inguinal ring*** and opens into urethra.
4. Terminal portion of both the tubes is little dilated and called as ***'ampulla'.***

5. ***Function:*** Transport of sperm from epididymis to urethra.

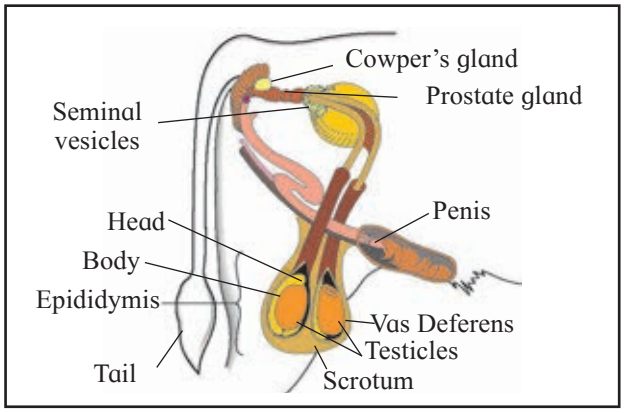


Fig. 9.20 Reproductive system of Bull

5. Urethra

1. It extends from the neck of the bladder to tip of the glans penis.
2. It has three distinct parts viz. pelvic part, bulb of urethra and penile part
3. *Function* **:** It is a common passage for urine and semen.

6. Penis

1. It is cylindrical in shape. It is about 3 feet long and 1 inch in diameter in adult bull.
2. It consists of 3 parts - root, body and glans.
3. The free portion of penis in non-erectile state remains covered by a cutaneous pouch known as ***'prepuce'.***
4. ***Function :*** It is an organ of copulation in male.

Accessory Sex Glands

Accessory sex glands of male reproductive system include seminal vesicles, prostate glands and bulbo-urethral gland or Cowper's gland.

1. Seminal vesicles

1. These are two lobulated elongated glands situated in pelvic cavity.
2. They are located on either side of ampulla above the neck of urinary bladder.
3. They secrete ***seminal fluid*** which is rich in fructose and citric acid.

2. Prostate gland

1. It is unpaired gland situated at the junction of bladder and urethra.
2. It is composed of body and glandular part.
3. Its secretions are drained by approximately 30 ducts into urethra.
4. Its secretion is high in proteins, enzymes and minerals.

3. Bulbo-urethral glands or Cowper's glands

1. These are two, small, round and compact glands.
2. These are situated above the urethra near ischial arch.

Do you know ?

Secretions of the cowper's gland cleans the urethra from the harmful effects of urine.

9.6.2 Female Reproductive System

Female reproductive system of cattle consists of a pair of ovaries, a pair of fallopian tubes, the uterus, the cervix and the vagina.

1. Ovaries

1. These are paired glands situated in pelvic cavity.
2. They are oval in shape.
3. They weigh about 7-15 gms. Right ovary is slightly larger than left.
4. Each ovary consists of number of primordial follicles ranging between 75,000 to 3,00,000. The follicles

reach maturity through successive developmental stages viz. primary, growing and mature follicle.

Remember...

Ovaries are the primary sex organs of female.

Functions

1. Formation of ova or eggs (Oogenesis) i.e. female gamete.
2. Secretion of female sex hormones -

   a) Estrogen – secreted by follicular cells, is responsible for development of secondary sexual characters, sexual behaviour and regulation of estrous cycle.

   b) Progesterone - secreted by corpus luteum, is essential for maintenance of pregnancy.

Use your brain power

Which cells secret oestrogen ?

2. Fallopian Tubes

1. These are also called as oviducts or salpinx or uterine tubes.
2. These are paired, slender, zigzag like tubes extend from ovaries to uterus.
3. Each fallopian tube is divided into infundibulum, ampulla and isthmus.

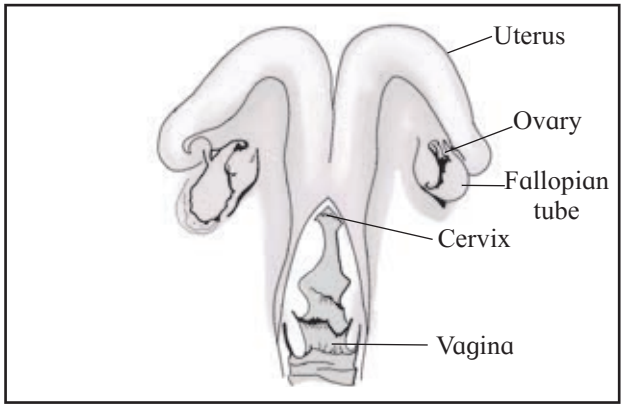


Fig. 9.21 Genitalia of cow (Dorsal view)

Functions

1. Infundibulum collects ovum or egg released by ovaries.
2. Facilitate transport of sperms to the site of fertlization.
3. Involved in transport of zygote to the uterus.

Do you know ?

Fertilization of ova takes place in ampulla.

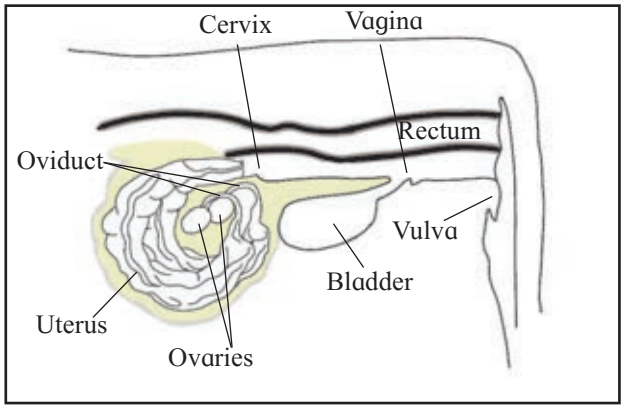


Fig. 9.22 Genitalia of cow (Dorsal view)

3. Uterus

Do you know ?

In which part of reproductive system foetus develops ?

1. It is hollow, elongated, musculo membranous 'Y' shaped sac.
2. It is located in pelvic cavity in non-pregnant animals, however in pregnant animal it descends in abdominal cavity.
3. It continues anteriorly with fallopian tubes and posteriorly with cervix.
4. It consists of short body and two horns.

5. The inner mucosa of uterus has raised spots called ***'caruncles'.***

Functions

1. Transport of sperms towards the fallopian tubes.
2. Secretion of ***uterine milk*** for nourishment of early embryo.
3. Implantation of zygote and maintenance of the pregnancy.
5. Uterine contractions help in expulsion of foetus during parturition.
6. Regulates oestrus cycle by secreting prostaglandins.

4. Cervix

1. It is also known as ***'neck of the womb'.***
2. It is thick walled fibrous structure ,lies between the uterus and vagina.
3. Its inner wall is arranged in the form of annular rings which gives spiral shape to the cervical canal.
4. The cervical canal is tightly closed during pregnancy and anoestrus, however relaxes during oestrus and parturition.

Functions

1. Storage and transport of sperms during oestrus.
2. Secretion of mucus during oestrus stage.
3. Acts as a barrier against ascending type of infections.
4. Formation of cervical seal during gestation/pregnancy.

5. Vagina

1. It is highly elastic musculo-membranous tube.
2. It is situated on floor of pelvic cavity above the urinary bladder and below rectum.
3. It is about 20-25 cm long and 10-15 cm wide.
4. It extends from cervix upto urogenital sinus or ***vestibule.***
5. Urethra opens on floor of vagina as external urethral orifice.

Functions

1. It is the organ of copulation in females.
2. It acts as a birth canal.

6. Vulva

1. It is the external opening of the uro-genital tract, lies just below the anus.
2. It has two lateral vulval lips, which are large, soft, thick and normally wrinkled.
3. The ***hymen*** is a transverse membranous partition situated in front of urethral orifice between vulva and vagina.

Remember...

Cervix remains open during parturtion, oestrus (heat) period and in case of uterine infections

Do you know ?

The clitoris is a small, rod like, erectile muscular elevation present on the posterior floor of the vulva.

9.7 UDDER

Mammary gland is considered as an accessory organ of reproductive system. The mammary gland or udder is modified sweat gland that produce milk for nourishment of off spring.

Do you know ?

In ruminants, individual glands are associated so closely to one another that they are commonly referred to as a single udder.

9.7.1 Anatomy of Udder

External structure

1. The udder in cow is located entirely outside the abdominal cavity in inguinal region.
2. Udder is divided longitudinally into right and left halves by inter mammary groove.
3. Each half of the udder is further separated into front and rear quarters.
4. The rear quarters are usually larger than fore quarters and posses more secretary capacity.
5. Each quarter is associated with teat which serves as a exit for secreted milk.

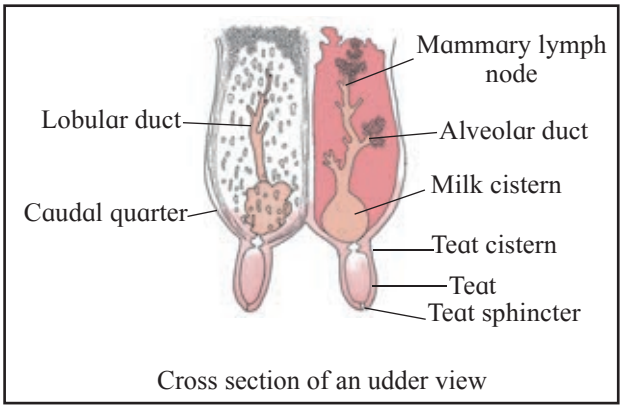


Fig. 9.23 Structure of Udder

6. The teats are long and tubular in shape with conical tip.
7. The skin of teat is smooth and free from hairs and sweat/sebaceous glands.

Internet my friend

Number of teats in different animal species.

Internal structure

1. The udder is divided into two halves, right and left, by median suspensory ligament.
2. Each half is further divided into fore and hind quarters by thin membrane.
3. Each quarter is composed of secretary tissue and some supporting connective tissue.
4. The secretary tissue comprises of tiny chambers lined with many secretary cells called ***alveoli*** which secrete milk.
5. Each alveolus is surrounded by myo-epithelial cells. These cells cause contraction of alveoli and thereby help in let-down of milk.
6. Each alveolus is drained by small duct called ***alveolar duct***. They unite and reunite to form inter-lobar ducts.
7. The inter-lobar ducts join in the center of gland to form sinus called as ***milk cistern***.
8. The milk cistern is continuous below with the ***teat cistern.***
9. The teat cistern opens in a streak / teat canal that opens at lower end of the teat i.e. teat orifice.
10. The teat orifice is guarded by a sphincter called *teat sphincter*.

9.7.2 Physiology of milk secretion

Milk secretion

Milk secretion means synthesis of milk by epithelial cells of alveoli and the passage of milk from the cytoplasm of the cells into the alveolar lumen.

Milk contains water, fats, proteins, lactose, minerals and vitamins.

1. **Milk fat / lipids :** Most of the lipids in milk are in the form of triglycerides which are composed of fatty acids and glycerol. The fatty acids required for synthesis of milk triglycerides are derived from the blood or synthesized within the mammary gland. In non-ruminants blood glucose is used for synthesis of fatty acids whereas in ruminants milk fat is synthesized from blood acetate and beta-hydroxy butyrate. The glycerol is derived from glucose metabolism.
2. **Lactose :** Lactose, the principal carbohydrate in milk, is composed of glucose and galactose. Secretary cells in mammary gland use blood glucose to synthesize galactose and combine it with glucose to form lactose.

Remember...

In ruminants glucose is synthesized from propionate which is a substrate for synthesis of lactose.

3. **Proteins :** Milk proteins viz. caseins (major protein), α-lactalbumin and β-lactoglobulin, are synthesized by mammary gland using blood amino acids.
4. **Other constituents :** Milk constituent like water, minerals, vitamins are filtered from the blood through epithelial cells.

Do you know ?

For synthesis of 1 ml of milk 400-500 ml of blood must pass through udder.

Lactogenesis

Lactogenesis means the initiation/ establishment of milk secretion / lactation.

At puberty, estrogen stimulates the growth of ductile system at each oestrus, while progesterone promotes growth and development

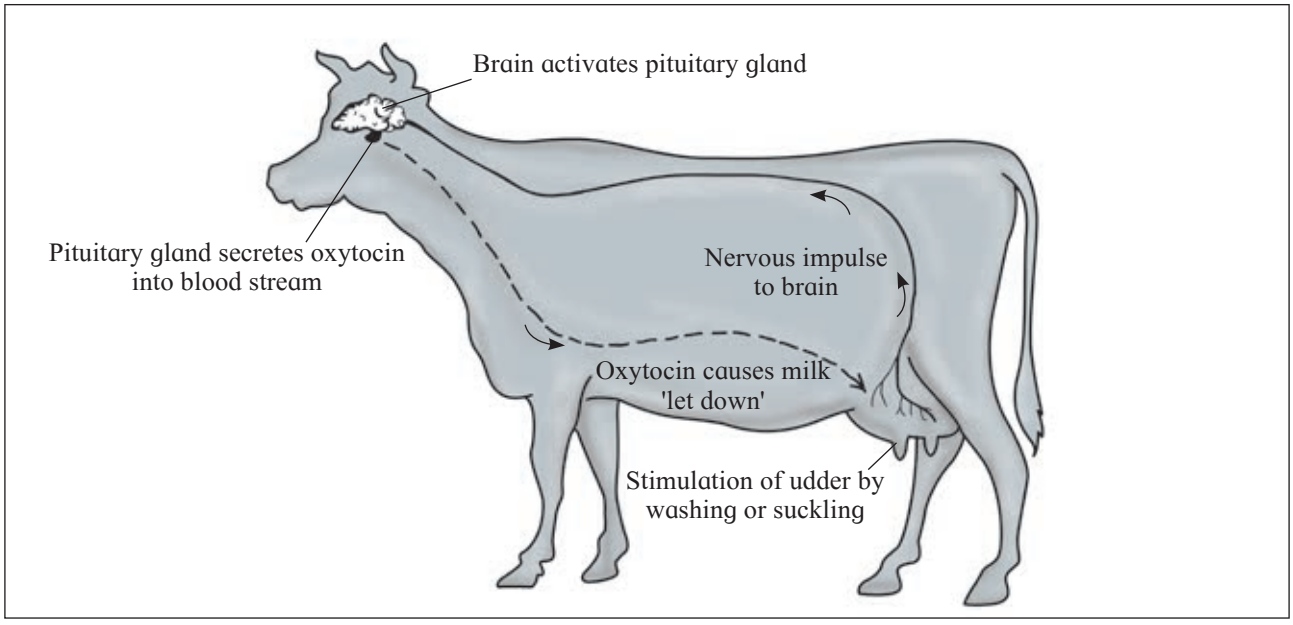


Fig. 9.24 Milk 'let-down' mechanism

of alveoli. Normal secretions of growth hormone and glucocorticoids are also required for complete development of mammary gland.

During pregnancy, progesterone stimulates extensive anatomical development of secretary alveoli but inhibits the functional activity of secretary epithelial cells. By the end of pregnancy, cow's udder is fully developed.

After parturition, sudden decline in placental oestrogen and progesterone and rise in prolactin stimulates production of intracellular enzymes required for milk secretion in secretary cells lining alveoli. This results in establishment of milk secretion / lactation.

Galactopoiesis

Galactopoiesis means maintenance of lactation or continued production of milk. For continuation of lactation, stimulation of teat either by milking or suckling is required. The stimulation increases secretion of prolactin which is required for maintenance of normal lactation. Along with prolactin STH, ACTH and TSH are essential for maintenance of lactation.

Milk ejection or let-down

Can you tell ?

The hormone responsible for let down of milk.

Suckling by calf or milking by milkman stimulates sensory nerves from mammary gland. The information reaches hypothalamus which regulates secretion of oxytocin from posterior pituitary gland. The oxytocin stimulates contraction of myoepithelial cells surrounding alveoli which results in milk ejection or milk let-down.

Internet my friend

Factors responsible for incomplete milk let down in milk cow.

9.8 NERVOUS SYSTEM

Nervous system performs important functions of co-ordination, integration and smooth activities of various parts of the animal body.

Remember...

Nervous system is the main integrating and coordinating system in animal body.

The nervous system consists of Central Nervous System (CNS) comprising of brain and the spinal cord and the Peripheral Nervous System (PNS) which includes nervous tissue outside CNS.

9.8.1 Neuron

1. Each neuron consists of nerve cell body and its processes.
2. Nerve cell body contains nucleus, cytoplasm and Nissl bodies.
3. The nerve cell possesses two types of processes- axon and dendron.
4. The ***dendrons*** are smaller processes which receives impulses.
5. An ***axon*** is the long process which conducts impulse away from the cell body.

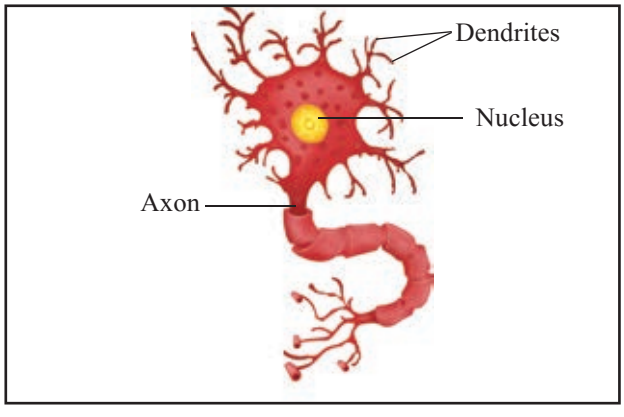


Fig. 9.25 Structure of neuron

6. The groups of axons travelling together are called as ***nerve fibres*** which group together to form ***nerve***.

7. Neurons are also classified as sensory and motor neurons. ***Sensory neurons*** conduct impulses towards CNS while ***motor neurons*** carry impulses from CNS to the effector organ/periphery.

9.8.2 Meninges

1. Meninges are the membranous covering of the brain and spinal cord.
2. Meninges consist of three layers viz, dura mater, arachnoid and pia mater.
3. **Dura mater :** It is the outermost tough fibrous covering of brain and spinal cord.
4. **Arachnoid :** It is the middle very thin delicate layer of meninges.
5. **Pia mater :** It is the innermost delicate layer of meninges close to brain and spinal cord.

9.8.3 Central Nervous System

The central nervous system consists of brain and spinal cord.

Can you tell ?

1. **Different parts of brain**
2. **Overall functions of the brain**

A. Brain

It is located in cranial cavity of skull and it is divided in three parts as fore brain, mid brain and hind brain.

a. Fore brain

Cerebrum

1. It is ovoid in shape and represents largest part of brain.
2. It is concerned with most highly developed functions of CNS like memory, intelligence.
3. It comprises centers for sense of smell, sight, taste and hearing.

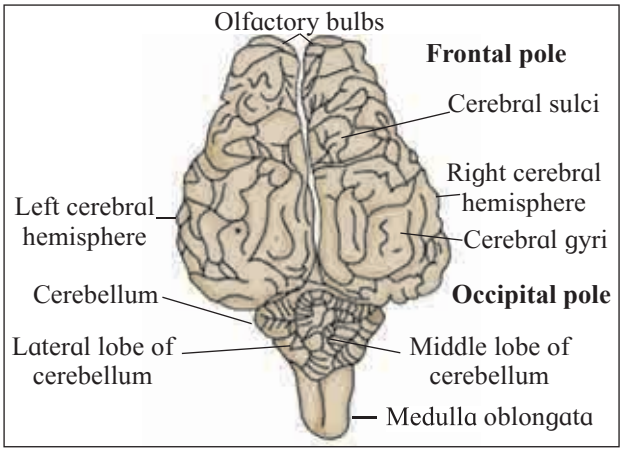


Fig. 9.26 Ventral surface of the brain

b. Mid brain

1. It consists of corpora quadrigemina, cerebral peduncles and aqueductus sylvi.
2. Corpora quadrigemina is associated with sense of sight and hearing.
3. Cerebral peduncles (crura cerebri) contain nerve fibers that carry motor impulses.

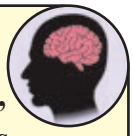
c. Hind brain

It consists of cerebellum, pons and medulla oblongata.

1. Cerebellum

1. It is irregularly globular structure located above pons and medulla oblongata.
2. Cerebellum is the second largest portion of brain.
3. It monitors and co-ordinates the voluntary movements.

Think about



1. **Touching to animal body, gives reflexes/shaking reflexes, why is it so?**
2. **Animals are unable to speak like humans**

4. It maintains equilibrium of the body and also regulates posture by maintenance of reflex muscle tone.

2. Pons

1. It is a transverse square structure situated ventral to the cerebellum.
2. It acts as a reflex center for respiration and reflexes mediated by cranial nerves.

3. Medulla oblongata

1. It is the posterior part of brain located between the pons and the spinal cord.
2. It contains the vital centers such as respiratory and cardiac centers and the reflex centers for coughing, salivation, vomiting and swallowing.

Remember...

- **Ventricles are large cavities in the brain which contains cerebrospinal fluid (CSF).**
- **Cerebrospinal fluid (CSF) protects and nourishes brain and spinal cord.**

B. Spinal cord

1. It is the thick, cylindrical structure located in the vertebral column/canal.
2. It extends from the skull to the middle of sacrum.
3. The spinal cord is composed of central grey matter surrounded by white matter.
4. It receives sensory afferent fibres by way of dorsal roots of the spinal nerves.
5. It gives off motor efferent fibres to the ventral roots of spinal nerves.
6. The spinal nerves arise from the lateral aspect of spinal cord.
7. *Functions* : It conveys nerve impulses to and from the brain. It serves as the main center for reflex action.

9.8.4 Peripheral Nervous System (PNS)

1. The nerves which arise from CNS and extend to the peripheral part of the body form the peripheral or somatic nervous system.
2. PNS provides communication of external and internal environment stimuli to CNS.
3. On the basis of functions, peripheral nerves are classified as follows :

   a. *Sensory or afferent nerves* : They conduct impulses from receptors to CNS.

   b. *Motor or efferent nerves* : They conduct impulses from CNS to effectors.

   c. *Mixed nerves* : They contain both sensory and motor nerve fibres so they have both sensory and motor functions.

4. On the basis of origin peripheral nerves are classified as follows :

   a. Cranial nerves *:* They originate from different parts of the brain. There are 12 pairs of cranial nerves. The cranial nerves are either sensory, motor or mixed (sensory & motor).

Do you know ?

Vagus nerve is the longest cranial nerve in animal body.

   b. Spinal nerves *:* These are the nerves which originates from the spinal cords. There are 37 pairs of spinal nerves in cattle.. All spinal nerves are mixed in nature.

9.8.5 Autonomus Nervous System (ANS)

1. The nervous system that works independently and involuntarily is the autonomus nervous system.
2. It is the visceral component of the nervous system.
3. The nerve fibres are distributed to the visceral organs, blood vessels, glands and smooth muscles.
4. ANS is divided in 2 sections i.e. parasympathetic and sympathetic.
5. It regulates heart rate, respiration, pupil, dilatation and contraction of blood vessels.

Can you recall ?

Exocrine glands

9.9 ENDOCRINE GLANDS

Endocrine glands are the ductless glands that discharge their secretions directly in the blood or indirectly via. lymph.

Hormones are the chemical substances of endocrine gland that are directly secreted into blood which stimulate or inhibit the function of target organ.

Various endocrine glands, the hormones secreted, their sites of actions and functions are mentioned in Table 9.5.

Use your brain power

Which is the master gland in animal body ?

Table 9.5 : Endocrine glands, their hormones and functions.

No.	Name of gland and Hormone	Site of Action (target organ)	Functions/Actions
1. Hypothalamus			
1	Gonadotropin releasing hormone (GnRH)	Anterior pituitary	Releases LH and FSH
2	Thyrotropin releasing hormone (TRH)	Anterior pituitary	Releases TSH
3	Corticotropin releasing hormone (CRH)	Anterior pituitary	Releases ACTH
4	Somatotropin releasing hormone (STH - RH)	Anterior pituitary	Releases STH/GH
5	Somatatropin inhibiting hormone (STH - IH)	Anterior pituitary	Inhibit STH output
6	Prolactin inhibiting hormone (PTH)	Anterior pituitary	Inhibit prolactin output
7	Prolactin releasing hormone (PRH)	Anterior pituitary	Releases prolactin

1. **Anterior pituitary (Adenohypophysis)**			
1	Growth hormone (GH)/ Somatotropic hormone (STH)	All tissues	Stimulates growth in young animals, protein and glucose synthesis .
2	Thyroid stimulating hormone (TSH)	Thyroid gland	Stimulates growth of thyroid gland and enhances production of thyroxine
3	Adrenocorticotropic hormone (ACTH)	Adrenal cortex	Maintenance of adrenal cortex and release of glucocorticoids.
4	Prolactin(PRL)	Mammary gland and CNS	Stimulates lactation and maternal behavior.
5	Follicle Stimulating Hormone (FSH)	Ovaries and Testes	Growth and maturation of ovarian follicles (oogenesis) and sperm development.
6	Luteinizing Hormone (LH)	Ovaries and Testes	Ovulation, development of corpus luteum and progesterone secretion, secretion of androgen.
2. **Posterior pituitary glands(Neurohypophysis)**			
1	Antidiuretic hormone (ADH)	Kidney, blood vessels.	Regulation of water excretion, Constriction of blood vessels .
2	Oxytocin	Mammary gland and uterus	Helps in milk let down. Promotes uterine contractions.
3. **Thyroid glands**			
1	Thyroxine and Triiodothyronine	All tissues	Stimulates glucose and protein synthesis. Mobilization of fat.
2	Calcitonin	Bone and Kidney	Lowers blood calcium level
4. **Parathyroid gland**			
1	Parathyroid Hormone (PTH)	Bone, Kidney and intestine	Increases the level of calcium in blood
5. **Pancreas**			
1	Insulin	Liver, muscle and adipose tissue	Lowers blood glucose. Stimulates protein and lipid synthesis.
2	Glucagon	Liver and muscle	Elevates blood glucose.
6. **Adrenal glands**			
1	Ephinephrine/ Nor- ephinephrine	Several organs	Stimulates sympathetic response to stress by action on different organs
2	Glucocorticoids	All tissues	Synthesis of glucose
3	Mineralcorticoids / Aldosterone	Kidneys	Increases reabsorption of sodium and promotes excretion of potassium ions

Q. 1 Fill in the blanks

1. Cattle heart is made up of …….. chambers.
3. Platelets are also called as ……..
4. …….. is the largest long bone in animal body.
5. …….. bones contain air space
6. The cervical vertebrae in cattle are …… in number
7. …….. blood cell is involved in blood clotting.
8. …….. is also known as sound box.
9. ……. is also known as wind pipe.
10. The right lung is divided into …….. lobes.
11. …….. is the main excretory organ in cattle
12 ……. carries urine from kidneys to bladder.
13. …….. is the major site for filtration of fluid from blood.
14. …….. is the chief prehensile organ in cattle.
15…… number of incisors are present in the lower jaw of cattle.
16. …… teeth are absent in cattle.
17. Ruminant stomach is made up of ……. chambers
18. …….. is the largest compartment of ruminant stomach.
19. …….. is the primary sex organ in males.
20. …… hormone is required for maintenance of pregnancy.

Q. 2 Match column I with column II

Column I	Column II
1. Artery	a) Pumping organ
2. Testes	b) Neck of the womb
3. Cervix	c) Androgen
4. Abomasum	d) Carry pure blood
5. Heart	e) True Stomach
6. Lungs	f) Milk holding hormone
7. Liver	g) Estrogen
8. Adrenaline	h) Largest Gland
9. Ovary	i) Milk lettingdown hormone
10. Oxytocin	j) Respiratory organ

Q.3 Identify the odd one out

1. Kidney, Ureter, Lungs, Urinary bladder, Urethra,
2. PCT, Testis, DCT, Henle's loop, collecting tubule
3. Ultrafiltration, Selective reabsorption, Tubular secretion, Circulation
4. Cortex, Medulla, Renal capsule, Ureter, Renal artery, Renal vei
5. Rumen, Reticulum, Omasum, Abomasum,Liver
6. Ovary, Oviduct, Uterus,Cervix,Penis
7. Scrotum, Epididymis, Vas deferens, Testes, Vagina

Q.4 State True or False

1. Aorta is the largest artery.
2. RBC are non-nucleated cells.
3. WBC are also called as erythrocytes .
4. Pulmonary artery carry deoxygenated blood.

5. Right side of heart contains oxygenated or pure blood.
6. Nephron is the structural and functional unit of kidney.
7. Kidneys are the main excretory organs.
8. Bowmans capsule is a part of nephron.
9. Urethra is a common passage for urine and semen in male.
10. Single kidney is present in cattle.
11. Alveolus is the structural and functional unit of lungs.
12. Right and left lungs have same number of lobes.
13. Out flow of air is called is called expiration.
14. Exchange of O_2 and CO_2 between blood and tissues is called internal respiration.
15. Nasal cavity is the first part of the respiratory passage.

Q. 5 Answer in brief

1. Give the location of kidneys in cattle.
2. Enlist the different parts of nephron.
3. Enlist different phases of urine formation.
4. Give the location of lungs in cattle.
5. Give the location of heart in cattle.
6. Write the function of RBC.
7. Enlist three layers of heart wall.
8. Which is the largest sesamoid bone in animal body ?
9. Write the functions of short bones.
10. Enlist the types of joints.
11. Enlist the various compartments of ruminant stomach.
12. Why abomasum is called as true stomach of ruminants ?
13. Which is the largest gland in the animal body ?
14. Give the function of scrotum.
15. Name the structural and functional unit of the nervous system.

Q. 6 Differentiate between

1. Ruminants and non-ruminant animals.
2. Right and left lung
3. RBC and WBC.
4. Arteries and veins.
5. Long and flat bones.

Q.7 Answer the following questions

1. Describe in brief lymphatic system.
2. Write short note on platelets.
3. Enlist major constituents of plasma.
4. Write in short about structure and functions of cerebellum.
5. Enlist the hormones secreted by adrenal gland and give their functions.
6. Give the functions of hormones secreted by pancreas.
7. Describe in brief the structure and functions of internal ear.
8. Write in brief about structure of eyeball.
9. Give the functions of bones.
10. Write short note on larynx.
11. Give structure and functions of trachea.

12. Describe in brief structure of nephron.
13. Enlist the functions of kidney.
14. Give location and functions of urinary bladder.
15. Describe in brief structure of lung.
16. Enumerate functions of liver.
17. Enlist the functions of intestine.
18. Give structure and functions of testes.
19. Enlist the symptoms of heat in cattle.
20. Describe in brief external features of cow's udder.

Q.8 Answer the following questions in detail.

1. Describe functions and composition of bone in detail.
2. Describe the classification of bones with suitable examples.
3. Define blood. Give functions and composition of blood.
4. Describe the structure of heart with the help of well labelled diagram.
5. Describe the respiratory system of cattle.
6. Describe the urinary system of cattle with well labelled diagram.
7. Describe the ruminant stomach with the help of well labelled diagram.
8. Describe in detail male reproductive system in cattle.
9. Describe in detail female reproductive system in cattle.
10. Explain in detail structure of udder in dairy cow.