

6 Reptilia

Reptiles are the first vertebrates which became adapted completely to terrestrial life. They are the *creeping* animals. They flourished well during the *Mesozoic* era and they were the dominant and ruling animals for 300 million years. Hence Mesozoic era is called the *Golden Age of Reptiles*. Most of the reptiles became extinct by the end of mesozoic era and now they are represented by only a few groups, namely lizards, snakes, turtles, crocodiles and *Sphenodon*.

The embryos of reptiles are protected by an embryonic membrane called *amnion*. As this membrane is also found in birds and mammals, reptiles, birds and mammals are together called *amniota*. Fishes and amphibians are called *anamniota* as they do not possess an amnion.

The study of reptiles is called herpetology.

Reptiles originated in the *Carboniferous period* of *Palaeozoic* era from *Labyrinthodont* amphibians.

General Characters

1. Reptilia are *creeping* land vertebrates. They are the *first land* vertebrates.
2. Reptiles are *poikilothermic* or *cold blooded* animals.
3. They are included in the phylum *Chordata* because the embryos develop a *notochord*.
4. They contain a *vertebral column*. So they are included in *Vertebrata*.
5. The brain is enclosed in a *cranium*. So they are included in *Craniata*.
6. They contain *jaws*. So they are included in *Gnathostomata*.
7. They contain 4 limbs. So they are called *Tetrapods*.
8. They develop *amnion*. So they are called *Amniota*.
9. They are *uricotelic* animals.
10. They are *terrestrial* and some are secondarily *aquatic*.
11. The body is covered with *horny scales* or *scutes*.

12. The skin is dry and skin glands are absent.

13. The limbs are *pentadactyl* type.

14. The skull has a single median *occipital condyle*.

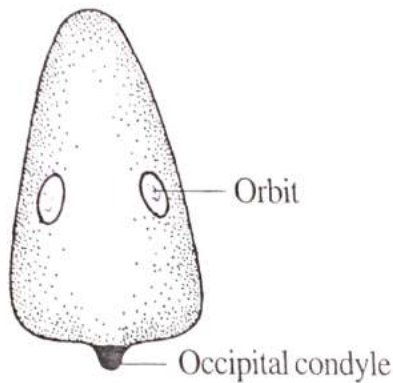


Fig.6.1: Skull of Reptilia with a single occipital condyle.

15. The mandible consists of many pieces and articulates with the cranium through the *quadrate* bone.

16. The vertebrae are *gastro-centrous*.

17. A true *sternum* is present.

18. Respiration is carried out by the *lungs*.

19. The heart is divided into two auricles and an incompletely divided *ventricle*. It is 3-chambered.

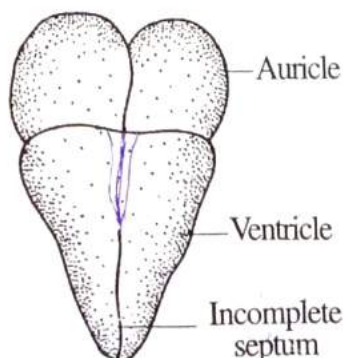


Fig.6.2: 3 Chambered heart of Reptilia.

20. It has 3 pairs of *aortic arches*. The right and left systemic arches are complete and functional.

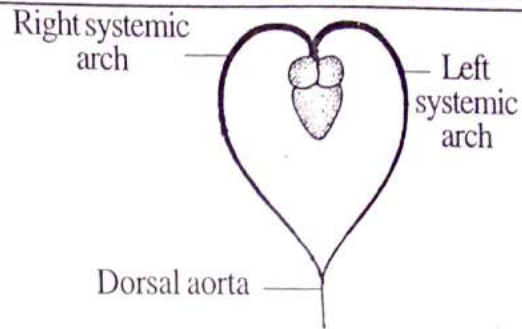


Fig.6.3: Complete right and left systemic arches of Reptilia.

21. The *red blood corpuscles* (RBC) are nucleated.

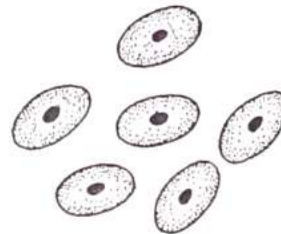


Fig.6.4: Nucleated RBC of Reptilia.

22. The kidneys are the *metanephric* type.

23. Twelve pairs of *cranial nerves* are present.

24. Lateral line sense organs are absent from reptiles.

25. A *cloaca* is present.

26. Copulatory organs are present.

27. Fertilization is *internal*.

28. The eggs are *cleidoic, megalecithal* and *amniotic*.

29. The embryos are protected by foetal membranes, namely *chorion, amnion, allantois* and *yolk sac*.

30. Development is *direct*, metamorphosis is absent.

Classification of Reptilia

Reptiles are *creeping* land vertebrates.

They are included in the phylum *Chordata* because the embryos develop a *notochord*.

7 Aves

The birds originated from reptiles in the *Mesozoic* era. *De Beer* stated that *nothing is more certain than the fact that birds have descended from reptiles*. Both reptiles and birds resemble with each other in many respects.

As the reptiles and birds are very similar, *Huxley* placed the two classes of vertebrates in a single superclass called *Sauropsida*.

Eventhough the birds have many reptilian characters they are highly specialized than the reptiles. This made *Huxley* to state that birds are the *glorified reptiles*.

Aves are birds. They are described as *feathered bipeds*. *Young* (1958) stated that birds are the *masters of air*. They are superior to the reptiles but inferior to the mammals in the evolutionary scheme.

The birds are defined as *warm blooded, bipedal, air-breathing vertebrates with fore limbs modified into wings and non-glandular skin covered with feathers*.

The *feathers*, the *wings* and the *beaks* are the three important identifying features which make the birds distinct from other vertebrates.

General Characters

1. *Aves* are *birds*. *Birds* are *warm blooded flying vertebrates with beaks, wings and feathers*.

2. They are *Chordates* because the embryo develops a *notochord*.

3. The brain is enclosed in a *cranium*. So they are *Craniata*.

4. They are *Vertebrates* because they contain a *vertebral column*.

5. They have *jaws*. So they are included in *Gnathostomata*.

6. They have 4 limbs. So they are called *Tetrapods*.

7. They develop *amnion*. So they are called *Amniota*.

8. The body is *spindle*-shaped and it consists of four regions, namely a *head*, a *neck*, a *trunk* and a *tail*.

9. The hind limbs are adapted for *walking, perching* and *swimming*; they bear four clawed digits.

10. The bird has an epidermal exoskeleton in the form of *feathers, scales, claws* and *beaks*.

11. The *skin* is *dry* and skin glands are absent.

12. The jaws are elongated into a *beak* or *bill*.

13. The *fore limbs* are modified into *wings*.

14. *Preen glands* (oil glands) are located at the base of the tail.

15. The *lower jaw* consists of *five or six bones* and it articulates with the quadrate.

16. The *teeth* are *absent*.

17. The vertebrae are *heterocoelous*.

18. The last three or four vertebrae are fused together to form a '*plough share bone*' called *pygostyle*.

19. The *sternum* is *large* and it bears a *keel* for the attachment of *flight muscles*.

20. The ribs are *double-headed*.

21. Each rib bears a backwardly directed bone called *uncinate process*.

22. The pectoral girdle has a stout coracoid and a *sabre* shaped scapula.

23. The clavicles of the two sides unite together to form a V-shaped bone called *furcula* or *merrythought bone* or *wish bone*.

24. The pelvic girdle is *tetraradiate*.

25. The pelvic girdle is fused with the *synsacrum* of the vertebral column.

26. The *acetabulum* is perforated.

27. The distal carpals fuse with the metacarpals to form the *carpo metacarpus*.

28. The proximal tarsals and the tibia fuse together to form the *tibio tarsus*.

29. The distal tarsals fuse with the *II, III* and *IV metatarsals* to form the *tarso metatarsus*.

30. The bones are *pneumatic* with air spaces.

31. The skull is *monocondylic* with a single *occipital condyle*.

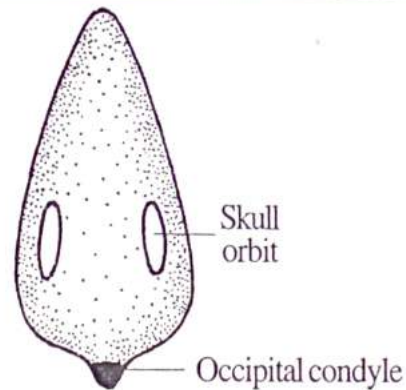


Fig.7.1: Skull of a bird with a single occipital condyle.

32. A *synsacrum* (fused vertebrae) is present in the vertebral column.

33. The heart is *4 chambered* with *2 auricles* and *2 ventricles*.

34. *Right systemic* arch alone persists. Left systemic arch is absent.

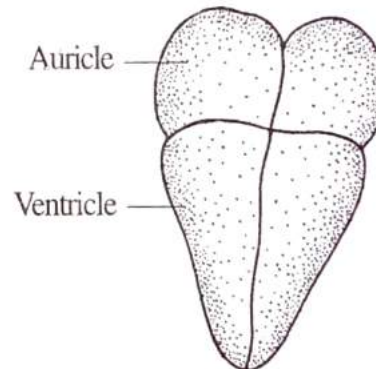


Fig.7.2: 4-chambered heart of a bird.

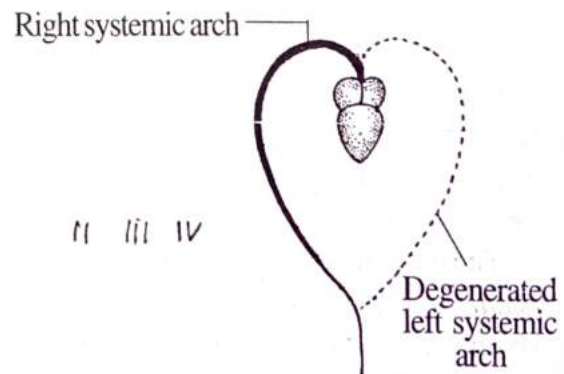


Fig.7.3: Right systemic arch of a bird.

35. The lungs are provided with air sacs. The birds exhibit *double respiration*.

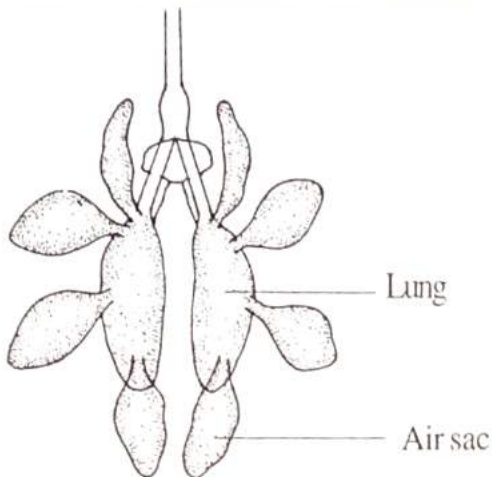


Fig.7.4: Air sacs found in the lungs of bird.

- 36. They have *twelve pairs* of cranial nerves.
- 37. The eyes are surrounded by *sclerotic plates*.
- 38. They have a *cloaca*.
- 39. RBC is *nucleated*.

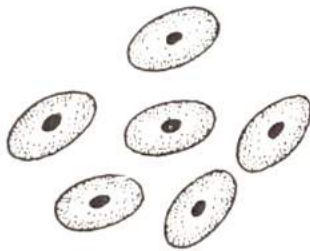


Fig.7.5: Nucleated RBC of birds.

- 40. *Air sacs* are present in the lungs.
- 41. A *syrinx* or *sound box* is present.
- 42. Kidney is *metanephric*.
- 43. Birds excrete *uric acid*. Hence they are *uricotelic animals*.
- 44. Two optic lobes (*corpora bigemina*) are present.

45. The ear containing a single bone called *columella auris*.

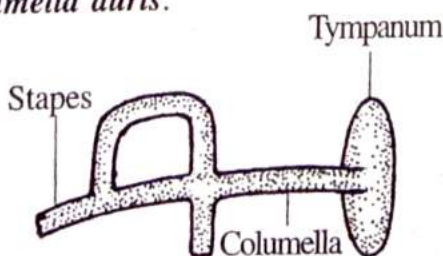


Fig.7.6: Columella auris of birds.

46. Eye contains a vascular body called *pecten*.

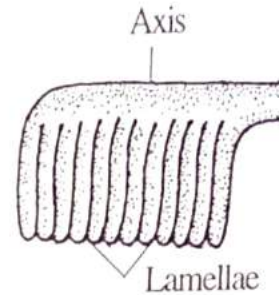


Fig.7.7: Eye of bird showing pecten.

- 47. Exhibit *sexual dimorphism*.
- 48. *Oviparous*.
- 49. Produce *cleidoic* eggs (eggs with a shell).
- 50. The female has a single *ovary* and a single *oviduct*.
- 51. The fertilization is *internal*.

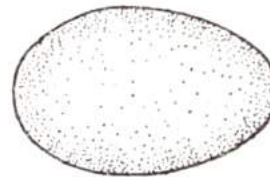


Fig.7.8: Cleidoic egg of a bird.

- 52. The eggs require incubation for hatching.
- 53. The cleavage is *meroblastic*.
- 54. The embryos develop *foetal membranes*.
- 55. They exhibit *parental care*.
- 56. Urinary bladder is absent.

Classification in Brief

Aves are *birds*. *Birds* are *warm blooded flying vertebrates with beak, wings and feathers*.

Birds are *Chordates* because the embryo develops a *notochord*.

The brain is enclosed in a *cranium*. So they are included in *Craniata*.

They have a *vertebral column*. So they are included in *Vertebrata*.

8 Mammalia

theodont
heloodont
diphyodont

Mammals are warm blooded vertebrates with mammary glands, hair and diaphragm (*Mamma*=breast).

Mammals *form the final product of evolution*. They form a very important group because of three reasons;

1. They occupy the top of the evolutionary tree;
2. They include man, the master of the present age
3. They include the largest and heaviest animals like whales.

Class Mammalia (*L. mamma* = breast) comprises animals having *mammary glands, hair, diaphragm, warm blood* and *viviparity*.

Mammals evolved during the *Triassic* period of the *Mesozoic* era from mammal-like reptiles. Several groups of mammal-like reptiles contributed to the early ancestry of mammals i.e. mammals had a *polyphyletic origin*. After their origin they evolved in different directions and the *coenozoic era* is rightly called the "*age of mammals*".

General Characters

1. *Mammals* are warm blooded vertebrates with mammary glands, hair and diaphragm (*Mamma*=breast).
2. They give birth to youngones and give milk to youngones. The skin has *sweat glands* and *sebaceous glands*.
3. In females, there are *mammary glands* to nourish the youngones.
4. Presence of *fleshy pinna* to collect air borne sound waves.
5. There are two *occipital condyles* (*Dicondylic*).

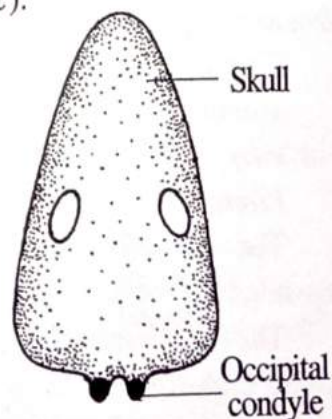


Fig.8.1: Skull of a mammal showing two occipital condyles.

6. A **secondary palate** separates the nasal passage from the food passage or buccal cavity.

7. The **auditory capsule** projects outwards as a swollen structure, the **tympanic bulla**.

8. Jaw suspension is **craniostylic**.

9. Lower jaw is formed of a large **dentary bone** which articulates with the **squamosal bone**.

10. **Cervical vertebra** are seven in numbers.

11. Coracoids and precoracoids of the pectoral girdle are much reduced.

12. The limbs are of the **pentadactyl type**.

13. Teeth are **thecodont** (present in sockets), **heterodont** (different types of teeth like incisors, canines, premolars and molars) and **diphyodont** (presence of **milk teeth** in young which are replaced by **permanent teeth**).

14. Presence of a **muscular diaphragm** that divides the body cavity into a **thoracic** and **abdominal** portions.

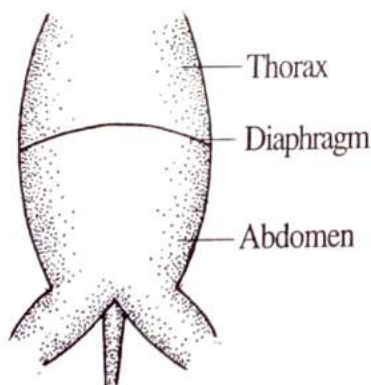


Fig.8.2: Mammalian body showing diaphragm.

15. Heart is **four chambered**. Only **one aortic arch** present on the left side.

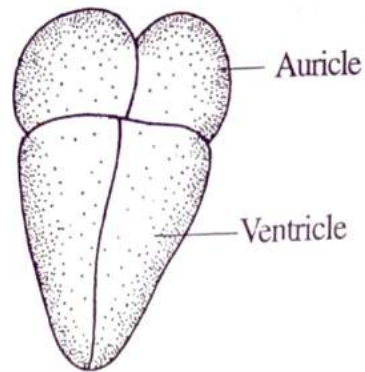


Fig.8.3: Four chambered heart of mammals.

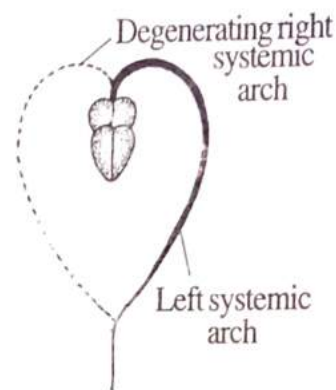


Fig.8.4: Left systemic arch of a mammal.

16. RBC is **non-nucleated**.



Fig.8.5: Non-nucleated RBC of mammals.

17. Lungs are contained in **pleural cavity**.

18. Presence of **corpus callosum** in the brain.

19. Optic lobes are four in numbers (**corpora quadrigemina**).

20. **Cochlea** of the inner ear is highly coiled.

21. **Three ear ossicles**, namely **malleus**, **incus** and **stapes** are present in the middle ear.

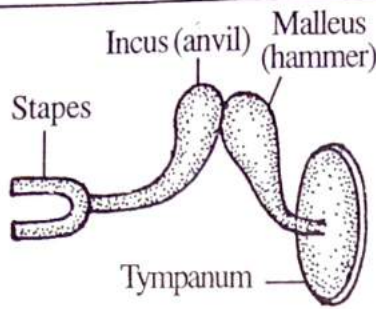


Fig.8.6: Ear ossicles of a mammals.

22. The copulatory organ is the *penis*. The testes are extra abdominal and present in the *scrotal sacs*.

23. Ovum develops in the *Graafian follicle* of the ovary.

24. All mammals except Prototheria are *viviparous*. A special structure called *placenta* develops by the union of the foetal and uterine tissues for the purposes of nutrition, respiration and excretion of the embryo.

25. Mammals show *parental care* of a high level.

Classification in Brief

Mammals are warm blooded vertebrates with mammary glands, hair and diaphragm.

They are included in the phylum *Chordata* because they develop a *notochord* in the embryos.

They have a vertebral column. So they are included in the subphylum *Vertebrata*.

The brain is enclosed in a cranium. So they are included in the group *Crania*.

They have *jaws*. So they are included in the superclass *Gnathostomata*.

They have 4 limbs. So they are included in the group *Tetrapoda*.

They develop an *amnion* around the embryos. So they are called *Amniota*.

They have *mammary glands*. So they are included in the class *Mammalia*.

Class *Mammalia* is divided into three subclasses, namely

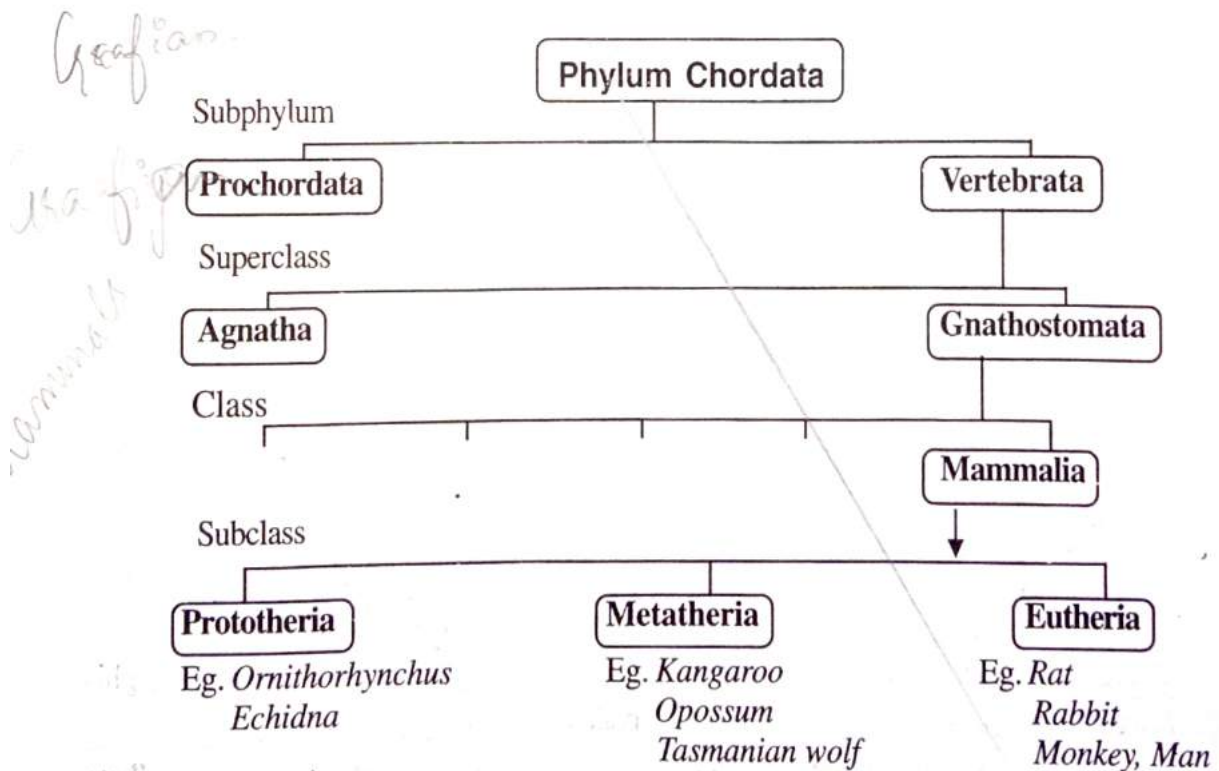


Fig.8.7: Classification of mammalia.

It is *terrestrial*, *gregarious* and *herbivorous*.

It grows to a height of 2 metres.

The body consist of a *head*, *neck*, *trunk* and a *tail*.

Anterior half of the body is small, but the posterior half is large.

Fore limbs are short used for feeding and not for walking.

Hind limbs are long and powerful and used for locomotion.

Tail is long, round and thick and used as a balancing organ while jumping.

It exhibits *bipedal* locomotion.

The female has a *marsupium* (pouch) on the ventral side.

Gestation period is 35 to 45 days. The newly born youngone is 3 cm long. It is kept inside the marsupium for 4 to 6 months.

It is hunted for flesh, fur and sport.

13. *Herpestes* (Mongoose)

- Phylum* : Chordata
- Subphylum* : Vertebrata
- Superclass* : Gnathostomata
- Class* : Mammalia
- Subclass* : Eutheria
- Order* : Carnivora

1. It is a small sized active carnivore commonly called *mangoose*.

2. The canines are large and sharply pointed for tearing. The zygomatic arch is strong.

3. The body is covered with grey *hair*.

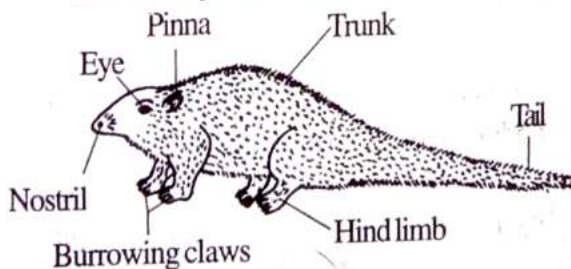


Fig.8.21: Mongoose.

4. There are *five digits* in both fore and hind limbs. Claws are present and they are non-retractile.

5. Pinnae are small and rounded.

6. It is highly predaceous and known to kill snakes.

7. Tail is long.

Detailed Study

Rabbit (*Oryctolagus uniculus*)

- Phylum* : Chordata
- Subphylum* : Vertebrata
- Class* : Mammalia
- Subciass* : Eutheria
- Order* : Lagomorpha ☐

Rabbit is a *typical mammal* with *mammary glands*, a covering of hair and warm blood.

It gives birth to youngones and nourishes them with milk.

It is a *warm blooded* animal.

It enjoys *cosmopolitan* distribution. It lives in forests. It is *gregarious* i.e., it lives in groups.

It is a *burrowing* or *fossorial* animal. It is *herbivorous*. It is *domesticated* for flesh. It is used extensively for biological and medical researches.

Rabbit is *polygamous* and one male lives with many females.

It is usually *brown in colour*; but its colour varies in domesticated animals. It is about 16 inches long and it weighs 2 to 4 pounds.

The body is divisible into four regions, namely a *head*, a *neck*, a *trunk* and a *tail*.

The trunk is further subdivided into an anterior *thorax* and a posterior *abdomen*.

The *head* is elongated. Anteriorly the head is produced into a pointed *snout*.

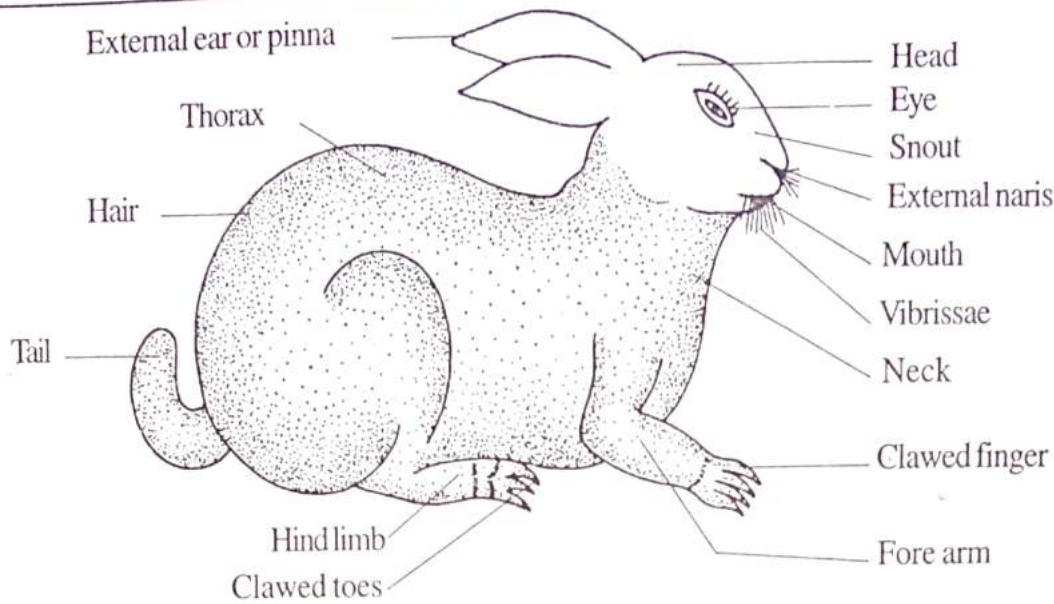


Fig.8.22: Rabbit.

The **mouth** is a transverse slit located at the anterior end, but on the ventral side of the snout. It is bounded by **two lips**, an **upper lip** and a **lower lip**.

The upper lip has a cleft in the middle through which the incisor teeth are clearly visible. Such a lip is called **hare lip**.

The sides of the upper lip produce stiff long thick hairs called **vibrissae** or **whiskers**. They are **tactile sensory organs** (organs of touch).

Just above the mouth, there are two oblique openings called **external nostrils** or **external nares**.

Two eyes are present on the sides of the head. They are protected by an **upper** and a **lower eyelid**.

A third eyelid called **nictitating membrane** is also present on the inner corner of the eye. It is also movable and used to clean the cornea.

The top of the head bears a pair of movable **pinnae**. They are used to direct the sound vibrations into the ear.

At the base of the pinna, there is an opening called **external auditory meatus**.

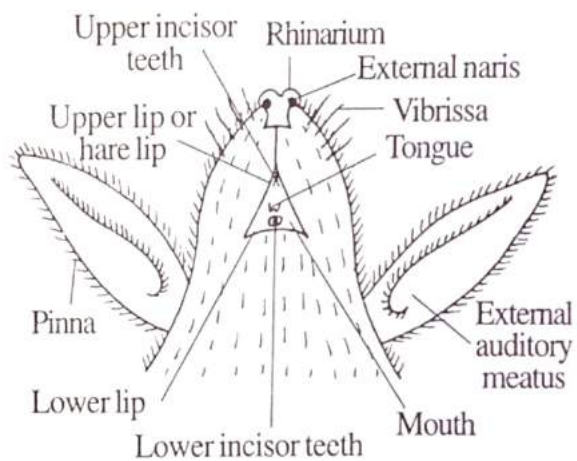


Fig.8.23: Rabbit - Head in ventral view.

The **neck** is short and it connects the head with the trunk. It helps in the free movement of the head.

The **trunk** is divisible into an anterior **thorax** and a posterior **abdomen**.

The thorax encloses a cavity called **thoracic cavity** and the cavity lying inside the abdomen is called **abdominal cavity**.

The two cavities are internally separated by a muscular partition called **diaphragm**.

The thoracic cavity is bounded by a skeletal framework formed of **ribs**.

The ventral side of the abdomen is provided with 4 or 5 pairs of *teats* or *nipples*. They are present in both sexes but well developed in females.

The ducts of the mammary glands open at the tip of teats.

The *anus* is present at the posterior end of the abdomen.

A pair of depressions are found on either side of the anus. These are called *perineal pouches*.

The *perineal glands*, lying inside open into these pouches. The secretions of these glands give the characteristic odour of the rabbit.

In male ventral to the anus, a *penis* is present. In female, in the same place a *slit-like vulva* is present.

The urinogenital opening is situated on the penis in the male and in the vulva in the female.

The male has a pair of *scrotal sacs*, one on either side of the penis. They enclose the testes.

The trunk bears two pairs of limbs, namely *fore limbs* and *hind limbs*.

Each fore limb is divided into three regions, namely a proximal *upper arm*

(brachium), a middle *fore arm* (antebrachium) and a distal *hand* (manus).

The hand is further divided into three regions, namely *wrist* (carpus), the *palm* (metacarpus) and the *digits* (5) with *claws*.

The hind limb is also divided into three regions, namely the *thigh*, the *shank* (crus) and the *foot* (pes).

The foot is further subdivided into an *ankle* (tarsus), an *instep* (metatarsus) and 4 *toes* with claws.

The tail is short and bushy and is located at the posterior end of the trunk.

Integument (Skin)

The integument forms the covering of the body. It is formed of two layers, namely an outer *epidermis* and an inner *dermis*.

The integument also contains several structures derived from it. They include hairs, claws, nails and glands like *sweat glands*, *sebaceous glands*, *mammary glands*, *perineal glands* and *meibomian glands*.

Epidermis: It is the outermost covering of the integument. It is formed of four distinct layers of *stratified epithelial* cells. They are: 1. the *stratum corneum* (outer), 2. the *stratum lucidum* 3. the *stratum granulo-*

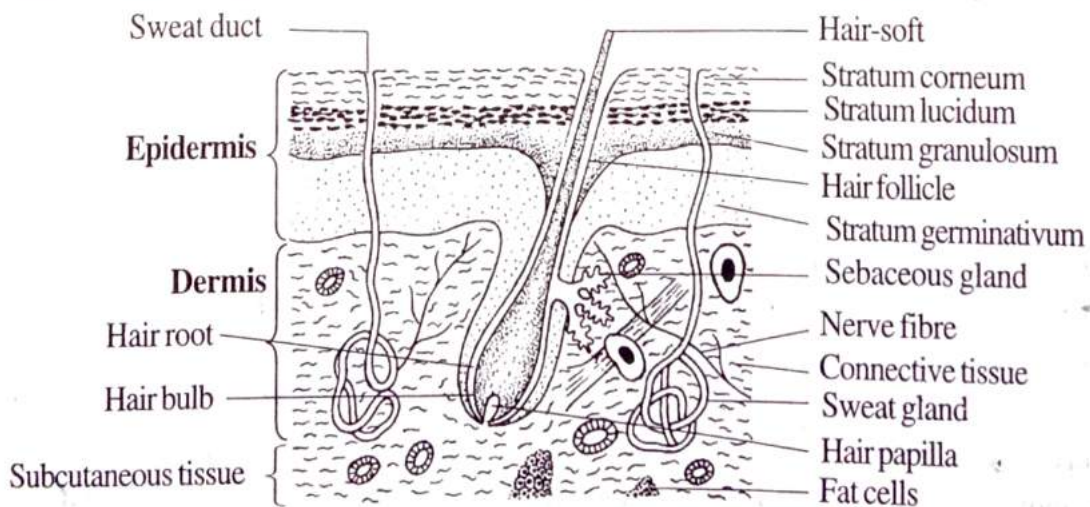


Fig.8.24: Rabbit - V.S. of skin.

sum and 4. the *stratum malpighi* or *stratum germinativum*.

The stratum corneum is the outermost layer. It is formed of dead cells. It is water proof because it contains *keratin*. This layer is peeled off periodically.

The second layer, stratum lucidum can replace the *stratum corneum*.

Stratum granulosum is formed of *granular cells*.

Stratum germinativum is the innermost layer and is formed of actively dividing cells. It receives the nutritive materials through blood vessels. This layer proliferates other layers of cells.

Dermis: The dermis is elastic in nature and is formed of *connective tissue fibres*.

In addition, it contains muscles, fat cells, nerves and blood capillaries.

The dermis also contains *integumental glands*. The root of the hair is embedded in the dermis.

Hair: The entire body is covered with hair. It develops from epidermis. It forms the exoskeleton.

Each hair has two parts, namely the *root* and the *shaft*.

The root is *bulb*-like and is embedded in the dermis.

The basal part of the root is enclosed in a *tube*-like structure called *hair follicle*. It is formed by the invagination of the stratum germinativum of epidermis.

The base of the hair follicle has a swelling of dermal tissues containing rich supply of blood capillaries. This is called *hair papilla*. It nourishes the hair.

The hair is covered throughout its entire length by the *cuticle*. Below the cuticle the hair is formed of two layers, namely an outer *cortex* and an inner *medulla*.

Sebaceous Glands: It is a branched *cutaneous gland* located by the side of *hair follicle*. It is derived by the out-pushing of hair follicle. Hence it is epidermal in origin. It opens into the hair follicle by a duct.

The secretion of this gland is called *sebum*. It keeps the hair only and water-proof.

Sweat Gland: It is an unbranched, long, tubular, much coiled cutaneous gland. It is derived from stratum germinativum; hence it is epidermal in origin. It opens to the outside on the surface of the skin.

It extracts *nitrogenous waste products* from the blood and disposes out in the form of sweat. It also helps to regulate the body temperature.

Mammary Gland: It is a modified sebaceous gland. It is formed of *alveoli* and *tubules*. It secretes *milk*.

Perineal Gland: It is a modified sebaceous gland. It is situated in the skin around the anus. It opens into the perineal pouches. The secretions are responsible for the characteristic odour of the rabbit.

Meibomian Gland: It is a modified sebaceous gland. It is located below the eyelids in the corner of the eye. It secretes an *oily secretion* which *lubricates the cornea*.

Coelom

Rabbit is a *coelomate* animal. The trunk encloses the coelom. It is divided into two compartments. They are *thoracic cavity* and *abdominal cavity*. The two cavities are separated by a partition called *diaphragm*.

Thoracic Cavity

The thoracic cavity contains two air-tight cavities called *pleural cavities*. They enclose

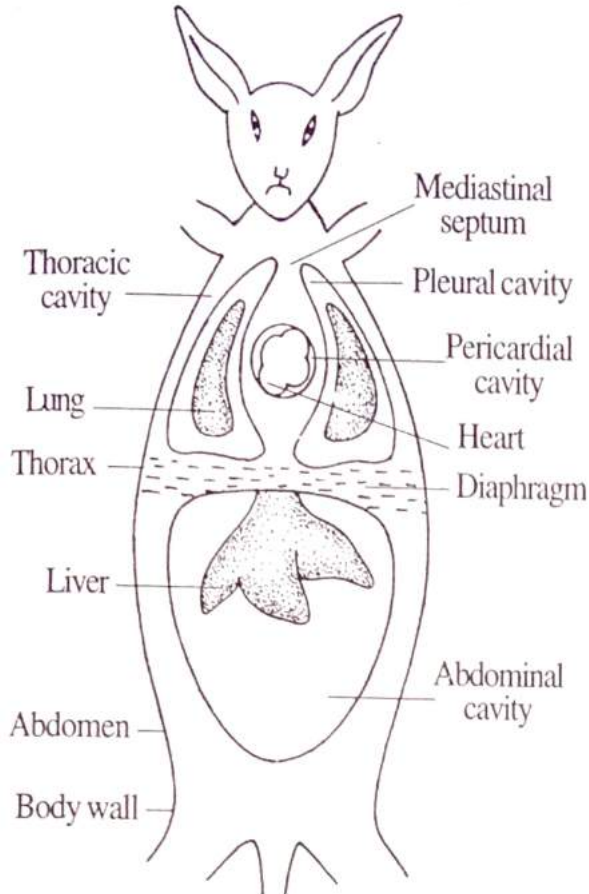


Fig.8.25: Rabbit - Coelomic cavities.

the lungs. The pleural cavity is lined by two layers of peritoneum, namely *pleura*. The inner layer is called *visceral pleuron*. It closely invests the lungs. The outer layer is called *parietal pleuron*. It lines the thoracic cavity.

The very narrow space lying between the two layers is filled with a fluid called *pleural fluid*. The pleural fluid prevents the sticking together of the two layers.

The heart is enclosed by the *pericardium*. The pericardium consists of two layers, namely the outer *parietal pericardium* and inner *visceral pericardium*.

A narrow space called *pericardial cavity* lies between the two layers. It is filled with a *pericardial fluid*.

Abdominal Cavity

The abdominal cavity contains *digestive* and *urinogenital* system. It is lined with an outer *parietal peritoneum* and an inner *visceral peritoneum*. The cavity is filled with a watery fluid which keeps the visceral organs moist.

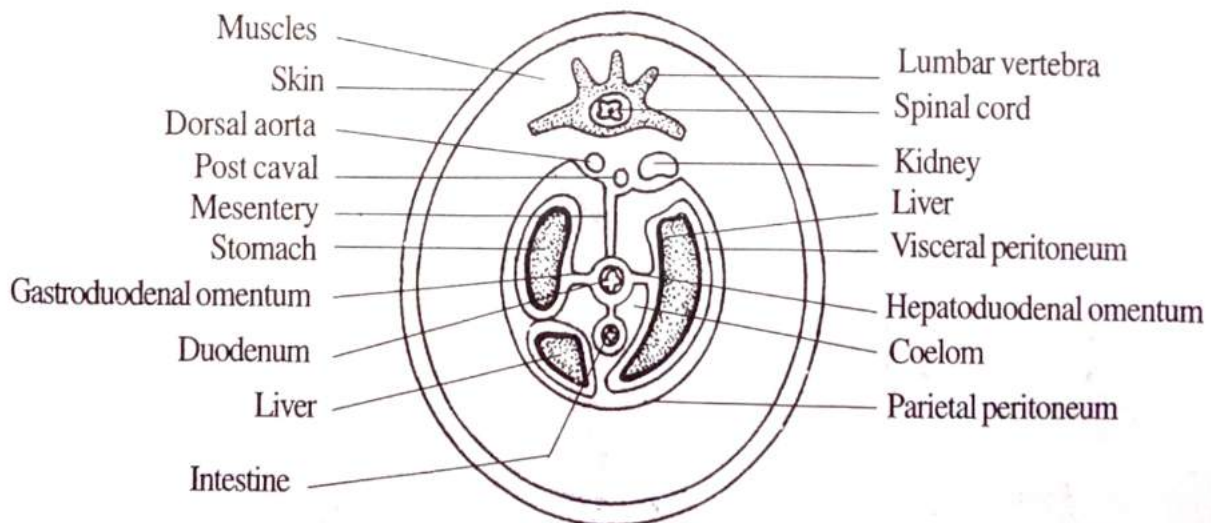


Fig.8.26: Rabbit - T.S. of abdomen through liver.

Mesentery

Mesentery is a double fold of peritoneum which suspends an organ from the body wall. Eg. The *dorsal mesentery* suspends the alimentary canal from the dorsal body wall.

Omentum

Omentum is a double fold of peritoneum which connects the stomach with some other internal organ. Eg. *Gastroduodenal omentum* connects the stomach with the duodenum.

Ligament

Ligament is a double fold of peritoneum which joins any two internal organs other than the stomach. Eg. *Hepatoduodenal ligament* joins the liver and the duodenum.

Diaphragm

Diaphragm is a characteristic feature of mammals. It is absent from other vertebrates.

It is a transverse partition lying between the thoracic cavity and the abdominal cavity.

The diaphragm is convex towards the thoracic cavity and concave towards the abdominal cavity.

Diaphragm assists in bringing breathing movements by altering its shape.

Digestive System

The digestive system includes the organs concerned with food-grinding, swallowing, digestion, absorption and egestion.

It consists of two components, namely *alimentary canal* and *digestive glands*.

Alimentary Canal

Alimentary canal is a coiled tube extending between mouth and anus and through which food passes. It includes mouth, vestibule, buccal cavity, pharynx, oesophagus, stomach, small intestine, caecum, large intestine and anus.

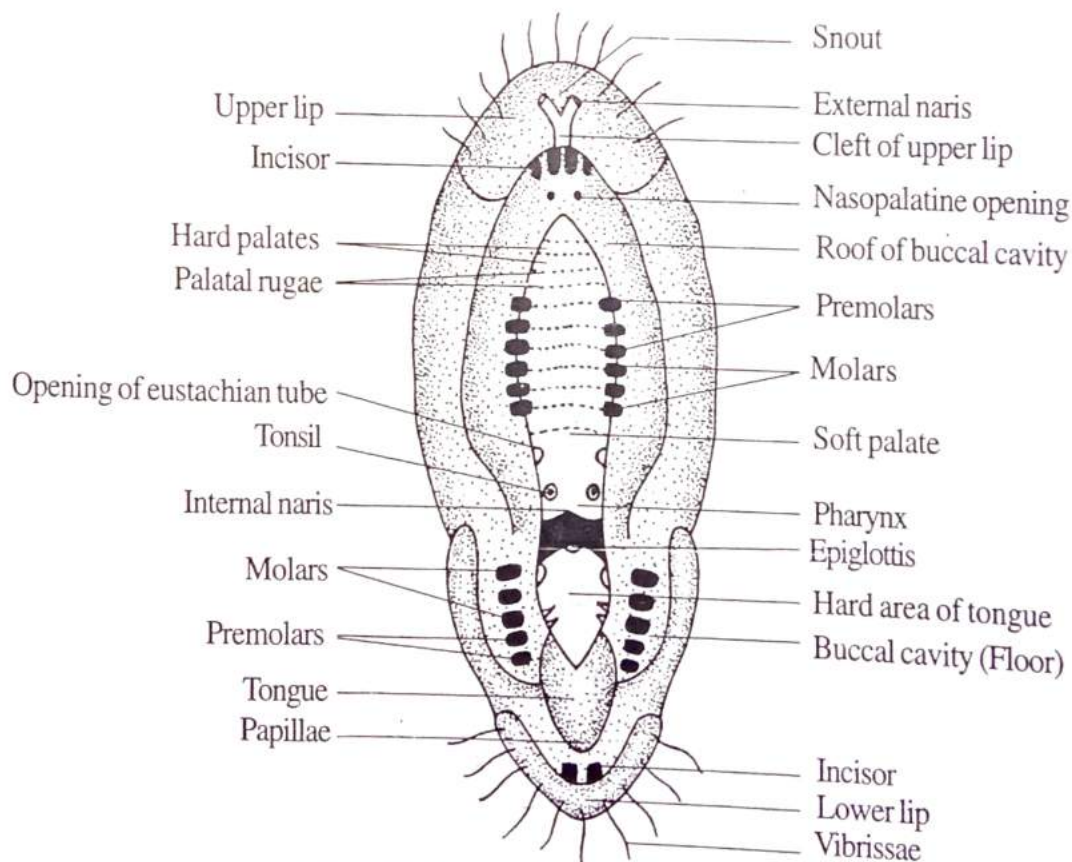


Fig.8.27: Rabbit - Buccopharyngeal cavity.

The alimentary canal starts from the **mouth**. It is bounded by two **lips**, an **upper lip** and a **lower lip**.

The upper lip is divided by a vertical cleft extending upto the nostrils. Through this cleft, the front teeth are exposed. This type of lip is called **hare lip**. Hare lip helps gnawing.

The mouth leads into the **buccal cavity**. It is bounded above by the **palate** and on the side by the **jaws**.

The jaws are **upper jaw** and **lower jaw**. They bear teeth. The floor of the buccal cavity contains a **tongue**.

Palate is the roof of the buccal cavity. It remains as a longitudinal partition between **food passage** and **nasal chamber**.

The anterior part of the palate is called **hard palate**. It is internally supported by the palatine processes of premaxilla, maxilla and palatine. The lower surface of the hard palate bears prominent transverse ridges called **palatal rugae**.

The floor of the buccal cavity is occupied by a muscular **tongue**. It is attached by most part of the posterior end and the anterior end is free.

The dorsal surface of the tongue bears numerous elevations called **papillae**. The papillae are of four types, namely **fungiform**, **filiform**, **circumvallate** and **foliate**. The papillae contain **taste buds**.

The tongue has three functions in rabbit:

1. The tongue manipulates the food.
2. It mixes the food with saliva.
3. It assists the teeth for grinding.

The human tongue, in addition, composes the words when speaking.

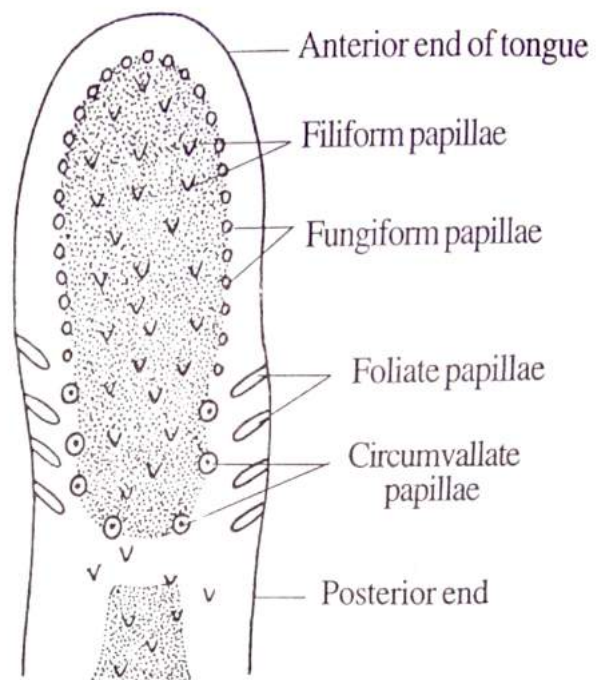


Fig.8.28: Rabbit - Tongue.

The buccal cavity leads into the **pharynx**. It lies beyond the soft palate. The pharynx can be divided into three regions, namely **nasopharynx**, **oropharynx** and **laryngopharynx**.

The **nasopharynx** lies dorsal to the soft palate. Anteriorly, it communicates with the nasal chamber through internal nares.

Laterally, it has a pair of **eustachian openings** leading into the middle ear through **eustachian tubes**. Behind the eustachian openings, a pair of lymphoid tissue, called **tonsils**, lies.

The **oropharynx** lies below the soft palate. It leads into a slit-like opening called **gullet**.

The **laryngopharynx** leads into the **glottis**. The glottis is guarded by a bilobed flap of skin called **epiglottis**.

The gullet leads into a narrow tube called **oesophagus**. It passes through the neck and in the thorax it pierces the **diaphragm** and reaches the abdomen. It serves to convey the food from the pharynx into the stomach.

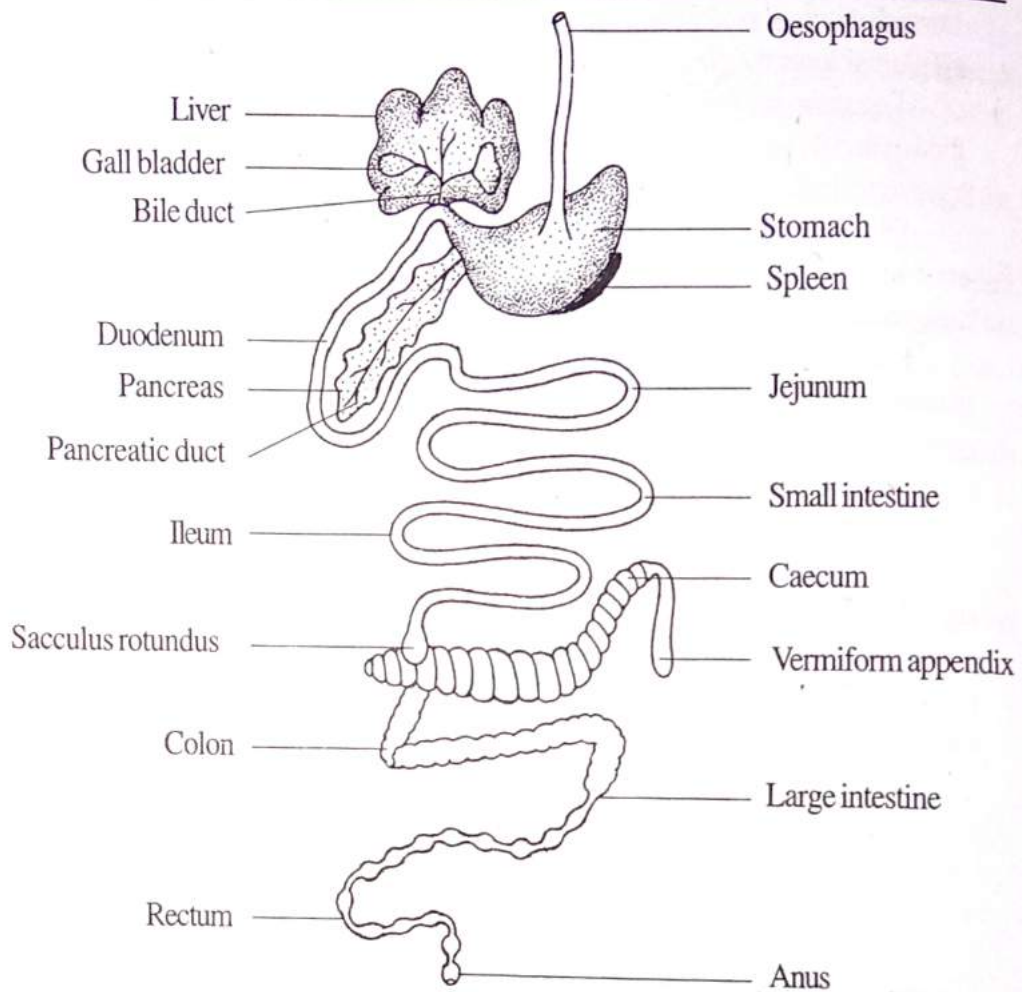


Fig.8.29: Rabbit - Digestive system.

The oesophagus opens into the stomach. It is a curved sac placed transversely at the anterior end of the abdomen. It has an anterior concave side called *lesser curvature* and posterior convex side called *greater curvature*. A *spleen* is attached to the greater curvature of the stomach.

The stomach has three regions, namely an anterior *cardiac stomach*, a middle *fundic region* and a posterior *pyloric stomach*.

The oesophagus opens into the cardiac stomach in the lesser curvature. This opening is called *cardiac aperture*. It is guarded by a valve called *cardiac sphincter* which prevents the passage of food back into the oesophagus.

The pyloric stomach opens into the small intestine by an opening called *pylorus* and is guarded by a valve called *pyloric sphincter*.

The stomach is followed by the *small intestine*. It is narrow coiled and much elongated. It comprises the longest part of the alimentary canal extending a length of 2 - 2.5 metres. It consists of three regions, namely *duodenum*, *ileum* and *saccus rotundus*.

The stomach leads into the *duodenum*. It is U-shaped. It has a *descending limb* and an *ascending limb*. The descending limb receives the *bile duct* and the ascending limb receives a *pancreatic duct*.

The duodenum leads into *ileum*. It is very long and greatly coiled. The internal lining of ileum is raised into numerous *finger*-like processes called *villi*. Villi increase the surface area of the intestine.

The ileum leads into a spherical sac called *sacculus rotundus*.

Caecum is a thin walled sac. It is located between the small intestine and large intestine. It is about one foot long. It has a spiral valve inside. The spiral valve is externally marked by spiral constrictions. The caecum leads into a blind tube called *vermiform appendix*. It is about 10 cm long.

The caecum contains *bacteria* which *digest cellulose*.

The small intestine opens into the *large intestine*. The large intestine helps in the formation, storage and elimination of faeces. It also helps in digestion and absorption. It is about 1 m long. It consists of two regions, namely *colon* and *rectum*.

Colon is the anterior part of the large intestine. On one side it has a longitudinal band called *taenia*. The colon has a sacculated appearance owing to a series of constrictions. The constrictions form *pocket*-like pouches called *haustra*.

The colon leads into the *rectum*. It is about 75 cm long.

It has a beaded appearance owing to the presence of faecal pellets in it.

The rectum opens to the outside by the *anus*. It is guarded by an anal *sphincter*.

Digestive Glands

The glands which help in digestion are called *digestive glands*. They have duct and are called *duct glands*. Their secretions are poured not into blood but into alimentary canal. Hence they are also called *exocrine glands*. Their secretions are called *enzymes*.

Rabbit has six types of digestive glands. They are mucous glands *salivary glands, liver, pancreas, gastric glands and intestinal glands*.)

1. Mucous Glands

Mucous glands secrete *mucus*. It contains mucin which is *proteinaecious* in nature. The mucus glands present in the *digestive tract*. They are mainly found in the lining of the vestibule. The mucus helps in the moistening and swallowing of food in the buccal cavity. The mucous lining throughout the alimentary canal protects it from the action of enzymes.

2. Salivary Glands

Salivary glands secrete *saliva*. They are present in the head. Their secretions are poured into the buccal cavity by *salivary ducts*.

Rabbit has *four pairs* of salivary glands. They are named according to their locations. They are

1. *Parotid glands*, situated at the base of the pinna.
2. *Infra-orbital glands*, situated below the orbits,
3. *Submandibular* or *submaxillary glands*, located near the angles of the jaws.
4. *Sublingual glands*, situated below the tongue.

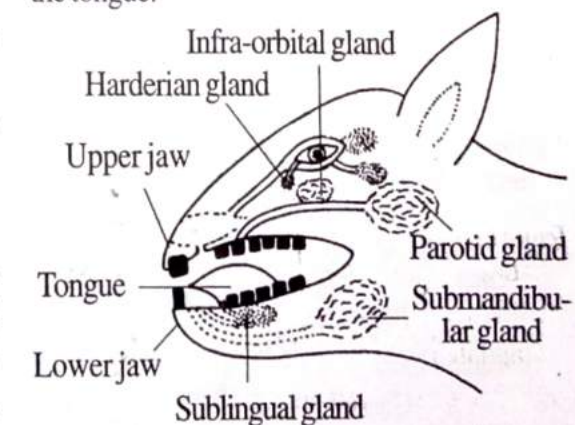


Fig.8.30: Rabbit - Salivary glands

The saliva mixes with the food in the buccal cavity. It functions as a lubricant for swallowing.

It also contain an enzyme called *ptyalin*.

3. Liver

Liver is the *largest digestive gland*. It is dark red in colour. It remains in the concavity of the diaphragm in the abdomen. It is attached to the diaphragm by a *suspensory ligament*.

The liver is formed of five lobes, namely a *caudate lobe*, a *right central* or *cystic lobe*, a dorsal *spigelian lobe*, a left *central lobe* and a left *lateral lobe*.

An elongated thin walled sac called *gall bladder* lies in the right central lobe. The liver cells secrete *bile*. It is stored in the gall bladder. Bile is a *greenish fluid*.

A duct arises from the gall bladder. It is called *cystic duct*. From each lobe arises a duct called *hepatic duct*. The hepatic ducts unite with the cystic duct and a common duct is formed. This common duct is called *bile duct*. The bile duct opens into the descending limb of duodenum near the pylorus.

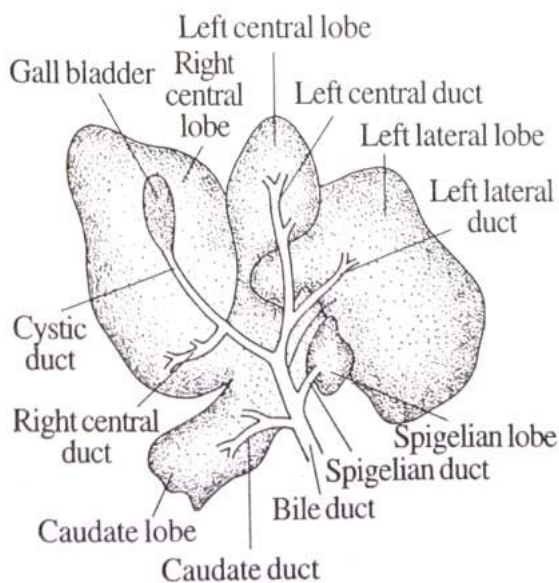


Fig.8.31: Rabbit - Liver.

4. Pancreas

Pancreas is an irregular *pinkish* gland located between the two limbs of the duodenum. It secretes *pancreatic juice* which is carried to the ascending limb of the duodenum by a *pancreatic duct*.

The pancreatic juice contains several enzymes like *trypsinogen*, *chymotrypsinogen*, *amylase*, *lipase*, *nucleases*, *nucleotidases* and *exopeptidases*.

The pancreas also contains an endocrine gland called *islets of Langerhans*. It secretes *insulin*.

5. Gastric Glands

The mucous membrane of the stomach contains numerous branched glands called *gastric glands*. They are of three types, namely *cardiac gastric glands*, *fundic gastric glands* and *pyloric gastric glands*. They secrete *gastric juice*.

The gastric juice contains, *pepsinogen*, *renin* and *hydrochloric acid*.

6. Intestinal Glands

The mucous membrane of the small intestine contains numerous, simple, tubular glands called *intestinal glands*. They secrete *intestinal juice* or *succus entericus*. It contains *mucous* and many enzymes such as *exopeptidases*, *nucleosidases* and *enterokinase*.

Feeding

Rabbit is a *herbivorous* animal. It feeds on green leaves, vegetables, grasses, cereals, roots, barks, etc.

The incisors cut the food materials. Food pieces are taken in by the lips. The premolars and molars grind the food materials.

Mucous and saliva are added to the masticated food. In the buccal cavity, the tongue mixes well and makes the food into a ball called *bolus*. The bolus is swallowed

through the gullet. During swallowing, the epiglottis closes the glottis.

Digestion is a process where the complex food materials are broken into simple materials by mechanical and chemical means.

Digestion starts in the buccal cavity, continues in the stomach and it is completed in the small intestine.

Rabbit and other herbivorous animals cannot digest cellulose because they do not contain cellulase. The caecum of these animals contain large number of *symbiotic bacteria*. They digest cellulose into sugars.

The semi-digested food present in the stomach is called *chyme*.

In the intestine, the chyme is converted into a watery emulsion called *chyle*. Chyle is ready for absorption.

Absorption refers to the diffusion of digested food materials into the blood and lymph. It occurs mainly in the *ileum* and also in the *colon*.

The efficiency of absorption in the ileum is increased by the great length of ileum, slow movement of digested food in the ileum and the presence of *villi*.

The *amino acids* and *sugars* are absorbed through the capillaries. The *fatty acids* and *glycerol* are absorbed through the lacteal (lymph vessel).

The undigested materials pass into the colon. In the colon, most of the water is reabsorbed.

In the rectum, the faeces form small pellets which are eliminated through the anus. This process is called *defaecation* or *egestion*.

Coprophagy

Rabbit has the habit of eating its own faeces. This habit is called coprophagy. Faeces produced during night alone are eaten up which are soft and moist owing to incompletely digested cellulose. Faeces

produced during day are dry and hard and not at all eaten.

By eating the faeces rabbit is able to extract the entire nutrients lost in the faeces. If the rabbit is prevented from eating its own faeces, it will die.

Teeth

Teeth are hard *bone*-like structures used to cut, tear and grind the food materials. The study of the structure, arrangement and function of teeth is called *dentition*.

They are present in a single row on the upper jaw and lower jaw. The basal portion of the teeth is embedded in sockets of the jaw bones. This type of teeth is called *thecodont* (L, *theca*-case of sheath; G, *odous*-teeth).

Rabbit has two set of teeth in its life time. The first set persists in the young rabbit and it is called *milk dentition* or *deciduous dentition*. It is lost in young and is replaced by another set in the adult. This second set of teeth is called *permanent dentition*.

The existence of two sets of teeth in the life of an animal is called *diphyodont dentition*.

In rabbit, the teeth are of different types. Hence the dentition is called *heterodont*.

Structure of a Typical Tooth

The tooth is a derivative of epidermis and dermis. A tooth consists of three regions, namely *crown*, *neck* and *root*.

The crown is the exposed part. The neck is the middle portion of the tooth and is surrounded by a soft fleshy skin called *gum*. The root is embedded in a socket of the jaw bone.

The tooth is made up of a substance called *dentine*. The tooth encloses a cavity in the centre called *pulp cavity*. The pulp cavity contains *pulp*. The pulp consists of a gelatinous connective tissue with blood vessels, lymph vessels and nerve fibres. The pulp cavity has a

canal at the base called *pulp canal*. Through the pulp canal blood vessels, nerve fibres, etc. enter the pulp cavity. The pulp cavity is lined by dentine forming cells called *odontoblasts*.

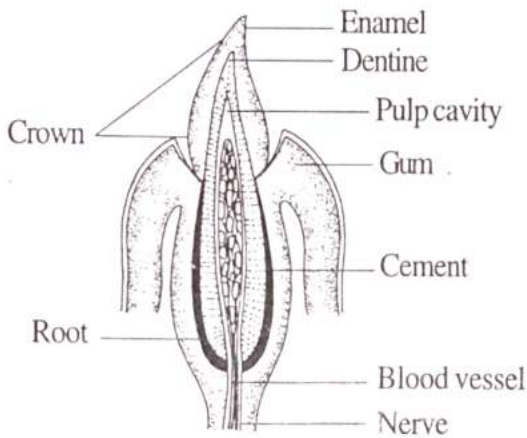


Fig.8.32: Rabbit - A typical tooth in vertical section.

The crown is coated with a white shining *calcareous* material called *enamel*. The root is coated with another substance called *cement*.

In rabbit, the pulp canal remains open permanently. This type of tooth is called *open rooted*. As the tooth receives blood throughout life, the tooth grows. But the size of the tooth remains constant as it wears when it is used.

In man, the pulp canal closes after the full growth of the tooth. Such a type of tooth is called *close rooted*. The close rooted tooth does not grow as the blood supply is denied.

Types of Teeth

A typical mammal has four types of teeth. They are, *incisors*, *canines*, *premolars* and *molars*. But rabbit has only three types of teeth. The canines are absent.

Incisors are the *front teeth* and are *chisel-shaped*. They are used for cutting and hence they are also called *cutting teeth*. They are single rooted.

The premolars and molars are collectively called *cheek teeth*. They have broad surfaces used for grinding. Hence they are also called *grinding teeth*.

The premolar tooth has two roots and the molar has more than two roots.

There remains a gap between incisors and premolars in the upper jaw and lower jaw. This gap is called *diastema*. Diastema is due to the absence of canines.

Diastema is present in herbivorous animals only. In carnivorous animals, this place is occupied by the canines.

Diastema helps to identify a skull, whether it belongs to a herbivorous or carnivorous animal.

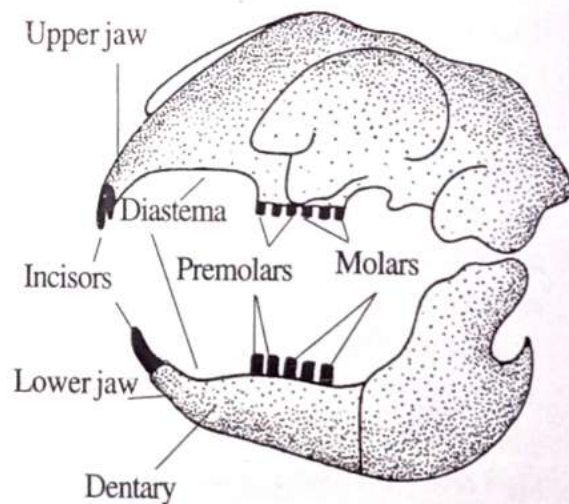


Fig.8.33: Rabbit - Dentition.

Dental Formula

The number and arrangement of teeth in a species of mammal can be represented in the form of a formula called *dental formula*. In dental formula, the types of teeth are represented by their first letters *i*, *c*, *p* and *m*. The teeth on the upper and lower jaws are separated by a horizontal line. The teeth on one side of the upper jaw and lower jaw are recorded in dental formula because the teeth

on both sides are identical. The dental formula for rabbit and a few mammals are given below:

Rabbit

$$i \frac{2}{1}, c \frac{0}{0}, p \frac{3}{2}, m \frac{3}{3} = \frac{8}{6} \times 2 = 28$$

Man

$$i \frac{2}{2}, c \frac{1}{1}, p \frac{2}{2}, m \frac{3}{3} = \frac{8}{8} \times 2 = 32$$

Opposum

$$i \frac{5}{4}, c \frac{1}{1}, p \frac{3}{3}, m \frac{4}{4} = \frac{13}{12} \times 2 = 50$$

Horse

$$i \frac{3}{3}, c \frac{1}{1}, p \frac{4}{4}, m \frac{3}{3} = \frac{11}{11} \times 2 = 44$$

Elephant

$$i \frac{1}{0}, c \frac{0}{0}, p \frac{0}{0}, m \frac{3}{3} = \frac{4}{3} \times 2 = 14$$

Dog

$$i \frac{3}{3}, c \frac{1}{1}, p \frac{4}{4}, m \frac{2}{3} = \frac{10}{11} \times 2 = 42$$

Respiratory System

Rabbit is a *terrestrial animal*. So it exhibits *aerial* or *pulmonary respiration* where atmospheric air is used by lungs.

The respiratory system of rabbit consists of two components, namely 1. *Respiratory tract* and 2. *Respiratory organs* or *lungs*.

1. Respiratory Tract

Respiratory tract is the passage through which air passes from the atmosphere to the

lungs and back. It consists of the following parts:

The respiratory system communicates to the exterior by a pair of openings called *external nares*. They are situated at the tip of the snout.

The external nares lead into two chambers called *nasal chambers* or *olfactory chambers*. They are situated above the buccal cavity and are separated from the buccal cavity by the *palate*. The two nasal chambers are separated from each other by a cartilaginous partition called *nasal septum*.

The nasal chamber has three functions:

1. The olfactory epithelium of the nasal chamber functions as the *olfactoreceptor* or *the organ of smell*.

2. The air chamber functions as the air conditioner to bring up the temperature of the inhaled air to that of the body.

3. The hairs present in the nasal chamber function as a sieve to filter the dust particles of the air.

The two nasal chambers open into the pharynx by a pair of openings called *internal nares*. The region of the pharynx, where the internal nares open, is called *nasopharynx*.

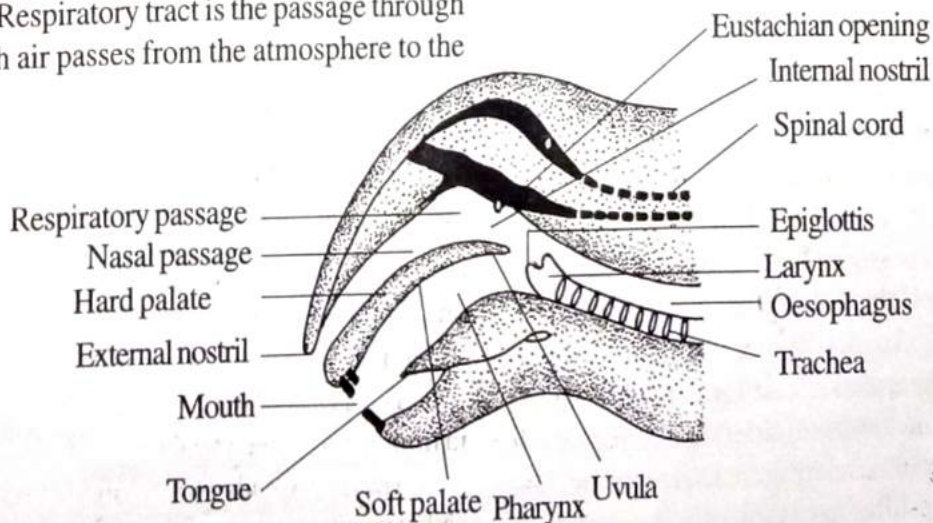


Fig.8.34: Rabbit-V.S. of head showing respiratory and digestive passages.

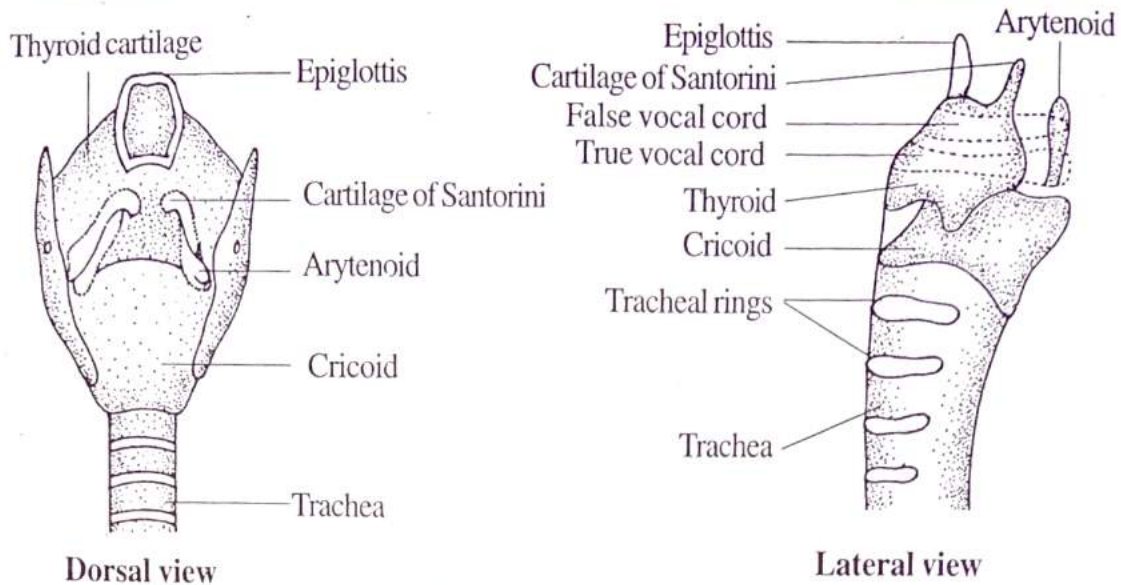


Fig.8.35:Rabbit - Larynx.

The posterior end of the soft palate hangs down into the nasopharynx as a small flap called *uvula*. The uvula raises up to close the internal nares during swallowing.

The floor of the pharynx has a slit-like opening called *glottis*. It is guarded by a bilobed flap called *epiglottis*. The epiglottis closes the glottis during swallowing to check the entry of food into the larynx.

The glottis leads into a chamber called *larynx*. It serves as the *voice box*.

The wall of the larynx is supported by 4 cartilages, namely a *thyroid* cartilage, a *cricoid* cartilage, two *arytenoid* cartilages.

The thyroid cartilage is large and shield-like and supports the larynx on the ventral and lateral sides.

The cricoid cartilage is signet ring-like and lies posterior to the thyroid cartilage. It is broad on the dorsal side and narrow on the ventral side.

The arytenoid cartilages are small and are present on the dorsal side of the laryngeal wall. Each arytenoid cartilage at its anterior end bears a nodule-like cartilage called *cartilage of Santorini*.

The cavity of the larynx is called *laryngeal chamber*. The laryngeal chamber contains two pairs of membranous folds. These are called *vocal cords*. They stretch dorsoventrally across the cavity. They are attached to arytenoid cartilages dorsally and to the thyroid cartilage ventrally and laterally.

The anterior two vocal cords are called *false vocal cords* and the posterior two are called *true vocal cords*.

Sound Production

In mammal, sound is produced by the vocal cords. When not in use, the vocal cords lie at an acute angle to one another and the glottis is wide for allowing air for respiration.

For the production of sound, the vocal cords are brought parallel to and closer to each other by the action of laryngeal muscles. Now air is passed over the vocal cords from the lungs under pressure. This vibrates the vocal cords resulting in sound production.

The quality of the sound is due to alteration in the tension of the vocal cords.

The larynx leads into long thin-walled tube called *trachea* or *wind pipe*. It passes through the neck and enters the thorax.

The trachea divides into two branches called **primary bronchi**. The primary bronchus enters the lung of its side. Inside the lung, the primary bronchi divide into smaller **secondary bronchi** which still divide into **tertiary bronchi**. The tertiary bronchi are further divided into fine tubules called **bronchioles**.

The wall of the trachea and the two primary bronchi are supported by **C-shaped cartilaginous rings**. They are incomplete dorsally.

2. Respiratory Organs or Lungs

Lungs are the **aerial** respiratory organs. Rabbit has a pair of lungs like other vertebrates. They lie inside the thoracic cavity one on either side of the heart.

Each lung is enclosed by two membranes called **pleura**. The outer membrane is called

parietal pleuron. It lines the thoracic cavity. The inner membrane is called **visceral pleuron**. It closely invests the lungs.

A narrow space lies between the two pleura. It is called **pleural cavity**. It is filled with a lubricating watery fluid called **pleural fluid**. It lubricates the pleura and prevents friction when the lungs expand and contract.

The lungs are **soft, spongy, elastic organs**. They are **pink** in colour. The left lung is divided by a cleft into two lobes, namely a **left anterior lobe** and a **left posterior lobe**.

The right lung is divided into four lobes. They are **anterior azygos lobe, right anterior lobe, right posterior lobe** and **posterior azygos lobe**.

In each lung, the bronchioles divide into fine tubules called **alveolar ducts**. Each

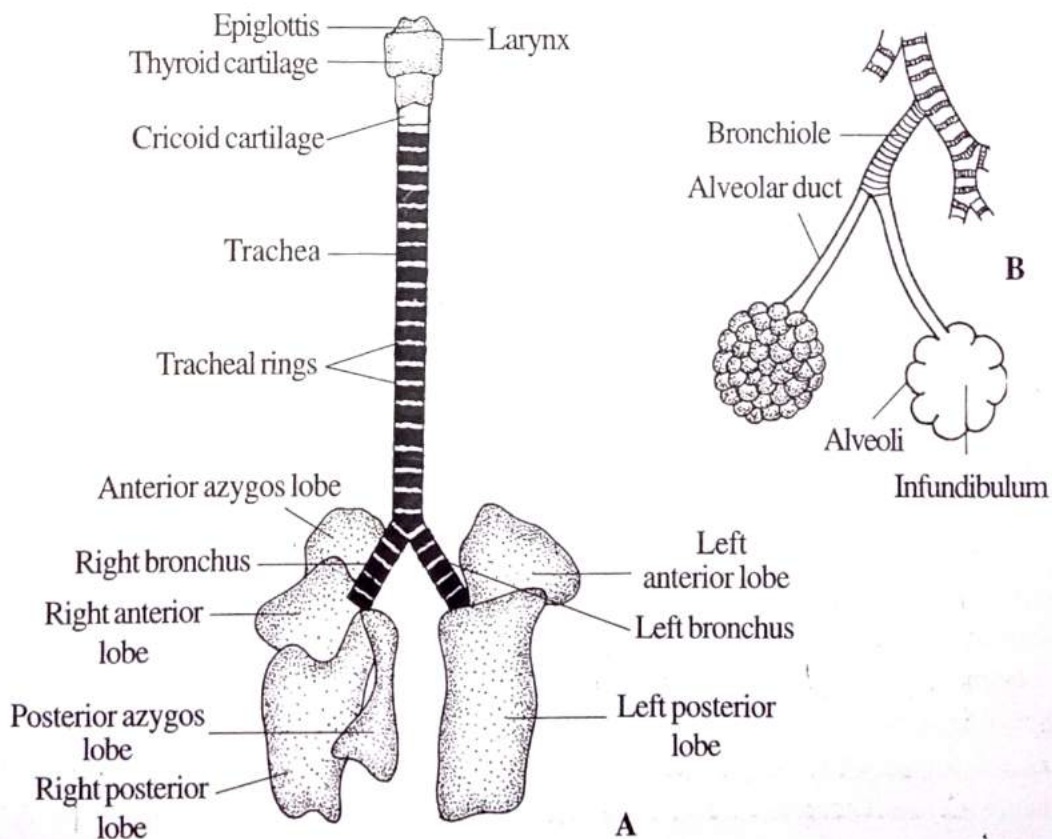


Fig.8.36: Rabbit: A. Respiratory system in ventral view. B. Internal structure of lung.

alveolar duct opens into a chamber called *alveolar sac* or *infundibulum*.

The alveolar sac gives out several small pouches called *alveoli* or *air sacs*. A group of alveoli looks like a bunch of grapes.

The wall of alveolus is extremely thin and is made up of elastic *connective tissue* fibres and surrounded by a fine network of capillaries.

Mechanism of Respiration

Respiration is the taking in of *oxygen* and giving out of *carbon dioxide*. It occurs in two stages, namely *inspiration* and *expiration*.

Inspiration

Inspiration is a stage of respiration where atmospheric air is brought into the lungs and from the lungs oxygen diffuses into the blood and carbon dioxide diffuses into the lungs. It is an active process.

During inspiration the atmospheric air takes the following route: *External nostril* → *Nasal chamber* → *Internal nostril* → *Nasopharynx* → *Glottis* → *Larynx* → *Trachea* → *Primary bronchi* → *Secondary bronchi* → *Tertiary bronchi* → *Bronchioles* → *Alveolar ducts* → *Infundibulum* → *Alveoli* → *Blood*.

The inspiration is brought about by the breathing movement.

Expiration

Expiration is a stage of respiration where air from the lungs passes out through the external nares. It is a *passive process*.

During expiration the air returns from the alveolus in the same route through which it has come.

Circulatory System

The various organs and tissues of the body are connected by the circulatory system. It is a

transporting system. It is formed of *blood*, *heart* and *blood vessels* (arteries and veins).

Blood

The blood is *reddish* in colour. It is formed of *plasma* and *corpuscles*. The corpuscles include *red blood cells* (RBC), *white blood cells* (WBC) and *blood platelets*. The RBC is *non-nucleated* and it contains *haemoglobin*.

Heart

The heart is the *central muscular pumping station* of the circulatory system. It is enclosed by a double-layered membrane called *pericardium*.

The pericardium encloses a cavity called *pericardial cavity* which is filled with *pericardial fluid*. It protects the heart from external shocks.

The heart is formed of four chambers, namely two *auricles* and two *ventricles*. The two auricles are separated by an *interauricular septum* and the two ventricles are separated by an *interventricular septum*. Sinus venosus and truncus arteriosus are absent.

The auricles open into the ventricles by *auriculo-ventricular apertures*. The right auriculo-ventricular aperture is guarded by a *tricuspid valve* and the left auriculo-ventricular aperture is guarded by a *bicuspid valve*.

The right auricle receives impure blood through precaval and postcaval veins. The left auricle receives pure blood from lungs through pulmonary veins.

The blood from the right ventricle is carried by pulmonary aorta and that from the left ventricle is carried by carotico systemic aorta.

The ventricle has *papillary muscles* and *chordae tendineae*.

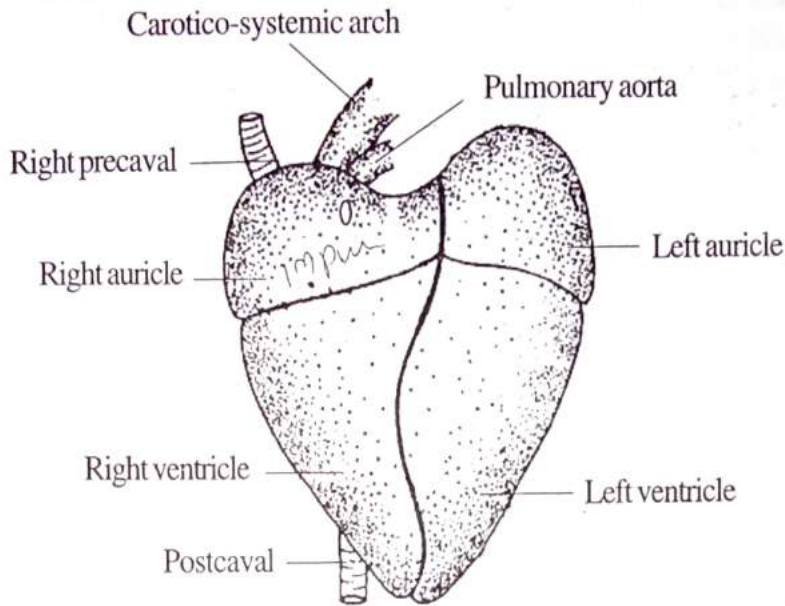


Fig.8.37: Rabbit - Heart in ventral view.

Working of the Heart

The heart has the capacity for rhythmic contraction and relaxation. The contraction is called *systole* and the relaxation is called *diastole*. The *systole* and *diastole* together constitute a *heart beat*.

The heart beat is initiated by a special kind of tissue situated on the inner wall of right auricle, called *sinu-auricular node* or *pace-maker*. The contraction starts from the auricles. The two auricles contract simultaneously. When the auricles contract, the

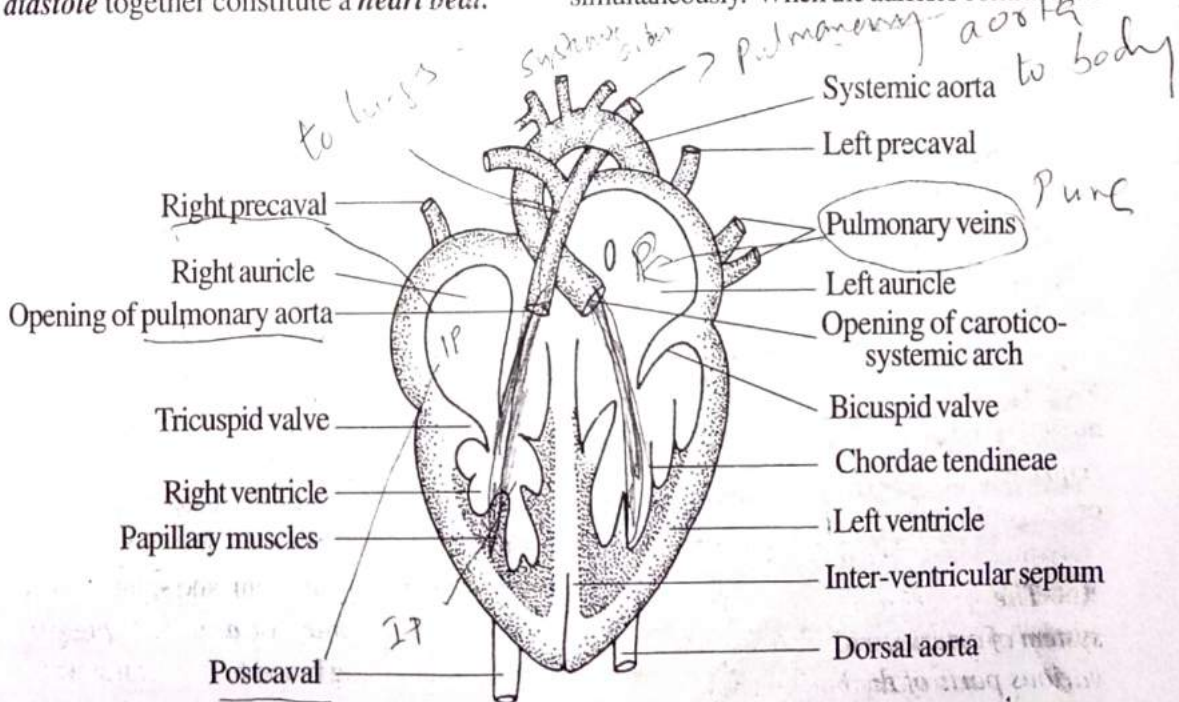


Fig.8.38: Rabbit - Heart in vertical section.

blood enters the ventricles of the respective sides. As soon as the contraction of auricles is completed they relax and blood comes in from the precavals.

When the ventricles are filled with blood, both the ventricles contract simultaneously. The tricuspid and bicuspid valves becomes closed.

The impure blood of the right ventricle flows into the pulmonary aorta. Similarly, the pure blood of the left ventricle flows into the systemic aorta. Then the ventricles relax. The entire process is repeated from auricles to ventricles.

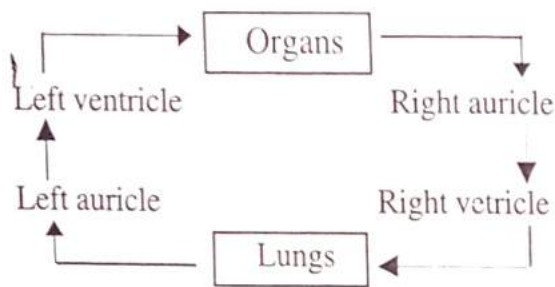


Fig.8.39: Rabbit-Double circulation.

Course of Circulation

In mammals, the blood passes through the heart twice to complete one circuit. This type of circulation is called *double circulation*. The pure and impure blood are kept separate.

The impure blood collected from the various organs are emptied into the right auricle. From the right *auricle* it passes into the right ventricle and then into the lungs.

In the lungs, the blood is oxygenated and the oxygenated blood passes into the left *auricle*. From the left auricle it enters the left *ventricle* and from there it flows to the various organs of the body.

Arterial System

The arterial system is formed of a system of arteries which supply blood to the various parts of the body. They carry pure blood. **Pulmonary** aorta is an exception because it carries impure blood.

Two large vessels called *aortic arches* arise from the ventricles. These are *pulmonary aorta* and *carotico-systemic aorta*. Pulmonary aorta arises from *right ventricle*. It divides into two branches called *pulmonary arteries*. These carry impure blood to the lungs.

The pulmonary aorta and carotico-systemic arch are connected together by a band of ligament called the *ligamentum arteriosum*. It is a functional tubular artery called *ductus arteriosus* in the embryos of mammals and the adults of lower vertebrates.

The *carotico-systemic* aorta arises from the left ventricle. It runs upwards, turns left and runs backwards along the left side of the heart.

At the bending, the carotico-systemic arch produces a median artery called *innominate artery*. The innominate artery immediately gives out *left common carotid artery*. Then the innominate divides into two branches, namely the *right subclavian artery* and the *right common carotid artery*.

The common carotid arteries divide into two branches called *internal carotid artery* and *external carotid artery*. The external carotid artery supplies blood to the superficial regions of head and face. The internal carotid artery supplies blood to the brain.

The carotico-systemic aorta after giving rise to the innominate artery is called *systemic aorta*. By the side of the innominate artery, the systemic aorta gives out another branch called *left subclavian artery*.

The subclavian artery (both left and right) divides into three branches, namely a *vertebral artery* supplying the brain and spinal cord, an *internal mammary* or *anterior epigastric artery* supplying blood to the ventral wall of thorax and a *brachial artery* supplying the fore limb.

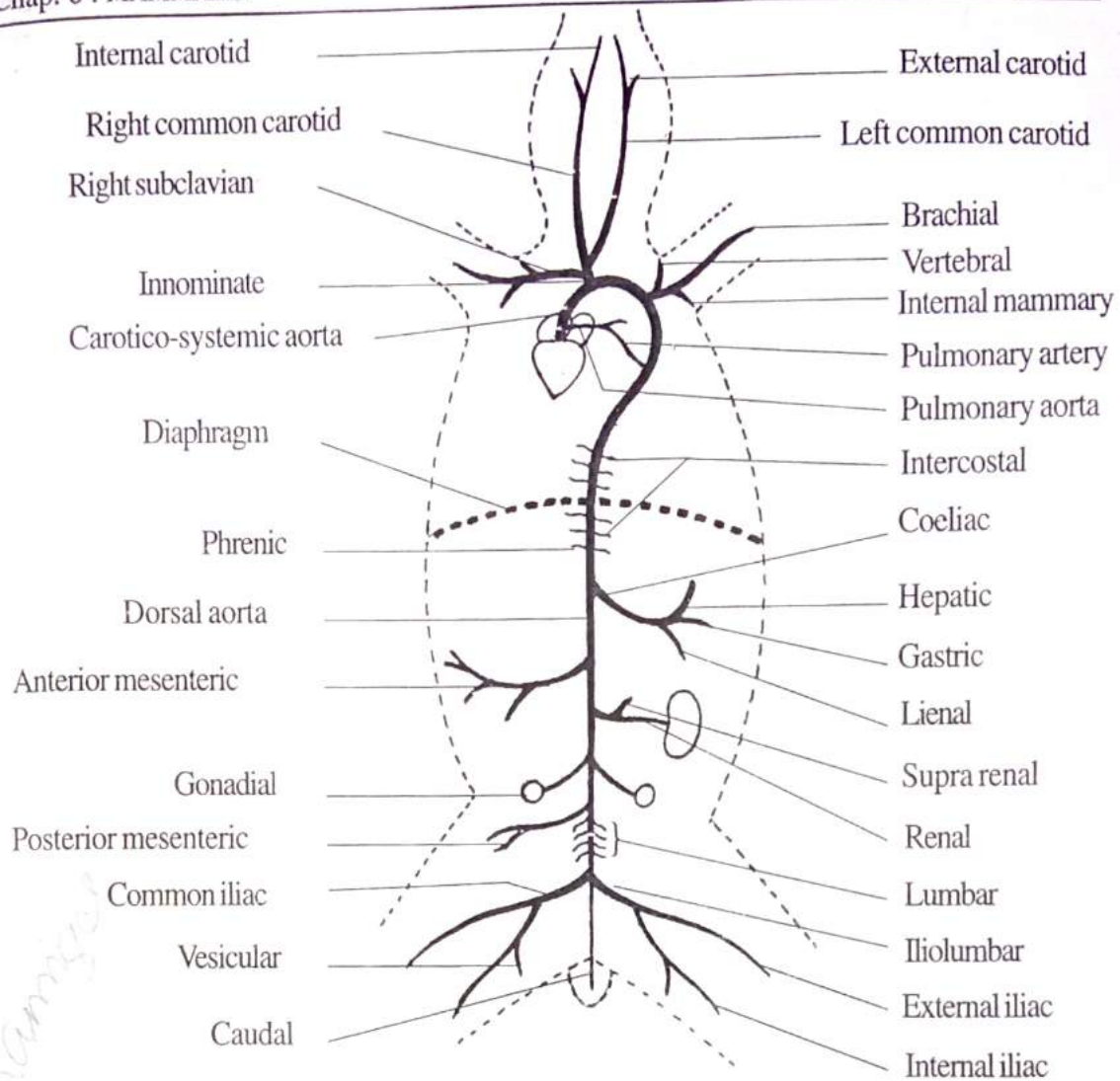


Fig.8.40: Rabbit - Arterial system.

Behind the heart the systemic aorta runs backwards along the mid-dorsal line as the **dorsal aorta**.

Behind the heart the dorsal aorta gives out a series of small paired arteries called **intercostal arteries**. They supply blood to the intercostal muscles located between the ribs.

A pair of **phrenic arteries** arises from the dorsal aorta behind the intercostal arteries and they supply blood to the diaphragm.

Behind the phrenic arteries the dorsal aorta gives out a median artery called **coeliac artery**. It supplies blood to the liver, stomach and

spleen. The coeliac artery immediately divides into two branches, namely **hepatic artery** and **lienogastric artery**. The hepatic artery supplies blood to the liver. The lienogastric artery divides into two branches, namely **gastric artery** supplying the stomach and **splenic artery** supplying the spleen.

Behind the coeliac artery, the dorsal aorta gives out another median artery called **anterior mesenteric artery**. It divides into many branches and supplies blood to the duodenum, pancreas, ileum, colon and caecum.

The kidneys receive **renal arteries** from the dorsal aorta.

The gonads receive *genital arteries*. In the male, they are called *spermatic arteries* supplying the testes and in the female, they are called *ovarian arteries* supplying the ovaries.

Behind the genital arteries, a median *posterior mesenteric artery* arises. It supplies blood to the posterior part of colon and rectum.

Posterior to the posterior mesenteric artery, a pair of *ilio-lumbar arteries* arises. They supply blood to the dorsal wall of the abdomen.

Posteriorly, the dorsal aorta itself divides into two branches called *common iliac arteries*. Each common iliac artery, then divides into two branches, namely *internal iliac artery* and *external iliac artery*. Internal iliac artery passes into the hind limb as the *femoral artery*.

On the way, the external iliac artery gives out three branches, namely *uterine artery* supplying blood to the uterus, *vesicular artery* supplying blood to the urinary bladder and *posterior epigastric artery* supplying blood to the ventral wall of abdomen.

A little in front of the bifurcation of the dorsal aorta, an artery arises. It is called the *sacral artery*. It runs backwards and passes into the tail as the *caudal artery*.

Venous System

The venous system is formed of a set of blood vessels called *veins*. They are the collecting vessels. They collect blood from the various parts of the body and pass it into the auricles. They carry impure blood, but *pulmonary vein* is an exception, it carries pure blood.

The left auricle receives pure blood from lungs through a pair of pulmonary veins. The right auricle receives three large veins, namely a pair of *precaval veins* and a *postcaval vein*. The precaval vein collects blood from the anterior region.

The right precaval vein (anterior venacava) is formed by the union of six veins. They are:

1. *External jugular vein* collecting venous blood from the face and ear.

The right and left external jugular veins are connected by a transverse vein called *jugular anastomosis*.

2. *Internal jugular vein* collecting blood from the brain.

3. *Subclavian vein* collecting blood from the fore limb and shoulder.

4. *Internal mammary vein* collecting blood from the ventral wall of the thorax.

5. *Intercostal vein* collecting blood from the anterior intercostal muscles.

6. *Azygos vein* *collecting blood from the posterior intercostal muscles.

The left precaval vein is formed by the union of 5 veins as in the right precaval vein, but the azygos vein is absent.

Both precaval veins open separately into the right auricle.

The *postcaval vein (posterior venacava)* is a large vein. It collects blood from the posterior region of the body.

The postcaval vein originates from the posterior end by the union of two *internal iliac veins* collecting blood from the thigh.

In front of the internal iliacs, a pair of *external iliac veins* opens into the postcaval vein. It receives four branches. They are the following:

1. A *femoral vein* brings blood from the hind limb. It extends upwards as the external iliac.

2. A *posterior epigastric vein* bringing blood from the ventral abdominal wall.

**Azygos = not paired. Azygos vein exists on the right side only.*

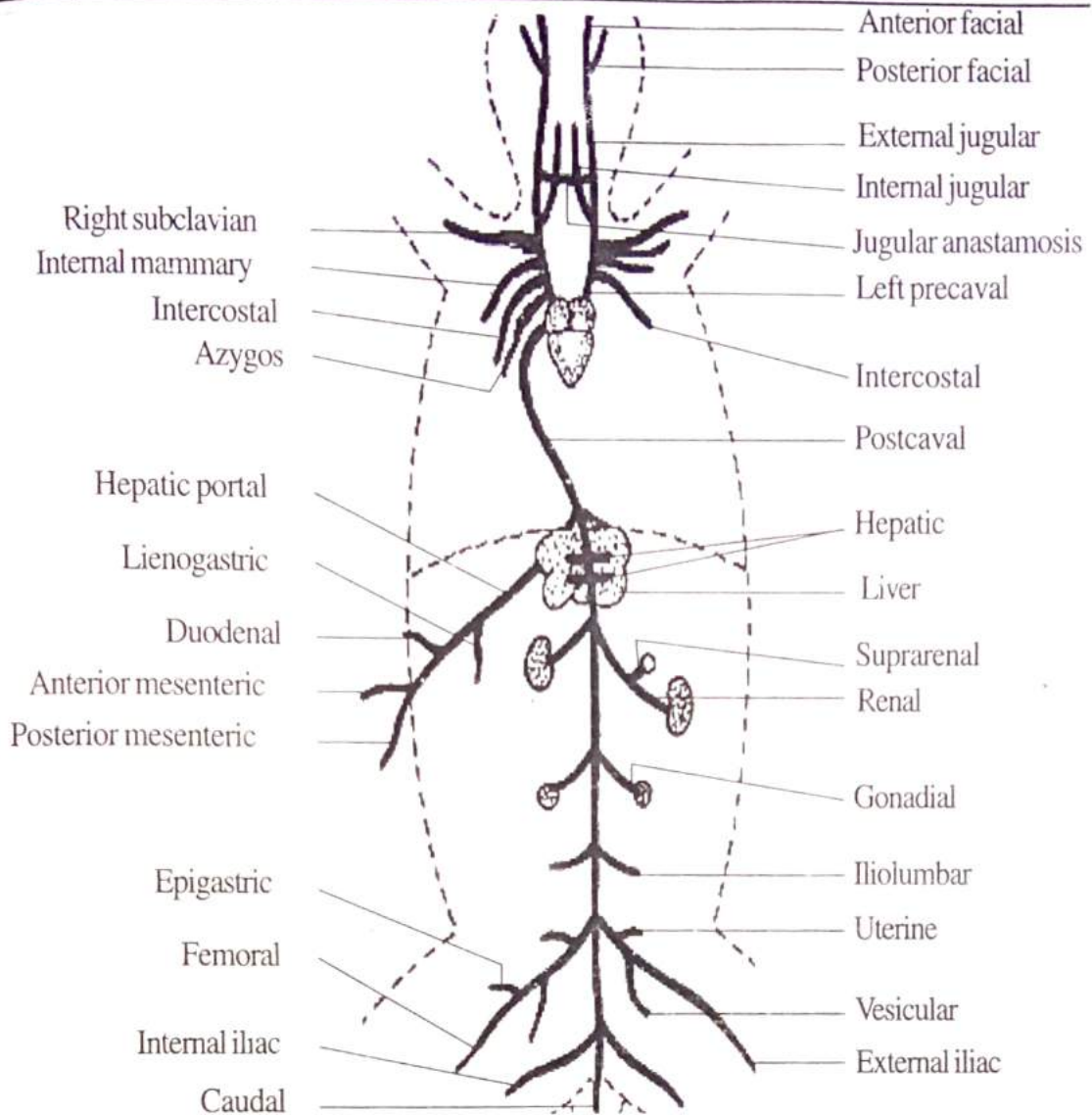


Fig.8.41: Rabbit - Venous system.

3. A **vesicular vein** bringing blood from the urinary bladder.

4. An **uterine vein** collecting blood from the uterus.

In front of the external iliac veins, the postcaval vein receives a pair of **iliolumbar veins**. They bring blood from the dorsal wall of the abdomen.

A pair of **genital veins** collect blood from the gonads and open into the postcaval vein. The genital veins of male are called **spermatic veins** and those of female are called **ovarian veins**.

The blood from the kidney is collected by a pair of **renal veins** which also open into the postcaval vein.

The postcaval vein passes through the liver. On the way, it receives two pairs of **hepatic veins** from the liver.

Portal Systems

The portal system is formed of a system of veins which carry blood from one organ to another organ but not to the heart. There are two portal systems in vertebrates. They are the renal portal system and the hepatic portal system.

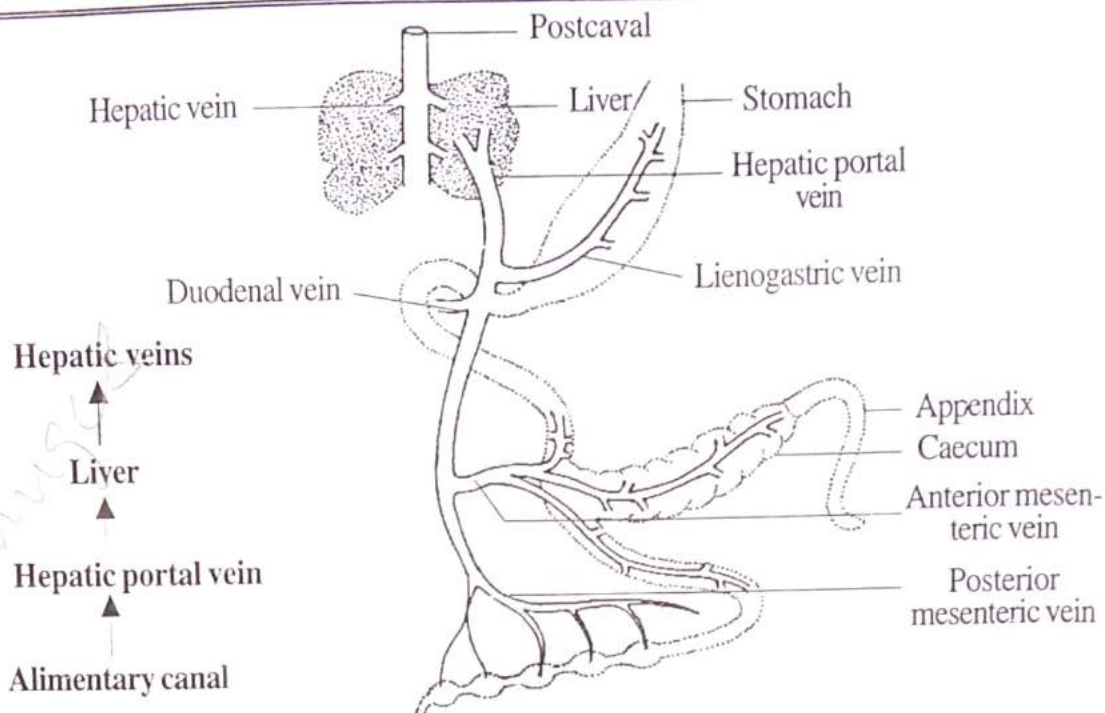


Fig.8.42: Rabbit - Course of circulation in hepatic portal system.

The renal portal system is absent from rabbit. But the hepatic portal system is well developed.

The hepatic portal system is formed of a **hepatic portal vein** which receives blood from the alimentary canal and empties itself into the liver.

The hepatic portal vein is formed by the union of four veins, namely the **lienogastric vein** collecting blood from the stomach and the spleen, the **duodenal vein** collecting blood from the duodenum, the **anterior mesenteric vein** collecting blood from the colon, caecum and ileum and the **posterior mesenteric vein** collecting blood from the rectum and the anus.

From the liver, the blood is carried to the postcaval by the **hepatic veins**.

Significance of Hepatic Portal System: The hepatic portal system transports the digested food from the alimentary canal to the liver directly.

The liver retains the surplus **sugar** coming with the blood, converts it into **glycogen** and stores it for later use.

The liver also deaminates the **proteins** and converts the resulting harmful **ammonia** into the harmless **urea**.

Double Circulation: The presence of 4 chambers helps to keep the pure and impure blood separately. The right side of the heart serves to keep the venous blood.

The right auricle receives venous blood. It passes to the lungs through the ventricle. This is called **venous circulation**.

The left side of the heart contains only oxygenated blood. The oxygenated blood is received from the lungs and is sent to the body. This is called **systemic circulation**.

Thus there is no mixing of venous and oxygenated blood in the heart and the blood passes through the heart twice, once along the pulmonary circuit and second time in the

systemic circuit. This is known as *double circulation*. It is a characteristic feature of birds and mammals.

Lymphatic System

Lymphatic system is a system of lymph vessels which transport lymph from the tissues to the blood.

All vertebrates possess a lymphatic system. It consists of *lymph, lymph capillaries, lymph vessels* and *lymph nodes*.

1. Lymph

The lymph consists of two parts,

1. *Plasma*
2. *White corpuscles*.

Both these components escape from blood through the thin walls of blood capillaries. The plasma oozes out by *ultrafiltration* and the white corpuscles come out by amoeboid movement.

The plasma and white corpuscles present in the intercellular spaces of the tissues form the *tissue fluid*. The excess of tissue fluid slowly enters the *lymph* capillaries, it is the lymph.

2. Lymph capillaries

The lymph is drained into a network of *lymph capillaries* located in the tissue spaces.

The walls are formed of simple *epithelium* which is permeable to *protein* molecules.

3. Lymph vessels

The lymphatic capillaries join to form the *lymphatic vessels*. All the lymphatic vessels join to form two main ducts, the *thoracic duct* and the *right lymphatic duct*.

The vessels are provided with *valves* which keep the lymph flowing in *one direction*.

4. Lymph nodes

The lymph node consists of a meshwork of *connective tissue fibres* enclosed in a *capsule*. The lymph nodes produce the *lymphocytes* of the blood.

Functions

The lymphatic system serves as an intermediary between blood and the tissues.

The tissue fluid or the lymph maintains a constant chemical environment around the tissues.

The lymph nodes produce and maintain the lymphocytes of the blood.

Nervous System

The nervous system is formed of three systems, namely the *central nervous system*, the *peripheral nervous system* and the *autonomous nervous system*.

The central nervous system is formed of *brain* and *spinal cord*.

The peripheral nervous system is formed of *cranial nerves* and *spinal nerves*.

The autonomous nervous system includes *sympathetic* nervous system and *parasympathetic* nervous system.

Brain

The brain is enclosed in a *bony cranium*. Inside the cranium the brain is protected by three membranes called *meninges*. They are an outer *duramater*, an inner *piamater* and a middle *arachnoid membrane*.

The brain has three major divisions. They are the following:

Forebrain or *prosencephalon*

Midbrain or *mesencephalon*

Hindbrain or *rhombencephalon*

Forebrain

The forebrain has three main parts, namely *olfactory lobes, cerebral hemispheres* and *diencephalon*.

At the anterior end of the brain two *olfactory lobes* or *bulbs* are situated. They enter into the brain as *olfactory tracts*.

The forebrain has two *cerebral hemispheres*. They are large. They are narrow in front but broad behind. The two

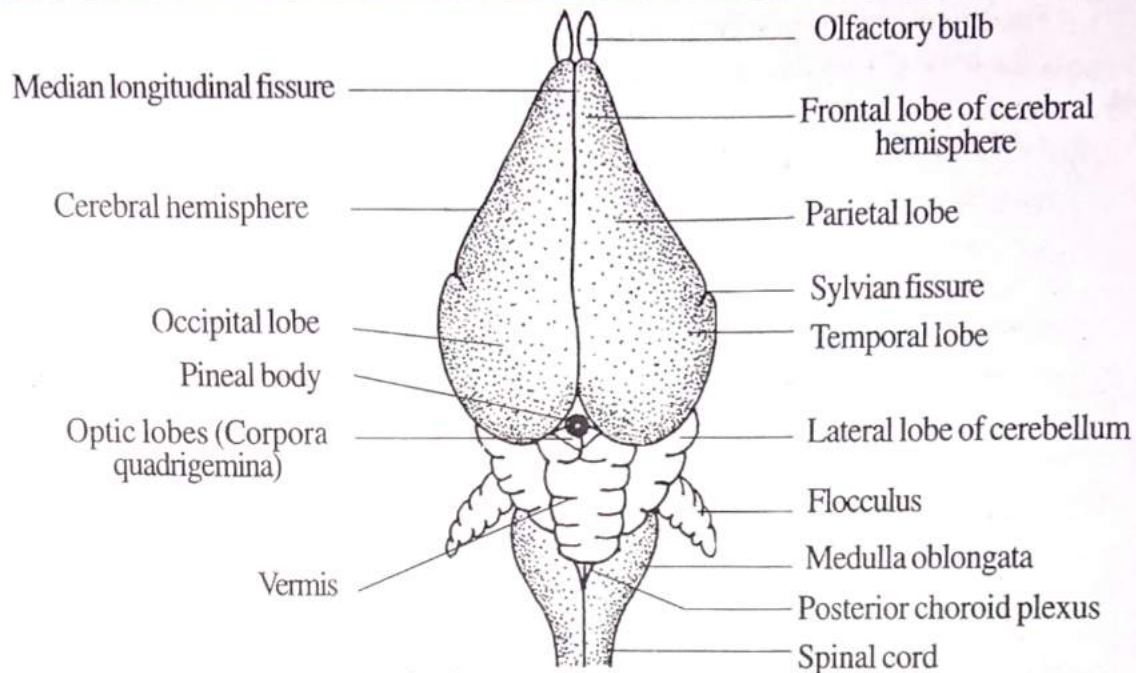


Fig.8.43: Rabbit - Brain in dorsal view.

cerebral hemispheres are separated by a *longitudinal median fissure*.

The two cerebral hemispheres are connected on the roof by a transverse band of nerve tissue called *corpus callosum*.

The lateral walls and floor of the cerebral hemispheres are formed of *corpus striatum*. The two corpora striata are connected by a transverse *anterior commissure*.

Each cerebral hemisphere has a lateral constriction called *sylvian fissure*.

The sylvian fissure divides the cerebral hemisphere into an anterior *frontal lobe*, a posterior *temporal lobe* and a central *parietal lobe*.

Ventrally the cerebral hemisphere has two longitudinal grooves, namely *rhinal fissure* and *hippocampal fissure*.

There are *two cavities* inside the cerebral hemispheres. They are called *I* and *II ventricles* or *lateral ventricles*. They are filled with *cerebrospinal fluid*.

The *diencephalon* lies behind the cerebral hemispheres. It encloses a cavity called *III ventricle*.

The *I* and *II* ventricles open into the *III ventricle* by a opening called *foramen of Monro*.

The roof of the *III ventricle* is called *epithalamus*, the floor is called *hypothalamus* and the thickened lateral walls are called *optic thalami*.

The two optic thalami are connected by a mass of nerve cells called *middle commissure*.

The roof of diencephalon gives out an outgrowth called *pineal stalk* containing an endocrine gland called *pineal gland*.

The roof of the diencephalon is highly vascular and is called *anterior choroid plexus*.

Ventrally the floor of diencephalon projects out as a funnel called *infundibulum*. Its lower end carries a *Rathke's pocket* or *hypophysis*.

The infundibulum and the Rathke's pocket are together called *pituitary gland*.

Posterior to the pituitary gland there is a rounded body called *corpus albicans*.

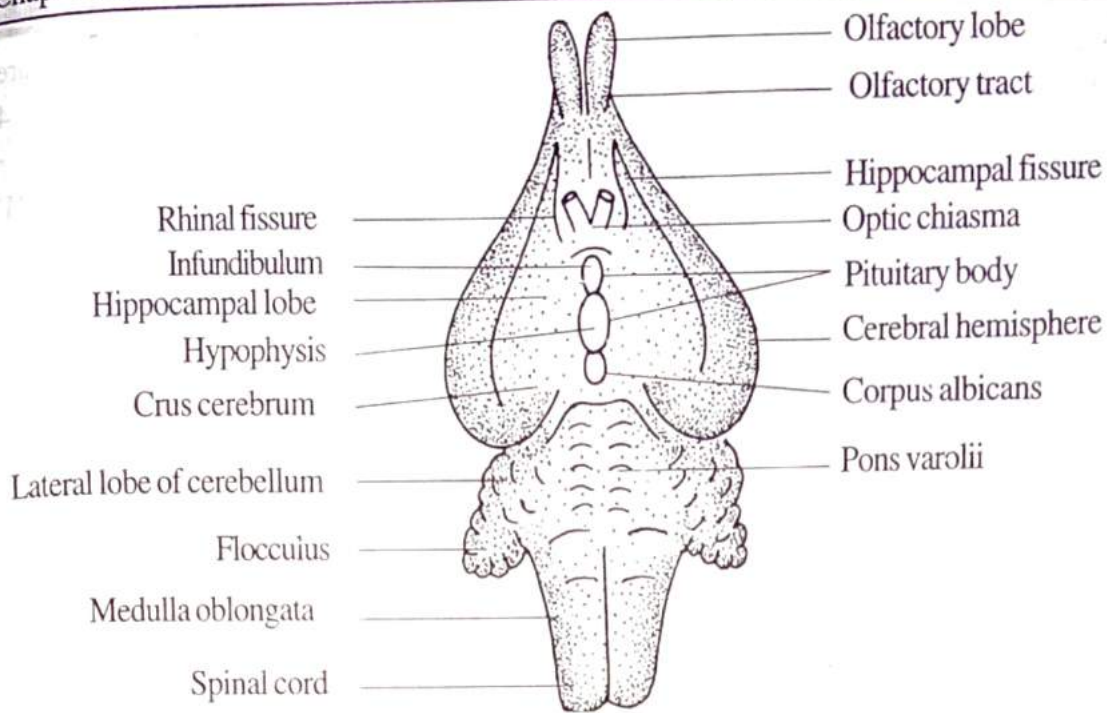


Fig.8.44: Rabbit - Brain in ventral view.

In front of the pituitary gland, the two optic nerves cross each other to form an X-shaped structure called *optic chiasma*.

Midbrain

The midbrain or *mesencephalon* is the *middle part* of the brain and it is the *smallest region*.

On the dorsal side of midbrain, there are four rounded *optic lobes*. They are together called *corpora quadrigemina*.

The mesencephalon encloses a narrow canal called *iter* or *aqueduct of Sylvius*. It

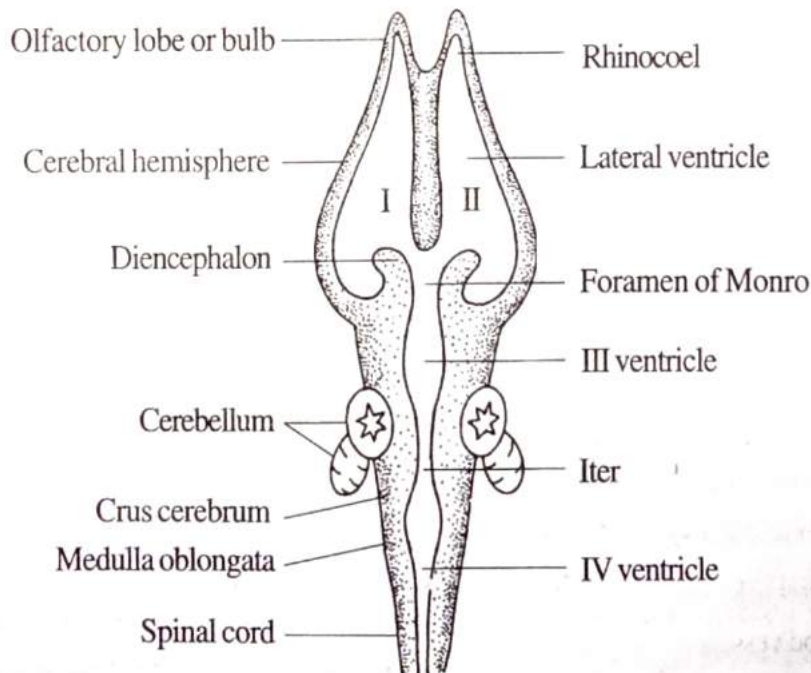


Fig.8.45: Rabbit - L.S. of brain to show ventricles.

communicates with the III ventricle in front and the IV ventricle behind.

The floor of it has thick tracts of fibres called *crura cerebri*. They link the fore brain with the hind brain.

Hindbrain

The hindbrain or rhombencephalon is the posterior region of the brain. It encloses a cavity called *IV ventricle*.

Anteriorly it communicates with it and posteriorly it passes into the *central canal* of the spinal cord.

The hindbrain contains three main parts, namely *cerebellum*, *pons varolii* and *medulla oblongata*.

The *cerebellum* consists of 5 lobes, namely a middle *vermis*, two *lateral lobes* and two *flocculi*.

The *pons varolii* is a transverse band of nerve fibres located on the ventral side of the hindbrain.

Medulla oblongata is the posterior part of brain. It encloses the *IV ventricle*.

The roof is non-nervous and is formed of a network of capillaries called *posterior choroid plexus*.

Ventricles

The cavities present inside the brain are called *ventricles*. The vertebrate brain has 4 ventricles. They are *I* and *II ventricles* or *lateral ventricles*, *III ventricle* and *IV ventricle*.

The *I* and *II ventricles* lie inside the cerebral hemispheres.

The *III ventricle* lies inside the diencephalon.

The *I* and *II ventricles* open into the *III ventricle* by a *Y-shaped* opening called *foramen of Monro*.

The *IV ventricle* lies inside the medulla oblongata.

The *III ventricle* is communicated to the *IV ventricle* through a narrow canal called *iter* or *aqueduct of Sylvius*.

The ventricles of the brain are filled with a *cerebrospinal fluid*.

Spinal Cord

The spinal cord is a part of the central nervous system. It lies within the *neural canal* of the vertebral column. It starts from the *medulla oblongata* of the brain. It passes backwards and extends into the tail as the *filum terminale*.

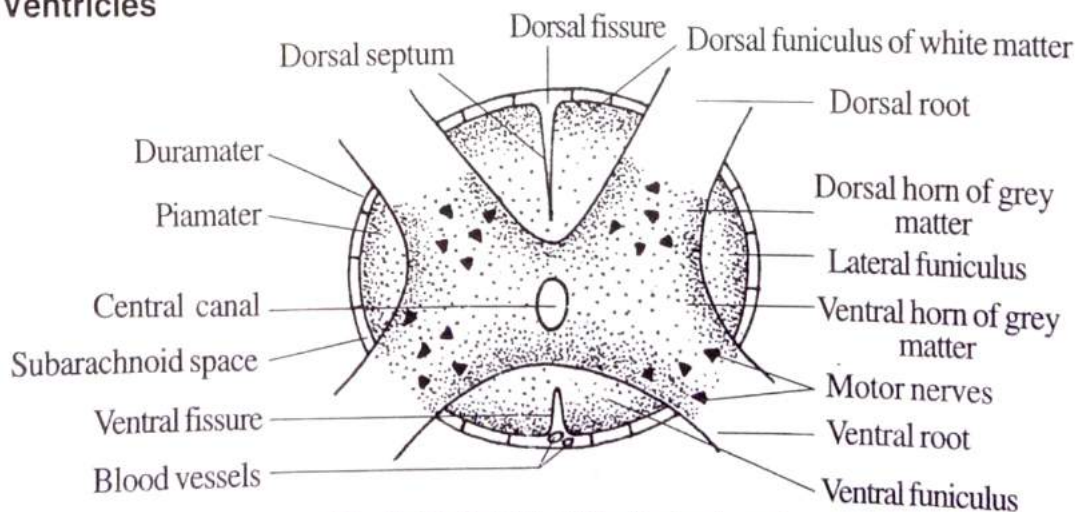


Fig.8.46: Rabbit - T.S. of spinal cord.

The spinal cord shows two *swellings*, one at the level of fore limb called *brachial swelling* and the other at the level of hind limb called *sciatic swelling*. Nerves to the limbs arise from these swellings.

Like brain, the spinal cord is also covered by three *meninges*. They are an outer *duramater*, a middle *arachnoid membrane* and an inner *piamater*. There is a space between the arachnoid membrane and *piamater* is called *subarachnoid space* and filled with *cerebrospinal fluid*.

Along the mid-ventral line, the spinal cord has a *groove* called *ventral fissure*. Similarly, there is a *groove*, but not deeper, on the mid-dorsal line called *dorsal fissure*.

A thin vertical sheet of connective tissue extends along the mid-dorsal line. It is called *dorsal septum*.

The centre of the spinal cord contains a longitudinal canal called *central canal*. It is filled with *cerebrospinal fluid*.

The spinal cord is made up of *nervous tissues*. They are arranged in two layers, namely a central *grey matter* and a peripheral *white matter*.

The grey matter is *H-shaped* or *butterfly-shaped*. The centre of grey matter has the *central canal*. The grey matter is mainly made up of *nerve cells*.

The grey matter is projecting dorsally and ventrally into four *horns*. They are two *dorsal horns* and two *ventral horns*. The roots of spinal nerves are attached to the *horns*.

The white matter is made up of *nerve fibres*. The white matter is divided into four *columns* or *funiculi* by the horns of the grey matter. They are a *dorsal funiculus*, a *ventral funiculus* and a pair of *lateral funiculi*.

Functions: The spinal cord has two main functions. 1. It conducts *sensory* and *motor impulses* to and from the brain.

2. It acts as a centre for *spinal reflexes*. Thus it reduces the brain's.

Cranial Nerves

Cranial nerves arise from the brain. There are *12 pairs* of cranial nerves in mammals. Of these, the first 10 pairs are similar to those of *fishes* and *amphibians*. The twelve pairs of cranial nerves are the following:

1. *Olfactory nerve*
2. *Optic nerve*
3. *Oculomotor nerve*
4. *Trochlear or pathetic nerve*
5. *Trigeminal nerve*
6. *Abducens nerve*
7. *Facial nerve*
8. *Auditory nerve*
9. *Glossopharyngeal nerve*
10. *Vagus nerve*
11. *Spinal accessory nerve*
12. *Hypoglossal nerve*

1. Olfactory Nerve: It arises from the anterior end of the *olfactory lobe of brain*. It innervates the olfactory organ and Jacobson's organs. It is concerned with *smell*. It is a *sensory* nerve.

2. Optic Nerve: They arise from the *diencephalon*. They cross each other to form a *cross* called *optic chiasma*.

The crossing is *incomplete* in mammals, especially primates due to *binocular vision*. About half of the nerve fibres of each nerve pass to the same side of the brain.

The optic nerve supplies the *retina*. It is a *sensory* nerve and it is concerned with the *sense of sight*.

3. Oculomotor Nerve: It starts from the *cerebrum*. It innervates the *eye muscles*, *iris* and *ciliary body*. It is a *motor* nerve and it controls the movement of *eyeball*, *iris*, *ciliary body* and *lens*.

4. Trochlear or Pathetic Nerve: This nerve originates from the dorsal surface of the brain between the *corpora quadrigemina* and

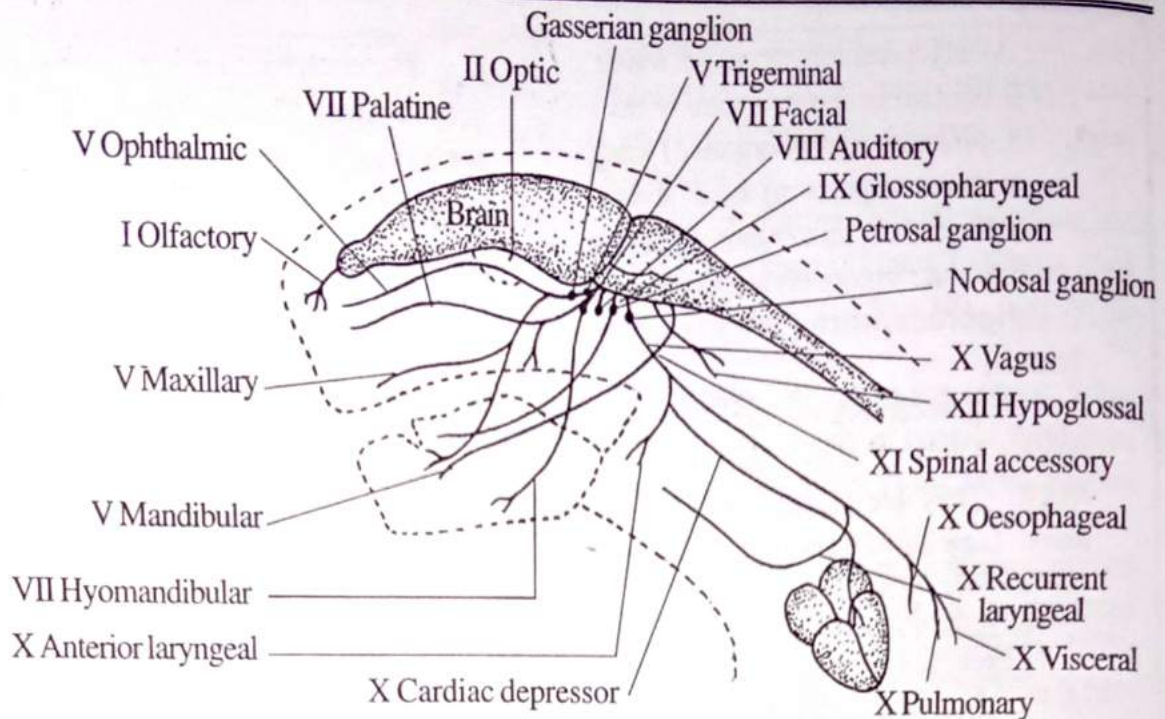


Fig.8.47: Rabbit - Cranial nerves.

the *cerebellum*. It supplies the *eye muscles*. It brings about the *rotation* of the *eyeball*. It is a *motor* nerve.

5. Trigeminal Nerve: It is a *mixed nerve* with *sensory* and *motor functions*. It starts from the *medulla oblongata*. It bears a ganglion called *Gasserian ganglion*. From the ganglion three branches arise. They are called *ophthalmic*, *maxillary* and *mandibular*.

Ophthalmic nerve is a *sensory* branch. It innervates conjunctiva, cornea, iris, ciliary body, lacrimal gland, mucous membrane of nasal sac and skin of forehead, snout and eyelids. It is concerned with the sense of touch.

Maxillary nerve is a *sensory* nerve. It innervates *lower eyelid*, *sides of snout*, *vibrissae*, *upper lip*, teeth of upper jaw and palate. It is concerned with the sense of touch.

Mandibular nerve is a *mixed nerve* with *sensory* and *motor nerve fibres*. Sensory fibres innervate the skin of temporal region, external ear, lower part of the face and lower

lip, mucous membrane of the anterior part of the tongue and teeth of lower jaw. The motor fibres innervate the lower jaw muscles.

6. Abducens Nerve: It arises from the ventral side of the *medulla oblongata*. It innervates the eye muscles and nictitating membrane. It is a *motor nerve*. It brings about the rotation of eyeball and the movement of nictitating membrane.

7. Facial Nerve: It is a *mixed* nerve. It controls taste, mastication, facial expression, neck movements and activation of salivary glands. It arises from the lateral side of the facial nerve. It bears a ganglion called *geniculate ganglion*. It divides into three branches, namely *palatine*, *chorda tympani* and *hyomandibular*.

Palatine nerve innervates the epithelium of palate. It is a *sensory* nerve. It is concerned with the sense of touch.

Chorda tympani innervates the taste buds of tongue. It is a *sensory* nerve and is concerned with the sense of taste.

Hyomandibular nerve is a mixed nerve with sensory and motor fibres. The motor nerves supply the muscles of lower jaw, face, hyoid, neck, pinna and salivary glands.

The hyomandibular nerve is concerned with facial expression, mastication and neck movements.

8. Auditory Nerve: Auditory nerve originates from the side of medulla oblongata. It bears a ganglion called *acoustic ganglion*. It divides into two branches, namely *vestibular nerve* and *cochlear nerve*.

They supply the inner ear. Auditory nerve is a sensory nerve. It controls equilibrium and hearing.

9. Glossopharyngeal Nerve: It is a *mixed* nerve. It controls, taste, touch, blood pressure, pharyngeal contractions and secretion of saliva. It starts from the side of medulla oblongata. It bears a *petrosal ganglion*. It has two branches, namely *lingual* and *pharyngeal*.

Lingual is a *sensory* nerve. It innervates the taste buds of the tongue and the mucous membrane of pharynx and *carotid sinus**. It controls the sense of taste and blood pressure.

Pharyngeal is a *motor* branch. It innervates the muscles of pharynx and the parotid salivary gland. It controls pharyngeal contraction and salivary secretion.

10. Vagus Nerve: Vagus nerve is the X nerve. It arises from the side of medulla oblongata. This nerve has two ganglia, one inside the cranium called *jugular ganglion* and the other outside the cranium called *nodosal ganglion*.

* *Carotid sinus* is a slight dilation at the origin of the internal carotid artery and contains baroreceptors for blood pressure.

The vagus nerve has six branches, namely *anterior laryngeal*, *cardiac depressor*, *recurrent laryngeal* (posterior laryngeal), *oesophageal*, *pulmonary* and *visceral nerves*.

Anterior laryngeal nerve innervates mucous membrane of larynx and cricothyroid muscles. It is concerned with touch and sound.

Cardiac depressor innervates heart. It is concerned with heart beat.

Recurrent laryngeal or *posterior laryngeal* innervates the muscles of larynx. It is concerned with the movement of larynx and sound. It is a motor nerve.

Pulmonary nerve innervates the lungs. It is concerned with the movement of lungs.

The *visceral* nerve divides into a few branches and they supply oesophagus, stomach and intestine. The visceral nerve is concerned with the movement of alimentary canal.

11. Spinal Accessory Nerve: It is a motor nerve originating from the medulla oblongata. It consists of a *cranial* and a *spinal part*. The cranial part is composed of fibres derived from the vagus nerve. The spinal part is formed of fibres of a few anterior spinal nerves.

The cranial fibres innervate the muscles of pharynx and larynx. The spinal fibres supply the muscles of neck and shoulder.

The spinal accessory nerve controls the movements of pharynx, larynx, neck and shoulder.

12. Hypoglossal Nerve: It originates from the ventral side of medulla oblongata. It innervates the muscles of the tongue and lower jaw. It brings about the movement of tongue. It is a *motor* nerve.

Spinal Nerves

The nerves arising from the spinal cord are called *spinal nerves*. Rabbit has 37 pairs

of spinal nerves. They are classified into 5 types according to the place of origin. They are as follows:

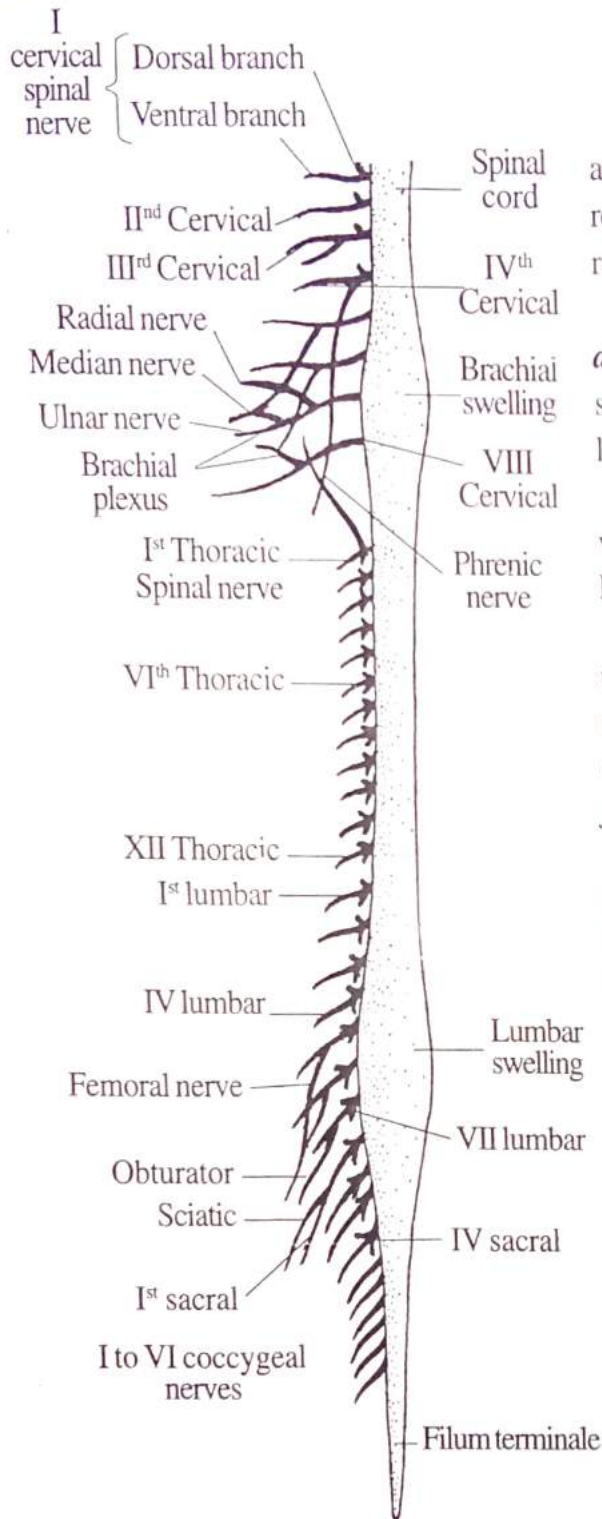


Fig.8.48: Rabbit - Spinal cord and spinal nerves.

<i>Cervical spinal nerves</i>	8 pairs
<i>Thoracic spinal nerves</i>	12 pairs
<i>Lumbar spinal nerves</i>	7 pairs
<i>Sacral spinal nerves</i>	4 pairs
<i>Coccygeal spinal nerves</i>	6 pairs

Each spinal nerve has two roots, namely a *dorsal root* and a *ventral root*. The dorsal root is a continuation of dorsal horn. The dorsal root has only *sensory fibres*.

The dorsal root has a ganglion called *dorsal root ganglion*. The ganglia of all the spinal nerves except that of the second cervical lie within the neural canal.

The ventral root is the prolongation of the ventral horn. It is made up of motor fibres only. It has no ganglion.

Both dorsal and ventral roots unite together to form a single nerve. The union occurs within the neural canal. The single nerve comes out through an *intervertebral foramen*.

Each spinal nerve immediately after coming out of the vertebral column divides into three *branches* or *rami*. They are a dorsal branch called *dorsal ramus*, a ventral branch called *ventral ramus* and a visceral branch called *ramus communicans*.

The dorsal ramus supplies the skin and muscles of the back. The ventral ramus innervates the skin and muscles of the ventral and lateral sides. The ramus communicans joins a ganglion of the autonomic nervous system.

Sense Organ (Sensory Organs)

Sense organs are specialized organs used to detect environmental changes. They receive stimuli from the environment. Hence the sense organs are also called *receptors*. Rabbit has the following sense organs:

Chap. 8 : MAMMALIA

1. Tangoreceptors-organs of touch
2. Gustatoreceptors-organs of taste
3. Olfatoreceptors-organs of smell
4. Photoreceptors-organs of sight
5. Phonoreceptors-organs of hearing
6. Statoreceptors-organs of equilibrium

1. Tangoreceptors (Organs of Touch)

Tangoreceptors receive the *stimuli* of touch. They are also called *the organ of touch*. They are present on the *skin* and *hairs*. They are of three types:

- a. Free nerve endings
- b. Basket nerve endings
- c. Encapsulated nerve endings

a. Free Nerve Endings: Free nerve endings are fine branches of the nerve cells (neurons). They occur on the skin in the hairy parts of the body especially in the *epidermis*.

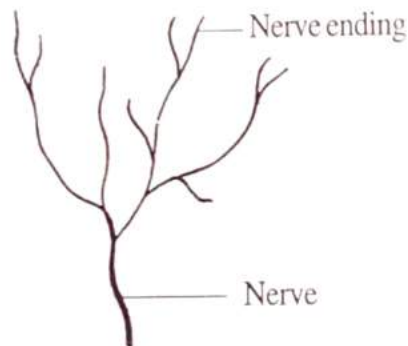


Fig.8.49: Rabbit - Tangoreceptors-Free nerve endings.

b. Basket Nerve Endings: These are fine branches of *neurons* and these branches form a network of basket around the *hair follicles*. They receive the stimuli when a hair is touched or bent. They are present in the hairy parts of the skin.

c. Encapsulated Nerve Endings: These are found in the *hairless parts* of the skin, especially *dermis*. Each encapsulated nerve ending consists of an axon with its branches surrounded by a connective tissue capsule.

The encapsulated nerve endings are of various types. They are *Merkel's corpuscle*, *Meissner's corpuscle* and *Pacinian corpuscle*.

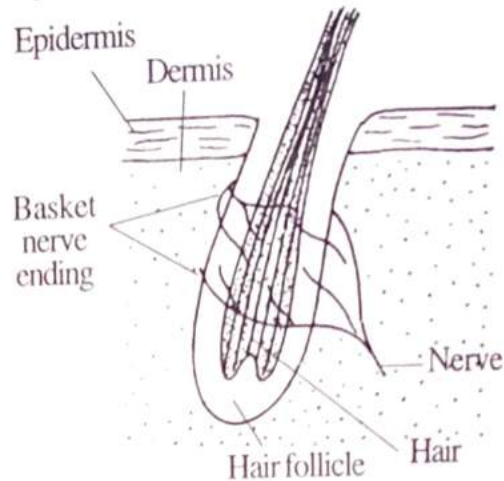


Fig. 8.50:Rabbit - Tangoreceptors.

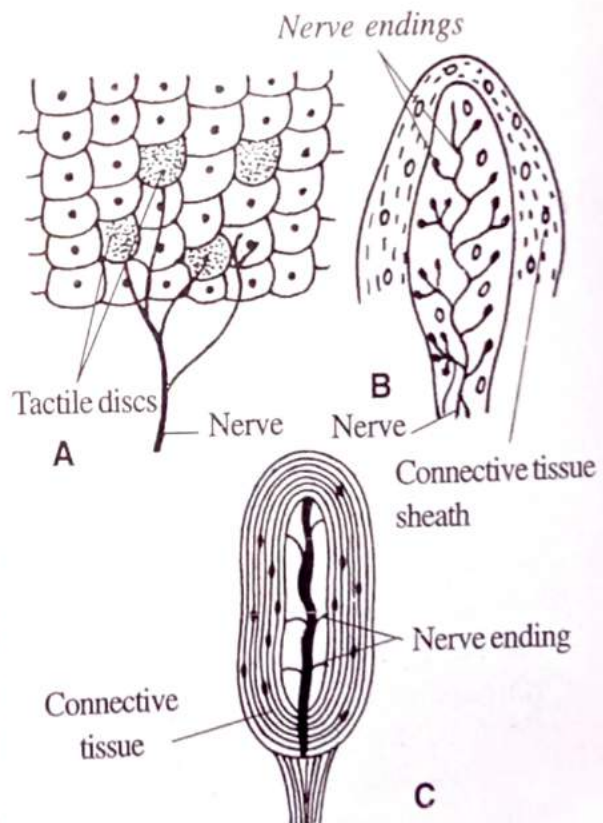


Fig.8.51: Rabbit - Tangoreceptors-A. Merkel's corpuscle, B. Meissner's corpuscle, C. Pacinian corpuscle.

Working of Tangoreceptors: When the hair or the skin comes in contact with an object, the nerve endings are stimulated. It creates impulses in the nerves.

The impulse is carried by the nerves to the *thalamus* and then to the cerebral hemispheres. In the *cerebral hemispheres*, the sensation is felt.

Tangoreceptor receive *humidity, tempera-ture, chemicals, pressure and pain.*

2. Gustatoreceptors (Organs of Taste)

Gustatoreceptors, receive the *taste* stimuli. They are situated on the tongue and soft palate.

The taste receptor cells are arranged in groups called *taste buds*. Each taste bud is situated on an elevation on the tongue called *papilla*.

A taste bud is oval in shape. It lies embedded in the epithelium of the *tongue* or *pharynx*. It consists of two types of cells, namely *receptor cell* and *supporting cells*.

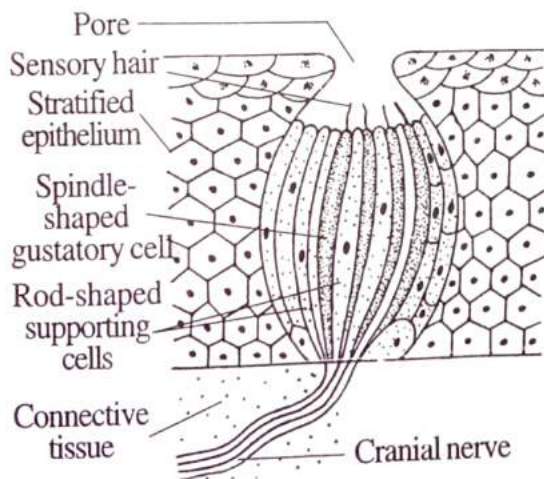


Fig.8.52: Rabbit - A single taste bud in vertical section.

The receptor cells are long, narrow and spindle-shaped. The outer free end of the

receptor cell contains a *sensory hair* and the inner end of the receptor cell is connected to the nerve fibre which is connected to VII or IX cranial nerve.

The supporting cells are also long and narrow but lack sensory hairs and nerve. Each tongue bud opens out by a taste pore on the surface of the tongue.

Working of Gustatoreceptors: When the taste buds come in contact with food (chemicals), the hairs in the taste, bud are stimulated.

In the nerve fibre, the stimuli are converted into impulse which is carried to the thalamus and then to the cerebral hemispheres. In the cerebral hemisphere, the sense of taste is felt.

3. Olfatoreceptors (Organs of Smell)

Olfatoreceptors are *chemoreceptors* which receive the *stimuli* for *smell*. The olfatoreceptors of rabbit consist of a pair of olfactory sacs and a pair of Jacobson's organs.

The olfactory sacs lie enclosed in the olfactory capsules of the skull. The receptor cells for smell lie in the roof of the olfactory sacs.

The roof of the olfactory sacs has a layer of epithelium. The epithelium consists of two types of cells, namely *olfactory cells* and *supporting cells*.

The olfactory cell is a long narrow spindle-shaped cell. The outer end of the cell bears numerous olfactory hairs.

The inner end is connected to a nerve fibre which is connected to the olfactory lobe of the brain.

The supporting cells are columnar occurring between the olfactory cells.

Many tubular *mucous glands* are present in the olfactory epithelium. They open into the nasal chamber. They secrete mucous which spreads over the epithelium to keep it moist.

Working: Olfactoreceptor is a *chemoreceptor*. The olfactory organ is very sensitive compared to taste buds. It can receive the stimulus produced by chemical in gas and in very low concentrations.

For example, the smell of a jasmine flower is due to small chemical molecules carried by the air to the olfactory organs.

The gaseous molecules entering the nasal chambers, dissolve in mucous covering the olfactory cells and stimulate the olfactory hairs. These produce an impulse in the olfactory nerve

Each coat has a specific function. The front of sclera facing the outside world is perfectly transparent and is called *cornea*.

The middle layer is called *choroid coat*. It is highly vascular and pigmented. The pigments absorb light and prevent internal reflections.

The front portion of choroid is interrupted by a small opening called *pupil*. The region of choroid visible through the cornea and

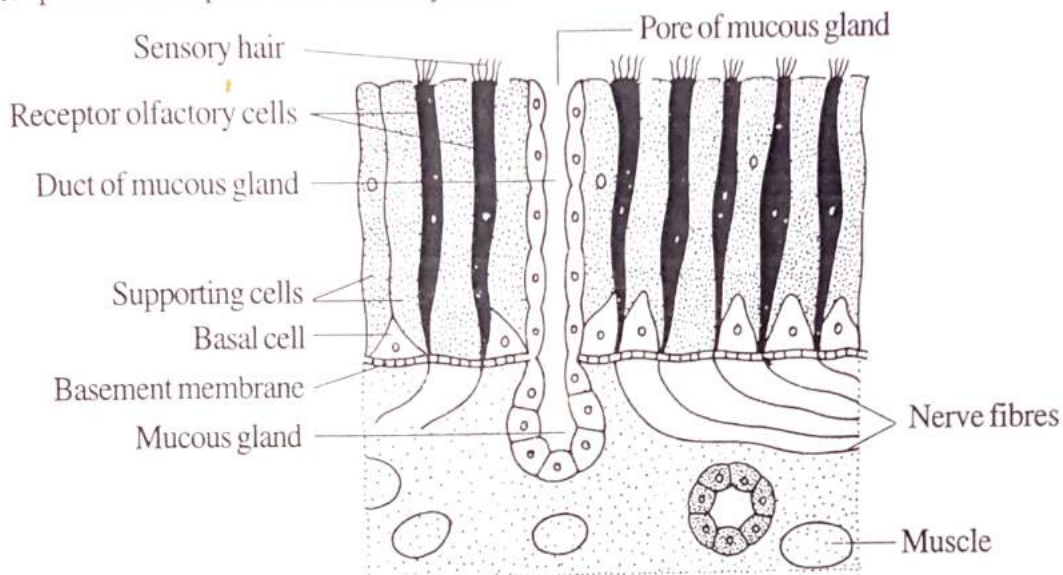


Fig.8.53: Rabbit - Olfactory epithelium with mucous gland in vertical section.

which is carried to the olfactory bulb of the brain. Here the sense of smell is felt.

Jacobson's Organ: Rabbit has a Jacobson's organ in the roof of buccal cavity opening into the mouth cavity. It is lined with olfactory epithelium and effectively smells the content of the mouth.

4. Photoreceptor (Organ of Sight)

The eye is a *photoreceptor*. It is a tender ball. It is about one inch in diameter. It is protected in a socket of the skull called *orbit*.

The eyeball has three concentric coats, namely an outer *sclerotic coat*, a middle *choroid coat* and an inner *retina*.

surrounding the pupil form a coloured band called *iris*.

The pupil is occupied by a *lens*. The lens is an elastic transparent balloon filled with a very clear jelly.

The lens is held in position by the *ciliary body* which encircles the lens. It is a thickened portion of choroid. It contains *ciliary muscles*.

The retina is the innermost layer of the eyeball. It is about the thickness of a postage stamp and not much thicker. It lines two thirds of the back of the choroid.

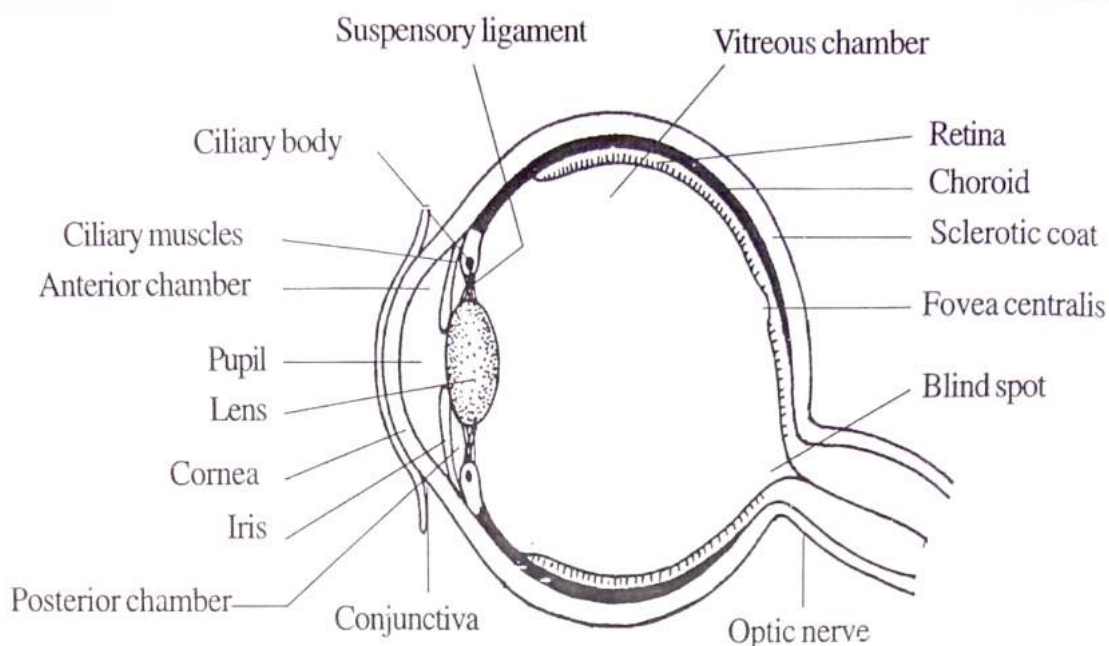


Fig.8.54: Rabbit - Eye.

The retina contains special photo-sensitive cells called *rods* and *cones*. The rods are *cylindrical* in shape and the cones are *pyramidal* in shape.

At the posterior pole of the eye, exactly opposite to the lens, there is a depression called *fovea centralis*. From the fovea, rods are absent; but *cones* are closely packed in it.

The place where the optic nerve leaves the eye is marked by a creamy white disc called *optic disc*. From this area rods and cones are absent. So no vision is effected in this area. Hence this area is called *blind spot*.

The eye encloses cavities filled with a transparent gelatinous fluid called *humour* (humor). The cavity lying between cornea and iris is called *anterior chamber*.

The small cavity lying between the lens and the iris is called *posterior chamber*. These two chambers are filled with a thinner watery liquid called *aqueous humour*. Hence these two chambers are collectively called *aqueous chambers*.

The large cavity lying between the lens and the retina is called *vitreous chamber* *and it is filled with a jelly-like material called *vitreous humour*.

The eye is protected in front of its outer surface by a thin transparent layer of epidermal cells called *conjunctiva*.

The outer skin above and below forms fold called *eyelids*.

The eyelids are provided with hairs called *eye lashes*. Above the upper eyelid is a ridge called *eyebrow* provided with hair.

A third eyelid, the *nictitating membrane* is also present. It lies in the inner corner of the eye. It can be drawn across the cornea for cleaning it and to protect from dust particles.

Eye contains three types of glands, namely *meibomian glands*, *Harderian glands* and *lacrimal glands*.

The meibomian and lacrimal glands are oil glands and their secretions *lubricate* the eyelids and cornea. They facilitate frictionless blinking of eye lashes.

**Vitreous chamber* is not posterior chamber of eye.

The lacrimal gland is situated beneath the upper eyelid towards outer corner. It secretes an antiseptic saline solution called *tears*.

Blinking spreads this fluid over the surface of eye keeping it moist, soft, clean and free from bacteria.

Excess of tears collect towards the inner corner of eye and is drained by a *nasolacrimal duct* into the nasal chamber.

Functions of the Eye

The eye is a *photoreceptor*. Vision is effected by a *photochemical reaction* occurring on the rods and cones of retina.

Cones are concerned with *colour vision* and bright light vision. Rods are concerned with dim light vision.

5. Phonoreceptors (Organs of Hearing)

Phonoreceptor is the hearing organ. The *ear* is the phonoreceptor. The ear has three regions, namely an *external ear*, a *middle ear* and an *inner ear*.

External Ear: The external ear is formed of pinna and the external auditory meatus. The

external auditory meatus is in the form of a tube. Internally, the external auditory meatus ends in a membrane called *tympanic membrane*.

Middle Ear: The middle ear has a cavity called *tympanic cavity*. It contains three ear ossicles arranged in a series, from the tympanic membrane to the inner ear in the order of *malleus* (*hammer-shaped*), *incus* (*anvil-shaped*) and *stapes* (*stirrup-shaped*).

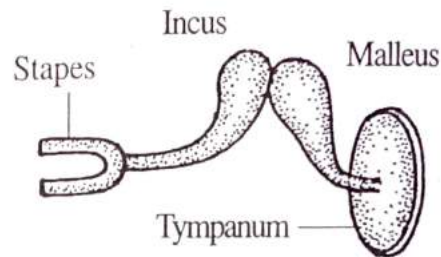


Fig.8.56: Rabbit - Ear ossicles.

The middle ear communicates with the inner ear through two openings called *fenestra ovalis* and *fenestra rotunda*. The stapes is located at the fenestra ovalis.

Inner Ear: The inner ear is called *membranous labyrinth*. It is enclosed in a *bony labyrinth*.

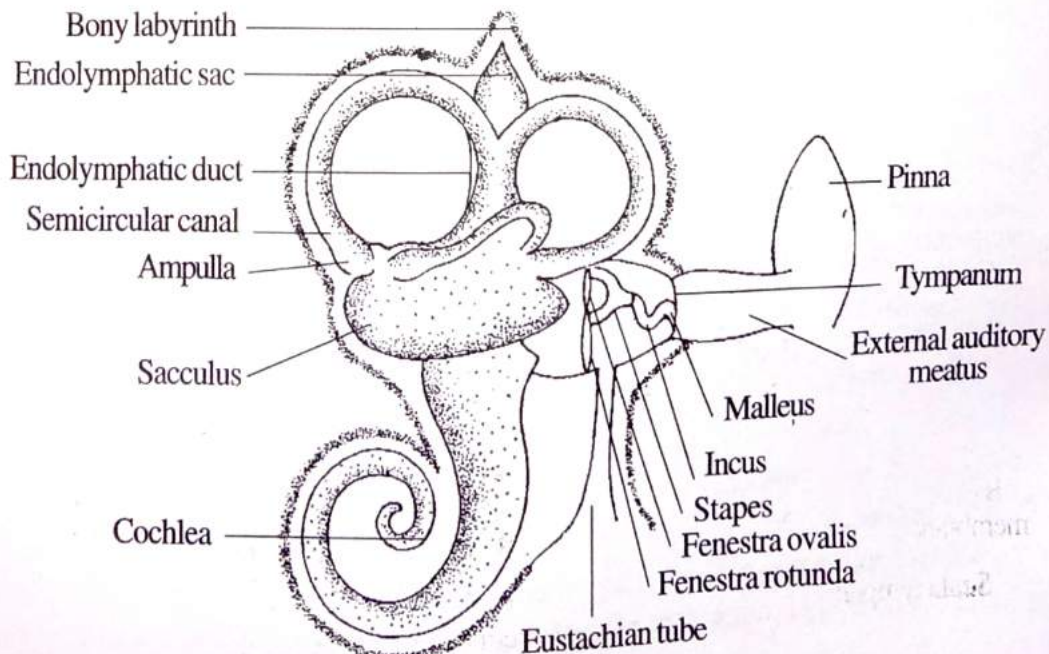


Fig.8.55: Rabbit - Ear.

The space lying between the bony and membranous labyrinth is filled with a fluid called *perilymph*.

The membranous labyrinth is filled with the *endolymph*.

The membranous labyrinth is formed of two major parts, namely *vestibule* and *cochlea*.

The vestibule is formed of three *semicircular canals* and two sacs, namely *utricle* and *sacculus*.

The semicircular canals open into the utricle by their both ends.

One end becomes dilated to form a sac-like structure called *ampulla*.

Each ampulla contains a sensory organ called *crista*. The utricle and sacculus contain another sensory organ called *macula*.

The cochlea is a spirally coiled tube. The cavity of cochlea is divided into three longitudinal parallel canals, namely *vestibular canal*, *middle canal* and *tympanic canal*.

The vestibular canal is connected with the fenestra ovalis and the tympanic canal is connected with the fenestra rotunda. These canals are separated by membranes.

The vestibular and the middle canals are separated by membranes. The vestibular and the middle canals are separated by *Reissner's membrane*.

The middle and the tympanic canals are separated by the *basilar membrane*.

The actual sound-receiving organ is located in the middle canal on the basilar membrane. This organ is called the *organ of Corti*. It consists of specialized *hair cells*.

Each hair cells has about 20 tiny hairs projecting into the middle canal. The hair cells are separated by pillars.

A membrane overhangs the free ends of the hairs of hair cells. This membrane is called *tectorial membrane*.

6. Statoreceptors (Organs of Equilibrium)

Whenever the body is tilted, it is brought to normal balance and posture. This equilibrium is maintained by all vertebrates and is brought about by the *maculae* and *crisetae* of the internal ear.

Maculae: Maculae are sensory spots present inside the vestibule of internal ear. There

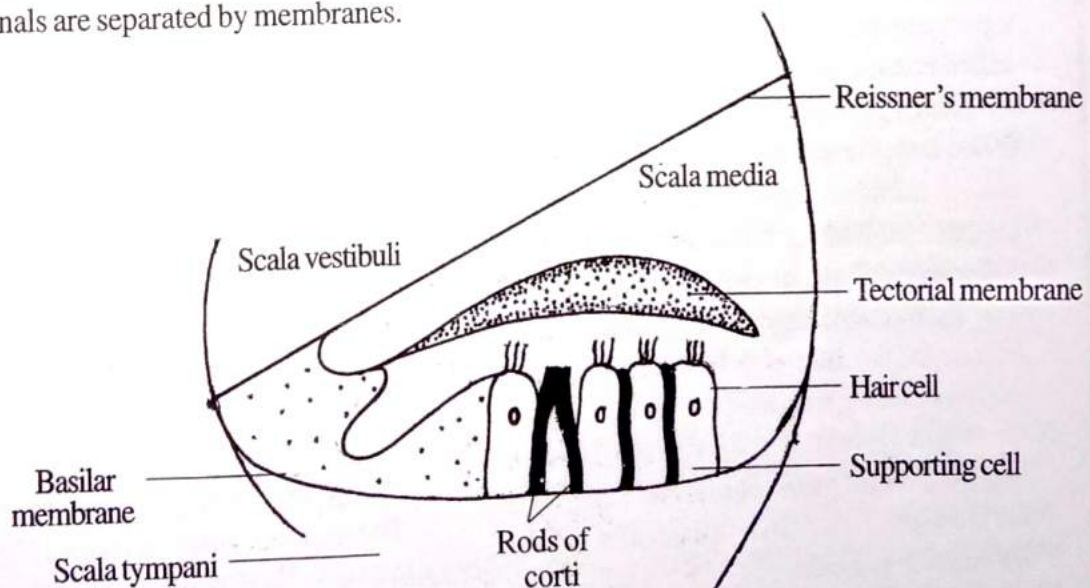


Fig.8.57: Rabbit - T.S.of cochlea to show the organ of Corti.

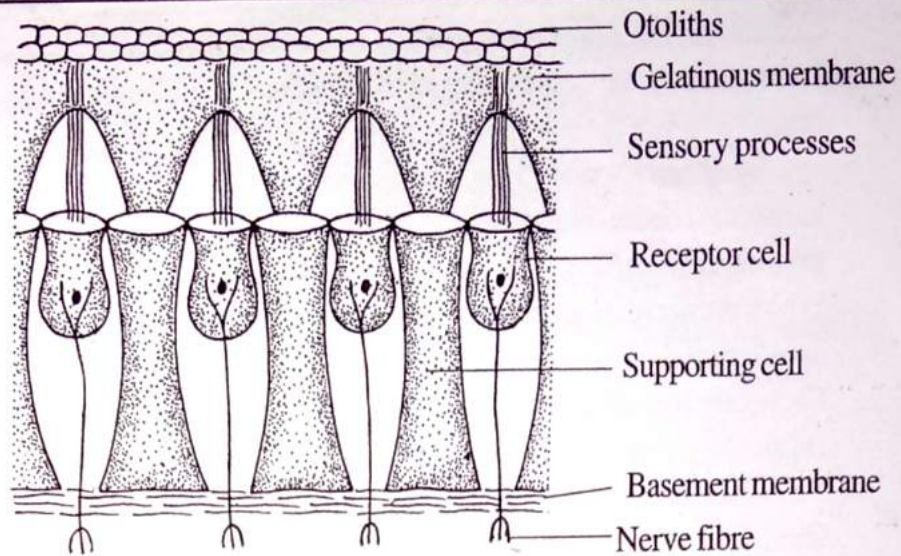


Fig.8.58: Rabbit - V.S.of maculae.

are two maculae in each ear. They are *macula utriculi* present in the wall of the utriculus and *macula sacculi* present in the wall of the sacculus.

Each macula consists of a group of *receptor cells* and *supporting cells*. One end of the receptor cell is connected to a nerve fibre which is connected to the auditory nerve.

The free end of the receptor cell bears a few hair-like non-vibratile *sensory processes*.

The sensory processes of the receptor cells are partly embedded in a gelatinous mass called *cupule* secreted by the supporting cells.

Tiny calcareous particles called *otoliths* occur among the sensory hairs. Whenever the position of the head is changed, the otoliths exert pressure on the sensory hairs.

Working: When the head is tilted, the otoliths bend the hairs to the side. This elicits

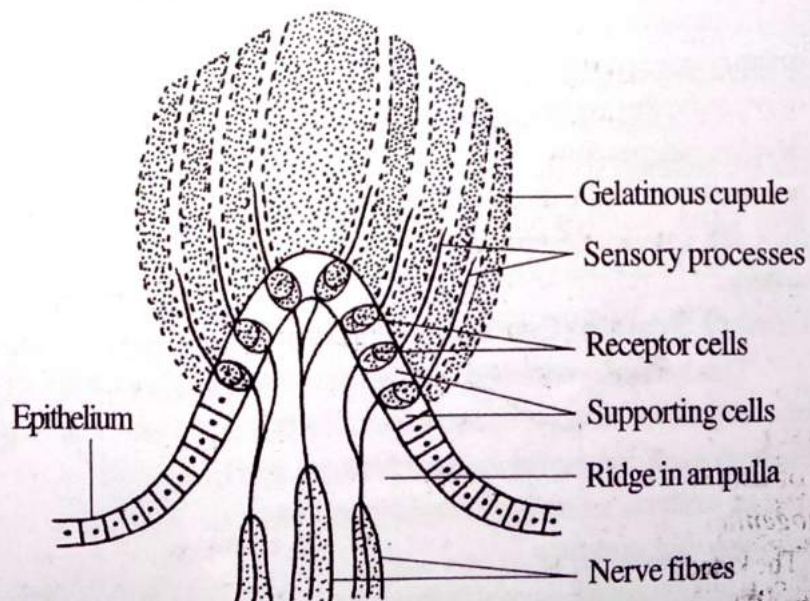


Fig.8.59: Rabbit - V.S. of crista.

an impulse on the nerve and is carried to the brain.

The brain responds by causing appropriate muscles to contract thus bringing the head back to its original position.

Cristae: Each ampulla of the semicircular canal contains a sensory spot called *crista*. Each crista consists of *receptor cells* and *supporting cells*.

The free end of the receptor cell bears a number of long *sensory hairs*. The sensory hairs are embedded in a gelatinous *cupule*.

The other end of the receptor cells is connected to a nerve fibre of the auditory nerve.

Working: The cristae respond to the changes in the direction or rotational movements of the head.

When the head is turned in a particular direction, the endolymph does not move as fast as the head thus bending the hairs in opposite direction, so that the brain is informed about the particular rotational movement.

Urinogenital System

It consists of two systems, namely the *urinary* or *excretory system* and the *genital* or *reproductive system*. In the embryos, they develop independently. But in the adult they become connected with each other. Therefore they are usually described as urinogenital system.

Urinary System (Excretory System)

This system is concerned with the removal of nitrogenous waste products. It is similar in both sexes. It consists of a pair of *kidneys*, a pair of *ureters*, an *urinary bladder* and an *urinogenital aperture*.

The kidneys are situated in the abdominal cavity. The right kidney is situated more anteriorly than the left. They are bean-shaped.

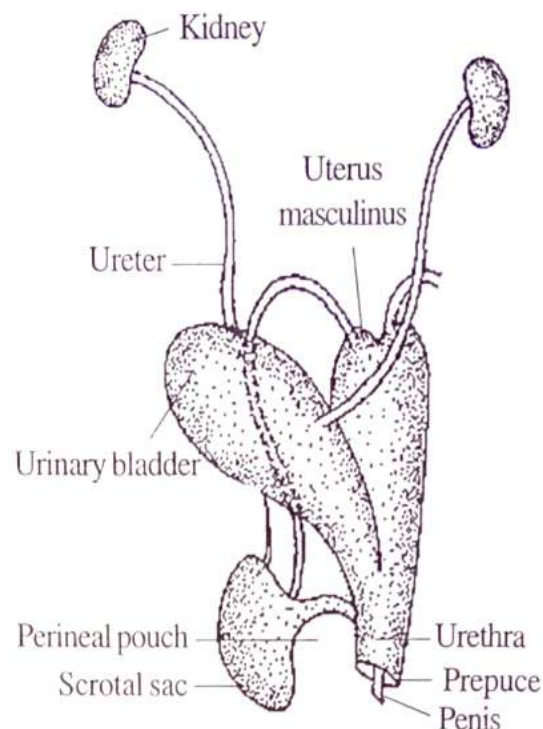


Fig.8.60: Rabbit - Excretory system.

Each kidney has a convex outer surface and a concave inner surface. The centre of the inner surface has a notch called *hilus*. From the hilus the *ureter* arises and it runs backwards to open into the *urinary bladder*.

At the point of origin, the ureter becomes dilated to form a funnel-shaped structure called *pelvis*. A *renal artery* and a *renal vein* pass into the kidney through the hilus.

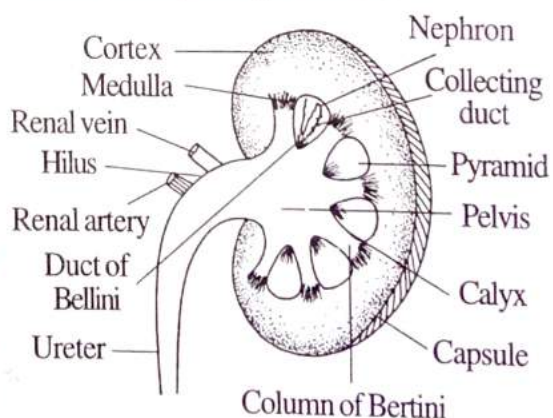


Fig.8.61: Rabbit - L.S. of Kidney.

The kidney is covered by a *capsule* of connective tissue. Each kidney is formed of

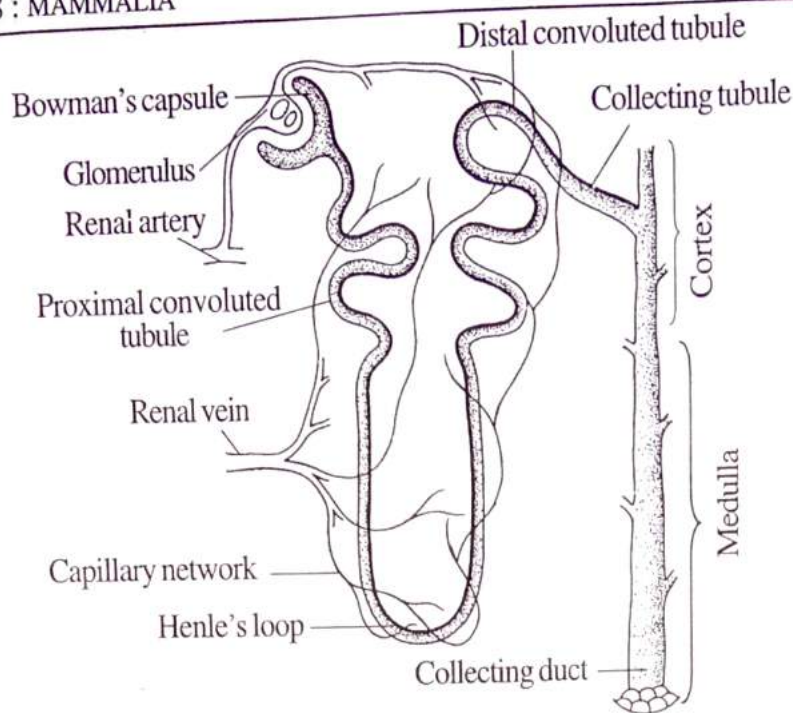


Fig.8.62: Rabbit - A nephron.

two layers, namely an outer **cortex** and an inner **medulla**.

The medulla is formed of several conical lobes called **pyramids**. The pyramids project into a cup-like structure called **calyx**. The calyces open into the pelvis.

The cortex extends into the medulla inbetween the pyramids. These extensions are called **renal columns of Bertini**.

Each pyramid has thousands of tubules called **uriniferous tubules** or **nephrons**. In each pyramid, many uriniferous tubules join together to form a common tubule called **collecting tubule** or **collecting duct**.

Many collecting ducts open into a straight duct called the **duct of Bellini** which opens at the apex of the pyramid.

Each nephron is a coiled tubule having a length of 3 cms. One end of the nephron is formed of a cup-like structure called **Bowman's capsule**.

The cavity of the cup contains a network of capillaries called **glomerulus**.

The Bowman's capsule and the glomerulus are together called **Malpighian corpuscle**.

The Malpighian corpuscle leads into a tubular portion. It is turned into many coils called **proximal convoluted tubule**. It leads into a U-shaped portion called **Henle's loop**. It has three regions, namely a proximal **descending limb**, a middle **thin segment** and a distal **ascending limb**.

The ascending limb leads into another coiled portion called **distal convoluted tubule**. It opens into the collecting tubule. The entire uriniferous tubule is closely associated with a network of **capillaries**.

Reproductive System

In rabbit the sexes are **separate**. It shows **distinct sexual dimorphism**. The male and female differ size, colour and external genitalia.

Male Reproductive System

The male has a pair of **testes**. They are oval in shape. They are kept in two sacs called **scrotal sacs** hanging down from the abdomen.

In other vertebrates, the testes are held inside the body well above the abdomen.

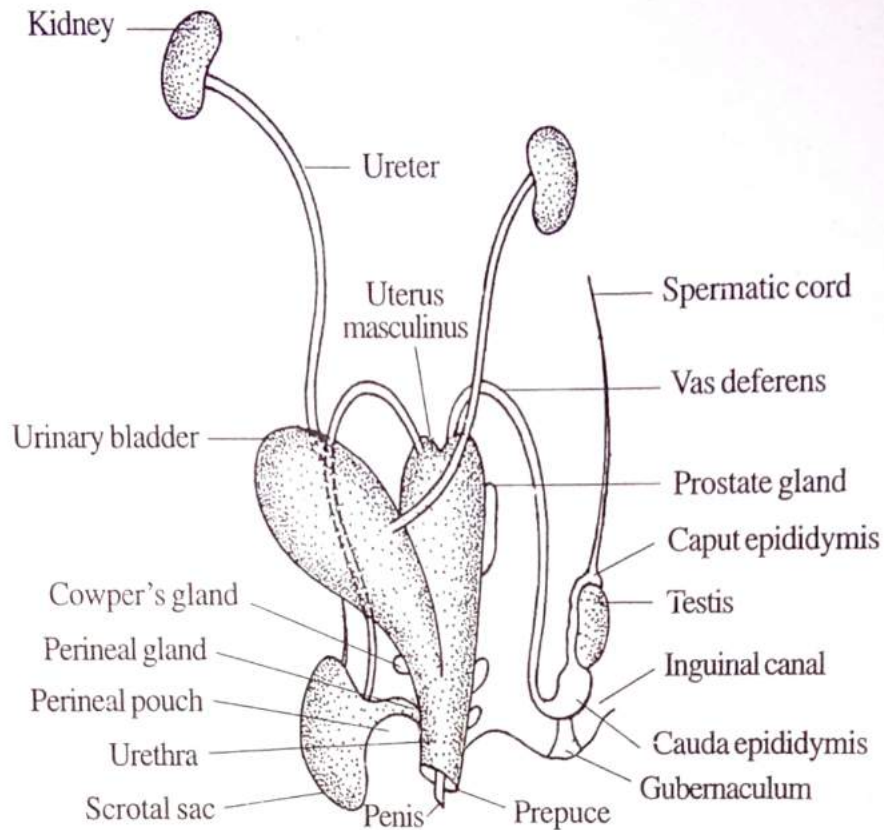


Fig.8.63: Rabbit - Male reproductive system.

In mammals also, the testes develop inside well above the abdomen and as development proceeds, they descend downwards and come out of the abdomen.

They are connected to the original place of development by a connective tissue strand called *spermatic cord*. The scrotal sac opens into the abdominal cavity through a narrow passage called *inguinal canal*.

The testis is formed of numerous fine tubules called *seminiferous tubules*. They produce *spermatozoa* by *spermatogenesis*.

The seminiferous tubules open into a network of tubules called *rete testis*. From the rete testis arise fine ductules called *vasa efferentia*.

The vasa efferentia lead into a coiled tubule called *epididymis*. It lies in close contact with the testis on the inner side.

The epididymis consists of three regions, namely an anterior *caput epididymis*, a middle *corpus epididymis* and a posterior *cauda epididymis*.

The caput epididymis is connected to the spermatic cord. The cauda epididymis is connected to the scrotal sac by a connective tissue strand called *gubernaculum*.

From the cauda epididymis arises a duct called *vas deferens*. The vas deferens runs forwards and enters abdominal cavity through the inguinal canal.

The two vasa deferentia open into a bilobed sac called *uterus masculinus*, lying dorsal to the urinary bladder.

The uterus masculinus opens into the urinary bladder posteriorly to form a common passage called *urinogenital canal* or *urethra*.

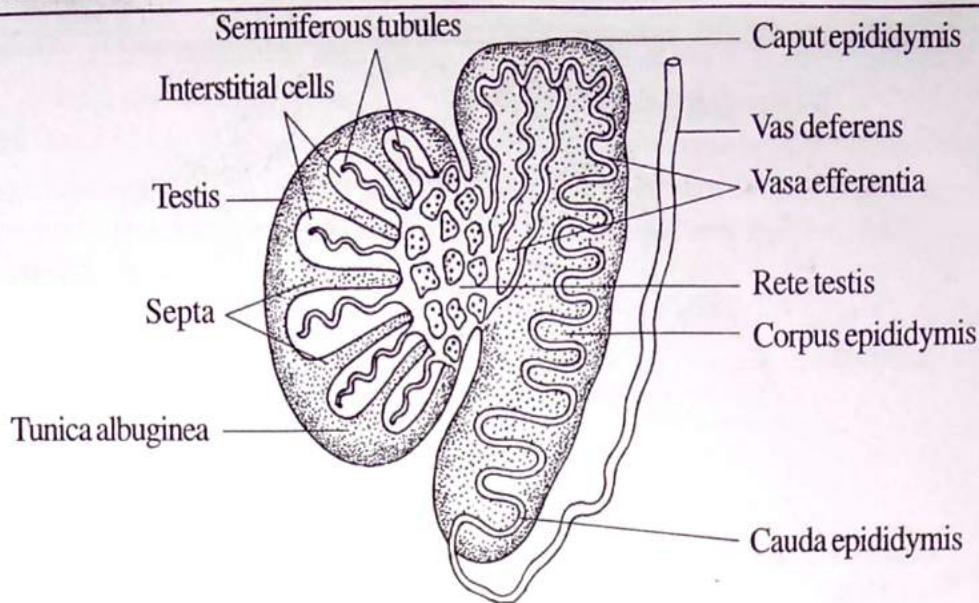


Fig.8.64: Rabbit - L.S.of testis.

The urethra runs backwards and passes into the *penis*. The penis is a cylindrical, erectile muscular organ hanging from the abdomen.

The tip of the penis is globular and is called *glans penis*. It is covered by a loose retractable fold of skin called *prepuce*.

The glans penis at its tip bears a opening called *urinogenital aperture*.

There are three accessory glands associated with the male reproductive system. They are prostate glands, *Cowper's glands* and *perineal glands*.

A *prostate* gland lies on the dorsolateral side of the urethra. It opens into the urethra by small ducts. The secretion nourishes and activates the spermatozoa.

A pair of *Cowper's* glands is present on the urethra posterior to the prostate gland. They open into the urethra by small ducts. Their secretion neutralizes the acidity of the urethra and the vagina.

A pair of *perineal* glands is lying behind the Cowper's gland. They open to the exterior

in the perineal pouches. Their secretion gives the characteristic odour of mammals.

Female Reproductive System

The female reproductive system consists of a pair of *ovaries*. They are located behind the kidney in the abdominal cavity. They are attached to the dorsal body wall by a double fold of peritoneum called *mesovarium*.

The ovary contains many button-like projections called *Graafian follicles*. Each Graafian follicle encloses an egg.

A pair of *oviducts* starts by the side of the ovaries. The oviduct opens into the abdominal cavity by the side of the ovary by a funnel-like structure called *oviducal funnel*. The opening is called *ostium*.

The oviducal funnel leads into a coiled tube called *fallopian tube*. The fallopian tube leads into a wider tube called *uterus*.

The two uteri join together to form a median tube called *vagina*. It opens into the neck of the urinary bladder.

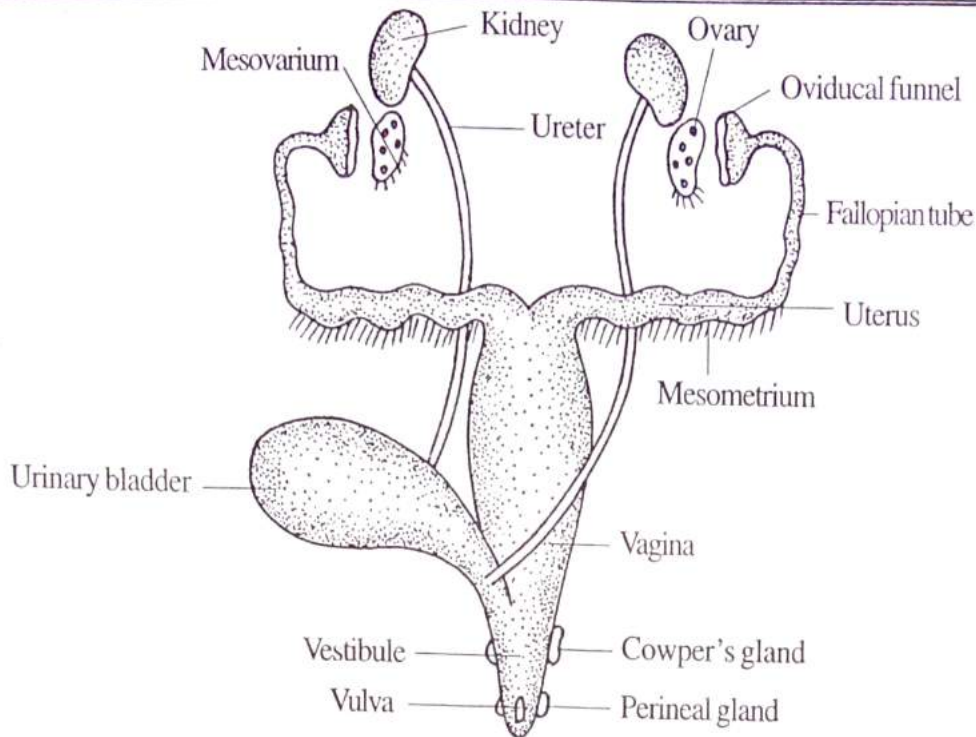


Fig.8.65: Rabbit - Female reproductive system.

The common tube formed by the union of the neck of urinary bladder and the vagina is called **urinogenital canal** or **vestibule**.

The vestibule runs backwards and opens to the exterior by a slit-like aperture called **vulva**.

The anterior wall of vulva has a small erectile knob called **clitoris**. It is homologous to the penis of male.

The female reproductive system has a pair of **Cowper's glands** and a pair of **perineal glands**. The prostate gland is absent from the female reproductive system.

Skeletal System

The skeletal system is broadly divided into two groups, namely **axial skeleton** and **appendicular skeleton**.

The axial skeleton lies in the long axis and it includes the **skull**, the **vertebral column**, the **ribs** and **sternum**.

The appendicular skeleton lies in the transverse axis and it includes the **girdles** and the **limbs**.

Skeletal System

Axial skeleton

Skull, vertebral column, ribs and sternum

Appendicular skeleton

Girdles and limbs

Skull

1. Skull is an **axial skeleton**.
2. The skull of rabbit is **bony** in nature.
3. The skull is **dicondylic**.
4. It is a **craniostylic** skull as the **mandible** articulates with **squamosal**.
5. The skull consists of a **cranium**, **auditory capsules**, **optic capsules**, **olfactory**