Digestive system

- Digestive system of rabbit is constituted by the alimentary canal and its associated digestive glands.

ALIMENTARY CANAL:

- As rabbit is an herbivore, its alimentary canal is very long and coiled. It begins with mouth and ends with anus.
- Alimentary canal of rabbit consists of the following parts :
  Region of ingestion—mouth, buccal cavity, pharynx
  Region of digestion—mainly stomach and small intestine
  Region of absorption—small intestine, and large intestine
  Region of egestion—rectum and anus

1. Mouth:

- Little below the snout, a transeverse slit-like mouth is present.
- It is bound by movable muscular upper and lower lips.
- Upper lip has a cleft in the middle through which incisors are visible. It is known as hare lip.
- Mouth leads into a buccal cavity through **vestibule**, (small cavity present among lips, cheeks and gums of teeth).

2. Buccal cavity:

- The roof of buccal cavity is formed by **palate**.
- Palate can be distinguished into an anteiror hard palate and a posterior soft palate.
- Anterior hard palate is formed by Pre maxilla and maxillary process
- Posterior hard palate is formed by palatine bones
- The palate separates the dorsal nasal passage and ventral food passage.
- Lower surface of the hard palate is lined by an ectodermal membrane, which forms transverse ridges called **palatine rugae.**
- Soft palate is formed by connective tissue and it hangs down into the pharynx as **uvula.**
- A pair of openings of nasopalatine ducts is present in the anterior part of the hard palate. They lead into nasal or olfactory chambers.
- Opening into each nasopalatine duct, is a **Jacobson's organ,** whose function is probably to recognise different kinds of food.

Teeth:

- Both the jaws of rabbit possess **thecodont, heterodont** and **diphyodont teeth.**
- [A typical mammal has four types of teeth, namely, incisors, canines, premolars and molars. Incisors are cutting teeth with sharp and chisel-like edges. Canines are conical, pointed teeth which help in tearing the flesh. The premolars and molars are grinding teeth].
- Rabbit has only three types of teeth, namely, incisors, premolars and molars. In rabbit, the milk teeth have only incisors and premolars.
- Canines are absent. Due to lack of canines, a large gap is formed on jaw between incisors are premolars. It is known as **diastema**. In the rabbit there are a total of 28 teeth.
- Formula showing the number of different types of teeth present in each half of upper and lower jaws is known as **dental formula.** The dental formula of rabbit is :
  i 2/1 c 0/0 pm 3/2 m 3/3 = 8/6 = 14 x 2 = 28

Structure of tooth:

- A typical mammalian tooth has three parts, namely, **crown** (visible part of the tooth), **neck** (enclosed by the gum) and **root.**
- The root is embedded in socket of jaw bone. Main bulk of the tooth is formed by a hard material called **dentine.**
- Chemically, dentine is formed by bone like mateiral (**without Haversian canals**).
- Tooth contains a cavity, known as pulp **cavity.** Many **canaliculi** traverse through dentine. They contain cytoplasmic processess of the **odontoblasts** lining the pulp cavity.
- Pulp cavity contains pulp and has an opening at the base of the root, through which blood vessels and nerves enter into it.
- The incisors of the rabbit are persistent, as they grow continuously.
- The opening of the pulp cavity in them is wide.
- The dentine of crown is covered by hard, shiny white **enamel.**
- Enamel is the hardest part of the body. The dentine of root is covered by cement.
- The socket is lined by the periodontal membrane formed by dense fibrous connective tissue.
- It is attached to the socket wall and surface of the root.

- Attachment of tooth on the jaw bone is strengthened by the gum.
- The socket is lined by the periodontal membrane formed by dense fibrous connective tissue.

Tongue:

In the floor of buccal cavity, there is a flat, muscular and movable tongue.

- It is attached behind and free in front. Free end is blunt.
- Tongue helps in manipulating the food and mixing it with saliva.
- Tongue is formed by **intrinsic muscles.** It is attached to other parts by **extrinsic muscles**
- Total number of tonsils 5
- On the upper surface of tongue, there are **papillae** which contain taste buds. The papillae are of four types:
  - **i) Fungiform papillae –** situated in the margin of the tongue.
  - **ii) Filiform papillae –** situated on the upper surface of tongue and are filamentous.
  - **iii) Circumvallate papillae –** situated at the base of tongue.
  - **iv) Foliate papillale –** situated at the sides of the base of the tongue.

Pharynx:

- Buccal cavity is continued as pharynx posteriorly. Soft palate divides the pharynx into three parts :
- **i) Nasopharynx :** Lies above the soft palate, into which internal nostrils and Eustachian tubes open.
- **ii) Oropharynx :** Lies below the soft palate. On either side, are lymphoid organs called tonsils.
- **iii) Laryngopharynx :** Nasopharynx and oropharynx are connected to larynogopharynx. It opens into larynx through glottis, which is guarded by an epiglottis and also into the oesophagus through gullet. Gullet is guarded by upper oesophageal sphincter

4. Oesophagus:

- It is a long, narrow, muscular tube extending through the neck, thoracic cavity and after piercing through the diaphragm; it enters the abdomen and opens into the stomach.
- Inner lining of oesophagus is raised into many **longitudinal folds**. **Mucous glands are present** on its inner surface.

5. Stomach:

- Stomach is a large, bean-shaped, muscular, sac-like structure having smaller inner concave surface and a larger outer convex surface.
- They are called lesser curvature and greater curvature respectively.
- Stomach lies on the left side in the anterior part of the abdominal cavity.
- It is divisible into three parts, namely, cardiac, fundic and pyloric stomach.
- Oesophagus opens into the cardiac stomach through cardia along its inner concave side.
- Cardia is guarded by a **cardiac sphincter**. Pyloric part of stomach opens into the duodenum through pylorus. It is guarded by **pyloric sphincter.**
- Cardiac sphincter prevents backward flow of food (*i.e.,* **regurgitation**) and pyloric sphincter regulates the flow of food into the duodenum.
- **Fundic region of stomach is the biggest** part and lies between cardiac and pyloric parts of the stomach.
- The wall of stomach is formed by four layers, namely, outer serous layer, muscle layer, sub mucosa and mucosa.
- **Serous layer** is formed by a thin layer of **squamous epithelium and connective tissue.**
- **Muscle layer** is present beneath the serous layer. It is composed of outer longitudinal muscles and inner circular muscles. These muscles are of unstriated type.
- **Sub mucosa** is present below the circular muscle layer. It is formed by connective tissue, which contains blood capillaries, lymph capillaries and nerves besides the bases of gastric glands.
- **Mucosa** is the innermost layer of stomach; It is formed by an outer muscularis mucosa [containing a layer of longitudinal muscles (outer) and a layer of circular muscles (inner)] and an inner layer of **columnar epithelium.**
- The epithelial cells rest on a basement membrane. The inner lining of stomach is thrown into many longitudinal folds called rugae and has many microscopic gastric glands. Rugae allow the expansion of stomach.

6. Small intestine:

- Small intestine is a narrow, coiled tube of about 2.5 m long. It is divisible into two parts, namely duodenum and ileum.

  a) Duodenum: It is the anterior part of the small intestine. It forms a typical U- shaped loop with two limbs. Bile duct from liver opens into the beginning of proximal limb and pancreatic duct from pancreas opens into the beginning of distal limb.

  b) Ileum: The remaining part of small intestine is the ileum. The terminal part of ileum is enlarged into a bulb-like structure called **sacculus rotundus.** Two tubes arise from it, namely, caecum and large intestine.

- The wall of intestine is also formed by four layers, namely, outer serous layer, followed by muscle layer (having outer longitudinal muscles and inner circular muscles), submucosa and mucosa. Submucosa of duodenum contains Brunner's glands. The finger-like elevations in the mucosa of ileum are called **villi.**
- Each villus contains an arteriole, a venule, a network of capillaries, and a lymph capillary called **lacteal.**
- Villi increase the area of absorption. Among the villi of ileum, there are **crypts of Leiberkuhn** (intestinal glands). In large intestine, villi are absent.

7. Caecum :

- It is a long, thin walled structure of about 25 to 40 cm long. It exhibits spiral constrictions which indicates the presence of spiral valve.
- Caecum ends with a thick walled blind tube of about 13 cm long. It is known as **vermiform appendix.**
- Ileum has an ileo-caecal valve, which directs the food into the caecum. Caecum contains symbiotic bacteria that help in cellulose digestion.

8. Large intestine:

- Large intestine is more than one meter long and is divisible into two parts, namely, colon and rectum.
- **a. Colon:** Anterior part of large intestine is called the colon and is about 45 cm long.
- Colon bears longitudinal muscular bands called **taeniae** along its mid dorsal line.
- Inner part of colon has a series of constrictions which form series of pouches called **haustra**.
- Large intestine absorbs water from undigested matter and helps in formation and elimination of faecal matter.
- **b. Rectum:** The terminal part of large intestine is called rectum. It shows beaded appearance due to the presence of faecal pellets. Rectum is about 75 cm long.

9. Anus:

- Rectum opens out through anus. It is situated at the base of the tail. Anus is guarded by an anal sphincter.

DIGESTIVE GLANDS:

- Associated with the alimentary canal of rabbit, the following digestive glands are present:

1. Salivary glands:

- Opening into the buccal cavity of rabbit, there are four pairs of salivary glands. These are :
- **i) Parotid glands:** They are located at the bases of pinnae. Each gland opens into the buccal cavity behind the upper incisors through a Stenson's **duct.**
- **ii) Sub maxillary glands:** These glands are situated on the inner side of angles of lower jaws. Each gland opens into the buccal cavity near lower incisors through **Wharton's duct.**
- **iii) Sub-lingual glands:** These glands are situated below the tongue. Their small ducts open into the buccal cavity below the free part of the tongue.
- **iv) Infra orbital glands:** These glands are situated below the orbits or eyes. Their ducts open into the buccal cavity near upper molars. [In man, infra orbital glands are absent.]
- Salivary glands are compound tubular glands, formed of mucus cells and serous cells. Salivary glands secrete saliva. It is slightly acidic (pH is 6.9) and contains water, mineral salts, mucin and an enzyme, **ptyalin or salivary amylase.**

2. Glands in the wall of alimentary canal:

a) Gastric glands:

- These are minute, tubular glands present in the wall of stomach. Based on their location in stomach, gastric glands are classified into three types :
- **i) Cardiac glands:** Present in the cardiac region of stomach. They are formed of mucus cells and secrete mucus.
  ii) Fundic glands: Found in fundic part of stomach. Each fundic gland is formed of four types of cells, namely, **oxyntic cells** or **parietal cells** (secrete hydrochloric acid), *neck* cells (secrete mucus), chief cells or zymogen cells (secrete pepsinogen and prorennin) and argentiffin cells (secrete Castle's intrinsic factor).
- **iii) Pyloric glands:** Found in the pyloric part of stomach. They are formed of mucus cells and secrete mucus.
- Gastric glands secrete gastric juice which contains hydrochloric acid, mucin, pepsinogen, prorennin, and Castle's intrinsic factor. Gastric juice is acidic in nature (pH is 1.5 -2.0).

b) Intestinal glands:

- These are present in the lining of small intestine. They are of two types:
  i) Brunner's glands: Present in the sub mucosa of duodenum.
  ii) Crypts of Leiberkuhn: These are pocket-like structures in the mucosa of ileum. They open into small pits among villi.
- Secretions of Brunner's glands along with that of crypts of Leiberkuhn constitute intestinal juice or succus entericus, which is alkaline (pH is 7.6) and contains mucin, enterokinase, peptidases (dipeptidase, tripeptidase, aminopeptidase), lipase, disaccharidases (maltase, sucrase, lactase etc.) etc.

3. Liver:

- Liver is the largest gland in the body. It is reddish brown in colour and lies towards right side of stomach, below the diaphragm.
- Liver of rabbit has **five lobes**, **two** on the **right** and **three** on the **left** side.
- The right lobes are - right central lobe and caudate lobe.
- The left lobes are - left central lobe, left lateral lobe and spigelian lobe.
- Between the right and left lobes is a green sac called **gall bladder**.
- From the gall bladder, arises a large **cystic duct**. It receives several small hepatic ducts from different parts of liver.
- Thus a common **bile duct** is formed, which opens into the proximal part of duodenum.
- This opening of bile duct is guarded by a **sphincter of Oddi.**
- Each lobe of liver is formed by numerous hepatic lobules, which are separated from each other by connective tissue (separation of hepatic lobules is incomplete).
- Each lobule contains a mass of hepatic cells arranged in radial rows called hepatic cords.
- Between the hepatic cords blood filled sinusoids are present.
- Some of the endothelial cells surrounding the sinusoids are present as Kupffer cells.
- Each lobule is surrounded by Glission's capsule. These capsules contain blood capillaries, bile capillaries, lymph vessels etc.
- Liver secretes bile juice, which is alkaline (pH is 7.6) in nature.
- **Enzymes are absent in bile juice**. Bile juice is a green fluid.
- It contains bile salts and bile pigments. Bile juice helps in **emulsification of fats**.

Functions:

1. Liver secretes an alkaline, greenish bile juice having bile salts and bile pigments. Bile salts help in emulsification of fats.
2. Liver stimulates peristalsis.
3. Bile juice helps in the absorption of vitamins A, D, E, and K.
4. If excessive quantities of glucose are present in blood, it is either converted into glycogen (glycogenesis) or into fats (lipogenesis) and is stored in the liver.
5. When there is need for glucose, glycogen is convened into glucose and is released into the blood (glycogenolysis).
6. Liver converts excess proteins and fats, into glucose through a process called **gluconeogenesis** (formation of glucose from non carbohydrate sources).
7. Liver synthesises plasma proteins necessary for clotting of blood, such as prothrombin and fibrinogen.
8. Liver produces anti-coagulants like heparin.
9. Ornithine cycle takes place in liver to produce urea.
10. Detoxifying organ
11. In embryonic stage, liver acts, as erythropoietic organ and produces R. B. C.
12. Liver breaks the products of haemoglobin which are excreted as bile pigments.
13. Liver produces heat.
14. Kupffer cells of liver capture and destroy harmful bacteria.
15. Liver **synthesises vitamin A** and **stores vitamin D.**
16. Stores glycogen, vitamin $B_{10,}$ Iron, copper
17. Erythoroclasting organ in adults

4. Pancreas:

- Pancreas is an irregular thin, flat, pinkish gland situated in the loop of duodenum. Pancreas is the **second largest gland**.
- It is partly exocrine and partly endocrine in nature. Exocrine part is formed by **acini** which secretes pancreatic juice.
- A number of small ducts formed from acini unite together and form a common pancreatic duct. This duct opens into the distal limb of duodenum.
- Pancreas secretes pancreatic juice, which is alkaline and contains trypsinogen, chymotrypsinogen, carboxypeptidase, nuclease, amylase, lipase etc.

Endocrine part of pancreas is formed by **islets of Langerhans** which secrete two hormones, namely, **insulin** and glucagon. They regulate level in blood glucose.

NUTRITION AND DIGESTION:

PROCESS OF DIGESTION:

- Rabbit is an herbivorous animal that eats leaves, roots, tubers, vegetables etc., as food.
- Food of rabbit contains carbohydrates, proteins, fats, water, mineral salts, vitamins etc.
- Out of these, carbohydrates, proteins and fats are macromolecules that can not diffuse into the blood directly in the gut.
- Hence these macromolecules are enzymatically broken into simple, diffusible molecules.
- Carbohydrates are converted into glucose, fructose, galactose etc., proteins into amino acids and fats into fatty acids and glycerol.
- **The process of breakdown of large, complex molecules of food into simple and diffusible molecules is called digestion.**
- The biochemical reactions during digestion are catalysed by enzymes.
- These digested molecules diffuse into the blood from the intestine. In rabbit, the digestion is extracellular.
- Digestion of rabbit involves three activities:
- **i) Mechanical digestion:** It involves chewing of food among teeth in the buccal cavity and thorough churning during chemical digestion inside the gut.
- **ii) Chemical digestion:** All the biochemical reactions that take place in the gut with the help of enzymes constitute chemical digestion.
- **iii) Microbial digestion:** Certain components of food like cellulose are digested by symbiotic bacteria in the caecum and colon.
- The substances like mineral salts, vitamins and water are simple molecules. Thus they are directly diffused into the blood. Hence they need no digestion.
- The process of digestion in rabbit involves the following steps :

1. Digestion in buccal cavity:

- Rabbit holds the food with its front legs and cut into small pieces with incisors and then masticate among premolars and molars.
- During mastication, saliva is mixed with the food and moistens it.
- Tongue manipulates the moistened food into ball like masses called **bolus.**
- The ptyalin (enzyme) of saliva converts the starches into dextrins and maltose in presence of chloride ions.
- Thus carbohydrates are partially digested.

$$\text{Starch} \xrightarrow[Cl^-]{\text{ptyalin}} \text{Dextrins} \longrightarrow \text{Maltose}$$

- Then the bolus is swallowed. The swallowed bolus passes down through the oesophagus by peristalsis. Oesophagus delivers the food bolus into stomach.

2. Digestion in stomach:

- Stomach receives the swallowed food where it is stored for some time.
- Due to churning movements, further mechanical breakdown of food takes place.
- Moreover, food is mixed with the gastric juice secreted by gastric glands. (35 million gastric glands in man)
- Gastric juice contains **hydrochloric acid, mucin, pepsinogen, prorennin, lipase and Castle's intrinsic factor.**
- Hydrochloric acid kills the bacteria and other microbes that enter the stomach along with food. In addition, HCl activates pepsinogen into pepsin and prorennin into rennin. [Rennin is said to be absent in adults].
- These two enzymes, *viz.,* pepsin and rennin act in acidic medium.

$$\text{Bacteria, harmful microbes} \xrightarrow{HCl} \text{Killed}$$

$$\text{Pepsinogen} \xrightarrow{HCl} \text{Pepsin}$$

$$\text{Pepsinogen} \longrightarrow \text{pepsin (Autocatalysis)}$$

$$\text{Prorennin} \xrightarrow{HCl} \text{Rennin}$$

- Rennin causes the coagulation of milk. In infants rennin prevents rapid flow of milk into the intestine from stomach.
- In presence of calcium, rennin changes the milk protein casein into paracasein, which is then digested by pepsin.

$$\text{Casein} \xrightarrow[Ca^{++}]{\text{Rennin}} \text{Paracasein} \xrightarrow{\text{Pepsin}} \text{Peptones}$$

- **Pepsin acts on proteins** including paracasein and breaks them into small bits called **proteoses and peptones.**
- Castle's intrinsic factor plays an important role in the absorption of vitamin B_{12} (cynacobalamin) through the lining of stomach.
- Mucin protects the lining of stomach from the action of acid and enzymes.
- Thus food is partially digested in stomach. This partially digested, acidic, fluidy food is known as **chyme.**
- In the stomach, carbohydrates and fats are not digested.
- Due to churning movements of stomach, chyme little by little passes into the duodenum through pylorus.

Digestion in intestine

- Whenever the acidic chyme enters the duodenum, bile juice, pancreatic juice (trypsinogen, chymotrypsinogen, carboxypetptidase, nuclease, lipase) and intestinal juice [enterokinase, peptidases (tripeptidase, dipeptidase, aminopeptidase), lipase, maltase, sucrase, lactase etc.] are mixed with it.
- The alkaline content of bile and pancreatic juice neutralises the chyme and changes the pH of chyme into alkaline condition.
- This is essential for the activity of enzymes of pancreatic juice and intestinal juice.

a. Digestion of proteins in intestine:

- Trypsinogen and chymotrypsinogen are the inactive forms of trypsin and chymotrypsin respectively.
- Trypsinogen is activated by enterokinase of intestinal juice. Then trypsin autocatalytically activates trypsinogen.
- Trypsin also activates chymotrypsinogen into chymotrypsin.

  Trypsinogen $\xrightarrow{\text{Enterokinase}}$ Trypsin

  Trypsinogen $\longrightarrow$ Trypsin (autocatalysis)

  Chymotrypsinogen $\xrightarrow{\text{Trypsin}}$ Chymotrypsin
- Trypsin and chymotrypsin attack native protiens; proteoses and peptones (formed in stomach) and digest them into peptides.
- Carboxy peptidase and amino peptidase break the peptides into tripeptides, dipeptides and amino acids (carboxy peptidases break the peptides exposing the carboxyl group. Amino peptidases break the peptides exposing amino group).
- Tripeptides are converted into dipeptides and amino acids by tripeptidase. Dipeptidases digest the dipeptides into amino acids.
- Proteins $\xrightarrow{\text{Trypsin}}$ Peptones and proteases
- Proteoses and peptones $\xrightarrow{\text{chymotrypsin}}$ Polypeptides
- Polypeptides $\xrightarrow{\text{Carboxypetidase}}$ Dipeptides, tripeptides, amino acids
- Polypeptides $\xrightarrow{\text{aminopeptidase}}$ Dipeptide, tripeptides, amino acids
- Tripeptides $\xrightarrow{\textit{tripeptidases}}$ Dipeptides, amino acids
- Dipeptides $\xrightarrow{\text{dipeptidases}}$ Amino acids

Digestion of fats in intestine:

- The bile salts of bile juice emulsify the fats present in the chyme.
- Lipases of pancreatic juice and intestinal juice digest the emulsified fats into fatty acids and glycerol.
- Fats $\xrightarrow{\text{bile}}$ Emulsified fats
- Emulsified fats $\xrightarrow{\text{lipase}}$ Fatty acids, Glycerol

c. Digestion of carbohydrates in intestine

- Amylase of pancreatic juice acts on carbohydrates and covert them into disaccharides like maltose, sucrose, lactose etc. Disaccharidases of intestinal juice digest them into monosaccharides.
- Carbohydrates $\xrightarrow{\text{amlayse}}$ Maltose, Sucrose, Lactose
- Maltose $\xrightarrow{\text{maltase}}$ Glucose + Glucose
- Sucrose $\xrightarrow{\text{sucrase}}$ Glucose, Fructose
- Lactose $\xrightarrow{\text{lactase}}$ Glucose, Galactose
- Thus, at the end of digestion amino acids are formed from proteins, monosaccharides are formed from carbohydrates and fatty acids and glycerol from fats.

Digestion of Nucleic acids

RNAase and DNAase are present in pancreatic juice

Phosphatases and nucleosidases are present in intestinal juice

Phosphotases hydrolyse the ester bonds to release phosphate from nucleotide

Nucleosidases hydrolyse gycosidic bonds to digest nucleosides into pentose sugars and nitrogen bases

4. Digestion in caecum

- Caecum contains symbiotic bacteria. They secrete cellulase, which digest cellulose into soluble sugars.

5. Absorption:

- Diffusion of digested food into blood is known as absorption.

a) Absorption in ileum:

- Major part of the digested food is absorbed in the ileum.
- Villi increase the area of absorption.
- Each villus contains an arteriole, a venule and a lymph capillary called **lacteal**.
- Microvilli, protruded from the surface of the intestinal epithelial cells further increase the efficiency of absorption.
- Glucose and galactose by secondary active transport by Na into epithelium and into blood through diffusion
- Fructose only through facilitated diffusion
- Amino acids and monosaccharides are directly diffused into the blood by secondary active transport with Na or primary active transport by simple diffusion.
- Fatty acids and glycerol are diffused into the lacteals and then reach blood.
- Small chain fatty acid are absorbed through diffusion
- In the absorption of Long chain fatty acids and glycerol micelles and chylomicrons are formed

b) Absorption in colon:

- In colon, water from the residue is absorbed till it becomes semi solid faeces. Simplified cellulose, vitamins formed during microbial digestion in caecum are also present in the faeces. Faeces, so formed are expelled at intervals at night.

Coprophagy:

- The faeces contain simplified sugars and vitamins. Hence this faeces is eaten up by the rabbit and the contents pass through the gut for complete digestion and absorption.

7. Egestion or defaecation:

The process of elimination of undigested matter is known as egestion. The faeces is collected into the rectum as pallets and are passed out through anus during day time.