ANIMAL PHYSIOLOGY-I

1-1 ELEMENTARY STUDY OF THE PROCESS OF DIGESTION

1·1·1 *Introduction :*

Primary concern of every animal is to obtain certain necessary substances to continue its life on the earth. Some of these important substances are oxygen, water and food. Animals obtain them from the nature. The food materials taken by the organisms include some simpler substances like water, inorganic salts, monosaccha rides and vitamins, can easily be absorbed into the wall of digestive tract. But other substances are in the complex form and must undergo degradation of digestion before they are absorbed in the intestine. Digestion is achieved when the food is subjected to mechanical processes such as mastication, swallowing and chemical processes in the digestive tract.

1·1·2 *Digestion - Definition :*

The digestion can be defined as a process involving a chemical breakdown of complex food materials into simple substances to be used readily by the animal through absorption and assimilation.

(Or)

The digestion is a catalytic chemical hydrolysis in which macro molecules of food materials are converted into micro molecules by the action of digestive enzymes.

1·1·3 *Kinds of Digestion :*

Digestion is classified into two main types i.e., the intracellular (amoeba) and the inter or extracellular digestion (Hydra). Between these two types, a transitional type of digestion is explained called the contact digestion as seen in anthozoans.

Finally symbiotic digestion is also seen in lower groups. (Zoochlorellae in hydra).

1·1·4 *Adaptations for digestion :*

The digestive system of an animal show certain adaptations to the kind of food and mode of feeding habits. The digestion of any vertebrate animal shows the following functional regions.

(a) The region of reception of food (mouth)

(b) The region of conduction and storage (stomach)

(c) The region of internal trituration and early digestion (Duodenum).

(d) The region of final digestion (small intestine)

(e) The region of faecal formation (large intestine)

The food material passes through the different regions of digestive system with the help of eiliary action and muscular activity of the digestive wall.

1·1·5 *Digestive enzymes :*

An enzyme is an organic substance produced by living cells that catalyses specific chemical changes like hydrolysis, oxidation, reduction, isomerisation, synthesis and analysis without undergoing itself any change.

Digestive enzymes p[illegible] food substances into micro molecules and regulate the chemical reactions. Many digestive enzymes are hydrolases and exhibit their catalytic action by the process of hydrolysis. Actual process of digestion in higher organisms is explained here under.

(a) Chemical digestion of proteins : Proteins are tough complex substances when compared to carbohydrates. The digestion of these proteins by proteolylic enzymes occur by the hydrolysis of peptide bonds. The sequence of protein digestion is represented as

Proteins → Proteoses → Peptones → Polypeptides → Amino acids

In the stomach of vertebrate animal the gastric glands secrete an inactive proteolytic enzyme like pepsinogen. The HCl secreted by the oxyntic cells activate the pepsinogen into active pepsin. The enzyme pepsin hydrolyses the proteins into proteroses and peptones. In the duodenum and small intestine the enzyme trypsin secreted by the pancreas converts proteins and incompletely digested proteins into polypeptides. In the small intestine another enzyme called *Erypsin* acts upon the polypeptides and convert them into amino acids.

The enzymes responsible for splitting proteins are called protelytic enzymes, some of them are pepsin, trypsin, chymotrypsin, aminopeptidases, carboxy peptidase, tripeptidase, and dipeptidase. These enzymes are classified into two groups.

(1) Endopeptidases - Pepsin, trypsin and chymotrypsin.

(2) Ectopeptidases - amino peptidase, carboxypeptidase, tripeptidase and dipeptidase.

Both these groups of enzymes are required for intracellular and extracellular digestion.

(b) Chemical digestion of carbohydrates : Simple sugars (glucose and fructose) are monossaccharides and soluble in water. They can easily be absorbed into the blood of animals without undergoing any digestion, but the disaccharides and polysaccharides (starch) cannot be absorbed directly unless they are hydrolized into simple sugars. One molecule of disaccharide when hydrolized with one molecule of water in the presence of relative enzymes two monosaccharides are formed.

$$\underset{\text{Disaccharide}}{C_{12}H_{22}O_{11}} + H_2O \rightarrow \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

The digestive enzymes cannot act on starch (polysaccharide) directly unless it is broken down by boiling, by chewing, by bacteria or by enzymes present in themselves. The chemical digestion on hydrolysis of carbohydrates takes place in the presence of different enzymes. In the saliva of mammals two enzymes are present *viz ptylin* (endoamylase) and *maltase*. In the small intestine another enzyme called *Erypsin* is present. The ptylin hydrolizes starch to dextrin and maltose. The maltase converts maltose into glucose. The optimum pH 6·2 to 6·8 is necessary for the activity of digestive amylases and it is maintained by chloride ions.

The process of digestion of carbohydrates by the ptylin is continued till the food material reaches the stomach. The acidity of the gastric juice stops further action of ptylin. Enzymes secreted by the small intestine continue the process of digestion. Maltase hydrolyzes maltose to glucose. The invertaese (sucrose) acts upon sucrose and hydrolizes it to glucose and fructose. Lactose hydrolizes lactose (milk sugar) to glucose and galactose. Glucose, Fructose and Galactose are being simple sugars can be absorbed into the blood.

The pancreatic juice secreted by the pancreatic cells (exocrine part of pancreas) is released into the duodenum and small intestine has Amylase or Amylopsin which resembles the ptylin of the saliva, reacts It with starch (carbohydrate) and splits it into dextrins, maltotrioses already formed by the salivary digestion to maltose.

In the small intestine the enzymes like Glucosidases or disaccharases, hydrolize various disaccharides into their respective hexoses. Enzymes like maltase and lactase are present both in the pancreatic and intestinal juices.

The lactose splits milk sugar (lactose) into glucose and galactose in young mammals.

The maltase spilts maltose to form two glucose molecules.

Another enzyme present in the intestinal juice is the sucrose, it hydrolizes sucrose to one molecule of glucose and one molecule of fructose.

(c) Chemical digestion of fats : Fats are a varied group of organic compounds characterised by their insolubility in water and their solubility in organic solvents. Enzymes that hydrolize lipids are actually esterases. Two essential processes are involved in the digestion of fat.

(i) Emulsification by agents ; (ii) Enzymatic hydrolysis by lipase.

In the vertebrates the bile from the liver, serve as emulsifying and lipase can only act upon the emulsified fat droplets. Enzymatic hydrolysis of fat converts it into two kinds of smallar molecules : glycerol and fatty acids. The fat, stearin is hydrolyzed as follows.

$$C_3H_5\text{–}O_3\ (C_{17}H_{35}\text{-}\ CO)_3 + 3H_2O \rightarrow C_3H_5\ (OH)_3$$

Stearin Water Glycerol

$$+\ 3HC_{18}\ H_{35}O_2\ +\ \text{Stearic Acid}$$

In artiodactyles (Cow, Buffalo, Sheep, Goat, Camel) the hydrolysis of fats is done by the bacteria present in the rumen (sac like anterior part of stomach) and the glycerol is converted to propionic acid.

(d) Digestion of cellulose in ruminants : The food of ruminants is fodder which is rich in cellulose or lignin. This substance cannot be digested directly. In herbivorous mammals like sheep and cattle, the cellulose is attacked by the enzymes produced by symbiotic bacteria living in the rumen. These bacteria also breakdown carbohydrates and proteins to simple substances. Cellulose breakdown by bacteria also takes place in the stomach of kangaroo (Setonix brachyurus) and sloth (Choleopus). Cellulose splitting bacteria are present mostly in the caecum and ventral colon of horses and in the caecum of Rabbits. The rabbits and other rodents have developed a habit of reingestion or pseudorumination. When rabbit takes fresh food it directly reaches the caecum, remains there for one or two days undergoing fermentation and is then excreted in the form of soft faeces. This again is eaten and it reaches the stomach for complete digestion by enzymes. After digestion and absorption the twice swallowed food is excreted as hard faecal pellets.

1·1·6 *Digestion in Mammals :*

In take of food is called injestion. In mammals this ingestion is helped by the parts like lips, teeth present on jaws and tongue associated with mouth and buccal cavity. The jaws are used to collect and hold the food and also to break it into small pieces.

The process of digestion in man involves a series of hydrolyses and shows similar cource in most of them. The structural plan of alimentary canal is almost similar and consists of the following parts.

Mouth ⟶ Buccal cavity ⟶ pharynx ⟶ oesophagus
⟶ stomach (cardiac and pyloric) ⟶ deuodenum
⟶ small intestine ⟶ large intestine ⟶ Rectum ⟶ Anus

Associated with the alimentary canal there are several digestive glands which produce digestive enzymes. They are - (i) Salivary glands in the mouth, (ii) Gastric glands in the stomach, (iii) Liver & Pancrease, (iv) Intestinal glands in the small intestine.

In man the food is digested in the mouth (oral cavity) stomach, duodenum and in the small intestine.

(A) Digestion in the mouth : The food enters the digestive tract through the mouth or oral cavity. The food is chewed or masticated with the help of teeth to break it down into smaller pieces. Then it mixes up with the salivary juice secreted by the salivary glands. In man three types of salivary glands are present in pairs *i.e.*, parotid glands in the upper jaw, sublingual and submaxillary in the lower jaw (infra orbital glands are absent). The saliva contains nearly 99·4% of water and the protein material in the form of mucin, a glycoprotein. The saliva is slightly acidic in nature having a pH of about 6·5. Number of buccal glands present in the mouth secrete mucous into it. The secretion and flow of saliva is stimulated by

(a) The food in the mouth stimulates salivary secretion.
(b) The dry food stimulates more than moist food.
(c) The thought, sight and smell of food will stimulate the flow of saliva.
(d) Acids, salts and many other chemical agents stimulate the salivary secretion.

The digestive action of saliva depends upon the salivary amylase or ptylin. The salivary amylase is a mixture of two enzymes called α and β amylase. Salivary amylase acts on starch converting it into maltose.

Insoluble starch → Soluble starch → Erythro dextrin → Achroodextrin → Maltose

Maltose is the end product of starch in the salivary digestion.

Salivary amylase activity : (i) It acts rapidly at the normal body temperature.

(ii) It acts more rapidly at 50°C to 55° C.

(iii) At 75°C temperature it gets destroyed.

(iv) Amylase activity in the stomach is inhibited when the acidity in the stomach reaches a pH of less than two.

(v) The chloride ion is necessary for amylase activity. When the food in the mouth is well mixed with the saliva, the pepsin activity in the stomach is rapid.

When the food is masticated in the mouth in the presence of saliva and mucous, it becomes sticky. This sticky food reaches the stomach through oesophagus when it is swallowed. This phenomenon is called deglutition. It is also assisted by peristaltic action of muscles of oesophagus. No digestion occurs in oesophagus because digestive glands are absent here.

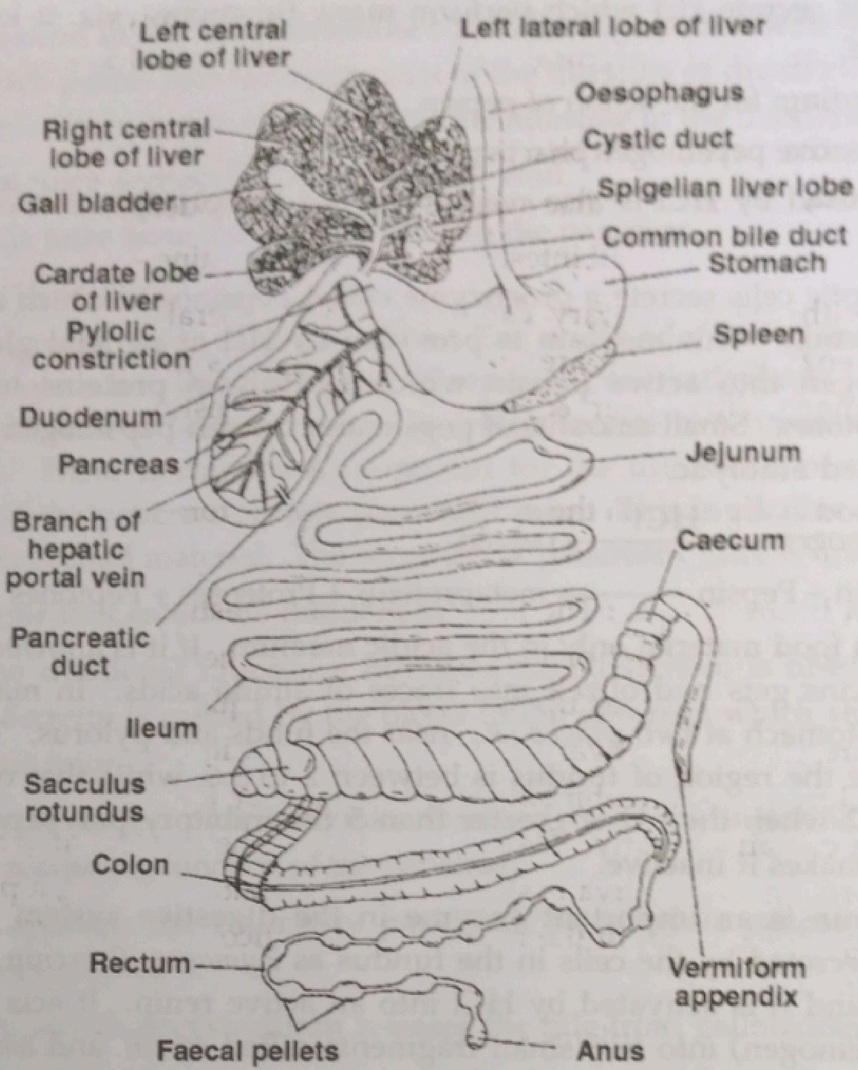

Fig. 1·1 : Mammal - Digestive system

(B) Digestion in the Stomach : Food material from oesophagus reaches the stomach where it mixes with the secretions of the stomach and forms into *Chyme*. When the food enters into the stomach the reaction of salivary anylase or ptylin continues till the gastric juice is secreted and penetrated into the food. Hormone *gastrin* stimulate the gastric glands of the stomach. Gastric glands are of two types *peptic glands* and *oxyntic glands*. Stomach acts as a reservoir for thorough mixing of food and enzymes.

Oxyntic cells first secrete HCl while the peptic glands secrete enzymes like pepsin, renin Musin and Amylase.

Stimulus to secrete gastric juice : Various stimuli are responsible for the secretion and flow of gastric juice.

1. Physiological stimullus, the thought, right and taste of food increases the flow of gastric juice.
2. The presence of food in stomach has an effect on gastric secretion.
3. The presence of products of protein digestion in the intestine stimulats gastric digestion.

The gastric secretion is under the control of both nervous system and hormones. Numerous small glands are scattered throughout the wall of the stomach which secrete this gastric juice. Three types of gastric glands are present. They are (i) Oxyntic or parietal glands which secrete HCl. (ii) Peptic or chief glands which secrete pepsin and other enzymes. (iii) Mucous glands secreting mucin.

Oxyntic cells secrete Hcl which perform many functions. viz. it kills the bacteria present in the food.

Provides medium for the action of pepsin.

Converts inactive pepsinogen into pepsin.

Low pH caused by HCl is also responsible for the precipitation of many soluble proteins.

Pepsin : Peptic cells secrete a proenzyme called pepsinogen which requires an acid medium for its action. This medium is provided by Hcl of parietal glands. This Hcl converts pepsinogen into active pepsin which hydrolyses proteins to metaproteins, proteoses and peptones. Small amounts of pepsin also convert pepsinogen into pepsin and the process is called autolytic.

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

$$\text{Protein + Pepsin} \longrightarrow \text{metaproteins + Proteoses + Peptones}$$

Pepsin reacts with food material only in the acidic medium. If it is allowed to continue its activity, the proteins gets hydrolized into traces of amino acids. In man the pepsin is produced in the stomach at two places *i.e.,* near the funds and pylorus. The pH value of pepsin secreted at the region of fundus is between 2 to 3.6. while that of the pylorus is between 1.5 to 3.2 when the pH is greater than 5 the inibitory polypeptides recombine with pepsin and makes it inactive.

Renin : Renin is an important enzyme in the digestive system of some young mammals. It is secreted by the cells in the fundus as *Zymogen Prorenin*. Prorenin is an inactive enzyme and it is activated by HCl into an active renin. It acts by splitting the milk protein (caseinogen) into two small fragments called *casein* and *whay* (watery part of milk). The enzyme casein combines with the calcium usually found in the milk to form an insoluble calcium protein or *curd*. As a result of this curding, the milk proteins are retained in the stomach long enough for pepsin to act on them. The optimum pH for its action is 4.

$$\text{Prorenin + HCl} \longrightarrow \text{Renin}$$

$$\text{Milk + Renin} \longrightarrow \text{Paracaein}$$

$$\text{Paracaesin} + Ca^{++} \longrightarrow Ca^{++} + \text{paracaesinate}$$

There is no clear evidence to show regarding the secretion of enzyme *lipase* in the stomach. Some amount for its presence is due to regurgitation of intestinal contents into the stomach. But the lypolytic activity of milk is observed in extracts of the gastric mucosa suggests that the gastric glands do secrete traces of lipase.

Mucin : It serves to buffer the strong acid and also act as barrier between the HCl and the mucous membrane of the stomach. In the absence of mucin, pepsin in the acid medium may digest the stomach wall.

Considering the action of pepsin in digesting the proteins, a question arises in the minds of people what prevents the stomach from digesting itself when the wall of stomach is made up of proteins. The explanation is as follows.

(1) Pepsin reacts with proteins only in acid medium. Conditions are not favourable in the living cells for such action, since the protoplasm of a cell is not having any acid.

(2) Living cell contain anti enzymes which inhibit the action of pepsin.

(3) The mucin secreted by the mucous cells stands as a protective barrier between the pepsin and the mucous membrane of the stomach wall.

(C) Digestion in the small intestine : The semidigested or semi liquid food or chyme from the stomach passes into the upper part of the intestine or duodenum where the chyme is fully digested. Three types of juices enter the intestine in the duodenum. They are

(1) Intestinal juice secreted by the duodenal wall.

(2) Pancreatic juice from the exocrine part in the pancreas.

(3) Bile from the liver.

The pancreatic juice : Pancreas is an Exo and Endocrine gland lying close to the duodenum. It opens into the duodenum by seperate Pancreatic ducts. The exocrine part of the pancreas consists of *Islets* of *Longerhan* which secrete two types of hormones, *Insulin* and *Glucogon*. These hormones are essential for the utilization of carbohydrates. The exocrine part of the pancreas secrete pancreatic juice. This is alkaline in nature and helps in the digestion of food material. The secretion of pancreatic juice is under the influence of

(a) acid chyme that enters the duodenum.

(b) From the duodenal mucosa a hormone called *secretin* is liberated by HCl of the chyme. *Secretin* is carried by the blood to the pancreas which stimulates to produce pancreatic juice.

(c) An enzyme called pancreozymin obtained from the intestinal juice controls the enzyme producing function of the pancreas.

(d) Secretin controls the volume of pancreatic juice, while pancreozymin controls the amount of enzymes.

The hormone cholecystochinin releases the bile from gallbladder.

The action of pancreatic enzymes on food material depend upon the emulsifying action of bile. This action of bile is due to bile salts. When bile is not secreted from the liver, as it happens in *jaundice patients* the fat from the food forms a coating over proteins and carbohydrates of the chyme. This prevents the action of pancreatic enzymes in digesting proteins and carbohydrates because the water soluble pancreatic enzymes cannot penetrate through the fatty coating.

The pancreatic juice contains enzymes for the digestion of complex food materials like proteins, carbohydrates, fats and nucleic acids.

Pancreatic proteases : The three proteases present in the pancreatic juice are chymotrypsin, and carboxy polypeptidase.

The chymotrypsin and trypsin which are protein in nature are secreted in inactive form like *chymo trypsinogen* and *trypsinogen*.

Trypsinogen is converted into active trypsin by the intestinal enzyme, the enterokinase. In turn the trypsin activates the *chymotrypsinogen* into *chymotrypsin*.

The trypsin and chymotrypsin react with proteins, hydrolyzing them to proteoses, peptones, polypeptides and into amino acids. Trypsin acts actively at a pH of 7.0 to 9.0 and hydrolyses peptide linkages of the carboxyl groups of *arginine*, and *lysine*, chymotrypsin involves in carboxyle group tryosine and *phenylalanine*. Tryspin and chymotrypsin are also referred to as endopeptidases.

Carboxy polypeptidase hydrolyzes polypeptides to simpler peptides and amino acids. This enzyme is also called as exo-peptitidase.

Pancreatic lipase : This is formerly called as *steapsin* which hydrolyzes fats into *glycerol* and *faty acids.* In the presence of bile salts the activity of pancreatic lipase on fats does not takes place but the pancreatic lipase is acclerated. According to FRAZER complete hydrolysis of fats does not take place by the pancreatic lipase, but the fats are partially broken down to *Manoglycerides* and *Diglycerides* . These can be absorbed in an emulsified form.

Pancreatic amylase : This is a starch splitting enzyme of the pancreatic juice which resembles the salivary amylase. It acts in a neutral or slightly alkaline medium, and hydrolyses starch to maltose.

In addition to the above enzymes pancreatic juice also contains maltase and two polynucleotidases. The maltase splits maltose into glucose and polynucleotidases hydrolizes RNA and DNA.

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

$$\text{Proteins, peptones and proteoses} \xrightarrow{\text{Trypsin}} \text{Polypeptides + Amino acids}$$

$$\text{Polypeptides} \xrightarrow{\text{Carboxypeptidase}} \text{Amino acids}$$

$$\text{Strach, Glycogen} \xrightarrow{\text{Amylase}} \text{Maltose}$$

$$\text{Maltose} \xrightarrow{\text{Maltase}} \text{Glucose}$$

The Intestinal Juice : The secretion of Intestinal Juice is stimulated in three ways.

(1) The presence of food in the intestine gives a mechanical stimulation of the mucosa of the glands.

(2) The intestinal mucosa secretes a hormone called the enterokinin which stimulates the mucosal glands.

(3) A hormone, secretin which stimulates the pancreas to secrete the pancreatic juice and the liver to produce Bile stimulates the mucosal glands to produce intestinal juice. Cholocystokinin hormone contracts the gall bladder and see that bile is evacuvated from it.

Brunners glands present in duodenum secrete mucus which protects the lining of duodenum from Hcl and alkaline Bile.

The enzymes present in the intestinal juice and their functions are as follows :

Peptidases : The peptidases are present in the intestinal juice viz *aminopolypeptidase* and *dipeptidase.* Aminopolypeptidase hydrolyses polypeptides to amino acids. Due to repeated action of the aminopolypeptidase the polypeptides are converted into dipeptides. The enzyme dipeptidase hydrolizes the dipeptides.

Disaccharide splitting enzyme :

(a) Sucrase - splits sucrose to glucose and fructose.

(b) Maltase - converts maltose into glucose.

(c) Lactase - breaks down lactose (milk sugar) into *glucose* and *galactose.*

(d) Nucleases - hydrolyze nucleic acids.

(e) Enterokinase - converts the inactive proteolytic proenzyme of the pancreatic juice trypsinogen into active trypsin.

$$\text{Sucrose} \xrightarrow[\text{Sucrase}]{} \text{Glucose + Fructose}$$

$$\text{Maltose} \xrightarrow[\text{Maltase}]{} \text{Glucose + Glucose}$$

$$\text{Lactose} \xrightarrow[\text{Lactase}]{} \text{Glucose + Galactose}$$

Nucleases : The nuclic acids are hydrolized by three nucleases. Viz.

(a) Polynucleotidase - hydrolizes nucleic acids into nucleotides.

(b) Phosphatase - It removes phosphoric acid from nucleotides forming nucleosides.

(c) Nucleosidase - hydrolizes purine nucleosides to sugar and purine.

No enzyme is present in the intestinal juice which is capable of hydrolizing pyramidine nucleosides.

Bile : The bile is produced by the liver and is liberated into the duodenum and intestine through bile duct. Gall balder acts as a reservior for storing bile. Bile is produced continuously by the liver, but the amount of secretion depends upon the amount of food. When the chyme enters the duodenum, liver is stimulated to produce more bile caused by the hormone *Secretin*. The contraction of the gall bladder to release the bile is controlled by a hormone *cholocystokinin* produced by the duodenal mucosa.

The bile is a viscid liquid, alkaline in nature, bitter in taste and yellowish brown to green in colour. Bile has no enzymes, but contain two *bile pigments*, the *bile salts* and *cholestrol*. The *bile is thought to be both as a secretory and excretory product*.

(a) The bile salts are necessary for digestion and absorption of fats, hence considered as a secretion.

(b) The bile pigments and cholestrol have no digestive function, they are largely eliminated from the body in the bile, hence they are considered as excretory products.

Haemoglobin a scarlet red pigment present in plasma of RBC (Erythrocytes) is a compound protein having a protein called globulin and the red colouring matter *Heme* (Iron salt). When an average life of R.B.C. is completed (100-120 days), *haemoglobin* is liberated and converted into bile pigments, *Biliverdin* and *Bilirubin*. These pigments are derived from the Heme. The heme contains iron, but the bile pigments have no iron. Before the heme is excreted, the Iron is seperated and used again to synthesize the haemoglobin. Biliverdin is the original bile pigment which is green in colour. In man the biliverdin is reduced to bilirubin which is yellow in colour.

When the bile reaches the intestine further changes take place due to bacterial action. Bilirubin is reduced to *mesobilirubinogen* this is further reduced to *storcobilinogen*. This on oxidation gives Strecobivin, the brown pigment responsible for the colour of faecus.

Some pigments are excreted with the urine and they are called as *urobilinogen* and *urobilin*. These substances are responsible for the colour of urine.

If there is any obstruction for the free flow of bile or liver function is impaired or destruction of R.B.C. is more rapid than normal, bile pigments remain in the blood and skin becomes yellow. This conditon is known as *Jaundice*.

taurocholic acid which have physiological importance. These acids are complicated structures composed of *glycoll* and *taurine* in combination with *cholic acid*. Glycoll is the other name for the simplest amino acid, *Glycine*. *Taurine* is the amino acid called *cysteine*. These salts are soluble in water and alcohol, hence they are alkhaline in nature. The activity of the pancreatic lipase is greatly increased in the presence of bile salts. Bile salts have remarkable power of lowering the surface tension and aid in emulsification of fats. Bile salts helps in absorption of fattly acids. The fatty acids in combination with bile salts are soluble and can be absorbed through the intestinal wall. These bile salts are carried to the liver where they are again secreted in the bile. Thus the circulation of bile salts takes place in the body.

Bile salts not only aid in fat digestion but also indirectly in the digestion of other food substances.

Cholesterol : In addition to bile salts and bile pigments, cholesterol is another important constituant of the bile. It is present in greater quantities in bile than in any other body fluid. Cholesterol is held in solution in the bile by means of bile salts. If too much cholesterol is excreted in the bile or the concentration of bile salts is low, the cholesterol may precipitate. Precipitation of cholesterol in large quantities in liver may result in the formation of stones in the gall bladder.

1·1·7 *Hormonal control of digestive juices :*

The action of the digestive glands and their secretions is controlled by the nervous system and the hormones.

(1) Salivary glands in the oral cavity are under the control of nervous system.

(2) The secretion of gastric juice by the gastric glands is partly under the control of nervous system and partly by the action of a hormone, *Gastrin* secreted by the gastric mucosal cells of the stomach.

(3) The pancreas is stimulated for the secretion of pancreatic juice by two hormones like secretin and pancreozymin. The role of nervous system is negligible.

(4) The secretion of intestinal juice is influenced by two hormones, called *enterocrinin* and *duocrinin*.

(5) The release of bile juice from the gall bladder is effected by a hormone called cholocystokinin secreted by the intestinal secretion of the gut.

1·1·8 *Summary of hydrolysis of Food Materials By enzymes in man :*

S. No.	Name of the digestive juice	Secretory gland	Place of action	Medium and pH	Substrate	Enzyme	End product
1.	Saliva	Salivary glands	Oral cavity	Neutral or lightly alkhalene 7·0	Carbohydrates or starch	Salivary Amylase or ptylin	Maltose
2	Gastric juice	Gastric glands	Stomach	Acidic 2·0	proteins Caseinogen	pepsin Renin Gastric lipase	peptides Casein, Glycerol and Farry acid

	juice	cells of pancreas		Alkaline 7-8·0	Proteins peptides	Trypsin, Chymotrypsin, Carboxy peptidase	Peptides, Amino acids
					Starch	amylase or Amylopsin	Maltose
					Maltose	Maltase	Glucose
					Fats	Pancreatic lipase or steapsin	Glycerol and Fatty acids.
					RNA	Ribonuclease	Nucleotides
4.	Succus entericus (Intestinal juice)	Small intestine	Small intes-tine	Alkaline 7-8·0	Trypsinogen	Enterokinase	Trypsin
					Peptones and proteoses	Erypsin	Amino acids
					Maltose	Maltase	Glucose
					Sucrose	Sucrase	Glucose and Galactose
					Lactose	Lactase	Glucose and Galactose
					Peptides	Peptidases	Amino acids
					Fats	Lipase	Glycerol and fatty acids
					DNA RNA	Nucleases	Nucleotides

1·1·9 ***Summary of HoRmonal control of digestive juices :***

S. No.	*Name of the hormone*	*Place of secretion*	*Place of action*	*Function*	*Other factors*
1.	Gastrin	Cardiac stomach	Gastric glands	stimulates the gastric glands to secrete gastric juice	Neutral
2.	Secretin	Duodenum or small intestine	Exocrine cells of pancreas	Stimulates the secretion of pancreatic juice	Neutral
3.	Pancreozymin	Duodenum	Exocrine cells of pancreas	Stimulates the pancreas to release pancreatic enzymes into the duodenum	–
4.	Enterocrinin	Small intestine	intestinal glands	increases the flow of intestinal juices	–
5.	Duocrinin	Duodinum	Duodinum	Activate Brunners glands to rerete mucus.	–
6.	Cholocystokinin	Small intestine	Gall blader	Constriction of gland to release bile juice	Neutral

Note : All the hormones are released into the blood and they will be carried through the blood to their respective target organs.

1·1·10 *Absorption of Digested Food :*

The process of absorption of digested food material mainly takes place in the small intestine. Little absorption of food materials, water, alcohol, mineral salts also takes place in the stomach of man. Small intestine, is the most suitable and well adapted region for absorption. The small intestine has an extensive absorbing surface formed due to the large number of small papilliform intestinal villi containing network of blood and lymph capillaries to absorb the digested food substances. Amino acids and simple sugars are absorbed directly into the blood stream through the blood capillaries of the villi to the liver before they are sent into the general circulation.

(a) Absorption of carbohydrates : Carbohydrates of the food are converted into monosaccharides (glucose, fructose and galactose) during digestion. These monosaccharides are directly absorbed into the blood. During absorption they combine with phosphoric acid to form hexose phospates. They are hydrolized into hexoses before entering into the blood stream. Hence hexoses are only found in the blood instead of hexose phosphates. The hexoses are converted into glycogen and stored in the liver.

The disaccharides like *lactose* is less easily digested than *Maltose* and *Sucrose*, hence reaches the large intestine and serve as food for symbiotic intestinal organisms.

(b) Absorption of fats : Fats are converted into glycerol and fatty acids. The digested fat is a mixture of *triglycerides*, *diglycerides* and monoglycerides and free fatty acids along with glycerol.

(c) Absorption of Proteins : On examination of blood after protein meal an increase in the Aminoacids concentration is noticed, particularly in the R.B.C. This indicates that proteins absorbed as amino acids are carried by the blood to the tissues and are oxidised to produce energy.

At the end of protein digestion most of the proteins are converted to aminoacids, but a part is left in the form of polypeptides. The peptides having a molecular weight of 200-300 are poorly absorbed and pass out in the faecus. Some dipeptides are digested intracellularly, enter the intestinal cells and are hydrolysed there. The free aminoacids are absorbed both by *diffusion* and *active transport*.

(d) Absorption of Nucleic Acids : RNA and DNA are hydrolysed first and then converted into nucleotides and nucleosides absorbed by the mucosal cells of small intestine.

(e) Absorption of vitamins : The vitamins (vital amines) are organic in nature and are responsible for growth and good health of an animal.

Water soluble vitamins - (B and C) are absorbed by simple diffusion.

Fat soluble vitamins - (A, D, E and K) are absorbed in foresence of bilejuice.

(f) Absorption of Water and Electrolytes : Water and electrolytes enter the intestinal lumen from two sources -

(i) through the ingested food, (ii) through the intestinal juices.

(g) Mechanism of Absorption : The exact mechanism by which the simple food molecules are absorbed through intestinal wall is not known. Osmosis and Donnan equilibrium may play an important part but clear explanation is not there.

There is little evidence that the W.B.C. which are numerous in the intestinal mucosa, actually pass through the intestinal wall, become loaded with food and carry such food material into the blood and lymph for circulation.

(h) Assimilation : This is the process of conversion of various digested food materials into life substance composed of complex proteins, carbohydrates and fats, besides the formation of excretory products from excess food materials available. Thus glucoses are utilized by the tissues for releasing energy. Excess glucoses are stored in liver and muscles as Glycogen. CO_2 is released as excretory product during the release of energy. Proteins are synthesized from aminoacids in the cells while the excess aminoacids are converted to the nitrogenous waste materials in liver. Finally the fatty acids and glycerols are assimilated for the construction of life substances while the excess fats are stored in various process as fat bodies.