Chapter - 22
Digestive System of Human

The system of body in which complex food material is converted into simple and absorbable substances by their enzymatic hydrolysis is known as digestive system.

Human digestive system composed of **alimentary canal** and **associated digestive glands.**

Structure of Alimentary canal

Alimentary canal extends from mouth to anus. It is in the form of long, coiled muscular tube. Its length is about 4.5 meters in living, and after death its length becomes 7-8 meters due to relaxation.

Its main parts are as follow- (i) Mouth (ii) Buccal cavity (iii) Pharynx (iv) Oesophagus (v) Stomach (vi) Ileum (Small Intestine) (vii) Colon (large intestine) (viii) Rectum and (ix) Anus

Mouth and Buccal cavity- Mouth is an aperture surrounded by upper and lower lips. It opens into buccal cavity. The upper part of buccal cavity is made of up hard and soft palate. It has walls in lateral side and muscular tongue on ventral surface. Taste buds are present on the surface of tongue which identifies the taste of sour, sweet, salty and bitter tastes.

Mouth opening is surrounded by a non-movable upper and movable lower jaw. Both jaws have teeth. Teeth are used to cut the food into smaller pieces and in chewing. Human dentation is heterodont because teeth are of different kinds. Each jaw has four incisors for cutting, two canines for tearing and piercing, four premolars and six molars are for crushing food. Thus an adult human has total 32 teeth. The configuration of teeth is expressed in term of dental formula.

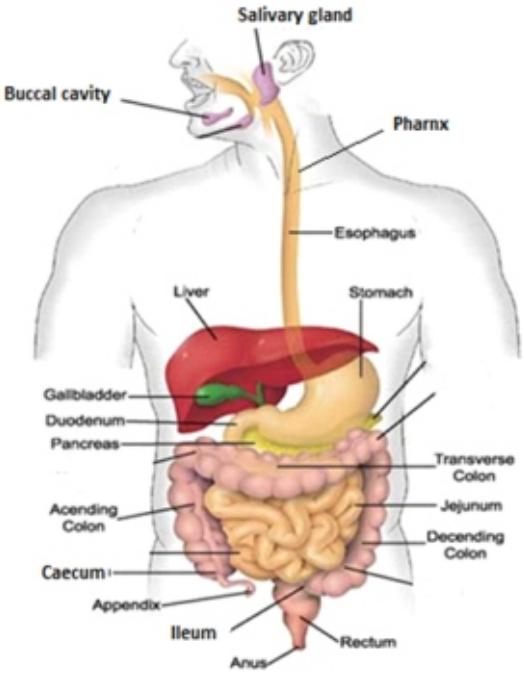

Fig. 22.1 : Human Digestive system

Dental formula of Human =

$$\left[I=\frac{2}{2},C=\frac{1}{1},PM=\frac{2}{2},M=\frac{3}{3}\right]\times 2$$

Teeth are developed twice in the life of human. The first set of teeth is called Milk teeth and other set is called Permanent teeth. Milky teeth are 20. The condition of appearing teeth in two times is known as diphyodont. Premolars are absent in milk teeth.

Structure of teeth - Teeth is much hard

structures. Each tooth has three parts. Lower part is fixed in bony socket of jaw is known as Root. Upper part is crown and in between of both middle parts is neck surrounded by gums. Tooth is formed by bone like hard dentine. Central part of tooth has pulp cavity. It contains odontoblast, blood vessels and nerve fibres. Its basal part has a pore which is called apical pore.

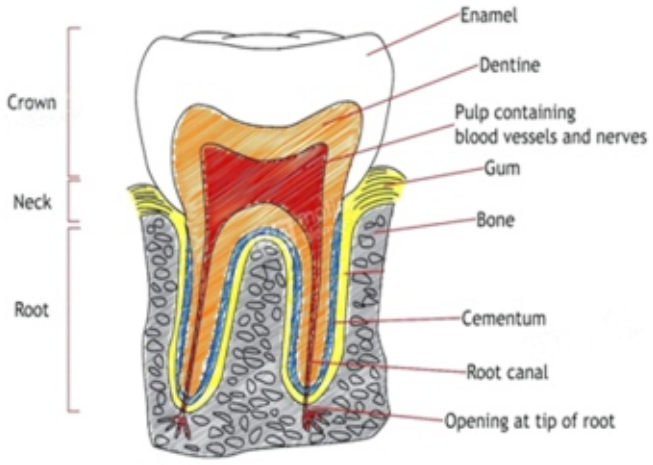

Fig. 22.2 : Structure of Human teeth

Blood and neural conduction is given to tooth by this pore. Due to the activity of odontoblasts, tooth increases in size. After a particular age generally it becomes inactive and development of tooth stops. Odontoblast secretes dentine. The crown of tooth is covered by enamel, which is the hardest substance of body. Root remains fix in socket by bone like cement.

Pharynx– The middle part of buccal cavity and Oesophagus is pharynx. It is common part of respiratory and digestive system. Its wall is made of voluntary muscles. The openings of Eustachian tubes are present in pharynx. Its posterior part has two apertures – Glottis and Gullet. Pharynx opens in tube like Oesophagus through gullet.

Oesophagus- It is approximately 25cm long. The common layer of tissues, serosa, external muscular layer, sub- mucosa and mucosa are found in its wall. Serosa is actually visceral peritoneum. It is layer of only elastic fibrous connective tissue. In muscular layer outer longitudinal and inner circular muscle layers are involuntary muscles. Sub-mucosa is a layer made up of connective tissue which has nerves, blood and lymph vessels, collagen and elastic fibres and mucous glands. Mucosa is the inner most layer in which epithelium, lamina proporia and mucous membrane are present. Inner epithelium of oesophagus is in the form of stratified squamous epithelium. Striated muscles are found in initial part of oesophagus. Oesophagus sends food from pharynx to stomach by peristalsis. Entry of food in trachea is checked by epiglottis.

Stomach – It is located below diaphragm and on left side of abdominal cavity. Oesophagus enters the abdominal cavity by piercing the diaphragm and opens into stomach. Stomach is muscular bag like structure which has three parts – (i) Cardiac part (ii) Fundus part (iii) Pyloric part.

Cardiac part– it is small part jointed with oesophagus. The passage between oesophagus and cardiac part is known as cardia. At the junction, with oesophagus a cardiac sphincter is found which prevents the entry of food from stomach to Oesophagus. It is called cardiac valve or Gastro esophageal sphincter.

Fundus part– It forms maximum (80%) part of stomach and digestive juices are secreted here. It forms the middle part of stomach.

Pyloric part– It is terminal part of stomach which joins with duodenum. The aperture between pyloric part and duodenum is known as pylorus. The place where it joins with duodenum pyloric sphincter is present. It prevents food to move in opposite direction. It is called pyloric valve.

The stomach wall is generally made of four layers. Mucosa is folded and thick layer. Mucosa epithelium is simple and columnar. It also contains mucous secreting cells. Mucous prevents stomach from self-digestion. Long tubular glands are also found which are formed from folds of epithelium. Theses glands are of two types (i) gastric gland and (ii) pyloric glands. Both these are present in basal membrane.

Gastric glands secrete acidic gastric juice and pyloric glands secrete mucous. Chief cells or Zymogen cells of these glands secrete pepsinogen and oxyntic or parietal cells secrete hydrochloric

acid. These glands are found in fundus and mid body part and form about 80% part of stomach.

Pyloric glands are found in pyloric part which forms about 20% part of stomach. Three layers are found in external muscular layer of stomach named as outer longitudinal, middle circular and inner oblique muscles.

Small Intestine– Stomach opens into small intestine by pylorus. It is 3 meter long in living condition. It's about 25 cm long U shaped initial part is known as duodenum. Pancreatic duct and common bile duct open into this part. Sphincter of oddi is present on their opening. Second part of small intestine is one meter long and coiled which is known as Jejunum. Last section of small intestine is nearly 1.75 meter long and highly coiled, known as Ileum.

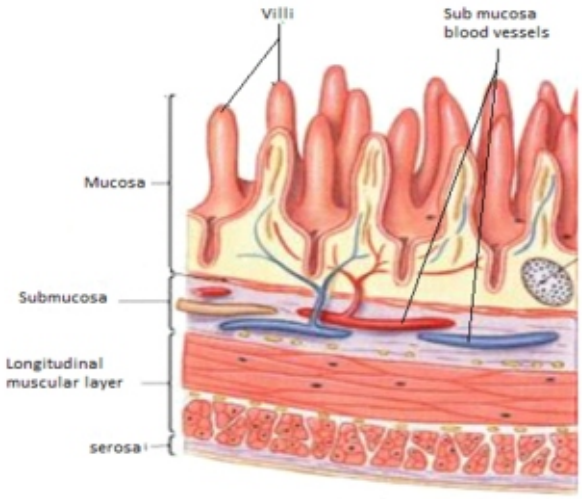

Fig. 22.3 : Structure of llium

Intestinal wall has four common tissue layers. Mucosa and sub mucosa layer both layers become folded. Folds are approximately 8mm and called Folds of Kerckring. Folds of mucosa have 1 mm long finger like projections known as villi. Each villus has lacteal vessels or lacteal capillaries, blood capillaries ands mooth muscles are found in each velum.

1 µm long nearly one thousand micro villi are present on epithelial cell or villi. These microvilli forms brush border. Presence of folds, villi and microvilli increases surface area of intestine for digestion and absorption. Lacteal glands are found in solitary or in groups in mucosa layer of ileum which are known Peyers patches. Intestine becomes folded and form tubular intestinal glands. These glands are known as crypts of Lieberkuhn. Goblet cells, intestinal cells and Peneth cells are present in these crypts. Goblet cells secrete mucous. Intestinal cells secrete water and hydrolytes in much amount.

Digestive enzymes are filled in them. Peneth cells secrete bacteria killing enzyme Lysozyme.

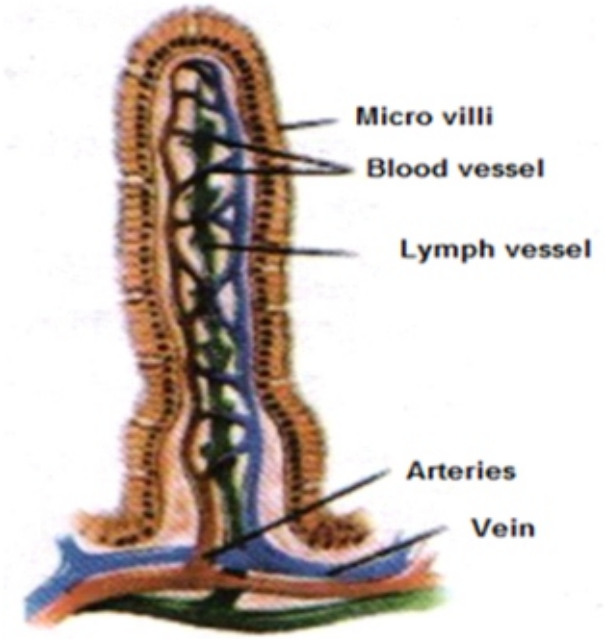

Fig. 22.4 : Structure of villus

For secretion of mucous, small coiled mucous glands are found in sub mucosa layer of duodenum these are known as **Brunner's glands**.

Large intestine– The last part of alimentary canal is large intestine. Its diameter is more. Its length is nearly 1.5 meter. Large intestine has three parts caecum, colon and rectum. Caecum is found at the junction of ileum and large intestine. It is considered as vestigial organ. At the end of caecum nearly 1 cm in diameter and 8 cm long finger like projection is present which is known as **Vermiform appendix**. Appendix has no function. In between ileum and colon, **Ileo-caecal valve** is present which allows movement of substances from ileum to colon but no backward movement in ileum. Colon has three parts – ascending, transverse and descending colon.

Rectum and anus - Last part of large intestine

is rectum which opens outside by anus. Anus is surrounded by two sphincters inner sphincter is made up of smooth muscle and outer sphincter is made up of striated muscles.

The wall of large intestine has four tissue layers. The mucous cells secret only mucous which also contain bicarbonates. Villi are absent in large intestine. Its epithelial cells have no any digestive enzymes. Three plates of longitudinal muscle layer of large intestine are arranged in **Taeniae coli** form**.** In between these plates intestinal wall is exposed in the form of haustoria. Many symbiotic bacteria are also live in colon.

Digestive Glands

Three digestive glands associated with human alimentary canal are –

1. Salivary glands 2. Liver 3. Pancreas.

1. Salivary glands - Three pairs of salivary glands are found in human. These are **Sublingual, Sub maxillary** and **Parotid glands.** Saliva secreted by these glands comes in buccal cavity. Saliva is alkaline fluid.It has water, ptyalin or α - amylase or salivary amylase, lysozyme, mucous and ions of sodium chloride, potassium bicarbonate etc. Ptyalin is digestive enzyme. Lysozyme destroys bacteria.

2. Liver – It is largest digestive gland of human body which is derived from embryonic endoderm. Its weight in healthy human is about 1.2 to 1.5 kg. It is about 15 to 22 cm broad. Liver lies in right side just below diaphragm. Liver has two main lobes i.e. right lobe and left lobe. Right lobe is larger than left lobe. Beside these two extra lobes are also found, these are known as quadrate and caudate lobes.

Below the right lobe of liver a small, thin walled sac like green coloured **Gall bladder** is present. Gall bladder stores bile secreted by liver cells. Bile is yellowish green coloured fluid having bile pigments and bile salts. It is alkaline substance.

The hepatic duct coming out from both liver lobes join together and form a common hepatic duct. Common bile duct is formed by joining of hepatic duct and cystic duct. It is also called **Ductuscholedochus**. It supplies bile juice in duodenum. Common bile duct opens in the proximal arm of duodenum in human. A valve is present at its opening which is known as **sphincter of oddi**. Sphincter of oddi controls this aperture.

Liver is composed by many hepatic lobules. These are functional unit of liver. Hepatocytes form hepatic lobules. Narrow spaces are found between cords of liver cells. The cells of discontinuous endothelium are situated in these spaces. These spaces are known as liver sinusoids. Adjoining the wall of sinusoids **Kupffer cells** are present. These are also called macro phagocytes. They decompose bacteria and damaged blood cells. Hepatic artery, hepatic portal vein and branches of bile duct are situated in between lobes at its outer corners. These three together form **portal triad**.

Main functions of Liver –

1. Formation of bile – The main function of liver is to secrete bile. Bile is green coloured alkaline fluid. It contains bile salts, bile pigments; cholesterol, lecithin etc. Sodium bicarbonate, glycocholate and taurocholate are mainly present in bile salts. Biliverdin and bilirubin are the main in bile pigments. Bile pigments are formed by decomposition of haemoglobin. Bile juice plays an important role in digestion of fats and emulsifies them. It checks the food from rotting. It destroys harmful bacteria present in food. It removes the acidity of food and makes it alkaline, so that the enzymes of pancreatic juice may react.

2. Hepatic cells convert excess amount of glucose into glycogen and then stores. This process is known as **Glycogenesis.**

3. When sugar level becomes low in blood, the liver cells convert glycogen into glucose and complete its deficiency. This process is known as **Glycogenolysis**.

4. Liver cells also synthesize glucose from fatty acid, amino acid etc. It is known as **Gluconeogenesis.**

5. Liver cells synthesize vitamin A and store Vitamin D, and B_{12}.

6. Liver cells synthesize urea.

7. Liver cells form heparin which prevents blood clothing in blood vessels.

8. Liver cells synthesize prothrombin and fibrinogen named blood protein. At the time of injury they have important role in blood clotting.

9. Liver acts as haemopoitic (blood producing) organ in embryonic stage. Despite it in adult stage Kupffer cells destroy dead red blood corpuscles.

3. Pancreas – It is the second largest digestive gland of human body. It is located between two arms of duodenum. It is irregular shaped mixed gland because it has dual function: exocrine as well as endocrine. It originates from embryonic endoderm. It has two types of group of cells.

(i) Acini- It is group of exocrine cells, which is found between connective tissue. These cells synthesize pancreatic juice.

(ii) Islets of Langerhans– These are endocrinal nature of cell group which are found at some places between acini cell groups. It has three types of endocrine cell groups which secretes different kind of hormones.

(A) Alpha cells (α-cells) – It secrete glucagon hormone.

(B) Beta cells (β -cells) – It secrete insulin hormone.

(C) Gama or delta cells (γ or δ – cells) - It secrete somatostanin, gastrin and serotonin hormones.

Mechanism of digestive system of human

Mechanism of digestion in human is studied under following steps –

(i) Ingestion (ii) Digestion (iii) Absorption (iv) Assimilation (v) Egestion.

(i) Ingestion -

The process of intake of food by human and any other living organism is known as ingestion. Human is an omnivorous animal. Ingestion of food completes in two steps in human. Food is masticated in first step and swallowed in second step. Food is taken inside after cutting by incisors then it is masticated by premolar and molar. By collective activity of teeth, tongue and muscles food is masticated in buccal cavity. Food is rotated in buccal cavity by tongue; and by the mixing of saliva food is converted it into semi solid ball which is known as bolus. The process of mastication is completed due to reflex action originates by presence of food in buccal cavity.

(ii) Digestion

(a) Digestion in buccal cavity– Saliva is mixed with food in buccal cavity. Saliva is secreted by salivary glands. pH (6.8) of saliva is slightly acidic. Amylase present in saliva initiates digestion of carbohydrate. Starch present in food is hydrolyzed into maltose and α- limit dextrin. Bicarbonate ions of saliva neutralize the acid present in food. Food remains for a short time in buccal cavity; hence starch is partially digested here.

$$\text{Starch (polysaccharides)} \xrightarrow[\text{pH6-7}]{\text{Amylase}} \underset{\text{(Disaccharide)}}{\text{Maltose + Dextrin}}$$

Dextrin has 3-9 molecules of glucose.

(b) Digestion in stomach – Food is churned by peristaltic waves in stomach and gastric juice is mixed in it. Food remains 3-4 hours in stomach. Partial digestion of proteins takes place here. Gastric juice contains HCl, mucous, pepsinogen and gastric lipase in small quantity. Gastric juice is highly acidic (pH 1-2) due to presence of HCl. It reduces pH of food. In low pH activity of salivary amylase stops. Hydrochloric acid destroys bacteria, present in food. It also dissolves hard elements of food. Pepsinogen is in inactive form which has not enzymatic activation. Hydrochloric acid converts it in active form of pepsin.

$$\text{Pepsinogen (Inactive)} \xrightarrow{\text{HCl}} \text{Pepsin (Active)}$$

Active pepsin hydrolyses proteins into proteose, peptones and some polypeptides.

$$\text{Protein} \xrightarrow[\text{(pH 2-3)}]{\text{(Pepsin+HCl)}} \underset{\text{Polypeptide.}}{\text{Proteose + peptones +}}$$

Pepsin is main enzyme in stomach for digestion of protein. Milk coagulating enzyme renin is absent in human.

Gastric lipase is a weak enzyme for the digestion of fats. It can digest fat in very low

quantity. It digests tri butyrin (fat present in butter) into fatty acids. After digestion in stomach, food is converted into semiliquid food paste like substance chyme.

Milk fat+gastric lipase → Fatty acid + Glycerol

HCl is a strong acid but it does not harm stomach wall because inner wall of stomach has a thick covering of mucous which is not penetrated by HCl so it cannot reach to the cells and does not harm to its wall.

c) Intestinal digestion - Partially digested food, acidic chyme having carbohydrate and protein slowly moves into duodenum. Burnner's glands secrete enzyme free alkaline liquid (bicarbonate) and mucous in high amount. This alkaline (pH 8-9) liquid protects duodenum wall from acidic gastric juice. Pancreatic juice and bile juice also enters in duodenum. Pancreatic juice and bicarbonates of bile neutralize chyme and reduces its acidity.

Intestinal juice contains hydrolytes and water in high amount. Digestive enzymes are virtually absent in it. It is slightly alkaline (pH 7.5-8) liquid. The process of digestion is completed by digestive

Table 22.1 Main digestive enzymes and their activities (Inactive form in bracket)

Part of Alimentary canal		Glands	Digestive enzyme	Food be digested	Products
1	Buccal cavity	salivary glands	**α- amylase**	Starch	Maltose Malto triose and α- limit dextrin
2	Stomach	Gastric glands	Pepsin (pepsinogen)	Protein	Proteose Peptone poly peptide
3	Duodenum and other parts of intestine	Pancreas	Trypsin (Trypsinogen)	Protein proteose etc	Small polypeptide,
			Chymotrypsin (Chymotripsinogen)	Protein proteosesetc	Tripeptide, Dipeptide, small poly peptide
			Carboxypeptidas (procarboxy peptidase)	Small polypetides Dipeptides	Tripeptides, Dipeptides Amino Acids
			Elastase (proelastase)	Elastin	Large, Small poly peptides
			Lipase	Triglycerides	Fatty acid. Monoglyceride
			α- amylase	Starch	Maltose, Maltotriose and α- limit dextrin
			Nuclease	Nucleic Acid	Nucleotide
		Intestinal mucosa	Aminopeptidase Dipeptidase Maltase	Small polypetide Dipeptide Maltose Maltotriose	Aminoacids, Dipeptide, Two amino Acid Glucose
			Lactase	Lactose	Glucose Galactose
			Sucrase	Sucrose	Glucose Fructose
			α- limit dextrinase	α- limit dextrin	Glucose

enzymes, secreted by enterocyte cells of intestinal glands. Maximum digestion completes in duodenum while absorption completes in remaining part of intestine. For this, nearly 4-5 hours food remains in intestine.

Bile salts (Bile acid and salt of sodium and potassium) and lecithin are important in emulsification of fat. These act as natural detergent.

One part of bile salt and lecithin molecules are polar and other part is non-polar. The non-polar part dissolves in surface of fat globules and polar part remains dissolve in water present in food. Due to this activity surface tension of fat globules reduced. Resulting break down of large fat globules into small sized (1μm diameter) fat droplets. This activity is known as emulsification. Enzymes quickly react on emulsified fat.

$$\text{Fat} + \text{Bile} \xrightarrow{\text{Emulsification}} \text{Emulsified fat}$$

Pancreatic juice has protein digestive enzymes trypsin, chymotrypsin, corboxy-peptidase and elastase. These are secrated in inactive form. First of all inactive trypsinogen is activated by enterokinase (enzyme secreted by intestine). After activation different enzymes take part as follow in digestion

$$\text{Trypsinogen (Inactive)} \xrightarrow{\text{Enterokinase}} \text{Trypsin (Active)}$$

$$\begin{matrix}\text{Chymotrypsinogen} \\ \text{Pro carboxy peptidase} \\ \text{Proelastase} \\ \text{(Inactive)}\end{matrix} \xrightarrow{\text{Trypsin}} \begin{matrix}\text{Chymotrypsin} \\ \text{Carboxypeptidase} \\ \text{Elastase} \\ \text{(Activate)}\end{matrix}$$

$$\begin{matrix}\text{Proteose,} \\ \text{Peptone} \\ \text{polypeptide}\end{matrix} \xrightarrow[\text{pH 7}]{\text{Trypsin, Chymotrypsin}} \begin{matrix}\text{Small} \\ \text{polypeptide,} \\ \text{Tripeptide and} \\ \text{Dipeptide}\end{matrix}$$

$$\begin{matrix}\text{Small} \\ \text{polypeptide}\end{matrix} \xrightarrow[\text{pH 7}]{\text{Carboxy peptidase}} \begin{matrix}\text{Amino acid,} \\ \text{Dipeptide}\end{matrix}$$

Elastin fibres present in food are digested by elastase.

Starch, glycogen and other carbohydrate molecules are hydrolyzed by pancreatic amylase and are converted into maltose and oligosaccharides. It is a strong enzyme which digests all starch present in duodenum nearby within half an hour.

Pancreatic juice has alarge amount of lipase enzyme which digests all triglycerides available in food within few minutes.

$$\begin{matrix}\text{Emulsified fat} \\ \text{(triglyceride)}\end{matrix} \xrightarrow[\text{pH 7}]{\text{Lipase}} \begin{matrix}\text{Fatty acid and} \\ \text{2-monoglycerides}\end{matrix}$$

Cholesterol ester hydrolase and phospholipase–A gradually hydrolyses cholesterol esters and phospholipid respectively and separate fatty acids from them. Ribonucleaseand deoxyribonucleasegradually hydrolyses RNA and DNA and change them into nucleotide.

The enzymes present in enterocyte cells of small intestine carry out digestive activities as follows. These enzymes are bonded on outer surface of microvilli and hydrolyze the food coming in contact with them before absorption.

$$\text{Sucrose} \xrightarrow[\text{pH 8.5}]{\text{Sucrase}} \text{Glucose + Fructose}$$

$$\text{Maltose} \xrightarrow[\text{pH 8.5}]{\text{Maltase}} \text{Glucose + Glucose}$$

$$\text{Lactose} \xrightarrow[\text{pH 8.5}]{\text{Lactase}} \text{Glucose + Galactose}$$

$$\alpha\text{- Limi dextrint} \xrightarrow[\text{pH 8.5}]{\alpha\text{-limit dextrinase}} \text{Glucose}$$

$$\text{Polypeptide} \xrightarrow[\text{pH 8.5}]{\text{Amino peptidase}} \begin{matrix}\text{Dipeptides +} \\ \text{Amino acids}\end{matrix}$$

$$\text{Dipeptide} \xrightarrow[\text{pH 8.5}]{\text{Dipeptidase}} \text{Amino acids}$$

Triglycerides (Emulsified) $\xrightarrow[\text{pH 8.5}]{\text{Intestinal lipase}}$ Fatty acids + 2-mono glycerides

3. Absorption of digested food

Transfer of digested food (i.e. food substances, vitamins, salts, and water) from epithelial cells of intestine to blood and lymph is known as absorption. Maximum substances are absorbed by ileum (small intestine). Fat soluble some substances like alcohol and drugs are absorbed in stomach. Mainly water is absorbed in colon (large intestine).

By the presence of many folds, millions of villi and microvilli increases the surface area of ileum mucosa up to approximately 100 times. The microvilli present on epithelial cells of mucous membrane combines to form brush border. Each villus has a central lymph vessel and blood capillaries (Fig. 22.3 and 22.4). End products of digestion are mono saceharides (glucose, galactose, Fructose), amino acids, mono glycerides and fatty acids which are mainly absorbed.

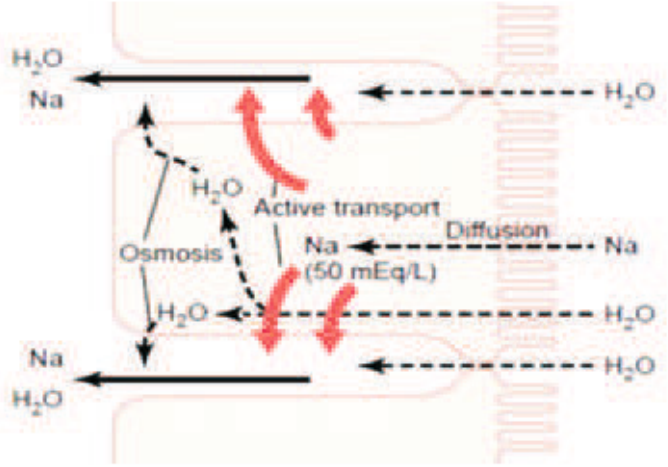

Fig. 22.5 (a) : Sodium Co-transtport process of absorption

Active transport and diffusion are the main mechanism of absorption. Amino acids and glucose are absorbed by blood through active transport(Fig. 22.5 a).

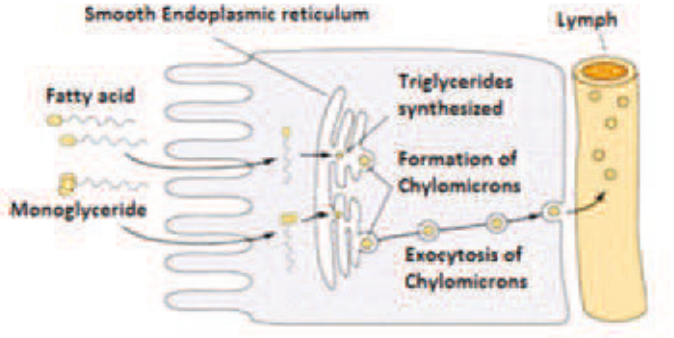

Fig. 22.5 (b) : Process of Fat Absorption

Fat is absorbed in the form of fatty acid, mono glyceride and cholesterol in lymph vessel by diffusion. Bile plays an important role in absorption. Bile form minute complex structures with these fats. These structures are known as Micelles. Micelles are dissolved in chyme. Each micelle is smaller spherical or rod shaped globules of fats and bile salts. Their diameter is 3 to 6 µm. Central part of theses globules has fatty acid and mono glyceride. Bile salts deposited around them. When micelles come near micro villi, fat released from micelle and diffused into cell because fats present init are soluble in cell membrane. Bile salts remain back in chyme and again reform micelles.

Fatty acids and monoglycerides enter into smooth endoplasmic reticulum and synthesize new triglycerides in the cell. These triglyceride molecules are surrounded by protein. Such lipoprotein globules are known as chylomicron (diameter 0.1 to 3.5 µm). Chylomicron comes out by exocytosis and enters into lymph capillaries, which in turn enter to blood plasma of vein through lymphatic system. With the help of lipase lipoprotein transformed them in fatty acids and monoglycerides in plasma (Fig. 22.5b).

Vitamins and salts are absorbed by active or passive transport methods. Water is absorbed only by diffusion. Water and some vitamins (i.e. vitamin K) are absorbed in colon.

Table 22.2 Main Protein, their sources, function and deficiency disease

Vitamin symbol name		Major food source	Function	Deficiency disease
[A] Fat soluble				
1	A Retinol	Green vegetables carrot, tomato, liver, yolk, milk	Formation of visual pigments	Night blindness xerophthalmia(dry eye)
2	D Calciferol	Fish-liver oil, Milk, synthesized by skin in presence of sunlight	Absorption of Ca^{++}ion, bone formation	Rickets disease
3	E Tocoferol	Green leaves, oil of germinating wheat, liver, Milk	Prevent oxidation of unsaturated fat (anti-oxidant)	Infertility, paralysis
4	K-Naphthoquinon e or Phylloquinone	Green leaves, synthesized in intestine by bacteria	Formation of prothrombin, Formation of blood clot	Bleeding, No formation of blood clot.
	[B] water soluble			
5	B-Thiamine	Yeast, liver, Milk, Yolk, Whole grains	Coenzyme TPP formation	Bereberi disease
6	B_2 - Riboflavin	Milk, Yolk, Liver, yeast	Growth, part of FAD	Cracking in corners of mouth (Cheilosis)
7	B_3 - Nicotinic acid	Whole grains, Liver, Yeast, Milk	Part of NAD and NADP	Pellagra disease
8	B_5 - Pantothenic acid	Most Food, Yeast	Part of CoA	Burning feet syndrome
9	B_6 - Pyridoxine	Milk, Vegetables, Yeast whole grains	In metabolism of fatty acid and amino acid	Dermatitis (Skin disease)
10	B_{12} - Cyanocobala - min	Milk, Liver, Produced by intestinal bacteria	Maturation of RBC	Pernicious anemia
11	H- Biotin (It is also called) B_7	Milk, Liver, Yolk, Yeast	Fatty acid metabolism	Spectacle eye, fall of hairs
12	B_9- Complex folic acid	Liver, Green leaves yeast	Formation of Red blood corpuscles	Macrocytic anemia
13	C- Ascorbic acid	Fruits of citrus group,Tomato, amla	Collagen synthesis anti-oxidant	Scurvy disease bleeding from gums.

4. Assimilation–

Absorbed food materials are reached in cells through blood. These are decomposed for energy in cells and energy is stored in ATP form. Extra quantity of food materials is stored in the form of glycogen or fats. Necessary new materials like protein, carbohydrate, fat etc. are also synthesized from these materials for body. Liver plays an important role in these activities.

5. Egestion-

Remaining undigested part of food passes into colon. It has many bacteria which decompose cellulose present in remaining undigested food. Absorption of water and formation of faeces is the main function of colon. Colon absorbs maximum water and also minerals. Remaining undigested part, mucous, dead epithelial cells, dead bacteria, bile pigment (bilirubin) etc. combine and form faeces.

Faeces are discharged once or twice in nearly 24 hours. When faeces passes into rectum,and then pressure is created on it by contraction of rectum wall by creating pressure sphincter opens and faecal matter is discharged out by anus. Faeces discharge is controlled by nervous system and it is a reflex response which originates stimulus from lower part of colon, which is filled with faeces. It completes when pressure on rectum wall reaches on a definite range (about 20mm Hg).

Malnutrition and Nutritional disorders

Malnutrition means defective or incomplete nutrition. Malnutrition can define in such type of physical condition of a person which is caused by the diet which does not supply all nutrients in proper amount or due to disability of metabolic absorption by any disease.

Malnutrition may be of four types-

Under nutrition- When availability of food in insufficient quantity for a long period then it is called under nutrition.

Over nutrition- When food is taken in much quantity for a long period then it is called over nutrition.

Imbalanced nutrition- The use of such type of diet, which has some nutrients in more ratio and others are in less ratio then it is called imbalanced nutrition.

Specific deficiency– When any specific nutrient available in less quantity or completely absent in diet, hence the specific nutrient becomes less in body.

Malnutrition makes person weak and diseased. About 30 crore people are suffering from malnutrition in the world.

Due to malnutrition children's growth and mental development related. Five main diseases related to nutrition are identified by World Health organization (WHO).

1. Kwashiorkor- It is caused by deficiency of protein.

2. Marasmus or Dry disease– This disease is caused by deficiency of protein and calorie.

3. Exophthalmia- This disease is also caused by deficiency of vitamins 'A'.

4. Anemia– This disease is caused by deficiency of iron.

5. Goiter- This disease is caused by deficiency of iodine.

The disease caused by deficiency of carbohydrates, fats, proteins or minerals are as follow-

1. Protein- Protein- energy malnutrition, PEM.

2. Mineral deficient disease – i.e. osteoporosis is caused by deficiency of calcium.

3. Vitamin deficient disease – Given in (table-22.2)

Protein energy malnutrition (PEM) is caused by deficiency of protein, fats and carbohydrates in diet. It affects children up to 1 to 5 years. PEM is of two types- **Kwashiorkor** and **Marasmus**. These diseases are prominent in African Children. These diseases are caused when mothers get off early breast feeding to baby and protein deficient diet is given them. Peoples of these countries use maize as main food. Essential amino acid tryptophan is absent in maize and hence protein is not synthesized in body. Thus, deficiency of protein is caused.

Kwashiorkor- This disease is caused due to high deficiency of protein. Children of 1-3 years age group get less protein than one gram per kilo body weight daily may suffer from this disease.

Main symptoms of this disease are -

1. Loss of weight, irritability and appetite.

2. Skin becomes black, rough and cracks.

3. Swelling in body and stomach enlarges.

4. Hairs become thin, loss and red or white.

Marasmus or dry disease– This disease is caused due to deficiency of protein, fats and carbohydrates in infants below the age of one year.

Main symptoms of this disease are-

1. Loss of weight (loss of weight up to 60% in child's average weight at this age).

2. Languid, dry and wrinkled face and sunken eyes.

3. Thin muscles, thin legs and arms. Ribs are seen from outside.

4. No swelling in body and hairs remains unaffected.

These diseases may cure by providing protein-rich- diet otherwise this disease may be dangerous.

The diseases caused by over nutrition are normal in developed countries (Europe, America). Obesity is such type of disease. When a person has 20% excess weight than usual person by using more energy in compare to required energy then it is called obesity. The possibility of heart related disease, blood pressure, diabetes is increased due to obesity.

Important Points

1. Alimentary canal and its associated glands are main parts of digestive system.
2. The breakdown of complex organic substances into simple substances by hydrolytic activity is known as digestion.
3. Digestion of carbohydrate is initiated in buccal cavity and of protein in stomach.
4. Bile is helpful for emulsification and absorption of fat.
5. Digested food is absorbed mainly in ileum.
6. Vitamins and minerals are essential for normal growth and regulation of metabolic activities.
7. Nutrition related diseases are caused by deficiency of vitamins, protein, minerals and energy providing substances in food. Kwashiorkor and Marasmus are protein deficiency diseases.
8. Obesity is a disease. The possibility of heart related disease, high blood pressure and diabetes etc. diseases are increased due to obesity.

Practice Questions

Multiple choice questions-

1. Renin is secreted from where?
   (a) Liver (b) Colon
   (c)Stomach (d) Sectum
2. Pancreatic juice is –
   (a) Acidic (b) Alkaline
   (c) Neutral (d) None of above
3. Kupffer cells are found in -
   (a)Pancreas (b) Small intestine
   (c) Large intestine (d) Liver
4. Amylase enzyme acts on –
   (a) Protein (b) Carbohydrate
   (c) Fatty acid (d) Fat
5. Inactive pepsinogen is converted into active pepsin by-
   (a) Ptyalin (b) HCl
   (c) Bile juice (d) Renin
6. How many salivary glands are found in human-
   (a) 5 Pairs (b) 2 Pairs
   (c) 4 Pairs (d) 3Pairs
7. Liver cells synthesize-
   (a) Bile (b) Trypsin
   (c) Amylopsin (d) Lipase
8. Islet's of Langerhans are found in –
   (a) Pancreas (b) Small intestine
   (c) Large intestine (d) Liver
9. The vitamin, motivates the maturation of Red blood corpuscle is
   (a) D (b) A
   (c) B (d) B 12
10. The part of alimentary canal which has villi is.
    (a) Stomach (b) Intestine
    (c) Oesophagus (d) Rectum

Very short Answer Questions-

1. Where are Kupffar cells present?
2. What is the function of Vitamin K?
3. Which organ synthesizes and stores glycogen?
4. Which mineral deficiency occurs due to deficiency of vitamin – D?
5. Write the name of disease caused by deficiency of protein energy malnutrition?
6. Where digested fat does is absorbed?
7. Which vitamin can be synthesized by human?
8. Write dental formula of human.

9. What is bolus?
10. What are Brunner's glands?
11. What do you mean by payer's patches?
12. What is sphincter of Oddi?

Short Answer Questions

1. Write functions of Liver.
2. What is emulsification? What is its significance?
3. What is chylomicron?
4. What is kwashiorkor disease? Mention its symptoms.
5. What is Marasmus disease? Mention its symptoms.

Essay Type Questions

1. Describe the alimentary canal of human with diagram.
2. Describe the structure of human teeth with diagram.
3. How and where digested food is absorbed in human?
4. Explain in detail intestinal digestion in human.

Answer Key

1. (c)	2. (b)	3. (d)	4. (b)
5. (b)	6. (d)	7. (a)	8. (a)
9. (d)	10. (b)		