CHAPTER-11
DIGESTION

Food

Food is necessary to sustain life. The food is utilized at the cellular level. Most of the food we eat, however, is not suitable for cellular utilization until it is mechanically and chemically reduced to forms that can be absorbed through the intestinal wall and transported to the cells by the blood.

Science Titbits

Inflammation of the parotid is called parotiditis or parotitis. The most common type of parotitis, caused by a viral infection, is mumps.

Teacher's Point

Teacher would guide the students to list structural features that increase surface area of small intestine.

Science Titbits

Mucus is secreted in large amount by duodenal glands, intestinal glands, and goblet cells. The mucus provides the wall of intestine with protection against the irritating effects of acidic chyme and against the digestive enzymes that enter the duodenum from the pancreas.

Science Titbits

Lipoproteins are referred to as high or low-density lipoproteins. A lipoprotein with high lipid content has a very low density (LDL), whereas a lipoprotein with high protein content has a relatively high density (HDL). Chylomicrons, which are made up of 99% lipid and only 1 % protein, have an extremely very low density.

Did You Know?

The appendix contains a small amount of mucus associated lymphoid tissue which gives the appendix an undetermined role in immunity. However, the appendix is known to be important in foetal life as it contains endocrine cells that release biogenic amines and peptide hormones important for homeostasis for during early

growth and development. Appendicitis is an inflammation of the vermiform appendix and usually occurs because of obstruction of the appendix. An appendectomy is removal of the appendix.

Accessory Glands

The accessory glands of the digestive system are liver, gall bladder and pancreas.

Science Titbits

Some bacteria in the large intestine (colon) synthesize vitamin K, which is passively absorbed in the colon, and breakdown a small amount of cellulose to glucose. Gases called flatus (meaning, blowing) are produced by bacterial actions in the colon.

Teacher's Point

Teacher would guide the student to relate hepatitis and Jaundice with the function of liver.

Did You Know?

In the early 1980's an Australian medical resident named Barry Marshall firmly believed that bacteria play a role in ulcers, but physicians have always blamed the open B sores on stress or prescription drug side effects. Marshall set out to prove the bacterial link. One morning in 1984, he walked into his lab, stirred a beaker full of beef soup and *Helicobacter pylori* and gulped the concoction. After five days he began to vomit. Marshall and others demonstrated that *Helicobacter pylori* is responsible for 70% of ulcer. Marshall and his co-worker Robin Varan were awarded Nobel Prize in 2005.

Science, Technology and Society Connections

- **Relate ulcer, food poisoning and dyspepsia with eating habits of the society.**

Solution: See Q#44 From (Extensive Questions).

Activity

1. Tests to locate buds on tongue for detection of salt, sweet, sour and bitter taste
2. Microscopic observation of the villi, liver and pancreas from prepared slides

EXERCISE

MCQs

1. Select the correct answer.

(i) Pepsinogen is activated to pepsin by

(A) active secretin (B) hydrochloric acid
(C) active pepsin and HCl (D) gastrin

(ii) Líver secretes bile into the

(A) duodenum (B) ileum
(C) jejunum (D) peritoneum

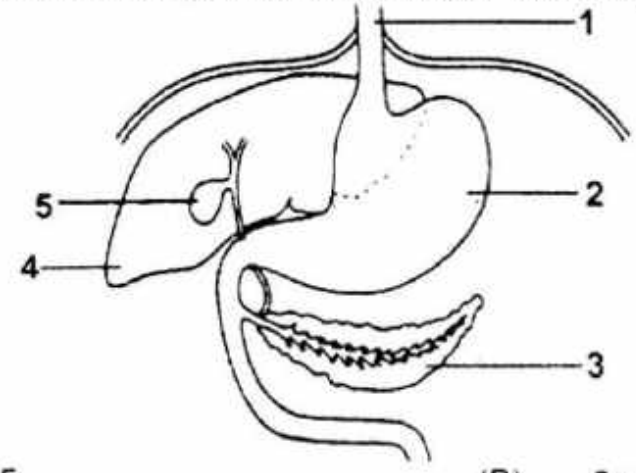
(iii) Emulsification of fat will not occur in the absence of

(A) lipase (B) bile pigment
(C) bile sat (D) pancreatic juice

(iv) Fatty acids and glycerol are first absorbed by

(A) lymph vessel (B) villi
(C) blood capillaries (D) hepatic portal vein

(v) The diagram shows part of the human alimentary canal. Which two structures produce substances involved in the digestion of fat?



(A) 1 and 5 (B) 3 and 4
(C) 2 and 3 (D) 4 and 5

(vi) The hormone responsible for stimulating secretion of hydrochloroic acid by stomach cells is

(A) pepsin (B) secretin
(C) gastrin (D) insulin

(vii) On removal of pancreas the compound, which remains undigested, is

(A) protein (B) fat
(C) glucose (D) lactose

(viii) Excess intake of the following causes obesity

(A) vitamin (B) proteins
(C) carbohydrates (D) mineral

(ix) Enzyme trypsinogen is changed to trypsin by

(A) gastrin (B) enterokinase
(C) secretin (D) hydrochloric acid

Answers

(i) C	(ii) A	(iii) C	(iv) A	(v) B
(vi) C	(vii) A	(viii) C	(ix) B	

SHORT QUESTIONS

2. Describe the gastrointestinal tract of man.

Ans: Digestive System of Man:

Anatomically and functionally the digestive system can be divided into a tubular **gastrointestinal tract (GIT)** or **digestive tract** or alimentary canal and **accessory digestive organs.** The organs of **GI tract** include oral cavity, pharynx, oesophagus, stomach, small intestine and large intestine. The accessory digestive organs include the teeth, tongue, salivary glands, liver, gall bladder and pancreas

Alimentary Canal - Structure and Function:

The GIT, which extends from the mouth to the anus, is a continuous tube. It is a locally differentiated structure. It is specialized at various points along its length, with each region designed to carry out a different role. GIT is approximately 9 m (30 ft) long. It traverses (passing across) the thoracic cavity and enters the abdominal cavity at the level of diaphragm.

The digestive tube consists of four major layers, or **tunics:** an internal mucosa and an external serosa with a submucosa and muscularis in between. These four tunics are present in all areas of the digestive tract from the oesophagus to the anus.

3. Describe the human tongue.

Ans: Human Tongue:

The mouth is surrounded by the lips, cheeks, tongue and a palate and includes a chamber between the palate and tongue called **oral cavity.** The tongue nearly fills the oral cavity when the mouth is closed. Rough projections called **papillae** on the surface of the tongue cause friction, which is useful in handling the food. These papillae also contain **taste buds.** The tongue forms the chewed and moistened food into a ball like mass called **bolus** and pushes it into the **pharynx** (oropharynx)

4. Describe and write the function of each type of teeth.

Ans: There are 32 teeth. Different teeth are adapted to handle food in different ways

Incisors Teeth:

The **incisors** (front teeth) are chisel shaped and their sharp edges are used to bite off relatively large pieces of food

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Canine Teeth:

The **canine teeth** are cone shaped and they are useful in grasping or tearing food.

Premolars and Molars:

The **premolars** and **molars** have somewhat flattened surfaces and are specialized for grinding food particles.

5. What is mechanical digestion?

Ans: Functions of Oral Cavity:

In the oral cavity mechanical and chemical digestion takes place. Mechanical digestion is the physical division of a mass of food into smaller masses while chemical digestion is the chemical conversion of larger molecules into smaller molecules.

Mechanical digestion:

Cooking and thorough chewing of food destroys the cellulose of starch covering and increases the efficiency of the digestive process. Food taken into the mouth is chewed, or masticated, by the teeth. Mastication breaks large food particles into smaller ones, which have a much larger total surface area for the action of digestive enzymes

6. What is chemical digestion?

Ans: Chemical digestion:

Saliva is secreted by salivary glands. The serous (watery) part of saliva contains a digestive enzyme called **salivary amylase** (meaning, starch-splitting enzyme), which breaks the covalent bonds between glucose molecules in starch and other polysaccharides to produce the disaccharides, maltose and isomaltose. Only about 3%-5% of the total carbohydrates are digested in the mouth.

7. What is pharynx? Write its functions.

Ans: Pharynx:

The pharynx is a cavity behind the mouth.

Functions:

The pharynx connects the nasal and oral cavities with larynx and oesophagus.

The pharynx can be divided into three:

(a) The **nasopharynx** communicates with nasal cavity and provides a passage way for air during breathing.

(b) The **oropoharynx opens** behind the soft palate into nasopharynx. It functions as a passageway for moving food downwards from the mouth and air moving to and from the nasal cavity,

(c) The **laryngopharynx** is located just below the oropharynx. It opens into the larynx and oesophagus.

8. Describe the parts of human pharynx.

Ans: The pharynx can be divided into three.

(i) Nasopharynx:

The **nasopharynx** communicates with nasal cavity and provides a passage way for air during breathing.

(ii) Oropoharynx Opens:

The **oropoharynx opens** behind the soft palate into nasopharynx. It functions as a passageway for moving food downwards from the mouth and air moving to and from the nasal cavity,

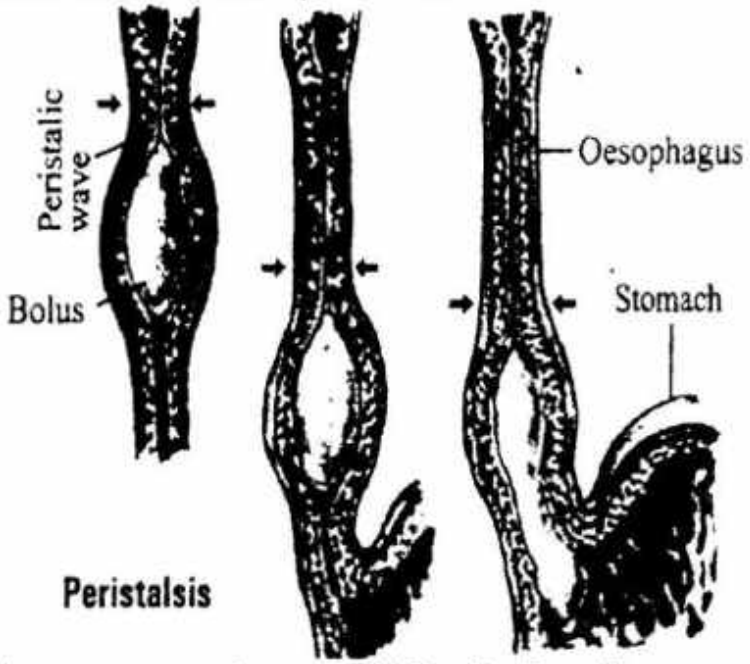
(iii) Laryngopharynx:

The **laryngopharynx** is located just below the oropharynx. It opens into the larynx and oesophagus.

9. Explain peristalsis with diagram.

Ans: Peristalsis:

In peristalsis a wave of relaxation of circular muscles in front of food is followed by a wave of strong contraction of circular muscles behind food, propels the mass of the food through the digestive tract. As the food moves it expands the tube wall, the expansions stimulates peristalsis



Peristalsis

10. Describe human oesophagus. Write its function.

Ans: Oesophagus:

The oesophagus (meaning passageway) (North American spelling esophagus) is that part of the digestive tube that extends between the pharynx and the stomach. It is about 25 cm long. It begins at the base of the pharynx and descends behind the trachea, passing through mediastinum (space between the right and left lungs). The oesophagus penetrates the diaphragm and is continuous with the stomach on abdominal side of the diaphragm.

Function:

Digestion which started in the oral cavity continues in the oesophagus. As oesophagus is a passage way so no digestion takes place here.

11. Name and write the function of epithelial cells of stomach of man.

Ans: The epithelial cells of stomach can be divided into four main types The first type is **surface mucous cells,** which produce mucus, is on the surface and lines the gastric pit. The remaining three are in the gastric gland.

They are

(1) Parietal (oxyntic) cells produce hydrochloric acid and intrinsic factors

(2) **Principal cells** or **chief (zymogenic) cells** secrete pepsinogen

(3) **Endocrine cells** secrete the hormone gastrin into the blood

12. Give one reason as to why some enzymes in stomach and intestine are secreted inactive form?

Ans: The major proteolytic enzymes are **trypsin, chymotrypsin,** and **carboxypeptidase.**

They are secreted in their inactive forms as trypsinogen, chymotrypsinogen, and procarboxypeptidase and are activated by the removal of certain peptides from the larger precursor proteins. ***If these were produced in their active forms, they would digest the tissues producing them.***

13. Name the enzymes involved in protein digestion.

Ans: Trypsinogen:

The intestinal glands secrete an activator enzyme called enterokinase. The enterokinase converts trypsinogen into trypsin. The trypsin is the active form, which acts on proteins and converts them into polypeptides.

Chymotrypsinogen:

The inactive chymotrypsinogen is converted to active form by trypsin.

14. How could no secretion of HCl in our stomach affect food digestion?

Ans: **Hydrochloric acid** produces the low pH of the stomach, which is normally between 1 and 3, but is usually close to 2. Although the hydrochloric acid secreted into the stomach has a minor digestive effect on digested food, one of its main functions is to kill bacteria that are ingested with essentially everything humans put into their mouths. The low pH of the stomach also stops carbohydrate digestion by inactivating salivary amylase. The low pH also denatures many proteins so that proteolytic enzymes can reach internal peptide bonds, and it provides the proper pH environment for the function of pepsin.

OR (Second Answer)

Hydrochloric acid is secreted by the glands present on the stomach walls. It dissolves bits of food and creates an acidic medium. The acidic medium allows pepsinogen to be converted into pepsin. Pepsin plays an important role in the digestion of proteins. Therefore, if HCl were not secreted in the stomach, then pepsin would not be activated. This would affect protein digestion. A pH of about 1.8 is necessary for proteins to be digested. This pH is achieved by HCl.

15. How the stomach does protect itself from the damaging effect of HCl?

Ans: The gastric glands secrete HCl which has a pH of 2 to 2.5. This is highly acidic and can itself digest the stomach. But the gastric glands along with pro-enzymes also release mucus. This mucus forms inner lining of the stomach and prevent HCl from corroding the tissues of stomach.

OR (Second Answer)

Our **stomach protects itself** from being digested by its own enzymes, or burnt by the corrosive **hydrochloric acid**, by secreting sticky, neutralising mucus that clings to the **stomach** walls. If this layer becomes damaged in any way it can result in painful and unpleasant **stomach** ulcers.

OR (Second Answer)

Small pores called **gastric** pits contain many exocrine cells that secrete digestive enzymes and **hydrochloric acid** into the lumen, or hollow region, of the **stomach**. Mucous cells found throughout the **stomach lining** and **gastric** pits secrete mucus to **protect** the **stomach** from its own digestive secretions.

16. Why there are villi in the intestine and not in stomach?

Ans: The digested food is passed into the **intestine** for absorption. The **villi** are **present** here to increase the surface area for the absorption of the digested food.

OR (Second Answer)

Because the stomach doesn't absorb nutrients.

Explanation:

Villi of the small intestine are small finger-like projections on the surface. One villus contains many cells and thereby increase the surface area (see image below). This is required because a lot of nutrients have to be absorbed in the small intestine. Lots of cells on a small area makes this process efficient.

The **stomach** collects the food, adds gastric acid and enzymes for digestion of food. The stomach does not absorb any nutrients and therefore does not require a larger surface area.

17. Trypsin acts at alkaline pH. What provides the alkalinity?

Ans: Bicarbonates present in bile juice, pancreatic juice and intestinal juice provide alkalinity.

OR (Second Answer)

The mucus secreted by goblet cells of intestinal mucosal epithelium and bicarbonate ions of pancreatic juice together makes the medium alkaline in small intestines. Two actions performed by trypsin are:

1. Activation of pancreatic enzymes.
2. Digestion of proteins into dipeptides.

18. What would happen to the activity of the intestinal enzymes if the pH in the small intestine remained at 2?

Ans: The enzymes in the small intestine would become inactive and not be able to carry out the digestion process.

OR (Second Answer)

Digestion will not be proper systematic. Due to acidic medium, it will create acidity which is harmful for human being. Soon it happen as, it may be effect our digestive system.

19. How does the absorption of fat differ from absorption of glucose?

Ans: Fat is absorbed by lacteals in the small intestine these have large surface areas to help with absorption and capillaries to absorb the fatty acids. Glucose and Amino acids is absorbed in the glomerulus in the kidney transported by the blood to the heart etc then it is reabsorbed in the bowman's capsule in the kidney.

OR (Second Answer)

Fats are absorbed into the cells as fatty acids and monoglycerides but are then modified for absorption into the blood; amino acids and glucose are not modified further.

20. Describe defaecation reflex in adults.

Ans: Defaecation reflex in adults:

When it is appropriate a person usually can initiate the defaecation reflex (North America spelling defecation) by holding a deep breath and contracting the adnominal muscles. The action increases the internal pressure and forces the faeces into the rectum. When the rectum is filled, its wall is distended and the defaecation reflex is triggered. As a result, peristaltic waves in the descending colon are stimulated, and the internal and anal sphincter relaxes. The external anal sphincter is signalled to relax and the faeces are forced to the outside. The defaecation reflex persists only for a few minutes and quickly dies. A person usually can inhibit defaecation voluntarily by keeping the external sphincter contracted.

21. Describe defaecation reflex in infants.

Ans: Defaecation reflex in infants:

In infants the defaecation reflex causes automating emptying of the lower bowel at inconvenient times during the day because of lack of conscious control exercised through voluntary contraction of the external anal sphincter.

22. Bile juice contains no digestive enzymes, yet it is important for digestion. Why?

Ans: The liver produces and secretes bile. It is stored in the gall bladder. Bile contains no digestive enzymes. Bile consists of water, bile salts: sodium glycocholate and sodium taurocholate, bile pigment, bilirubin, cholesterols, lecithin (a phospholipids) mucus, cells and cell debris

Bile salts reduce the surface tension of fat globules and emulsify them into droplets and thus increase their total surface area. This process is called emulsification. These small droplets are then acted upon by the enzyme lipase. **Bilirubin** results from the breakdown of haemoglobin. In the intestine, bacteria convert bilirubin into pigments that give the faeces its characteristic brown colour. Some of these pigments are absorbed from intestine, modified in the kidneys and excreted in the urine, contributing to the characteristic yellowish colour of the urine. Bile salts help in the absorption of fatty acids from the intestinal tract.

OR (Second Answer)

Bile is a digestive juice secreted by the liver. Although it does not contain any digestive enzymes, it plays an important role in the digestion of fats. Bile juice has bile pigments such as bilirubin and biliverdin. These break down large fat globules into smaller globules so that the pancreatic enzymes can easily act on them. This process is known as emulsification of fats. Bile juice also makes the medium alkaline due to presence of $NaHCO_3$ and also activate lipase.

23. What is the role of hormone gastrin in digestion?

Ans: Gastrin is a peptide **hormone** that stimulates secretion of gastric acid (HCl) by the parietal cells of the stomach and aids in gastric motility. It is released by G cells in the pyloric antrum of the stomach, duodenum, and the pancreas.

Role of nervous system and gastrin hormone on the secretion of gastric juice:

Approximately 2-3 litres of gastric secretions (gastric juice) are produced each day. Both nervous and hormonal mechanisms regulate gastric secretions.

Hormones that regulate stomach secretions:

Hormones that regulate stomach secretions include gastrin, secretin, gastric inhibitory polypeptide, and cholecystokinin.

Gastric Secretion:

The sensations of the taste and smell of food, stimulation of tactile receptors during the process of chewing and swallowing, and pleasant thoughts of food stimulate centres within the medulla that influences **gastric secretion.** Neuronal stimulation of the stomach mucosa results in the secretion of **acetylcholine,** which stimulates the secretory activity of both the parietal and chief cells and stimulates the secretion of **gastrin** from endocrine cells. Gastrin is released into the circulation and travels to the parietal cells, where it stimulates additional gastric juice (hydrochloric acid and pepsinogen) secretion.

Volume of Gastric Secretions:

The greatest volume of gastric secretions is initiated by the presence of food in the stomach. The primary stimuli are distention of the stomach and the presence of amino acids and peptides in the stomach. Peristaltic waves occur less frequently, are significantly more powerful than mixing waves, and force the chyme near the periphery of the stomach toward the pyloric sphincter. The pyloric sphincter usually remains partially closed because of mild tonic contraction. Each peristaltic contraction is sufficiently strong to force a small amount of chyme through the pyloric opening and into the duodenum.

24. What is the role of hormone secretin in digestion?

Ans: When hydrochloric acid passes from the stomach into the duodenum, **secretin** is released into the bloodstream and stimulates the acinar cells of the pancreas to secrete water and bicarbonate into the pancreatic ducts that drain into the duodenum.

Secretion of pancreatic juice is related to secretin hormone:

Pancreatic juice secretion is regulated by the hormones secretin and cholecystokinin which is produced by the walls of the duodenum upon detection of acid food, proteins, fats and vitamins. Pancreatic secretion consists of an aqueous bicarbonate component from the duct cells and enzymatic component from the acinar cells. A clear alkaline secretion of the pancreas containing enzymes that aid in the digestion of proteins, carbohydrates, and fats. The predominant effect of secretin on the pancreas is to stimulate duct cells to secrete water and bicarbonate. As soon as this occurs, the enzymes secreted by the acinar cells are flushed out of the pancreas, through the pancreatic duct into the duodenum.

25. Describe the storage role of liver.

Ans: Storage role of liver:

Hepatocytes can remove sugar from the blood and store it in the form of glycogen. They can also store fat, vitamins (A, B12, D, E, and K), copper and iron. This **storage function** is usually short-term and the amount of stored material in the hepatocytes varies, thus the cell size fluctuates during a given day.

26. What is gall bladder? Write its function.

Ans: Gall bladder:

The **gall bladder** is a saclike structure on the inferior surface of the liver that is about 8 cm long and 4 cm wide. The gall bladder is connected to the common bile

duct by the cystic duct. **Bile** is continually secreted by the liver and stored in the gall bladder (North American spelling gallbladder)

OR (Second Answer)

The **gallbladder** is a small organ located on the underside of the liver Its **primary purpose** is bile storage. The liver makes bile, a substance that helps the body break down fats. The **gallbladder** then stores the extra bile the liver makes, releasing it when you eat a meal with fats that need to be digested.

27. Name three eating disorders.

Ans: Eating Disorders:

Ulcer, food poisoning, dyspepsia, obesity, anorexia nervosa and bulimia nervosa.

28. Define/Describe/Explain:
tunic, oral cavity, peristalsis, mixing waves, parietal cell, chief cells, intrinsic factor, acetylcholine, gastrin, secretin, mesentery, villi, pancreatic juice, micelles, chylomicrons, bilirubin, biliverdin.

Ans: Tunic:

The digestive tube consists of four major layers, or **tunics**: an internal mucosa and an external serosa with a submucosa and muscularis in between. These four tunics are present in all areas of the digestive tract from the oesophagus to the anus.

Oral Cavity:

The mouth is surrounded by the lips, cheeks, tongue and a palate and includes a chamber between the palate and tongue called **oral cavity.**

Peristalsis:

In peristalsis **a** wave of relaxation of circular muscles in front of food is followed by a wave of strong contraction of circular muscles behind food, propels the mass of the food through the digestive tract. As the food moves it expands the tube **wall,** the expansions stimulates peristalsis.

Mixing Waves:

The mixing action of the stomach walls allows mechanical digestion to occur **in** the stomach. The smooth muscles of the stomach produce contractions known as **mixing waves**.

Parietal Cell:

Parietal cells in the gastric glands of the pyloric region secrete intrinsic factor and a concentrated solution of hydrochloric acid.

Chief Cells:

The gastric **chief cell** (also known as a zymogenic**cell** or peptic **cell**) is a **cell** in the stomach that releases pepsinogen and chymosin. Pepsinogen is activated into the digestive enzyme pepsin when it comes in contact with acid produced by gastric parietal **cells**.

Intrinsic Factor:

Intrinsic factor is a glycoprotein that binds with vitamin B12 and makes the vitamin more readily absorbed in the ileum

Acetylcholine:

Neuronal stimulation of the stomach mucosa results in the secretion of **acetylcholine**, which stimulates the secretory activity of both the parietal and chief cells and stimulates the secretion of **gastrin** from endocrine cells.

Gastrin:

Gastrin is a peptide hormone that stimulates secretion of gastric acid by the parietal cells of the stomach and aids in gastric motility. It is released by G cells in the pyloric antrum of the stomach, duodenum, and the pancreas.

Secretin:

Secretin produced by the duodenum is carried through the circulatory system to the liver and stimulates duct cells in the liver to release bicarbonate into the bile

OR

Secretin is a hormone that regulates water homeostasis throughout the body and influences the environment of the duodenum by regulating secretions in the stomach, pancreas, and liver.

Mesentery:

The entire small intestine is about 6 m long (range: 4.6-9 m). The duodenum is about 25 cm long and 5 cm in diameter, and the ileum is about 3.5 m long. These portions are suspended from the posterior abdominal wall by a double-layered fold of peritoneum called **mesentery.**

Villi:

The mucosal wall of the small intestine forms millions of tiny finger-like projections known as villi. These villi increase the surface area for more efficient food absorption.

OR

Villi are specialised for absorption in the small intestine as they have a thin wall, one cell thick, which enables a shorter diffusion path. They have a large surface area so there will be more efficient absorption of fatty acids and glycerol into the blood stream.

Pancreatic Juice:

The secretion of pancreas is called pancreatic juice. It is poured through the pancreatic duct. Pancreatic juice is slightly alkaline. Its pH is about 8. It neutralizes the acidic action of digestive enzymes secreted by the pancreas.

The important enzymes are (a) Pancreatic amylase (b) Pancreatic lipase (c) Trypsinogen (4) Chymotrypsinogen.

Micelles:

Once lipids are digested in the intestine, bile salts aggregate around small droplets to form micelles (meaning: a small morsel). When a micelle comes into contact with the epithelial cell of the small intestine, the contents of micelle pass by means of simple diffusion through the lipid cell membrane of the epithelial cell

OR

A micelle or micella is an aggregate of surfactant molecules dispersed in a liquid colloid.

Chylomicrons:

The fats are then mixed with cholesterol and proteins, forming small globules called **chylomicrons,** most of which are transported by exocytosis out of epithelial cells into lacteals. Lymph containing chylomicrons, eventually drains from the lymphatic system into large veins that return blood to the heart.

OR

Chylomicrons are lipoprotein particles that consist of triglycerides, phospholipids, cholesterol, and proteins. They transport dietary lipids from the intestines to other locations in the body

Bilirubin:

The bile pigment **bilirubin** (orange pigment) is formed from the breakdown of haemoglobin.

OR

Bilirubin is a yellow compound that occurs in the normal catabolic pathway that breaks down heme in vertebrates.

Biliverdin:

The bile pigment **biliverdin** (green pegment) is formed from the breakdown of haemoglobin.

OR

Biliverdin is a green tetrapyrrolic bile pigment, and is a product of heme catabolism. It is the pigment responsible for a greenish color sometimes seen in bruises.

29. Write the differences between:

(a) mechanical digestion and chemical digestion.
(b) pharynx and larynx
(c) pancreatic amylase and pancreatic lipase
(d) trypsinogen and chymotrypsinogen
(e) pepsinogen and pepsin
(f) food poisoning and dyspepsia
(g) bulimia nervosa and anorexia nervosa

Ans: (a) mechanical digestion and chemical digestion:

Functions of oral cavity:

In the oral cavity mechanical and chemical digestion takes place. Mechanical digestion is the physical division of a mass of food into smaller masses while chemical digestion is the chemical conversion of larger molecules into smaller molecules.

Mechanical digestion:

Cooking and thorough chewing of food destroys the cellulose of starch covering and increases the efficiency of the digestive process. Food taken into the mouth is chewed, or masticated, by the teeth. Mastication breaks large food particles into smaller ones, which have a much larger total surface area for the action of digestive enzymes.

Chemical digestion:

Saliva is secreted by salivary glands. The serous (watery) part of saliva contains a digestive enzyme called **salivary amylase** (meaning, starch-splitting enzyme), which breaks the covalent bonds between glucose molecules in starch and other polysaccharides to produce the disaccharides, maltose and isomaltose. Only about 3%-5% of the total carbohydrates are digested in the mouth

OR (Second Answer)

Difference Between Mechanical and Chemical Digestion:

Mechanical Digestion	Chemical Digestion
Definition:	
Mechanical digestion refers to the break down of food into digestible particles, mainly by the teeth.	Chemical digestion refers to the process by which compounds with a high molecular weight in the food are broken down into small substances that can be absorbed by the body.
Occurrence:	
Mechanical digestion occurs from the mouth to the stomach.	Chemical digestion occurs from the mouth to the intestine.
Major Part:	
A major part of mechanical digestion occurs in the mouth.	A major part of chemical digestion occurs in the stomach.
Driven by:	
Mechanical digestion is driven by teeth.	Chemical digestion is driven by enzymes.
Mechanism:	
The mechanical breakdown of large food particles into small food particles occur in the mechanical digestion	The chemical breakdown of compounds with high molecular weights into low molecular weight compounds occurs in the chemical digestion.
Role:	
Mechanical digestion increases the surface area for the enzymatic reactions in the chemical digestion.	Chemical digestion enhances the absorption of the nutrients by breaking down them into small molecules.

(b) pharynx and larynx:

Pharynx:

The pharynx is a cavity behind the mouth.

Functions:

The pharynx connects the nasal and oral cavities with larynx and oesophagus. The pharynx can be divided into three. (a) the **nasopharynx** communicates with nasal cavity and provides a passage way for air during breathing. (b)The **oropoharynx opens** behind the soft palate into nasopharynx. It functions as a passageway for moving food downwards from the mouth and air moving to and from the nasal cavity. (c) The **laryngopharynx** is located just below the oropharynx. It opens into the larynx and oesophagus.

Larynx:

As part of this reflex action the voice box or **larynx** rises up to meet the epiglottis (meaning upon the glottis), with this action epiglottis cartilage drops over the glottis, the opening to the larynx and trachea. In this way food is passed over the trachea without entering it. If you place your hand over your larynx (Adam's apple),

you can feel it moves up when you swallow. After food enters the oesophagus, the soft palate lowers and the epiglottis is raised.

OR (Second Answer)

Difference Between Pharynx and Larynx:

Pharynx:	**Larynx:**
Definition:	
Pharynx is a membrane-lined cavity behind the mouth and the nose, connecting them to the esophagus and the larynx respectively.	Larynx is a hollow muscular organ, which forms an air passage to the lungs and hosts the vocal cords.
Location:	
The pharynx is located just behind the mouth.	The larynx is located at the C3-6 vertebral levels.
System:	
Pharynx is a part respiratory system and digestive system.	Larynx is a part of the respiratory system.
Walls:	
The walls of the pharynx are made up of muscles.	The walls of the larynx are made up of cartilage.
Anatomy:	
The pharynx is made up of three regions, nasopharynx, oropharynx, and laryngopharynx.	The larynx is made up of mainly four cartilage; thyroid cartilage, cricoid cartilage, arytenoid cartilage, and corniculate cartilage.
Structure:	
The pharynx is a set of regions.	The larynx is an organ.
Vocal Cords:	
The pharynx does not consist of vocal cords.	The larynx consists of vocal cords.
Conclusion: Pharynx and larynx are two components of the throat. The nasal and the oral cavities open into the pharynx. The pharynx opens into the larynx and the esophagus. The larynx opens into the trachea. Therefore, both food and air pass through the pharynx. The main difference between pharynx and larynx is the structure and the function of each component.	

(c) pancreatic amylase and pancreatic lipase:

Pancreatic amylase:

It is the starch digesting enzyme. It hydrolyses the polysaccharides to maltose and even to glucose.

Pancreatic lipase:

It is the principal enzyme for the hydrolysis of fats. It hydrolyses fats to neutral fat in parts to its (i) mono and diglycerols (diglycerides) (ii) glycerol (iii) fatty acids.

OR (Second Answer)

Difference between Amylase and Lipase:

Lipase	Amylase
Definition:	
Lipase is an enzyme that is involved in the hydrolysis of lipids.	Amylase is an enzyme involved in the hydrolysis of starch molecules into sugars.
Type of Enzyme and Classification:	
A sub-class of hydrolases known as Esterases	Hydrolases. It is further classified into three groups known as α-amylases, β-amylase, and γ-Amylase.
Bond Type:	
Lipase acts on the ester bond in a lipid.	Amylase acts on the glycosidic bonds in a carbohydrate.
Substrate:	
Fatty acids esters such as triglycerides, fats, oils	Starch molecules
End Product:	
Glycerol, Di-glycerides, Mono-glycerides fatty acids like less complex forms of fats	Oligosaccharides (Dextrose, maltodextrin) and disaccharides (Maltose)
Enzyme Secretion Organ in the Human Body:	
Salivary lipase and pancreatic lipase are secreted by the salivary gland pancreas respectively. Other examples are hepatic lipase, endothelial lipase, and lipoprotein lipase	Salivary gland secretes salivary amylase and pancreatic amylase is secreted by the pancreas.
Function:	
Lipid metabolism	Carbohydrate metabolism
Mechanism of Action:	
Fats are not water-soluble but lipase dissolves in water. Therefore, lipase cannot directly break down the fat molecules. First, fat, bile salts from the gall bladder must break up fats and emulsify them into water-soluble beads.	Both amylase and starch are water soluble substances, so amylase enzymes secreted into the digestive tract mix easily with food particles (chyme) and easily digest dissolved carbohydrate in that food.
Related Health Issues:	
Lysosomal lipase deficiency can cause the Wolman disease as well as Cholesteryl Ester Storage Disease	An increased level of amylase in the blood serum is an indicator that the person could be suffering from acute

(CESD) which are autosomal recessive diseases. Both diseases are caused by a mutation in the gene encoding the enzyme.	pancreatic inflammation, peptic ulcer, ovarian cyst or even mumps.
Uses:	
It is used in baking industry, Laundry detergents, Biocatalyst, Production of alternative sources of energy.	Flour additive: Amylases are used in bread making process and thereby break down complex starch in flour into simple sugars. Yeast then feeds on these simple sugars and converts it into the alcohol and CO_2 and this imparts flavor and causes the bread to rise. Fermentation: Both alpha and beta amylases are vital in brewing beer and alcohol made from sugars derived from starch. Amylase removes starch from starched clothes and, therefore, it is used as a detergent.

(d) trypsinogen and Chymotrypsinogen:

Trypsinogen:

The intestinal glands secrete an activator enzyme called enterokinase. The enterokinase converts trypsinogen into trypsin. The trypsin is the active form, which acts on proteins and converts them into polypeptides.

Chymotrypsinogen:

The inactive chymotrypsinogen is converted to active form by trypsin.

OR (Second Answer)

Difference Between Trypsin and Chymotrypsin:

Trypsin	Chymotrypsin
Trypsin is a protein-digesting enzyme which will cleave the peptide bond at the basic amino acids such as lysine and arginine.	Chymotrypsin which is also a protein-digesting enzyme cleaves the peptide bond at aromatic amino acids such as phenylalanine, tryptophan, and tyrosine.
Molecular Weight:	
The molecular weight of trypsin is 23.3 k Da.	The molecular weight of chymotrypsin is 25.6 k Da.
Substrates:	
Complex proteins are digested into its monomers of amino acids and are absorbed via the small intestines.	Aromatic amino acids substrates such as tyrosine, tryptophan, and phenylalanine act on chymotrypsin.
Zymogen Form of the Enzyme:	
Trypsinogen is the inactive form of trypsin.	Chymotrypsinogen is the inactive form of chymotrypsin.

Activators:	
Lanthanides are activators of trypsin	Cetyltrimethylammonium bromide, Dodecyltrimethylammonium bromide, Hexadecyltrimethylammonium bromide and Tetrabutylammonium bromide are activators of chymotrypsin.
Inhibitors:	
DFP, aprotinin, Ag^{+}, Benzamidine, and EDTA are inhibitors of trypsin.	Peptidyl aldehydes, boronic acids, and coumarin derivatives are inhibitors of chymotrypsin.

(e) pepsinogen and pepsin:

Chief **cells** within the gastric glands secrete inactive **pepsinogen.** Pepsinogen is packaged in **zymogen** (meaning, related to enzymes) granules, which are released by exocytosis when pepsinogen secretion is stimulated. Once **pepsinogen** enters the lumen of the stomach, it is converted to **pepsin** by hydrochloric acid and previously formed pepsin molecules. Pepsin exhibits optimum enzymatic activity at a pH of 3 or less. Pepsin catalyzes the cleavage of some covalent bonds in proteins, breaking them into smaller peptide chains.

OR (Second Answer)

Difference between Pepsin and Pepsinogen:

- Pepsin is a proteolytic enzyme, whereas pepsinogen is a proenzyme.
- Pepsin is the active form of pepsinogen while pepsinogen is the inactive precursor of pepsin.
- Unlike the pepsin, pepsinogen is secreted by chief cells and pyloric glands.
- Pepsinogen is converted to pepsin by hydrochloric acid or performed pepsin.
- Unlike the pepsin, pepsinogen secretion is stimulated by vagal simulation, gastrin, and histamine.
- Pepsinogen is stable in both neutral and alkaline solutions, whereas pepsin is not.
- Unlike pepsinogen, pepsin can hydrolyze proteins.
- Pepsin can be activated by lowering the pH of the medium, whereas pepsinogen cannot.

(f) food poisoning and dyspepsia:

Food poisoning:	**Dyspepsia:**
It includes diarrhoea (North American spelling: diarrhea), vomiting and abdominal pain. It is an illness from indigestion of food containing toxic substances.	Incomplete or imperfect digestion is called dyspepsia.
Aetiology: Due to the **toxins** produced by bacteria, *Salmonella* and *Campylobacter*	**Aetiology:** It may occur due to excessive acidity in stomach or faulty function of stomach and intestine or insufficient quality and quantity of bile secretion
Prevention: Basic hygiene should be	**Prevention:** Avoid food that worsens

followed. Avoid unboiled /unbottled water, ice, cubes, salads and peel on fruits. Consume freshly prepared hot food or thoroughly rewarmed food.	symptoms. Stop smoking, weight reduction, small meals, avoid alcohol, tea, fatty food, heavy lifting, bending specially after meals and late night meals to reduce reflex during sleep.
Treatment: Soft easily digested diet, such as soup, fruits drinks; tea and cold drinks are preferred. Oral rehydration salt (ORS) is given. Antidiarrhoeal agent such as Loperamide, antibiotics are prescribed.	**Treatment:** Antibiotics to be given against this disease. Drugs which decrease HCl production such as Cimetidine; stop NSAID (Non-Steroidal Anti Inflammatory Drugs), e.g., Aspirin

(g) bulimia nervosa and anorexia nervosa:

Bulimia nervosa:	**Anorexia nervosa:**
It is a neurotic disorder in slightly older girls.	It is the loss of appetite due to the fear of becoming obese. Such a feeling is common in human females between the ages of 12 and 21 years. Usually just after the onset of puberty.
Symptoms: It is characterized by bouts of over eating fattening food such as fried food or cream cakes. This voracious (eating in large quantity) eating followed immediately by self-induced vomiting, fasting or purging (to empty bowels) may cause physical effects including serum electrolytes imbalance and frequent recurring infections.	**Symptoms:** It includes loss of appetite due to the fear of becoming obese. The anorexic girls over estimate the size of her own body and so insist that she is overweight, when in reality her weight has dropped to a dangerous level. These girls are often not matured psychologically and unable to cope with the challenges of puberty and their emerging sexuality. The losses of feminine characteristics enable the girls to retreat into a childlike state in which she feels safe.
Treatment: Treatment of bulimics is likely to be prolonged. The initial treatment is to overcome the effects of weight loss and malnutrition. It is necessary to undertake the treatment in hospital under strict supervision.	**Therapy:** Psychiatric therapy is usually required to treat anorexic girls. Such patients are fed through any other route other than alimentary canal, i.e., intravenously. The recovery is very slow. It may take 2-4 years and in some cases longer.

EXTENSIVE QUESTIONS

30. Describe human oral cavity. What are the functions of oral cavity?

Ans: Oral Cavity:

The mouth is surrounded by the lips cheeks tongue and a palate and includes a chamber between the palate and tongue called **oral cavity**.

Tongue:

The tongue nearly fills the oral cavity when the mouth is closed Rough projections called **papillae** on the surface of the tongue cause friction which is useful in handling the food. These papillae also contain **taste buds.**

Palate:

The **palate** forms the roof of the oral cavity It consists of a hard anterior part the **hard palate** and a soft posterior part the **soft palate.**

Teeth:

There are 32 teeth Different teeth are adapted to handle food in different ways. The **incisors** (front teeth) are chisel shaped and their sharp edges are used to bite off relatively large pieces of food. The **canine teeth** are cone shaped and they are useful in grasping or tearing food

Premolars and Molars:

The **premolars** and **molars** have somewhat flattened surfaces and are specialized for grinding food particles.

Salivary Glands:

There are three pairs of **salivary glands:** parotid or parotis, submandibular and sublingual. These glands secrete saliva having enzyme

Functions of oral cavity:

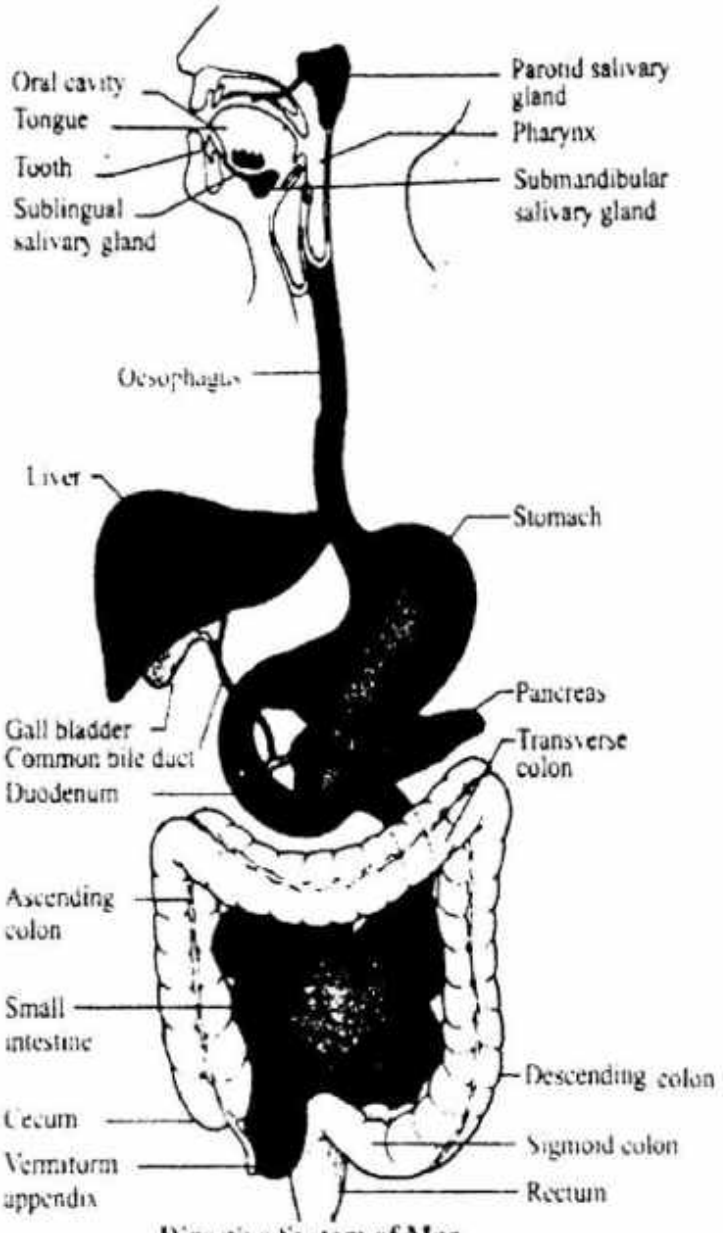
In the oral cavity mechanical and chemical digestion takes place. Mechanical digestion is the physical division of a mass of food into smaller masses while chemical digestion is the chemical conversion of larger molecules into smaller molecules

Mechanical digestion:

Cooking and thorough chewing of food destroys the cellulose of starch covering and increases the efficiency of the digestive process Food taken into the mouth is chewed or masticated by the teeth Mastication breaks large food particles into smaller ones which have a much larger total surface area for the action of digestive enzymes

Chemical digestion:

Saliva is secreted by salivary glands The serous (watery) part of saliva contains a digestive enzyme called **salivary amylase** (meaning starch-splitting enzyme), which breaks the covalent bonds between glucose molecules in starch and other polysaccharides to produce the disaccharides maltose and isomaltose. Only about 3%-5% of the total carbohydrates are digested in the mouth



Digestive System of Man

Composition of Saliva

Salivary amylase digests starch. Mucin is a proteoglycan that gives a lubricating quality to the secretions of the salivary glands. Water moistens food and mucous membrane. Saliva also contains various mineral salts including chloride ions which speed up the activity of enzymes. Saliva prevents bacterial infection in the mouth as it contains lysozyme and immunoglobulin. Saliva has a pH between 6.00 and 7.0, a favourable range for the digestive action of amylase.

31. Desribe the process of swallowing in man.

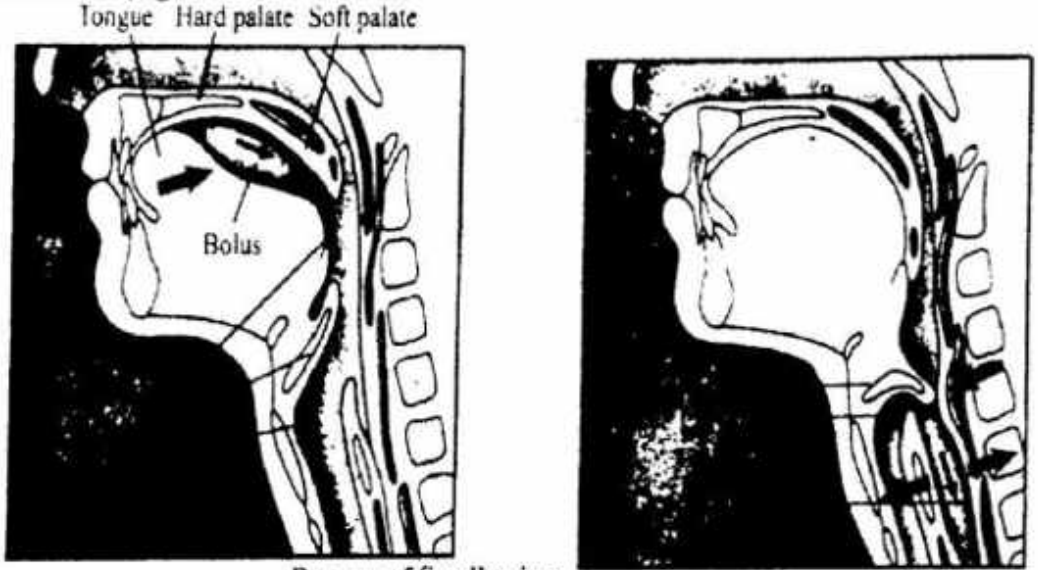
Ans: Swallowing:

The tongue forms the chewed and moistened food into a ball like mass called **bolus** and pushes it into the **pharynx** (oropharynx)

Muscles raise the soft palate against the back wall of the pharynx, which closes the passage between nasal cavity and pharynx preventing food from entering the nasal cavity .

The pressure of the food in the pharynx stimulates nerves in its walls that begin the swallowing reflex, an involuntary action. As part of this reflex action the voice box or **larynx** rises up to meet the epiglottis (meaning upon the glottis), with this action epiglottis cartilage drops over the glottis, the opening to the larynx and trachea. In this way food is passed over the trachea without entering it.

If you place your hand over your larynx (Adam's apple), you can feel it moves up when you swallow. After food enters the oesophagus, the soft palate lowers and the epiglottis is raised.

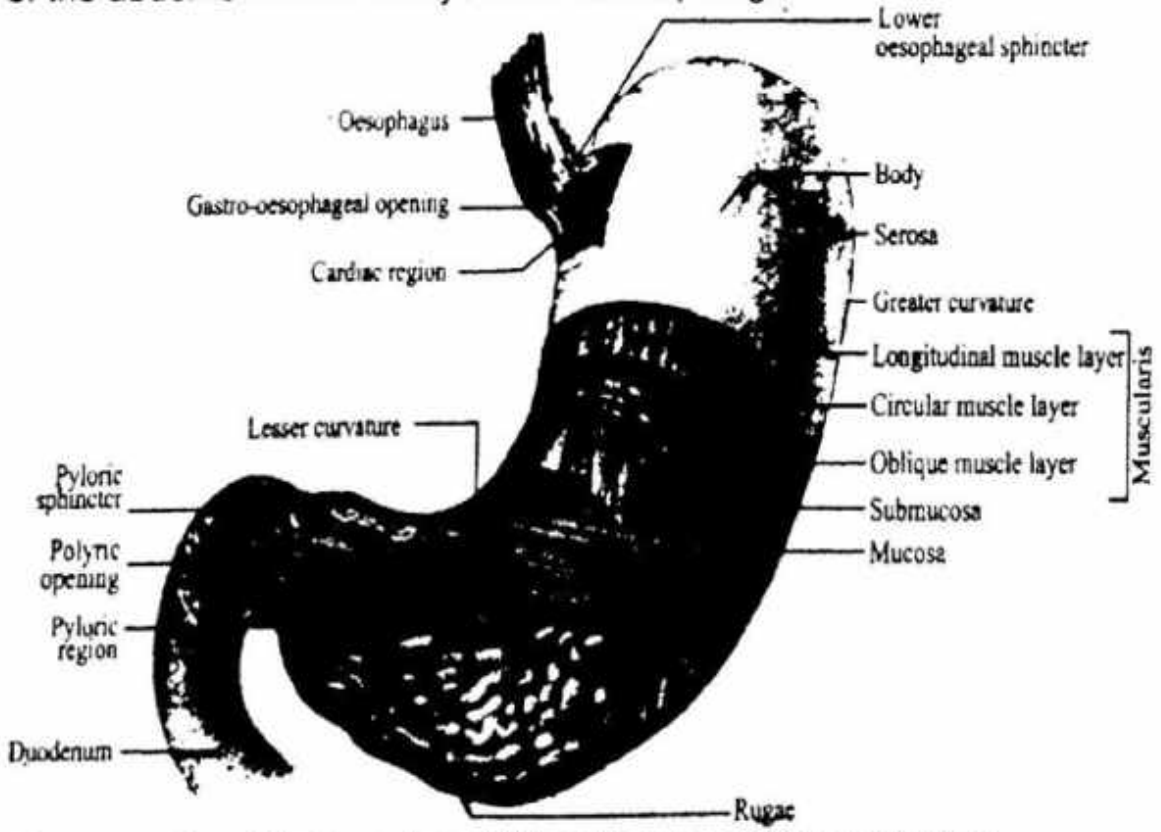


Process of Swallowing

32. Describe the human stomach with diagram.

Ans: Stomach:

The stomach is an enlarged segment of the digestive tract in the left superior part of the abdomen immediately below the diaphragm.



Cutaway section of the Stomach reveals Muscular layers and internal Anatomy

Structure:

Typically J-shaped when empty, the stomach is continuous with the oesophagus anteriorly and empties into the small intestine posteriorly.

Cardiac Opening:

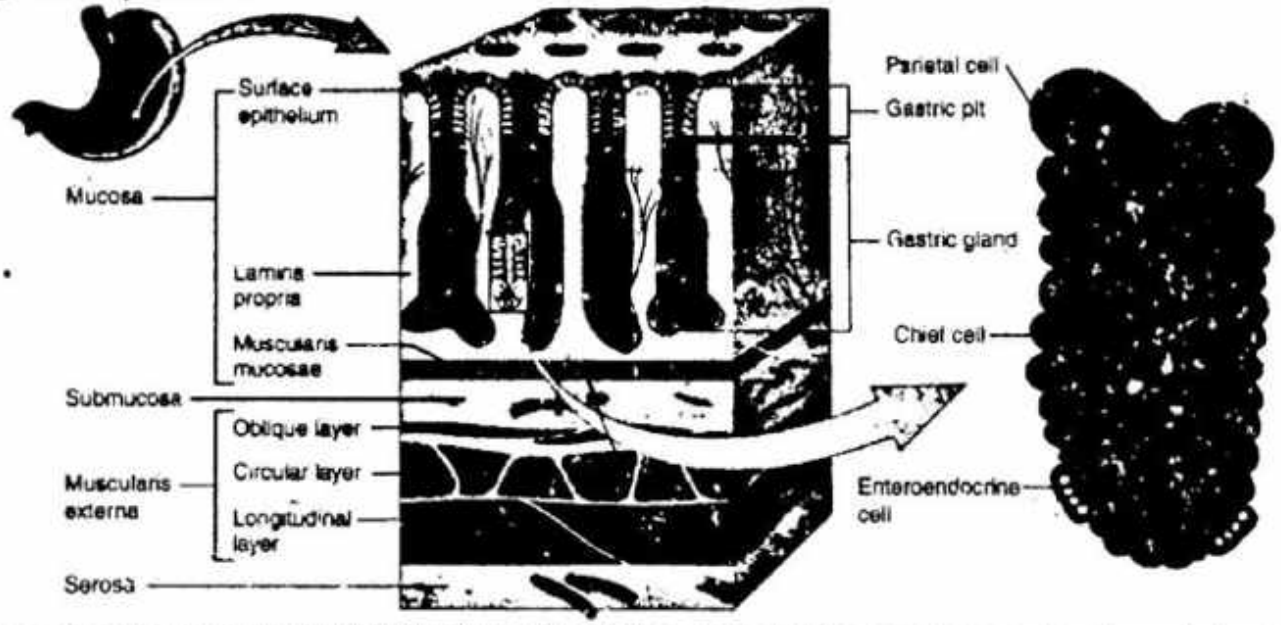
The opening from the oesophagus into the stomach is the **cardiac opening** (located near the heart). The **cardiac sphincter** surround the cardiac opening. Although this is an important structure in the normal function of the stomach, it is a physiologic constrictor only and cannot be seen anatomically.

Body of Stomach:

The largest part of the stomach is the **body** which narrows to form the **pyloric** (meaning, gatekeeper) **region,** that joins the small intestine.

Pyloric Opening:

The opening between the stomach and the small intestine is the **pyloric opening,** which is surrounded by a relatively thick ring of smooth muscle called the **pyloric sphincter.**



A section of stomach wall that illustrates its histology, including several gastric pits and glands

Layer of the Stomach:

The **serosa** or vertical peritoneum is the outer most layer of the stomach.

The **muscularis** of the stomach consists of three layers: an outer longitudinal layer, a middle circular layer and an inner oblique layer. The next two layers are **submucosa** and **mucosa.** The stomach is lined with simple columnar epithelium. The mucosal surface forms numerous tube like **gastric pits,** which are the openings for the gastric glands.

The epithelial cells of stomach can be divided into four main types. The first type is **surface mucous cells,** which produce mucus, is on the surface and lines the gastric pit. The remaining three are in the gastric gland.

They are:

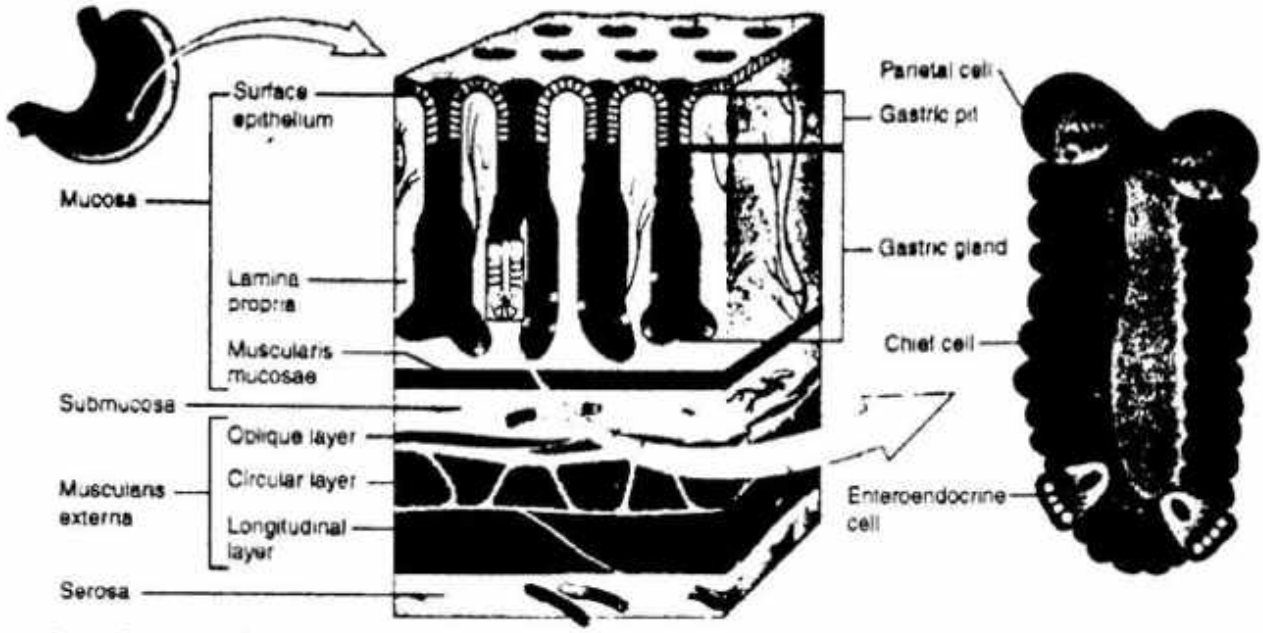
(1) **Parietal (oxyntic) cells** produce hydrochloric acid and intrinsic factors.

(2) **Principal cells** or **chief (zymogenic) cells** secrete pepsinogen.

(3) **Endocrine cells** secrete the hormone gastrin into the blood.

33. Draw, describe and label section of human stomach wall.

Ans:



A section of stomach wall that illustrates its histology, including several gastric pits and glands

34. Describe the functions of human stomach.

Ans: Functions of stomach:

Digestion in the stomach can be divided into two types: mechanical digestion and chemical digestion.

Mechanical digestion:

The mixing action of the stomach walls allows mechanical digestion to occur **in** the stomach. The smooth muscles of the stomach produce contractions known as **mixing waves**. This is made more efficient by the fact that unlike other region of the alimentary canal the stomach has three layers of smooth muscles. The churning action of the stomach **or** mixing waves mix the boluses of food with gastric juice.

This mixing leads to the production of the thick liquid known as **chyme** (meaning juice).

Chemical digestion:

Stomach secretions include mucus, hydrochloric acid, gastrin, intrinsic factor and pepsinogen. The mucous cells secrete viscous and alkaline **mucus.** The thick layer **of** mucous lubricates and protects the epithelial cells of the stomach wall from the damaging effect of the acidic chyme and pepsin.

Functions of components of gastric juice:

Parietal cells in the gastric glands of the pyloric region secrete intrinsic factor and a concentrated solution of hydrochloric acid. **Intrinsic factor** is a glycoprotein that binds with vitamin B12 and makes the vitamin more readily absorbed in the ileum.

Hydrochloric acid produces the low pH of the stomach, which is normally between 1 and 3, but is usually close to 2. Although the hydrochloric acid secreted into the stomach has a minor digestive effect on digested food, one of its main functions is to kill bacteria that are ingested with essentially everything humans put into their mouths. The low pH of the stomach also stops carbohydrate digestion by inactivating salivary amylase. The low pH also denatures many proteins so that

proteolytic enzymes can reach internal peptide bonds, and it provides the proper pH environment for the function of pepsin.

Chief **cells** within the gastric glands secrete inactive **pepsinogen.** Pepsinogen is packaged in **zymogen** (meaning, related to enzymes) granules, which are released by exocytosis when pepsinogen secretion is stimulated. Once **pepsinogen** enters the lumen of the stomach, it is converted to **pepsin** by hydrochloric acid and previously formed pepsin molecules. Pepsin exhibits optimum enzymatic activity at a pH of 3 or less. Pepsin catalyzes the cleavage of some covalent bonds in proteins, breaking them into smaller peptide chains.

35. What is the role of nervous system and gastrin hormone on the secretion of gastric juice?

Ans: Role of nervous system and gastrin hormone on the secretion of gastric juice:

Approximately 2-3 litres of gastric secretions (gastric juice) are produced each day. Both nervous and hormonal mechanisms regulate gastric secretions.

Hormones that regulate stomach secretions:

Hormones that regulate stomach secretions include gastrin, secretin, gastric inhibitory polypeptide, and cholecystokinin.

Gastric Secretion:

The sensations of the taste and smell of food, stimulation of tactile receptors during the process of chewing and swallowing, and pleasant thoughts of food stimulate centres within the medulla that influences **gastric secretion.** Neuronal stimulation of the stomach mucosa results in the secretion of **acetylcholine,** which stimulates the secretory activity of both the parietal and chief cells and stimulates the secretion of **gastrin** from endocrine cells. Gastrin is released into the circulation and travels to the parietal cells, where it stimulates additional gastric juice (hydrochloric acid and pepsinogen) secretion.

Volume of Gastric Secretions:

The greatest volume of gastric secretions is initiated by the presence of food in the stomach. The primary stimuli are distention of the stomach and the presence of amino acids and peptides in the stomach. Peristaltic waves occur less frequently, are significantly more powerful than mixing waves, and force the chyme near the periphery of the stomach toward the pyloric sphincter. The pyloric sphincter usually remains partially closed because of mild tonic contraction. Each peristaltic contraction is sufficiently strong to force a small amount of chyme through the pyloric opening and into the duodenum.

36. Describe the structure of human small intestine.

Ans: Small intestine:

The small intestine consists of three parts:

i. The duodenum (meaning: twelve fingers breadth in length)

ii. The jejunum (meaning: empty, because after death no food is found here. Jejunum comes from Latin word *"jejunus"* meaning hungry)

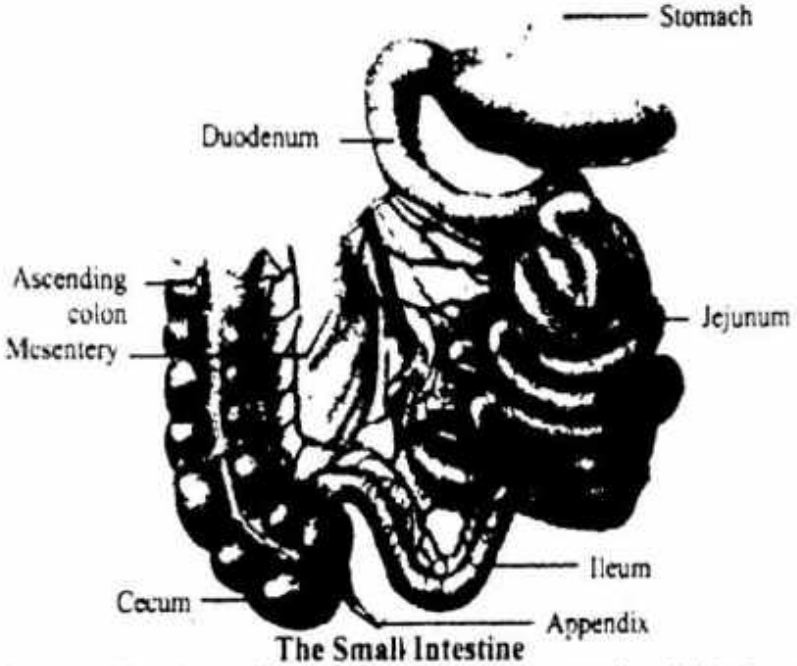
iii. The ileum (meaning: twisted).

Length of Small Intestine:

The entire small intestine is about 6 m long (range: 4.6-9 m). The duodenum is about 25 cm long and 5cm in diameter, and the ileum is about 3.5 m long.

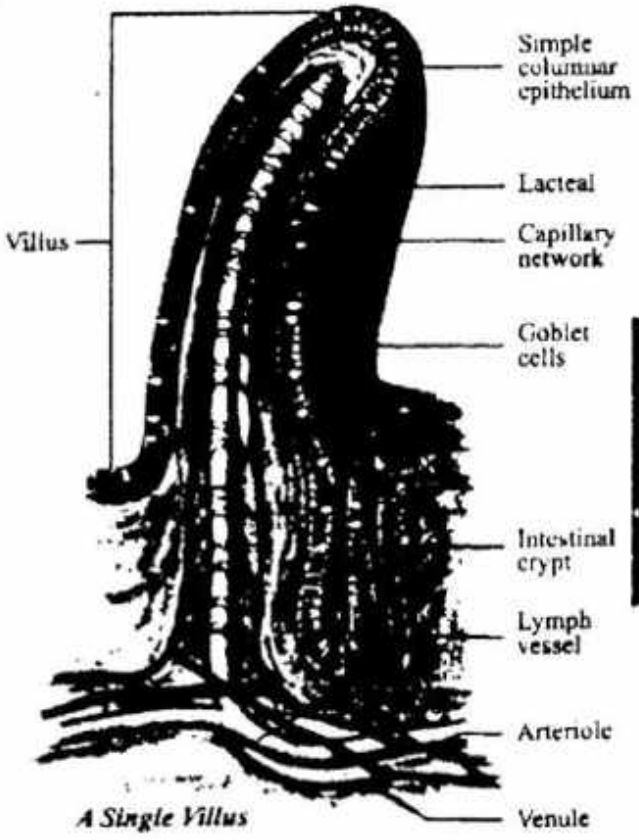
Structure of Small Intestine:

These portions are suspended from the posterior abdominal wall by a double-layered fold of peritoneum called **mesentery.** Two major accessory glands, the liver and the pancreas, are associated with the duodenum.

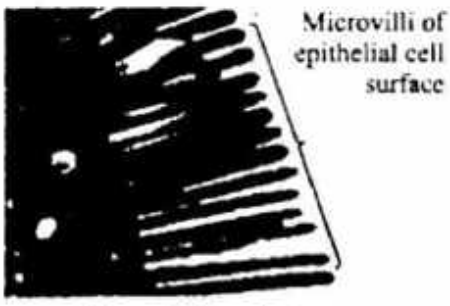


The Small Intestine

The **duodenum** begins with a short superior part, which is where it exits the pylorus of the stomach and ends in a sharp bend, where it joins the jejunum. Tiny finger like projections of the mucosa form numerous **villi** (meaning, shaggy hair), which are 0.5-1.5 mm in length. Each villus is covered by simple columnar epithelium. It contains a blood capillary network and a lymph capillary called a **lacteal.**



A Single Villus



Transmission electron micrograph of microvilli on the surface a villus.

Histology of the Duodenum

The **jejunum** and **ileum** are similar in structure to the duodenum, except that there is a gradual decrease in the diameter of the small 'intestine, the thickness of the intestinal wall, the number of circular folds and the number of villi as one progress through the small intestine. The duodenum and jejunum are the major sites of nutrient absorption. The junction between the ileum and the large intestine is the **ileocecal junction.** It has a ring of smooth muscle the **ileocecal sphincter,** (also written as ileocolic sphincter) and increase surface area of a one-way **ileocecal valve.**

The structural features increase the surface area of small intestine and make it the largest part of the alimentary canal. The internal walls are folded to increase surface area for absorption. Villi and microvilli further increase surface area for absorption.

37. Describe the major actions carried out in food in the three regions of small intestine.

Ans: Digestion in the three regions of the small intestine:

We have already seen that the three parts of the small intestine are: duodenum, jejunum and ileum.

Digestion in duodenum:

When food enters the duodenum the secretions of pancreas and liver are poured into it.

Pancreatic juice:

The secretion of pancreas is called pancreatic juice. It is poured through the pancreatic duct. Pancreatic juice is slightly alkaline. Its pH is about 8. It neutralizes the acidic action of digestive enzymes secreted by the pancreas. The important enzymes are (a) Pancreatic amylase (b) Pancreatic lipase (c) Trypsinogen (4) Chymotrypsinogen.

Pancreatic amylase:

It is the starch 'digesting enzyme. It hydrolyses the polysaccharides to maltose and even to glucose.

Pancreatic lipase:

It is the principal enzyme for the hydrolysis of fats. It hydrolyses fats to neutral fat in parts to its (i) mono and diglycerols (diglycerides). (ii) glycerol (iii) fatty acids.

Enzyme precursors:

Two important enzyme precursors are found in pancreatic juice. They are trypsinogen and chymotrypsinogen. Both are the inactive forms.

Trypsinogen:

The intestinal glands secrete an activator enzyme called enterokinase. The enterokinase converts trypsinogen into trypsin. The trypsin is the active form, which acts on proteins and converts them into polypeptides.

Chymotrypsinogen:

The inactive chymotrypsinogen is converted to active form by trypsin.

Bile:

Bile is manufactured in liver but stored in gall bladder. Bile emulsifies fat causing them to breakdown into numerous small droplets called emulsion. Emulsification provides relative large surface are of lipid for the action of lipase

enzyme and hence speed up the digestion of fats and oils. (You will study more about bile later on in this chapter).

Digestion in jejunum and ileum:

Here the digestion of protein carbohydrates and fats is completed. The lining of the jejunum and ileum secrete several enzymes

Amino peptidase: It splits polypeptides into dipetides and amino acids

Enterokinase: It converts trypsinogen to trypsin.

Dipeptidase: Such as **(a) Erepsin:** It splits peptides into amino acids. **(b) Lactase:** It converts lactose to glucose and fructose **(c) Maltase:** It converts maltose to glucose. **(d) Sucrase:** It converts sucrose to glucose and fructose.

Pancreatic lipase: It completes the digestion of fats into fatty acids and glycerol.

Chyle: By the action of enzymes, chyme is turned into a watery emulsion called chyle.

38. Explain the absorption of digested products from the small intestine lumen to the blood capillaries and lacteals of the villi.

Ans: Absorption of digested food from the lumen of intestine:

To reach the blood or lymph a nutrient molecule must pass through an epithelial cell of the intestinal lining and through a cell lining the blood capillaries or lymph vessel.

Absorption of carbohydrates:

Absorption occurs by a combination of simple diffusion and active transport. The monosaccharides are transferred by facilitated diffusion to the capillaries of intestinal villi and are carried by the hepatic portal system to the liver, where non-glucose sugars are converted to glucose. Glucose enters the cell through facilitated diffusion.

Absorption of Lipids:

The primary products of the digestive process are free fatty acids and glycerol. Cholesterol and phospholipids also constitute part of the lipid digestion products. Once lipids are digested in the intestine, bile salts aggregate around small droplets to form micelles (meaning: a small morsel). When a micelle comes into contact with the epithelial cell of the small intestine, the contents of micelle pass by means of simple diffusion through the lipid cell membrane of the epithelial cell.

After glycerol and fatty acid are absorbed by epithelial cells, they are recombined into fats within these cells. The fats are then mixed with cholesterol and proteins, forming small globules called **chylomicrons,** most of which are transported by exocytosis out of epithelial cells into lacteals. Lymph containing chylomicrons, eventually drains from the lymphatic system into large veins that return blood to the heart.

Absorption of Protein:

Once the proteins and polypeptide chains leave the stomach, proteolytic **enzymes** produced in the pancreas continue the digestive process, producing small **peptide chains.** These are broken down into dipeptide, tripeptides and amino acids by **peptidases** bound to the **microvilli** of the small intestine. Dipeptides and tripeptides enter intestinal epithelial cells. Once inside the cells, dipeptidase and tripeptidase split the dipeptides and tripeptides into their component amino acids. Individual amino acids then leave the epithelial cells and enter the **hepatic portal system,** which transports them to the **liver.** The amino acids may be modified in the

liver or released into the bloodstream and distributed throughout the body. Most amino acids are used as building blocks to form new proteins, but some amino acids may be used for energy.

39. Describe the large intestine of man. What are the functions of large intestine?

Ans: Large intestine:

The **caecum** (North American spelling: cecum), which is the proximal end of the large intestine, is where the large and small intestines meet. The caecum extends inferiorly about 6 cm behind the ileocecal junction in the form of a blind sac. Attached to the inferior surface of the caecum is a small blind tube about 9 cm long called the **vermiform appendix.** The walls of the appendix contain many lymph nodules. The **colon** is about 1.5 to 1.8 m long and consists of four parts: the **ascending colon, transverse colon, descending colon,** and **sigmoid colon.** The **rectum** (means: straight) is a straight, muscular tube that begins at the termination of the sigmoid colon and ends at the anal canal. The last 2-3 cm of the digestive tract is the **anal canal.** It begins at the inferior end of the **rectum** and ends at the **anus** (external GI tract opening). The smooth muscle layer and skeletal muscle form **sphincter** of the anal canal.

Functions of large intestine:

The large intestine performs several important functions. The major functions of the large intestine are:

(a) Absorbing water

(b) Absorption of vitamins

(c) Reducing acidity and protecting from infections

(a) Absorbing water and electrolytes:

Further digestion or breaking down of nutrients does not take place in the large intestine. The proximal half of the large intestine functions to reabsorb some of the water and electrolytes making the stools solid. The substances that remain in the tube becomes faeces (North American spelling: feces), which is stored for a time in the distal portion of the large intestine.

(b) Absorption of vitamins:

The large intestine also helps in absorption of vitamins made by bacteria that normally live in the large intestine. These bacteria also produce large amounts of vitamins. The most important of these is Vitamin K and Biotin (a B vitamin).

(c) Reducing acidity and protecting from infections:

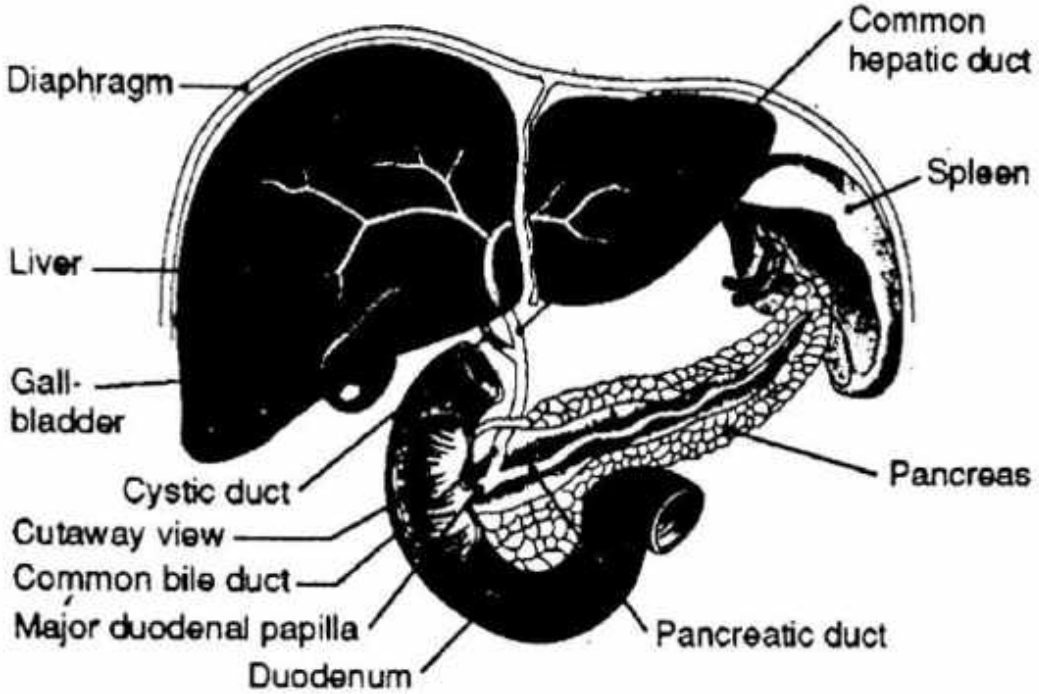
The mucosa of the large intestine also secretes bicarbonates to neutralize the increased acidity resulting from the formation of these fatty acids and other digestive components at earlier parts of the intestines.

40. Describe the structure of liver.

Ans: Liver:

The liver is the largest internal organ of the body. The liver consists of two major lobes, left and right, and two minor lobes. A **porta** (gate) is on the inferior surface of the liver where the various vessels, ducts, and nerves enter and exit the liver. The **hepatic ducts** transport **bile** out of the liver. The right and left hepatic ducts unite to form a single **common hepatic duct.** The common hepatic duct is joined by the **cystic duct** from the gall bladder to form the **common bile duct,**

which empties into the duodenum at the major duodenal papilla in union with the pancreatic duct.



Duct system of the major abdominal digestive glands

41. What is bile? Describe the composition of bile. What is the role of constituents of bile? How secretion of bile is related to the secretion of hormone secretin?

Ans: Composition of bile:

The liver produces and secretes bile. It is stored in the gall bladder. Bile contains no digestive enzymes. Bile consists of water, bile salts: sodium glycocholate and sodium taurocholate, bile pigment, bilirubin, cholesterols, lecithin (a phospholipids) mucus, cells and cell debris.

Role of constituents of bile:

Bile salts reduce the surface tension of fat globules and emulsify them into droplets and thus increase their total surface area. This process is called emulsification. These small droplets are then acted upon by the enzyme lipase. **Bilirubin** results from the breakdown of haemoglobin. In the intestine, bacteria convert bilirubin into pigments that give the faeces its characteristic brown colour. Some of these pigments are absorbed from intestine, modified in the kidneys and excreted in the urine, contributing to the characteristic yellowish colour of the urine. Bile salts help in the absorption of fatty acids from the intestinal tract.

Secretion of bile is related to secretin hormone:

Fatty acids in the lumen of the duodenum stimulate endocrine cells to release the hormone cholecystokinin (CCK). CCK stimulates contractions in the smooth muscle of the gall bladder. CCK also causes relaxation of the hepatopancreatic sphincter allowing bile release into the duodenum. Acidic chyme in the lumen of the duodenum stimulates other endocrine cells to release the hormone **secretin.** Secretin produced by the duodenum is carried through the circulatory system to the liver and stimulates duct cells in the liver to release bicarbonate into the bile.

42. Write the functions of liver of man.

Ans: Functions of liver:

The liver performs important digestive and excretory functions, stores and processes nutrients, synthesizes new molecules and detoxifies harmful chemicals.

Storage role of liver:

Hepatocytes can remove sugar from the blood and store it in the form of glycogen. They can also store fat, vitamins (A, B12, D, E, and K), copper and iron.

This **storage function** is usually short-term and the amount of stored material in the hepatocytes varies, thus the cell size fluctuates during a given day.

Metabolic role of liver:

Metabolism of glucose occurs in liver. Whenever needed, glucose is obtained by the hydrolysis of glycogen (glycogenosis). Glucose is also synthesized from amino acids or fatty acids and glycerol (gluconeogenesis). Denaturation of fatty acids and phosphorylation of fats takes place in liver cells. Excess of amino acids undergo deamination producing pyruvic acid and ammonia. Ammonia produced by deamination of amino acids in hepatic cells is converted to urea (omithine-arginine cycle)

Synthesis of vitamin A from carotin (carotene) and synthesis of albumin from amino acids takes place in liver. Formation of blood proteins (like prothrombin, fibrinogen) are synthesized in liver cells. These are necessary for blood clotting. **Phagocytosis** also occurs in liver i.e., dead RBCs are destroyed. The bile pigments **bilirubin** (orange pigment) and **biliverdin** (green pegment) are formed from the breakdown of haemoglobin. Liver produces **heparin,** an enzyme that prevents clotting of blood inside the blood vessels. Red blood cells are formed during foetal (US spelling: fetal) life. **Detoxification** occurs in liver.

43. What is the structure of pancreas? Explain the functions of pancreas as an exocrine gland.

Ans: Pancreas:

The **pancreas** is a complex organ composed of both endocrine and exocrine tissues that perform several functions.

Parts of Pancreas:

The pancreas consists of a head, located within the curvature of the duodenum, a body and a tail, which extends to the spleen. The endocrine part of the pancreas consists of **pancreatic islets** (islets of Langerhans).

Pancreas as an exocrine gland:

The exocrine secretion of the pancreas is called **pancreatic juice** and has two major components: an aqueous component and an enzymatic component. Bicarbonate neutralizes the acidic chyme that enters the small intestine from the stomach. The **enzymatic component** of the pancreatic juice is important for the digestion of all major classes of food. The major proteolytic enzymes are **trypsin, chymotrypsin,** and **carboxypeptidase.**

They are secreted in their inactive forms as trypsinogen, chymotrypsinogen, and procarboxypeptidase and are activated by the removal of certain peptides from the larger precursor proteins. If these were produced in their active forms, they would digest the tissues producing them. Trypsinogen is activated by the proteolytic enzyme enterokinase (meaning, intestinal enzyme) into **trypsin.**

Trypsin then activates more trypsinogen, as well as **chymotrypsinogen** and **procarboxypeptidase. Amylase,** continues the polysaccharide digestion that

was initiated in the oral cavity. **Pancreatic lipases**, breakdown lipids into free fatty acids, glycerides, cholesterol **Deoxyribonucleases** and **ribonucleases**, reduce DNA and ribonucleic acid to their component nucleotides, respectively

44. Describe the aetiology, prevention and treatment of the following disorders:

(a) Ulcer (b) Food poisoning (c) Dyspepsia.

Ans: (a) Ulcer

Aetiology (North American spelling: etiology, means the medical study of the causation of disease): Peptic ulcer is classically viewed as a condition in which the stomach acids digest the mucosal lining of the GI tract itself.

i. *Helicobacter pylori* is the most important factor in peptic ulcer disease, accounting for 90% of duodenal ulcer and 70% of the gastric ulcer.

ii. Aspirin (acetyl salicylic acid) and other non-steroidal anti-inflammatory agents are an important aetiologic factor.

iii. Peptic ulcer tends to run in families i e. it is a hereditary disease.

Prevention:

Aggravating factors such as smoking, asprin, excess intake of coffee and tea, alcohol, missing a meal are to be avoided.

Treatment:

The relieving factors of ulcer are antacid and milk, vomiting relieves pain in gastric ulcer, and intake of food relieves pain in duodenal ulcer. Medicines for acid suppression are the first choice of therapy

(b) Food poisoning:

It includes diarrhoea (North American spelling, diarrhea), vomiting and abdominal pain. It is an illness from indigestion of food containing toxic substances.

Aetiology:

Due to the **toxins** produced by bacteria, *Salmonella* and *Campylobacter*.

Prevention:

Basic hygiene should be followed. Avoid unboiled /unbottled water ice, cubes salads and peel on fruits. Consume freshly prepared hot food or thoroughly rewarmed food

Treatment:

Soft easily digested diet, such as soup, fruits drinks, tea and cold drinks are preferred. Oral rehydration salt (ORS) is given. Antidiarrhoeal agent such as Loperamide, antibiotics are prescribed.

(c) Dyspepsia: Incomplete or imperfect digestion is called dyspepsia.

Aetiology:

It may occur due to excessive acidity in stomach or faulty function of stomach and intestine or insufficient quality and quantity of bile secretion.

Prevention:

Avoid food that worsens symptoms. Stop smoking, weight reduction, small meals, avoid alcohol, tea, fatty food, heavy lifting, bending specially after meals and late night meals to reduce reflex during sleep.

Treatment:

Antibiotics to be given against this disease. Drugs which decrease HCl production such as Cimetidine, stop NSAID (Non-Steroidal Anti Inflammatory Drugs) e g Aspirin

45. Describe obesity in terms of its causes, preventions and related disorders.

Ans: Obesity:

When a person has abnormal amount of fat on the body it is called obesity.

Aetiology:

Excessive intake of food is responsible for obesity. Emotional disturbances, inherited tendency to obesity, disorder of the thyroid, pituitary or adrenal glands etc., can also cause obesity.

Prevention:

Food should be taken according to energy intake and energy expenditure. Diet control, regular exercise can prevent obesity.

Related disorders:

The distribution of fat difference can be clinically significant because upper body obesity is associated with an increased likelihood of diabetes mellitus, cardiovascular disease, and stroke. Many other diseases are associated with obesity like angina, heart failure, anaemia, arthritis etc. Obesity shortens life expectancy.

46. Explain the symptoms and treatments of:

(a) Bulimia nervosa (b) Anorexia nervosa

Ans: (a) Bulimia nervosa:

Symptoms:

It is a neurotic disorder in slightly older girls. It is characterized by bouts of over eating fattening food such as fried food or cream cakes. This voracious (eating in large quantity) eating followed immediately by self-induced vomiting, fasting or purging (to empty bowels) may cause physical effects including serum electrolytes imbalance and frequent recurring infections.

Treatment:

Treatment of bulimics is likely to be prolonged. The initial treatment is to overcome the effects of weight loss and malnutrition. It is necessary to undertake the treatment in hospital under strict supervision.

(b) Anorexia nervosa:

It is the loss of appetite due to the fear of becoming obese. Such a feeling is common in human females between the ages of 12 and 21 years. Usually just after the onset of puberty.

Symptoms:

It includes loss of appetite due to the fear of becoming obese. The anorexic girls over estimate the size of her own body and so insist that she is overweight, when in reality her weight has dropped to a dangerous level. These girls are often not matured psychologically and unable to cope with the challenges of puberty and their emerging sexuality. The losses of feminine characteristics enable the girls to retreat into a childlike state in which she feels safe.

Therapy:

Psychiatric therapy is usually required to treat anorexic girls. Such patients are fed through any other route other than alimentary canal, i.e., intravenously. The recovery is very slow. It may take 2-4 years and in some cases longer.