

UNIT 14**DIGESTIVE SYSTEM**

The system which consists of the structures associated with intake of food (ingestion), its digestion and absorption of digested food and finally removal of indigestible residue is known as digestive system.

Functions of Digestive System

1. Ingestion and digestion of food.
2. Absorption of necessary nutrient materials.
3. Excretion of unwanted or harmful substances.
4. Secretion of several kinds of juice and mucus.
5. Movement of food.
6. Regulation of acid base balance.
7. Maintenance of water balance.

ORGANS/PARTS OF DIGESTIVE SYSTEM**A. Alimentary tract**

- Mouth
- Pharynx
- Oesophagus
- Stomach
- Small intestine
- Large intestine
- Rectum
- Anus

B. Accessory organs

- Salivary Glands
- Pancreas
- Liver & Biliary tract
- Gall bladder

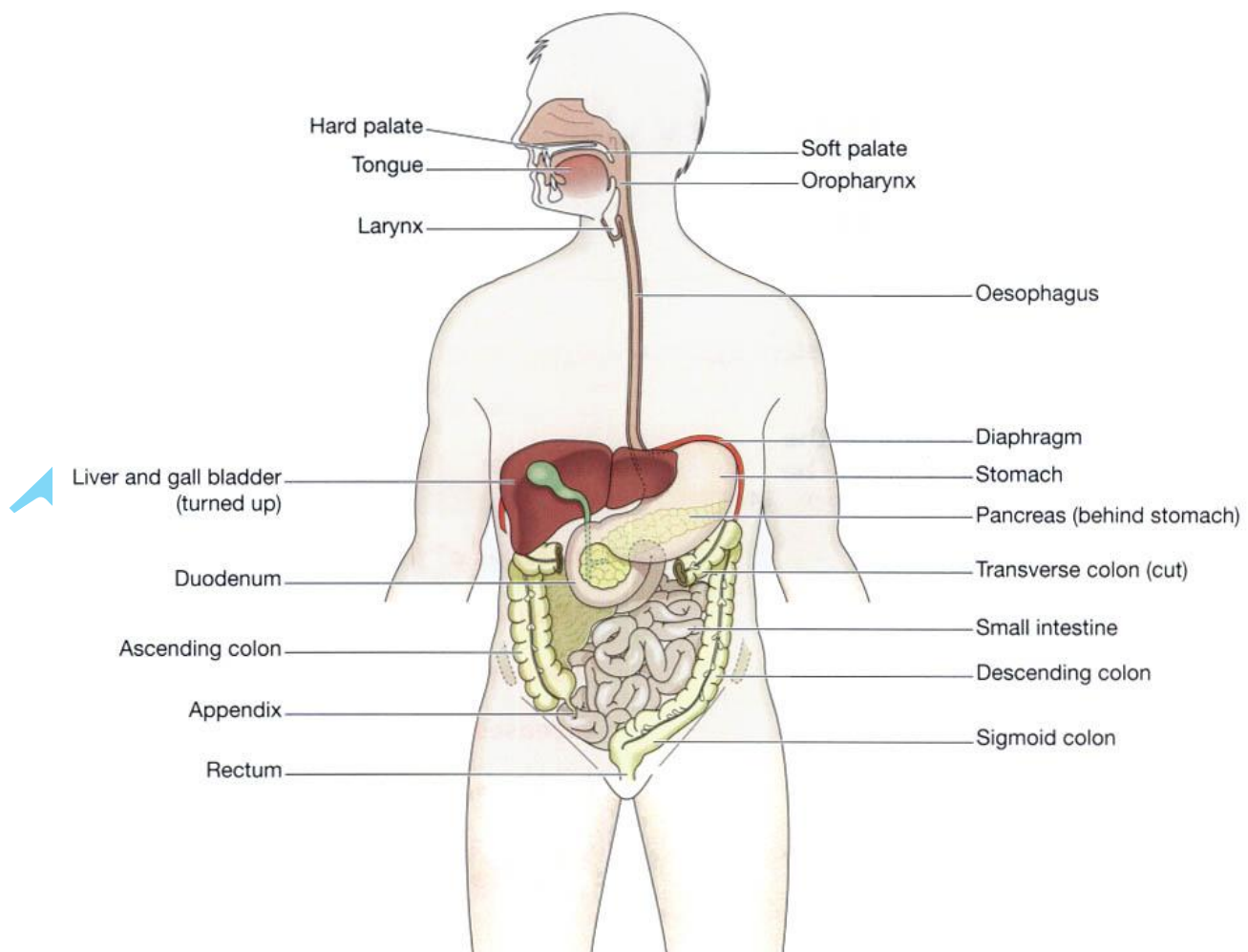


Fig. Organs of the digestive system

BASIC STRUCTURE OF ALIMENTARY CANAL

The wall of the alimentary canal is formed by the four layers of tissues.

1. **Serous or fibrous layer:** It is the outer layer of alimentary canal formed by loose fibrous connective tissue.
2. **Muscular layer:** Muscle layer in lips, cheeks and wall of pharynx contains skeletal muscle fibers. The oesophagus has both skeletal and smooth muscles fibers. The wall of the stomach and intestine is formed by smooth muscle fibers.
3. **Sub mucus layer:** It contains (except mouth and pharynx) loose collagen fibers, elastic fibers, reticular fibers, few cells of connective tissue, blood vessels, lymphatic vessels and nerves.
4. **Mucus layer:** It is the inner layer of alimentary canal. It is also known as gastrointestinal mucosa or mucus membrane.

MOUTH

The starting and upper expanded portion of the alimentary tract is known as mouth. It is also known as buccal cavity or oral cavity. The mouth is lined by mucous membrane and consisting of stratified squamous epithelium tissue.

a. Tongue: Tongue is a voluntary muscular structure. It lies at the floor of mouth and base is attached to the hyoid bone. The superior surface of tongue consists of stratified squamous epithelium with numerous papillae.

Nerve supply of tongue: The nerves involve:

- The hypoglossal nerves (12th cranial nerves), which supply the voluntary muscle.
- The lingual branches of the mandibular nerves, which arise from the 5th cranial nerves, are the nerve of somatic (ordinary) sensation i.e. pain, temperature and touch.
- The facial and glossopharyngeal nerves (7th and 9th cranial nerves) are the nerves of taste.

Functions of tongue

1. It helps in swallowing and chewing of food.
2. It plays a role in speech.
3. It helps to find the taste.
4. It acts as a brush to clean the teeth.

b. Teeth: Teeth are very hard structures embedded in the alveoli or socket of mandible and maxilla bones. Each tooth of individual develops two sets. The milk teeth appear first, and are progressively replaced by the permanent teeth. Teeth have different shapes and sizes and possess uneven biting surfaces.

Functions of teeth

1. Biting of pieces of food.
2. Grinding or chewing of food.

PHARYNX

The pharynx is a wide muscular tube like organ. It extended from the base of the skull to the level of 6th cervical vertebra, where it continues with oesophagus. It lies behind the nose, mouth and larynx.

Parts/Structure of Pharynx

The cavity of pharynx is divided into three parts:

1. **Nasopharynx:** The upper or nasal part of pharynx is known as nasopharynx. It lies behind the nasal cavity.
2. **Oropharynx:** The middle or oral part of pharynx is known as oropharynx. It lies behind the mouth.
3. **Laryngopharynx:** The lower or laryngeal part of pharynx is known as laryngopharynx. It lies behind the larynx.

Functions of Pharynx

- It provides passageway of food from mouth to oesophagus.

OESOPHAGUS

Oesophagus is a long, narrow, straight and muscular tube like organ. It is also known as food pipe or gullet. It lies in the median plane in the thorax in front of the vertebral column behind the trachea and the heart. It is continuous with the pharynx and just below the diaphragm and joins the stomach. It is about 25cm (10 inch) long.

Function of Oesophagus

- It transports food from pharynx to stomach.

STOMACH

Stomach is the widest organ of the alimentary canal. It is hollow, bag like and J shaped structure. It is situated in the left side of abdominal cavity. It is about 25 cm in long.

Structure of Stomach

a. Parts of stomach: The stomach is divided into four parts:

- Cardiac part
- Fundus
- Body or corpus
- Pyloric part

b. Orifices of stomach

The stomach has two orifices:

- Cardiac orifice
- Pyloric orifice

c. Curvatures of stomach

The stomach has two curvatures:

- Lesser curvature
- Greater curvature

d. Wall of stomach: Histologically, the wall of stomach is made up of four layers:

- **Serous layer:** It is the outer layer of stomach covering of serous membrane (peritoneum).
- **Muscular layer:** It is made up of smooth muscle fibers.
- **Sub mucus layer:** It is made up of loose connective tissue, blood vessels, lymphatic vessels and part of autonomic nervous system.
- **Mucus layer:** It is the inner layer of stomach made up of simple columnar epithelium.

Functions of Stomach

1. It stores food for long time.
2. It secretes gastric juice.
3. It digests protein by action of pepsin and rennin.
4. It produces chyme.
5. It secretes gastrin hormone.
6. It destroys many types of bacteria entering the body along with food.
7. It excretes many substances like toxins, alkaloids, metals etc.
8. It absorbs vitamin B₁₂.

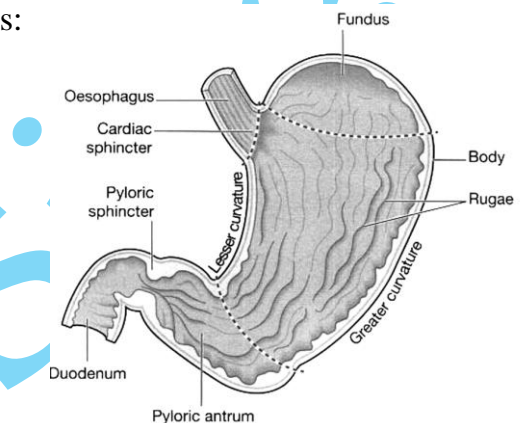
CHYME

It is the liquid substance found in the stomach before passing through the pyloric valve and entering the duodenum. It results from the mechanical and chemical breakdown of a bolus and consists of partially digested food, water, hydrochloric acid, and various enzymes.

GASTRIC GLANDS

The innermost mucosal region of stomach consists of microscopic, tubular glands known as gastric glands. Each gastric gland consists of four types of cells:

1. **Mucous cells (goblet cells):** It secretes mucous which reduces the acidic effects.
2. **Oxyntic cells or parietal cells:** It secretes hydrochloric acid (HCl) and intrinsic factor.



- 3. Peptic cells (chief or zymogenic or zymogen cells):** It secretes pepsinogen (inactive form of pepsin).
- 4. Argentaffin cells:** It secretes serotonin and gastric hormones.

Gastric Juice

The secretion of gastric gland is known as gastric juice. It is the clear, watery, strongly acidic fluid. The normal human secretes about 1200-1500 ml/day.

Composition of gastric juice

The gastric juice is made up of:

- Water : 98-99%
- Solids : 1-2%

The solids substances of gastric juice are made up of organic and inorganic substances. Examples: Gastric enzymes: (pepsin, rennin, gastric lipase), gastric mucus, hydrochloric acid (HCL), sodium, potassium, calcium, chloride, bicarbonate, phosphate, sulphate etc.

Functions of gastric juice

1. It liquefies the food.
2. It kills the bacteria.
3. It provides acid medium for the action of enzymes.
4. It acts on carbohydrates (gastric amylase).
5. It digests the butter fat (gastric lipase).

SMALL INTESTINE

Small intestine is a long, coiled, tube like organ. It is situated between the pyloric sphincter to stomach and ileocecal valve, which opens into large intestine. It is about 6m long.

Parts of Small Intestine

Small intestine is divided into three parts:

1. **Duodenum:** It is small C- shaped and about 25cm long.
2. **Jejunum:** It is the second part of small intestine that lies between the duodenum and ileum.
3. **Ileum:** It is last and the longest part of small intestine. It is highly coiled part.

Structure of Small Intestine

The wall of small intestine consists of four layers of tissue:

- **Serous layer:** It is the outer layer of small intestine and consists of serous membrane (peritoneum).
- **Muscular layer:** It consists of smooth muscle fibers.
- **Sub mucus layer:** It consists of areolar connective tissue, blood vessels, lymph vessels and nerves.
- **Mucus layer:** It is the inner layer of small intestine and consists of columnar epithelium tissue.

Functions of Small Intestine

1. It completes digestion of carbohydrate, proteins and fats.
2. It absorbs nutrients.
3. It secretes intestinal juice.
4. It secretes hormones such as cholecystokinin (CCK) and secretin.

LARGE INTESTINE

The large intestine is a "U" shaped and tube like organ. It is also known as colon. It extends from ileocecal valve up to anus. It is about 1.5 meter long.

Parts of Large Intestine

The large intestine consists of seven parts.

- Cecum with appendix Colon
- Ascending colon

- Transverse colon
- Descending colon
- Sigmoid colon or pelvic colon
- Rectum
- Anal canal

Functions of Large Intestine

1. It absorbs water, electrolytes and salts.
2. It excretes heavy metals like mercury, leads, bismuth and arsenic through the faeces.
3. It secretes mucin and inorganic substances like chlorides and bicarbonates.
4. It synthesizes folic acid, vitamin B₁₂ and vitamin K.

SALIVARY GLANDS

The salivary glands are exocrine glands of the body. It is situated in the oral cavity. There are three pairs of salivary glands. It secretes saliva.

1. **Parotid glands:** It is the largest salivary glands present in the side of the face just below the external auditory meatus.
2. **Sub-mandibular glands:** It is present on each side of the face under the angle of jaw.
3. **Sublingual glands:** It is present under mucous membrane of the mouth.

Saliva: Saliva is a viscous, colorless, cloudy fluids secreted by the salivary glands. About 1.5 liter of saliva is produced daily and about 1ml /min.

Composition of saliva

The mixed saliva is made up of:

- Water: 98-99%
- Solid: 1-2%

The solids part of saliva is made up of organic and inorganic substances. The gages are also present in the saliva.

Functions of saliva

1. It helps in mastication, mixes with the food forming bolus.
2. It lubricates mouth and helps in swallowing.
3. It helps in keeping mouth clear and pathogen free.
4. It stimulates the taste.
5. It moistens and lubricates soft part of mouth and lips.
6. It helps in speech.
7. It excretes certain heavy metals and thyocyanate ions.

PANCREAS

The pancreas is both an exocrine and endocrine gland of the body. It is pale, yellowish, grey gland or organ. It is situated in the epigastric and left hypochondriac region of the abdominal cavity. It is about 60-90gm weight and about 12-15 cm long.

Structure of Pancreas

Histologically, the pancreas consists of two parts such as exocrine part and endocrine part.

- Exocrine part:** The exocrine part of pancreas consists of large number of pancreatic cells or acini, connective tissue, blood vessels. The pancreatic cell secretes pancreatic juice. The normal human secretes 500-800ml of pancreatic juice per day. The pancreatic juice consists of proteolytic enzyme, lipolytic enzyme, amylolytic enzyme.
- Endocrine part:** The endocrine part of the pancreas takes the form of many small clusters of cells known as islet of langerhans. The pancreas has about one million islets of langerhans. Each islet of langerhans consists of four types of cells such as:
 - Alpha cells (α cells):** It secretes glucagon hormone which increases the sugar level in blood.
 - Beta cells (β cells):** It secretes insulin hormone which converts excess glucose into glycogen in the liver and muscles. Deficiency of insulin causes diabetes mellitus.

- c. **Delta cells (δ cells):** It secretes somatostatin (ss) hormone which decreases the rate of nutrient absorption into the blood from GI tract.
- d. **Pancreatic polypeptide cells (PP-Cells or PF cells):** It secretes pancreatic polypeptide (PP) hormone which inhibits the release of pancreatic juice.

LIVER

Liver is the largest digestive gland of the body. It is situated in the upper right part of the abdominal cavity below the diaphragm and under the curve of lower ribs. It is reddish brown in colour. It generally weighs 1.3-1.8 kg (male) and 1.2 -1.4 kg (female) which is about 2% of the body weight.

Structure of Liver

(i) External structure

Externally, the liver contains two lobes and four surfaces:

Lobes: They are:

- Right lobe
- Left lobe

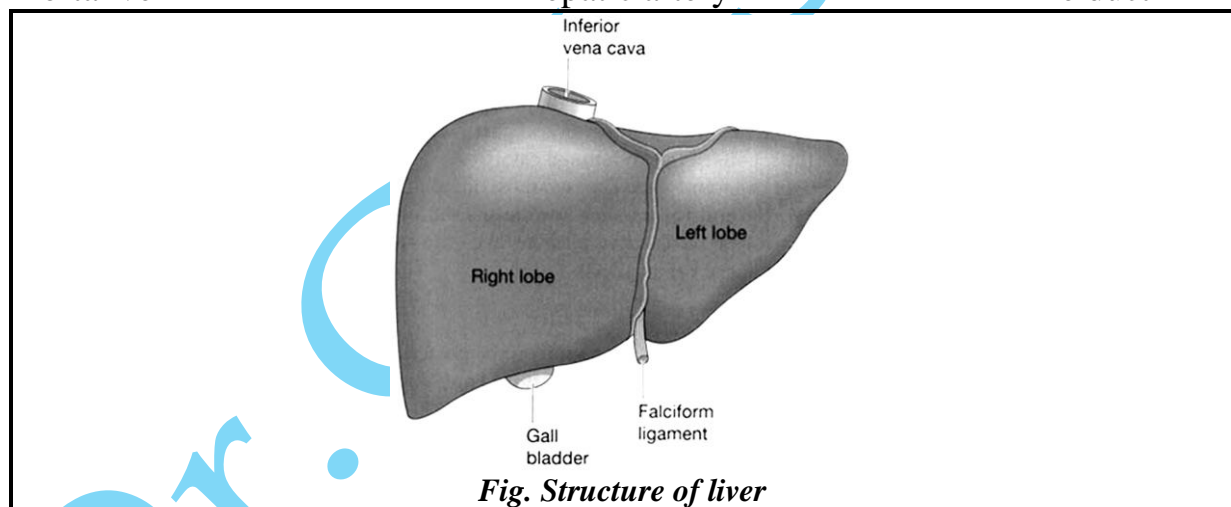
Surfaces: They are:

- Superior surface
- Anterior surface
- Inferior surface
- Posterior surface

(ii) Internal structure

The liver consists of a large number of liver cells known as lobules. Each lobule has a central vein or intra lobular vein. The connective tissue lying in between the lobules contains the branches of:

- Portal vein
- Hepatic artery
- Bile duct



Functions of Liver

1. It removes the nitrogenous portion from the amino acids which is excreted in the urine.
2. It stores vitamin A, D, E, K & B₁₂, copper, iron, glycogen, and folic acid.
3. It detoxifies toxins.
4. It balances the glucose level in blood.
5. It produces red blood cells in embryo.
6. It carries out metabolism of carbohydrates, proteins, lipids vitamins and many of hormones.
7. It destroys the senile red blood cells after the life span of 120 days.
8. It produces maximum heat due to the metabolic actions.
9. It synthesizes vitamin A, non essential amino acids and blood clotting factors etc.
10. It produces bile juice.
11. It stores fat that can be converted in the form of energy.
12. It metabolizes ethanol in alcoholic drinks.

GALL BLADDER

Gall bladder is a pear shaped organ. It is attached to the posterior surface of the liver by connective tissue. It is about 7-10cm long, 3cm wide & capacity of bladder is 30-60ml.

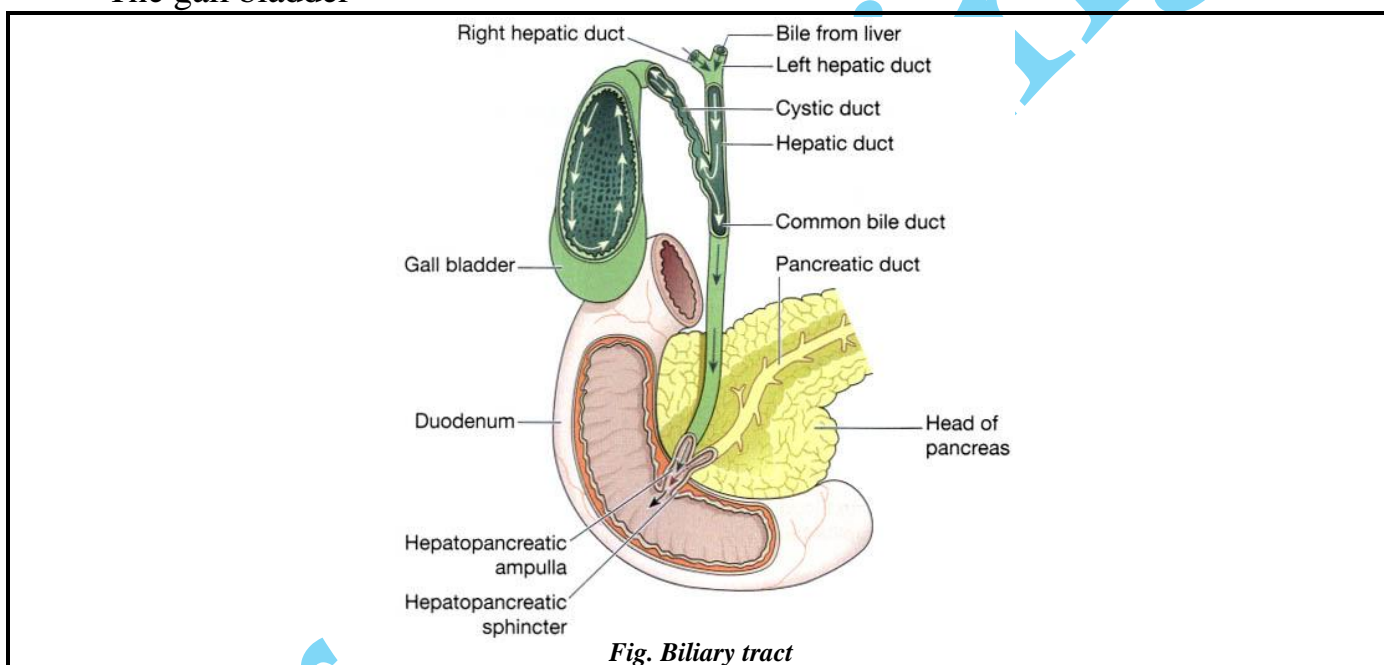
Functions of Gall Bladder

1. It stores bile.
2. It absorbs water.
3. It secretes mucin.
4. It maintains pressure of biliary tract.

BILIARY TRACT/PATHWAY OF BILE

The biliary tract or apparatus includes the passage through which hepatic bile and gall bladder bile is conveyed into the second part of the duodenum. The biliary tract is the apparatus of the liver and consists of:

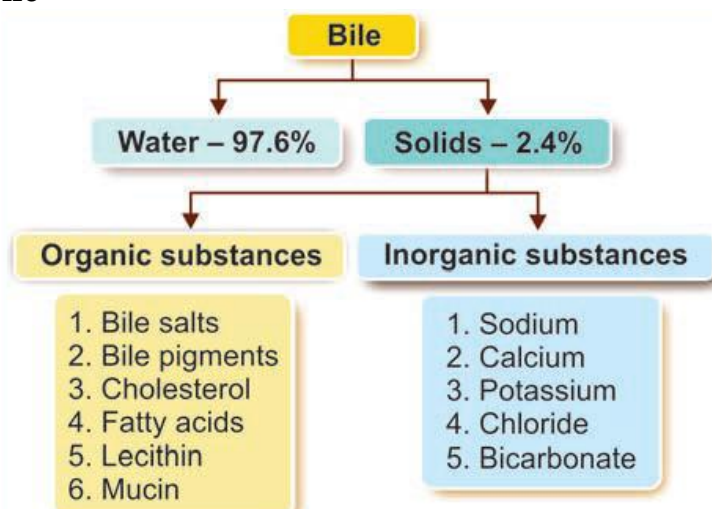
- Left & right hepatic ducts
- The common hepatic duct
- The gall bladder
- The cystic duct
- The common bile duct



BILE

Bile is a bitter-tasting, dark green to yellowish brown fluid, produced by the liver.

Composition of the bile



Functions of bile

1. It helps in neutralizing acidic chyme.
2. It helps to absorb product of fat digestion.
3. It is necessary for absorption of fat soluble vitamins.
4. It acts as antiseptic fluid.
5. It helps in laxative action.
6. It helps in maintenance of pH in gastrointestinal tract.

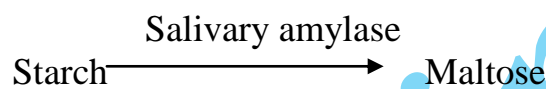
PHYSIOLOGY OF DIGESTION

Digestion: Digestion is the chemical complex process which changes complex food into simpler forms by the action of different chemical enzymes within the alimentary canal.

DIGESTION OF CARBOHYDRATE

a. In mouth

The saliva contains enzyme known as salivary amylase, which breaks down complex carbohydrates into disaccharides.

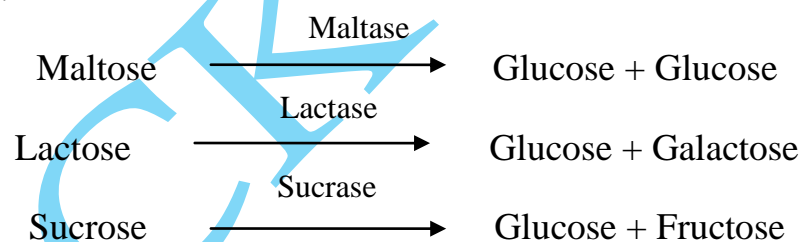


b. In stomach

Acid stops the action of salivary amylase, so no digestion occurs in stomach.

c. In intestine:

- **Pancreatic juice:** Pancreatic amylase act on polysaccharides (starch, glycogen) and convert them into disaccharides [maltose, lactose, sucrose].
- **Intestinal juice:** Maltase, lactase, sucrase act on disaccharide to liberate monosaccharide.



The monosaccharide is then absorbed by the intestinal villi.

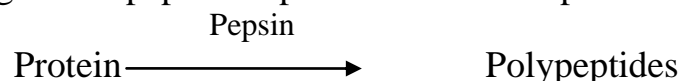
DIGESTION OF PROTEIN

a. In mouth:

No digestion of protein occurs in mouth.

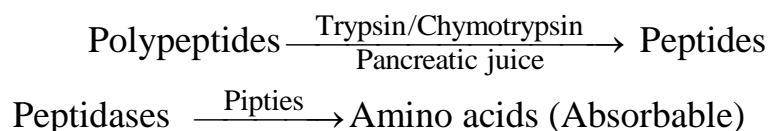
b. In stomach:

HCl converts pepsinogen into pepsin. Pepsin then converts proteins into polypeptides.



c. In intestine:

- Enterokinase converts chymotrypsinogen and trypsinogen into chymotrypsin and trypsin.
- Chymotrypsin, trypsin and peptidase then convert polypeptides into tripeptides, dipeptides and amino acid.



The amino acid is then absorbed by intestinal villi.

DIGESTION OF FAT

a. In mouth:

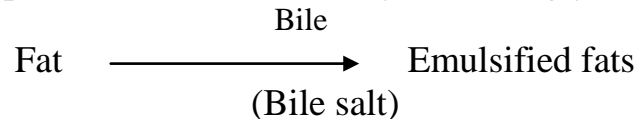
No digestion occurs in mouth.

b. In stomach:

No digestion occurs in stomach.

c. In intestine:

- Bile from liver emulsifies fats. Pancreatic lipase converts fat into fatty acid and glycerol.
- In the enterocytes, lipase converts fat into fatty acid and glycerol.



The end products are then absorbed by the intestinal villi.

Emulsification: Fat is largely digested in the small intestine. Bile salts combine with fats and break down fat droplets into many small ones by reducing the surface area of fat droplets; this process is known as emulsification.

DEGLUTITION OR SWALLOWING

It is the process by which the bolus of food, formed during chewing is propelled backward and passes into stomach through oesophagus is known as deglutition. It takes about 9-12 seconds.

DEFECATION

The voiding of faeces is known as defecation. Faeces is formed in the large intestine and stored in the sigmoid colon, by the influence of an appropriate stimulus, it is expelled out through the anus.

PERITONEUM

Peritoneum is the largest serous membrane of the body and consists of a closed sac within the abdomen cavity. The peritoneum has two layers:

- Parietal layer
- Visceral layer

There is cavity between the two layers of peritoneum called peritoneal cavity. The cavity is filled with serous fluid secreted by the cells which prevents friction of the layers.

Functions of peritoneum

1. It gives support to the abdominal organs.
2. It forms a protective covering from the abdominal organs.
3. It acts as storage for fats.
4. The presence of peritoneal fluid prevents friction of organs from each other.

PERISTALSIS

Peristalsis is a wave like movement occurring in hollow, tubular organs of the body having smooth muscle fibers, especially the alimentary canal, by which their contents are expelled.