Alimentary system or digestive system

Digestive system

The digestive system is a group of organs working together to convert food into energy and basic nutrients to feed the entire body. Food passes through a long tube, known as the alimentary canal or the gastrointestinal tract (GI tract). The alimentary canal is made up of the oral cavity, pharynx, esophagus, stomach, small intestines, and large intestines. In addition to the alimentary canal, there are several important accessory organs, include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas.

Digestion

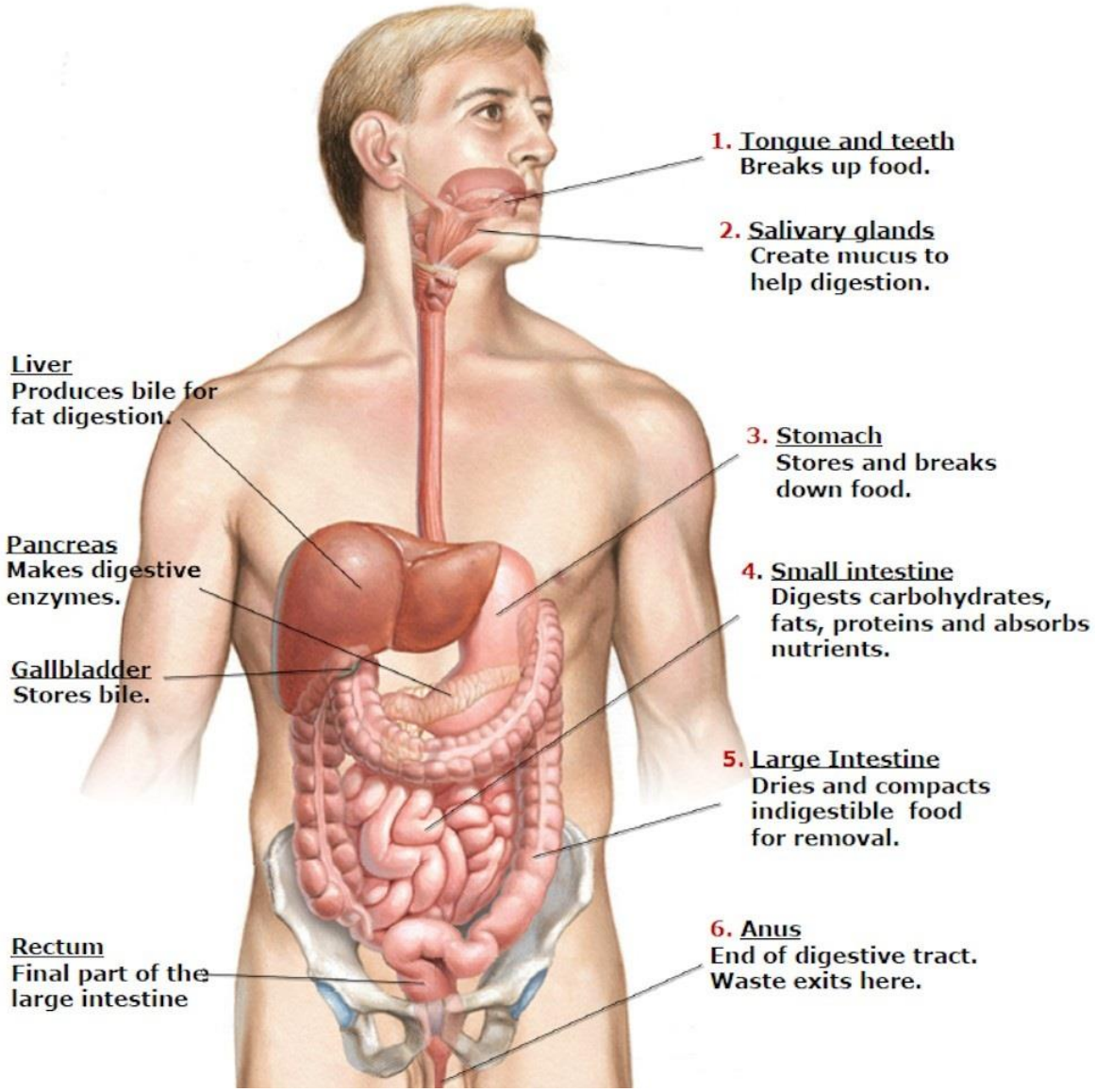
Digestion is the physiological breakdown of large insoluble food molecules into small water-soluble food molecules so that they can be absorbed into the watery blood plasma. It is the process of breaking down of food by mechanical and enzymatic action in the alimentary canal into substances that can be absorbed and used by the body.

Functions of digestive system

1. Receive food
2. Break down food into absorbable nutrients
3. Move food through the digestive system
4. Secrete hydrochloric acid, mucus, digestive enzymes, bile and pepsin
5. Absorb nutrients
6. Elimination of toxic waste products and unabsorbed food

Parts of alimentary system

1. **Mouth**
    a. **Teeth**
    b. **Tongue**
    c. **Salivary glands**
2. **Pharynx**
3. **Esophagus**
4. **Stomach**
5. **Small intestine**
    a. **Duodenum**
    b. **Jejunum**
    c. **Ileum**
6. **Liver**
7. **Gallbladder**
8. **Pancreas**
9. **Large intestine**
    a. **Cecum**
    b. **Ascending colon**
    c. **Transverse colon**
    d. **Descending colon**
    e. **Sigmoid colon**
    f. **Rectum**
    g. **Anal canal**



 # Hormones of GIT

1. Gastrin
2. Secretin
3. Cholecystokinin
4. Pancreozymine
5. Gastric inhibitory peptide
6. Vaso-active intestinal peptide
7. Villikinin
8. Enterocrinin
9. Enterogastrone
10. Motiline
11. Somatostatin
12. Bombesin

Hormones	Site of production	Stimuli	Site of action	Functions
Gastrin	Mucosal layer of Stomach	Protein and protein digestion products in stomach.	Stomach, small intestine, lower esophageal sphincter and gallbladder.	Stimulates gastric acid, pepsinogen. Increase stomach motility. Stimulates the movement of colon.
Secretin	Duodenum and jejunum.	Acid in duodenum.	Pancreas	Stimulate pancreatic bicarbonate secretion. Inhibit gastric secretion and motility. Stimulate bile secretion and potentiate action of CCK.
Cholecystokinin (CCK)	Duodenum and jejunum.	Fat or protein digestion product in duodenum.	Pancreas and gallbladder.	Potentiates the secretion of pancreatic bicarbonate secretion. Inhibit gastric acid secretion and motility. Stimulate bile secretion by liver. Stimulate gallbladder secretion.
Gastric inhibitory peptide (GIP)	Duodenum and jejunum.	Intestinal cell in response to fat, glucose or acid.	Stomach, gallbladder.	Insulin secretion. Inhibit gastric secretion and motility.
Vasoactive Intestinal peptides (VIP)	Enteric nerves of intestine.	Intestinal cell in response to glucose.	Intestine	Increase water and electrolyte secretion. Relaxes smooth muscles from gut.
Motilin	Throughout the gut.	Fat in duodenum	Intestine and stomach.	Increase small bowel motility and gastric emptying.
Somatostatin	Stomach, small intestine and pancreas.	In response of acid.	stomach	Decrease the stomach acid.

 # Enzymes of GIT

1. Alpha amylase
2. Lingual lipase
3. Pepsin
4. Gastric lipase
5. Trypsin
6. Chymotrypsin
7. Ribonuclease
8. Maltase
9. Pancreatic lipase
10. Dipeptidase

 # Saliva

Saliva is a viscous, colorless, oplacent fluid which is secreted by the three pairs of salivary glands.

Composition:

a. Water: 99.5%
b. Solid: 0.5%
    i. Organic: 0.3%
        i. Enzymes: salivary alpha amylase, Lingual lipase, Lysozymes
        ii. Other organic: Mucin, urea, cholesterol, amino acids
        iii. Blood group substances: Antigen of ABO blood groups.
    ii. Inorganic (0.2%): NaCl, KCl, acid and alkaline sodium phosphate, calcium phosphate, $CaCO_3$.
    iii. Cellular constitutions: yeast cell, bacteria, protozoa.
    iv. Gases: O_2, N_2, CO_2.

Functions:

i. Mechanical functions:
    a. It keeps the mouth moist and helps in speech.
    b. It facilitates swallowing.
    c. It helps the food to prepare for digestion
    d. It dilutes hot and irritated food stuff.
ii. By dissolving food stuff saliva helps in taking the sensation of taste.
iii. Digestive functions: It breaks down starch into maltose by the presence of ptyline enzyme.
iv. Excretory functions: It excretes urea, heavy metal, certain drugs and antibiotics.
v. Helps in water balance: Reduction of saliva on mouth, stimulates the desire of thirst.
vi. Buffering functions: Due to the presence of bicarbonate and phosphate ion, it acts as a buffering agent.
vii. Bacteriolytic functions: Enzymes present in saliva act as a bacteriolytic agents.

 # Gastric juice

It is a digestive fluid, formed in the stomach. Composed of hydrochloric acid (HCl) .05–0.1 M, potassium chloride (KCl) and sodium chloride (NaCl). Gastric acid is produced by gastric parietal cells in the lining of the stomach. These cells also produce mucus, which forms a viscous physical barrier to prevent gastric acid from damaging the stomach.

Composition:

a. Water: 99.5%
b. Solid: 0.5%
    i. Organic
        i. Enzymes: Pepsin, Gastric lipase.
        ii. Mucin
        iii. Intrinsic factor
        iv. Blood group substances: Antigen of ABO blood groups.
    ii. Inorganic: Na^+, K^+, Mg^{++}, H^+, Cl^-, HCl, $CaCl_2$.

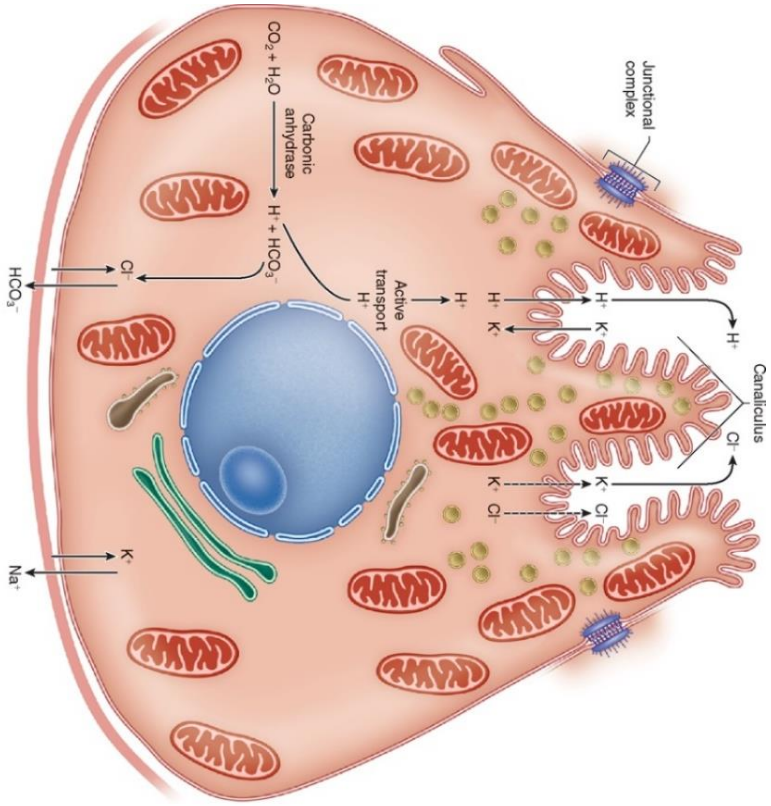
Functions:

i. Digestive functions
    a. Pepsinogen, with gastric HCl digest the protein.
    b. Gastric lipase digests the fat.
    c. Renin helps to digest milk into insoluble calcium caseinate.
ii. Toxins, heavy metals and certain alkaloids are excreted through gastric juice.
iii. Functions of HCl
    a. It converts inactive pepsinogen into active pepsin.
    b. It acts as antiseptic agents against bacteria.
    c. It causes hydrolysis of all food stuff.
    d. It keeps iron in ferrous state for absorption.
    e. It gives optimum environment for pepsin, renin and lipase enzymes.
iv. The intrinsic factors of gastric juice help in absorption of Vit-B12, that is essential for maturation of RBC.
v. Lubricating functions: Mucin of gastric juice lubricates any irritant in stomach.
vi. Protective functions: Mucin is also responsible for protecting gastric mucosa.
vii. Acid base regulation: It is responsible for the alkaline tide of blood.

 # Mechanism of secretion of gastric HCl.

The stomach membrane contains parietal cells or oxyntic cells. These cells developed a system of intracellular canaliculi. HCl is formed at the membranes of these canaliculi. Mechanism involved:

1. When stimulated, Cl- are actively transported from the cytoplasm of parietal cell into the lumen of the canaliculus and Na+ are actively transported out of the lumen.
2. These create passive diffusion of K+ from cytoplasm of parietal cell into the lumen.
3. Water becomes dissociated into H+ and OH- at cytoplasm.
4. The H+ is then actively transported into canaliculus in exchange of K+ by H+/K+ ATPase (Proton pump).
5. In addition, diffused out Na+ are actively reabsorbed into cytoplasm by Na pump.
6. Thus, H+ replaces the concentration of K+ and Na+ at the canaliculus.
7. This gives a strong solution of HCl at lumen of canaliculus.
8. Water is also passes into canaliculus by osmosis process.
9. Meanwhile, CO_2, formed during metabolism in cell or entering cell from blood, combines with OH- (under the influence of carbonic anhydrase) and form bicarbonate ion.
10. This HCO_3^- is then diffuses out from the cytoplasm into extracellular fluid in exchange of Cl- ion.



 # Pancreatic juice

Composition:

a. Water: 98.5%
b. Solid: 1.5%
    i. Organic
        i. Enzymes
            1. Carbohydrate splitting enzymes: Pancreatic alpha amylase
            2. Protein splitting enzymes: Trypsin, chymotrypsin, elastase, RNAase, DNAase.
            3. Fat splitting enzymes: Pancreatic lipase, colipase, Phospholipase A2.
    ii. Inorganic: Na+, K+, Mg++, Ca++, H+, Cl-, HCO3-, SO4-.

Functions:

a. Digestive action
    1. Proteolytic activity: Trypsin, chymotrypsin like proteolytic enzymes split down the protein into small amino acids.
    2. Amylolytic activity: Pancreatic amylase convert both boiled and unboiled starch, glucagon into disaccharides.
    3. Lipolytic activity: Pancreatic lipase hydrolyses neutral fat, Cholesterol esterase hydrolyses cholesterol ester and phospholipase A2 split down the phospholipid.
b. Neutralizing action
    Pancreatic juice containing HCO3-, neutralize the acid chyme into the duodenum.

 # Bile

Bile is made up of the bile salts, bile pigments and other substances dissolved in an alkaline electrolyte solution. It is about to 500 ml secreted by liver every day. Bilirubin and biliverdin are the bile pigments and their glucuronides are responsible for the yellow color of bile. Bile acid are the derivative end product of cholesterol. The four bile acids are: taurocholic acid and glycocholic acid (derivatives of cholic acid) and taurochenodeoxycholic acid and glycochenodeoxycholic acid (derivatives of chenodeoxycholic acid).

Composition:

1. Water 97.5g/dl
2. Bile salts 1.1g/dl
3. Bilirubin 0.04g/dl
4. Cholesterol 0.1g/dl
5. Fatty acid 0.12g/dl
6. Lecithin 0.04g/dl
7. Na+ 145mEq/L
8. K+ 5mEq/L
9. Ca++ 5mEq/L
10. Cl- 100mEq/L
11. HCO3- 28mEq/L

Functions:

1. It is a means for the body to excrete waste products from the blood.
2. Emulsify fats and break it down into small particles. This is a detergent-like action of bile.
3. Helps the body absorb the breakdown products of fat in the gut.
4. Bile salts bind with lipids to form micelles. This is then absorbed through the intestinal mucosa.
5. The other important function of bile is that it contains waste products from hemoglobin break down. This is known as bilirubin.
6. Bile also carries excess cholesterol out of the body and 'dumps' it into the gastrointestinal tract where it can be passed out with other waste matter.

 # Carbohydrate

a. Digestion

Three major sources of carbohydrates are existing in usual diet: Sucrose, lactose and starches. Besides these amylose, glycogen and cellulose are also present. Their digestion in different part of GIT occurs as below:

a. In the mouth:
   i. Saliva contain an alpha amylase: ptyalin secreted by parotid glands.
   ii. It converts starch into disaccharide maltose and other small polymer (3-9) of glucose.

Starch $\xrightarrow{\text{ptyalin}}$ Maltose and other glucose polymers.

b. In the stomach
   i. Here the pH of the secretion is falls and activity of salivary amylase enzymes is blocked.

ii. However, the starch digestion is still continuing for around 1 hr before the food become mixed with stomach secretion.
iii. In stomach, 30-40% starches hydrolyzed by maltase enzyme.

c. In the small intestine
   i. At this stage, almost all starches are converted into maltose and small glucose polymers.
   ii. In duodenum, they are mixed with pancreatic alpha amylase, which digest the rest of the carbohydrates.

d. Membrane digestion

Here, enzymes hydrolyze all the disaccharides into glucose and other basic elements.

Maltose ⟶ Glucose+ Glucose

Lactose ⟶ Glucose+ Galactose

Sucrose ⟶ Glucose+ Fructose

b. Absorption

a. Absorption of Glucose and galactose

Glucose and galactose are absorbed at intestine with the help of Na-co transport carrier. They are found at the brush border of intestinal epithelial cells. Na+ ion is attached with the receptor site of transporter and along with glucose they are transported out of the intestine. From there, glucose is transported into blood stream by facilitated diffusion.

b. Absorption of fructose

Fructose does not couple with the Na transport. On entering into cell, it is phosphorylated and converted into glucose. Finally, it is absorbed by the same Na transporter system.

 # Protein

Digestion

The dietary proteins are found of long chains of amino acids bound together by peptide linkages. The digestion of protein at different part of GIT is described below:

i. In the mouth

No protein is digested in mouth.

ii. In the stomach

In the presence of pepsin and gastric HCl only 10-20% proteins are digested into proteoses, peptones and few polypeptides.

iii. In the duodenum

Here, through the pancreatic juice, trypsin and chymotrypsin digest broken and unbroken proteins into amino acid polypeptides. Finally, the aminopolypeptidase and several dipeptidase digest the rest of the amino acid polypeptide into small amino acids.

Fat

Digestion

Triglycerides are the most abundant fats of the diet. Besides this, phospholipids, cholesterol and cholesterol esters are also present.

1. In the mouth: No digestion of fat occurs in mouth.
2. In the stomach: With the help of gastric lipase (fat splitting enzyme), fat may be digested at stomach but at the condition of basic media. Besides this, fat may be also digested by lingual lipase at stomach but with less than 10% in amount.
3. In the intestine: The main digestion of fat occurs in the duodenum and small intestine by pancreatic lipase with the help of bile salts. Bile salts at first emulsified the fat globules and broken them into simple form and increases the surface area of fat globules. Then enzyme lipase act on the surface of fat globules and splits into free fatty acids and monoglycerides.