

1 BASIC REQUIREMENTS OF LIVING ORGANISMS

Digestion: The process of conversion of complex food substances to simple absorbable forms by mechanical and biochemical methods.

1. Food: Provide energy and organic material for growth and repair of tissues.

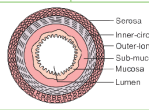
- Major components**
- Carbohydrates, Proteins and Fats
- Minor components**
- Vitamins, minerals

2. Water:

- Important for metabolic processes.
- Prevent dehydration of the body.

3 HISTOLOGY OF GUT

Layers	Typical
Serosa	Outermost layer, made up to thin mesothelium (epithelium of visceral organs) with some connective tissues.
Muscularis	Inner - Circular muscles Outer - Longitudinal muscles
Sub-mucosa	Loose connective tissue with nerve, blood and lymph vessels.
Mucosa	Innermost layer lining the lumen

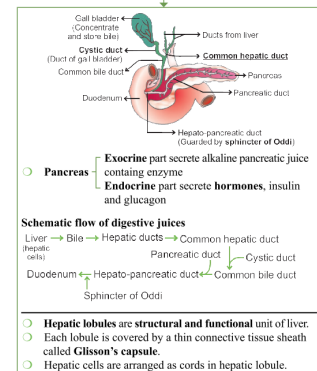


Modification

- Oblique muscle layer is present
- Irregular folds of mucosa called **Rugae**
- Finger like foldings of mucosa called **villi**
- Cells lining villi produce microscopic projections called **microvilli** giving **brush border** appearance

- Villi, microvilli, rugae** - Increase surface area for absorption
- Villi are supplied with blood capillaries and **lacteals** (lymph vessels)
- Gastric glands, goblet cells and crypts of Lieberkuhn Present in mucosa
- Brunner's gland** - Present in sub-mucosa
- The muscular activities of different parts of alimentary canal can be moderated by neural mechanisms, both local and through CNS.

6 DUCTS ASSOCIATED WITH LIVER AND PANCREAS



Schematic flow of digestive juices

Liver → Bile → Hepatic ducts → Common hepatic duct (hepatic ducts)

Pancreas → Pancreatic duct → Common bile duct

Duodenum → Hepato-pancreatic duct → Common bile duct

Sphincter of Oddi

Hepatic lobules are structural and functional unit of liver.

- Each lobule is covered by a thin connective tissue sheath called **Glisson's capsule**.
- Hepatic cells are arranged as cords in hepatic lobule.

2 HUMAN DIGESTIVE SYSTEM

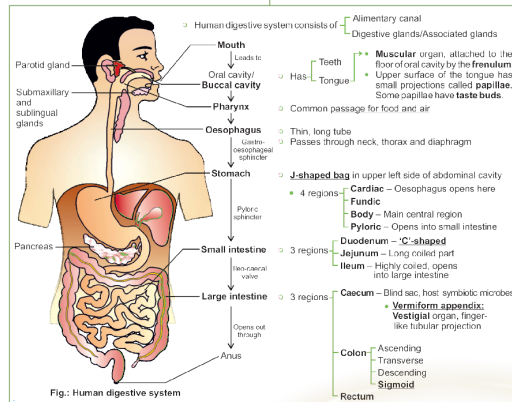
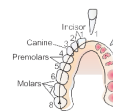


Fig.: Human digestive system

- Epiglottis** prevents the entry of food into the **glottis** (opening of trachea/wind pipe) during swallowing.
- Sphincters** are muscular structures that regulate the flow of partially digested food in the alimentary canal.

4 TEETH

- Dentition:**
 - Thecodont** - Each tooth is embedded in socket of jaw bone
 - Heterodont** - Different types: Incisor (I), Canine (C), Premolar (PM), Molar (M)
 - Diphyodont** - 2 sets of teeth during life
 - A set of **temporary/milk/deciduous** teeth which are replaced by a set of **permanent/adult teeth**
- Dental formula** = $\frac{\text{Teeth in each half of upper jaw}}{\text{Teeth in each half of lower jaw}} \times 2 = 32$



- Enamel** - Hard chewing surface, helps in mastication of food.

5 DIGESTIVE GLANDS

Glands	Location	pH	Secretion	Contents	Function
Salivary Glands	Outside buccal cavity	6.8	Saliva/salivary juice into oral cavity	Mucus Electrolytes - Na ⁺ , K ⁺ , Cl ⁻ , HCO ₃ ⁻ Lysozymes Salivary amylase	Lubrication and adhering of masticated food into bolus Antibacterial agent, prevent infections Carbohydrate spitting enzyme
Gastric glands	Mucosa of stomach	1.8	Gastric juice in stomach	Mucus Pepsinogen (Active form) Prorenin (Active form) Lipase HCl Intrinsic factor	Lubrication and protection of mucosal epithelium from excretion by HCl Protein digestion Digestion of milk proteins Fat digestion Acidic pH, activation of gastric proenzymes Absorption of vitamin B ₁₂
Liver (Largest gland) 1.2-1.5kg	Right side of abdomen below diaphragm	>7	Bile released into duodenum	Bile salt Bile pigments Cholesterol Phospholipids	Emulsification of fats Bilirubin and biliverdin Bile activates lipases
Pancreas (Heterocrine glands)	Between limbs of duodenum	>7	Pancreatic juice released into duodenum	Trypsinogen Chymotrypsinogen Procarboxypeptidase Amylase Lipase Nucleases	Active form Protein digestion Carbohydrate digestion Fat digestion Nucleic acid digestion
Intestinal glands	Sub mucosa of duodenum	7.8	Intestinal juice/Succus entericus	Mucus Brush border enzymes Disaccharidases Dipeptidases Lipases Nucleosidases Enterokinase	Lubricate and protect intestinal mucosa from acid and provide alkaline medium for enzymatic activities Carbohydrate digestion Protein digestion Fat digestion Nucleosides digestion Activates trypsinogen into trypsin which in turn activates other enzymes in the pancreatic juice

- Control of activities of gastro intestinal tract**
 - Saliva secretion - Stimulated by sight, smell and or presence of food in oral cavity
 - Gastric and intestinal secretion - **Local hormones** produced by gastric and intestinal mucosa
 - Neural mechanisms - local and via CNS

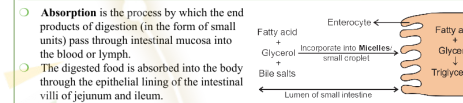
7 DIGESTION OF FOOD

Juice	Site of Digestion	Carbohydrates	Proteins	Fats	Nucleic Acids
Saliva	Buccal cavity	(30%) Starch → Salivary amylase → Maltose	—	—	—
Gastric juice	Stomach (stores food for 4-5 hrs.)	—	Pepsinogen → HCl → Pepsin Proteins → Peptones (peptides) + proteoses Milk protein → Rennin → Peptones + proteoses	Lipase minor role Emulsification of fats i.e. Fats → micelles Activates lipases	—
Bile	Intestine	—	—	Fats Emulsification of fats i.e. Fats → micelles Activates lipases	—
Pancreatic juice	Intestine	Polysaccharides (Starch) → Pancreatic amylase → Disaccharides	Trypsinogen → Enterokinase → Trypsin Chymotrypsinogen → Chymotrypsin Procarboxypeptidase → Carboxypeptidase Proteins → Peptones Proteoses → Dipeptides	Lipases → Diglycerides Monoglycerides	Nucleic acids Nucleosides
Succus entericus	Intestine	Maltose → Maltase → 2 Glucose Lactose → Lactase → Glucose + Galactose Sucrose → Sucrase → Glucose + Fructose	Dipeptides → Dipeptidases → Amino acids	Monoglycerides → Lipases → Fatty acids Diglycerides → Glycerol	Nucleosides → Nucleosidases → Nucleobases Nucleobases → Nucleobases Sugars + Nitrogen bases

Food in stomach mixes with acidic gastric juice by churning movements and is called **chyme**. Breakdown of biomacromolecules into its simplest form occurs in the duodenum.

8 ABSORPTION OF DIGESTED PRODUCTS

Method	Mechanism	Examples	Summary of different substances absorbed in different parts of alimentary canal
Passive: (Along concentration gradient)	Simple diffusion Facilitated transport Osmosis	Glucose, amino acids, Cl ⁻ ions Glucose, amino acids Water	Mouth and lower side of tongue Certain drugs
Active: (Against concentration gradient) by utilising energy	—	Glucose, amino acids, Na ⁺ ions	Stomach Simple sugars, alcohol, water



Absorption is the process by which the end products of digestion (in the form of small units) pass through intestinal mucosa into the blood or lymph.

The digested food is absorbed into the body through the epithelial lining of the intestinal villi of jejunum and ileum.

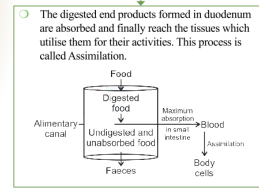
12 ENERGY VALUES

Gross Calorific Value	Physiological Value
Amount of heat liberated from complete combustion of 1 gm of food in bomb calorimeter (metal chamber filled with O ₂)	Actual amount of energy released on combustion of 1g of food in body
Carbohydrates - 4.1 Kcal/g Proteins - 5.65 Kcal/g Fats - 9.45 Kcal/g	4.0 Kcal/g 4.0 Kcal/g 9.0 Kcal/g

1 kilo calorie is the amount of energy required to raise the temperature of 1 kg of water by 1°C

Energy requirements of animals, and the energy content of food expressed in terms of heat energy, (calorie (cal) or joule (J)). Since this value is tiny amount of energy, physiologists commonly use kilocalorie (kcal) or kilo joule (kJ).

9 ASSIMILATION



The digested end products formed in duodenum are absorbed and finally reach the tissues which utilise them for their activities. This process is called **Assimilation**.

10 ROLE OF LARGE INTESTINE

- No significant digestive activity occurs here.
- Absorption** of water, minerals, certain drugs
- Secretion** of mucus, to adhere waste and for lubrication
- Solid faeces initiate neural reflex, causing urge for its removal
- Undigested, unabsorbed substances enter caecum through **ileo-caecal valve** and the wastes solidified into **coherent faeces** which is temporarily stored in rectum till defaecation.
- Egestion of faeces to outside through anal opening is called **defaecation**. It's a **voluntary process** and is carried by a **mass peristaltic movement**.

11 PROTEIN ENERGY MALNUTRITION (PEM)

Parameters	Kwashiorkor	Marasmus
Dietary deficiency	Proteins	Proteins and calories
Age	Child more than 1 year	Infants less than 1 year
Reason	Replacement of mother's milk by high calorie, low protein diet	Replacement of mother's milk too early by other foods or mother has second pregnancy when older infant is too young
Characteristics	Extensive oedema i.e. swelling of body parts Wasting of muscles, thinning of limbs	Extensive emaciation of body, Skin is dry, thin and wrinkled, thinning of limbs

In PEM - Growth rate and body weight decline
Growth and development of brain and mental faculties are impaired

13 DISORDERS OF DIGESTIVE SYSTEM

Disease/Problem	Cause and Symptoms
Inflammation of intestinal tract	Most commonly due to bacterial and viral infections. Can be due to parasites like roundworm, tapeworm, threadworm, hookworm, pin worm etc.
Jaundice	Liver affected Skin and eyes turn yellow due to deposit of bile pigments
Vomiting	Ejection of stomach content, feeling of nausea precedes vomiting. It's a reflex action controlled by vomit centre, medulla
Diarrhoea	Abnormal Frequency of bowel movement and increased liquidity of faecal discharge, reduces food absorption
Constipation	Faeces are retained within the colon as bowel movement occurs irregularly.
Indigestion	Food not digested properly, feeling of fullness Can be due to inadequate enzyme secretion, anxiety, food poisoning, over eating and spicy food.