

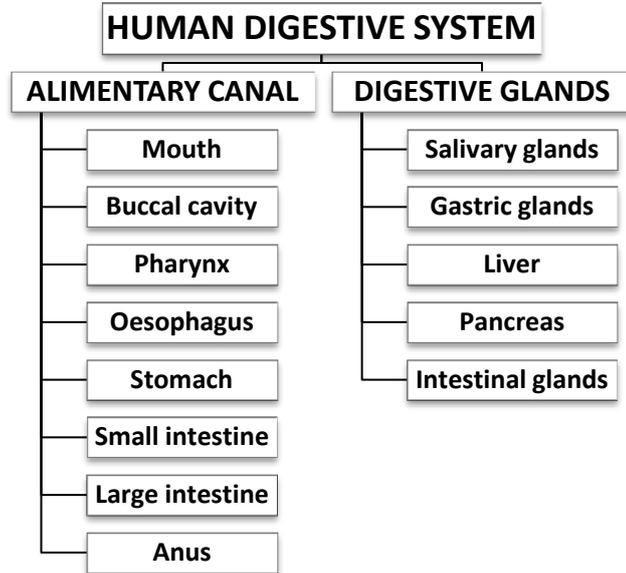
DIGESTION AND ABSORPTION

Nutrition is the getting and utilization of energy rich nutrients (food) by an organism.

Food consists of **carbohydrates, proteins, fats (lipids), vitamins, minerals and water.**

Food provides *energy for life activities, materials for growth, maintains body temperature* and *repairs tissues.*

The water plays an important role in metabolic processes and prevents dehydration of the body.



- 5 Processes of Digestive system**
- Ingestion
 - Digestion
 - Absorption
 - Assimilation
 - Egestion

I. ALIMENTARY CANAL (GUT)

It includes the following parts:

- **Mouth:** To receive the food (**ingestion**).
- **Buccal cavity (oral or mouth cavity):**
 - Consists of *palate (roof), teeth & muscular tongue.*
 - Palate has anterior *hard palate* and posterior *soft palate.*
 - Tongue is a muscular organ attached to the floor of oral cavity by the **frenulum**. Tongue has small projections called **papillae**. Some papillae bear **taste buds**.
 - At the back, on either side of tongue *tonsils* present.
- **Pharynx:**
 - Common passage for digestive and respiratory systems.
 - When food materials pass through the pharynx, the cartilaginous *epiglottis* closes the *glottis* (opening of larynx) and prevents the entry of food into trachea.
- **Oesophagus:**
 - Muscular tube (30 cm) that conducts food into stomach.
 - At the posterior region of oesophagus, *gastro-oesophageal sphincter* (a circular muscle) is present. It controls the opening of oesophagus into stomach.
- **Stomach:**
 - 'J' shaped structure for storage and digestion of food.
 - **3 parts:** upper (anterior) **fundus**, middle **cardiac stomach** & lower (posterior) **pyloric stomach (antrum)**.
 - Pyloric stomach leads to small intestine by an opening called **Pylorus**, guarded by *pyloric sphincter muscle*.
 - Inner wall of stomach bears **rugae** (longitudinal folds).
- **Small intestine:**
 - Longest part of gut (7 m long and 2.5 cm diameter).
 - Consists 3 parts, namely **duodenum** (C shaped first part), **Jejunum** (middle part) and **Ileum** (terminal part).
 - Finger-like **villi** are seen at the mucosa. Each villus has a brush-bordered columnar epithelial layer provided

with *microvilli*. Villus consists of a capillary network and a small lymph vessel (**lacteal**).

- **Large intestine:**
 - 1.5 m long. Consists of **caecum, colon** and **rectum**.
 - Caecum is well-developed in herbivores but in man it is very small. Arising from the caecum is a finger-like vestigial organ, the *vermiform appendix*.
 - The colon consists of *ascending colon, transverse colon* and *descending colon*.
 - Pelvic colon leads to **rectum** that opens out by **anus**. Anus is guarded by *sphincterni* (circular voluntary muscles).
 - In some herbivores, the large intestine consists of several cellulose digesting bacteria.

Teeth

Nature & mode of arrangement of teeth is called **dentition**.

Human dentition is

- **Thecodont:** It means teeth are placed in the jaw sockets.
- **Heterodont:** It means different kinds of teeth are present. They are *incisors (I)* for cutting, *canines (C)* for tearing, *premolars (PM)* and *molars (M)* for mastication. Premolars & molars are collectively called as *cheek teeth* which have **cusps**.
- **Diphyodont:** It means teeth appear twice in the lifetime. They are *milk (deciduous) teeth* and *permanent teeth*. Milk teeth (**20** in number) are erupted at **6-7 months** of birth. They are replaced by permanent teeth (**32** in number) at the age of **6-7**. The last 4 molars (*wisdom teeth*) appear only at the age of 18.

The hard chewing surface of teeth is made up of **enamel**.

Dental formula: It explains the kinds and number of teeth.

Human dental formula (of permanent teeth):

$$I^{2/2} C^{1/1} PM^{2/2} M^{3/3} \times 2 = 32 \left(\frac{2123}{2123} \right)$$

Dental formula of milk dentition:

$$I^{2/2} C^{1/1} PM^{0/0} M^{2/2} \times 2 = 20 \left(\frac{2102}{2102} \right)$$

Histology of human gut (Transverse section)

Human gut is formed of 4 layers,

1. **Mucosa:** Innermost, moist epithelial layer. Contains secretory and absorptive cells.
2. **Submucosa:** Soft connective tissue layer just outside the mucosa. Nerves and blood vessels are present.
3. **Muscularis externa:** Outer to submucosa. Smooth muscle layer (inner circular & outer longitudinal muscles).
4. **Serosa:** Outermost fibrous layer.

II. DIGESTIVE (ASSOCIATED) GLANDS

They secrete **digestive juices**.

They include **salivary glands, gastric glands, intestinal glands, pancreas & liver**.

a. Salivary glands

- 3 pairs. They are
 - o **Parotids (2):** largest salivary gland. Seen in cheeks.
 - o **Submaxillary/submandibular (2):** Seen in lower jaw.
 - o **Sublingual (2):** Below the tongue.
- Salivary glands secrete **saliva**. It contains 99.5% water, **mucin (mucus)**, enzymes like **salivary amylase (Ptyalin)** and **Lysozyme** and electrolytes (Na^+ , K^+ , Cl^- , HCO_3^- etc).

b. Gastric glands

Tubular glands found on the inner wall. They consists of

- a. **Mucus neck cells:** Secrete **mucus**. Mucus and **bicarbonates** protect the stomach wall (mucosal epithelium) from HCl and prevents **autodigestion**.
- b. **Chief (zymogen or peptic) cells:** Secrete proenzymes like **pepsinogen & prorennin** and some **lipase**.
- c. **Oxyntic (parietal) cells:** Secrete **HCl & Castle's intrinsic factor** (for absorption of vitamin B₁₂).

Gastric glands secrete acidic (pH 1.8-2.0) **gastric juice**.

c. Liver

- Largest gland (1.2 - 1.5 kg). Reddish brown.
- Situated in abdominal cavity, just below the diaphragm.
- Bilobed (large right lobe & small left lobe). Each lobe is formed of **hepatic lobules** (structural & functional units).
- A lobule has many **hepatic cells** arranged as cords around a **central vein**. They secrete alkaline **bile juice**.
- Liver lobule is covered by **Glisson's capsule**.

d. Pancreas

- Bile is transported from liver to duodenum as follows:
Bile → Hepatic duct → Gall bladder → Cystic duct → Common bile duct → Common hepato-pancreatic duct → Duodenum.
- **Hepato-pancreatic duct** is guarded by **sphincter of Oddi**.
- Bile has **no enzymes** but contains **bile pigments (bilirubin & biliverdin)**, **bile salts**, **cholesterol** and **phospholipids**.
- Second largest gland. Seen near **duodenal loop**.
- It is a cream-coloured **heterocrine gland**, i.e. it has both **exocrine** and **endocrine** parts.
- The exocrine part has a **pancreatic duct** that opens into duodenum along with bile duct (**hepato-pancreatic duct**).
- Exocrine part secretes alkaline **pancreatic juice**. It contains inactive protease enzymes (**trypsinogen, chymotrypsinogen & procarboxypeptidases**), **amylases, lipases & nucleases**.

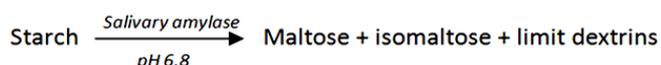
e. Intestinal glands

- Simple tubular glands. 2 types
 1. **Crypts of Lieberkuhn:** consists of mucus-secreting **Goblet cells** and enzyme-secreting **Paneth cells**.
 2. **Brunner (duodenal) glands:** confined to submucosa of duodenum. Secrete **mucus** only.
- Intestinal glands secrete alkaline **intestinal juice (succus entericus)**. It contains enzymes such as **maltase, lactase, sucrase, dipeptidase, lipases, nucleotidases, nucleosidases etc**.
- The **bicarbonate** and **mucus** provide alkaline medium and protect intestinal mucosa.

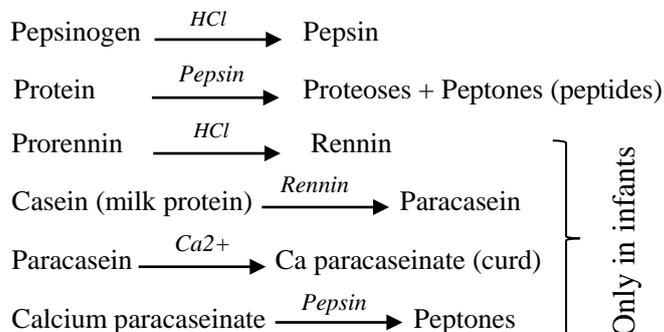
DIGESTION OF FOOD

Digestion is the conversion of complex insoluble food materials into simple and absorbable form. It includes mechanical processes such as **mastication** (chewing), **deglutition** (swallowing) & **peristalsis** (wave-like movement of food bolus through the gut by muscular contraction).

- **Digestion in buccal cavity:** Only starch digestion. Ptyalin converts starch (polysaccharide) into disaccharides. About 30% of starch is digested by ptyalin.



- **Digestion in stomach:** Stomach stores food for 4-5 hrs. It is mixed with gastric juice by the churning movements and is converted into acidic pasty form (**chyme**).

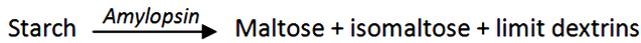


The **gastric lipase** hydrolyses a small amount of lipids.

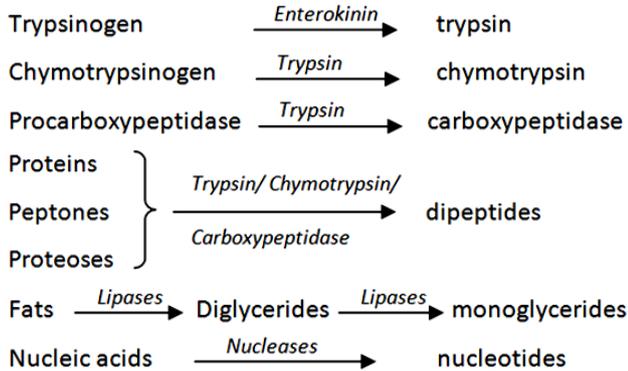
- **Digestion in small intestine:** Chyme is mixed with **succus entericus, pancreatic juice & bile juice**. Pancreatic juice & bile reach the duodenum through **hepato-pancreatic duct**.

a) **Action of bile:** Bile helps in digestion by *emulsification* (conversion of *fat* into *micelles* or tiny droplets). It provides large surface area for the action of lipase on fat. Bile also activates lipase.

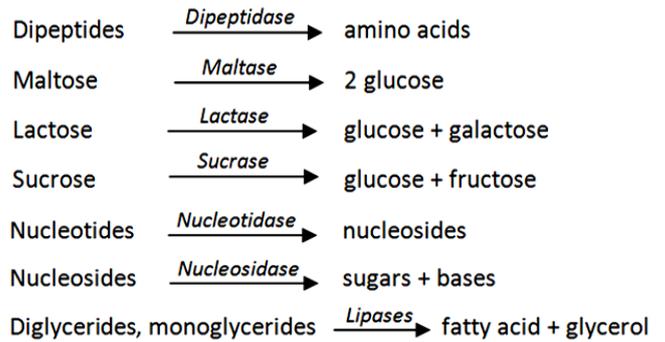
b) **Action of pancreatic juice:** *Amylopsin (Pancreatic amylase)* hydrolyses remaining starch into *disaccharides*.



Enterokinase (Enterokinin) secreted by intestinal mucosa activates *trypsinogen* to active *trypsin*. Trypsin activates *chymotrypsinogen* & *procarboxypeptidase*.



c) **Action of intestinal juice:** The enzymes of the intestinal juice act on the end products of the above reactions.



Fully digested semi fluid and alkaline food formed in small intestine is called *chyle*.

The digestive activities like gastric and intestinal secretions are controlled by the *neural* and *hormonal mechanisms*. The *sight, smell or the presence of food* in the buccal cavity stimulate the salivary secretions. Gastric & intestinal mucosa secretes **digestive hormones**. They control secretion of digestive juices.

CALORIFIC VALUE OF PROTEIN, CARBOHYDRATE & FAT (Not for evaluation)

- Heat is the ultimate source of all forms of energies. So energy requirements of animals and energy content of food are expressed as measure of **heat energy**.
- Its unit is **calorie (cal) or joule (J)**.
- **One calorie** is the amount of heat energy required to raise the temperature of **1g of water by 1°C**.
- This value is tiny amount of energy. So physiologists use **kilocalorie (kcal or Cal) or kilo joule (kJl or Joule)**.
- **One kilo calorie** is the amount of energy required to raise the temperature of **1kg of water by 1°C**.

- Amount of heat liberated from complete combustion of 1g food in a **bomb calorimeter** (a closed metal chamber filled with O₂) is its **gross calorific (gross energy) value**.
- Actual amount of energy combustion of 1g of food is the **physiologic value of food**.

| | Gross calorific value | Physiologic value |
|---------------|-----------------------|-------------------|
| Carbohydrates | 4.1 kcal/g | 4.0 kcal/g |
| Proteins | 5.65 kcal/g | 4.0 kcal/g |
| Fats | 9.45 kcal/g | 9.0 kcal/g |

ABSORPTION OF DIGESTED PRODUCTS

Absorption is the transfer of end products of digestion through the intestinal mucosa into blood & lymph.

It is 2 types- passive and active.

a) **Passive absorption (Passive transport):** Absorption of nutrients from higher concentrated region to lower concentrated region without the expenditure of energy.

It includes **osmosis** (absorption of water) and **diffusion** (absorption of solute molecules).

Diffusion is 2 types:

i. **Simple diffusion:** In this, molecules alone can be diffused. E.g. Small amounts of monosaccharides like *glucose, amino acids, vitamins*, electrolytes like *chloride ions* etc.

ii. **Facilitated diffusion:** Diffusion with the help of carrier proteins. E.g. *glucose, amino acids* etc.

b) **Active absorption (Active transport):** Absorption of nutrients from lower concentrated region to higher concentrated region (i.e. against concentration gradient).

It needs energy. E.g. absorption of *amino acids, monosaccharides* like *glucose*, electrolytes like Na⁺ etc.

Absorption of lipids

- *Monoglycerides, diglycerides* and *fatty acids* cannot be absorbed directly as they are insoluble in water.
- *Bile salts* and *phospholipids* convert them into small spherical water soluble droplets called *micelles*.
- They are reformed into small protein coated fat globules (*chylomicrons*). They are transported into *lacteals* in the villi. From the lymph, the chylomicrons enter the blood.

Absorption in different parts of alimentary canal

- **Mouth:** Certain drugs.
- **Stomach:** Water, simple sugars, some drugs & alcohol.
- **Small intestine:** Almost all nutrients including minerals, vitamins etc.
Ileum is the *chief area of absorption* due to the presence of villi (it increases surface area of absorption), its great length and coiled nature.
- **Large intestine:** Water, some minerals & drugs.

The absorbed materials are incorporated into tissues for their activities. It is called **assimilation**.

The undigested substances like plant fibres, dead bacteria etc. form **faeces**.

It enters into caecum through the **ileo-caecal valve**, which prevents back flow of faeces.

Faeces are temporarily stored in **rectum** and are eliminated through anus. It is called **egestion (defaecation)**.

DISORDERS OF DIGESTIVE SYSTEM

- 1. Jaundice:** Here, the skin and eye turns yellow due to the deposition of bile pigments. It indicates liver damage.
- 2. Vomiting:** Ejection of stomach content through mouth. It is controlled by medulla oblongata.
- 3. Diarrhoea:** Frequent elimination of watery faeces. It reduces the absorption of food.
- 4. Constipation:** Infrequent elimination of dry stool. It is due to decreased peristalsis in colon.
- 5. Indigestion:** Condition leading to feeling of fullness due to improper digestion. It is due to anxiety, inadequate enzyme secretion, food poisoning, spicy food etc.
- 6. Protein-Energy malnutrition (PEM):** It is the dietary deficiencies of proteins & food calories. It is widespread in underdeveloped countries of South and South-East Asia, South America and West & Central Africa. PEM may affect during draught, famine and political turmoil. This happened in Bangladesh during the liberation war and in Ethiopia during severe drought in mid-eighties.

PEM causes **Marasmus & Kwashiorkor** in children.

- **Marasmus:** It is due to deficiency of both **proteins and calories**. It is found in infants less than a year in age.

Reason: Replacement of mother's milk by foods with poor proteins and caloric value. This often happens if mother has second pregnancy or child birth when the older infant is still too young.

Symptoms: Impaired growth and replacement of tissue proteins; extreme emaciation of the body, thin limbs, dry, thin and wrinkled skin, declined growth rate and body weight, impaired growth and development of brain and mental faculties.

- **Kwashiorkor:** It is due to **protein deficiency** only.

Reason: Replacement of mother's milk by a high calorie-low protein diet in a child more than one year in age.

Symptoms: Like marasmus, it shows wasting of muscles, thinning of limbs, failure of growth & brain development. Unlike marasmus, some fat is still under the skin; extensive oedema and swelling of body parts are seen.