Notes

# 13

# NUTRITION AND DIGESTION

Plants manufacture their own food by photosynthesis, but all animals including humans have to take in ready made food. Most part of such food consists of complex organic molecules (carbohydrates, proteins and fats) which have to be broken down into simpler forms before they can be absorbed into the body. Such breaking down of the food and subsequent absorption of food constituents occur inside the digestive tract (alimentary canal). The digestive tract together with the associated glands constitute the digestive system.

## OBJECTIVES

After studying this lesson, you will be able to :

- *define the term nutrition and give its types;*
- *draw a labelled diagram of the alimentary canal of cockroach and humans;*
- *describe the steps involved in the nutrition of humans viz., ingestion, digestion, absorption, assimilation and egestion;*
- *differentiate between intracellular and intercellular digestion;*
- *tabulate the organs of digestion, the enzymes they secrete, the substances acted upon by enzymes and the end products formed.*
- *explain the process of food absorption in various regions of digestive tract;*
- *explain briefly the role of hormones in digestion.*

## 13.1 NUTRITION AND DIGESTION

Our food contains a number of food constituents to meet the requirements of our body. These food constituents must be digested to be utilized by our body. The process by which organisms obtain and utilize food for their growth, development and maintenance is called **nutrition** and the chemicals present in the food are called **nutrients**. On the other hand, **digestion** is the breaking down of complex constituents of food by enzymes into simpler soluble forms that can be absorbed and utilised by the cells of the body.

In this lesson you will study the various types (modes) of nutrition, the types of digestion, the process of digestion of food, its absorption and assimilation in humans. The nutritional role of food constituents will be discussed in lesson 27.

**Types of nutrition**

There are mainly two types of nutrition **autotrophic nutrition** and **heterotrophic nutrition**.

**Nutrition**

| Autotrophic nutrition | Heterotrophic nutrition |
|---|---|
| (Auto : self, trophos : food) Green plants and certain bacteria manufacture their own food (organic substances) from inorganic substances ($CO_2$ and $H_2O$) using sunlight energy. | (Hetero : different, trophos : food) Food (organic substances) obtained by feeding on other organisms. |

| Holozoic | Saprotrophic | Parasitic |
|---|---|---|
| Organisms take food into the body, digest it and absorb the soluble products of digestion, eg., humans. | Ogranisms secrete digestive enzymes on to dead organic material and absorb the products of digestion, eg., certain bacteria and fungi. | Food derive from other living organisms by living on or inside their body eg., certain bacteria,roundworm, tapeworm, cuscuta, etc. |

**There are Five Major Steps in Animal Nutrition (Holozoic nutrition)**

The food we take contains highly complex substances like **protein, carbohydrates** and **fats**. These substances cannot be utilized as such by our body. These have to be broken down into simipler and smaller molecules before they can enter into the cells. Proteins must be broken down into amino acids, carbohydrates into glucose, fats into fatty acids and glycerol. Amino acids, glucose, fatty acids and glycerol are simpler substances, and can be utilised by our body. This breakdown of complex food constituents and their absorption is accomplished by the **digestive system**. The processes involved in nutrition are :

(i) **Ingestion :** Taking in of the food, its chewing or sucking and swallowing.

(ii) **Digestion :** Conversion of complex food into simpler absorbable form.

(iii) **Absorption :** Absorbing digested food from the gut to reach the body tissues.

(iv) **Assimilation :** Utilization of digested food nutrients by the body tissues.

(v) **Egestion :** Removal of undigested and unabsorbed food from the body.

## 13.2 TWO TYPES OF DIGESTION (Intracellular and extracellular)

generally two types of digestion are seen in heterotrophs :

(a) Intracellular (b) Extracellular

### 13.2.1 Intracellular Digestion (Intra = inside)

All the five steps of nutrition occur inside the cell itself, as in Amoeba, **Paramecium** and other unicellular organisms.

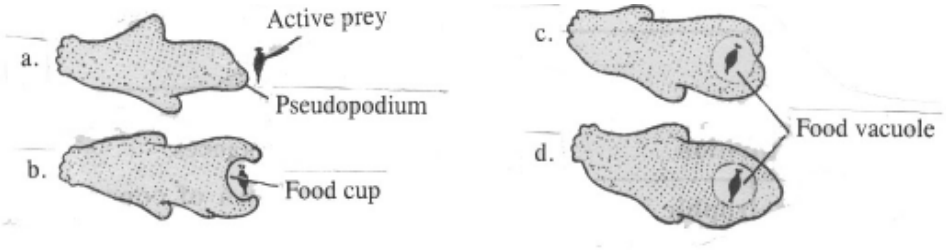


**Fig. 13.1** Intracellular digestion in Amoeba

- Food particles such as minute bacteria are enclosed (caught) by pseudopodia (pseudo = false, podia = feet) to form a *food vacuole (Ingestion).*
- Enzymes from cytoplasm are secreted into the food vacuole to break down complex food. *(Digestion)*
- Digested food is absorbed into the cytoplasm. *(Absorption)*
- The absorbed food is used up wherever required in the cell. *(Assimilation)*
- The undigested unabsorbed food is expelled out, when the food vacuole comes up on the cell surface and bursts open. *(Egestion)*

Food vacuoles are temporary structures and every time the Amoeba feeds, a new food vacuole is produced. All free-living *unicellular* microorganisms carry out intracellular digestion.

### 13.2.2 Extracellular digestion (extra = outside)

Digestion occurs outside the cell. All animals (excluding sponges) carry out extracellular digestion. They have either a cavity, a tube, or a food canal which receives the ingested food. Digestive enzymes are poured over the food, and the products of digestion are absorbed back into the cells. The undigested, unabsorbed food is thrown out of the digestive cavity. For example, Fig.13.2 shows digestive organs of cockroach where extracellular digestion occurs.

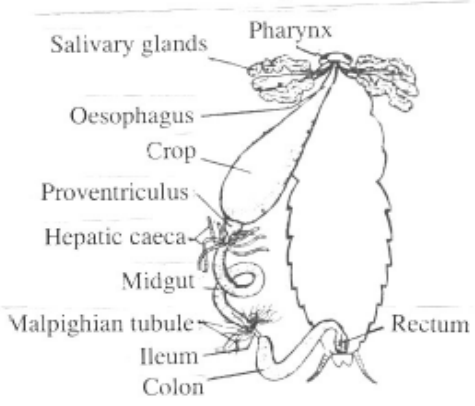


**Fig. 13.2** Digestive organs of a cockroach extracellular digestion occurs

### 13.2.3 Joint Intracellular and Extracellular digestion

In Hydra and other Cnidarians, the food (tiny prey) is caught by the tentacles and ingested through the mouth into the single large digestive cavity, the gastro-vascular cavity (Fig. 13.3). Enzymes are secreted from the cells bordering this cavity and poured on the food for extracellular digestion. Small particles of the partially digested food are engulfed into the vacuoles of the digestive cells for intracellular digestion. Any undigested and unabsorbed food is finally thrown out of the mouth.

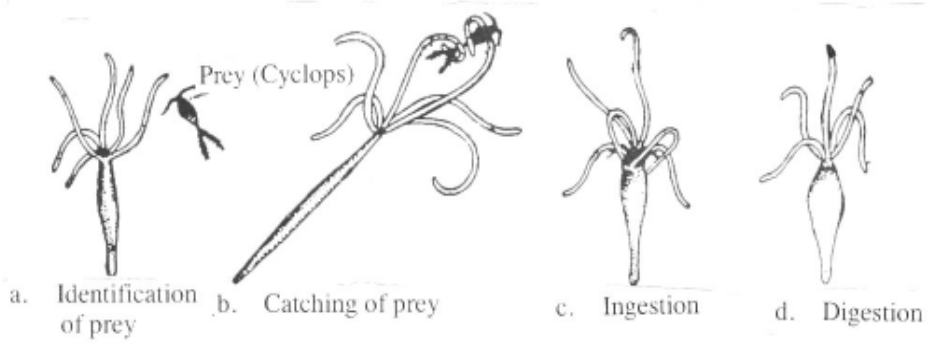


**Fig. 13.3** Hydra catching its prey

## INTEXT QUESTIONS 13.1

1. List the five major steps in animal nutrition
   (i) .....
   (ii) .....
   (iii) .....
   (iv) .....
2. What is intracellular digestion? Give example of an organism showing intracellular digestion.
   .....

## 13.5 THE HUMAN DIGESTIVE SYSTEM

The digestive system in human consists of an alimentary canal and associated digestive glands. The human alimentary canal (aliment: nourish) is a continuous muscular digestive tube that runs through the body. It digests the food, breaks it down into smaller substances, and absorbs the digested food. The alimentary canal has the following parts (Fig. 13.4).

1. **Mouth** and associated organs (teeth, tongue)
2. **Pharynx (or throat) :** A cavity at the back of the mouth. It is a common passage for the inhaled air and the swallowed food.
3. **Oesophagus :** A narrow tube arising from pharynx, continuing through the thorax and ending in the stomach.

4. **Stomach :** An elastic bag with highly muscular walls, located below the diaphragm.
5. **Small intestine :** A tube about 7 meters long and about 2.5 cm wide. Much coiled and folded, it is contained in the abdomen. Its three subdivisions are:
   (i) **Duodenum–**Short upper part, next to stomach
   (ii) **Jejunum–**Slightly longer part, about 2 meters long.
   (iii) **Ileum–**Longest, about 4 meters long, coiled and twisted.

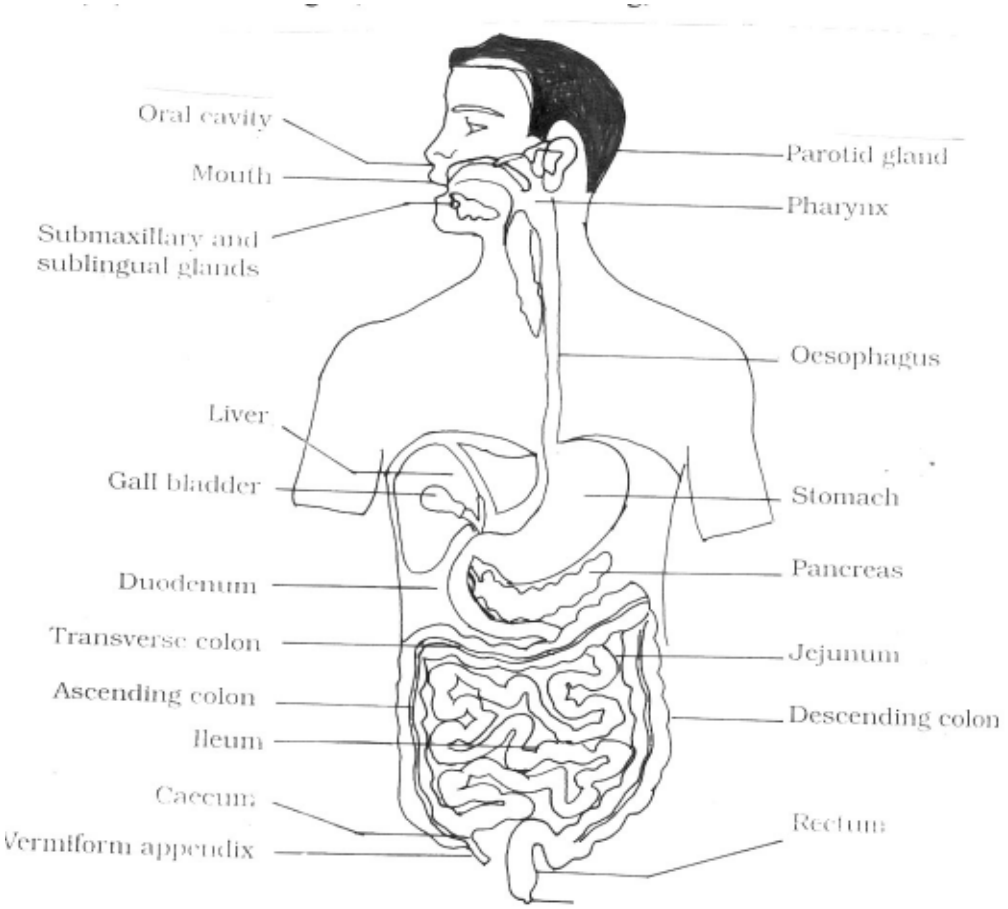


**Fig. 13.4** Human Alimentary canal and the associated glands.

6. **Large Intestine :** About 15 meters long and has three parts.
   (i) **Caecum–**Small blind pouch at the junction of small and large intestine. A narrow worm-shaped tube (vermiform appendix) projects from the caecum.
   (ii) **Colon :** A little over 1 meter long, it has three parts termed ascending, transverse and descending limbs.
   (iii) **Rectum :** Last part, about 15 cm. long. It has two parts, the rectum proper and anal canal. Anus is the external opening surrounded by circular muscles (sphincters).

The vermiform appendix is a vestigial (functionless) organ in humans, but is large and functional in herbivorous mammals.

**(a) Digestive Glands (Sources of digestive enzymes)**

There are two sources of digestive enzymes :

1. The glandular cells of the **gut epithelium** of stomach and intestine, which directly pour their secretion into the lumen of the gut.
2. Special glands such as the **salivary glands**, the **liver** and the **pancreas** which pour their secretions into the gut through their ducts.

Our mouth is always moist, even on a hot summer day. How does this happen? This happens because there is a watery fluid called saliva which is secreted by salivary glands into the mouth cavity. It is this saliva, that keeps the mouth moist all the time.

**(b) Salivary Glands**

There are three pairs of Salivary glands in our mouth cavity (Fig. 13.4).

1. **Parotid glands** located in front of and below each ear, produces watery saliva rich in amylase.
2. **Submaxillary glands** close to inner side of lower jaw, produce water and mucus.
3. **Sublingual glands** below the tongue, produce water and mucus.

These glands continuously pour saliva into the mouth cavity. Do you know that the amount of saliva secreted is about 1000 to 1200 ml per day.

**(c) Functions of Saliva**

1. It cleans the mouth cavity and tends to destroy germs that cause teeth decay. It contains lysozymes which help in destroying the bacteria.
2. It moistens and lubricates food which again helps in swallowing.
3. It acts as solvent, dissolving some food particles to stimulate taste buds of the tongue.
4. Saliva helps in the digestion of food as it contains an enzyme salivary amylase which digests the starch.

**(d) Liver**

Liver is the largest gland, located in the upper right side of the abdomen below the diaphragm. It secretes bile, which gets collected in gall bladder and is finally poured into the duodenum through the common bile duct (Fig. 13.4). Besides secreting bile, which helps in digestion, the liver has numerous other functions.

**(e) Pancreas**

Pancreas is a reddish brown gland located in the bend of the duodenum. Its digestive secretion (pancreatic juice) is poured into the duodenum by the pancreatic duct. (Pancreas also produces certain hormones, which will be taken up in details in lesson no 16)



## INTEXT QUESTIONS 13.2

1. Match the characteristics in column A with the parts of digestive system given in column B

| Column A<br>Characteristics | Column B<br>Part |
|---|---|
| (1) Common passage for air breathed and the food swallowed. | (a) Small intestine |
| (2) Elastic bag | (b) Pancreas |
| (3) Has three limbs-ascending, transverse and descending | (c) Duodenum |
| (4) Largest part of the food canal | (d) Pharynx |
| (5) Receives bile and pancreatic juice | (e) Appendix |
| (6) Narrow worm-shaped projection | (f) Stomach |
| (7) Largest gland in body | (g) Colon |
| (8) Gland located in the bend of duodenum | (h) Liver |

2. Name the **three** salivary glands and mention their location.

.....

## 13.6 THE DIGESTIVE PROCESS

Digestion involves two kinds of processes :

(a) ***Mechanical process*** that includes cutting, grinding and swallowing the food thus broken into small particles and then pushing the food along the food canal. **Smaller particles expose greater surface area for action by enzymes.**

(b) ***Chemical process*** which includes the enzymatic breakdown of complex food into simpler absorbable form.

Digestion involves hydrolysis, i.e. spliting by addition of water ($H^+$ and $OH^-$ ions) to a molecule resulting in its break down into two or more simpler molecules. The enzymes only act as catalysts to accelerate the reaction.

For example $\underset{\text{(sucrose)}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Sucrase}} \underset{\text{(glucose)}}{C_6H_{12}O_6} + \underset{\text{(fructose)}}{C_6H_{12}O_6}$

### (a) Mechanical Process in Digestion

- The lips hold the food within mouth and help in sucking and sipping of liquids.
- The teeth cut, tear and grind the food.

- The tongue manipulates food while chewing, mixes saliva in it, rolls it into a ball termed **bolus** and helps in swallowing.
- The oesophagus conducts the food (bolus) down into the stomach by a wave of constriction of the circular muscles (Fig. 13.5). This wave of constriction is called peristalsis.

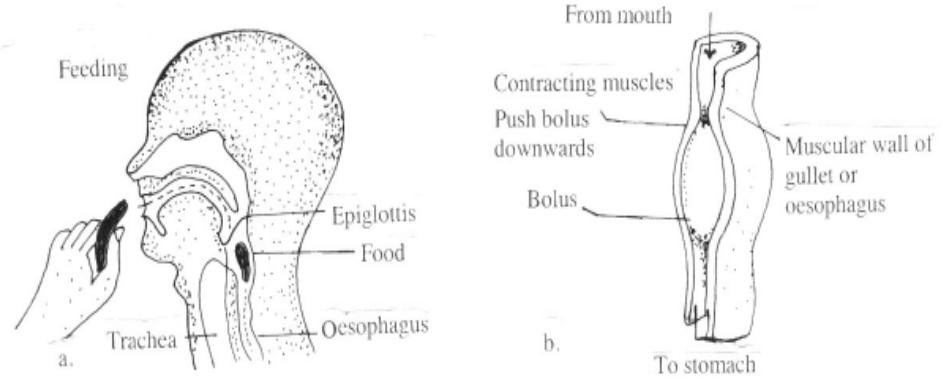


**Fig. 13.5 A**-During swallowing, the epiglottis closes the opening of the trachea, momentary stoppage of breathing, and the food is pushed down the oesophagus, **B**-Peristalsis is a wave of contraction of muscles of alimentary canal which pushes food down through the alimentary canal.

- The stomach churns the food mixing it with gastric juice and thus produces a creamy **chyme** (partially digested food).
- The peristaltic movements keep pushing the food from stomach to the intestine and finally upto the rectum.

### (b) Chemical Processes in Digestion

#### 1. In Mouth

Saliva contains only a single enzyme Amylase (old name Ptyalin) which acts on starch in two ways :

(i) Raw *uncooked* starch $\xrightarrow{\text{Amylase}}$ Dextrins
(soluble, partially hydrolysed starch)

(ii) Cooked starch $\xrightarrow{\text{Amylase}}$ Maltose
(a sweet-tasting disaccharide)

#### 2. In Oesophagus

Food as bolus moves into the stomach through peristalsis. Salivary amylase continues digesting starch.

#### 3. In Stomach

Initial digestion of starch by salivary amylase continues till the contents of stomach becomes acidic. The gastric juice produced from the epithelial lining of the stomach is a colourless highly acidic liquid (pH 1-2). It contains *Water* (98%), some salts, ***hydrochloric acid*** (0.5%), the lubricant mucin and two enzymes ***pepsin*** and ***lipase***.

*Hydrochloric acid* is secreted by ***Oxyntic (parietal)*** cells in the stomach wall. It performs following function :

*(i) kills bacteria entering along with food,*
*(ii) loosens fibrous material in food,*
*(iii) activates the inactive pepsinogen to its active form pepsin,*
*(iv) maintains acidic medium for action by pepsin,*
*(v) curdles milk so that it does not flow out and stays for action by pepsin.*

**Pepsin** is secreted in its inactive form or the proenzyme called pepsinogen secreted from the chief cells of the stomach wall. In the presence of HCl it turns into the active pepsin which acts on proteins and breaks them down into proteoses and peptones.

$$\text{Protein} \xrightarrow{\text{Pepsin}} \text{Proteoses and peptones}$$

### 4. Small Intestine

In the small intestine the food which is partially digested in the stomach and called **chyme** is acted upon by three main digestive juices.

(i) Bile juice from the liver
(ii) Pancreatic juice from the pancreas
(iii) Intestinal juice secreted from special cells in the intestinal epithelium at the base of intestinal villi. (Fig. 13.6)

The bile juice and pancreatic juice are poured into the duodenum by their respective ducts which join together to form a common hepato pancreatic duct. The intestinal juice directly mixes with the food.

#### (i) Bile Juice

Bile is a yellowish, green, alkaline liquid (pH about 8). It consists of (i) *water* (98%), (ii) *sodium carbonate* in large quantity which neutralizes the acid of the **chyme** (semi digested food) received from stomach; makes it alkaline, and (iii) *bile salts* (sodium glycocholate and sodium taurocholate) which emulsify fats.

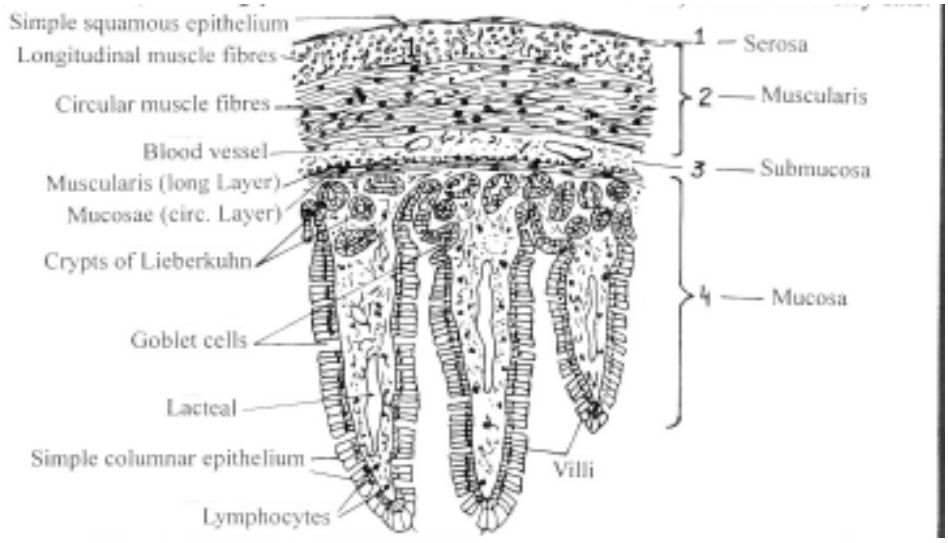


**Fig. 13.6** Portion of intestinal wall showing villi and the associated structures.

Emulsification is the breaking up of large lipid (fat) droplets into small droplets, which provides greater surface for enzyme action.

The yellowish green colour of the bile is due to the pigments ***biliverdin*** and ***bilirubin*** produced by the breakdown of the dead and worn out RBCs (Red Blood corpuscles). These pigments are excreted in faeces. (solid or semi-solid waste and undigested food).

Bile has no digestive enzymes. It simply emulsifies fats.

**(ii) Pancreatic Juice**

The pancreatic juice contains *six* major categories of enzymes, which act in an **alkaline medium**.

(a) **Amylase –** completes conversion of starch into maltose.

(b) **Lipase –** also called *steapsin*. Acts on emulsified fats to produce *fatty acids* and *glycerol*.

(c) **Nucleases –** digest nucleic acids, i.e. DNA and RNA content of the food.

(d) **Trypsinogen –** the inactive precursor (proenzyme) of trypsin. It is activated into *trypsin* by the enzyme *enterokinase* secreted by the lining of duodenum. Trypsin acts on remaining proteins (not digested by pepsin) and the proteoses and peptones to produce *peptides* and *amino acids*.

(e) **Chymotrypsin –** acts on milk protein casein to produce *paracasein* (curd), and also converts other proteins into *peptides*.

(f) **Carboxypeptidases –** act on peptides to produce small *peptides* and *amino acids*.

**(iii) Intestinal Juice or Succus Entericus**

It contains the following categories of enzymes :

(i) **Glycosidases** (including maltase, sucrase and lactase). These hydrolyse the disaccharide maltose (malt sugar), sucrose (cane sugar) and lactose (milk sugar) into the simpler absorbable monosaccharides (glucose, fructose and galactose).

Disaccharides ($C_{12}H_{22}O_{11}$)

1. Maltose $\xrightarrow{\text{Maltase}}$ gluscose + glucose
2. Sucrose $\xrightarrow{\text{Sucrase}}$ gluscose + Fructose
3. Lactose $\xrightarrow{\text{Lactase}}$ gluscose + galactose

Monosaccharides ($C_6H_{12}O_6$)

(ii) **Lipase** completes the digestion of any lipid (fat) not digested by pancreatic juice.

(ii) **Peptidases** (aminopeptidase and dipeptidase) act on peptides and dipeptides to produce smaller peptides and amino acids.



(iii) **Nucleases** breakdown nucleotides into phosphate, sugar and different nitrogenous bases.

Summary of digestion in various parts of human alimentary canal is shown in table 13.1

**Table 13.1 :** Various digestive enzymes secreted and their role in the digestion of food in humans

| Site of Secretion | Digestive juice | Enzyme | Mode of action |
|---|---|---|---|
| Mouth | Saliva | Salivary amylase (ptyalin) | Converts starch into maltose |
| Stomach | Gastric juice | Pepsin | Converts proteins into peptones and proteoses |
| Duodenum | Bile juice | No Enzyme | Emulsification of fats |
| | Pancreatic juice | Trypsin | Converts peptones and small peptides into amino acids. |
| Small intestine | Intestinal juice | Erepsin | Converts peptones and small peptides into amino acids. |
| | | Sucrase | Converts sucrose into glucose and frutose. |
| | | Maltase | Converts maltose into glucose |
| | | Lactase | Converts lactose into glucose and galactose. |
| | | Lipase | Converts fats into fatty acids and glycerols. |

## INTEXT QUESTIONS 13.3

1. How is grinding of food in the mouth helpful in digestion?

   .....

2. Name the source gland for following enzymes.

   (i) amylase .....

   (ii) pepsin .....

   (iii) lipase .....

3. List at least **four** enzymes that contribute towards digesting proteins.

   (i) …… (ii) ……. (iii) ……. (iii) ……..…....

## 13.7 ABSORPTION OF NUTRIENTS

Some absorption occurs in the mouth itself, some in the stomach but most absorption occurs in the intestine. The summary of absorption of nutrients is given below.

### 1. In Mouth

Minute quantities of water, water-soluble vitamins and simple sugars like glucose (as in honey) are absorbed in the mouth.

### 2. In Stomach

Water, glucose, ethanol (alcohol), certain minerals, vitamins and certain drugs may be absorbed into the cells lining the stomach. This absorption occurs by osmosis, diffusion (down the concentration gradient) and active transport (against concentration gradient).

### 3. Small Intestine

Most absorption of digested food occurs in small intestine. For this, the small intestine is adapted in many ways :

(i) It is very long and therefore provides more surface area for absorption.

(ii) Many folds in its wall called *villi* (sing *villus*) further increase the surface area of absorption. (Fig. 13.6).

(iii) Single cell eptithelial lining reducing the distance between the food and underlying blood vessels.

(iv) The epithelial cells have **microvilli** which are projections of plasma membrane to further increase the absorptive surface.

(v) It is narrow for slow movement of nutrients allowing absorption.

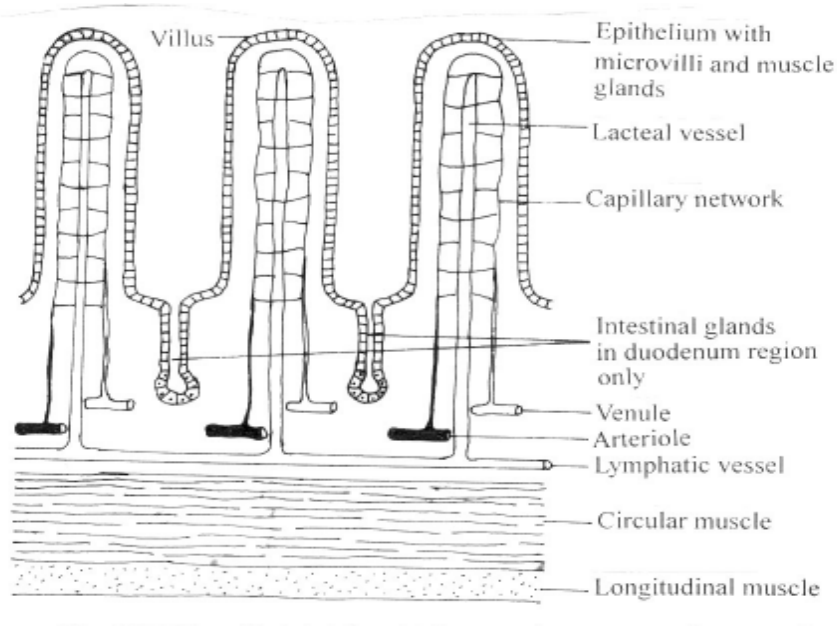


**Fig. 13.7** Magnified details of Microscopic structure of a part of the wall of small intestine.

- Products absorbed *into the blood capillaries* of the villi are amino acids and monosaccharides (glucose, fructose, galactose).



- Products absorbed into the lacteals (lymph vessels) of the villi are fatty acids and glycerol.
- Nutrients absorbed into the blood is carried by veins into the liver, and the Nutrients absorbed by the **lacteals** (small lymph vessels) enters the lymphatic system.

### 4. Large Inestine

Most of the water present in the food is absorbed in the *colon* by diffusion. Some mineral ions are absorbed by the colon through active transport.

## 13.8 ASSIMILATION

The final conversion of the absorbed nutrients into the living substance, i.e. their utilization by the cells is called **assimilation**.

After absorption from the food canal the digested food is assimilated by the body in the following ways.

(i) Fatty acids and glycerol are again converted into fats, that may be used or stored (in adipose tissue).

(ii) Simple sugars (monosaccharides) which are in excess are converted into complex polysaccharides (glycogen) in liver.

(iii) Amino acids are utilized in the synthesis of proteins for building up the body tissues and enzymes.

(iv) Excess amino acids are deaminated (removal of nitrogenous part) to produce simple sugar. (*Amino acids* cannot be stored).

## 13.9 EGESTION (DEFAECATION)

The undigested part (plant fibers etc.) and the unabsorbed digested substances pass into the *rectum*. Such food remnants are temporarily stored in rectum. More water is absorbed and the remnants become semisolid to form *faeces*.

A special reflex called defaecation reflex causes emptying of the rectum and the faeces are passed out via the anal canal by the relaxation of *sphincter* muscle (A ring shaped muscle around tubular organ which contract, can narrow or close the passage of the organ).

## INTEXT QUESTIONS 13.4

1. In which part of the alimentary canal does maximum absorption of water occur?

   .....

2. List any three ways in which the intestine increases the surface area for absorption?

   (i) .....

   (ii) .....

   (iii) .....

3. Which end products of digestion are absorbed by

   (i) blood capillaries of intestinal villi?.....

   (ii) Lacteals? .....

## 13.10 NEURAL AND HORMONAL CONTROL OF DIGESTIVE SYSTEM

Do digestive juices flow into the alimentary canal all the time? If it were so, it would mean terrible wastage of enzymes when there is no food in the alimentary canal. So, everything must be so timed that there is neither wastage not shortage. How is it possible? Let us see how it happens.

Think of the following situations:

1. When we see or smell good food or even think or talk about it, our mouth begins to "water" (salivation). This happens through stimulation by nerves coming from the brain. The secretion of thicker saliva is stimulated by chewing action (even if you chew wax instead of food, you will salivate).
2. On reaching the stomach, the presence of food stimulates the stomach lining to secrete gastric juice. Secondly, the mechanical stimulation of stomach wall produces a hormone, **gastrin** which again stimulates the secretion of gastric juice.
3. As the food enters duodenum, the duodenal epithelium secretes four hormones- **Secretin, Pancreozymin, Cholecystokinin, Enterogastrone**.
   (i) **Secretin** stimulates the flow of pancreatic juice, which is rich in bicarbonates (to neutralize acid).
   (ii) **Pancreozymin** helps in the flow of pancreatic enzymes.
   (iii) **Cholecystokinin** stimulates flow of bile from gall bladder.
   (iv) **Enterogastrone** stops secretion of gastric juice, because stomach becomes empty as food now posses from stomach to duodenum.

Several nerves (from sympathetic and parasympathetic nervous system, supply the gut to accelerate or slow down the movements of the gut or peristalsis.

### INTEXT QUESTIONS 13.5

1. Mention the source of secretion and the effect of the following:

   (i) Gastrin .....

   (ii) Enterogastrone .....

## 13.11 ROLE OF LIVER IN METABOLISM

Liver is the largest gland associated with the alimentary canal. It is reddish brown in colour and is located on the upper side of the abdomen just below the diaphragm. Its numerous functions can be grouped under five major categories :



**Blood related functions :**

(i) Produces *red blood cells* in the embryo. (In adults, RBCs are produced in bone marrow).

(ii) Produces *prothrombin* and *fibrinogen* required for blood clotting.

(iii) Produces *heparin* which prevents unnecessary coagulation of blood.

(iv) Destruction of dead and worn out red blood cells.

(v) Removal of toxic and metallic poisons from the blood (protective function).

**Storage functions :**

(i) Storage of iron and some other metallic ions.

(ii) Storage of vitamins A, D and $B_{12}$.

(iii) Converts extra blood glucose into glycogen and stores it.

**Metabolic functions**

(i) **Regulation of blood** sugar level by retaining excess glucose received as products of carbohydrate digestion from the intestines, and storing it as insoluble *glycogen* to release it again as soluble glucose when the blood sugar level falls.

(ii) **Breaking down of excess amino acids** Amino acids are the end products of protein digestion. Liver breaks down excess amino acids into urea and sugar. Urea is excreted out in urine and sugar is stored for use.

(iii) **Synthesizes fatty acids** from carbohydrates, which can be used or stored as fat.

## INTEXT QUESTIONS 13.6

1. Name any three substances relating to the blood, produced by liver.
   (i) ……..... (ii) ……..... (iii) …….....
2. List any three substances which the liver stores.
   (i) ……..... (ii) ……..... (iii) …….....
3. What happens to excess amino acids absorbed from gut ?

   .....

## WHAT YOU HAVE LEARNT

- Digestion is the breakdown of complex food, and nutrition include taking in and utilization of food.
- All animals are heterotrophic or phagotrophic or holozoic (ingesting bulk food) while the green plants are autotrophic (or holophytic)
- Animal nutrition involves five steps-ingestion, digestion, absorption, assimilation and egestion (defecation).

- Digestion can be either intracellular or extracellular.
- The human alimentary canal consists of mouth, pharynx, oesophagus, stomach, small intestine, large intestine and anus.
- The digestive enzymes poured into the gut, are secreted from two kinds of sources; gut epithelium of stomach and intestine, and special glands (salivary glands, liver and pancreas).
- Starch is digested in the mouth by salivary amylase, in the duodenum by pancreatic amylase. Other carbohydrates like maltose, sucrose and lactose are digested by the respective enzymes in the intestine.
- Fats are emulsified by bile, and are hydrolysed by lipases in stomach and intestine.
- Proteins are digested by pepsin in the stomach and by trypsin in the intestine and the peptidases break them into amino acids.
- Absorption of digested food mainly occurs in the small intestine – simple sugars and amino acids are absorbed into the blood capillaries of the intestinal villi and the fatty acids and glycerol into lacteals.
- Most water from the digested food is absorbed in colon and rectum.
- Defaection is the expulsion of semi-solid faeces.
- Several hormones regulate the secretion of digestive juices from different parts, at the right time and in right quantity.
- Besides playing an important digestive role, the liver has numerous other functions in connection with blood and general metabolism.

## TERMINAL EXERCISES

1. Explain the term “autotrophs”. How are animals different from plants with regard to their mode of nutrition?
2. Enlist at least ten organs of the alimentary canal of man.
3. Define the term “digestion”. List the digestive processes occurring in the small intestine.
4. How does digestion of carbohydrates and proteins take place in humans?
5. Explain the role of the following in the digestive process in humans :

   (a) Gastrin (b) Hydrochloric acid (c) Secretin
6. Write short notes on

   (a) absorption of the digested food (b) assimilation

   (c) defaecation (d) role of liver in metabolism.



7. Name the enzymes concerned with the digestion of various carbohydrates, the region of the gut where they act and their products in the table given below:

| | Carbohydrate | Enzyme | Region of gut | Product |
|---|---|---|---|---|
| 1. | Starch | ..... | ..... | ..... |
| 2. | Dextrin | ..... | ..... | ..... |
| 3. | Maltose | ..... | ..... | ..... |
| 4. | Sucrose | ..... | ..... | ..... |
| 5. | Lactose | ..... | ..... | ..... |

8. Bile has no digestive enzyme yet it plays a key role in digestion. What is its role?
9. Draw a well labelled diagram of alimentary canal in humans.

## ANSWERS TO INTEXT QUESTIONS

**13.1** 1. Ingestion, digestion, absorption, assimilation, egestion

2. All the five steps of digestion occur inside the cell itself. Paramecium, Amoeba etc.

**13.2** 1. 1. d, 2. f, 3. g, 4. a, 5. c, 6. e, 7. h, 8. b

2. Parotid – in front of and below ear

Submaxillary – inner side of lower jaw.

Sublingual – below the tongue

**13.3** 1. Smaller particles provide larger surface area for digestive action.

2. (i) Salivary glands (ii) Stomach (iii) Pancreas

3. 1. Pepsin 2. Trypsin, 3. Chymotrypsin, 4. Carboxypeptidase.

**13.4** 1. Colon/large intestine.

2. (i) very long (ii) villi (iii) microvilli

3. (i) Amino acids and simple sugars, (ii) fatty acids and glycerol.

**13.5** 1. (i) Gastrin-stomach, stimulates secretion of gastric juice

(ii) Enterogastrone-Duodenum, stops secretion of gastric juice.

**13.6** 1. Fibrinogen, prothrombin, heparin

2. Sugar/glycogen, iron, vitamin A/D/$B_{12}$

3. Broken down to produce sugar and urea, sugar is used and urea is excreted.