11 DIGESTIVE SYSTEM

Syllabus : The structure of a tooth, different types of teeth. *Structure of a tooth to be discussed with the help of a diagram. Functions of different types of teeth. Dental formula for an adult.*
Digestive System : Organs, digestive glands and their functions (including enzymes and their functions in digestion; absorption, and assimilation of digested food).
Organs and glands of the digestive system and their functions with reference to digestion, absorption and assimilation. Brief idea of peristalsis.

11.1 WHY THE DIGESTIVE SYSTEM

The food that we eat cannot be utilized as such in the body. It must be changed into a **soluble absorbable** form to get absorbed by the blood for distribution in the body. Certain foods, like cane-sugar are already soluble in water, but they require a **breaking down of their molecules into smaller units so that they could pass through the cell membranes** of the wall of the gut.

Digestion is the break-down of naturally occurring foodstuffs into diffusable form.

OR

Digestion is any change which makes the foods soluble and of such chemical nature that they can be absorbed through living membranes.

ENZYMES

Enzymes play a key role in the digestion of food taken in. There are hundreds of enzymes in addition to those involved in digestion, but the general characteristics of all enzymes are same.

Characteristics of an enzyme

1. It is a *protein* and is, therefore, *destroyed* by *heating.*
2. It acts only on one kind of substance called the substrate *i.e.* it is *specific.*
3. It always forms the *same end-product*(s) from the substrate.
4. It *only affects the rate* of a chemical reaction and always speeds up the reaction.
5. Like a catalyst it *can be used again and again.*
6. It acts best only at a particular pH, *i.e.* at a particular degree of acidity or alkalinity.
7. It acts best within a narrow temperature range, usually between 35° and 40°C which is also called *optimum temperature.*

11.2 THE DIGESTIVE SYSTEM

The digestive system consists of :

(i) **alimentary canal** and (ii) **digestive glands**

The alimentary canal (Fig. 14.1) is a muscular tube which starts with the mouth and ends at the anus. It is about 9 metres long and is highly coiled in certain regions especially in the small intestine. Its various regions, shown in Fig. 13.1, are different both in structure and function. In addition to the digestive glands located in the lining of the various regions of the digestive tube, two large digestive glands, the liver and pancreas, are also associated with it, and three different salivary glands are associated with the mouth cavity.

The various organs of the digestive system are described as follows :

11.2.1 THE MOUTH

The mouth or the mouth cavity is the space where the food is chewed and mixed with saliva. Its front limits are formed by the upper and lower lips. The **lips** help in (i) closing the mouth, (ii) sucking and sipping liquids, (iii) speaking and also in (iv) perceiving certain sensations, especially those of touch and heat.

A muscular **tongue** helps in (i) manipulating the food while chewing and mixing it with saliva, (ii) tasting, (iii) cleaning the food particles from the teeth after eating and also in (iv) speaking.

11.2.2. THE TEETH — DENTITION

The **teeth** have a very special role – they cut and break the food into smaller bits. The small sized bits have a relatively larger surface for the enzymes to

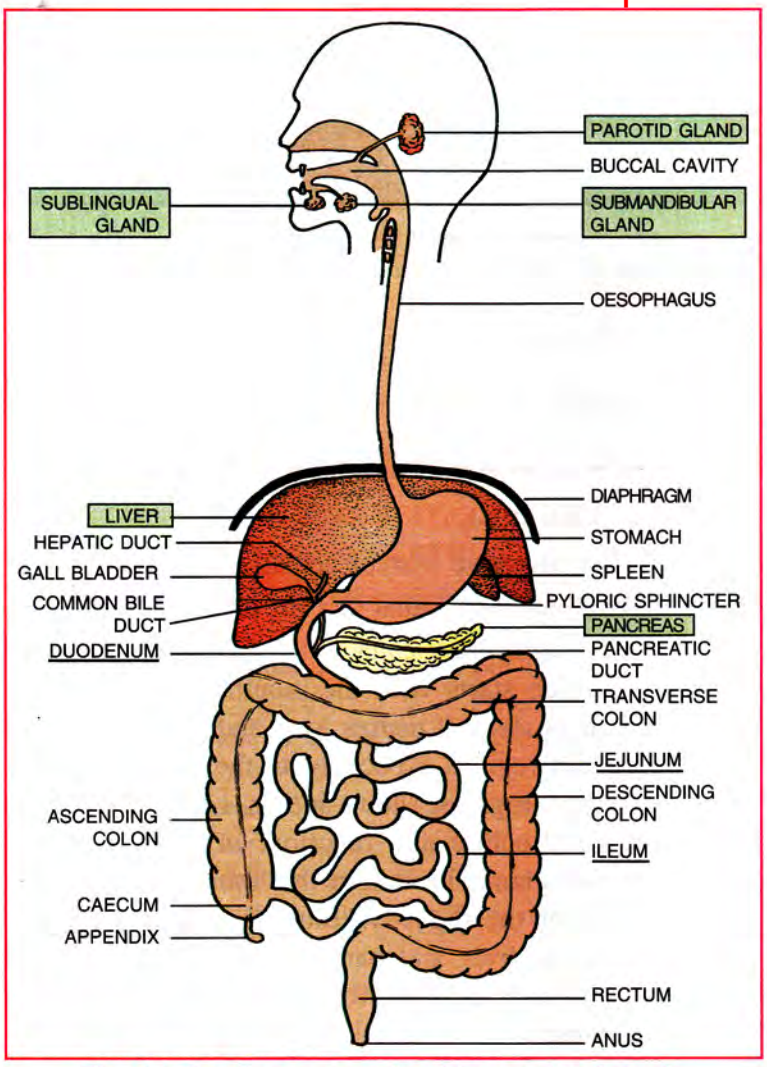


Fig. 11.1 The alimentary canal and its associated glands

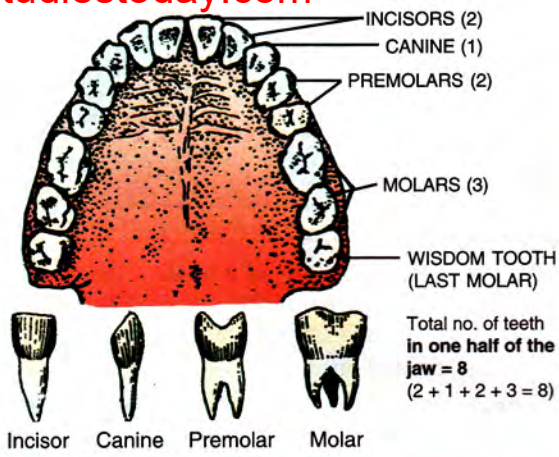


Fig. 11.2 Different kinds of teeth, in natural position in the upper jaw in a normal human adult, each category is also shown separately in the lower row of sketches.

act on for better digestion. The teeth help in speaking (How ? Find out for yourself - try to speak 'thick', 'talwar', 'tandoor', 'thin', 'through', 'the', *etc.*). Teeth also add to facial beauty.

An adult human normally has 32 teeth. These teeth (Fig. 11.2) are different in shape and perform different functions as follows :

(a) **Incisors** are the four front teeth in the centre of each jaw. Their cutting edges are broad and sharp like a chisel. They are used for biting and cutting.

(b) **Canines** are one on either side of the incisors in each jaw. These are conical and sharply pointed for holding and tearing the food.

(c) **Premolars** are two on each side in each jaw next to the canines. Each premolar has two hill-like projections or *cusps* on its surface, and hence known as *bicuspid.* Premolars help in grinding and crushing the food.

(d) **Molars** are the last three teeth on each side in each jaw. They have a larger surface than the premolars. They are principal grinders and crushers of food. The last molar of each side in each jaw is called **wisdom tooth.** The wisdom teeth are so called because they appear last at an age of about 17-20 years when the human body is reaching maturity. In this manner the human or mammalian teeth are different in shape and are called **heterodont** (***hetero*** : different, ***dont :*** teeth) as opposed to homodont (***homo*** : similar) teeth of other animals like those of the lizard and frog.

"Confusion" over the name "molar"

The dentists usually call the premolars of a child as "molars" (literally meaning "grinders"). But, since the grinders appear in two sets—first the ones that are shed and regrown (premolars), and second those that appear only once as permanent grinders (molars), it is scientifically more appropriate to give two separate names to the two kinds as premolars and molars right from the beginning (to avoid any confusion).

Mammalian teeth ***appear in two sets during life.*** In humans, the first set, or milk teeth, consists of 20 teeth (all, but not the molars) which start growing through the gums (sometimes painfully) when the child is about 7-8 months old and are completed

when he is about 2 years old. These **temporary** (or the **deciduous** teeth) fall out as a result of their roots being dissolved away in the jaw and are completely replaced by the **permanent** teeth by about 12 years of age. (Fig. 11.3).

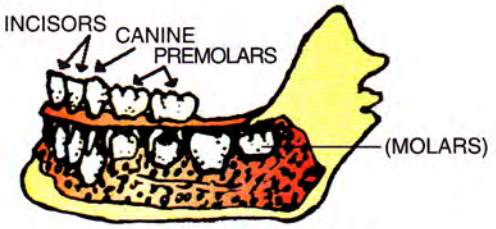


Fig. 11.3 Temporary teeth in a child and the permanent teeth growing below them.

The number of permanent teeth of mammals is usually indicated in a formula in which the number of incisors (i), canines (c), premolars (pm), and molars (m) is given strictly in the same order **for one-half of each jaw**. The human dental formula is as follows :

Human **child** up to about 2 years :

$$\frac{2, 1, 2, 0}{2, 1, 2, 0} = 20 \text{ (milk teeth)}$$

Human **adolescent** up to about 17-20 years :

$$\frac{2, 1, 2, 2}{2, 1, 2, 2} = 28 \text{ (permanent teeth)}$$

Human **adult** : $\frac{2, 1, 2, 3}{2, 1, 2, 3} = 32$ (permanent teeth) with wisdom teeth added

11.2.3 STRUCTURE OF A TOOTH (Fig. 11.4)

The general structure of all types of teeth is the same. Each tooth consists of a **crown** or the part exposed above the gum and the **root** or the part embedded in a cup-like socket of the jaw bone. The root consists of a single process or fang as in incisors and canines, or of two processes or fangs as in premolars and lower molars and three in upper molars. The **neck** is a slight constriction between the root and the crown. In a vertical section, a tooth shows the following parts.

Enamel or the "ivory" is the material which covers the crown. It is the hardest substance in the body.

Dentine forms the bulk of the tooth. It is harder than bone but not as much as the enamel. It has minute canals through which run the strands of cytoplasm of the cells in pulp cavity.

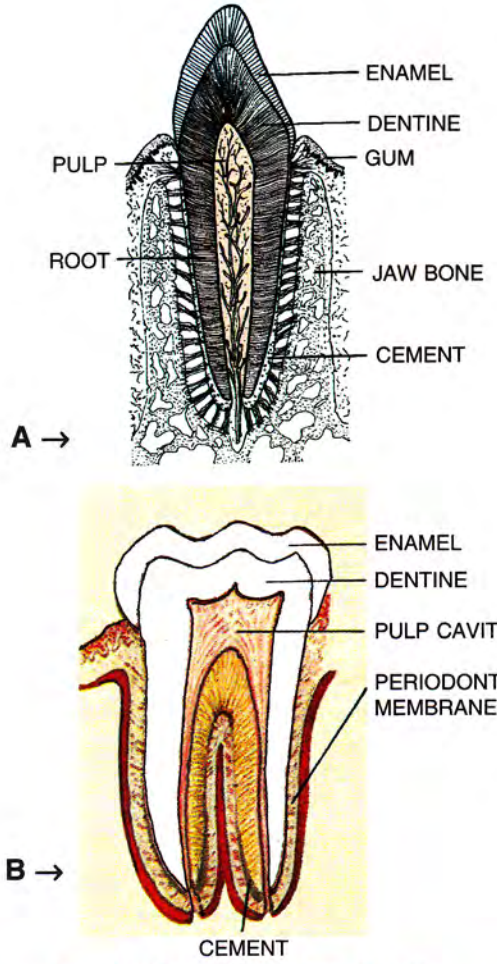


Fig. 11.4 Internal structure of tooth
A-incisor or canine (biting or piercing), with one root.
B-Premolar (grinding) with two roots.

Cement is another bone-like structure covering and fixing the root in position.

Pulp is the soft connective tissue contained in the central space (pulp cavity) of the tooth. It consists of blood capillaries, lymph vessels and nerve fibres which are continuous below those of the body through the opening of the pulp cavity at the base of the root.

? ***PROGRESS CHECK***

1. Given below is a jumbled sequence of the different parts of the human alimentary canal. Rewrite them in correct sequence.
   Stomach, Oesophagus, Large intestine, Small intestine, Pharynx.
2. Name the following :
   (i) The three subdivisions of the small intestine.
   (ii) The three subdivisions of the large intestine.
   (iii) The three salivary glands.

3. Give the technical names for the following types of teeth in humans (on each side, in each jaw)
   (i) The three last grinders.
   (ii) The pointed tooth for holding and tearing.
   (iii) The broad sharp cutting teeth.
   (iv) The two temporary (deciduous) grinding teeth.
4. Name the following parts of a tooth:
   (i) Part exposed above the gum.
   (ii) The hard substance making the covering of the tooth.
   (iii) The soft connective tissue contained in the central space of the tooth.
   (iv) Bone-like structure fixing the root in position.
   (v) Slight constriction between the root and the crown.

11.2.4 THE SALIVARY GLANDS

The saliva is secreted by three pairs of salivary glands,

- **parotid** glands located just in front of and beneath each ear,
- **submandibular** glands lying close to the inner side of the lower jaw on each side,
- **sublingual** glands below the tongue.

Ducts from each gland transport the secreted saliva into the mouth. Small quantities of saliva keep secreting at all times. While eating, the salivary flow is considerably increased. Sometimes, even the sight, smell, or just a thought of tasty food can cause an increased flow of saliva resulting in "watering of the mouth".

How much saliva you normally produce every day ?

About 1000-1500 ml, *i.e.*, enough to fill 5-7 empty bottles of any soft drink ! Can you guess where all this goes ?

Saliva is very slightly acidic (pH 6.8) fluid containing water (about 99%), salts, mucus and an enzyme **salivary amylase** (also called **ptyalin**).

Functions of Saliva :

1. Moistens and lubricates the inner lining of mouth cavity and the surface of the tongue to **facilitate speaking and swallowing.**
2. Moistens and **lubricates food** which again helps in swallowing.
3. Acts as a **solvent**, dissolving some food particles to stimulate taste buds of the tongue.
4. Helps food particles to stick together to form **bolus** so that they can be swallowed in a mass.
5. Digests starch. Its enzyme ptyalin **(amylase) converts starch into maltose**. This explains why if boiled rice is chewed very well it begins to taste sweet.

$$\text{Starch} \xrightarrow[\text{(Saliva)}]{\text{Ptyalin/Salivary amylase}} \text{Maltose (disaccharide)}$$

6. **Cleans the mouth** and tends to **destroy germs** to prevent tooth decay.
7. Dryness in mouth (due to less water in **saliva**) gives a feeling of **thirst** to replenish body water. Thus saliva aids in **water balance** in the body.

11.2.5 SWALLOWING AND PERISTALSIS

In swallowing, there are several simultaneous actions.

- The **tongue** presses upward and back against the roof (palate) of the mouth and this forces the bolus (the ball of chewed food) into the throat or the pharynx.
- The back part of the roof of the mouth cavity **(soft palate)** closes the opening between the throat and the nasal passage.
- The larynx ("voice box") which is located at the entrance of the windpipe is pulled upward to bring it close to the back of the tongue when a flap called **epiglottis** closes its opening (Fig. 11.5 A,B). Thus the only passage available to the swallowed food is that of the gullet or oesophagus.

Once the food reaches the oesophagus it is conducted behind by a special movement called **peristalsis. Peristalsis is the wave of constrictions caused by the circular muscles of the gut pushing the food along** (Fig. 11.5 C). As the wave passes the circular muscles relax. **Peristalsis occurs through all regions of the gut.** Mucus secreted by all the regions of the gut is a slimy fluid which lubricates the food.

Food going the wrong way !

If, by any chance, the food you swallow gets into the windpipe, there is an immediate coughing to forcibly throw out the wrongly entered substance.

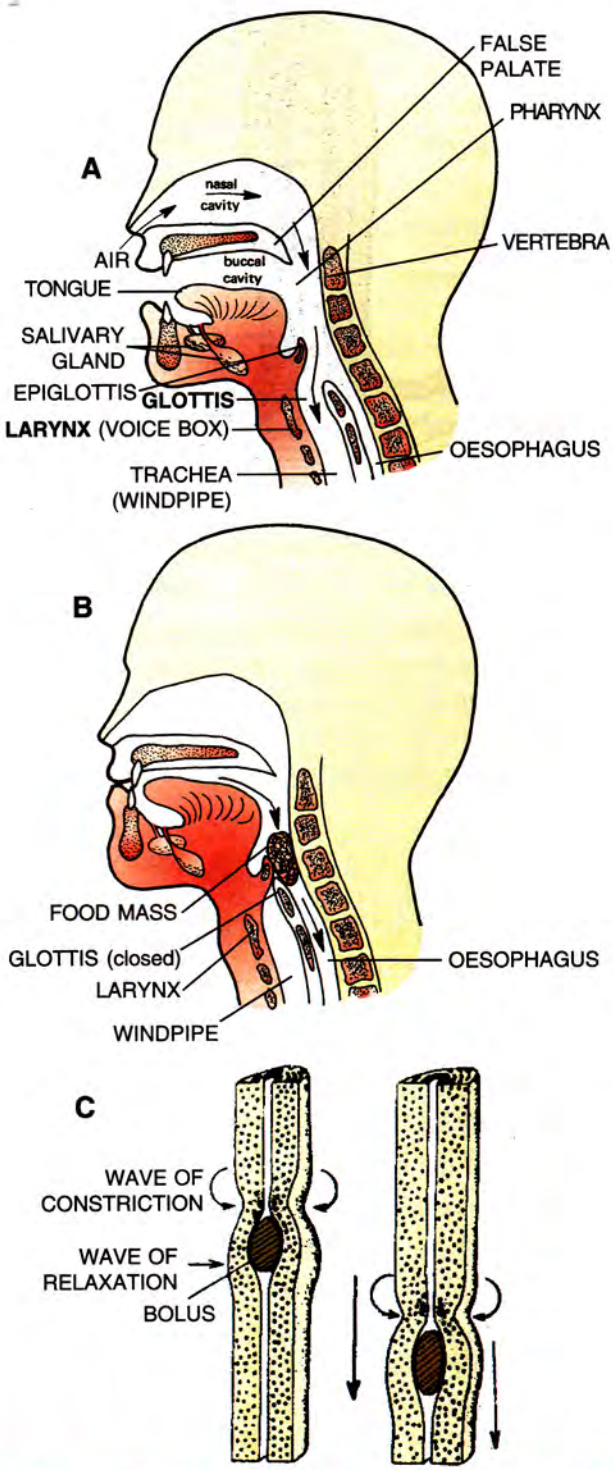


Fig. 11.5 A—During breathing the larynx is lowered and the glottis opened; B—During swallowing the larynx is raised and the glottis is closed by epiglottis; C—Peristaltic movement of food through oesophagus, by a wave of contraction.

11.2.6 OESOPHAGUS

Oesophagus is a tube which simply conducts the food from the throat to the stomach. It passes through the diaphragm close to the backbone. It does not produce any digestive enzyme.

11.2.7 STOMACH

The stomach is an elastic bag located below the diaphragm. In an average adult it can hold 2 to 3 litres of food. Its walls are highly muscular and churn the food thoroughly to mix with the gastric juice secreted by the inner lining. The opening of the stomach into the intestine is called **pylorus** (**Gk.** *pylon* : gate, *pylorus* : gate-keeper). It has a ring of muscles (**sphincter**) to keep the opening closed like a valve to prevent food passing from the stomach until it is thoroughly churned up. It also prevents regurgitation from the duodenum. A similar sphincter termed cardiac sphincter is present at the front end of the stomach to prevent back flow of food into the oesophagus.

VOMITING

Sometimes when the stomach is overloaded or disturbed, vomiting occurs in which the cardiac sphincter opens and a reverse wave of muscular contraction (antiperistalsis) is caused throwing the contents out through the mouth.

Gastric juice is secreted by the inner lining of the stomach. It is a colourless highly acidic liquid containing water, some salts, hydrochloric acid and an enzyme called **pepsin.** The acid serves two functions — (i) it kills any germs which may have entered along with the food, and (ii) it activates pepsin to act on proteins. In fact, the pepsin is first secreted as **pepsinogen** which is then changed to pepsin by the acid. Pepsin digests proteins (about 20% only) into peptides.

(i) Pepsinogen (inactive) $\xrightarrow{HCl}$ **PEPSIN** (active)

Proteins $\xrightarrow[\text{Enzyme}]{\textbf{Pepsin}}$ Peptides

(ii) Prorennin (inactive) $\xrightarrow{HCl}$ **RENNIN** (active)

Milk Protein/casein (soluble) $\xrightarrow[\text{Enzyme}]{\textbf{Rennin}}$ **PARACASEIN** (a peptide) (insolube)

The food stays in the stomach for about 3 hours and it attains a pulp-like form called the **chyme**. Now the pylorus opens intermittently to allow the chyme to move to the intestines little by little.

PROGRESS CHECK

Mention if the following statements are **true** (T) or **false** (F) :

(i) Saliva moistens and lubricates food.
(ii) Saliva contains a protein-digesting enzyme.
(iii) Saliva tends to destroy germs in the mouth.
(iv) Peristalsis occurs through all regions of the gut.
(v) The food in stomach stays for about 10 hours.
(vi) Gastric juice is alkaline.
(vii) Gastric juice contains pepsinogen.

11.2.8 THE SMALL INTESTINE

The small intestine is a tube about 7 metres long and about 2.5 cm wide. It is coiled and folded in the abdomen. Its three sub-regions are as follows :

(i) **Duodenum :** Short upper part next to stomach. ("**duodenum**" means 12, *i.e.* twelve finger breadths in length, *duo* : two, *deni* : ten). The common bile duct opens into this part.

(ii) **Jejunum** : Next short region of about 2 metres. ("**jejunum**" means empty, because it is nearly always empty after death as found in dissections or in post-mortems.)

(iii) **Ileum** : About 4 metres. ("**ileum**" means to twist roll, referring to the twisting movements of this part).

The inner lining of the ileum is produced into a great number of tiny finger-like projections called **villi** (singular **villus**). The villi enormously increase the inner surface area of the intestines (nearly 8 times that of the outer body surface) which facilitates the absorption of digested food. Between the villi are small holes through which the intestinal juice secreted by its glandular cells is poured into the lumen of the intestine. Each **villus** (Fig. 11.7) is covered by a single-cell thick epithelium. Inside the villus are contained an artery, a vein, inter-connecting blood capillaries and a lymph vessel called **lacteal.**

The small intestine serves both for digestion and absorption. It receives two digestive juices; (i) the **bile** and (ii) the **pancreatic juice** in the duodenum and its own walls secrete the intestinal juice in the ileum.

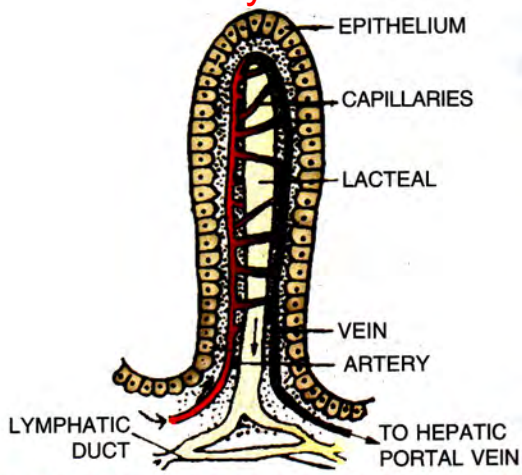


Fig.11.6 Microscopic structure of an intestinal villus

Adaptations of the ileum for absorption of digested food :

1. It is very long ; more surface area provided.
2. The large number of villi further increase the surface area for absorption.
3. Single-cell epithelium.
4. It is narrow for slow movement of food allowing absorption.

(1) **BILE.** This is a yellowish green watery fluid **produced in the liver**, which is transported through the hepatic duct (Fig. 11.7). The hepatic duct is joined by the *cystic duct* to form the common bile duct. The bile may flow directly into the duodenum or as it generally happens, gets temporarily stored in the gall bladder. The colour of the bile is due to certain pigments (**biliverdin** and **bilirubin**) produced by the breakdown of the dead and worn-out red blood cells. It contains a lot of sodium bicarbonate which neutralises the acid content of the food received from the stomach and makes it alkaline to enable the

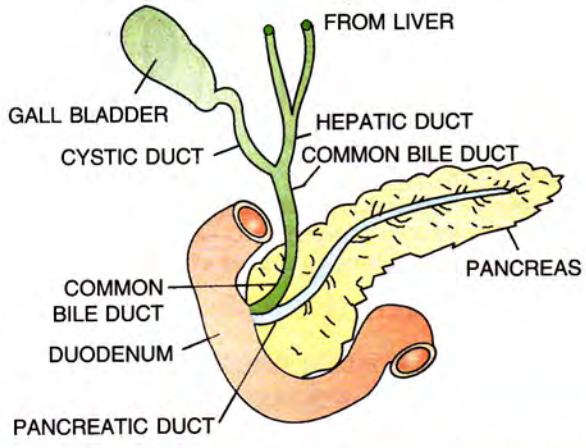


Fig.11.7 Bile duct and pancreatic duct opening into duodenum.

pancreatic and intestinal enzymes to act. Bile salts reduce the surface tension of fats and break them into tiny droplets (emulsification) for providing greater surface area for the action of enzymes. Overall the role of the bile is as follows :

(i) Fat $\xrightarrow{\text{bile}}$ Emulsion/emulsified fat

(ii) Acidic chyme $\xrightarrow[NaHCO_3]{\text{bile}}$ alkaline chyme

(2) **PANCREATIC JUICE.** This is produced in a whitish gland, pancreas, located behind the stomach. The pancreatic duct opens into the duodenum by an aperture common to that of the bile duct. The pancreatic juice contains three kinds of enzymes—

(i) **Amylopsin** (pancreatic amylase) digests leftover starch into maltose,

(ii) **Trypsin** acts on the remaining proteins and polypeptides to produce smaller peptides and amino acids. *Trypsin is first secreted as inactive trypsinogen* which is activated to trypsin *by an enzyme, enterokinase* (also called enteropeptidase), secreted by the inner lining of the duodenum. and

(iii) **Steapsin** which acts on emulsified fats to split them into fatty acids and glycerol.

Overall the role of pancreatic enzymes is as follows:

(i)	**Trypsinogen (inactive)**	$\xrightarrow{\text{Enterokinase}}$	**Trypsin (active)**
(ii)	**Proteins & Peptides**	$\xrightarrow{\text{Trypsin}}$	**Smaller Peptides + Amino acids**
(iii)	**Leftover starch**	$\xrightarrow{\text{Amylase}}$	**Maltose**
(iv)	**Emulsified fat**	$\xrightarrow{\text{Steapsin}}$	**Fatty acids + Glycerol**

Intestinal juice contains **erepsin (peptidases)** to convert remaining peptides into amino acids, **maltase** to digest maltose into glucose, **lactase** to digest lactose into glucose and galactose, **invertase** (or sucrase) to split sucrose into glucose and fructose, and some traces of **lipase** to digest fats into the fatty acids and glycerol. All these changes are summarised as follows :

(i)	**Peptides**	$\xrightarrow{\text{Erepsin / Peptidase}}$	**Amino acids**
(ii)	**Maltose**	$\xrightarrow{\text{Maltase}}$	**Glucose**
(iii)	**Sucrose**	$\xrightarrow{\text{Sucrase}}$	**Glucose + fructose**
(iv)	**Lactose (milk sugar)**	$\xrightarrow{\text{Lactase}}$	**Glucose + galactose**
(v)	**Emulsified fat**	$\xrightarrow{\text{Lipase}}$	**Fatty acids + glycerol**

Absorption of food. The final products of food are mainly absorbed in the intestine itself.

- The **amino acids** and the **simple sugars** (glucose, fructose, galactose) have relatively small-sized molecules which are absorbed through the thin epithelium of the villi and reach their blood capillaries to finally enter the blood circulation first to reach the liver through the hepatic portal vein.
- The **fatty acids** and **glycerol** are absorbed into the lymph vessel or the lacteal to enter the lymphatic system which forms a network all over the body to ultimately empty its contents into the blood stream. The food passes very slowly through the intestine taking about four hours to enter the last part large intestine.

11.2.9 THE LARGE INTESTINE

The large intestine is about 1.5 metres long. It has three parts—caecum, colon and rectum.

1. The **caecum** is a small blind pouch situated at the junction of the small and large intestines. From its blind end projects a narrow worm-shaped tube called **vermiform appendix** (when inflamed it causes appendicitis) and today it is a functionless (vestigial) organ (Fig. 11.1).
2. The **colon** is much broader than the ileum and is a little more than a metre long. It passes up the abdomen on the right (ascending colon), crosses to the left just below the stomach (transverse colon) and down on the left side (descending colon).
3. The **rectum** is the last part, about 15 cm long which opens at the anus. The anus has circular muscles (sphincters) to keep it closed except when passing bowels.

Functions. The large intestine secretes no enzyme. It absorbs much water but very little digested food from the contents which mainly consist of undigested material. After much water is absorbed the contents become semi-solid **faeces** which pass into the rectum and are expelled at intervals. The expulsion of the undigested remains of the food from the alimentary canal is called **defaecation**.

- The **faeces** are normally composed of nearly:
  - — 75% water
  - — 25% solid matter which again consisting of:

Table 11.1 : Summary of digestion in various parts of human alimentary canal

Note : Enzymes are given in italics and the products of digestion printed in **bold face** are the end products.

Region		Secretion (Source gland)	Enzymes	Nutrient (Substrate)	Product of digestion
Mouth (Mastication)		Saliva (Salivary glands)	*Ptyalin* (Salivary amylase)	Starch	Maltose
Oesophagus		None	—	—	—
Stomach (Churning and temporary storage)		Gastric juice & Hydrochloric acid (Lining of stomach)	*Pepsin*	Proteins	Polypeptides
			Rennin (Not found in adult humans)	Milk protein or caseinogen	Curdles milk (to produce casein protein)
SMALL INTESTINE	Duodenum	Bile (Liver)	None	Fats	Emulsifies fats, food made alkaline
		Pancreatic juice (Pancreas)	*Amylopsin* (Pancreatic amylase)	Starch	Maltose
			Trypsin	Proteins and Polypeptides	Small peptides and **Amino acids**
			Steapsin (lipase)	Emulsified fats	**Fatty acids** *and* **glycerol**
	Ileum	Intestinal juice (Intestinal glands between villi)	*Erepsin* (Peptidase)	Proteins and Peptides	**Amino acids**
			Maltase	Maltose	**Glucose**
			Sucrase (Invertase)	Sucrose	**Glucose** *and* **fructose**
			Lactase	Lactose	**Glucose** *and* **galactose**
			Lipase	Fats	**Fatty acids & glycerol**
LARGE INTESTINE	Colon	None	—	—	Absorbs water and some remnants of digested food
	Rectum	None	—	—	Temporarily stores undigested food and wastes

- 30% dead bacteria
- 10-20% fat
- 2-3% proteins
- 30% roughage

(The bad odour of faeces is due to bacterial action in it).

[**Note :** The composition of faeces varies from person to person as well as according to the kind of food consumed].

PROGRESS CHECK

1. Mention if the following statements are **true** (T) or **false** (F)
   (i) Intestinal villi have a lymph vessel called lacteal.
   (ii) Intestine is narrow for fast movement of food.
   (iii) Large intestine secretes no enzymes.
   (iv) Bile neutralizes the acid content of the food received from the stomach.
   (v) Pancreatic juice has enzymes to digest all the major components of food.
   (vi) The anus is surrounded by circular muscles.
2. Name the enzyme which digests :
   (i) starch in the mouth (ii) fats in the ileum
   (iii) protein in duodenum (iv) sucrose in the ileum
3. What are the end-products of digestion of :
   (i) Proteins (ii) Fats
   (iii) Starch (iv) Sucrose

11.3 ASSIMILATION OF FOOD

Assimilation is the conversion of the absorbed digested food into body material.

The foods digested and absorbed by the gut are transported in two ways — through hepatic portal

system and through lymphatic system. Simple sugar, amino acids, vitamins and minerals, *etc*. are carried to the liver by the hepatic portal vein. The liver converts any **excess *glucose*** (or other simple sugars) into insoluble ***glycogen*** which can be temporarily stored. When needed the liver reconverts the glycogen into glucose and puts it back in blood circulation. The glucose is required in the body tissues as a source of energy in cellular respiration and also in the synthesis of certain compounds.

The ***amino acids*** circulate in the body and they serve as building blocks of protein. The amino acids cannot be stored. Any excess amino acids are broken down in the liver by a process called **deamination** in which the nitrogen-containing amino group is removed and converted into urea for excretion and the remaining part forms glucose which can be utilized.

The ***fatty acids*** and ***glycerol*** absorbed by the gut are transported mainly through the intestinal villi and lymphatic system. The thoracic duct of the lymphatic system empties into large veins carrying blood to the heart. Some fats are used in the synthesis of certain compounds in the body-cells, the excess quantity is deposited chiefly below the skin as subcutaneous fat or around certain visceral organs in smaller quantity.

13.4 LIVER

The liver is the largest gland of the body weighing about 1500 gm on an average. It is a reddish brown organ located in the upper right side of the abdomen just below the diaphragm.

Extra : **Not in syllabus**

FUNCTIONS OF THE LIVER OTHER THAN PRODUCTION OF BILE

1. **Control of blood sugar levels :** It **regulates blood sugar** by retaining excess glucose received as products of carbohydrate digestion from the intestine and storing it as glycogen, and releasing it again when needed.
2. **Control of amino acid levels :** Excess amino acids are broken to remove the nitrogen part **(deamination)** producing urea and sugar. Urea is eliminated through excretion and sugar is ultilized in metabolism.
3. **Synthesis of foetal red blood cells :** It produces **red blood cells in embryo.** (In adults RBCs are produced in bone marrow).
4. It produces **fibrinogen** and prothrombin which are used in blood clotting.
5. It produces **heparin** (an anticoagulant).
5. It regulates **blood volume** by acting as a temporary store of excess water.
7. It **destroys dead red blood cells.**
8. **Storage :** It **stores iron, copper** and several **vitamins (A & D),** etc.
9. It **excretes** toxic and metallic poisons.
10. It produces **heat** (by cellular metabolism)
11. **Detoxification :** Detoxifies substances including drugs and alcohol.

The liver provides a dependable clue to the suspected cases of poisoning through food, and thus it is an important organ in post-mortem examination.

11.5 CERTAIN EXPERIMENTS ON DIGESTION

1. The action of saliva on starch. Prepare a suspension of some starch by heating 1 gram of it in 100 mL of water in a beaker. Put some of this suspension in two test-tubes. Test a sample from one of the test-tubes for starch (by iodine solution) and another sample from the other test-tube for sugar. Take a little starch suspension in a third test-tube and add to it an equal amount of saliva which you may collect earlier by chewing some wax. Hold this test-tube in your hand for 15 minutes to keep it warm, or you can put the test-tube in a beaker containing water at about 38°C. Next, perform sugar and starch test on the samples taken from it. It will no longer give a positive starch test but will show presence of sugar.

2. The action of pepsin on egg-white (a protein). Stir white of an egg in about 500 mL of water. Boil the mixture and filter it through glass wool. The filtrate will be a cloudy liquid (suspension). Take 4 test-tubes and mark them A, B, C and D. Take a small quantity (about 3 mL) of the suspension in each test-tube. Now add a few drops of 1% solution of pepsin and hydrochloric acid as follows :

Test-tube A—only pepsin

Test-tube B—only HCI

Test-tube C—Pepsin + HCI

Test-tube D—Acid + boiled pepsin solution

Place all the test-tubes in a beaker of water at about 35°C for nearly 10 minutes. Only the test-tube C will show the cloudy suspension changed to a clear solution. The experiment proves three things:

1. Pepsin can digest protein only when it is acidic.
2. Acid alone has no effect on the protein.
3. Boiled pepsin fails to digest protein. In other words, the enzyme pepsin is destroyed by heat.

3. Effect of acidity and alkalinity on an enzyme reaction. In the same experiment as above take a fifth test-tube E in which take the egg white suspension and add to it similar quantity of pepsin plus a few drops of mild sodium bicarbonate solution to make it alkaline, and keep it at 35°C. No change will be noticed in the cloudiness of the suspension. It proves that the pepsin does not act in alkaline medium.

PROGRESS CHECK

Fill in the blanks.

(i) Liver stores glucose as _____.

(ii) Liver produces _____ only in embryo

(iii) Urea is produced in _____ by the de-amination of extra _____.

(iv) For testing the action of saliva on starch the material has to be kept at a temperature of about _____ °C.

11.6 PRACTICAL WORK ON FOOD TESTS

1. TEST FOR GLUCOSE (Sugar)

A little glucose is added to a blue-green chemical called Fehling's solution in a test-tube. Tilt the test-tube away from you and heat it over a flame until bubbles begin to appear but not allowing it to boil over. The colour would change from *blue-green* to a *deep brick red* with the appearance of a precipitate. A small piece of apple or grape will give the same result. Similar test is performed to test sugar in urine of the suspected cases of diabetes (*diabetes mellitus*).

Sucrose (cane-sugar) does not give the above test until after it has been boiled with dilute hydrochloric acid and neutralized with sodium bicarbonate.

2. TEST FOR STARCH

A little starch powder is shaken in a test tube with some water and then boiled to make a solution. When the solution is cold, add a few drops of **iodine solution**. (Iodine solution can be prepared by dissolving 1 g iodine and 1 g potassium iodide in 100 mL of distilled water. The solution should be diluted before using). The starch solution would turn blue-black indicating the presence of starch. Foods like potato and rice give a positive test of starch.

3. TEST FOR PROTEIN

Place a piece of hard-boiled egg-white in a test-tube. Add a few drops of dilute nitric acid just to cover the food (one should be very cautious in using acids). Heat the test-tube gently, then rinse off the acid with water and add ammonium hydroxide. You would note a colour change—first from *white* to *yellow* and then (after adding ammonium hydroxide) from *yellow* to *orange*.

4. TEST FOR FATS AND OILS

Rub a piece of groundnut, walnut, a piece of butter on a plane paper. The spot rubbed turns translucent especially when viewed against light.

TEST FOR THE PRESENCE OF WATER
(Extra information)

Take some cobalt chloride paper which is blue when dry but turns pink on exposure to moisture. The dry cobalt chloride paper can be directly touched with the cut surface of a food like potato or banana to observe the colour change.

TEST FOR THE PRESENCE OF MINERALS
(Extra information)

Place a piece of banana or potato in a crucible. Heat till it burns completely. An ash is left behind that does not burn. The ash indicates mineral substance.

PROGRESS CHECK

Mention the constituent of food if the end result of the test shows:-

(i) White to yellow and yellow to orange colour (after adding ammonium hydroxide).

(ii) Turning blue-black after adding iodine solution.

(iii) Blue green to deep red with appearance of precipitate when added to Fehling solution.

(iv) Ash that does not burn after continued heating.

POINTS TO REMEMBER

- *Digestion is brought about by enzymes which have several characteristic properties.*
- *Chewed by the teeth and swallowed by the tongue the food passes through the oesophagus to reach the stomach.*
- *Carnivores like dog are meat-eaters and they have sharp canines and projections-bearing premolars and molars.*
- *Sheep is herbivorous, has no canines, and premolars and molars have broad grinding surfaces.*
- *Saliva has several functions, including the digestion of starch.*
- *Gastric juice of the stomach kills bacteria and starts digesting proteins only.*
- *Bulk of digestion and absorption of digested food takes place in the small intestine.*
- *Bile and pancreatic juice are poured into the duodenum, and they help in the digestion of fats and of starch, proteins and fats respectively.*
- *The pancreatic juice contains starch-digesting amylopsin, protein-digesting trypsin and fat digesting steapsin.*
- *The colon absorbs water and some remnants of digested food.*
- *The rectum temporarily stores undigested food and wastes, to be defaecated through the anus.*
- *The liver is the largest gland and besides producing bile, it serves several other functions.*
- *There are tests for different foods like iodine test for starch, Fehling test for glucose, etc.*

REVIEW QUESTIONS

A. MULTIPLE CHOICE TYPE

1. Pylorus is an opening from
   (a) oesophagus into stomach
   (b) mouth cavity into oesophagus
   (c) stomach into intestine
   (d) intestine into rectum
2. Gastric juice contains
   (a) HCl and pepsin
   (b) pepsin and trypsin
   (c) trypsin and HCl
   (d) amylopsin and pepsin
3. The water from the digested food is mainly absorbed by
   (a) stomach (b) duodenum
   (c) colon (d) rectum
4. Which one of the following **pairs of types of teeth** perform one common function as stated against it?
   (a) Incisors, canines — Holding
   (b) Canines, premolars — Tearing
   (c) Premolars, molars — Grinding
   (d) Molars, incisors — Tearing

B. VERY SHORT ANSWER TYPE

1. What is the **dental formula** of a normal human adult?
2. Mention *two* reflexes which occur when a person chews and swallows food.
3. Consider the following two statements A & B and select the right from (i)-(iv) about their correctness.
   A. Small intestine is shorter than large intestine.
   B. Small intestine is wider than large intestine.
   Options :
   (i) Both the statements are correct.
   (ii) Both the statements are wrong.
   (iii) Statement A is correct, B is wrong.
   (iv) Statement B is correct, A is wrong.

C. SHORT ANSWER TYPE

1. What is digestion ? Why do only animals require a digestive system ?
2. What are the **end-products** of the digestion of : starch, proteins and fats respectively ?
3. Why is there no enzyme to digest vitamins ?
4. How is thorough chewing of food helpful in digestion ?
5. What is the function of rectum ?
6. What is roughage ? Give *two* examples.
7. Mention *two* ways in which the ileum of a mammal is adapted for the absorption of digested food.
8. The stomach secretes gastric juice, which contains hydrochloric acid. What is its function ?

D. LONG ANSWER TYPE

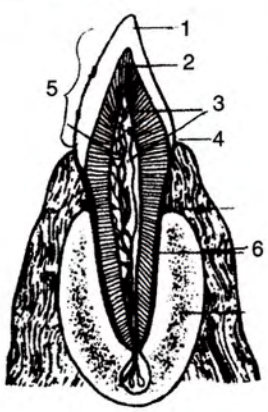
1. Prepare a possible **vegetarian menu** for your dinner which would provide all the necessary nutrients.
2. What are the **main characteristics** of an enzyme ?
3. Why is the small intestine the most important organ of the digestive system ?
4. How is the liver an important organ in our body ?
5. **Define** the following terms :
   (a) Peristalsis (b) Omnivore
   (b) Pylorus (d) Kilocalorie
   (c) Basal metabolic rate
6. List the enzymes and their action on food in the **stomach** and **intestine**.
7. Give any *four* reasons why water is necessary in our body.
8. You have been supplied with a sample of food. How will you perform tests for the presence of **starch** and **proteins** in it ?

E. STRUCTURED/APPLICATION/SKILL TYPE

1. Draw a labelled diagram to show the internal structure of a mammalian tooth with *two roots*.
2. Try to swallow the saliva in your mouth, and feel with your hand your neck. What happens in the neck ?
3. Complete the following table by filling in the blanks 1 to 8.

Organ	Engyme	Food acted upon	Find product
1	Pepsin	2	3
Mouth	4	5	Disaccharide
6	7	Maltose	8

4. Study the diagram given below and then answer the questions that follow :



   (a) Name the parts labelled 1, 2, 3, 4, 5 and 6.
   (b) Identify the tooth and give a reason to support your answer.
   (c) Describe the structure of the part labelled '3'.
   (d) Give the total number of the type of tooth mentioned in '1' above, in the mouth of an adult and state its function.
5. Study the following dental formula and then answer the questions that follow :

$$i\ \frac{3}{4} \quad c\ \frac{0}{0} \quad pm\ \frac{0}{1} \quad m\ \frac{1}{1}$$

   (a) State the total number of teeth present in the dentition.
   (b) Is the dentition that of a carnivore or herbivore ? Give a reason to support your answer.
   (c) Name an animal possessing such a dentition.
   (d) Give the dental formula of an adult human being.

JUMBLED SPELLINGS

Write the correct word for the items (i) to (viii).

(i) A predator:
GRIET .....

(ii) Deficiency of Folic acid (B_{11}) produces
MIAAAEN .....

(iii) A digestive enzyme:
ENPISP .....

(iv) A part of tooth:
TEEDINN .....

(v) Fatty acids are absorbed into :
TACLELAS .....

(vi) Maltase acts on:
LESOMAT .....

(vii) Excess amino acids are broken down in:
RIVEL .....

(viii) An enzmye which digests starch :
YEALMAS .....