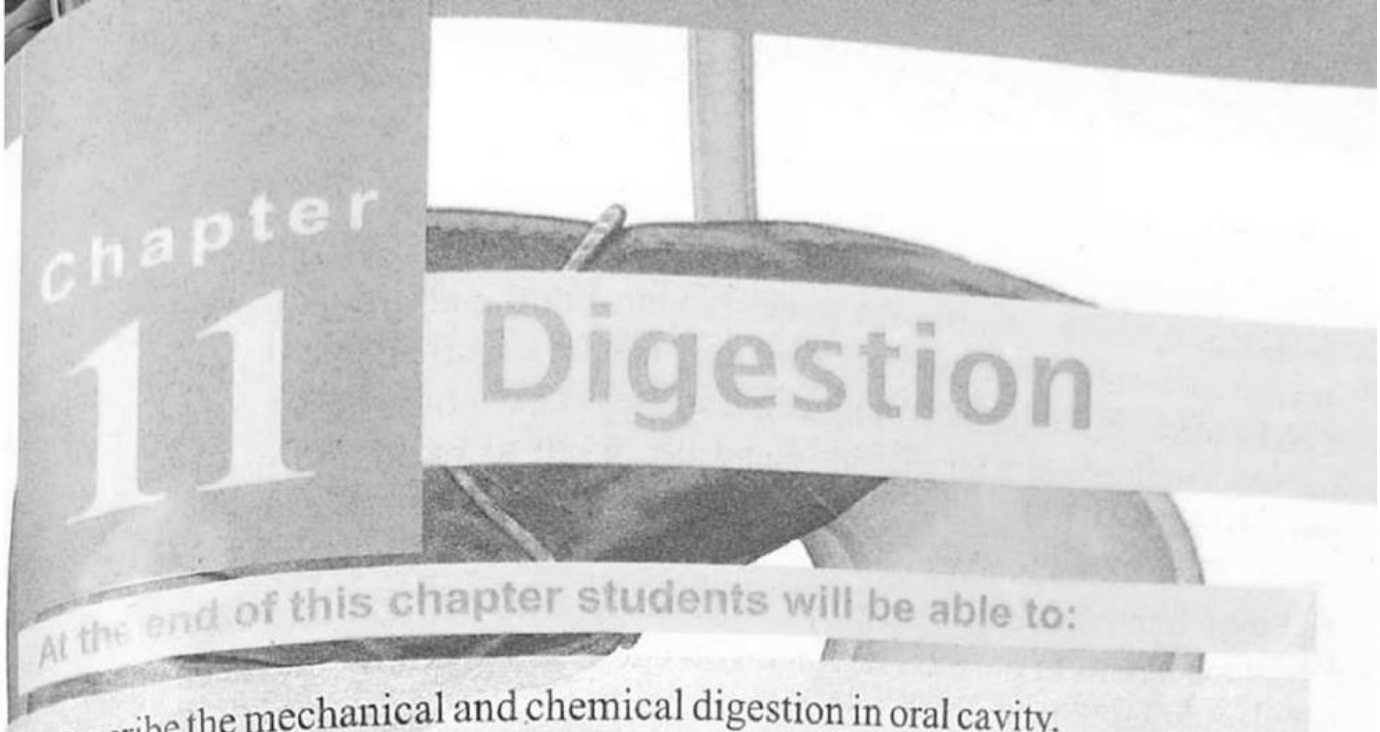


chapter

11 Digestion

At the end of this chapter students will be able to:

- Describe the mechanical and chemical digestion in oral cavity.
- Explain swallowing and peristalsis.
- Describe the structure of stomach and relate each component with the mechanical and chemical digestion in stomach.
- Explain the role of nervous system and gastrin hormone on the secretion of gastric juice.
- Describe the major actions carried out on food in the three regions of the small intestine.
- Explain the absorption of digested products from the small intestine lumen to the blood capillaries and lacteals of the villi.
- Describe the component parts of large intestine with their respective roles.
- Correlate the involuntary reflex for egestion in infants and the voluntary control in adults.
- Explain the storage and metabolic role of liver.
- Describe composition of bile and relate the constituents with respective roles.
- Outline the structure of pancreas and explain its function as an exocrine gland.
- Relate the secretion of bile and pancreatic juice with the secretin hormone.
- Describe the causes, prevention, and treatment of the following disorders; ulcer, food poisoning, dyspepsia.
- Describe obesity in terms of its causes, preventions and related disorders.
- Explain the symptoms and treatments of bulimia nervosa and anorexia

Introduction

When we eat foods—such as bread, meat, and vegetables—they are not in a form that the body can use for nourishment. Food and drink must be changed into smaller molecules of nutrients before they can be absorbed into the blood and carried to cells throughout the body. Digestion is the process by which food is broken down into its smallest parts so the body can use them to build and nourish cells and to provide energy.

Digestion involves mixing food with digestive juices, moving it through the digestive tract, and breaking down large molecules of food into smaller molecules. Digestion begins in the mouth, when you chew and swallow, and is completed in the small intestine.

The digestive system is made up of the digestive tract—a series of hollow organs joined in a long, twisting tube from the mouth to the anus—and other organs that help the body break down and absorb food.There are also two solid digestive organs, the liver and the pancreas, which produce juices that reach the intestine through small tubes. In addition, parts of other organ systems (for instance, nerves and blood) play a major role in the digestive system.

11.1 Mechanical and Chemical Digestion in the Oral cavity

The **gastrointestinal tract** starts in the oral cavity where your teeth grind and chew food, breaking it into small manageable pieces. This chewing process, known as **mastication**, is dependent upon powerful muscles (masseter and temporalis), as well as smaller muscles that permit fine control; they move the mandible (lower jawbone) against the upper jaw and enable crushing of relatively hard food.

Mastication causes exocrine glands under the tongue and in the back of the mouth to secrete a watery liquid called **saliva** which performs two essential functions. It moistens and compacts the chewed food so your tongue can roll it into a ball (bolus) and push it to the back of your mouth for swallowing and easy passage through the pharynx and esophagus.

In addition, saliva contains **digestive enzymes** (e.g. salivary amylase) which begin the breakdown of carbohydrates. Mastication and saliva secretion work in harmony: chewing

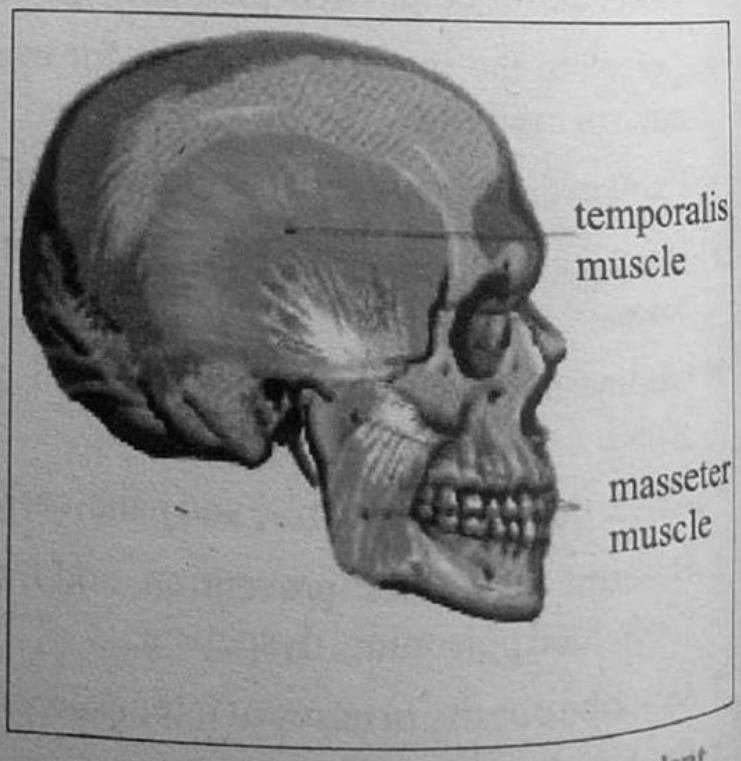


Fig: 11.1 Chewing process is dependent upon masseter and temporalis.

increases the surface area of foods which helps to accelerate the breakdown of starch molecules into simple sugars by the digestive enzymes. Almost no protein or fat digestion occurs in the mouth, except for the release of **lingual lipase** an enzyme secreted by Ebner's glands on the dorsal surface of the tongue.

The actions of the teeth and tongue prepare food for swallowing. When you are ready to swallow, the tongue pushes a piece of chewed food (a bolus) toward the back of your throat and into the opening of the esophagus - the tube which leads to the stomach. To prevent food in the throat from rising into the nasal cavity or moving down the **windpipe** (trachea), the act of swallowing triggers two involuntary events. The **soft palate** (the back of the roof of the mouth) closes off the nasal cavity while the **epiglottis**, a flap of cartilage attached to the root of the tongue tilts downward to seal the **trachea**. The swallowing procedure is regulated by nerves in the medulla oblongata and pons. The reflex is instigated by receptors in the throat as a bolus of food is pushed to the back of the mouth by the tongue.

Tidbit

Choking is a reflex action when food or liquid passes into the trachea; it involves a sudden forceful expulsion of air through the larynx to clear the airway.

11.1.1 Swallowing process

The three stages of swallowing are as follows:

Stage 1: The Oral Stage

Food is placed in the mouth. The process of chewing together with the stimulation of the gums and palate by the movement of food begins some of the reflex activities which take over once the food moves into Stage 2, the pharynx.Enzymes in the saliva help to form the food into a bolus, which the tongue squeezes into the pharynx by moving up towards the palate.

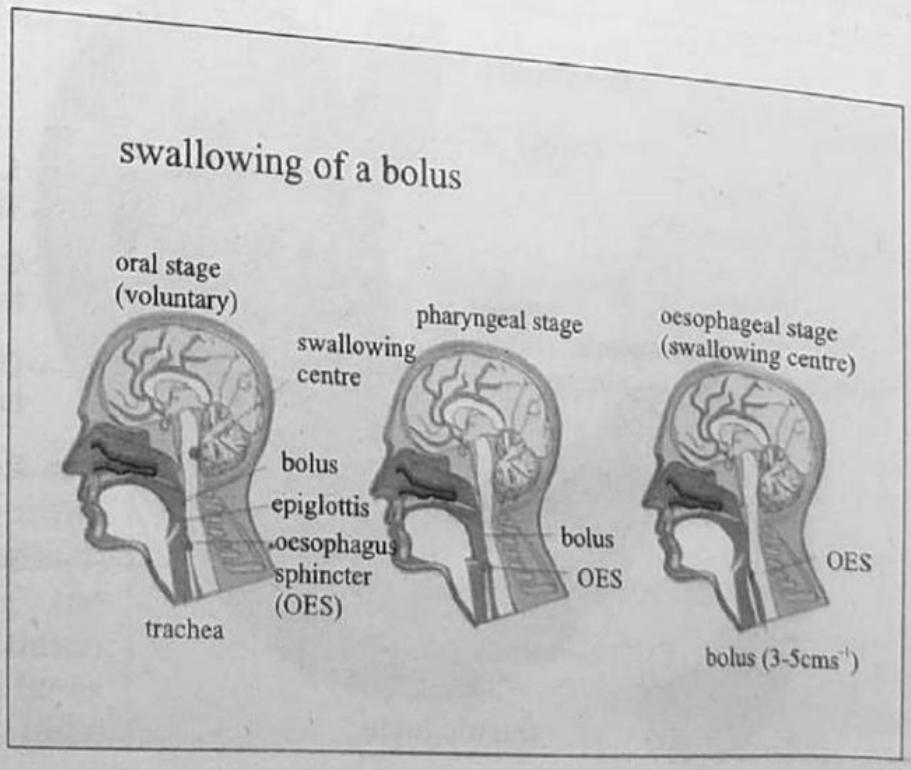


Fig: 11.2 Stages of swallowing process.

Stage 2: The Pharyngeal Stage

The larynx lifts up to meet the epiglottis, which lowers, making a seal that prevents material from entering the windpipe. This is important as it stops food or liquid from being aspirated into the lungs.

Stage 3: The Oesophageal Stage

The bolus is passed into the oesophagus by automatic contractions of the pharynx. It then travels to the stomach by gravity and reflex action. This stage of swallowing is entirely automatic and cannot be controlled.

11.1.2 Peristalsis

Once the food ball enters the esophagus, it is pushed towards the cardiac sphincter by smooth muscle contractions called peristalsis. Food travels from the mouth to the stomach in about 4 to 8 seconds. Peristalsis occurs throughout the length of the digestive tract and is responsible for keeping things moving and the occasional strange sounds that arise. The digestive tract is surrounded by both circular and longitudinal smooth muscle that allows for rhythmic contractions or peristalsis.

11.1.3 Food in stomach

Food enters the stomach from the esophagus, through the lower esophageal sphincter. The stomach is the part where physical and chemical breakdown of food really begins. It operates like a food mixer, churning the food bolus to a pulp called chyme, and releasing numerous chemicals such as digestive hormones, enzymes and gastric juices which help to break down food molecules in the chyme into small

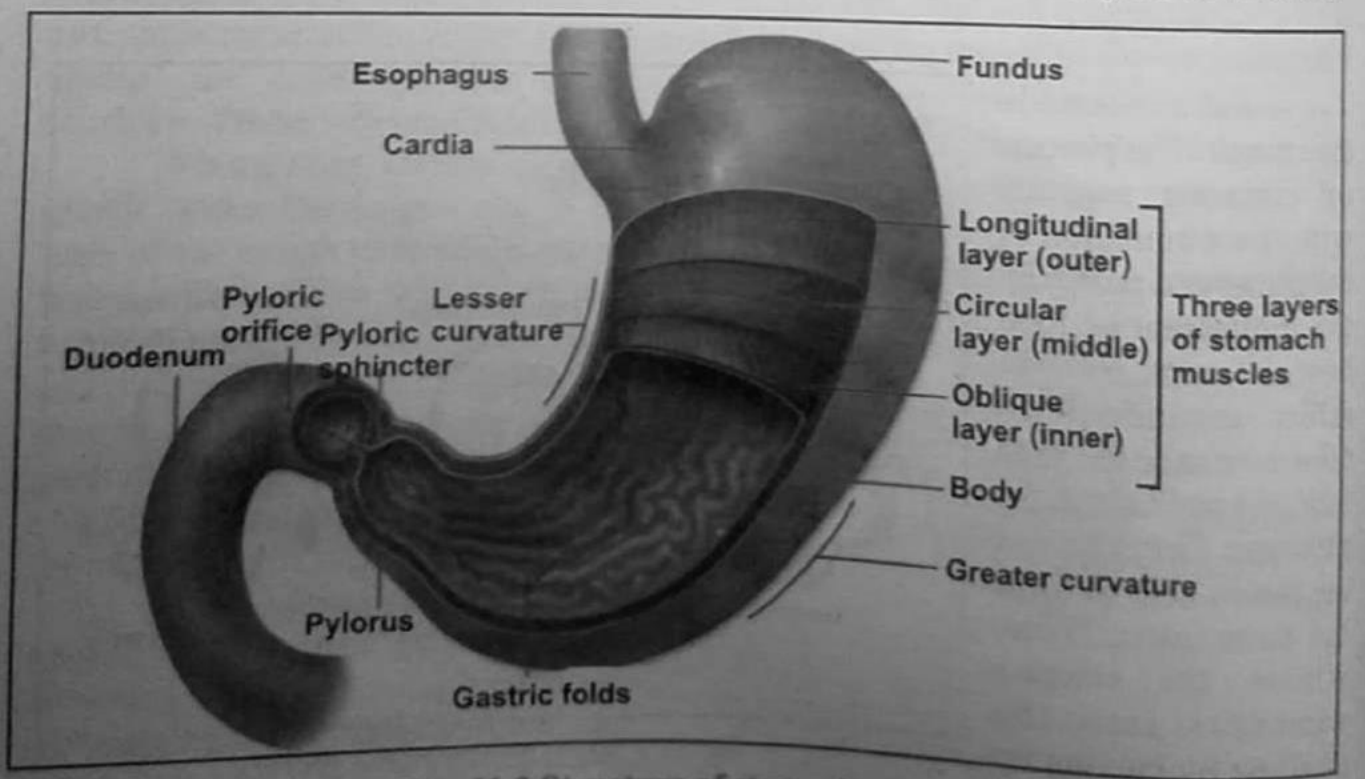


Fig: 11.3 Structure of stomach

articles for further digestion. An empty stomach has a volume of approximately 50 ml. But typically after a meal, its capacity expands to about 1 liter of food, and may expand to hold as much as 4 liters. The chyme slowly exits the stomach via the pyloric sphincter or valve and passes into the duodenum - the first segment of the small intestine - where digestion continues.

1.1.4 Structure of Stomach

The stomach is a muscular organ located on the left side of the upper abdomen. It is subdivided into 4 regions:

Cardiac region: Here the contents of the esophagus empty into the stomach through the lower esophageal or cardiac sphincter.

Fundus: An expanded area curving up above the esophageal opening.

Body: The central and largest region.

Pylorus: The narrow end of the stomach that joins the small intestine at the pyloric sphincter. Like the cardiac sphincter, the pyloric sphincter is a ring of muscle that regulates the movement of food out of the stomach.

The wall of the stomach is lined with millions of **gastric glands**, which together secrete 400–800 ml of gastric juice each meal. Several kinds of cells are found in the gastric glands

- parietal cells
- chief cells
- mucus-secreting cells
- hormone-secreting (endocrine) cells

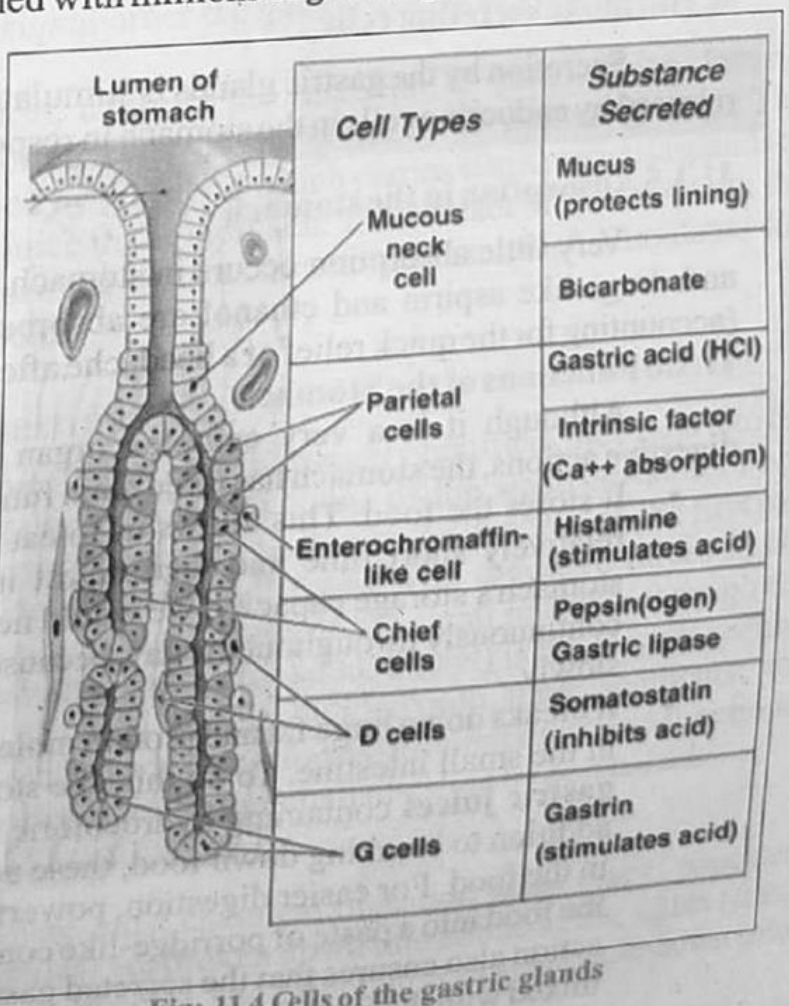


Fig: 11.4 Cells of the gastric glands

Parietal cells

Parietal cells secrete

- hydrochloric acid
- intrinsic factor

Hydrochloric acid (Hcl)

Parietal cells contain a H^+ and ase. This transmembrane ein secretes H^+ ions (protons) active transport, using the gy of ATP. The concentration in the gastric juice can be as as 0.15 M, giving gastric juice some what less than 1.

ii. Intrinsic factor

Intrinsic factor is a protein that binds ingested vitamin B_{12} and enables it to be absorbed by the intestine in intact form.

b. Chief cells

The chief cells synthesize and secrete pepsinogen, the precursor to the proteolytic enzyme pepsin.

c. Mucus secreting cells

Special cells secrete a protective coating called mucus, on the stomach walls to prevent damage from gastric acids. Originally it was thought that peptic ulcers were caused by an erosion of this mucus lining by these acids. However recent research indicates that these ulcers are caused largely by the spread of a type of bacteria called *Helicobacter pylori* bacterium into the gastric walls.

d. Hormone secreting cells

Secretion by the gastric glands is stimulated by the hormone gastrin. Gastrin is released by endocrine cells in the stomach in response to the arrival of food.

11.1.5 Absorption in the stomach

Very little absorption occurs in stomach. However, some water, certain ions, and drugs like aspirin and ethanol are absorbed from the stomach into the blood (accounting for the quick relief of a headache after swallowing aspirin).

11.1.6 Functions of the Stomach

Although it is a very complex organ which performs a wide variety of digestive actions, the stomach has three main functions:

- It stores the food. This allows us to eat a large number of food calories in a relatively short time and then digest it over a longer period. Without the stomach's storage capacity, we would need to eat very small amounts of food continuously throughout the day, because the small intestine digests food very slowly.
- It breaks down large fat and protein molecules in food, so they can be absorbed in the small intestine. To do this, the stomach releases a number of powerful **gastric juices** containing hydrochloric acid and other digestive enzymes. In addition to breaking down food, these acidic juices (pH 1-3) also kill bacteria in the food. For easier digestion, powerful muscles in the stomach wall churn the food into a paste of porridge-like consistency, called chyme. This churning action also ensures that the secreted gastric acids and enzymes are thoroughly mixed with the food.

- It empties **the partially digested chyme into the duodenum** (the first segment of the small intestine) at a manageable speed, through the the pyloric sphincter. While the intestine is full and still digesting food, the stomach acts as storage area for food. The absorption of food and water by the stomach is negligible, but iron and highly fat-soluble substances like alcohol are absorbed directly.

11.1.7 Mechanism of secretion of gastric juice

An interesting question is raised here. What causes gastric juice to be secreted? There are two possible answers to this question – chemical control and nervous control. Sometimes even the sight, smell, taste or hearing of delicious food, stimulate the nervous system which orders for the secretion of small amount of gastric juice like watering of mouth. This is proved by the experiment of Russian, Pavlov. He cut the esophagus of a dog and left the cut end open to the outside.

When he fed this dog, the food, of course, never reached the stomach, yet the stomach resulted in the secretion of about one fourth the normal amount of gastric juice. This showed that the gastric secretion was under the reflex control and cutting of the gastric nerves proved it. If there are more proteins in the food, a signal is sent to the brain which in response to this signal order the gastric glands to secrete more gastric juice.

A hormone called gastrin, controls the secretion of gastric juice. Protein molecules stimulate the endocrine cells of the stomach to secrete gastrin. The liberating gastrin is soon absorbed by the blood which carries it to the gastric glands to secrete large amount of gastric juice in the stomach. The contact of the food with the lining of the stomach also causes the cells to secrete gastrin which stimulated the gastric glands to secrete gastric juice.

11.2 Food in the Small Intestine

As the contents of the stomach become thoroughly liquified, they pass into the **duodenum**, the first segment (about 10 inches long) of the small intestine. Food typically takes 4-5 hours to pass through the stomach into the duodenum, the first part of the small intestine.After being churned and mixed with digestive juices in the stomach, food chyme moves slowly into the folds of the small intestine through the pyloric sphincter or valve. The small intestine (or small bowel) is the longest section of the digestive tract (approx 17 feet) and is divided into three segments: the duodenum, jejunum and ileum, each of which performs different digestive functions. Chyme from the stomach is propelled through the small intestine by peristalsis.

11.2.1 Functions of the Small Intestine

The small intestine is where most chemical digestion takes place; peptides (complex chains of protein molecules) are broken down into amino acids; lipids (fats) are broken down into fatty acids and glycerol; and carbohydrates are broken down into

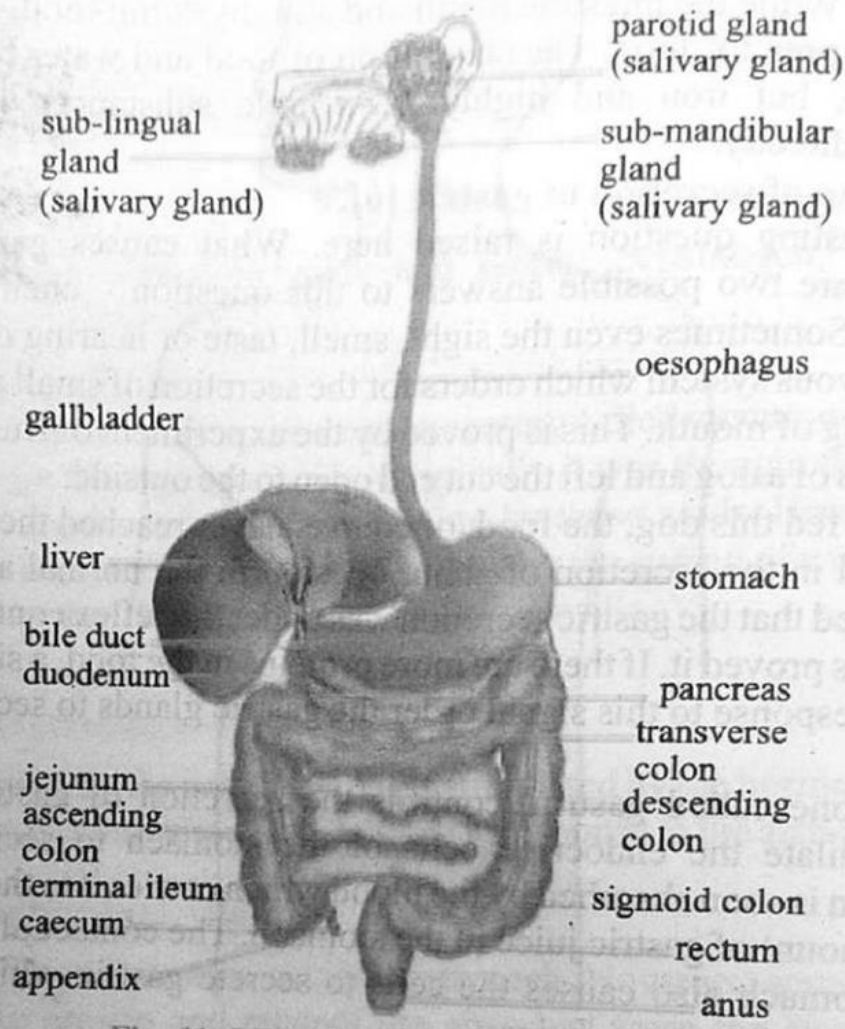


Fig: 11. 5 The Human Alimentary canal

simple sugars like glucose. To accomplish this, chyme is mixed with additional digestive juices including bile from the liver and pancreatic juice and amylase from the pancreas, as well as other intestinal enzymes such as maltase, lactase and sucrase to break down the chyme and assist in nutrient absorption. Absorbed nutrients flow in the bloodstream to the liver where they are further metabolized and then either stored or sent to cells in other parts of the body. In total, food typically takes 4-5 hours to transit all three sections of the small intestine. Along the way its consistency changes from porridge (chyme) to a thin watery mixture.

Do You Know?

Since the small intestine (about 17 feet) is much longer than the large intestine (about 5 feet) people often wonder why it is referred to as "small". The answer lies in its diameter (3-4 cm), which is about 3 times narrower than the "large" intestine.

11.2.2 Digestive Function of the Duodenum

The duodenum continues the process of food breakdown. Its name stems from the Latin "duodenum digitorum", meaning twelve fingers or inches. It is roughly horse-shoe-shaped. Anatomically, it is is sub-divided into four segments: the superior, descending, horizontal and ascending duodenum. Inside the duodenal tube, chyme is mixed with fluids from the gallbladder (bile) and pancreas (pancreatic juice). Bile breaks down fat particles into smaller droplets, while pancreatic juice contains enzymes that convert fats into fatty acids and glycerol, and sodium bicarbonate to neutralize stomach acid.

11.2.3 Digestive Function of the Jejunum

Roughly 4-7 feet in length, the jejunum is where chemical breakdown of the food chyme is completed. Pancreatic enzymes, along with enzymes produced by the jejunum wall, finalize the food digestion process. The term jejunum stems from the Latin jejunus, meaning empty.

11.2.4 Digestive Function of the Ileum

Ileum is 5-7 feet long. It is the final section of the intestine and is connected to large intestine by the ileocecal valve.The main function of the ileum is to absorb nutrients. Bile is also absorbed here and returns to the liver through blood vessels in the intestinal walls.The unabsorbed watery remains of the food chyme now pass into the large intestine for water-removal and final processing, before being expelled from the body.

11.2.5 Absorption of Nutrients in the Small Intestine

It is inside the small intestine that we absorb most of the nutrients in our food. Although the small intestine has a relatively small diameter, the intestinal walls are covered in wrinkles called rugae, which are themselves covered in millions of finger-like projections called villi, which are themselves studded with millions of smaller projections called microvilli. This provides a surface-area of about the size of a tennis court for nutrient absorption. Inside each villus is a series of lymph vessels (lacteals) and blood vessels (capillaries). The lacteal lymph vessel absorbs digested fat into the lymphatic system which eventually drains into the bloodstream. The blood vessels receive other nutrients and transport them via the hepatic portal vein to the liver. Here the blood is filtered, toxins are removed and the nutrients are processed. An important task performed by the liver in this context is the regulation of blood glucose levels to provide sufficient energy for the body. Excess glucose is converted in the liver to glycogen in response to the hormone insulin, and stored. When blood glucose levels begin to drop, (eg. between meals), the glycogen is re-converted to glucose in response to messages conveyed by the hormone glucagon.

11.3 Digestion in the Large Intestine

After all nutrients have been absorbed from ingested food during its passage through the small intestine, the watery waste passes into the large intestine. It is the final section of the gastrointestinal tract and its main function is to remove water (plus any remaining minerals) from the food waste and compress it into a form for easy expulsion from the body. As the chyme passes through the large intestine, the water is removed and the chyme is combined with mucus and bacteria (gut flora), and is converted into feces.

As in the esophagus and small intestine, undigested food is propelled through the large intestine by waves of muscular contraction and expansion, called peristalsis. However, unlike in the small intestine where these waves occur at irregular intervals, peristalsis in the large intestine is continuous. In addition, 2-3 times a day, a more vigorous type of movement (gastrocolic reflex) occurs which propels material towards the rectum and anus. As waste matter is pushed into the rectum, it triggers a desire to defecate.

11.3.1 Structure of the large intestine

The large intestine (also referred to as the large bowel, or the lower gastrointestinal tract) is a thick tube of about 5 feet in length which gets progressively narrower in diameter. It consists of four regions: the ceacum, colon, rectum, and anal canal. (The term "colon" is sometimes used to describe the entire large intestine). The cecum (or caecum) is a short pouch into which food enters from the ileum (via the ileocecal valve) and exits into the ascending colon of the large intestine. The colon is the longest segment of the large intestine. It is sub-divided into four sections, named after their position in the pelvis: the ascending colon, transverse colon, descending colon and sigmoid colon. The rectum is the final part of the large intestine. Feces formed in the colon collect in the rectum before being excreted via the anus. After the rectum comes the anal canal, a short passage about 1.5 inches long, terminating in two muscular rings: the internal and external sphincters. As waste products from the rectum pass into the anal canal, nerves in the rectum cause the internal sphincter to relax and open. Then the external sphincter also relaxes, permitting fecal discharge. Defecation may be involuntary or under voluntary control. Young children learn voluntary control through the process of toilet training. Once trained, loss of control causing fecal inconvenience may be caused by physical injury (such as damage to the anal sphincter, intense fright, inflammatory bowel disease, impaired water absorption in the colon and psychological or neurological factors.

11.4 Liver

The liver is one of the most important and largest organ in the human body. It is located in a central position of the abdomen, and is closely involved in almost every aspect of the body's physiological activities. Because of its central role, liver disease

can be extremely life-threatening. The liver has a multitude of important and complex functions. Some of these functions are:

a. Carbohydrate metabolism

Glucose is a vital energy source for cells and its levels in the blood stream must remain constant. The liver helps maintain blood glucose levels in response to the pancreatic hormones insulin and glucagon. After a meal, glucose enters the liver and levels of blood glucose rise. This excess glucose is dealt with by **glycogenesis** in which the liver converts glucose into glycogen for storage. The glucose that is not stored is used to produce energy by a process called glycolysis. This occurs in every cell in the body.

In between meals or during starvation, blood glucose levels fall. The hepatocytes (bile secreting liver cells) detect this change, and restore glucose levels by either glycogenolysis which converts glycogen back to glucose, or gluconeogenesis in which non-sugars such as amino-acids are converted to glucose.

b. Fat metabolism

The liver is involved in fat metabolism and synthesizes lipoproteins, cholesterol and phospholipids essential for many body functions. If fat is in excess, the liver prepares for storage. Lipogenesis is the metabolic process in which fats, composed of fatty acids and glycerol, are converted for storage in subcutaneous tissue and other storage depots.

If energy and glucose levels are low, stored fat is converted back into glycerol and fatty acids by a process called lipolysis. This occur in adipose cells, but the fatty acids and glycerol are transported to the liver for use as an alternative energy supply.

c. Protein metabolism

Amino acids are transported to the liver during digestion and most of the body's protein is synthesized here. If protein is in excess, amino acids can be converted into fat and stored in fat depots, or if required, made into glucose for energy by gluconeogenesis which has already been mentioned. However, before amino acids can be utilized in these ways, the first step is to remove the nitrogen-containing amino group NH_2. This very important metabolic process is called deamination.In the hepatocytes, NH_2 (the amino group) quickly changes into ammonia NH_3, which is highly toxic to the body. The liver acts fast to convert ammonia into urea that then can be excreted in the urine and eliminated from the body.

d. Detoxification

The liver plays a vital role in detoxification and destruction of endogenous and exogenous harmful substances. The liver's own phagocytes which reside within the lobules, known as Kupffer cells, digest and destroy cellular debris and any invading bacteria. Other exogenous substances such as drugs and alcohol are detoxified by the liver. Amino acids are deaminated, some hormones are inactivated, and bilirubin, a product of the breakdown of old red blood cells, is also detoxified and rendered

harmless by liver metabolism.

e. Storage

The liver plays an important role as a storage facility. The hepatocytes take up many types of vitamins and minerals from the blood and store them. These include vitamins A, B_{12}, D, E, K and minerals like iron and copper. Glycogen which is formed from excess glucose is also stored by the liver, although muscle tissue can also store glycogen too.

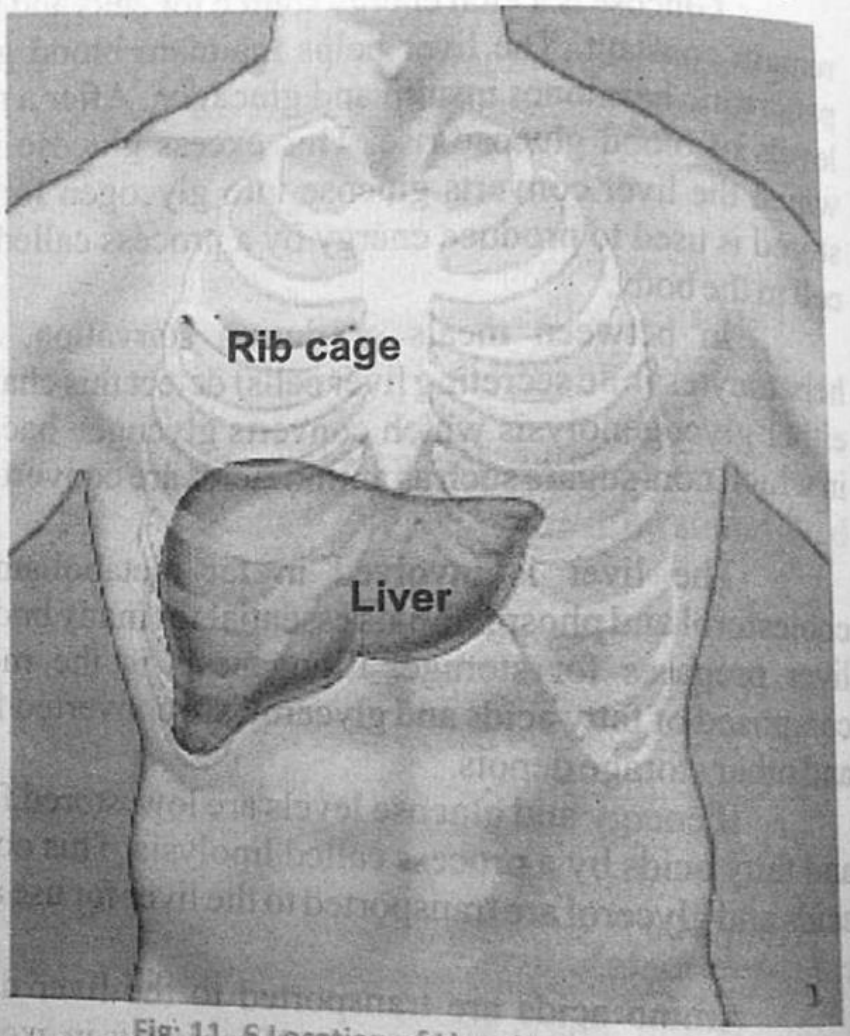


Fig: 11. 6 Location of Liver in rib cage

f. Bile

The liver synthesizes bile which is important for fat digestion and is also a route of excretion from the body. Bile consists of water, bile salts, cholesterol, phospholipids, electrolytes and bile pigments which give it its typical yellowish-green colour. Bile is stored and concentrated in the gall bladder. The presence of fats in the gut during meals stimulates the gall bladder to empty. Bile enters the duodenum emulsifying fats into smaller globules, which can then be broken down further by lipase enzymes. Metabolic wastes and drug products may form part of the bile which can then be excreted from the body through the digestive tract in the faeces. Bilirubin, the toxic end product of haemoglobin breakdown, is excreted from the body in this way.

11.5 Pancreas

The pancreas is located in the abdomen. It is pink in color and lies in close to the duodenum. It can be divided into three regions: the head, the body and the tail. The head is an expanded portion that lies in the C-shaped region of the duodenum to 'which it is intimately attached by connective tissue, and which is connected by a common blood supply. The body and tail extend across the midline of the body towards the hilum of the spleen.

1.5.1 Structure of Pancreas

The bulk of the pancreas is composed of pancreatic exocrine cells and their associated ducts. Embedded within this exocrine tissue are roughly one million small clusters of cells called the ***Islets of Langerhans***, which are the endocrine cells of the pancreas and secrete insulin, glucagon and several other hormones.

Pancrease has two main components – Acinar cells and Ducts. These two constitute 80% to 90% of the pancreatic mass. Twenty to forty acinar cells join into a unit called the acinus. Acinar cells secrete the digestive enzymes. In each acinus another type of cells called centroacinar cells are present which are responsible for fluid and electrolyte secretion by the pancreas.

Ductular system of pancreas consists of a network of conduits that carry the exocrine secretions into the duodenum. The contents of acinus drains into small intercalated ducts and then to interlobular duct from where it passes into pancreatic duct. Interlobular ducts contribute to fluid and electrolyte secretion along with the centroacinar cells

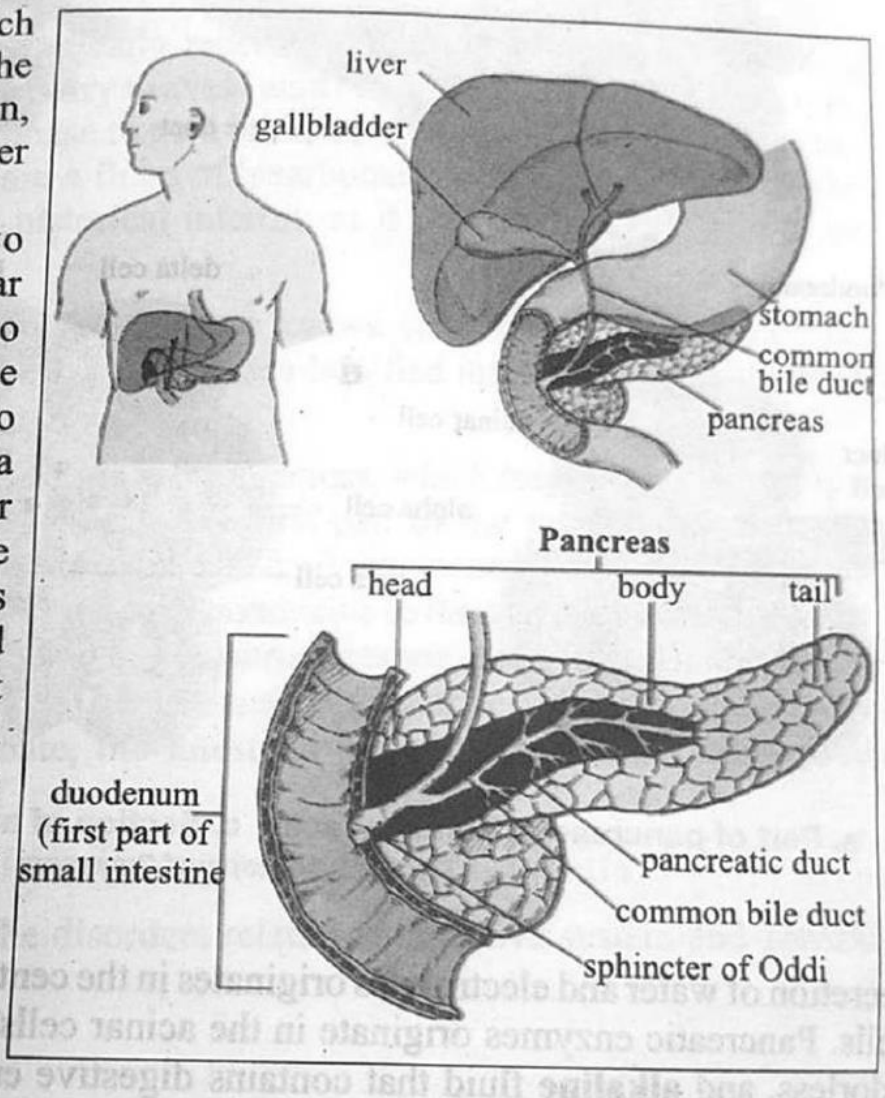
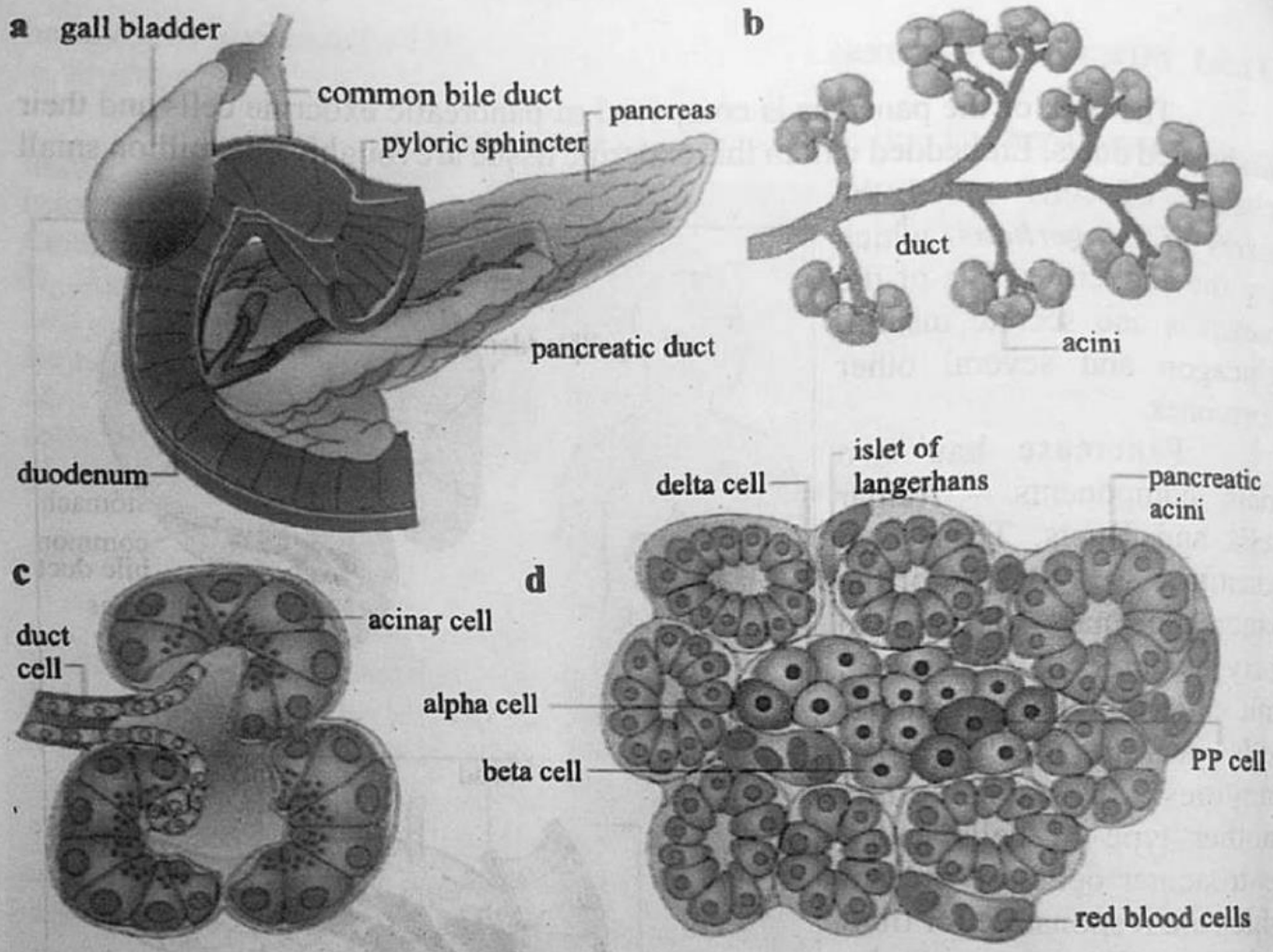


Fig: 11. 7 The Structure of Human Pancreas

Accounts for only 2% of the pancreatic mass there are nests of cells called as islets of Langerhans which consists of the following four major cell types

a. Alpha (A) cells secrete glucagon.
b. Beta (B) cells secrete insulin.
c. Delta (D) cells secrete somatostatin.
d. F cells secrete pancreatic polypeptide.



a. Part of pancreas b. Bunch of acini c. Section of acini d. Section of acinar

Fig: 11. 8 Anatomy of Pancrease

Secretion of water and electrolytes originates in the centroacinar and intercalated duct cells. Pancreatic enzymes originate in the acinar cells. Final product is a colorless, odorless, and **alkaline** fluid that contains digestive enzymes (amylase, lipase, and trypsinogen). 500 to 800 ml of pancreatic fluid is secreted per day. Alkaline pH results from secreted bicarbonate which serves to neutralize gastric acid and regulate the pH of the intestine. Enzymes digest carbohydrates, proteins, and fats.

Acinar cells secrete isozymes like amylases, lipases, and proteases. These are synthesized in the endoplasmic reticulum of the acinar cells and are packaged in the zymogen granules. Released from the acinar cells into the lumen of the acinus and then transported into the duodenal lumen, where the enzymes are activated

Amylase is the only digestive enzyme secreted by the pancreas in an active form. It functions optimally at a pH of 7. It hydrolyzes starch and glycogen to glucose, maltose, maltotriose, and dextrins. Lipase function optimally at a pH of 7 to 9. It emulsify and hydrolyze fat in the presence of bile salts. Proteases are essential for

protein digestion. These are secreted as proenzymes and require activation for proteolytic activity. Duodenal enzyme, enterokinase, converts trypsinogen to trypsin. Trypsin, in turn, activates chymotrypsin, elastase, carboxypeptidase, and phospholipase.

11.6 Relation of bile and pancreatic juice with the secretin hormone

The small intestine periodically receives acid from the stomach, and it is important to put out that fire in a hurry to avoid acid burns. Secretin functions as a type of fireman: it is released in response to acid in the small intestine, and stimulates the pancreas and bile ducts to release a flood of bicarbonate base, which neutralizes the acid. Secretin is also of some historical interest, as it was the first hormone to be discovered.

Secretin is secreted in response to one known stimulus: acidification of the duodenum, which occurs most commonly when liquified ingesta from the stomach are released into the small intestine.

The principal target for secretin is the pancreas, which responds by secreting a bicarbonate-rich fluid, which flows into the first part of the intestine through the pancreatic duct. Bicarbonate ion is a base and serves to neutralize the acid, thus preventing acid burns and establishing a pH conducive to the action of other digestive enzymes. A similar, but quantitatively less important response to secretin is elicited by bile duct cells, resulting in additional bicarbonate being dumped into the small gut. As acid is neutralized by bicarbonate, the intestinal pH rises toward neutrality, and secretion of secretin is turned off.

11.7 Disorders related to digestive system and food habits

Following are some of the disorders related to digestive system and general food habits.

11.7.1 Ulcer

Destruction of the gastric or intestinal mucosal lining of the stomach by hydrochloric acid is a direct cause of peptic ulcer. Infection with the bacterium *Helicobacter pylori* is thought to play an important role in causing both gastric and duodenal ulcers. *Helicobacter pylori* may be transmitted from person to person through contaminated food and water.

Injury of the gastric mucosal lining, and weakening of the mucous defenses are also responsible for gastric ulcers. Excess secretion of hydrochloric acid, genetic predisposition, and psychological stress are important contributing factors in the formation and worsening of duodenal ulcers. Another major cause of ulcers is the chronic use of anti-inflammatory medications, such as aspirin. Cigarette smoking is also an important cause of ulcer formation and ulcer treatment failure.

The stomach defends itself from hydrochloric acid and pepsin by creating a mucus coating (that shields stomach tissue), by producing bicarbonate and by circulating blood to the stomach lining to aid in cell renewal and repair. If any of these functions are impaired it can lead to the formation of an ulcer. Peptic ulcers were formerly thought to be caused by stress, coffee consumption, or spicy foods. Now it is clear that about 60% of peptic ulcers are caused by a bacterial infection that can usually be cured. The bacterium (*H. pylori*) was established as the leading cause of peptic ulcers in the early 1980s. It was also found to cause gastritis (inflammation of the stomach lining).

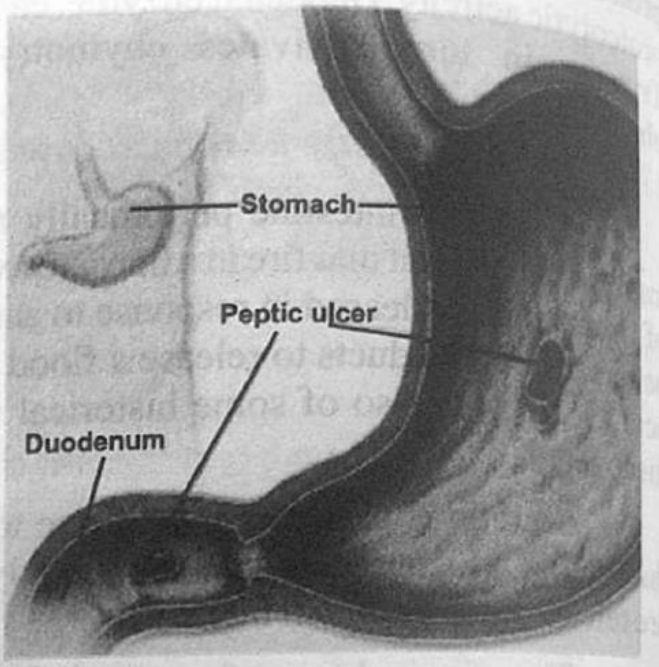


Fig: 11.9 Ulcer is the destruction of mucosal lining.

H. pylori weakens the stomach's defenses by thinning the mucous coating of the stomach, making it more susceptible to the damaging effects of acid and pepsin; inflaming the area; poisoning nearby cells and producing more stomach acid.

Treatment

Most commonly, ulcers related to *H. pylori* are treated with a two week course of treatment called triple therapy, consisting of two antibiotics to kill the bacteria and either an acid suppressor or stomach-lining shield medication.

11.7.2 Obesity

Obesity refers to an increase in total body fat. Obesity or weight gain occurs when we eat more calories than our body uses up. If the food we eat provides more calories than our body needs, the excess is converted to fat. Initially, fat cells increase in size. When they can no longer expand, they increase in number. If we lose weight, the size of the fat cells decreases, but the number of cells does not.

a. Causes of obesity: Obesity, however, has many causes. The reasons for the imbalance between calorie intake and consumption vary by individual. Age, sex, and genes, psychological makeup, and environmental factors all may contribute.

b. Genes and environmental factors: Having obese relatives does not guarantee that you will be obese; however, obesity tends to run in families. This is caused both by genes and by shared diet.The most important environmental factor is lifestyle. Your eating habits and activity level are partly learned from the people around you.

Overeating and sedentary habits (inactivity) are the most factors for obesity.

c. **Age and Sex:** People tend to lose muscle and gain fat as they grow older. Their metabolism also slows somewhat. Both of these lower their calorie requirements. Men have more muscle than women, on average. Because muscle burns more calories than other types of tissue, men use more calories than women, even at rest. Thus, women are more likely than men to gain weight with the same calorie intake.

d. **Emotions:** Some people overeat because of depression, hopelessness, anger, boredom, and many other reasons that have nothing to do with hunger. Their feelings influence their eating habits, causing them to overeat.

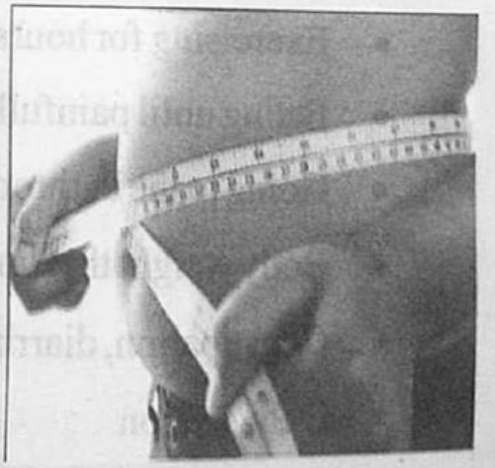
e. **Pregnancy:** Women tend to weigh an average of 4-6 pounds more after a pregnancy than they did before the pregnancy. This weight gain may contribute to obesity in women.

f. **Medical conditions and Medications:** Certain medical conditions and medications can cause or promote obesity, although these are much less common causes of obesity than overeating and inactivity. Some examples of these are as follows: Hypothyroidism, Cushing syndrome, Depression.

g. **Risk factors associated with obesity**

It is the second leading cause of preventable death (after smoking), and is associated with type II diabetes, hyperlipidaemia (presence of excess lipids in the blood), coronary artery disease, arthritis, gallstones, psychosocial disability. Certain cancers - colon, rectum and prostate in men; uterus, biliary tract, breast and ovary in women - are more prevalent in the obese.

Are you obese or not? Try this.



The easiest and most widely accepted method of determining whether you are obese is by measuring your Body Mass Index, or BMI. To calculate your BMI, follow these steps:

1. Multiply your weight in pounds by 705; divide by your height in inches; divide this number by your height in inches a second time.

A normal BMI = 18.5 to24.9; overweight=25.0 to 29.9; obese = 30 or greater; and morbidly obese = 40 or greater.

h. Treatment of Obesity

Successful programs for weight loss reduction and maintenance should be started and followed under the care of a physician and/or a nutritionist. A weight-loss program may include:

- Exercise (30 minutes of physical activity on most days of the week)
- A low-fat, high-complex carbohydrate, high fiber diet
- Behavior modification to change eating behavior
- Social support
- Medications

11.7.3 Bulimia nervosa

Bulimia nervosa is an eating disorder in which a person may eat a lot of food at once and then try to get rid of the food by vomiting, using laxatives, or sometimes over-exercising. People with bulimia are preoccupied with their weight and body image. Bulimia is associated with depression and other psychiatric disorders and shares symptoms with anorexia nervosa, another major eating disorder. Because many individuals with bulimia can maintain a normal weight, they are able to keep their condition a secret for years. If not treated, bulimia can lead to nutritional deficiencies and even fatal complications.

a. Signs and Symptoms:

Bulimia is often accompanied by the following signs and symptoms:

- Binge eating of high-carbohydrate foods, usually in secret
- Exercising for hours
- Eating until painfully full
- Going to the bathroom during meals
- Body weight that goes up and down
- Constipation, diarrhea, nausea, abdominal pain
- Dehydration
- Irregular menstruation or lack of menstrual periods in females
- Damaged tooth enamel, bad breath, sore throat or mouth sores
- Depression

b. Treatment:

Psychotherapy is a cornerstone of bulimia treatment. Cognitive behavioral therapy, which teaches you to replace negative thoughts and behaviors with healthy ones, is often used. Other mind-body and stress-reduction techniques, such as yoga, tai chi, and meditation, may help you become more aware of your body and form a more positive body image.. It is important for the person with bulimia to be actively involved in their treatment. Antidepressants are often prescribed for bulimia.

11.7.4 Anorexia nervosa

Anorexia is an emotional disorder that focuses on food, but it is actually an attempt to deal with perfectionism and a desire to control things by strictly regulating food and weight. People with anorexia have an extreme fear of gaining weight, which causes them to try to maintain a weight far less than normal. They will do almost anything to avoid gaining weight, including starving themselves or exercising too much. Anorexia most commonly affects teens. Although anorexia seldom appears before puberty.It can be a chronic disease, one that you deal with over your lifetime. But treatment can help you develop a healthier lifestyle and avoid anorexia's complications.

a. Signs and Symptoms:

The primary sign of anorexia nervosa is severe weight loss. People with anorexia may try to lose weight by severely limiting how much food they eat. They may also exercise excessively. Some people may engage in binging and purging, similar to bulimia. They may vomit after eating or take laxatives. At the same time, the person may insist that they are overweight.

b. Physical Signs

- Excessive weight loss
- Very rare menstrual periods
- Thinning hair, dry skin
- Bloated or upset stomach
- Low blood pressure
- Fatigue
- Abnormal heart rhythms
- Osteoporosis

c. Psychological and Behavioral Signs

Anorexia patients have distorted perception of self (insisting they are overweight when they are thin). Being preoccupied with food thoughts they refuse to eat and also refusing to acknowledge the seriousness of the illness. They suffer from

depression and refuse to eat in public. Such patients constantly weigh themselves and do regular excercises.

e. Treatment:

The most successful treatment is a combination of psychotherapy, family therapy, and medication. It is important for the person with anorexia to be actively involved in their treatment.

11.7.5 Food Poisoning

This type of intestinal condition is characterized by sudden illness caused by eating food or drinking liquids contaminated by a toxin or infectious organism. Poor food hygiene is a risk factor.

a. Symptoms of food poisoning

The symptoms may start hours or days after consuming the contaminated food. Usually the symptoms are confined to the gastrointestinal tract. However, some food poisoning may cause more widespread symptoms. For example, the *Clostridium Botulinum* bacterium (Botulism) causes muscle weakness and paralysis, and Listeriosis may cause flu-like symptoms and lead to meningitis.

b. Causes of food poisoning

Most cases of food poisoning result from contamination of food or water by bacteria, viruses or, less commonly, protozoan parasites. Unhealthy food hygiene can enable these microorganisms to multiply. In some cases of bacterial food poisoning, it is not the presence of the bacteria themselves that cause poisoning but the effect of toxins produced by the bacteria. If infectious organisms are ingested with the food they can multiply in the digestive tract. If the food poisoning is caused by bacterial toxins, they may be produced in the food before it is eaten. Most types of food poisoning cause diarrhea and/or vomiting, often with abdominal pain. The severity of symptoms and the speed at which they develop and the duration of the illness depends on the cause of food poisoning.

Major food Poisoning Agents

i. ***Staphylococci***
ii. ***Escherichia Coli***
iii. ***Salmonella***
iv. ***Campylobacter***

c. Treatment of food poisoning

Treatment of food poisoning is usually aimed at preventing dehydration. In severe cases fluids and salts may be administered intravenously in hospital. Typically,

antibotics are prescribed only if specific bacteria have been identified. Patients usually recover quite rapidly from an attack of food poisoning and rarely experience longlasting health consequences. In very rare cases, there is a risk of **septicemia** if bacteria spread into the blood stream. Both dehydration and septicemia can cause shock - a condition that is sometimes fatal.

11.7.6 Dyspepsia

Pain or discomfort in the upper abdomen that is not associated with a structural abnormality. Dyspepsia describes recurrent and persistent indigestion that occurs without an identifiable cause or abnormality of the digestive tract. The condition is more common in adults, especially men, and may be made worse by stress, obesity, smoking and a diet high in rich, fatty foods.

a. Symptoms of dyspepsia

The symptoms of dyspepsia may include pain in the upper abdomen, often made worse by eating, and nausea, particularly in the morning. Patients with Non-ulcer Dyspepsia often experience these symptoms several times a week for months.

b. Treatment for dyspepsia

A blood test may be carried out to check for infection of the stomach lining from the bacterium *Helicobacter pylori*. Also, upper digestive tract endoscopy or contrast X-Rays may be carried out to look for abnormalities in the gastrointestinal tract.

c. Prevention of dyspepsia

In order to help reduce both the frequency and severity of bouts of indigestion, follow these steps:

- Eat small portions of food at regular intervals, without eating too fast or overfilling your stomach.
- Avoid eating in the three hours before going to bed to allow your body enough time to digest food.
- Avoid rich, fatty foods such as butter and fried foods.
- Learn to overcome stress, which can often trigger episodes of abdominal discomfort.
- If overweight, try to reduce weight and avoid tight fitting clothing.
- If possible, avoid medicines that irritate the digestive tract, such as aspirin and other nonsteroidal anti-inflammatory drugs.

KEY POINTS

- Digestion is the process by which food and drink are broken down into their smallest parts so the body can use them to build and nourish cells and to provide energy.
- Peristalsis occurs throughout the length of the digestive tract and is responsible for keeping things moving.
- Stomach is subdivided into four regions which are: the Cardiac region, the Fundus, the Body and the Pylorus.
- A hormone called gastrin, controls the secretion of gastric juice. Protein molecules stimulate the endocrine cells of the stomach to secrete gastrin.
- The small intestine has a relatively small diameter, the intestinal walls are covered in wrinkles called rugae, which are themselves covered in millions of finger-like projections called villi.
- The large intestine is a thick tube which gets progressively narrower in diameter and it consists of four regions: the ceacum, colon, rectum, and anal canal.
- The liver helps maintain blood glucose levels in response to the pancreatic hormones insulin and glucagon.
- Lipogenesis is the metabolic process in which fats, composed of fatty acids and glycerol, are converted for storage in subcutaneous tissue and other storage depots.
- If energy and glucose levels are low, stored fat is converted back into glycerol and fatty acids by a process called lipolysis.
- The liver plays a vital role in detoxification and destruction of endogenous and exogenous harmful substances.
- The bulk of the pancreas is composed of pancreatic exocrine cells and their associated ducts. Pancreatic exocrine cells are arranged in grape-like clusters called acini.
- Secretin is released in response to acid in the small intestine, and stimulates the pancreas and bile ducts to release a flood of bicarbonate base, which neutralizes the acid.
- Destruction of the gastric or intestinal mucosal lining of the stomach by hydrochloric acid is a direct cause of peptic ulcer.
- Obesity or weight gain occurs when we eat more calories than our body uses up.
- Bulimia nervosa is an eating disorder in which a person may eat a lot of food at once and then try to get rid of the food by vomiting, using laxatives, or sometimes over-exercising.
- Anorexia is an emotional disorder which deals with perfectionism and a desire to control things by strictly regulating food and weight.
- Dyspepsia describes recurrent and persistent indigestion that occurs without an identifiable cause or abnormality of the digestive tract.

EXERCISE

Choose the correct answers in the following questions.

1. Which of the following convert's pepsinogen to the active form of pepsin in the stomach?
   a. Mucus
   b. Gastrin
   c. HCl
   d. Chief cells

2. Which of the following does NOT manufacture digestive juices?
   a. Liver
   b. Kidneys
   c. Stomach
   d. Pancreas

3. Which of the following is NOT a function of the liver?
   a. Storing food
   b. Manufacturing insulin
   c. Producing digestive juices
   d. Healing itself when it is damaged

4. Which of the following is **NOT** part of the accessory organs in the digestive system?
   a. liver
   b. pancreas
   c. large intestines
   d. acini

5. What is the function of the soft palate?
   a. To keep opening to nasal cavity open at all times
   b. To keep opening to nasal cavity open during swallowing
   c. To keep opening to nasal cavity closed during swallowing
   d. To keep opening nasal cavity closed at all times

6. An enzyme that acts only in an acidic medium is _____
   a. pepsin
   b. trypsin
   c. pancreatic amylase
   d. lipase

7. Absorption is maximum in the small intestine because of _____.
   a. the presence of villi
   b. its length
   c. its thin walls
   d. its thick walls

8. Appendix is a part of _____.
   a. ileum
   b. duodenum
   c. caecum
   d. colon

9. Bile juice is _____.

a. alkaline b. acidic
c. semialkaline d. near acidic

10. The digestive juice that is almost neutral is _____.

a. gastric juice b. bile juice
c. pancreatic juice d. saliva

11. Which of the following is **NOT** a function of the small intestines?

a. Receives secretions from the pancreas and liver
b. Completes digestion of nutrients
c. Absorbs products of digestion
d. Transports the residue to the anal canal

12. Which of the following statement is false regarding the function of the large intestines?

a. The only important secretion is mucous
b. Feces are formed and stored here
c. Main absorption is water and electrolytes
d. Digestive activity remain high in the large intestines

13. What disorder is associated with self-imposed starvation and an obsession with thinness?

a. Obesity b. Anorexia nervosa
c. Bulimia nervosa d. Binge eating

14. Which of the following is **NOT** a sign or symptom of anorexia nervosa?

a. Loss of menstrual cycles or periods
b. Low blood pressure
c. Increased sore throats and tooth decay
d. Increased dry, scaly, cold skin

B. Write short answers to the following questions.

1. What do you mean by physical digestion?
2. Name the cells that secretes mucus. What are the functions of mucus ?
3. Name the different parts of large intestine of humans in their natural sequence.
4. What is the advantage of emulsification of fats by bile juice?
5. Name the largest gland of human body and where is it located ?
6. What are the main symptoms of dyspepsia?
7. What measures are to be adopted for the diagnosis of anorexia nervosa?

Write in detail the answers of the following questions.

1. Explain the role of nervous system and gastrin hormone on the secretion of gastric juice.
2. Describe the mechanism of digestion in the stomach.
3. Describe the composition of bile and relate the constituents with respective roles.
4. Discuss the mechanism of digestion and absorption of food in the small intestine.
5. Explain the symptoms and treatment of bulimia nervosa?

Projects

1. Identify some common digestive disorders and record some common household remedies being followed for their treatment. Give your justifications or otherwise for the effectiveness of these remedies. Share your finding in the classroom.