ABDUR REHMAN BIOLOGY

8 Human nutrition

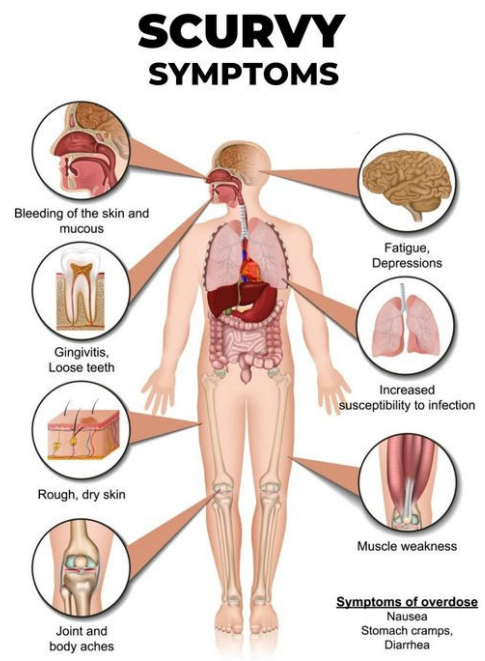
8.1 Diet

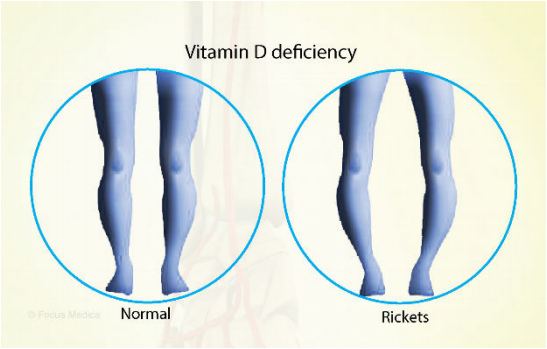
List the principal sources of, and describe the dietary importance of, carbohydrates, lipids, proteins, vitamins (C and D only), mineral salts (calcium and iron only), fibre (roughage) and water.

Component	Sources	Dietary Importance
Carbohydrates	Rice, potato, plants, bread, millet, sugary foods as cake, honey.	Storage, source of energy. Component of DNA and RNA Reserve Food.
Lipids	Milk, Cheese, egg-yolk, butter, animal fat, groundnuts, beans.	Cell membrane formation. Source of energy twice as much of carbohydrates. Insulation against heat loss.
Proteins	Meat, fish, egg-white, soya, groundnuts, pulses.	Formation of structural and functional protein. Growth. Tissue repair. Enzymes. Hormones. Antibodies. Cell membrane formation. Cell division. Keratin formation for skin, hairs and nails.
Vitamin C	Citrus fruits, fresh green vegetables, unripe fruits.	Connective tissue formation. Iron absorption from intestine. Maintain healthy skin and gums.
Vitamin D	Fish liver oil, cod liver oil, butter, milk, cheese, egg-yolk.	Calcium absorption. Bones formation.
Calcium	Milk, cheese, fish, eggs, hard water.	Bones and teeth formation. Nervous coordination. Muscle contraction.
Iron	Red meat, liver, kidney, eggs, dark green vegetables.	Haemoglobin formation.

Name the diseases and describe the symptoms resulting from deficiencies of vitamin C (scurvy), vitamin D (rickets), calcium (rickets) and iron (anaemia).

Components	Disease	Symptoms
Vitamin C	Scurvy	Swollen joints. Bleeding Gums. Delayed wound healing.
Vitamin D	Rickets	Soft and deformed bones. Frequent fractures.
Calcium	Rickets	Weak and brittle nails and muscle cramps. Soft teeth and bones. Osteoporosis.
Iron	Anemia	Heamoglobin deficiency. Feeling of tiredness. Lack of energy.





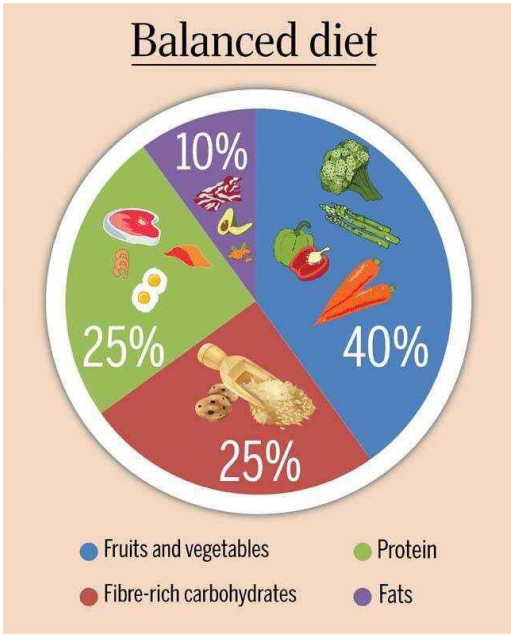
Understand the concept of a balanced diet.

Definition.

Balanced diet is a diet that contains all the essential nutrients in the correct proportions to maintain good health. The nutrients needed are carbohydrates, proteins, lipids, vitamins mineral salts, fibers and water.

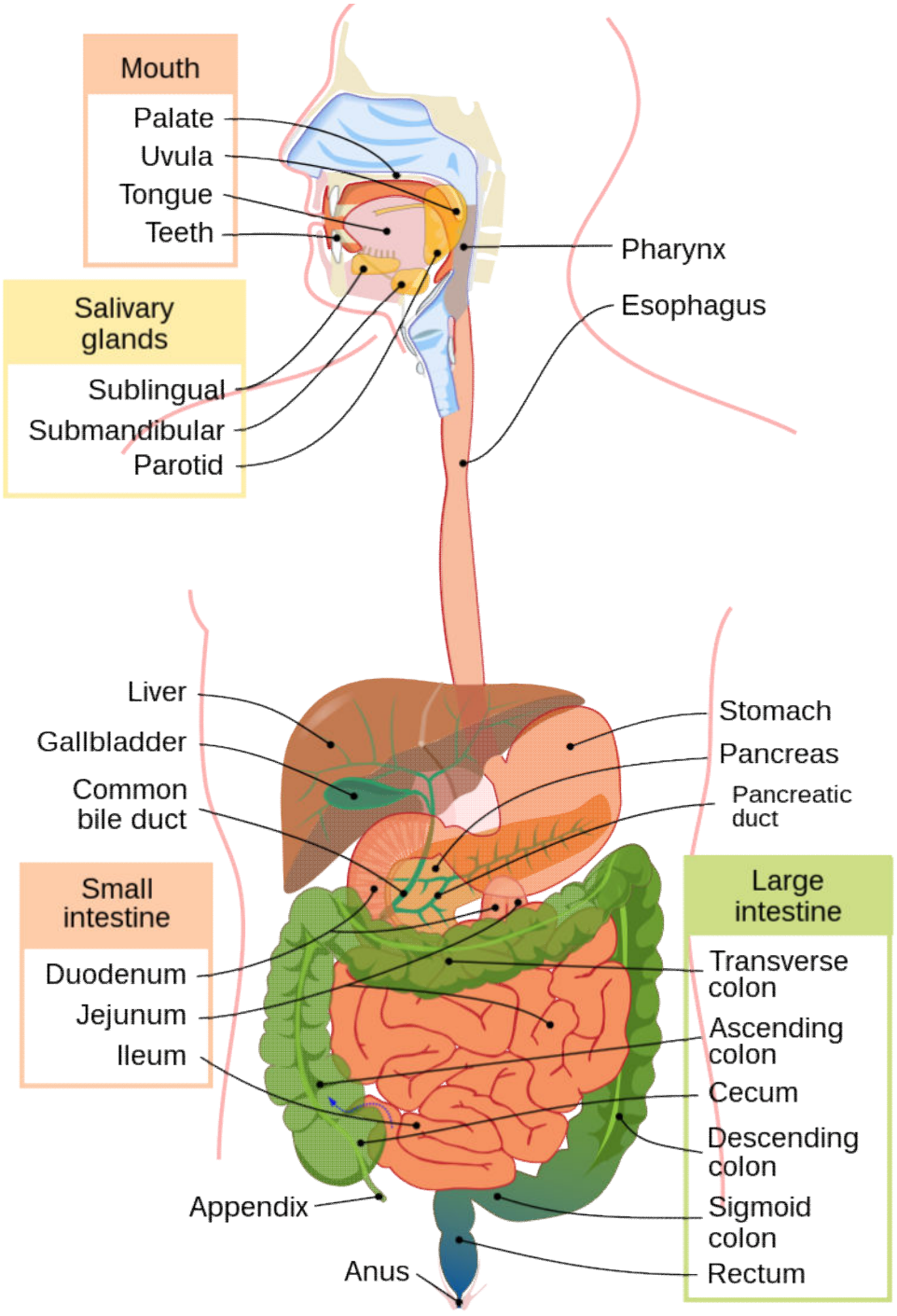
A balanced diet should contain carbohydrate, fat, protein, fibre, vitamins, minerals and water. Note that fibre cannot be digested; it is used to form 'roughage' in the intestines, so the intestine walls have something to push against when moving the food along the alimentary canal. A balanced diet for different people is slightly different because our energy and nutrient requirements vary from person to person.

Having an unbalanced diet can lead to malnutrition. Malnutrition can cause a variety of different health problems in humans.



8.2 Human digestive system.

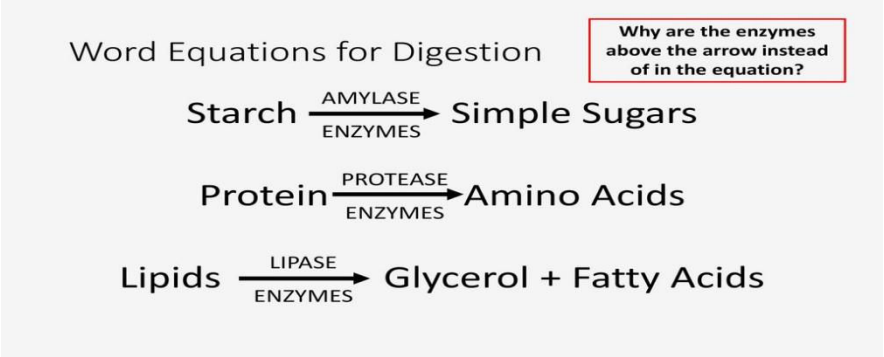
Identify the main regions of the digestive system: mouth, salivary glands, oesophagus, stomach, small intestine (duodenum and ileum), pancreas, liver, gall bladder and large intestine (colon, rectum and anus).



Explain why most foods must be digested before they can be absorbed.

Absorption is the movement of digested food molecules from the digestive system into the blood (glucose and amino acids) and lymph (fatty acids and glycerol)

The food needs to be digested so that it can be converted into simple soluble forms. Food molecules like proteins and polysaccharides cannot cross the epithelium of intestine. The food that we eat mostly consists of macromolecules which are of no value to the body unless these are digested and broken down into smaller particles so that these can be absorbed into the blood stream and carried to the body where they are assimilated. So the foods are digested so that larger water insoluble substances are converted into small simple soluble substances that can be absorbed into the blood.



Describe physical digestion as the breakdown of food into smaller pieces without chemical change to the food molecules.

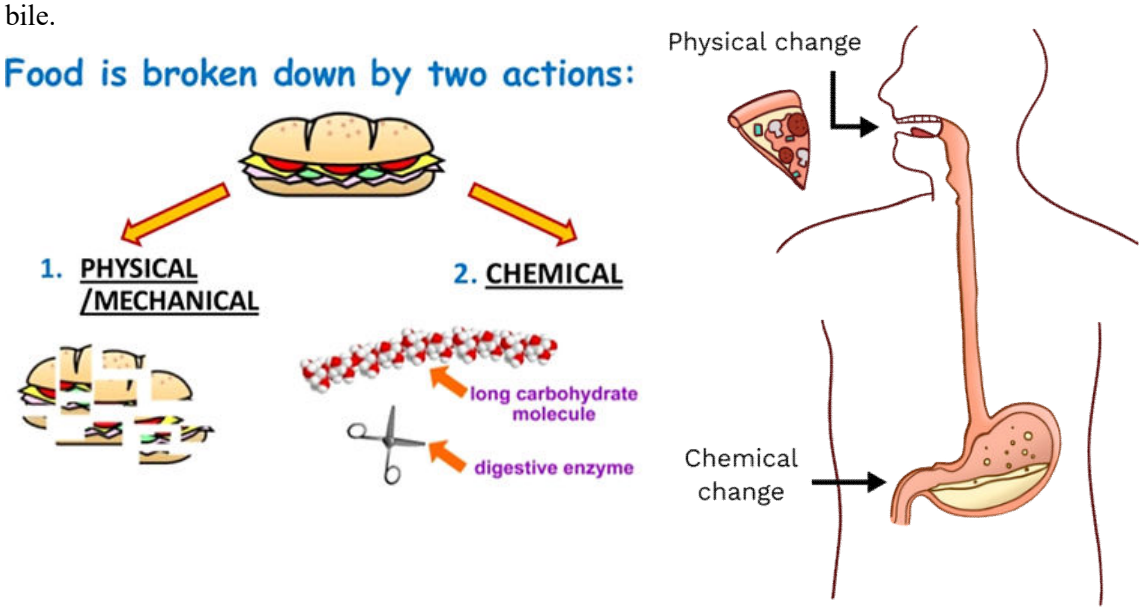
State that physical digestion increases the surface area of food for the action of enzymes in chemical digestion.

Physical digestion

Physical digestion involves the mechanical breakdown of food into smaller pieces without chemical change to the food molecules.

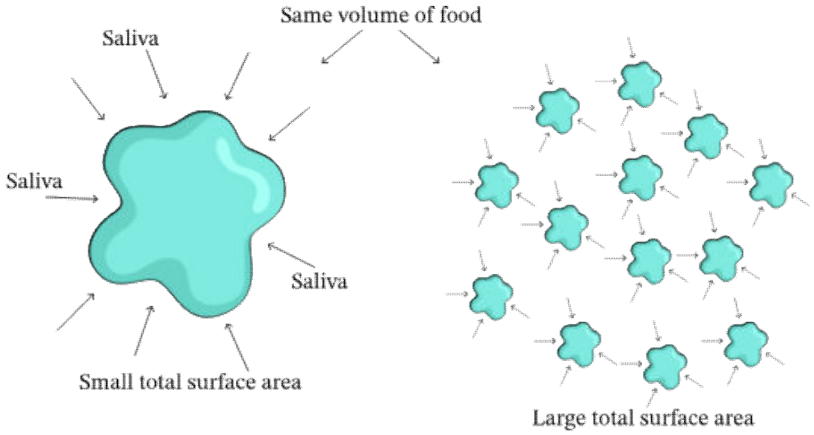
The process of physical digestion occurs mainly in the mouth. The teeth are used to chew food. This increases the surface area of food for the action of enzymes in chemical digestion.

Physical digestion also include the action of muscles in the stomach and the emulsification of fats by bile.



Importance of Physical Digestion.

- Increases the surface area for enzymes attachment.
- Large particles are converted into smaller ones without any change in chemical property.
- Increases the rate of reaction of enzymes.



Describe chemical digestion as the breakdown of large molecules into small molecules.

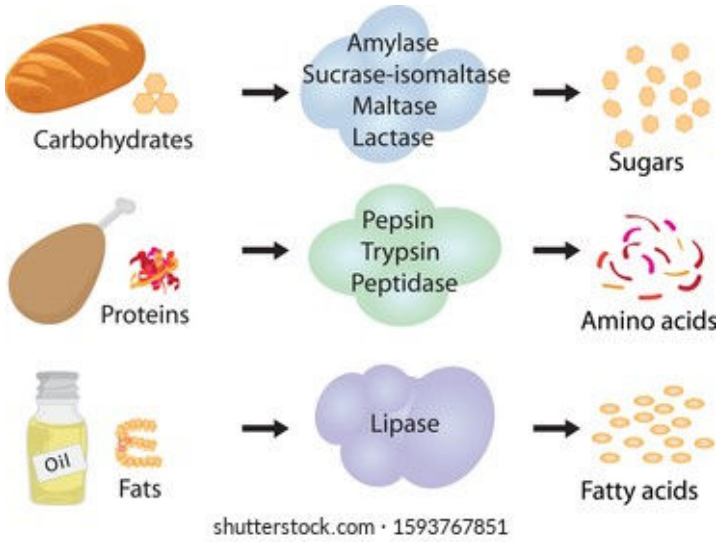
Definition.

Chemical digestion is the process in which large food molecules are broken down into smaller molecules through the action of enzymes and other digestive substances.

Digestion is mainly a chemical process and involves breaking down large molecules to small molecules. The large molecules are usually not soluble in water but the smaller ones are. The small molecules can be absorbed through the epithelium of the alimentary canal through the walls of the blood vessels and into the blood.

Some foods can be absorbed without digestion. The glucose in fruit juice can pass through the walls of the alimentary canal and enter the blood vessels without being broken down.

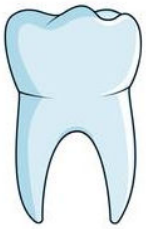
All the solid starch in foods is digested to glucose which is soluble in water. The solid proteins in meat are digested to small, soluble molecules called amino acids. Lipids are digested to soluble molecules called glycerol and fatty acids.

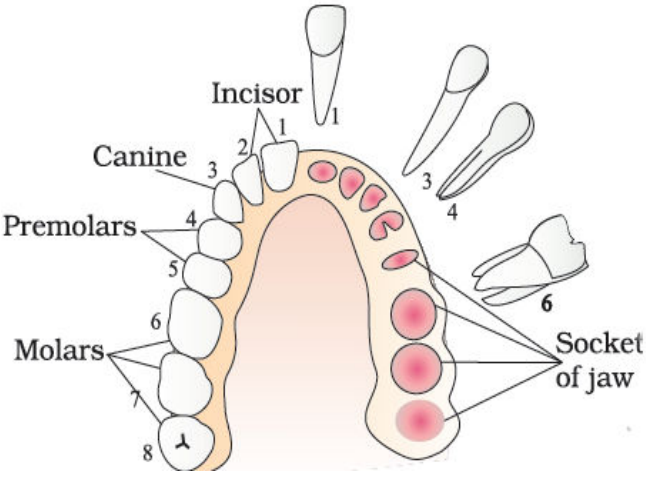


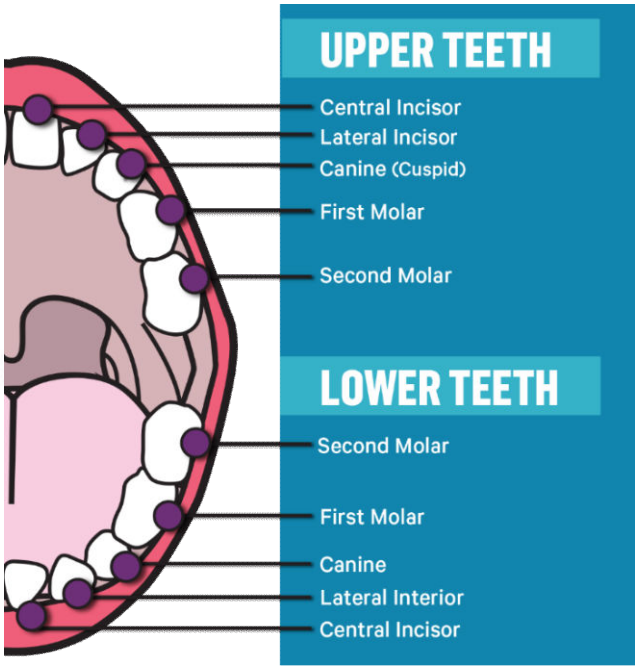
Identify the types of human teeth (incisors, canines, premolars and molars)

Describe the structure of human teeth, limited to: enamel, dentine, pulp, nerves and cement, and understand that teeth are embedded in the gum.

Describe the functions of the types of human teeth in physical digestion of food.

Teeth	Incisor	Canine	Premolars	Molars
Position in mouth	Front	Either side of incisors	Behind Canine	Back
Description	Chisel shaped (sharp edges)	Slightly more pointed than incisors	2 points (cusps), 1 or 2 roots	4 or 5 cusps, 2 or 3 roots
Function	Biting off pieces of food	Similar function to incisors	Tearing and grinding food	Chewing and grinding food
Image				





Crown

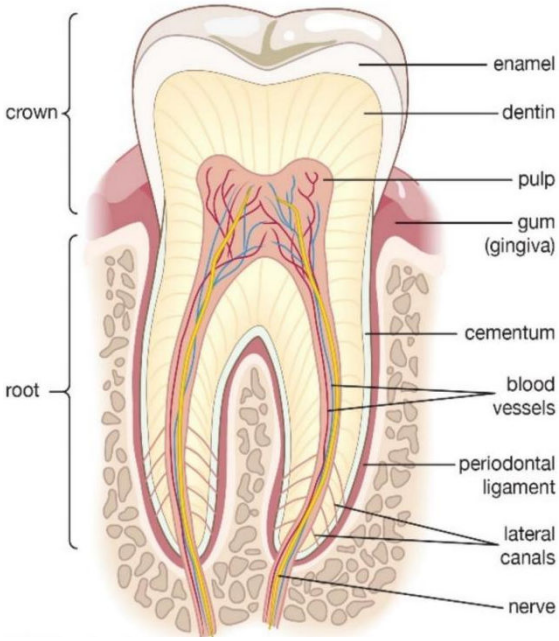
The part of a tooth that is visible above the gum line is called the crown. The gum is the tissue that overlays the jaws.

Root

Rest of the part of the teeth embedded in the jaw bone is called the root.

Enamel

The surface of the crown is covered by a hard layer of enamel. It is the outermost layer of the tooth and is the hardest substance in the human body.



Dentine

Below the enamel is a layer of dentine. It forms the bulk of the tooth's structure. It is a hard tissue but softer than enamel. Dentine also provides support to the enamel.

Pulp

Inside the dentine is a pulp cavity. It is the innermost part of the tooth. It contain nerves and blood vessels. These enter the tooth through a small hole at the base of the root. It nourishes the tooth and transmit nerve impulses.

Nerves

Nerves in the dental pulp help protect the tooth by allowing the sense damage to the tooth as well as changes in temperature or pressure. These are responsible for transmitting sensory information from the tooth to the brain.

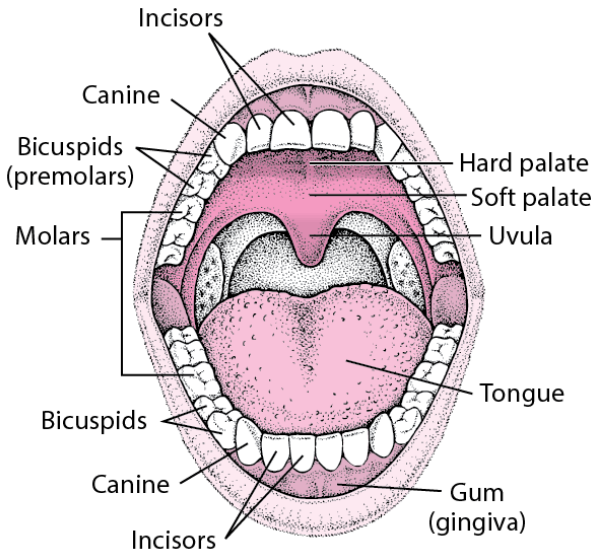
Cement

The enamel is replaced by cement in the route, which enables the truth to grip to its bony socket in the jaw. It cover's the tooth's roots. It helps anchor the tooth securely within the jawbone by attaching to the periodontal ligament.

Functions of Human Teeth

The differing shapes and sizes of teeth enable them to perform slightly different functions:

- Incisors - chisel-shaped for biting and cutting
- Canines - pointed for tearing, holding and biting
- Premolars and molars - larger, flat surfaces with ridges at the edges for chewing and grinding up food.



Describe the functions of the main regions of the digestive system, limited to: (a) mouth (b) salivary glands (c) stomach (d) small intestine (duodenum and ileum) (e) liver (f) gall bladder (g) pancreas (h) ileum and colon (i) rectum and anus.

There are five main process that are linked with the digestion. These are

- Ingestion.
- Digestion.
- Absorption.
- Assimilation.
- Egestion.

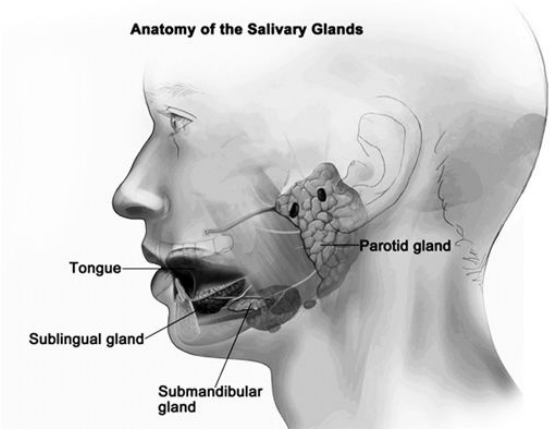
The roles and functions of the main regions of digestive system and the above processes related to them are explained below.

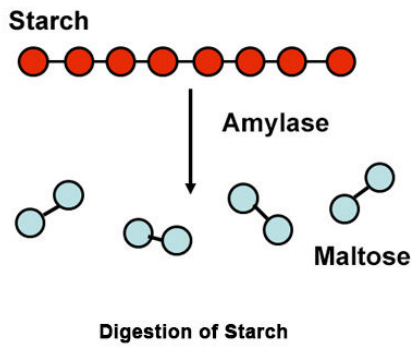
Mouth

The act of taking food into the mouth is called ingestion. The mouth is responsible for taking in food and preparing it for digestion. In the mouth teeth breaks the food into pieces that can be swallowed. These pieces are mixed with saliva which contain slavery amylase enzyme for the breakdown of starch. The chewing also increases the surface area for the enzymes to work on. The food after churning and mixing with saliva forms a ball like shape called bolus which is then swallowed. The swallowing process is voluntary at the beginning but when it reaches the back of the mouth it becomes involuntary.

Salivary Glands

Slightly glands in mouth produces saliva which is a digestive juice. This lubricates the food and contain an enzyme called salivary amylase which acts on the starch and begins to break it down into simple sugars.





Digestion of Starch

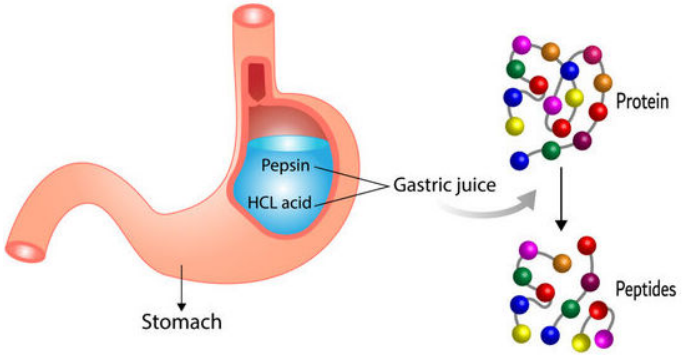
Stomach

A J-shaped organ located in the upper left abdomen of the human body. The main function of the stomach is to store food from a meal and turn it into a liquid. Digestion in stomach is done both physically/mechanically and chemically.

In physical digestion the muscular walls of the stomach contracts and relax, churning and squeezing the food in stomach and mixing it with the gastric secretions which contain protease enzyme and

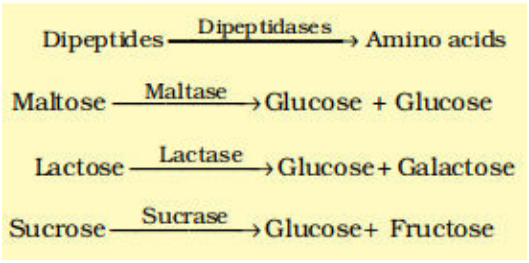
hydrochloric acid. This churning action helps break down ingested food into smaller particles, increasing the surface area for subsequent chemical digestion.

For chemical digestion glands in the lining of stomach produces gastric secretions which contain a protein digesting enzyme (protease) called pepsin. The enzyme breakdown large protein molecules into small soluble amino acids. The gastric secretion also contain hydrochloric acid which makes an acidic solution in the stomach. This acidic environment is essential for the proper working of protease enzymes. This lower pH and also kills harmful organisms such as bacteria taken within the food. There is a valve at the base of the stomach which stops solid pieces of food from passing through and let the liquid solubilized products of digestion pass into the small intestine.



Small Intestine

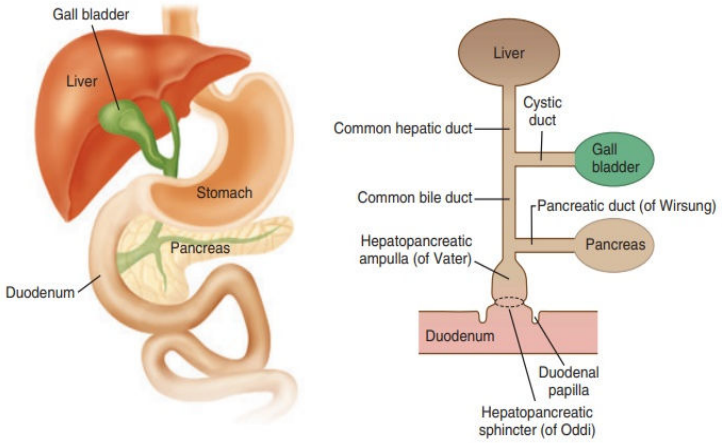
The small intestine consists of the duodenum and ileum. The first part of small intestine duodenum receives pancreatic juice for chemical digestion of proteins, lipids and starch. It also neutralizes the acid from the stomach. It receives bile to emulsify lipids(break large lipid globules into smaller). Pancreatic lipase is crucial for breaking down triglycerides (the main dietary fats) into fatty acids and glycerol. Bile, produced by the liver and stored in the gallbladder, emulsifies fat, creating smaller droplets that are more accessible to lipase.



This process is essential for the absorption of fats in the small intestine. Second part of small intestine is ileum. Enzymes in the epithelial lining carry out chemical digestion of starch into simple reducing sugars using pancreatic amylase, proteins to amino acids by proteases, and fats and oils into fatty acids and glycerol by lipases.

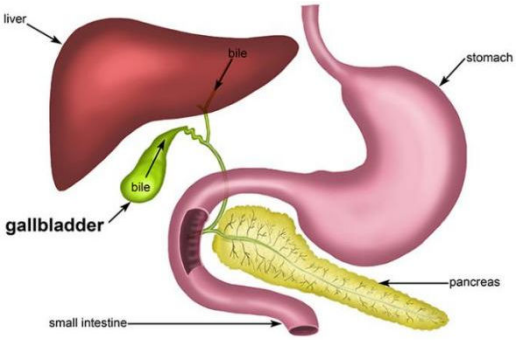
Liver

Liver is a vital organ with multifunctional roles. Liver makes bile containing salts to emulsify lipids. Bile is composed of bile salts, cholesterol, bilirubin, and water. The liver also acts as a storage site for glycogen, which is a polysaccharide composed of glucose molecules. Emulsification is a process in which large lipid globules are broken down into small lipids globules.



Gall bladder

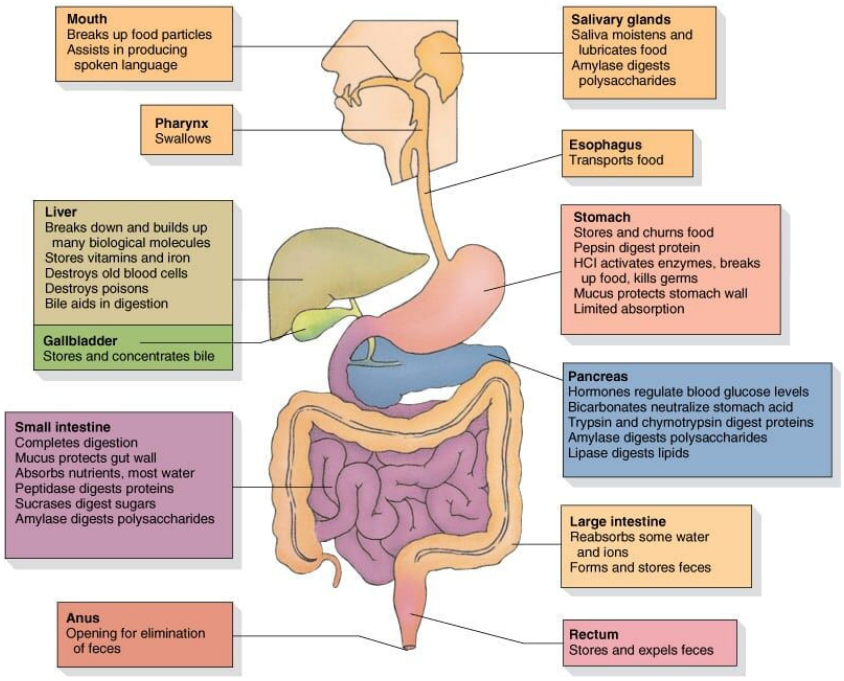
Bile is continuously produced by the liver. It is stored in the gall bladder which is secreted in the duodenum through the bile duct.



Pancreas

It is a vital organ with both endocrine and exocrine functions, and its exocrine role is particularly crucial for digestion. Pancreatic amylase is an enzyme that helps break down complex carbohydrates, specifically starch, into simpler sugars like maltose. Pancreas also secretes proteolytic enzymes, such as trypsin and chymotrypsin, which are crucial for breaking down proteins into smaller peptides and amino acids.

Pancreatic lipase is responsible for breaking down dietary fats (lipids) into fatty acids and glycerol. The pancreas also secretes an alkaline solution containing bicarbonate ions. This alkaline secretion helps neutralize the acidic chyme arriving from the stomach, creating a more favorable and slightly alkaline environment for the optimal activity of digestive enzymes in the small intestine.



Ileum and colon

The ileum and colon are segments of the small and large intestines, respectively, and they are involved in the absorption of nutrients, water, and electrolytes. Small intestine absorbs mostly nutrients. The large intestine secretes no enzyme but the bacteria in the colon digest part of the fiber to form fatty acids, which are absorbed by colon. The colon absorbs water from undigested material. Bile salts are also absorbed and returned to the liver in the blood. The structural details are explained in the next few pages.

Rectum and Anus

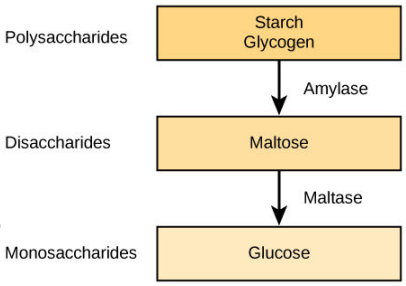
The semi solid waste remaining after absorption is called the faeces. It is past into the rectum by peristalsis and is passed out at intervals through the anus. The undigested material may spend from 12 to 24 hours in the intestine. The process of passing out the faces is called egestion.

Describe the functions of amylase, maltase, protease and lipase, listing the substrates and end-products, limited to:
(a) amylase breaks down starch to maltose (b) maltase breaks down maltose to glucose (c) protease (pepsin and trypsin) breaks down protein to amino acids (d) lipase breaks down lipids to fatty acids and glycerol.

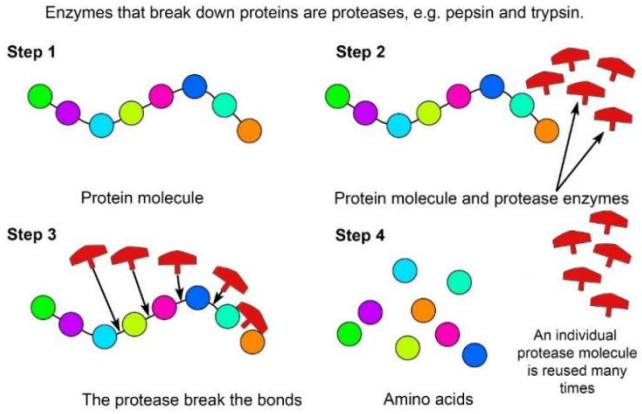
Starch is digested into two places in the alimentary canal, by salivary amylase and by pancreatic amylase in the duodenum. It works best in a neutral or slightly alkaline pH and breaks down large insoluble starch molecules into smaller soluble maltose molecules.

Enzyme	Produced By	Site of Action	Substrate Acting On	End Products
Salivary amylase	Salivary glands	Mouth	Polysaccharides (Starch)	Disaccharides (maltose), oligosaccharides
Pancreatic amylase	Pancreas	Small intestine	Polysaccharides (starch)	Disaccharides (maltose), monosaccharides

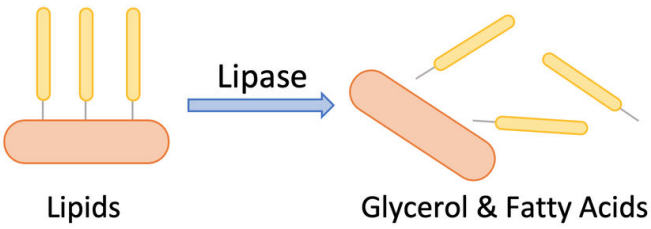
Maltose is a disaccharide sugar and is still too big to be absorbed through the wall of the intestine. It is broken down to glucose by the enzyme maltase which is present in the membrane of the epithelial cells of the villi.



Protein molecules are digested first to smaller molecules called peptides and then into completely soluble molecules called amino acids. There are several proteases which breaks down proteins. One of the proteases, pepsin works best in the acidic conditions in the stomach. It acts on proteins and breaks them down into soluble compounds called peptides. Another protein is called trypsin which is secreted by pancreas and is activated in the duodenum. Trypsin works best in alkaline conditions.



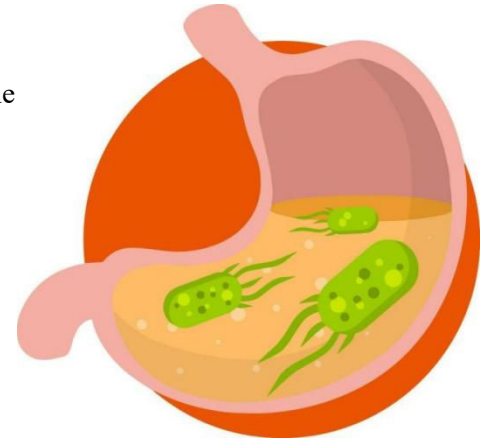
The pancreas produces lipase which is secreted into the duodenum in pancreatic juice. It works best in slightly alkaline conditions. Lipase digests lipids to fatty acids and glycerol.



Describe the function of hydrochloric acid in the stomach as killing ingested bacteria.

Understand that the different proteases present in the stomach and the duodenum work best at different pH levels.

Outline the role of bile in emulsifying fats to increase the surface area for the chemical digestion of fat to fatty acids and glycerol by lipase.



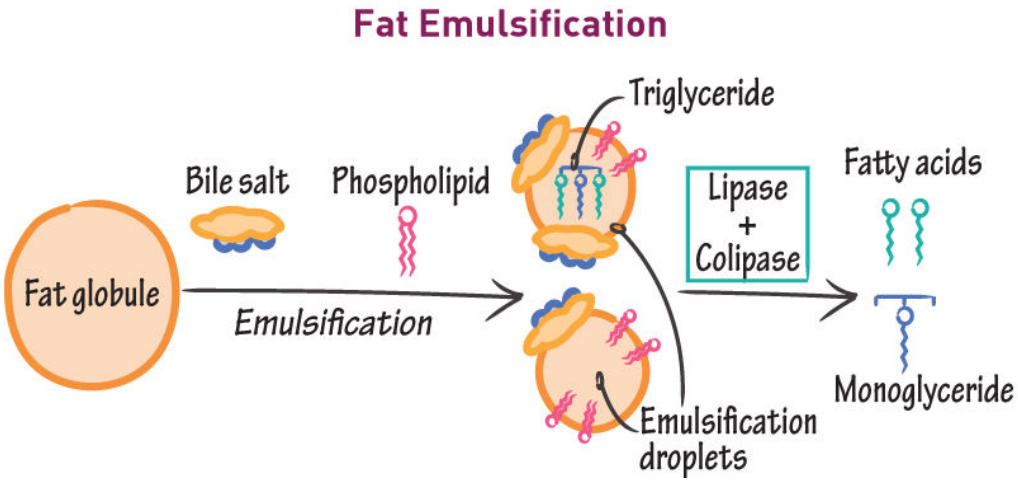
Hydrochloric acid (HCl) in the stomach plays a crucial role in creating an acidic environment that serves multiple functions, one of which is the destruction of ingested bacteria. Hydrochloric acid lowers the pH of gastric contents upto 2. This acidic environment is essential for the functioning of protease enzyme. This lower pH is potent to many micrograms including bacteria. Most bacteria grow at a neutral pH, but this acidic environment of the stomach destroys their cellular structure resulting in the destruction of a lot of microbes.

The activity of various proteases in the stomach and duodenum is influenced by the pH levels of these respective environments. The stomach maintains a low pH, typically between 1.5 and 3.5, due to the secretion of hydrochloric acid. Pepsin is active and efficient in breaking down proteins under these acidic conditions.

Trypsin and chymotrypsin, proteases present in the duodenum, work optimally in a less acidic and more neutral to slightly alkaline environment. The pH levels of chyme is increased up to 8 for the proper functioning of enzymes.

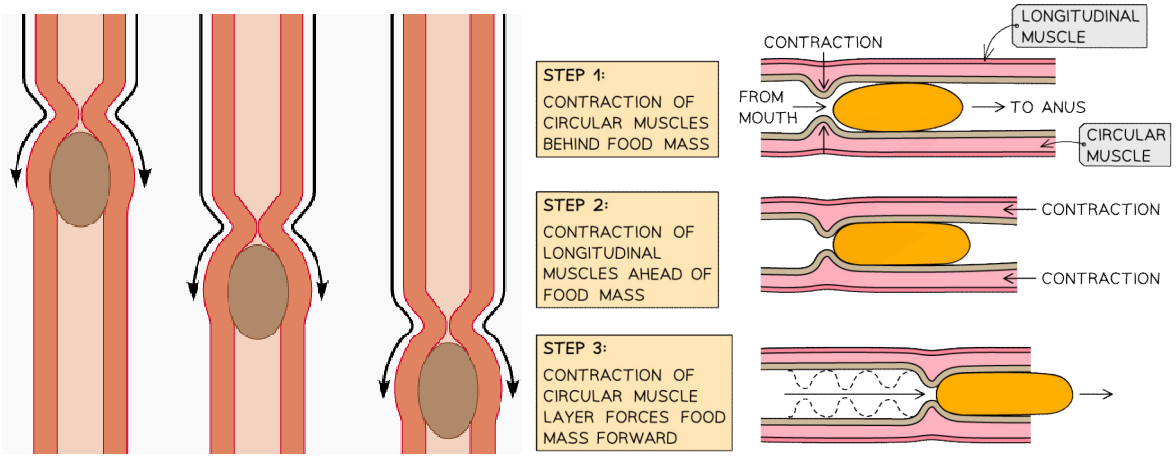
Bile has two main roles:

- It is alkaline to neutralize the hydrochloric acid which comes from the stomach.
- The enzymes in the small intestine have a higher (more alkaline) optimum pH than those in the stomach.
- It breaks down large drops of fat into smaller ones. This is known as emulsification. The larger surface area allows lipase to chemically break down the lipid into glycerol and fatty acids faster.



Describe peristalsis as waves of contractions of longitudinal and circular muscles which move food through the digestive system.

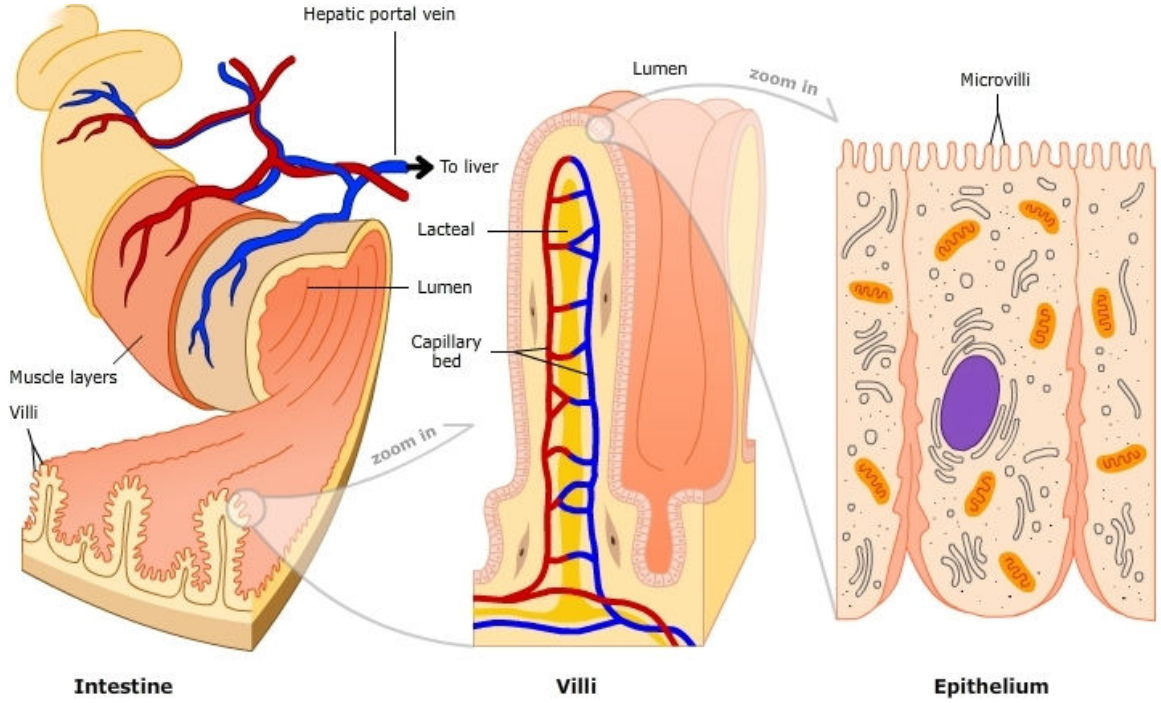
Peristalsis is a series of wave-like contractions of the muscles that are involved in the food movement and in the movement of other liquid particles in the digestive tract to various processing organs that are located in the digestive system.
The peristaltic movement is initiated from the oesophagus when the food is completely swallowed which includes the reflexive action of the longitudinal and circular muscles greatly in the digestive sites and some other times in hollow tubes that are present in progressive wave-like contractions.
Peristalsis occurs in the oesophagus, intestines, and stomach and the waves could be long, short, continuous or continual that transit within the complete length of the organs, basis their location.



8.3 Absorption and assimilation.

State that the small intestine is the region where nutrients are absorbed.
Describe the structure of a villus and the roles of capillaries and lacteals.
Explain the significance of villi and microvilli in increasing the internal surface area of the ileum.
State the function of the hepatic portal vein as the route taken to the liver by most of the molecules and ions absorbed from the ileum.

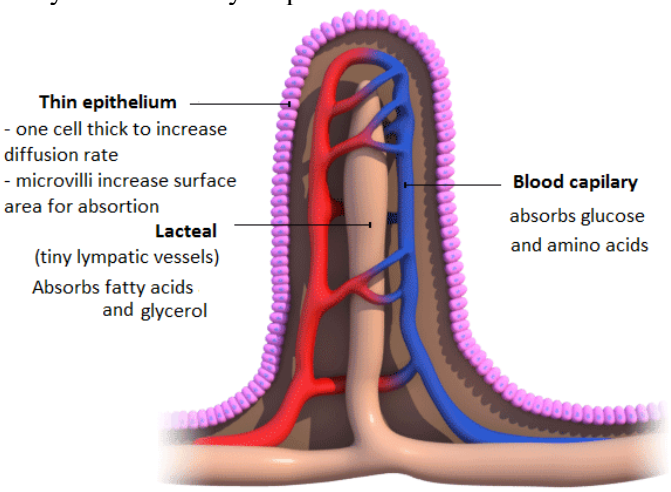
Absorption is the movement of nutrients from the intestines into cells lining the digestive system and then into the blood. The small intestine is a vital organ in the digestive system that plays a central role in the absorption of nutrients. It consists of the duodenum and the ileum. Nearly all the absorption of digested food takes place in the ileum along with most of the water. Ileum is quite long in length and has special projections called as villi. These further increases the surface area or maximum absorption.



The structure of ileum is well adapted for its function for several reasons.

- It is quite long and provides a large surface area to absorb the digested food.
- The internal surface is increased even more by circular folds bearing thousands of tiny projections called villi. These villi are 0.5 mm long and maybe finger like or flattened in shape.
- Epithelium lining is very thin and the fluids can pass rapidly through it.
- The outer membrane of each epithelial cell has microvilli which increases 20x the exposed surface of the cell. This makes the small intestine more efficient in the absorption of nutrients.
- The small molecules of digested food pass into the epithelial cells and then through the wall of the capillaries in the villus and into the bloodstream.
- They are then carried away in the capillaries which join up to form veins.
- These veins come together to form one large hepatic portal vein.
- This way it carries all the blood from intestine to the liver which may store or alter any of the digestive products. When these products released from the liver, they enter the general blood circulation.

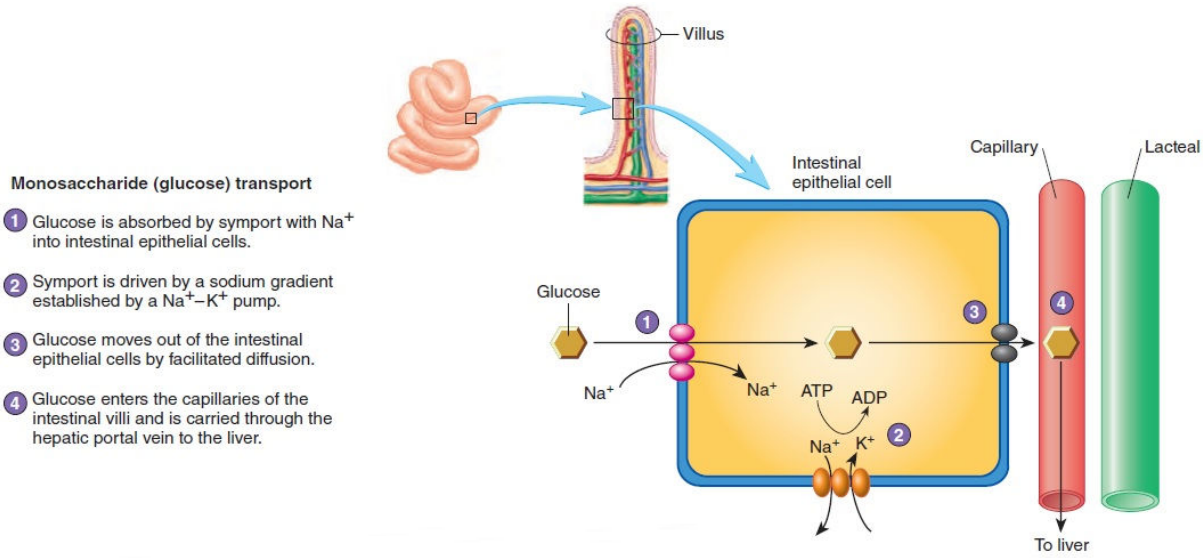
- Some of the fatty acids and glycerol enter the blood capillaries of the villi. However, a large proportion of fatty acids and glycerol combine again to reform lipids in the intestinal epithelium.
- These lipids then pass into the lacteals.
- A lacteal is a specialized lymphatic vessel found in the villi of the small intestine, particularly in the ileum.
- The fluids in the lacteal flows into the lymphatic system, which forms a network all over the body and eventually empties its contents into the bloodstream.



Understand that absorption (by diffusion, osmosis and active transport) is the movement of nutrients from the intestines into cells lining the digestive system and then into the blood.

Nutrient absorption in the digestive system involves the movement of substances through the intestines into cells lining the digestive tract, and subsequently into the blood.

- Fatty acids and glycerol are absorbed through diffusion.
- Movement of water is also against concentration gradient.
- Amino acids and peptides are absorbed through active transport.



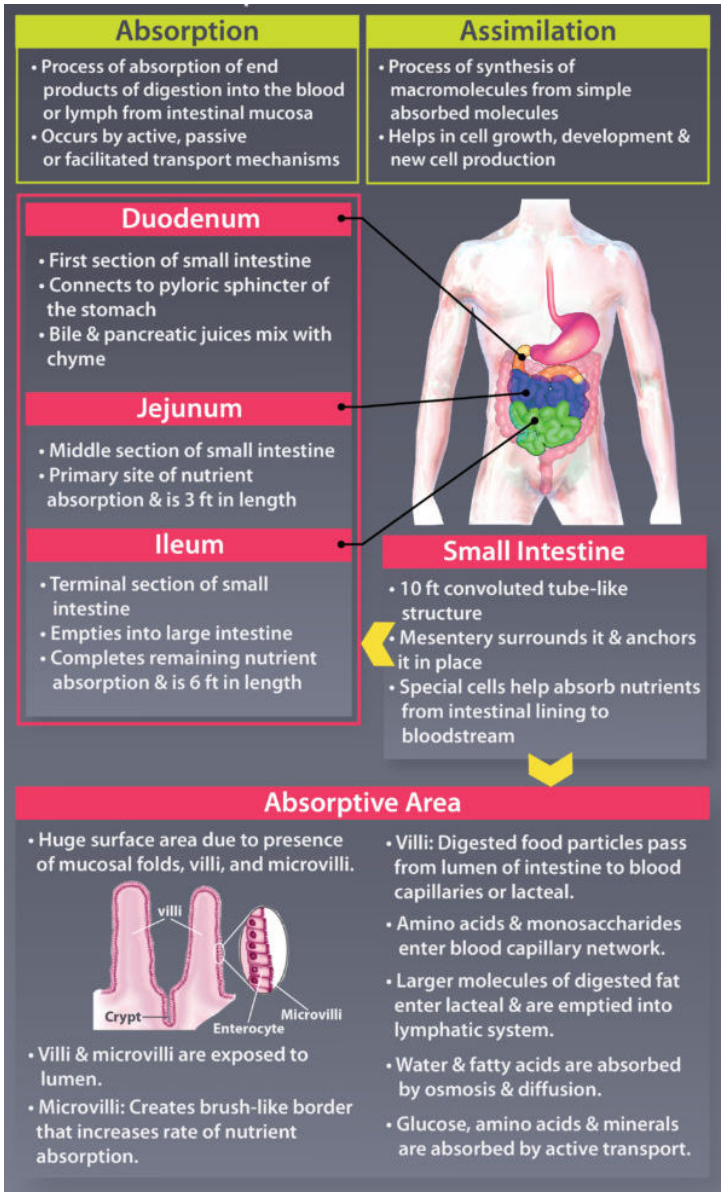
Understand that assimilation is the uptake and use by cells of nutrients from the blood.

Assimilation
Process of synthesis of macromolecules from simple absorbed molecules.
The products of digestion are carried around the body in the blood. From the blood, cells absorb and use glucose, lipids and amino acids. This uptake and use of nutrients by cells is called assimilation.

Glucose
During respiration in the cells, glucose is oxidized to carbon dioxide and water. This reaction provides energy to drive many chemical processes in the cells which result in the building up of proteins, contractions of muscles or electrical changes in nerves.

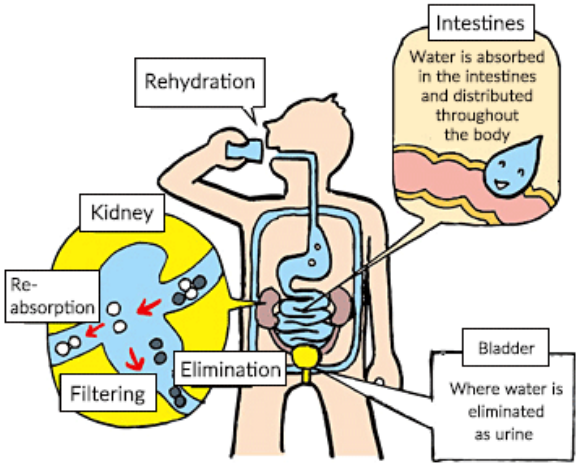
Lipids
These are built into cell membrane and other cell structures. Lipids also form an important source of energy for cell metabolism.

Amino Acids
These are absorbed by the cells and build up with the aid of enzymes into proteins. Amino acids not needed for making cell proteins are converted into glycogen by liver.



Understand that water is absorbed from the lumen of the small intestine and the colon, but that most absorption of water happens in the small intestine.

Most water absorption occurs in the small intestine, particularly the ileum. This process involves both passive and active mechanism, facilitated by the extensive surface area of villi and microvilli. The colon contributes to further water absorption, mainly concentrating remaining water and electrolytes from undigested material, forming faeces before elimination.



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