LIPIDS

Lipids are stored in the body for energy production. They also form structural components.

DEFINITION AND FUNCTIONS

Lipids belong to a heterogeneous class of predominantly nonpolar compounds, mostly insoluble in water, but soluble in nonpolar organic solvents such as chloroform and benzene. They are either esters of fatty acids with different alcohols, containing in many cases other constituents also, or the products of hydrolysis of such esters. They are compounds of mainly C, H and O, but carry in some cases P, N and S also. The ratio of H and O is generally much higher in lipids than in H_2O and carbohydrates.

Biological functions : (*a*) Fats are stored in the adipose tissue for *energy production* when necessary. Both fatty acids and glycerol, forming the fat molecule, are oxidized to produce energy. (*b*) Fats are also deposited under the skin and around vital organs in the form of adipose tissue for *thermoinsulation* and as *shock-absorbing* cushions. (*c*) Phospholipids, glycolipids, lipoproteins and sterols form *structural components* like plasma membrane, mitochondria, endoplasmic reticulum and myelin sheath. (*d*) Phospholipids, glycolipids and sterols are constituents of *plasma lipoprotein particles* which transport fats, sterols, fatty acids and other nonpolar materials between the liver and extrahepatic tissues. (*e*) Phospholipids help in the *intestinal absorption* of nonpolar nutrients like fats, fatty acids and fat-soluble vitamins. (*f*) Sterols are used in the *biosynthesis of bile acids, steroid hormones and vitamin D*. (*g*) Phospholipids help in the *excretion of cholesterol* in bile. (*h*) Prostaglandins, modified fatty acids, function as *regulatory* and *informational* molecules. (*i*) Dolichol and ubiquinones, which are polyisoprenoids, participate in respectively the glycosylation of proteins and the electron transport mechanism.

Lipid Digestion

Lipids are the second major source of energy for animals. The dietary lipids include neutral fats, phospholipids, cholesterides, free cholesterol, fatty acids and glycerol. During digestion, the lipids are split into ***fatty acids*** and ***glycerol***.

Lipids ⟶ **Fatty acids + Glycerol**

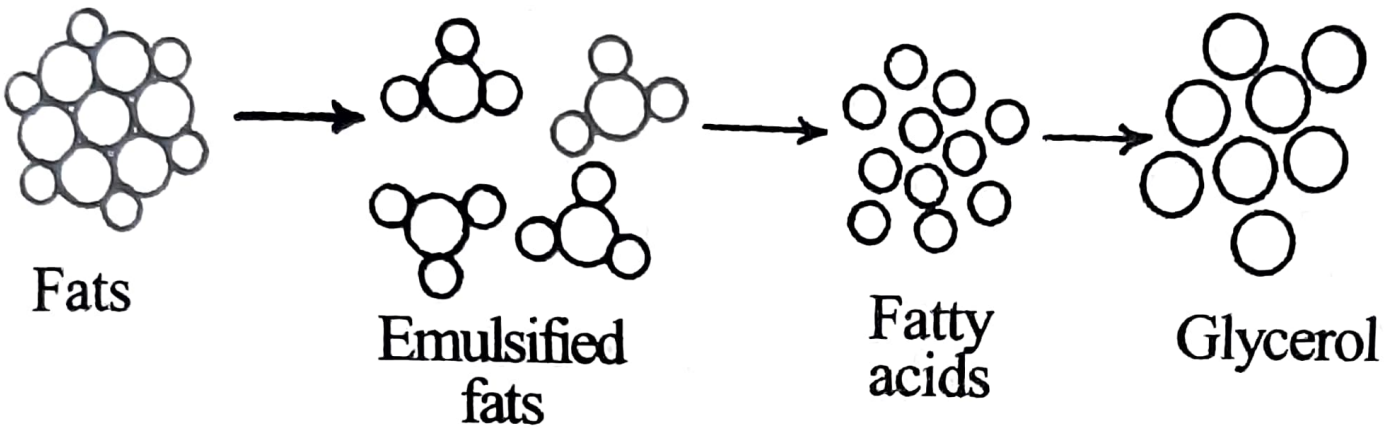


Fig. 7.170: Digestion of lipids.

Places of Lipid Digestion

The digestion of lipid occurs in the stomach and intestine. It does not occur in the buccal cavity.

Enzymes Involved in Lipid Digestion

The breakdown of the lipids is brought about by a set of enzymes called ***lipases***. The following are the lipases:

1. *Gastric lipase*
2. *Pancreatic lipase*
3. *Phospholipase*
4. *Phospho diesterase*
5. *Phosphatase* and
6. *Cholesterol esterase*

Emulsification

Emulsification is a process *by which the insoluble lipids are converted into a soluble milky liquid containing drops of oil and fat.* Emulsification is the first step in the digestion of fat. It occurs in the stomach.

Emulsification is brought about by the ***bile*** secreted by the ***liver***. Only after emulsification, the proteases and lipases begin their digestive function on lipids.

Digestion of Neutral Fats

Neutral fats are acted by ***gastric lipase*** and are split into fatty acids and glycerol in a series of steps.

First of all, hydrolysis of neutral fats leads to the formation of one molecule of fatty acid and another molecule of ***diglyceride.***

The diglyceride is then split into one molecule of fatty acid and another molecule of ***monoglyceride***.

The monoglyceride is then hydrolysed into one molecule of fatty acid and another molecule of ***glycerol***.

Thus each molecule of neutral fat produces three molecules of fatty acids and one molecule of glycerol.

Neutral fat ⟶ **Diglyceride + Fatty acid**

Diglyceride ⟶ **Monoglyceride + Fatty acid**

Monoglyceride ⟶ **Glycerol + Fatty acid**

Digestion of Lecithin and Cephalin

The pancreatic enzyme ***phospholipase*** acts on lecithin and cephalin and removes one fatty acid. This leads to the formation of substances called ***lysolecithins*** and ***lysocephalins.***

Lecithin $\xrightarrow{\textit{Phospholipase}}$ **Lysolecithin + Fatty acid**

Cephalin $\xrightarrow{\textit{Phospholipase}}$ **Lysocephalin + Fatty acid**

These are hydrolysed further and the second fatty acid is removed. This leads to the formation of ***glycerol phosphorylcholine*** and other similar compounds.

Glycerol is split off by phosphodiesterases. Choline and sphingosine are freed by the action of phosphatases. Cholesterol is freed from cholesterides by ***cholesterol esterase***.

Absorption of Lipids

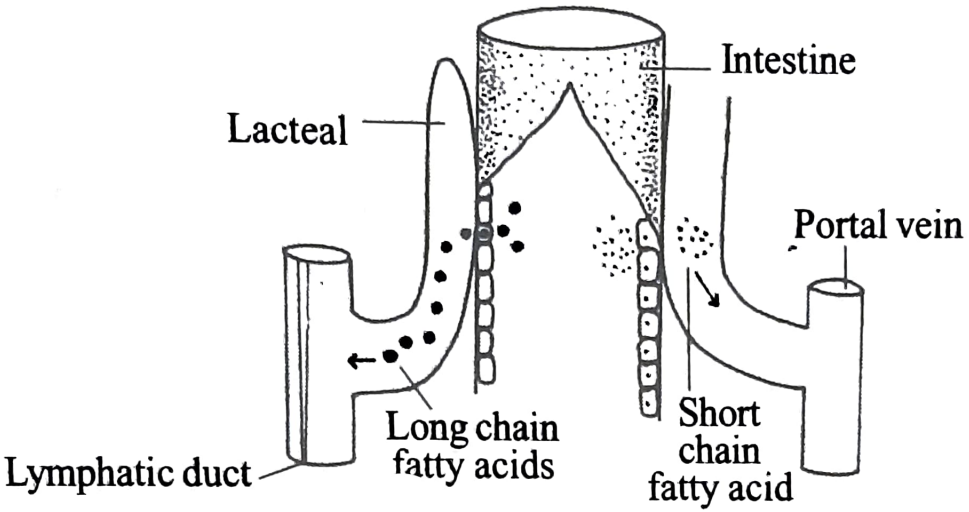
Absorption of lipids is the intake of fatty acids and glycerol from the lumen of intestine into the blood.

Absorption of lipids mainly occurs in the ***intestine.***

The fat is digested into fatty acids, glycerol, triglycerides, diglycerides, monoglycerides, phospholipids, cholesterol, cholesterol esters, etc.

Lipids are transported through two routes, namely ***venous blood*** and ***lacteals.***

Free fatty acids with 12 or less carbon atoms are absorbed into the ***portal blood.*** Fatty acids with 14 or more carbon atoms are absorbed through the ***lacteals*** and passed into the ***thoracic duct.***



Absorption of lipid.

The products of fat digestion are absorbed by the ***intestinal cells*** from the lumen of intestine.

The intestinal cells (endoplasmic reticulum) resynthesize ***triglycerides*** from the absorbed products of fat digestion. The triglycerides pass into the blood from the intestinal cells.

Lipid absorption is facilitated by ***bile salts*** of bile. The bile salts perform a ***ferrying function*** in transporting lipids from the lumen of intestine to the surface of intestinal cells. The bile salts function as the ***carriers*** of lipids.

Bile salts have a polar ***hydrophilic*** portion and a non-polar ***hydrophobic portion.*** Thus

they have affinity for both water and lipids. Bile salts, in the presence of lecithin, interact with fatty acids and monoglycerides to form minute complexes called ***micelles.*** They are water soluble.

The micelles make the lipid soluble and transport them to the brush border of the intestinal cells. On contact with the cell surface, the bile salts separate from the lipid portion. The lipid portion ***passively*** diffuses through the plasma membrane and enter the cytoplasm.

The separated bile salts move into the lumen and transport more fatty acids and monoglycerides to the brush border.

The micelles move down ***along the concentration gradient*** to the mucosal surface.

Free ***cholesterol,*** formed from cholesterol esters by the action of esterases, enters the cell and are re-esterified.

The lipids reach the venous blood through two routes, namely through the ***portal blood*** and through the ***lacteals.***

Most of the ***short chain fatty acids*** having 12 or less carbon atoms and ***glycerol*** of the mucosal cells ***diffuse*** into the ***portal blood.***

Long chain fatty acids having more than 12 carbon atoms of the mucosal cells are resynthesized into ***triglycerides.*** This synthesis occurs in the smooth ***endoplasmic reticulum.***

The resynthesized triglycerides and the absorbed phospholipids, cholesterol, cholesterol esters, free fatty acids with more than 12 carbon atoms and fat soluble vitamins are all combined with protein in the ***cisternae*** of ***endoplasmic reticulum*** to form large lipoprotein particles called ***chylomicrons.*** They enter the ***lacteals*** of the villus to be transported via the ***lymph*** to the ***thoracic duct*** and finally reach the ***venous blood.*** The chylomicrons do not enter the portal blood directly.