

Chapter 3 Lipids and Metabolism

Anatomy and Physiology Text and Laboratory Workbook, Stephen G. Davenport, Copyright 2006, All Rights Reserved, no part of this publication can be used for any commercial purpose. Permission requests should be addressed to Stephen G. Davenport, Link Publishing, P.O. Box 15562, San Antonio, TX, 78212

Lipids

- Lipids have many biological functions. Among their functions, they
 - (1) form the framework of cellular membranes,
 - (2) are stored within the cell and are used as a source of energy,
 - (3) serve as insulation, and
 - (4) serve as a cushion.
- Lipids are characterized by being insoluble in water and being composed mostly of carbon, hydrogen, and oxygen (C,H,O). Complex lipids usually contain phosphorus and include the phospholipids. Common lipid molecules include:
 - fatty acids,
 - glycerides,
 - phospholipids, and
 - steroids.

FATTY ACIDS

- Fatty acids are structured as long linear chain molecules of carbon and hydrogen atoms with an organic acid group (carboxyl group, COOH) at one end.
- Fatty acids conform to the general molecular formula of $\text{CH}_3(\text{CH}_2)_n\text{COOH}$, where the subscript "n" represents the number of CH_2 units in a linear chain. The carboxyl group (COOH) functions as a hydrogen ion (H^+) donor,

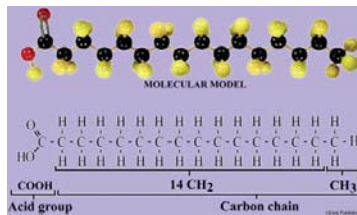


Fig 3C-1

Plasma Transport of Fatty Acids

- Fatty acids are usually found in the plasma in ionic form. Short chain fatty acids are amphiphatic and associate with water. Long chain fatty acids are hydrophobic and are transported in the plasma in association with proteins, especially the albumins.

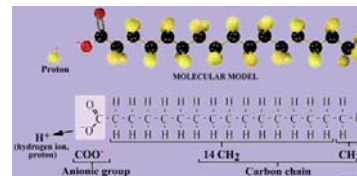


Fig 3C-2

Fatty Acids

A fatty acid is saturated (such as palmitic acid) when the carbons (of CH_2 chain) have the maximum number of hydrogen, each with a single covalent bond.

- An unsaturated fatty acid does not have maximum hydrogen bonding to the carbons, and at least one double covalent bond is present. The unsaturated fatty acid shown is oleic acid.

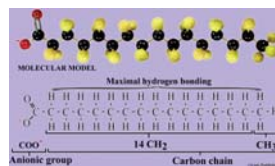


Fig 3C-3

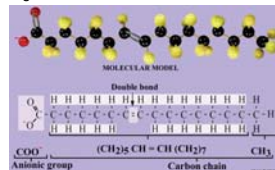


Fig 3C-4

GLYCERIDES

Glycerides

- Glycerides are a group of lipids commonly called fats (solid at room temperature) and oils (liquid at room temperature). They are formed from the union of glycerol and fatty acids.

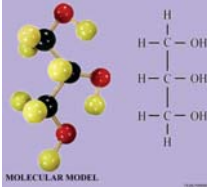


Fig 3C-5

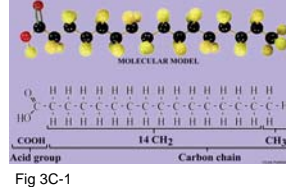


Fig 3C-1

Monoglyceride

- Monoglycerides are the simplest structural glyceride unit. A monoglyceride is constructed by bonding glycerol to a single fatty acid. Substituting different fatty acids produces different varieties of monoglycerides.

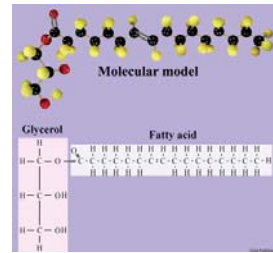


Fig 3C-6

Diglycerides

- Diglycerides consist of glycerol bonded with two fatty acids. Different varieties of diglycerides are formed by substitutions of the fatty acids.

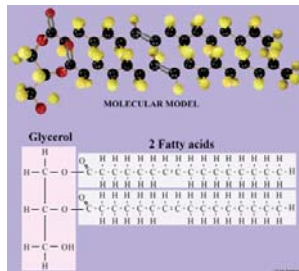


Fig 3C-7

Triglycerides

- Triglycerides consist of glycerol bonded with three fatty acids. Different varieties of triglycerides are formed by substitutions of the fatty acids.

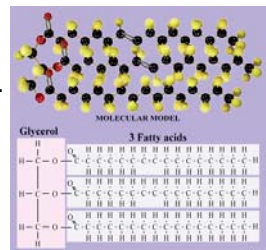


Fig 3C-8

Glyceride Dehydration Synthesis

- A dehydration synthesis reaction combines two subunits (molecules) into a larger unit (molecule) and produces a molecule of water.

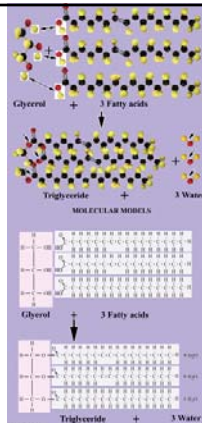


Fig 3C-9

Adipose Tissue

- Triglycerides are commonly stored in adipose tissue. Fat cells (adipocytes) begin to enlarge when triglycerides (identified as lipid droplets) are stored within the cell. As the lipid droplet continues to enlarge (dehydration synthesis) the cytoplasm and nucleus are seen displaced next to the cell membrane.

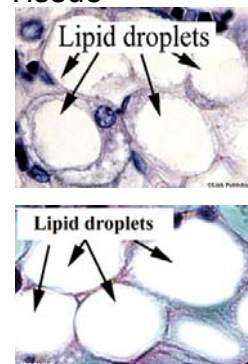
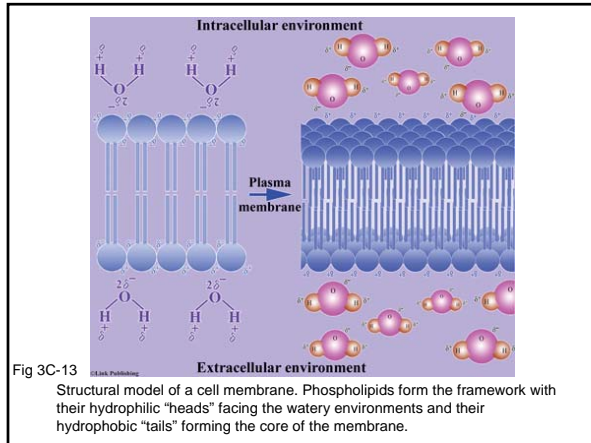
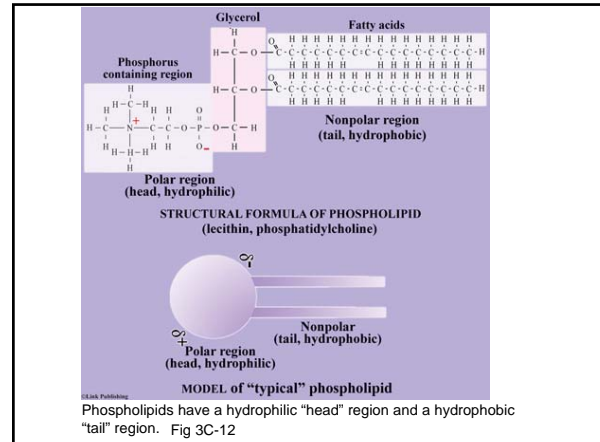


Fig 3C-10

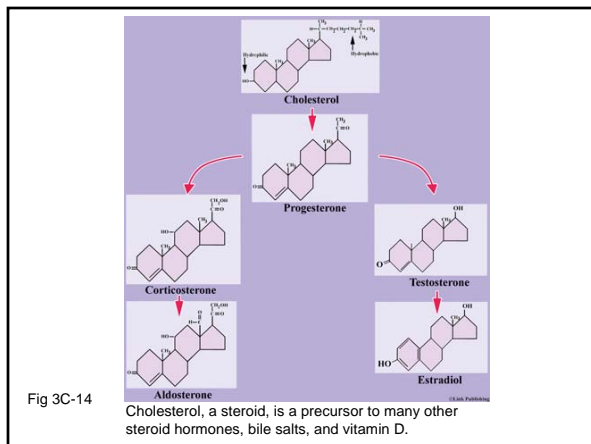
PHOSPHOLIPIDS

- Phospholipids are structured around glycerol and contain one or more phosphate groups. Their general structure is **similar to a triglyceride** except for the replacement of one of the fatty acid chains with a chain that contains at least one phosphate group (and usually another group that is a nitrogen base).
- The structure of phospholipids makes them **amphiphilic**. Amphiphilic molecules are compounds that consist of a portion having a polar water-soluble group (hydrophilic, or water loving) that is attached to a water-insoluble hydrocarbon chain (hydrophobic, or water fearing).
- In a phospholipid
 - the phosphorus containing "head" is hydrophilic and
 - fatty acid "tails" are hydrophobic



STEROIDS

- Steroids are fat-soluble lipids that are characterized by having four hydrocarbon rings.
- A steroid of major importance in the body is cholesterol.
- Among the functions of cholesterol are both functional and structural components of cell membranes, and as a precursor for the manufacture of many other steroid hormones, and vitamin D.



Fatty acid anabolism (in formation of triglycerides)

- In the well-fed state, the most common dietary fats, the glycerides are digested for absorption into fatty acids and monoglycerides. Once absorbed, they are re-synthesized in the absorptive cells into glycerides (especially triglycerides). The absorptive cells further synthesize the glycerides into water-soluble lipoproteins called chylomicrons. The chylomicrons are released into the blood and transported throughout the body. The primary target of chylomicrons is adipose tissue

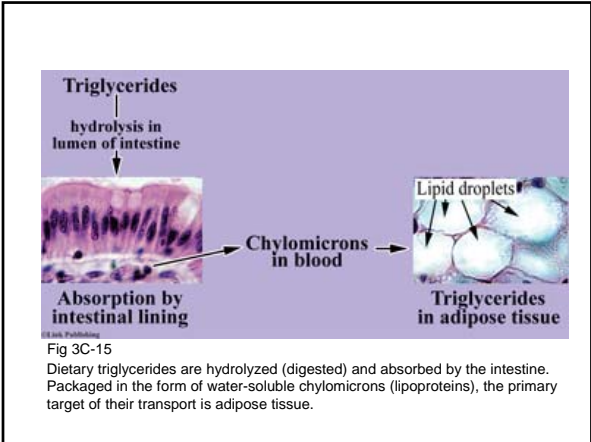


Fig 3C-15
Dietary triglycerides are hydrolyzed (digested) and absorbed by the intestine. Packaged in the form of water-soluble chylomicrons (lipoproteins), the primary target of their transport is adipose tissue.