**Chapter 10 Lipids**

* Lipids have different categories.
* storage lipids
* structural lipids
* signal, cofactor and pigments lipids
* Biological lipids are insoluble in water.

**10.1 Storage Lipids**

* Fats and oils are the principal stored forms of energy in living organisms.
* They are derivatives of **fatty acids**.
* The fatty acids are hydrocarbon derivatives.
* Fatty acid–containing compounds are two types (triacylglycerols and waxes).

**Fatty Acids Are Hydrocarbon Derivatives**

* They are carboxylic acids with hydrocarbon chains ranging from 4 to 36 carbons long (C4 to C36) (**Table 10-1)**.
* Some of them are saturated.
* Some of them contain one or more double bonds.



* The double bonds are in the cis configuration.
* The family of polyunsaturated fatty acids (PUFAs) with a double bond between the third and fourth carbon from the methyl end of the chain are of special importance in human nutrition.
* An alternative nomenclature is sometimes used for these fatty acids.
* The carbon of the methyl group (that is, the carbon most distant from the carboxyl group) is called the (omega) carbon and is given the number 1.
* PUFAs with a double bond between C-3 and C-4 are called omega-3 (-3) fatty acids.
* PUFAs with a double bond between C-6 and C-7 are called omega-6 (-6) fatty acids.







* Humans require but do not have the enzymatic capacity to synthesize the omega-3 PUFA - linolenic acid (18:3(9,12,15).
* Linoleate and - linoleate are essential fatty acids for mammals, because they are necessary precursors for the synthesis of other products.
* Therefore, humans must obtain it in the diet.

**Triacylglycerols Are Fatty Acid Esters of Glycerol**

* The simplest lipids constructed from fatty acids are the **triacylglycerols**.
* They are also referred to as triglycerides, fats or neutral fats.
* They are composed of three fatty acids each in ester linkage with a single glycerol (**Fig. 10-3)**.





* Most naturally occurring triacylglycerols are mixed.
* They contain two or three different fatty acids.

**Triacylglycerols Provide Stored Energy and Insulation**

* Oily droplets in the aqueous cytosol and fat cells serve as depots of metabolic fuel.
* **Lipases** catalyze the hydrolysis of stored triacylglycerols.
* There are two significant advantages to using triacylglycerols as stored fuels, rather than polysaccharides such as glycogen and starch.
* First, the carbon atoms of fatty acids are more reduced than those of sugars, and oxidation of triacylglycerols yields more than twice as much energy as the oxidation of carbohydrates.
* Second, because triacylglycerols are hydrophobic and therefore unhydrated, the organism does not have to carry the extra weight of water of hydration (2 g per gram of polysaccharide).
* Obese people with 15 to 20 kg of triacylglycerols can have their energy needs for months.
* In contrast, the human body can store less than a day’s energy supply in the form of glycogen.
* Carbohydrates such as glucose and glycogen do offer certain advantages as quick sources of metabolic energy, one of which is their ready solubility in water.
* In some animals, triacylglycerols stored under the skin serve not only as energy stores but as insulation against low temperatures (seals, penguins, bears).

**Waxes Serve as Energy Stores and Water Repellents**

* Biological waxes are esters of long-chain (C4 to C36) saturated and unsaturated fatty acids with long-chain (C16 to C30) alcohols (**Fig. 10-6)**.





* In plankton, waxes are the chief storage form of metabolic fuel.
* Certain skin glands of vertebrates secrete waxes to protect hair and skin and keep it pliable, lubricated, and waterproof. (Birds, shiny leaves)

**10.2 Structural Lipids in Membranes**

* The central feature of biological membranes is a double layer of lipids, which acts as a barrier to the passage of polar molecules and ions.
* Membrane lipids are amphipathic:
* one end of the molecule is hydrophobic
* the other is hydrophilic.
* They are two classes
* **phospholipids** and **glycolipids (Fig. 10-7)**.





**Glycerophospholipids Are Derivatives of Phosphatidic Acid**

* Glycerophospholipids, also called phosphoglycerides, are membrane lipids in which
* two fatty acids are attached in ester linkage to the first and second carbons of glycerol
* a highly polar or charged group is attached through a phosphodiester linkage to the third carbon.
* Glycerophospholipids are named as derivatives of the parent compound, phosphatidic acid, according to the polar alcohol in the head group **(Fig. 10–9)**.







**Some Glycerophospholipids Have Ether-Linked Fatty Acids**

* Some animal tissues and some unicellular organisms are rich in ether lipids, in which
* one of the two acyl chains is attached to glycerol in ether linkage.
* The ether-linked chain may be saturated or may contain a double bond between C-1 and C-2, as in **plasmalogens** **(Fig. 10–10)**.





**Chloroplasts Contain Galactolipids and Sulfolipids**

* In plant cells, the **galactolipids** contain one or two galactose residues connected by a glycosidic linkage to C-3 of a 1,2-diacylglycerol **(Fig. 10–11)**.
* Plant membranes also contain sulfolipids, in which
* a sulfonated glucose residue is joined to a diacylglycerol in glycosidic linkage **(Fig. 10–11)**.





**Sphingolipids Are Derivatives of Sphingosine**

* **Sphingolipids** are composed of
* one molecule of the long-chain amino alcohol sphingosine or one of its derivatives,
* one molecule of a long-chain fatty acid,
* a polar head group that is joined by a glycosidic linkage in some cases and a phosphodiester in others **(Fig. 10–13)**.





* **Glycosphingolipids** have one or more sugars connected directly to the ceramide
* **Cerebrosides** have a single sugar linked to ceramide.
* **Globosides** have two or more sugars linked to ceramide.
* Cerebrosides and globosides are sometimes called **neutral glycolipids**.
* **Gangliosides**, the most complex sphingolipids, have oligosaccharides.

**Sphingolipids at Cell Surfaces Are Sites of Biological Recognition**

* In humans, at least 60 different sphingolipids have been identified in cellular membranes.
* Many of these are especially prominent in the plasma membranes of neurons, and some are clearly recognition sites on the cell surface, but a specific function for only a few sphingolipids has been discovered thus far.
* The carbohydrate moieties of certain sphingolipids define the human blood groups and therefore determine the type of blood **(Fig. 10–15)**.





* Gangliosides are concentrated in the outer surface of cells, where they present points of recognition for extracellular molecules or surfaces of neighboring cells.

**Sterols Have Four Fused Carbon Rings**

* Sterols are structural lipids present in the membranes of most eukaryotic cells.
* The characteristic structure of sterols is the steroid nucleus.
* They are consisting of four fused rings, three with six carbons and one with five.
* Cholesterol is the major sterol in animal tissues **(Fig. 10-17)**.





* In addition to their roles as membrane constituents,
* the sterols serve as precursors for a variety of products with specific biological activities.
* **Steroid hormones**, for example, are potent biological signals that regulate gene expression.
* **Bile acids** are polar derivatives of cholesterol
* Theyact as detergents in the intestine.

**10.3 Lipids as Signals, Cofactors and Pigments**

* This group of lipids is present in much smaller amounts.
* They have active roles in the metabolic traffic as metabolites and messengers.
* Phosphatidylinositol **(Fig. 10-9)** and its phosphorylated derivatives act at several levels to regulate cell structure and metabolism.
* Prostaglandins, thromboxanes, and leukotrienes (the eicosanoids), derived from arachidonate (20:4(5,8,11,14)) **(Table 10-1)**, are potent hormones.
* Steroid hormones, such as the sex hormones, derived from sterols. They serve as powerful biological signals, altering gene expression in target cells **(Fig. 10-18)**.





* Vitamins D, A, E, and K are fat-soluble compounds made up of isoprene units.



* All play essential roles in the metabolism or physiology of animals.
* Vitamin D is precursor to a hormone that regulates calcium metabolism. **(Fig. 10-20)**





* Vitamin A is precursor to a hormone that furnishes the visual pigment of the vertebrate eye and is a regulator of gene expression during epithelial cell growth.
* Vitamins E and K and the lipid quinones are oxidation-reduction cofactors.
* Vitamin E functions in the protection of membrane lipids from oxidative damage.
* Vitamin K is essential in the blood-clotting process. Vitamin K deficiency slows blood clotting, which can be fatal.
* Ubiquinones and plastoquinones, also isoprenoid derivatives, are electron carriers in mitochondria and chloroplasts, respectively.
* Lipidic conjugated dienes serve as pigments in flowers and fruits and give bird feathers their striking colors.