Chapter 15

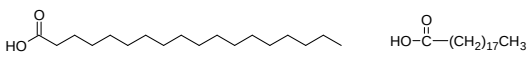
Lipids

Lipids

- Lipids are a class of biomolecules which are predominantly composed of hydrocarbons
- Recall that hydrocarbons are generally non-polar
- For this reason, lipids are insoluble in water
- Three important classes of lipids are
  - Fats
  - Oils
  - Steroids

Fats & Oils

- The term fat is usually applied to solid lipids, while the term oil is used for liquids
- For simplicity, we will refer to both as fats
- A fat molecule is formed by the reaction of glycerol with fatty acids, which are carboxylic acids which possess long, hydrocarbon chains
  - There are several different fatty acids, including stearic acid and oleic acid



two methods of representing stearic acid

Saturated and Unsaturated Fats

- An unsaturated fat contains at least one carbon-carbon double bond in its structure
  - Recall that we called this functional group an alkene
  - The double bonds in almost all naturally occurring fats are in the *cis* orientation
- Monounsaturated fats contain exactly one carbon-carbon double bond, while polyunsaturated fats contain two or more
- Saturated fats, on the other hand, contain no carbon-carbon double bonds

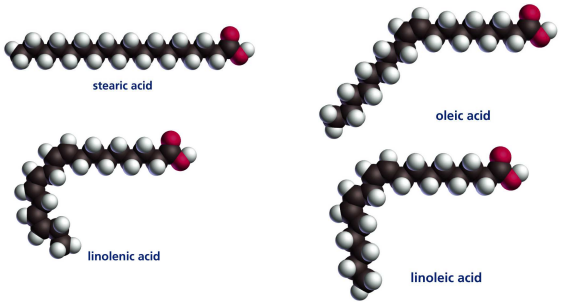
Saturated and Unsaturated Fats

- The long hydrocarbon chains in saturated fats (those made from saturated fatty acids, like stearic acid) tend to attract each other and "line-up"
- These tend to form solids, and require more energy to digest
  - They store energy very efficiently; they are therefore the most difficult type of fat to burn in an exercise program

Saturated and Unsaturated Fats

- Unsaturated fats have "kinks" in their structure
- The fatty acid chains do not line up very well, so there is little attraction between them
- These fats tend to form liquid oils at room temperature

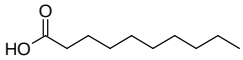
Fatty Acids

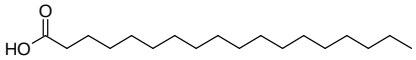


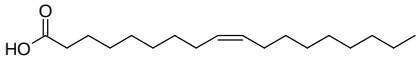
Fatty Acids

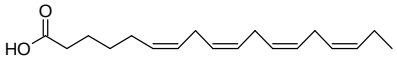
- Fatty acids are often designated by a two number code
  - The first number indicates the number of carbon atoms in the molecule
  - The second number indicates the number of carbon-carbon double bonds
    - Note that this system does not tell us where the double bond occurs in the chain

Fatty Acids

(10:0) 

(18:0) 

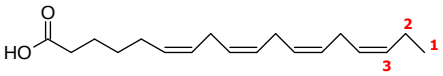
(18:1) 

(18:4) 

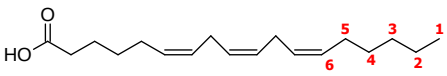
Fatty Acids

- Omega-6 and omega-3 fatty acids are molecules with a double bond 6 and 3 carbons away from the tail end of the acid, respectively
- Some of these acids form an essential part of the diet, including
  - Linolenic acid (18:3)
  - Linoleic acid (18:2)
  - Arachidonic acid (20:4)

Fatty Acids



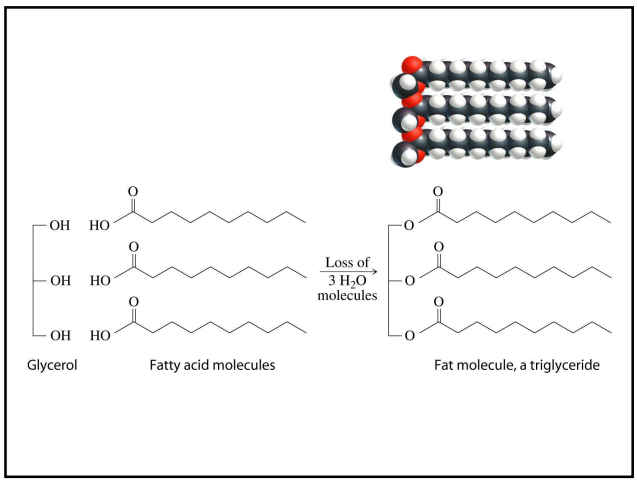
an omega-3 fatty acid



an omega-6 fatty acid

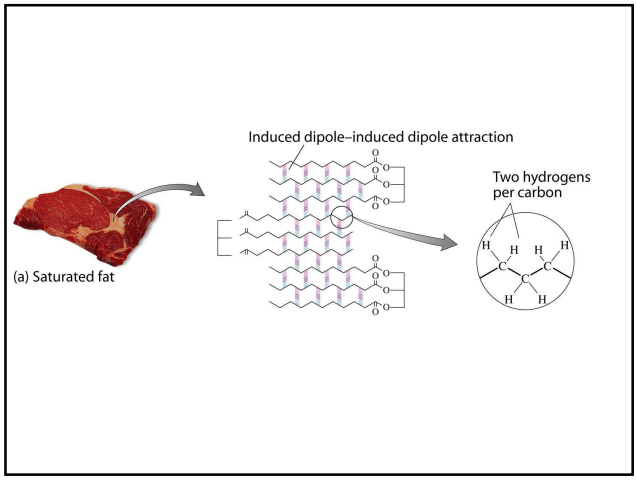
Triacylglycerides

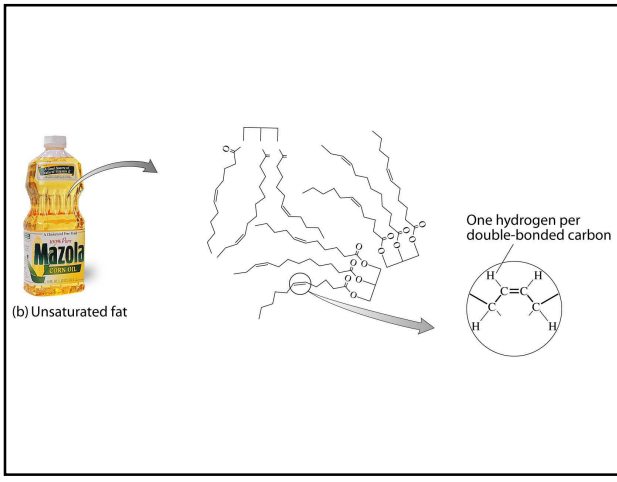
- Three fatty acids may combine with glycerol (a triol) to form a triester
  - Recall that alcohols combine with carboxylic acids to form esters
- The resulting molecules are called triacylglycerides (or triglycerides), and are the most abundant type of lipid in the humans and other animals
- The three fatty acids may be the same (simple triglycerides) or different (mixed triglycerides)



Triacylglycerides

Simplified Diagram of a Triacylglyceride





Degree of Unsaturation in Some Common Fats

Fat	Percentage of Total Fatty Acid Content		
	Saturated	Monounsaturated	Polyunsaturated
Coconut	93	6	1
Palm	57	36	7
Lard	44	46	10
Cottonseed	26	22	52
Peanut	21	49	30
Olive	15	73	12
Corn	14	29	57
Soybean	14	24	62
Sunflower	11	19	70
Safflower	10	14	76
Canola oil	6	58	36

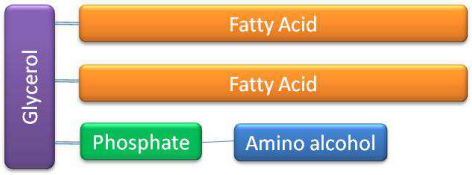
Phospholipids

- The membrane of cells and several of the compartments within them are composed of large molecules called phospholipids, derived from the more specific term *phosphoacyglycerol*
- The phospholipid is made up two main structures, which we describe as a head and two tails
- The "head" is polar, so it wants to be in the same environment as other polar molecules like water
  - We say that the head is hydrophilic, meaning "water loving"

Phospholipids

- The tails are long hydrocarbon chains which are nonpolar
- The tails try to orient themselves away from water, and towards the tails of other phospholipids
  - The tails are hydrophobic, or "water hating/fearing"

Phospholipids



Simplified Diagram of a Phosphoacylglycerol

Phospholipids

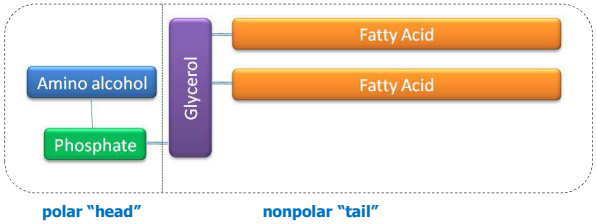


Diagram of a phosphoacylglycerol (like in previous slide), but with groups "twisted" to show polar head and nonpolar tail

Phospholipids

- The two fatty acids in a phosphoacylglycerol molecule are typically different
  - One is usually unsaturated, the other saturated
- Various amino alcohols may be present, depending on the role of the molecule
  - Typical amino alcohols include choline and serine (see p. 420 for details and structures)

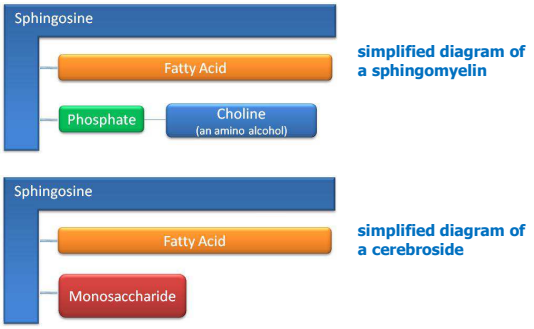
Phospholipids

- Phospholipids usually come together in one of two ways
- They may form a bilayer, with two layers of phospholipids lined up with their tails facing each other
  - Click here
- They may make a shape like a bubble, called a micelle, with the tails in the center of the bubble

Sphingolipids

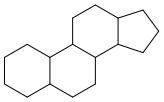
- Another important class of lipids, called sphingolipids, are concentrated in the nervous system
- These molecules are composed of a sphingosine molecule which is bonded to a fatty acid and some other polar group
- Sphingomyelins are important components of the myelin sheath which surrounds nerve cells
- Cerebrosides account for a significant proportion of dry brain mass (7%) and are also found in the myelin sheath

Sphingolipids



Steroids

- Steroids are a class of lipids which contain four hydrocarbon rings fused together
- Three of the rings contain six carbon atoms, the other contains five
- The basic “skeleton” of all steroids is shown here

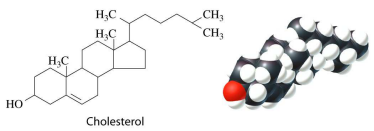


Steroids

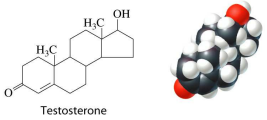
- Unlike fatty acids, steroids have a rigid structure
- However, steroids are generally nonpolar, the main characteristic of lipids
- Steroids are often found in the membranes of cells, where their rigid structure provides support

Steroids

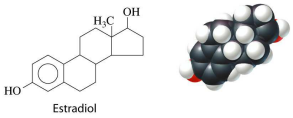
- Steroids have different roles throughout the body
- Some steroids, like testosterone and estradiol, are hormones
  - These molecules can be used to send signals throughout the body
- Cholesterol is the most abundant steroid in the body
  - Cells transform cholesterol into other steroids



Cholesterol



Testosterone

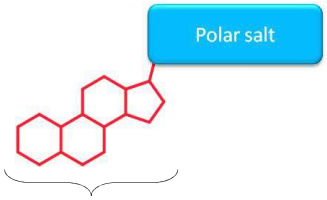


Estradiol

Bile Salts

- A bile salt is a molecule which consists of a nonpolar steroid bonded to a polar ionic group
- These compounds, which are manufactured in the gall bladder, act as *emulsifying agents* in the body
- The nonpolar portions of these molecules surround small bundles of consumed lipids
- The exterior polar portions of the molecular bundles are relatively soluble in water, effectively allowing oil and water to mix

Bile Salts



simplified diagram of a bile salt

Anabolic Steroids

- Anabolic steroids have been employed to enhance muscle growth
- These compounds mimic testosterone, signaling the body to build muscle
- Their use as a supplement is illegal and is generally forbidden in sports
- By disturbing the equilibrium within the body, these molecules often cause much more harm in the long term than they do benefit