Chapter 26: Lipids

[Sections: 26.1-26.7]

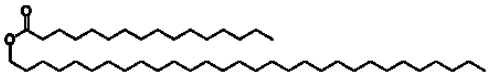
Definition

- *unlike amino acids and carbohydrates, which are defined by their structural features, lipids comprise a variety of molecular structures but share in common their solubility in nonpolar (or low polarity) solvents*
- *"complex lipids" are lipids that contain ester groups and are able to be hydrolyzed to simpler compounds*
- *"simple lipids" are molecules that do not undergo hydrolysis readily*

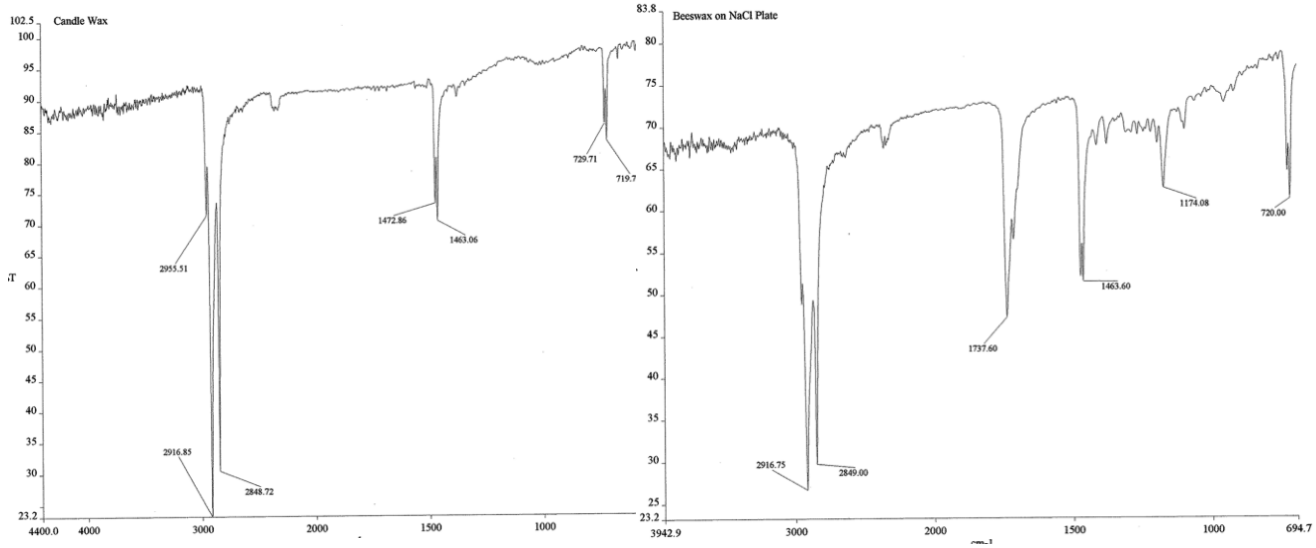
Complex Lipids

A. Waxes

- *waxes are typically esters made from high molecular weight carboxylic acids and alcohols*
- *their very hydrocarbon-like structure makes them behave like simple hydrocarbon waxes found in candles (i.e. water resistance)*

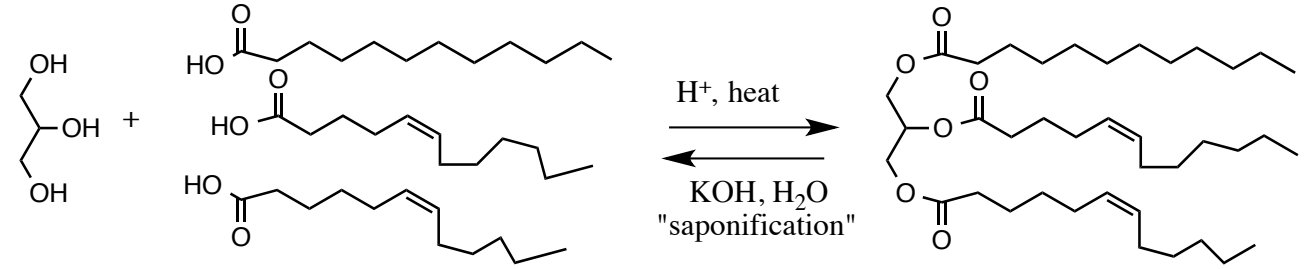


IR spectra of candle wax and beeswax

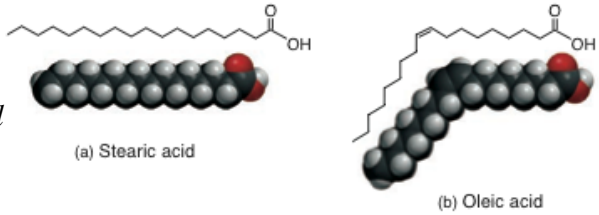


B. Fats and Oils (trigylcerides)

- *triglycerides are triester molecules made from glycerol and long chain carboxylic acids ("fatty acids")*

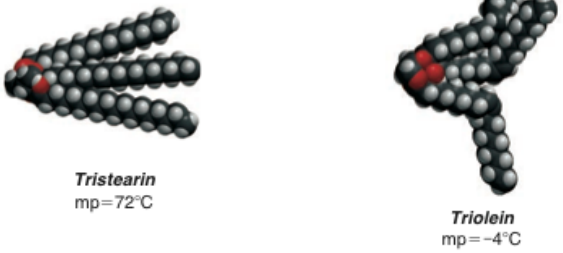


glycerol *typical "fatty acids"* *a typical triglyceride*



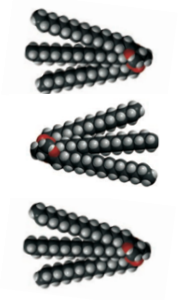
(a) Stearic acid (b) Oleic acid

- *if the triglyceride is a liquid at room temperature = oil*
- *if the trigylceride is a solid at room temperature = fat*
- *typically 12-20 carbons in length (usually an even number)*
- *branching is rarely observed (straight chains)*
- *often have double bonds (unsaturated fats or oils)*
- *if double bonds are present they are almost always cis*
- *the presence of double bonds decreases melting point and therefore increases the likelihood of a triglyceride being an oil*

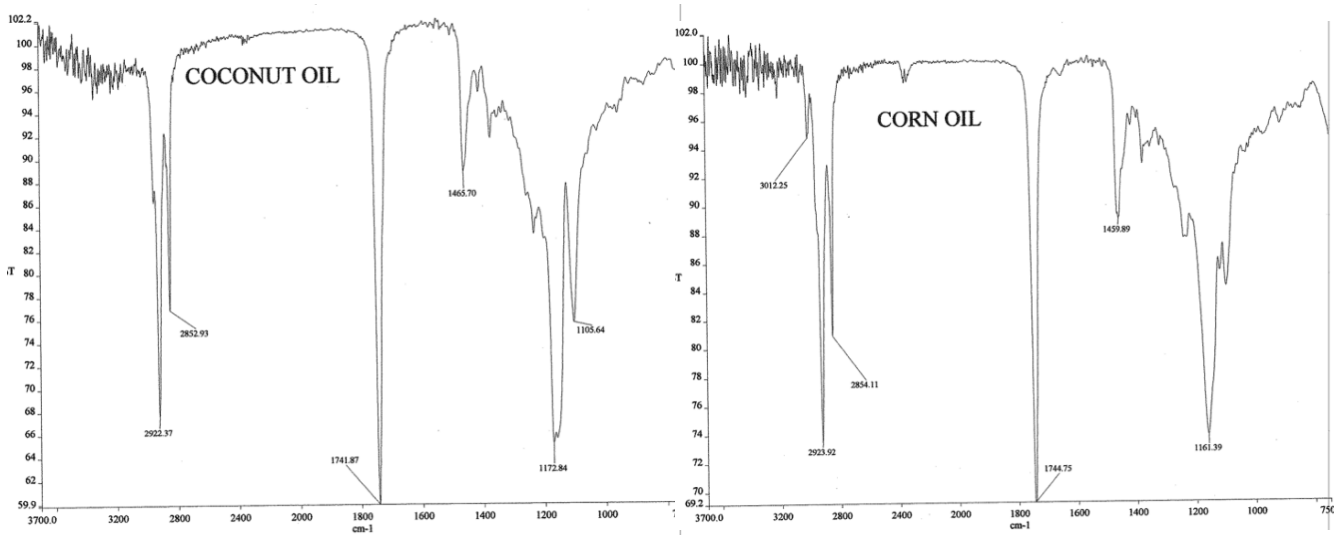


Tristearin mp=72°C

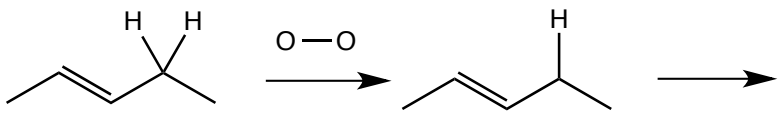
Triolein mp=−4°C



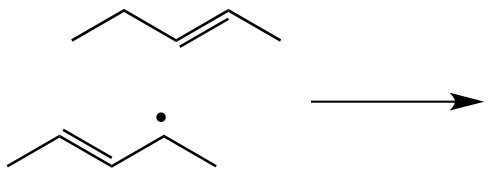
IR spectra of coconut oil and corn oil



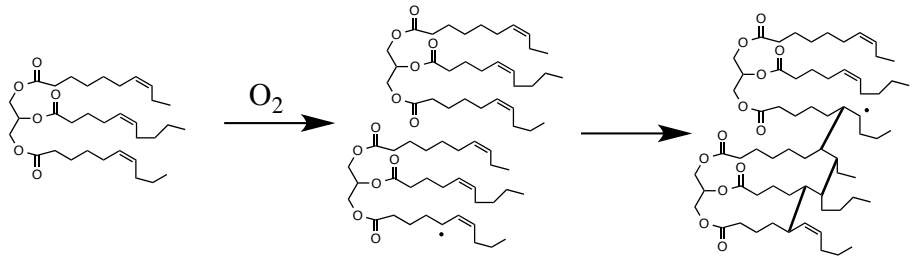
Triglycerides and Oxygen



- *presence of double bonds makes allylic hydrogens susceptible to reaction with molecular oxygen*
- *this is usually a slow reaction at room temperature but is accelerated at higher temperatures or in the presence of additives*
- *carbon radicals formed in this way can also react with the C=C bonds of neighboring molecules*



- *in triglycerides, intra and intermolecular linking of this type leads to food going stale or becoming rancid*



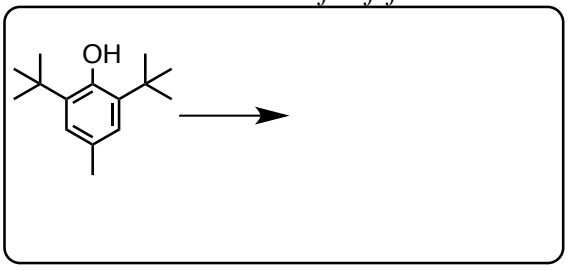
When could this type of reaction be useful?

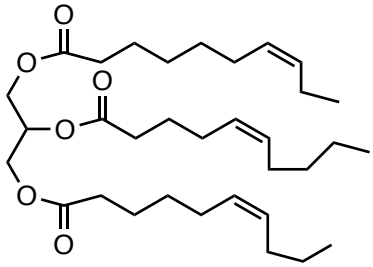
How can the reaction between triglycerides and O_2 be slowed down to extend the life of foods?

A.

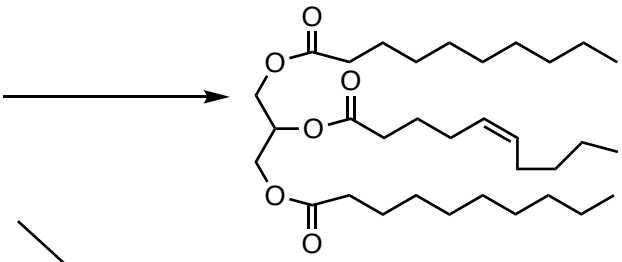
B.

C.

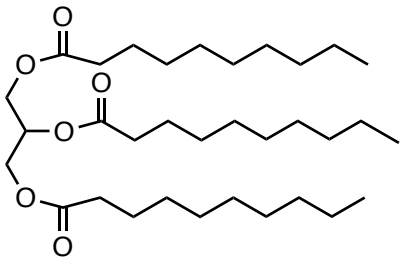


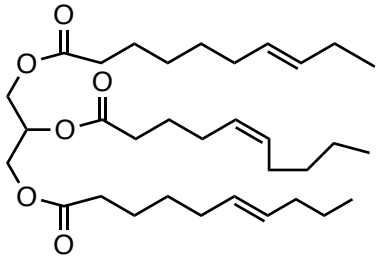


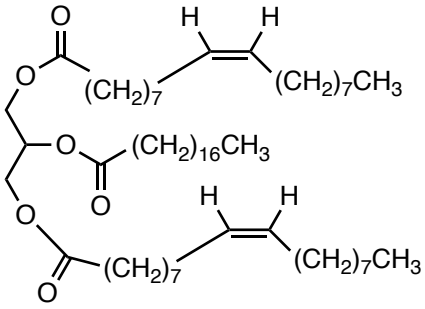
a typical trigylceride found in vegetable oil

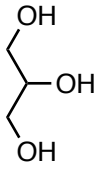


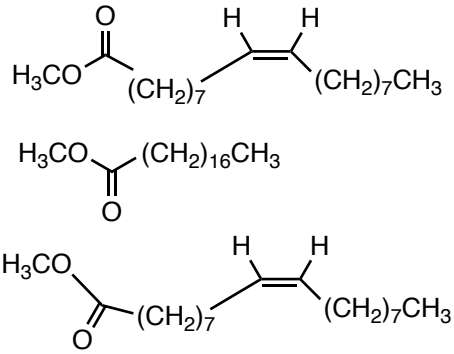
partial hydrogenation
or
high heat

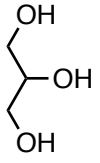


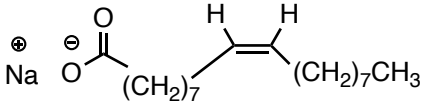


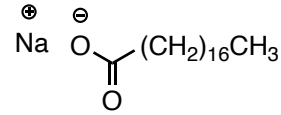


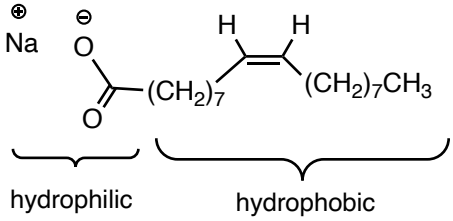


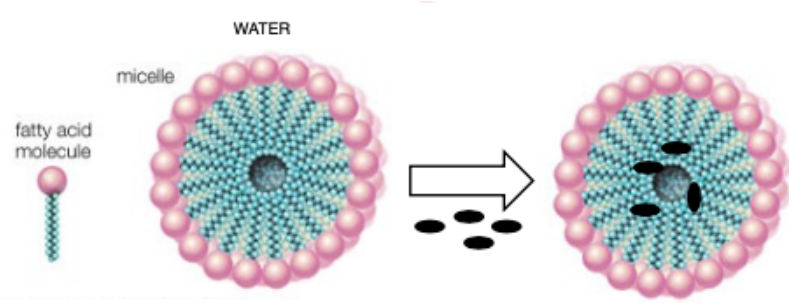




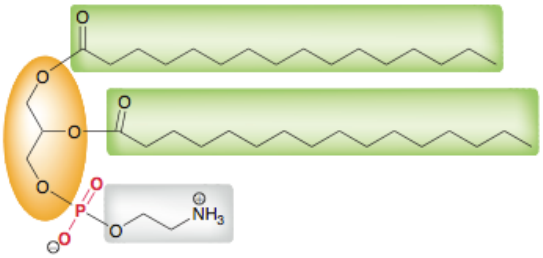


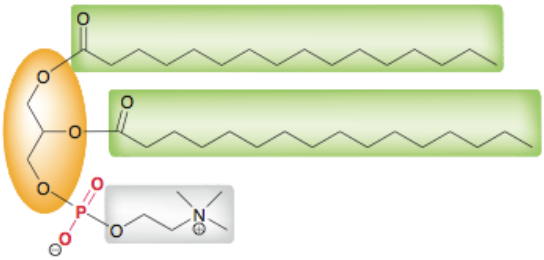




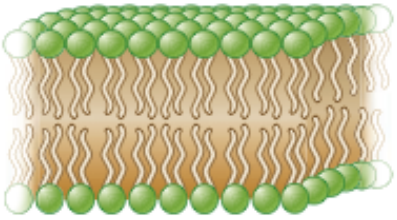


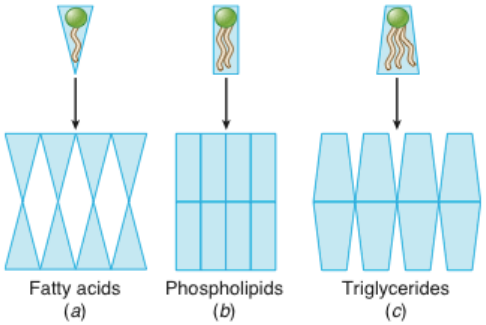
C. Phospholipids





- *similar in structure to triglycerides but one of the fatty acid chains has been replaced with a phophoric diester group*
- *cephalins and lecithins are differentiated by the type of group attached to the phosphorous atom and are found in human and plant cells*
- *phospholipids have the polar heads and nonpolar tails similar to those found in soaps*
- *phospholipics self-assemble into lipid bilayers that are the basis for cell membranes*
- *phospholipids have the shape necessary to form lipid bilayers that other compounds do not*



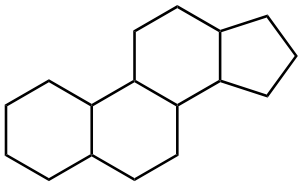


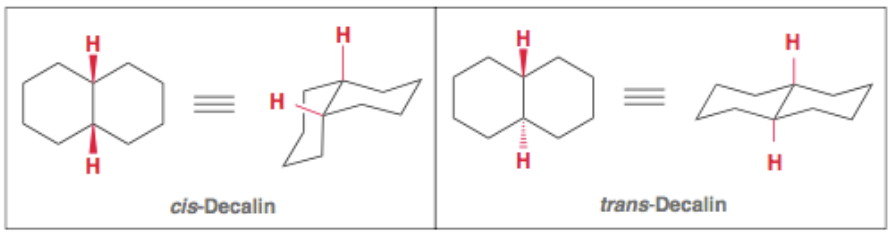
- *the hydrophobic interior of the membrane allows for control of passage of water and ions through the cell wall*

Simple Lipids

Steroids

- *a class of compounds that share a common tetracyclic ring system structure*
- *often serve as important chemical messenger in the body*





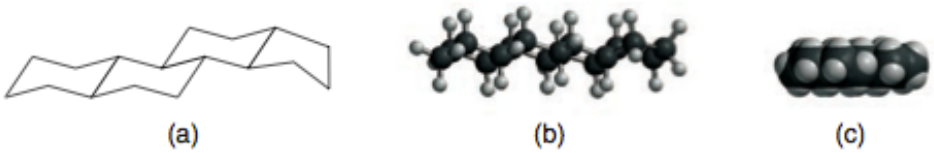
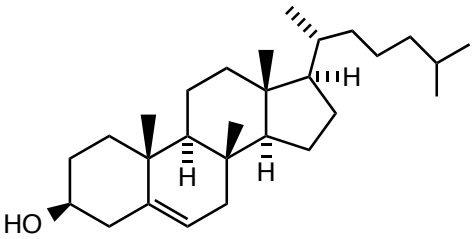
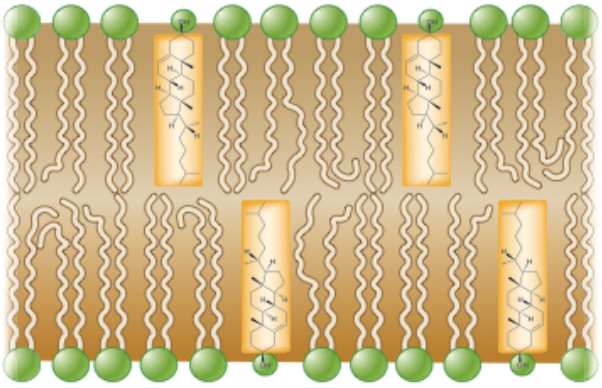


FIGURE 26.7
(a) The carbon skeleton of most steroids, (b) a ball-and-stick model of the carbon skeleton of a steroid, and (c) a space-filling model of the carbon skeleton of a steroid.



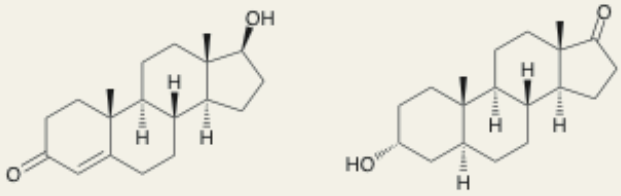
cholesterol



- *helps maintain integrity of cell membranes*
- *precursor to other steroids, including sex hormones*
- *body is able to synthesize cholesterol (liver) but it can also be absorbed from foods*
- *because of low solubility in aqueous environment of the blood, cholesterol is transported via water-soluble lipoproteins*
- *low density lipoproteins (LDL) transport cholesterol from the liver to the cells*
- *high density lipoproteins (HDL) transport cholesterol from the body to the liver for synthesis of other steroids*
- *if the concentrations of LDL > HDL, precipitation of LDL/cholesterol can occur causing blood flow blockage*

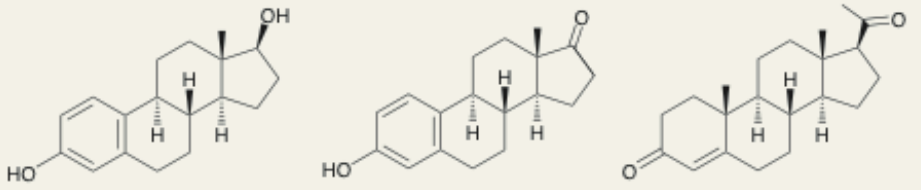
TABLE 26.3 THE MOST IMPORTANT MALE AND FEMALE SEX HORMONES

Male sex hormones



Androgens

Female sex hormones



Estrogens

A progestin

Chapter 26 *Essential Concepts*

1. Know what defines a lipid and the difference between simple and complex lipids.
2. Know the basic structure of a wax and the common occurrences
3. Know the characteristics of triglycerides (fats and oils), and the factors that affect their characterization
4. Know how IR spectra can be useful in identifying levels of saturation/unsaturation in triglycerides
5. Understand the implications of double bonds on reactivity of triglycerides with O_2 and how this can be mitigated.
6. Know how the food industry is affected by levels of unsaturation in triglycerides
7. Understand the basic structure of biodiesel and soaps. Know how soaps work.
8. Understand the relationship between soaps and phospholipids, the importance that phospholipids play in lipid bilayers, and the relevance of structure to phospholipid stability
9. Know the basic structure of steroids, the reason for their structural stiffness, and how their lack of flexibility plays a role in phospholipid stability
10. Know that male and female sex hormones play critical roles in determining sex characteristics (you do not need to memorize structures)
11. Understand the sources of cholesterol, how it relates to sex hormones, and how it is transported throughout the body including the participation of HDL and LDL lipoproteins.