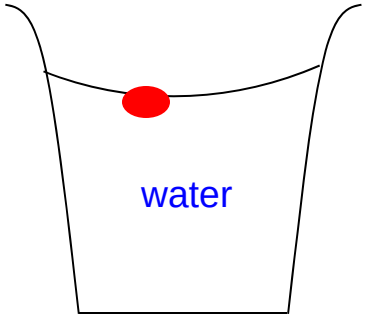
BIO 311C
Spring 2010

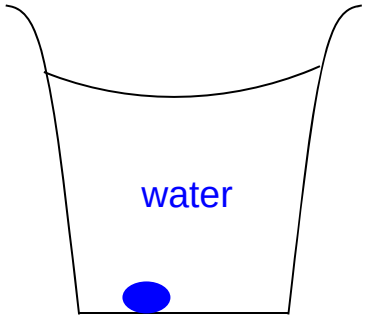
Lecture 14 – Monday 22 Feb.

Definition:

Lipids are biological molecules that are not water soluble (i.e. - they are hydrophobic) and that do not fit into any other major category of biological molecules. They are not characterized by any diagnostic functional group.



Lipids with densities lower than the density of water will float on top of aqueous solutions.



Lipids with densities higher than the density of water will settle to the bottom of aqueous solutions.

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Lipids generally have a high percentage of hydrogen covalently bonded to carbon, and a relatively low percentage of oxygen, nitrogen or phosphorous.

example: a straight-chain hydrocarbon

$CH_3—CH_2—CH_2\cdots\cdots CH_2—CH_2—CH_3$

structural formula shown in somewhat abbreviated form

$CH_3—(CH_2)_n—CH_3$

structural formula shown in more abbreviated form

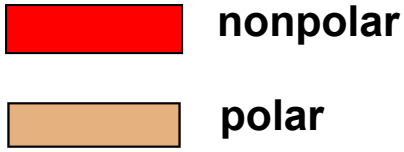
Lipids are called oils when liquid, or greases when solid. *

Lipids fall into two broad categories: nonpolar lipids and polar lipids

Neither kind of lipid is soluble in water, but nonpolar lipids do not have any polar part of the molecule, while polar lipids have a polar end that is attracted to water molecules.

a nonpolar lipid

a polar lipid



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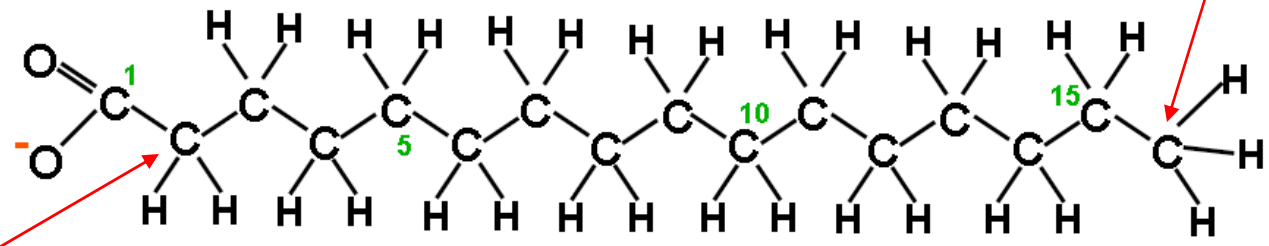
Fatty Acids

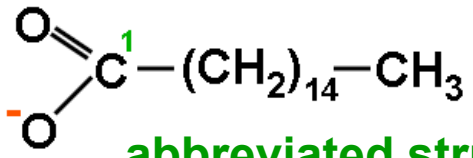
Example: stearic acid, a C_{16} fatty acid

ω carbon atom



α carbon atom

structural formula, showing all atoms and bonds



abbreviated structural formula

Except for a single carboxylate functional group at one end of the molecule, fatty acids are composed only of hydrocarbon. They nearly always contain an even number of carbon atoms, with at least 12 but seldom more than 20 carbon atoms. Carbon atoms are numbered sequentially, starting from the carboxylate end. The carbon atom closest to the carboxylate functional group is called the α carbon, while the most distant carbon atom is called the ω carbon.

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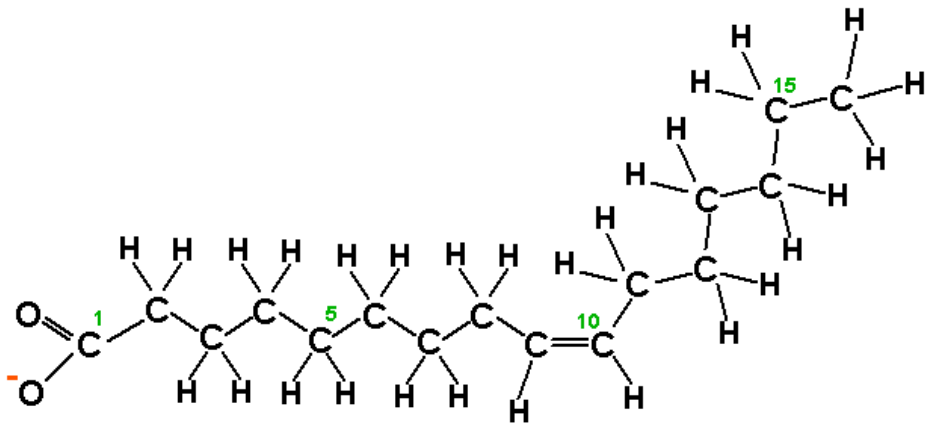
A fatty acid may contain one or more carbon-carbon double bonds.



A C_{16} unsaturated fatty acid

A fatty acid that contains no carbon-carbon double bonds is saturated.

A fatty acid that contains at least one carbon-carbon double bond is unsaturated.

A fatty acid that contains two or more carbon-carbon double bonds is polyunsaturated.

A carbon-carbon double bond in the hydrocarbon chain causes an abrupt rigid bend in the molecule at the site of the double bond.

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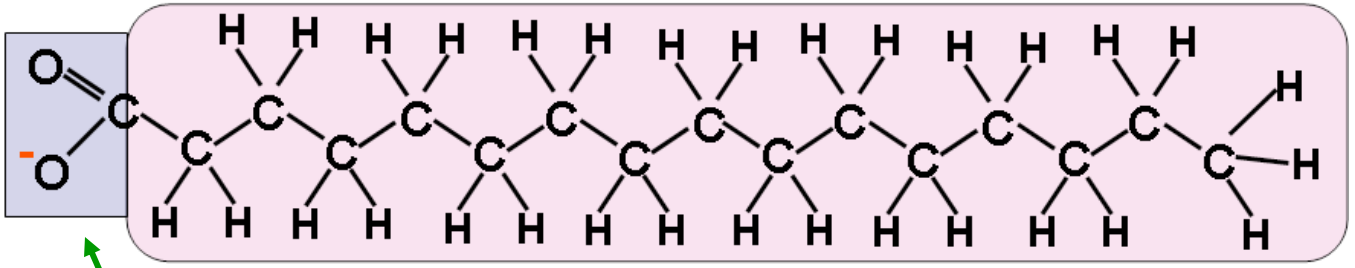
Fatty acids are polar lipids



Detailed structural formula

Polar end,
Carboxylate ion

Nonpolar end,
hydrocarbon

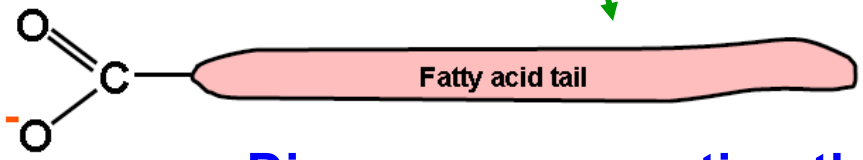


Diagram representing the structure

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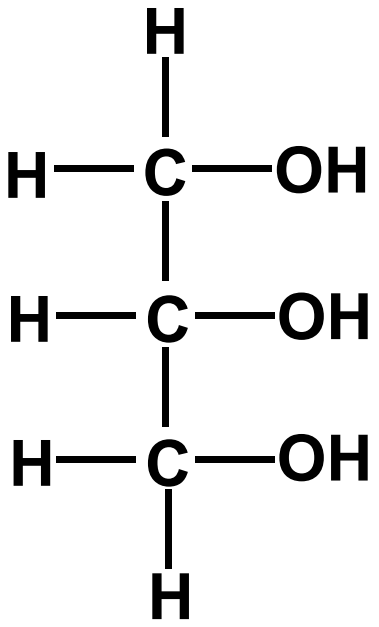
Glycerol is a 3-carbon (C_3) molecule that covalently bonds to fatty acids to produce relatively large lipids.



Glycerol

Is glycerol a lipid?

Is glycerol a carbohydrate?

How many asymmetric carbon atoms does glycerol have?

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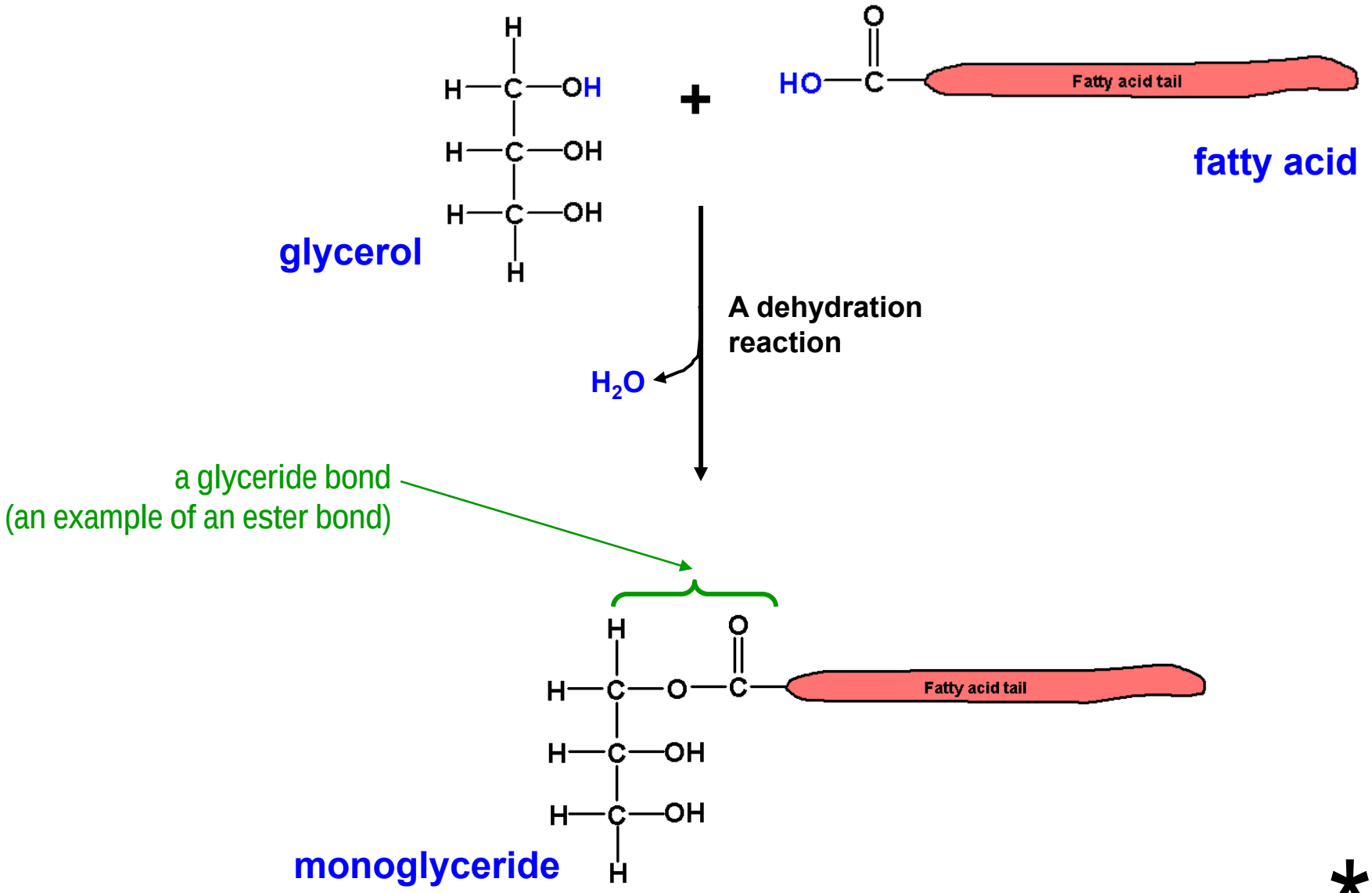
Formation of a monoglyceride from glycerol and a fatty acid



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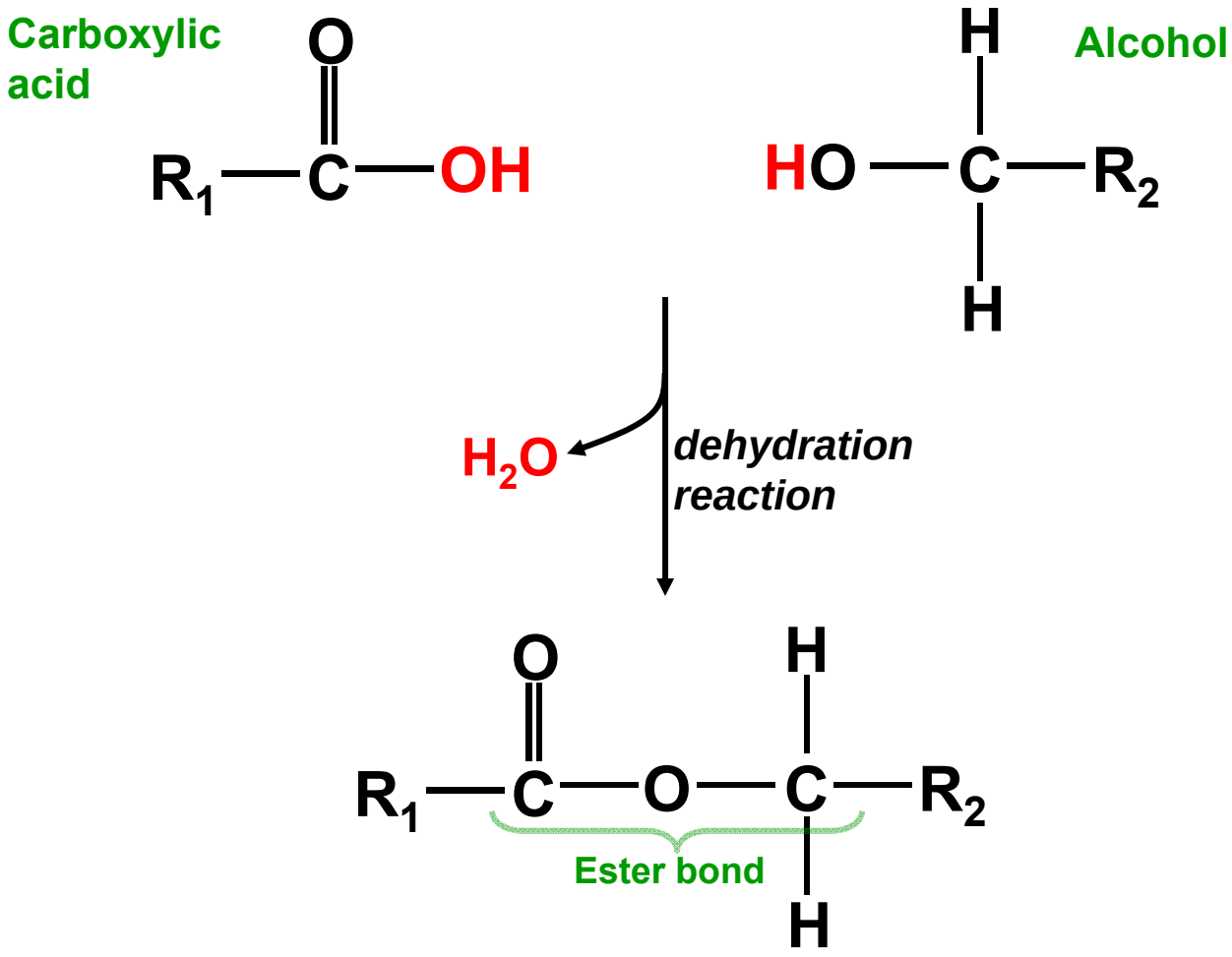
Ester Bond Formation from a Carboxylic Acid Functional Group and an Alcohol Functional Group



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Formation of Ester Bonds

acid + alcohol $\xrightarrow{\textit{dehydration reaction}}$ ester + water

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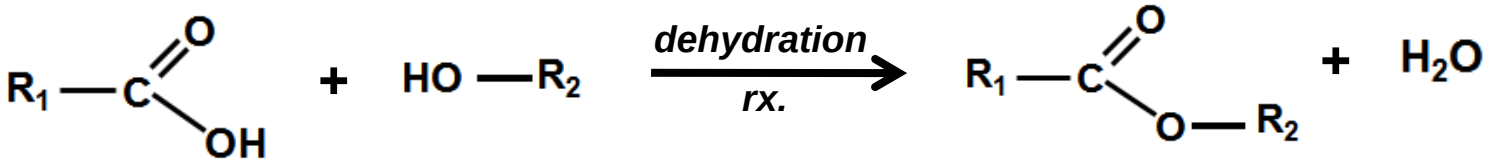
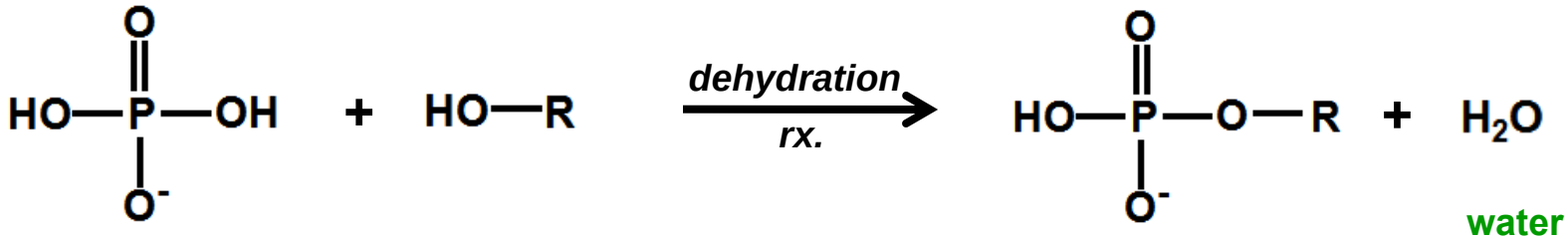
Examples

(1)



carboxylic acid + alcohol → carboxylic acid ester + water

(2)



phosphoric acid (phosphate) + alcohol → phosphoric acid ester + water

Question: Is a glycosidic bond a kind of ester bond?

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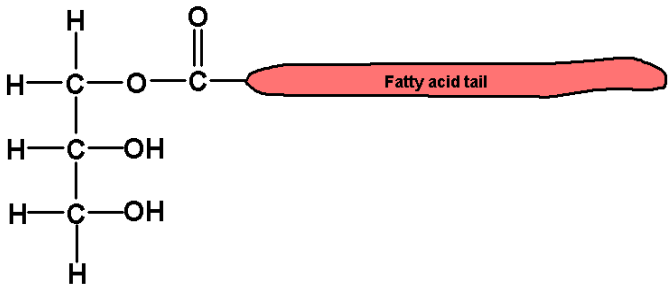
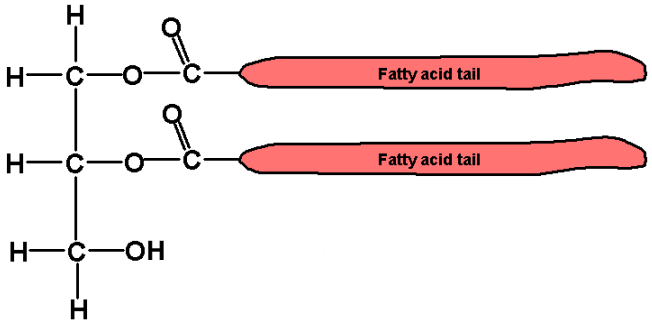
Some glyceride lipids



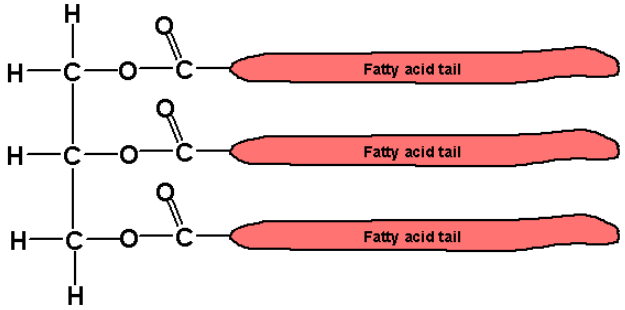
A monoglyceride
(one fatty acid,
(one glyceride bond)

a polar lipid



A diglyceride
(two fatty acids,
(two glyceride bonds)

a somewhat
polar lipid



A triglyceride
(three fatty acids,
(three glyceride bonds)

a nonpolar lipid

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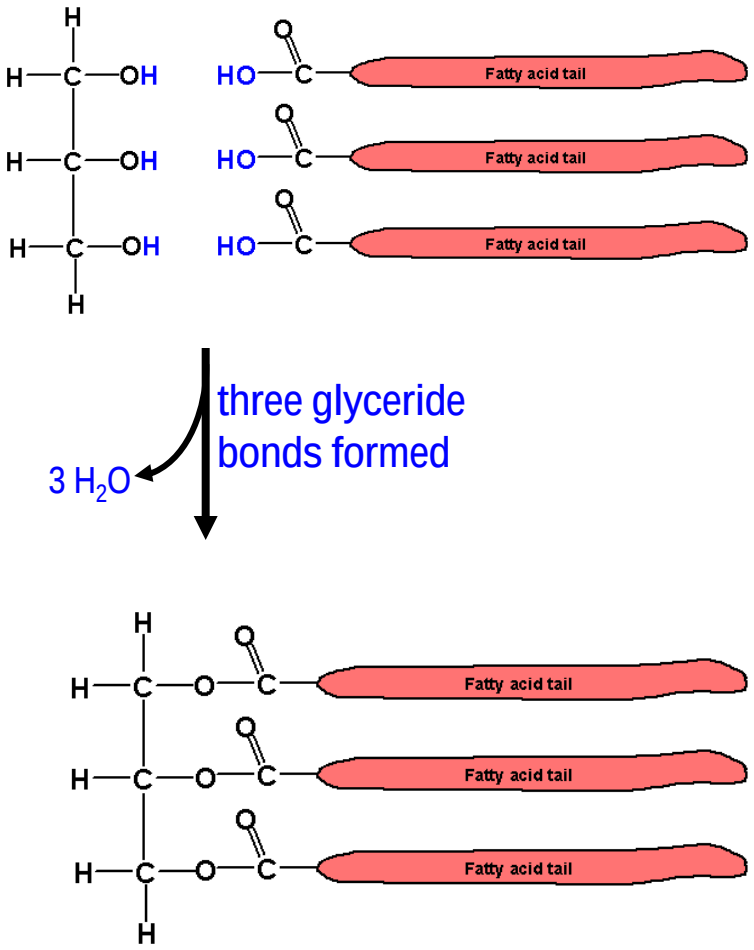
Formation of a triglyceride from a glycerol and three fatty acids In three separate dehydration reactions



glycerol + 3 fatty acids

dehydration reaction

triglyceride + 3 H_2O

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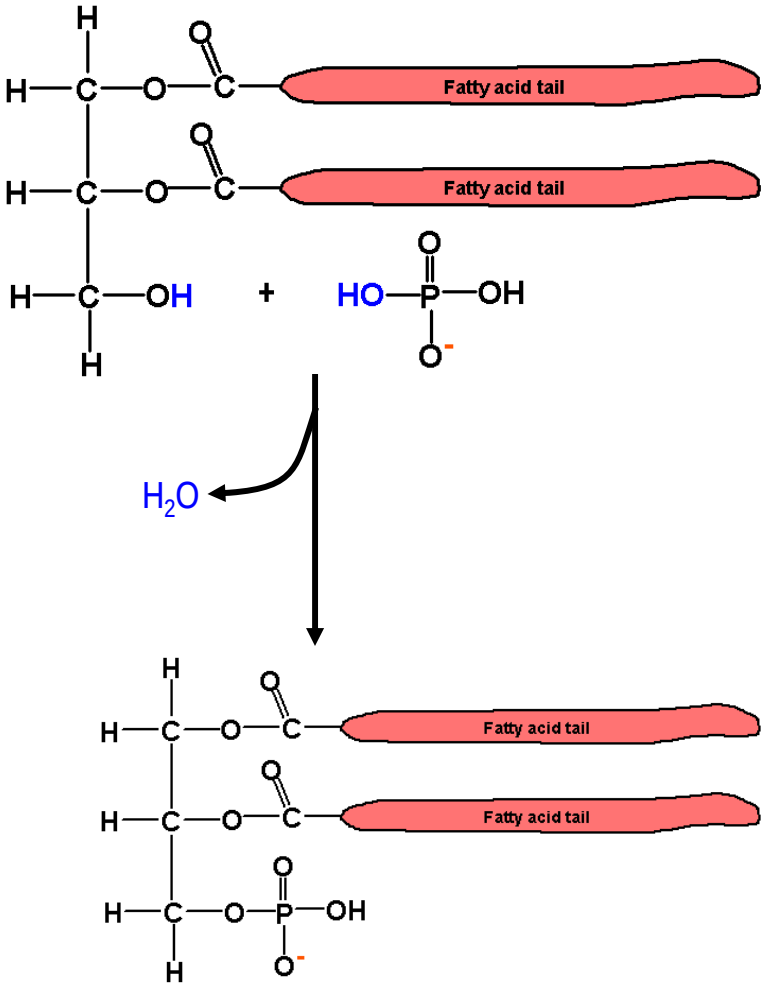
Formation of phosphatidic acid



diglyceride + phosphate

dehydration reaction

phosphatidic acid + H_2O

Phosphatidic acid contains 3 ester bonds, two carboxylic acid ester bonds (more specifically called glyceride bonds) and one phosphate ester bond.

Phosphatidic acid is a polar lipid.

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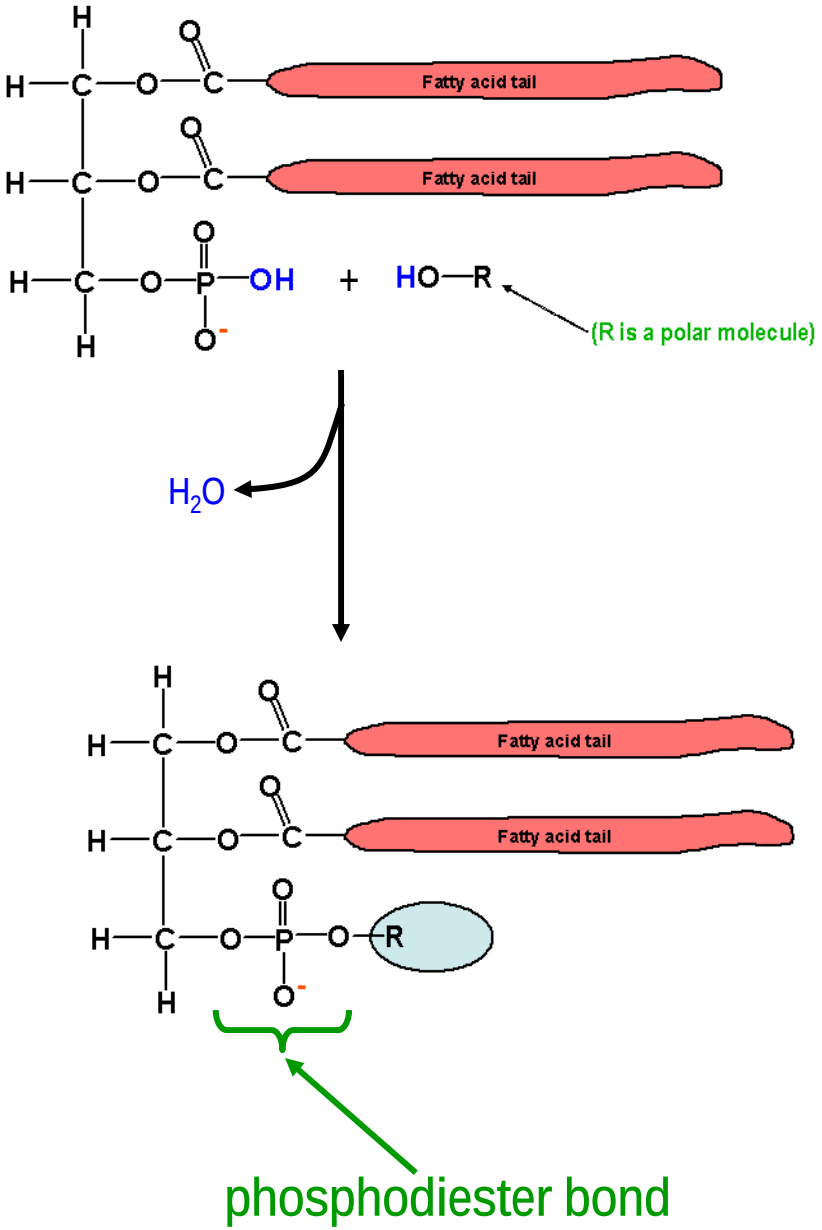
Formation of a phospholipid



phosphatidic acid + R_{polar}

dehydration reaction

phospholipid + H_2O

Phospholipids occur in all living cells and are essential components of their membranes.

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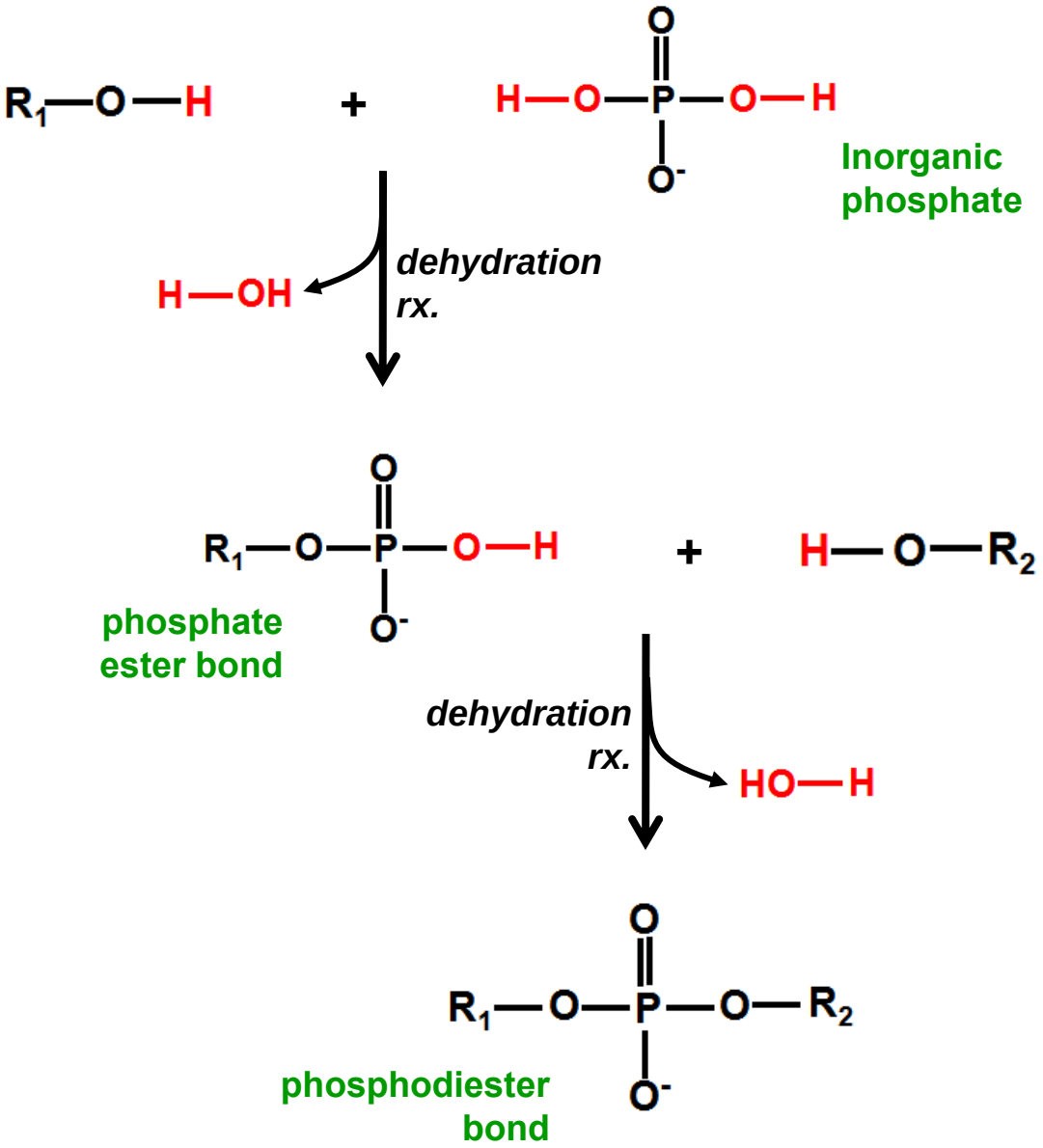
When a phosphate is covalently bonded to two alcohol functional groups at the same time, the resulting bonding arrangement is called a phosphodiester bond.



17a

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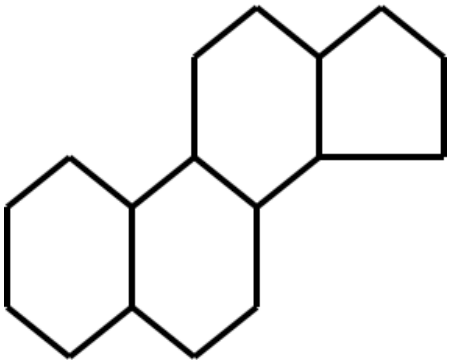
Steroids represent an important class of lipids with a characteristic "fused" ring structure.



The steroid ring structure

Interpretation of this abbreviated structure

Each line represents a single covalent bond between two carbon atoms.

Each point where two or more lines intersect represent a carbon atom.

There are sufficient hydrogen or other atoms attached to each carbon atom to satisfy the covalency of each carbon atom.

Most steroids are nonpolar lipids.

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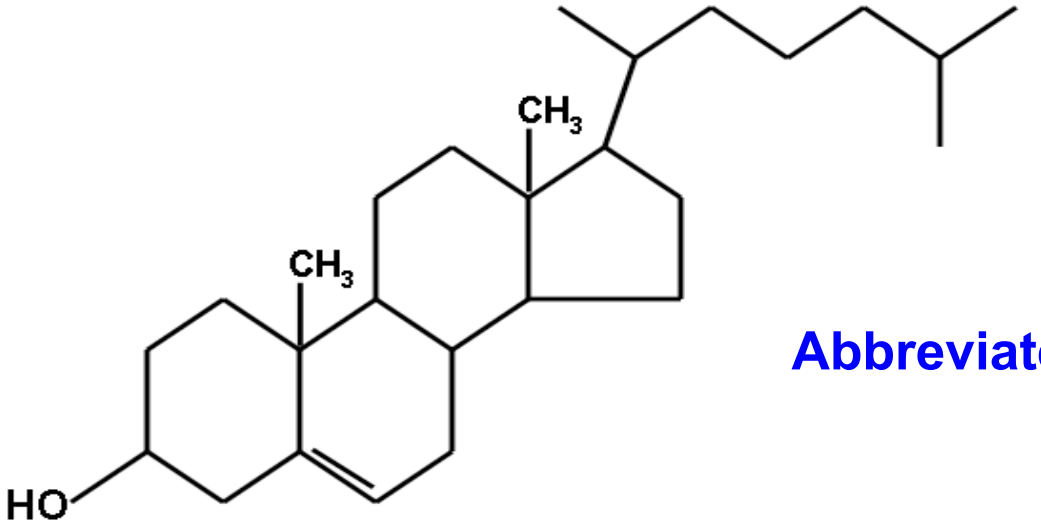
Cholesterol is an important lipid of animal cells



Abbreviated Structure of Cholesterol

Cholesterol is a nonpolar lipid, although the alcohol functional group gives it slight polarity and is very important for its functions.

You are not required to memorize the structure of specific molecules such as chlolesterol.

You should be able to recognize identifying features of various classes of molecules. For example, you should be able to recognize the steroid ring in the structure shown above.

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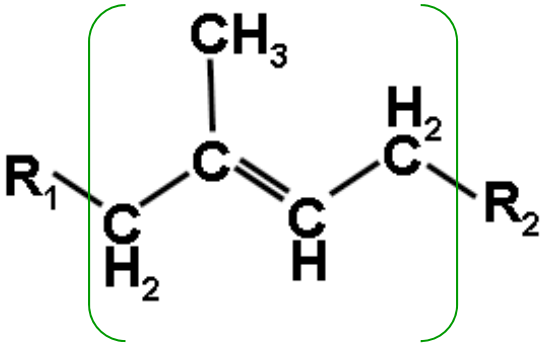
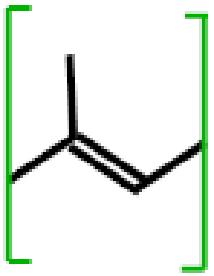
Isoprene units



Slightly abbreviated structure showing all atoms but not all covalent bonds



Very abbreviated structure, where carbon atoms represent ends of straight lines. Abbreviated structures shown like this assume that only carbon and hydrogen atoms are present.

Isoprene units are C_5 hydrocarbon portions of molecules with the chemical structure shown here

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Some General Functions Performed by Lipids

They are a major form of stored energy in cells.
(especially as triglycerides)

They are a major component of biological membranes.
(especially phospholipids and steroids)

Some hormones are lipids.
(usually modified fatty acids and some steroids)

Many plant "natural products" are lipids.
(isoprenoid lipids)

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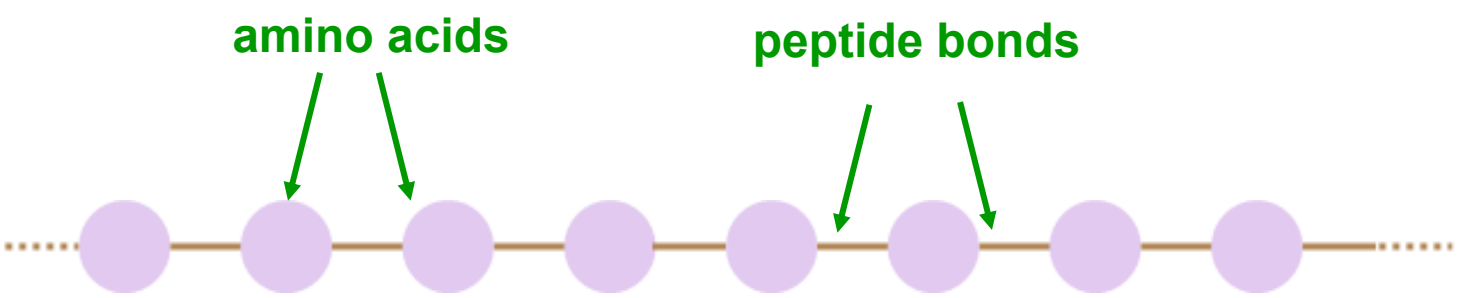
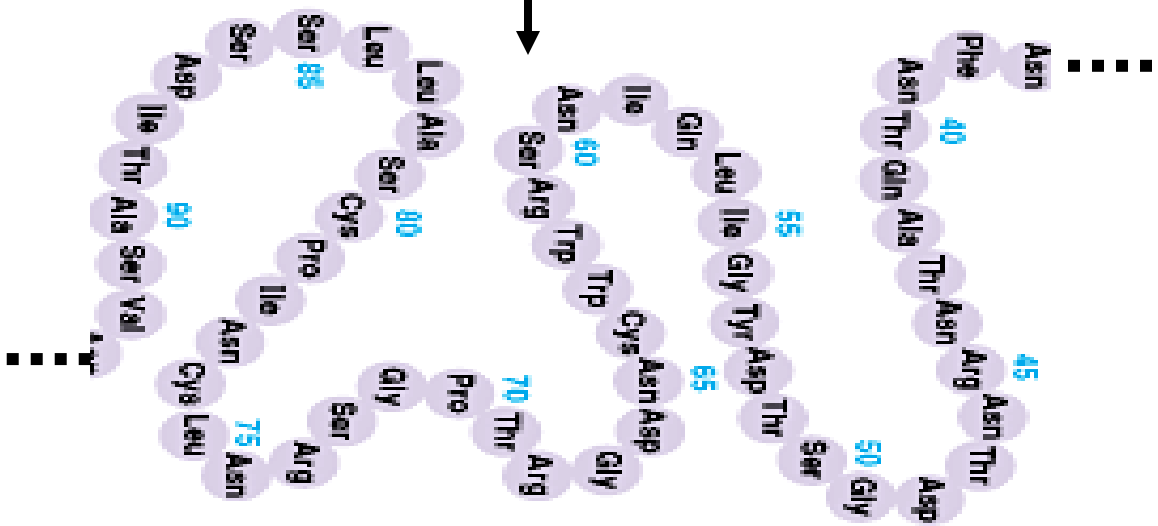
Illustration of a Polypeptide



Folding and
other modifications



Functional Protein

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