Lipids (2)

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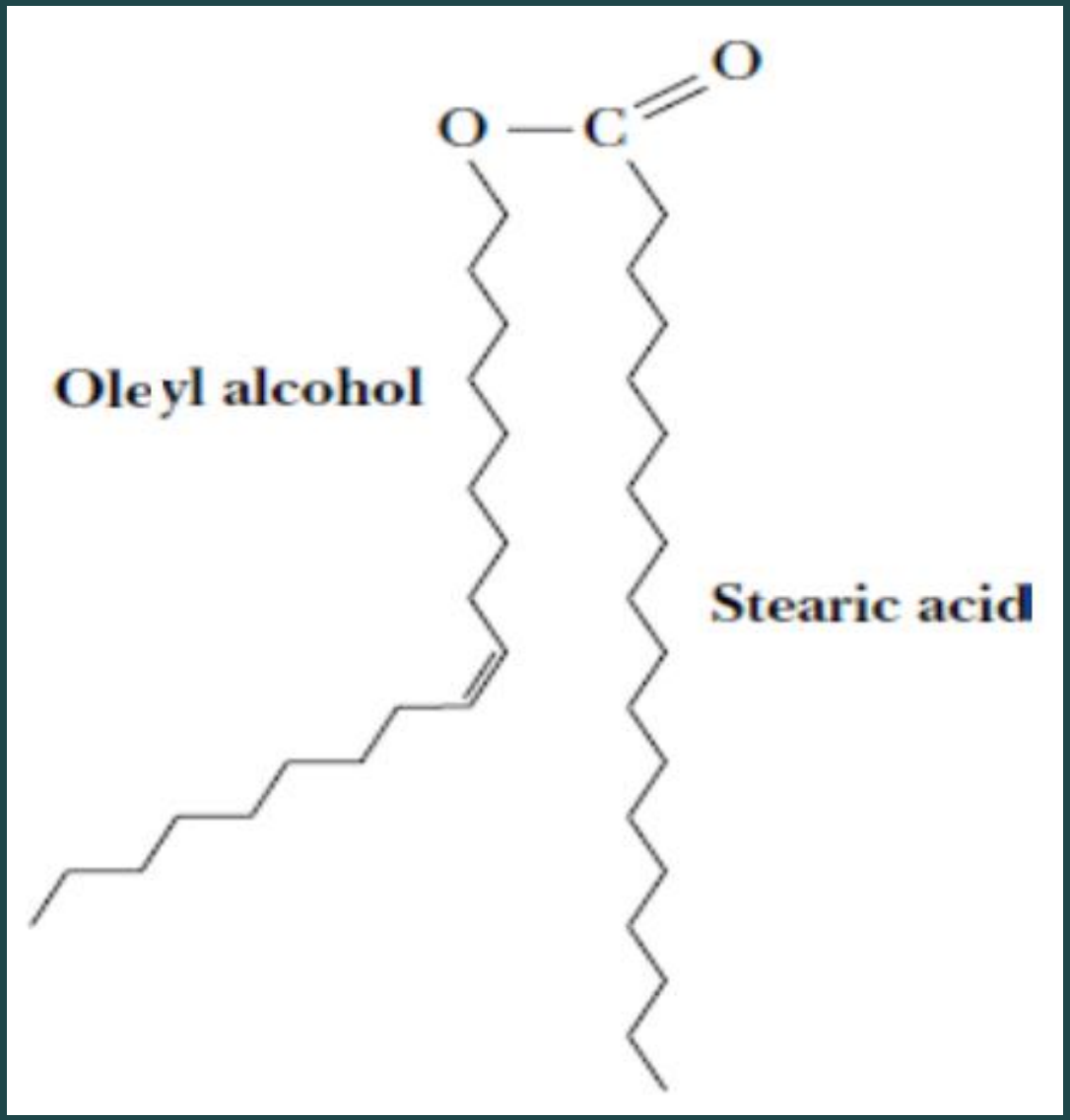
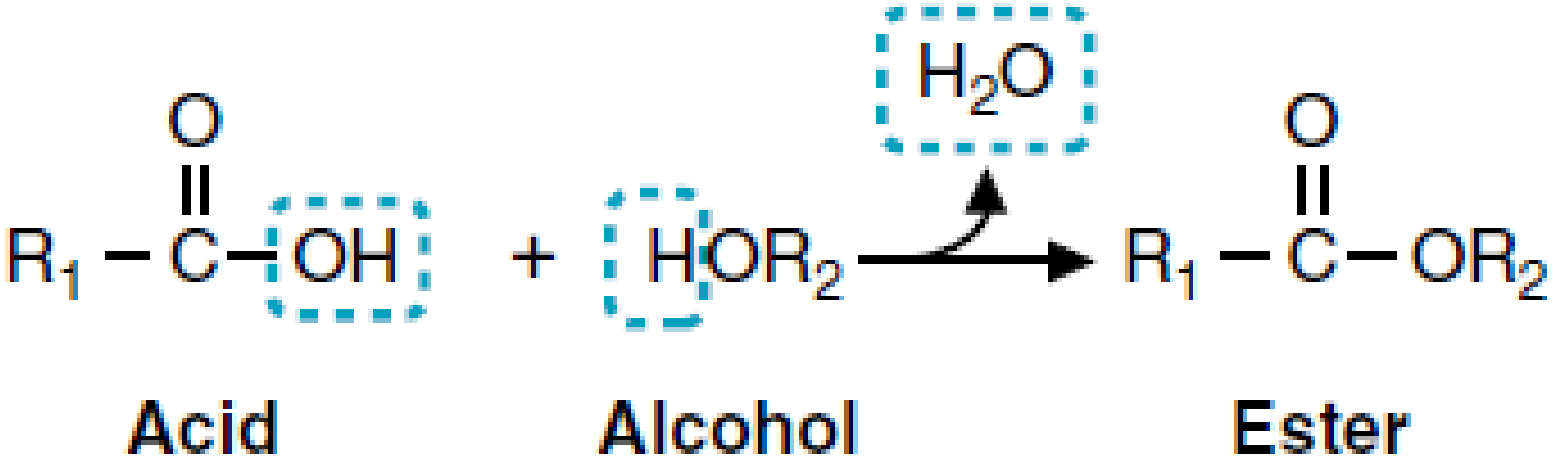
Waxes

- Waxes are esters of long-chain fatty acids and long-chain fatty alcohols (combination of a **fatty** acid with an alcohol).
- Fatty acids found in waxes are usually saturated.
- The fatty alcohols found in waxes may be saturated or unsaturated and may include sterols, such as cholesterol.
- Waxes are water-insoluble due to the weakly polar nature of the ester group.
- In plants and animals waxes provide a waterproof barrier.



- An example of a wax: Oleyl alcohol is esterified to stearic acid



Ester bond (linkage)

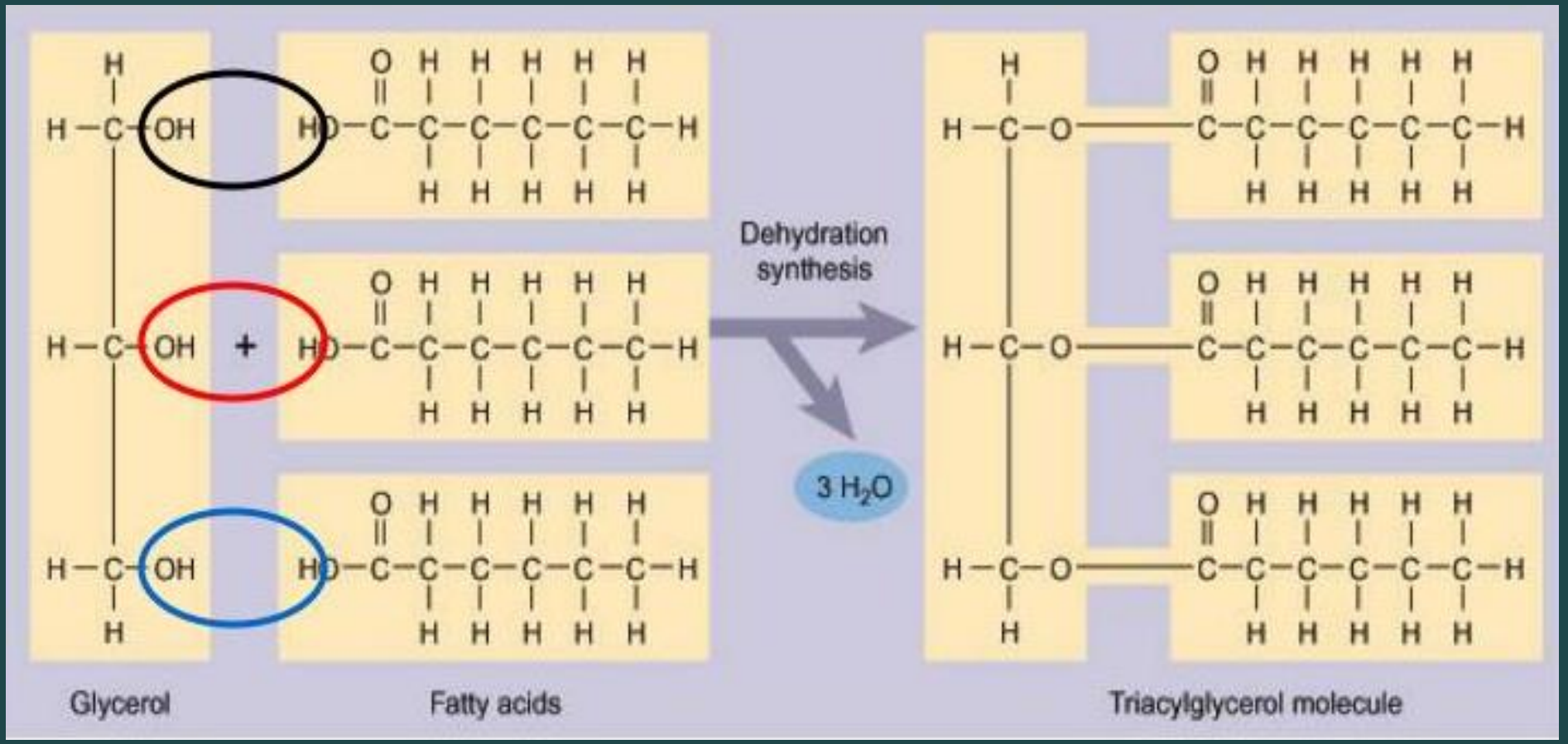
An ester bond is a type of covalent bond that is formed when a carboxylic acid and an alcohol combine, splitting out water

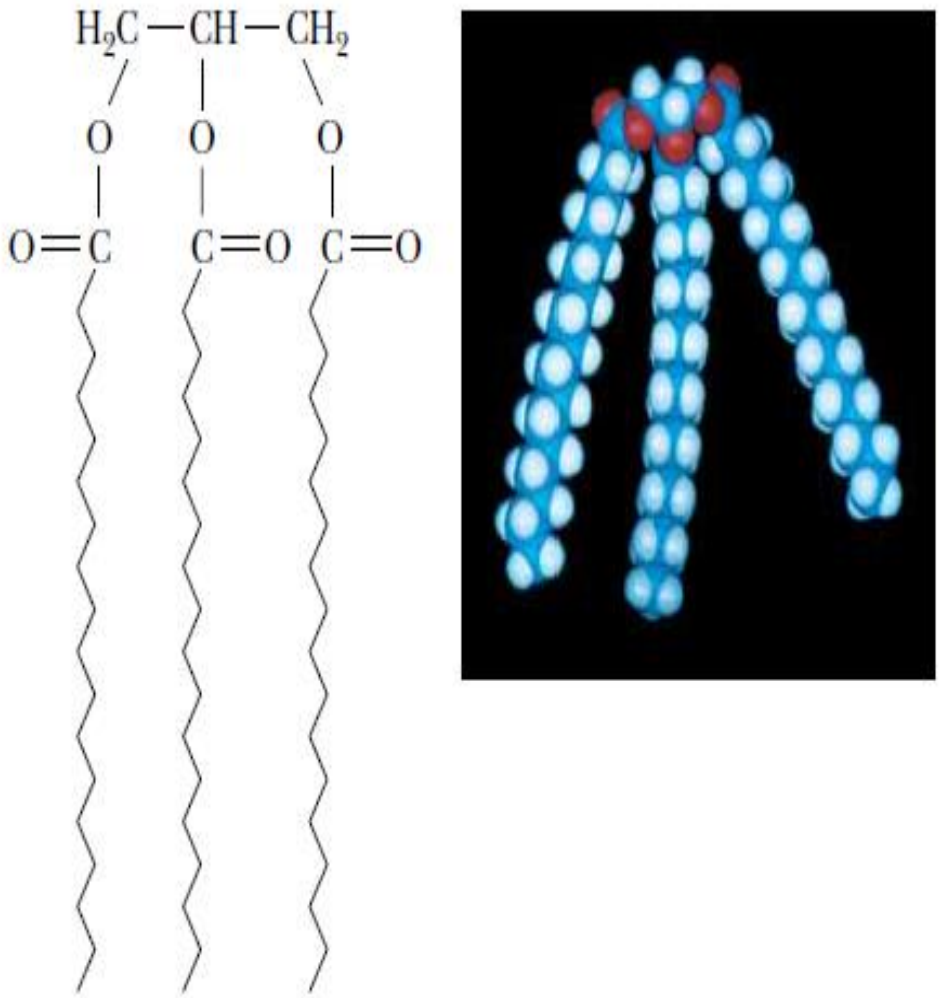
Triacylglycerols

- **Triacylglycerols** (also called **triglycerides**) consist of a glycerol esterified with three fatty acids.
- **Triacylglycerols** are the main components of animals fat mostly found in adipose tissue; they are also the main components of vegetable oils.
- **Triacylglycerols** makes 90% - 95% of dietary fat.
- **Glycerol** (or glycerine) is colorless, viscous, and sweet-tasting with a molecular formula **CH2OH-CHOH-CH2OH** and because of its three hydroxyl groups glycerol is soluble in water. The three hydroxyl groups of glycerol are each esterified typically by fatty acids which is then is known as triacylglycerol.

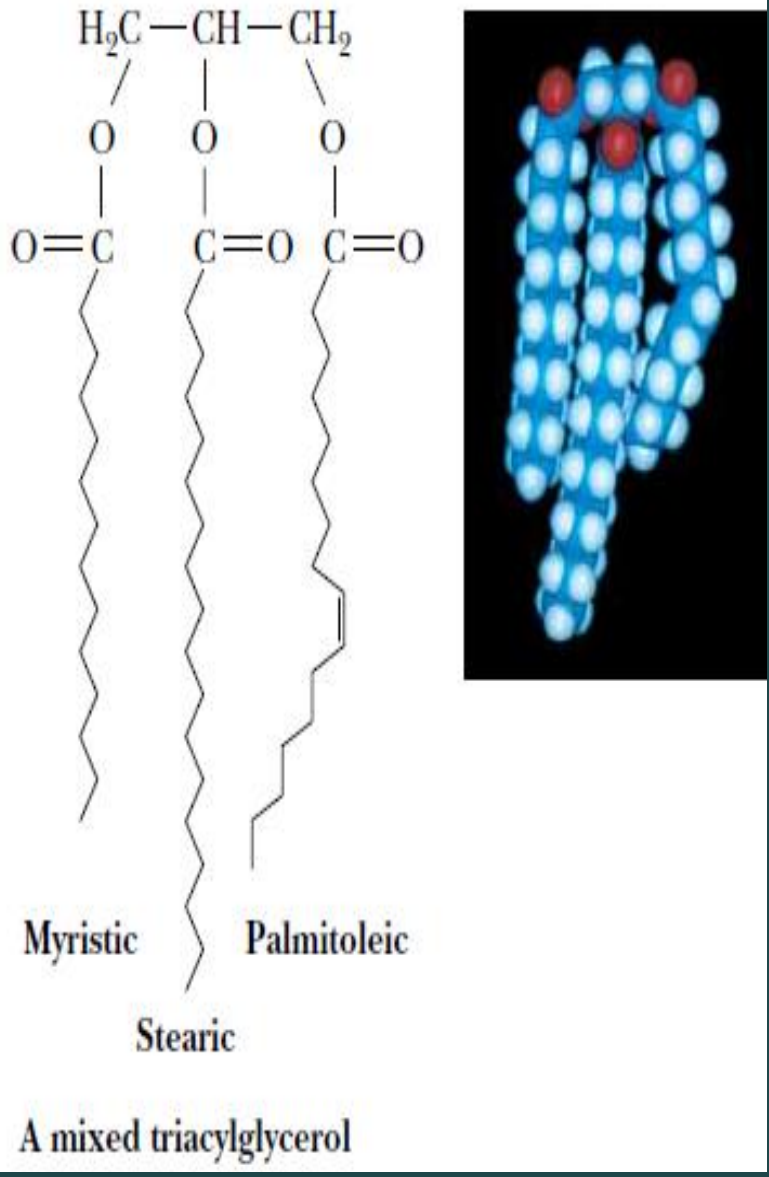
- If all three fatty acid groups are the same, the molecule is called a simple triacylglycerol and if different fatty acids it is called mixed triacylglycerols.
- Most natural plant and animal fat is composed of mixtures of simple and mixed triacylglycerols.
- Triacylglycerols in animals are found primarily in the adipose tissue (body fat), which serves as a storage site for lipids.
- Adipose tissue triacylglycerols are derived from two sources; dietary lipids and triacylglycerols synthesized in the liver.

Triacylglycerol formation





Tristearin
(a simple triacylglycerol)



A mixed triacylglycerol

Phospholipids

- Phospholipids are amphipathic lipids found mainly in cell membrane.
- There are two classes of phospholipids:

A- **Phosphoglycerides** are phospholipids that have glycerol as a backbone.

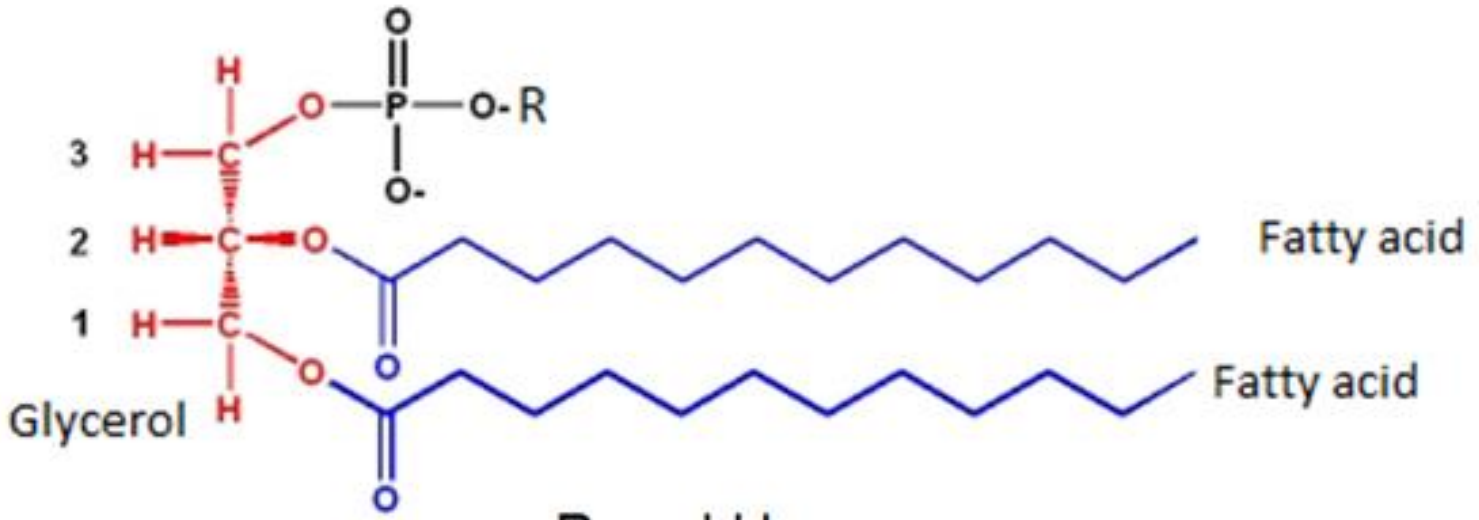
B- **Sphingolipids** are phospholipids that contain sphingosine as a backbone.

- Both classes are found as structural components of membranes, and both play a role in the generation of lipid-signalling molecules.

A. Phosphoglycerides

- Also known as **Glycerophospholipids**
- Function: component of cell membranes and in cell signaling.
- The hydroxyl groups at C-1 and C-2 of glycerol are esterified to the carboxyl groups of the two fatty acid chains.
- The C-3 hydroxyl group of the glycerol backbone is esterified to phosphoric acid.
- When no further additions are made, the resulting compound is **phosphatidate** the simplest phosphoglyceride and key intermediate in the biosynthesis of the other phosphoglycerides.
- The common alcohol moieties of phosphoglycerides are the amino acid serine to form phosphatidylserine, choline to form phosphatidylcholine (lecithin), and the inositol to form phosphatidylinositol.

Phosphoglycerides



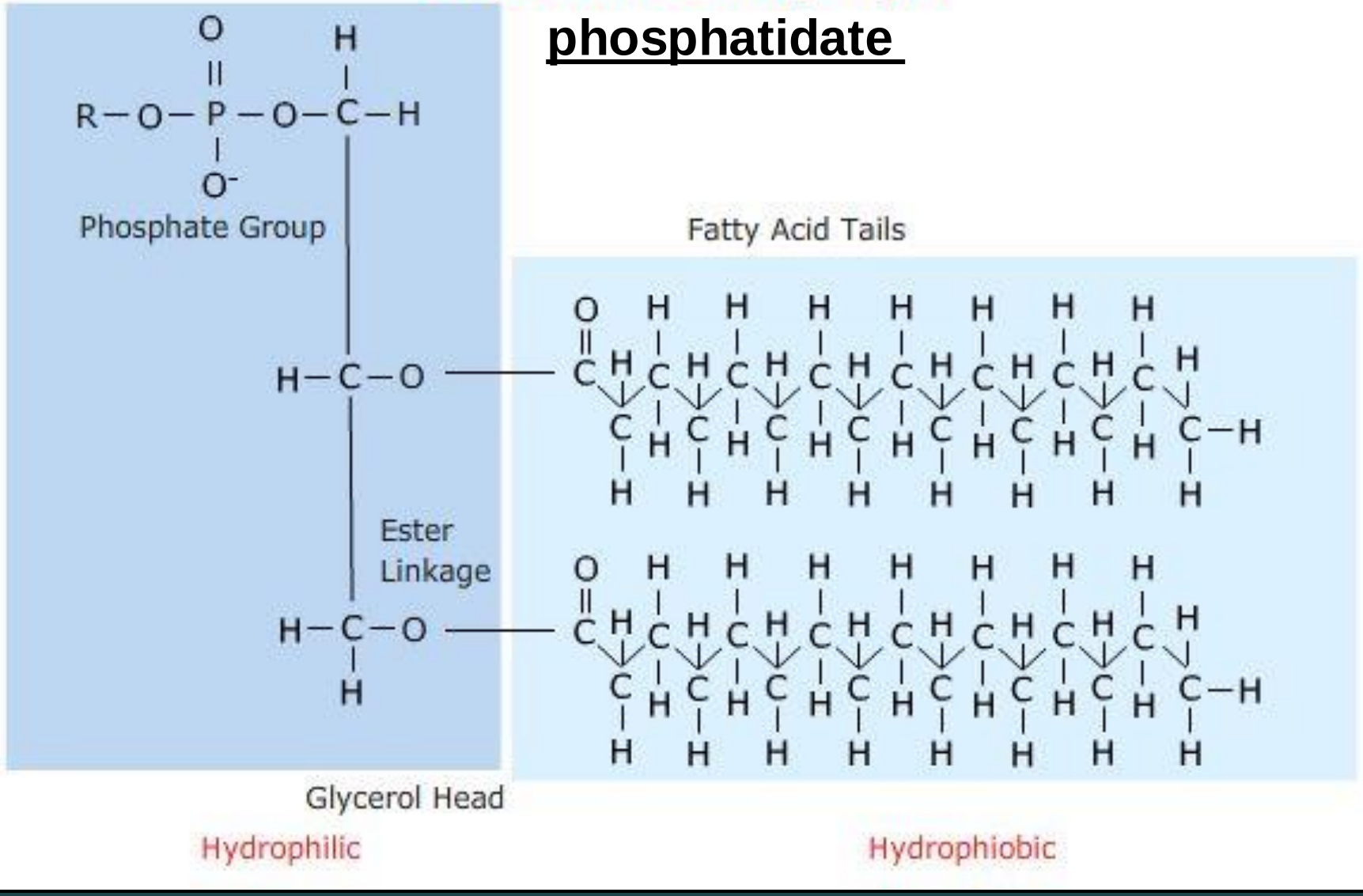
R could be

serine to form phosphatidylserine, (Function cell signaling)
choline to form phosphatidylcholine (function cell signaling, pulmonary surfactant)
inositol to form phosphatidylinositol (function cell signaling)

Phosphatidate (Phosphatidic acid) **the parent compound for** phosphoglycerides

Structure of a Phospholipid

phosphatidate



B. Sphingolipids

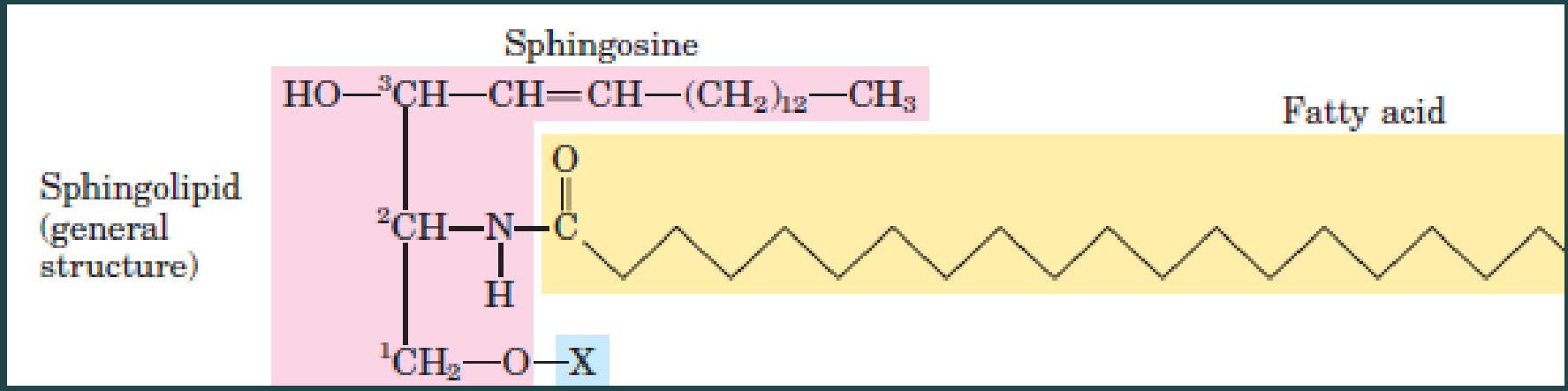
Found in cell membranes of nerve cells particularly important in forming the myelin sheath.

The major component of sphingolipids

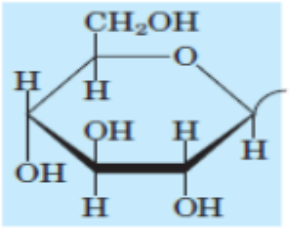
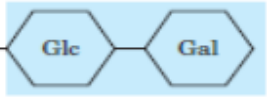
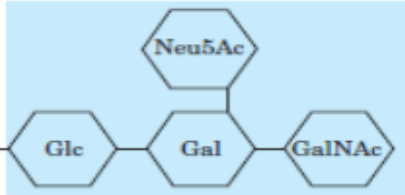
1- Sphingosine (the backbone of sphingolipids) an 18-carbon amino alcohol with an unsaturated hydrocarbon chain.

2- Fatty acid is attached in amide linkage **(**is a peptide bond in small molecules between COOH-group of the fatty acid and NH2–group**)** to the -NH_2 on C-2 of the sphingosine the resulting compound is a **ceramide**.

Ceramide is the fundamental structural unit to all sphingolipids.



In the structure of ceramide when X is phosphocholine the result is sphingomyelin Carbohydrate groups attach to ceramide, forming glycolipids (Glycosphingolipids) such as the cerebrosides, globosides, and gangliosides.

Name of sphingolipid	Name of X	Formula of X
ceramide	—	—H
Sphingomyelins	Phosphocholine	—O—P(=O)(O⁻)—O—CH₂—CH₂—N⁺(CH₃)₃
Cerebrosides	Glucose	
Globoside	Di-, tri-, or tetrasaccharide	
Gangliosides (GM2)	Complex oligosaccharide	

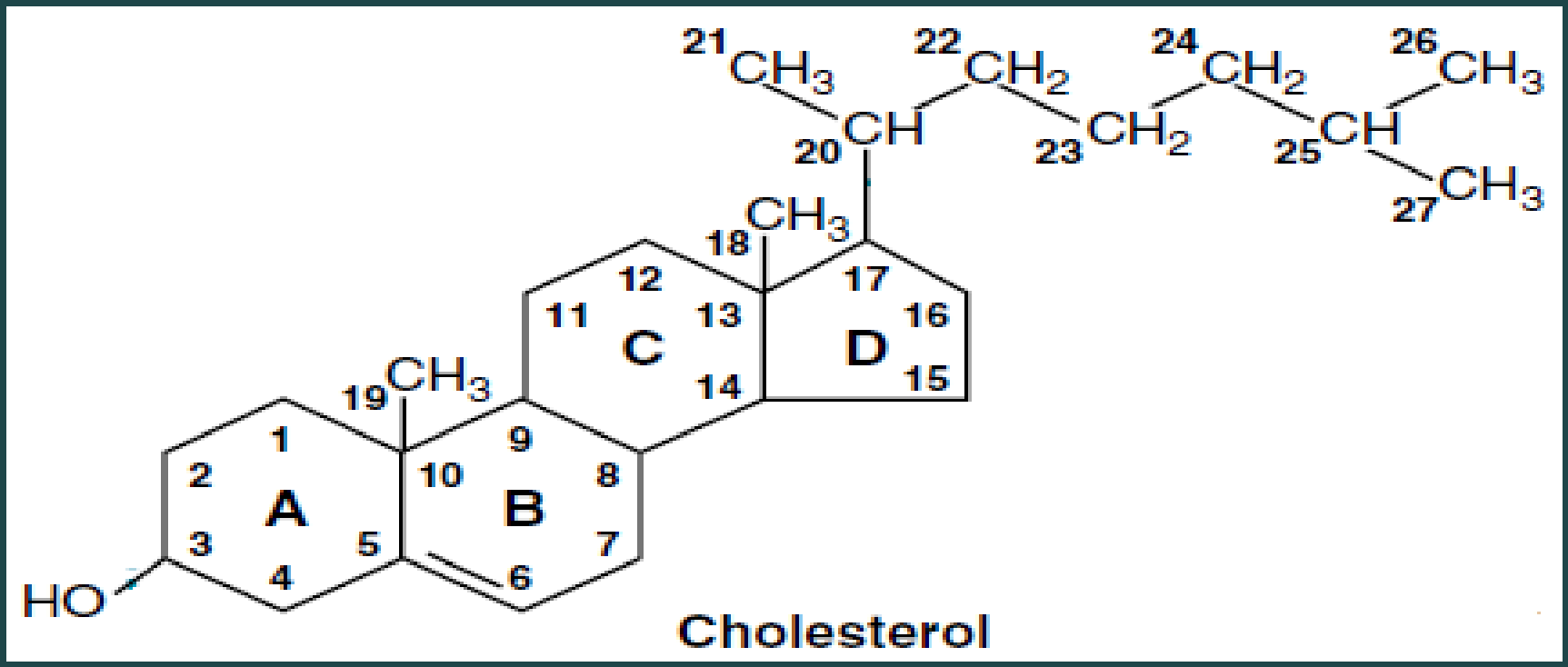
- **There are four major types of sphingolipids:**
- **1- Sphingomyelins** have a phosphorylcholine linked to ceramide. Sphingomyelins is a component of the myelin sheath
- **2- Cerebrosides** (**Neutral glycolipids**) found in cell membrane, they contain a monosaccharide (glucose or galactose) (glucosylceramide (GlcCer)) or galactose (galactosylceramide (GalCer)).
- **3- Globoside if two or more sugar residue linked to ceramide**
- **4- Gangliosides (GM2)** have oligosaccharide that contain **sialic acid**.
- The head of gangliosides possesses a net negative charge at neutral pH because of the presence of **sialic acid** in the oligosaccharide head group. They are present in the outer layer of the plasma membrane and are important as antigens (sites of biological recognition at cellular level) and cell receptors.

Cholesterol

- Cholesterol is a waxy, whitish-yellow fat.
- Our bodies need cholesterol to make cell membranes, steroid hormones (like testosterone and estrogen), vitamin D, bile acids and bile salts.
- Our liver and intestines make about 80% of the cholesterol that our body needs and only about 20% of cholesterol comes from the foods you eat.
- Only animals cells makes cholesterol.
- Plants do not make cholesterol
- Cholesterol has no caloric value for us because we cannot oxidize the carbons in its complex ring structure.
- The only way to get rid of cholesterol is through secondary bile acid that is excreted with stool.
- High concentrations of cholesterol in the blood, particularly low density lipoproteins (LDL), contribute to the formation of atherosclerotic plaques. These plaques (fatty deposits on arterial walls) are associated with heart attacks and strokes.

Cholesterol

- **Cholesterol made up of**
- Four fused hydrocarbon rings (A, B, C, and D, called the "steroid nucleus")
- Eight-carbon branched hydrocarbon chain attached to C17 of the D ring.
- Ring A has a hydroxyl group at C-3, and ring B has a double bond between C-5 and C-6.



Cholesterol

Eicosanoids

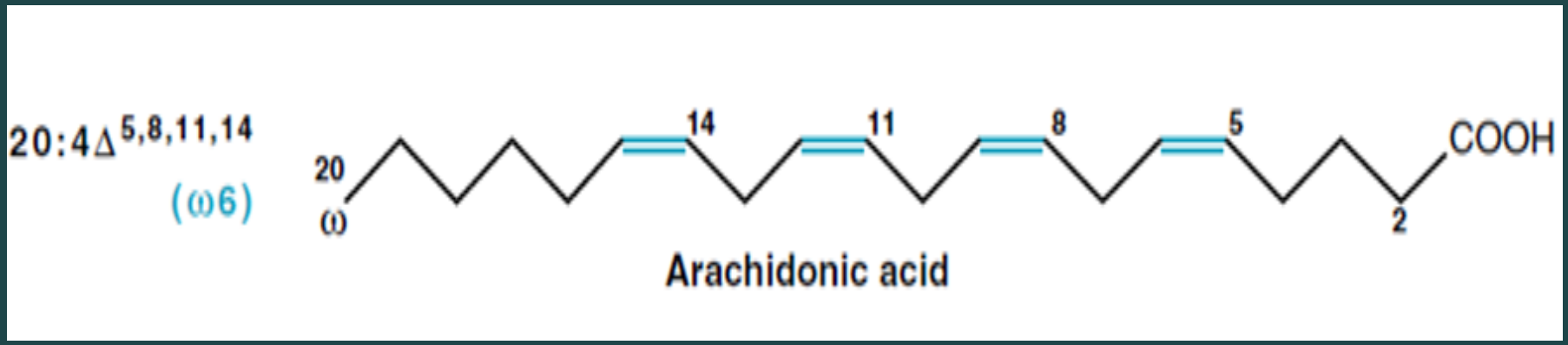
- "Eicosa" is the Greek word for the number 20.
- Eicosanoids are synthesized from polyunsaturated fatty acids with 20 carbon atoms.
- The most common precursor of the eicosanoids is **arachidonic acid** a polyunsaturated fatty acid with 20 carbons and 4 double bonds.
- These molecules almost always act on the cells that produce them or on neighboring cells, that is, over short distances and time periods and thus some books refer them as local hormones.

Eicosanoids include:

- **prostaglandins** (PG), **thromboxanes** (TX), and **leukotrienes** (LT).
- **prostaglandins and Leukotrienes:** play important role in inflammation response.
- **Thromboxanes: found in blood** platelets, **function** blood clotting and constriction of blood vessels.

Arachidonic acid (ARA)

= ARA is a 20-carbon atom fatty acid with four cis double bonds
= ARA belongs to the omega-6 (n-6) polyunsaturated fatty acids



Fat and Health

- A diet high in saturated fat causes cholesterol to build up in the arteries.
- Eating too much saturated fat is one of the major risk factors for heart disease.
- Fat consumption also increases the chance of becoming obese (another risk factor for heart disease and some types of cancer).
- Reducing daily fat intake help reduce the risk factors against developing cancer or heart disease.
- Poly and mono-unsaturated fat are considered healthy fats.

1- Cholesterol

The ranges for total cholesterol in adults:

- Normal: Less than 200 mg/dL (milligrams per deciliter)
- Borderline high: 200 to 239 mg/dL
- High: At or above 240 mg/dL

2- **Triglycerides** ranges in dult :

- Normal: Less than 150 mg/dL
- Borderline high: 150 to 199 mg/dL
- High: 200 to 499 mg/dL
- Very high: Above 500 mg/dL

- A milligram is one-thousandth of a gram.
- A decilitre measures fluid volume that is 1/10 litre.