

BIOL 158: LIPIDS

by

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Structure and function Lipids

- Lipids are class of biological molecules defined by **low solubility in water and high solubility in nonpolar solvents**.
- As molecules that are **largely hydrocarbon in nature**, lipids represent **highly reduced forms of carbon** and, upon oxidation in metabolism, **yield large amounts of energy**.
- Lipids are thus the molecules of choice for **metabolic energy storage**.

Lipids in living things:

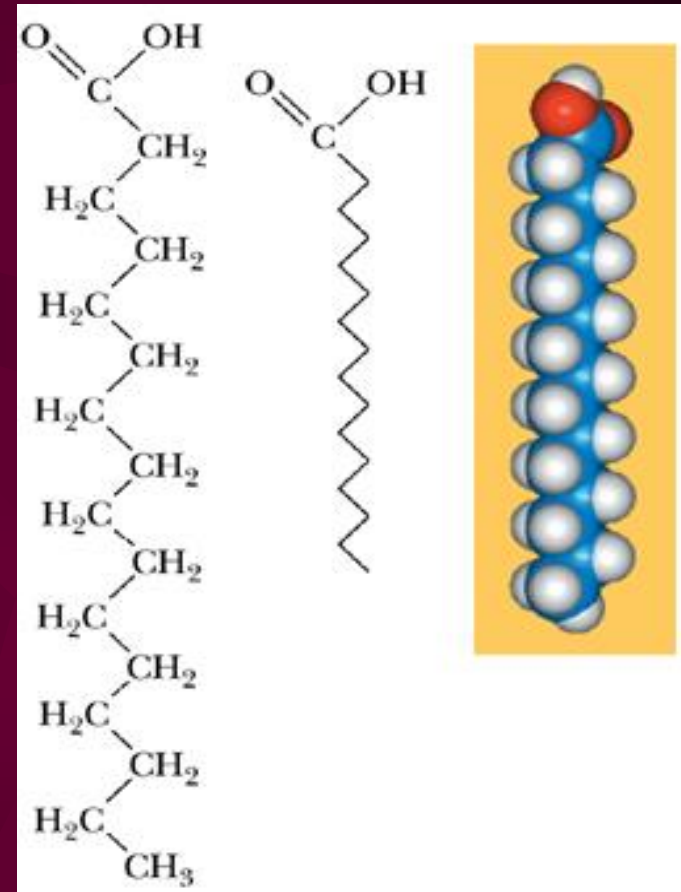
Fatty acids and their derivatives, Fats and oils (triacylglycerols), Wax esters, glycerophospholipids, sphingolipids and isoprenoids (terpenoids and steroids)

- What is the structure and chemistry of fatty acids?
- What is the structure and chemistry of triacylglycerols?
- What is the structure and chemistry of glycerophospholipids and sphingolipids?
- What are steroids, and what are their cellular functions?

What is the structure and chemistry of fatty acids?

Fatty acid: a long “tail” (hydrocarbon chain) and a “head” (carboxyl group)

- **The tail** (hydrocarbon chain):
 - Even number of carbon atoms (usually 14 ~24)
 - Saturated and unsaturated
 - Monounsaturated and polyunsaturated
- **Saturated fatty acids:**
 - Free rotation around C-C bonds, extremely flexible, fully extended conformation (most stable).



- **Unsaturated fatty acids:**

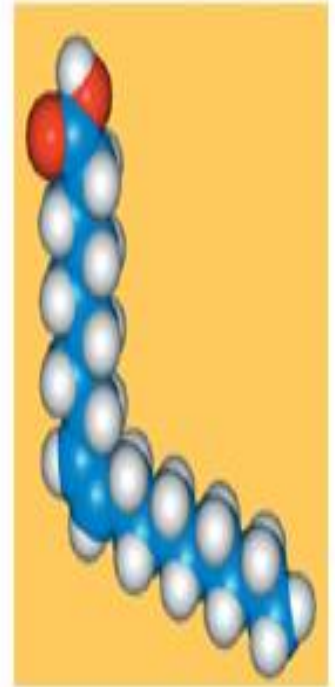
Slightly more abundant in nature than saturated

- Written form: 18:1(9): 18C,
 $C_9=C_{10}$
- Double bonds: *cis* form
- hydrocarbon chain: bend form

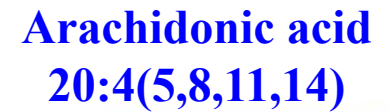
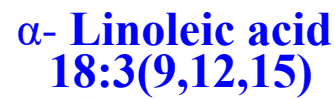
Prevent close packing, produce
flexible fluid aggregates



Oleic acid

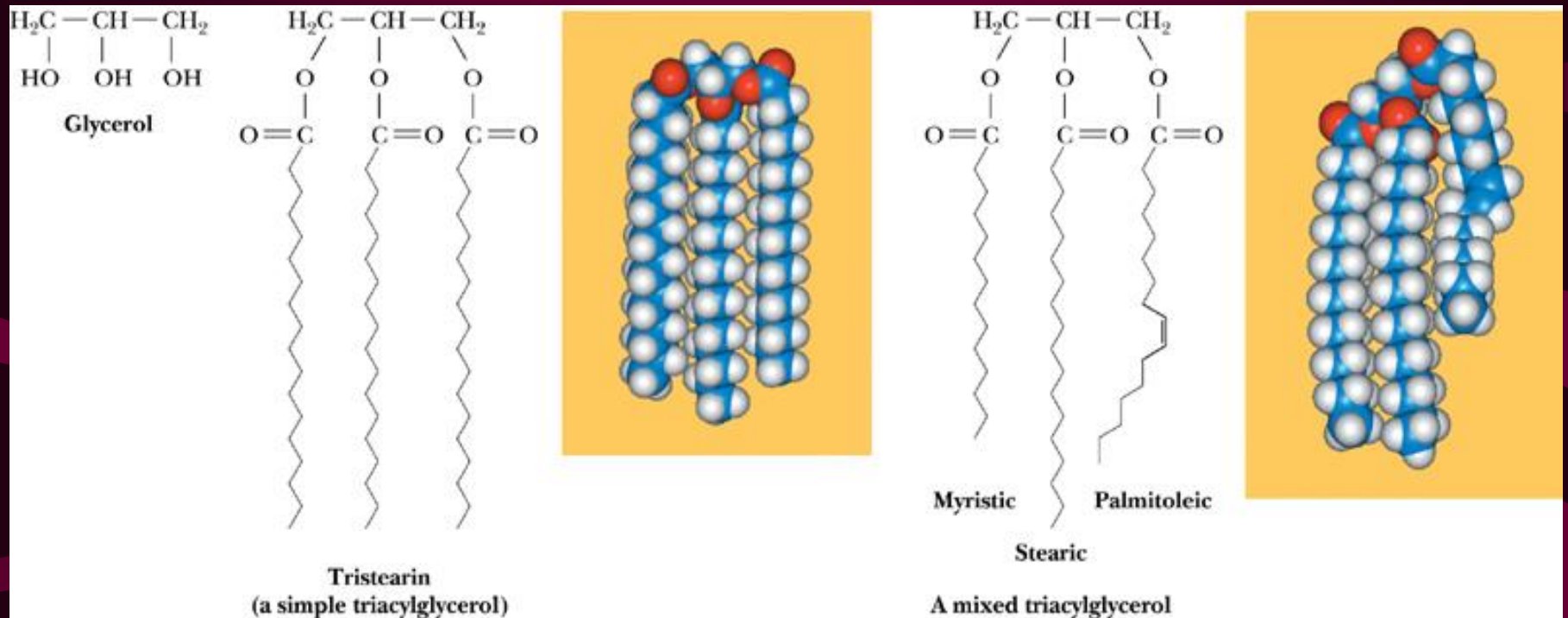


18:1(9)



What is the structure and chemistry of Triacylglycerols?

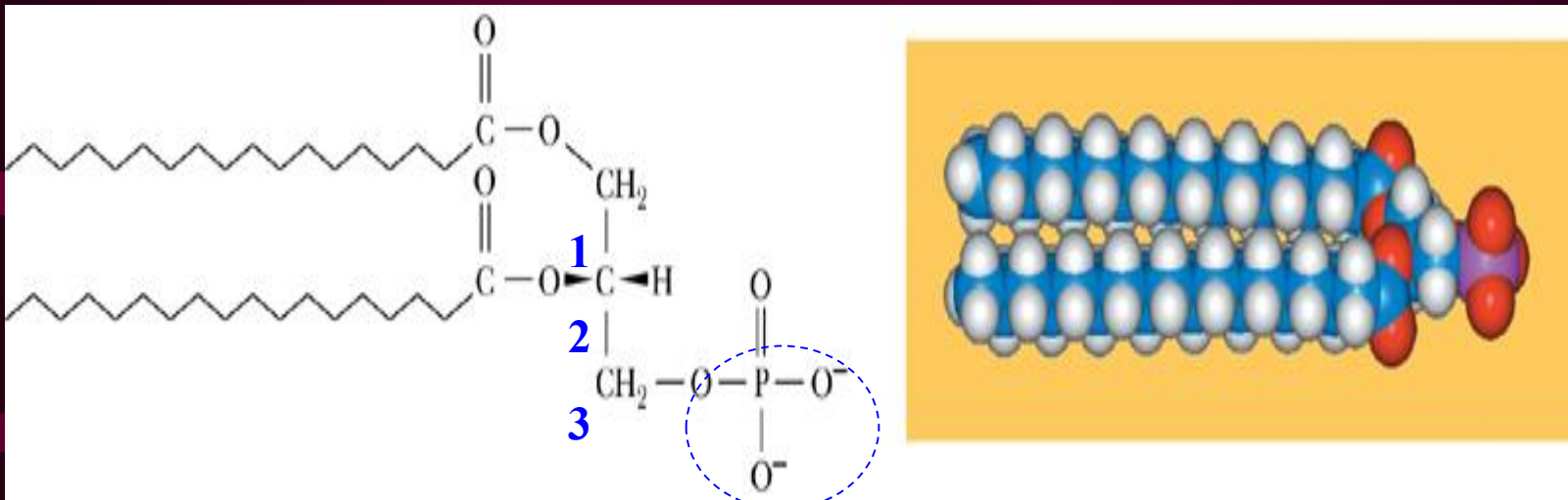
Triacylglycerols: triglycerides (TG)



- Insoluble in water, soluble in benzene, chloroform, ether, and hot ethanol.
- Fatty acid groups: simple or mixed triglycerides.
- Abundant reduced carbons: Major energy reserve in animals
- Oxidation: $1\text{g TG} \rightarrow 38\text{kJ}$; $1\text{g Pro./Carbohydrates} \rightarrow 17\text{kJ}$

What is the structure and chemistry of Glycerophospholipids?

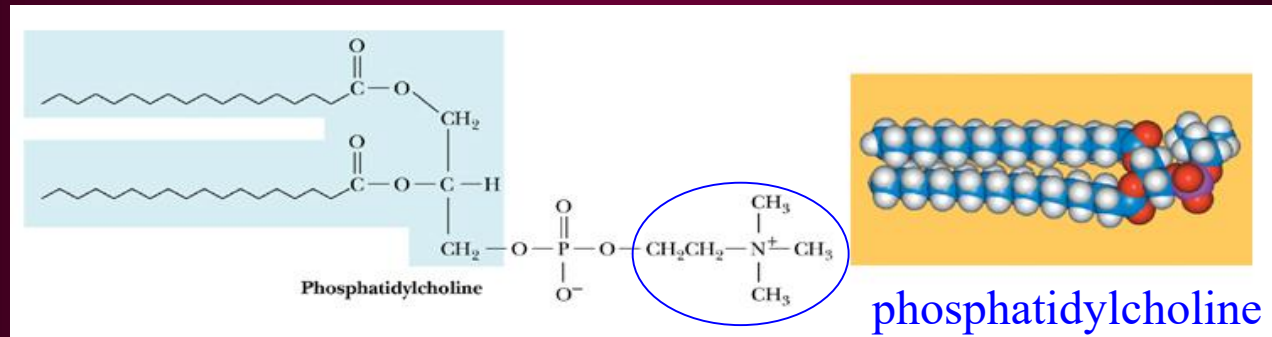
Glycerophospholipids: one kind of phospholipids



One esterified phosphate group

2C (2-position): asymmetric carbon

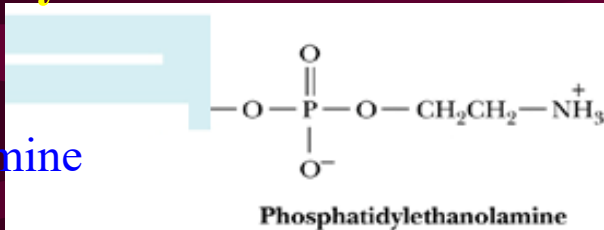
Glycerophospholipids are the most common phospholipids



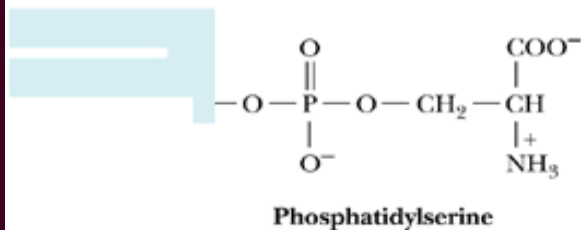
Polar head

Phosphatidyl-

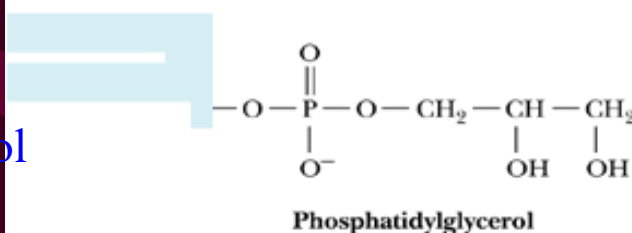
ethanolamine



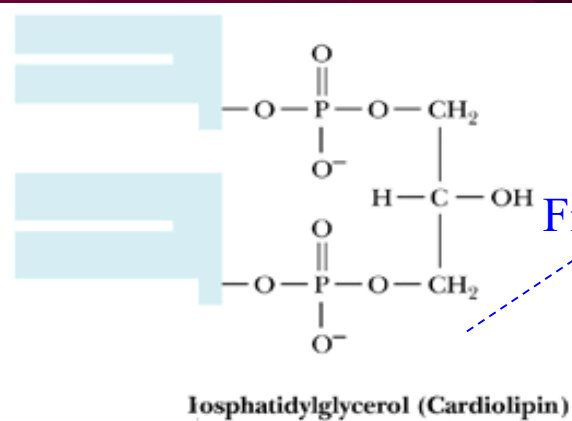
serine



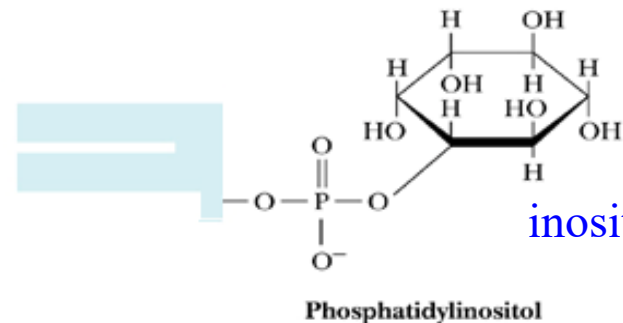
glycerol



First found in heart

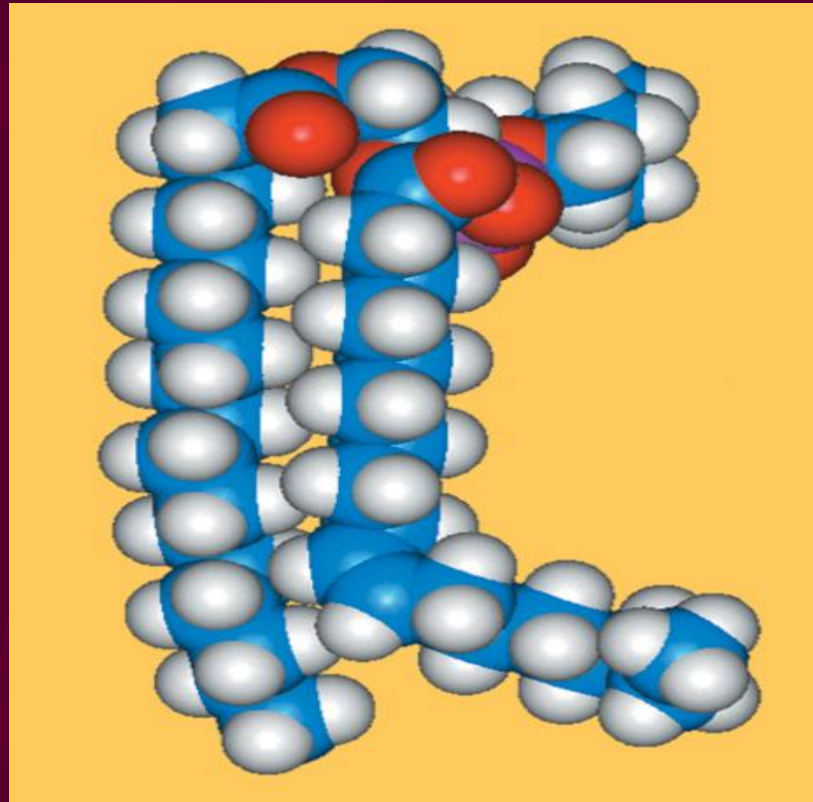


inositol

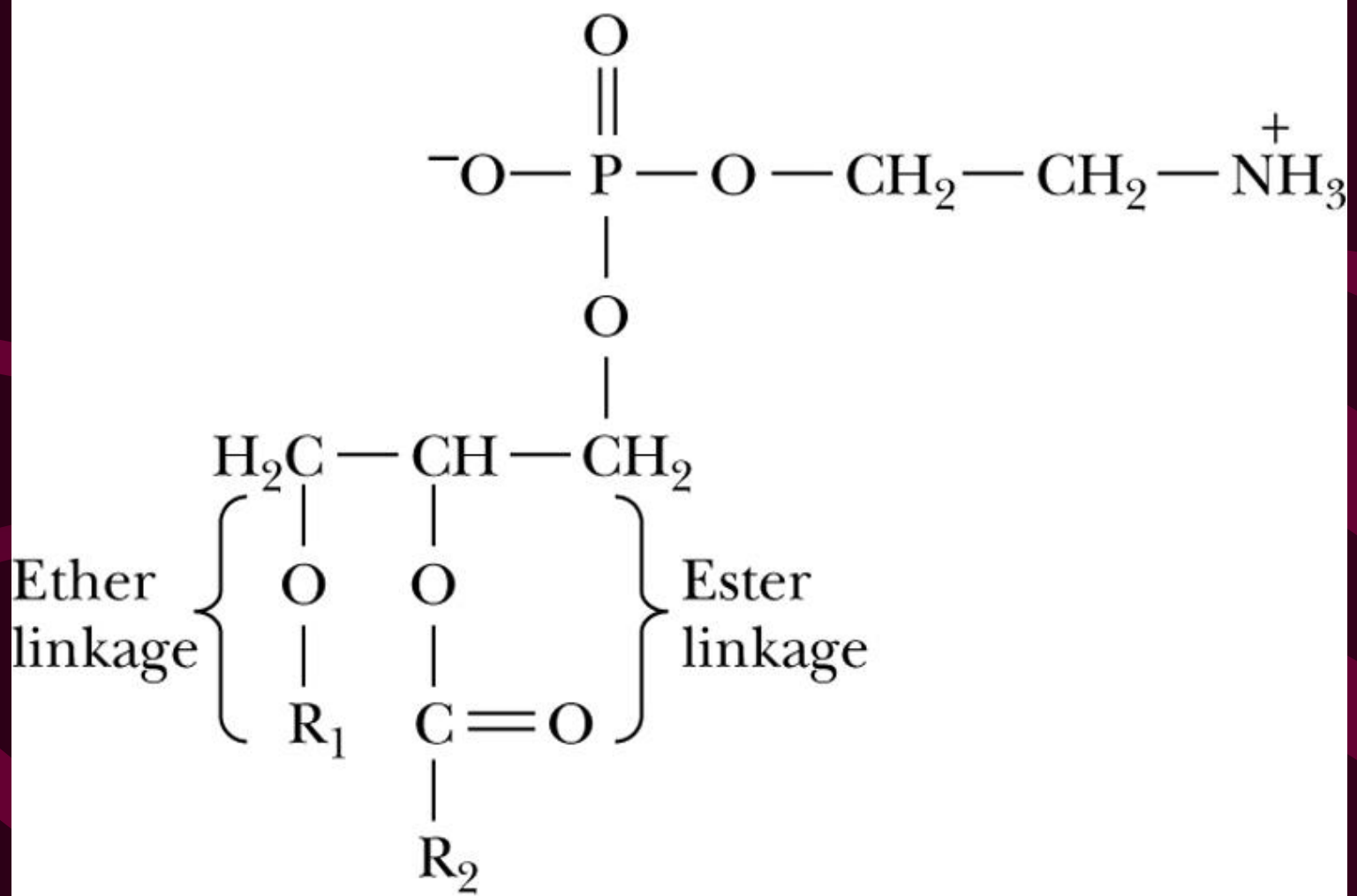


Glycerophospholipids

- In most cases, C1: saturated fatty acid; C2: unsaturated fatty acid

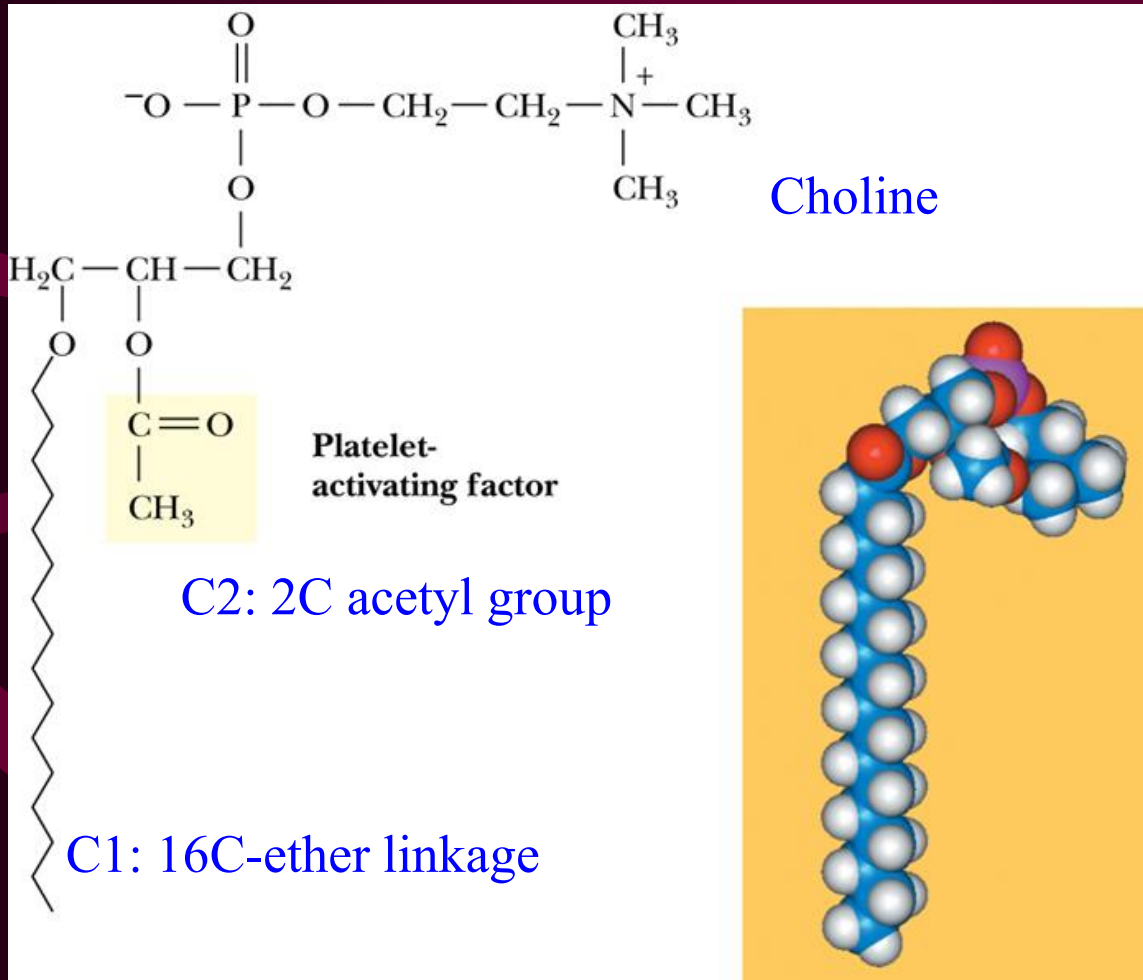


Ether Glycerophospholipids



Platelet-activating factor (PAF)

A soluble messenger in signal transduction

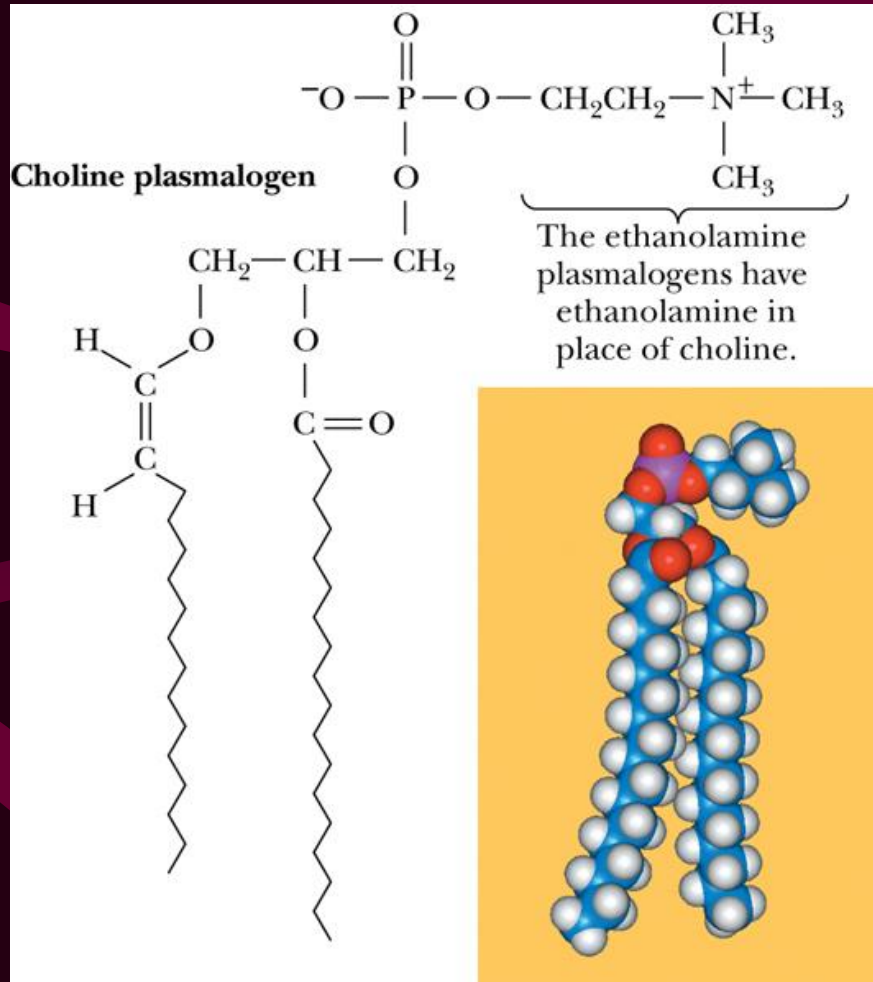


Physiological Functions:
Stimulate production of fetal lung surfactant (in newborn infant)

Pathological Functions:
Toxic shock syndrome,
↓ Blood pressure
↓ Blood volume pumped by heart

Plasmalogens

Ethanolamine; Serine; Choline



They are found in all mammalian tissues, with ethanolamine plasmalogens 10-fold higher than choline plasmalogens except in muscles.

The enol ether double bond at the sn-1 position makes plasmalogens more susceptible to oxidative stress than the corresponding ester-bonded glycerophospholipids.

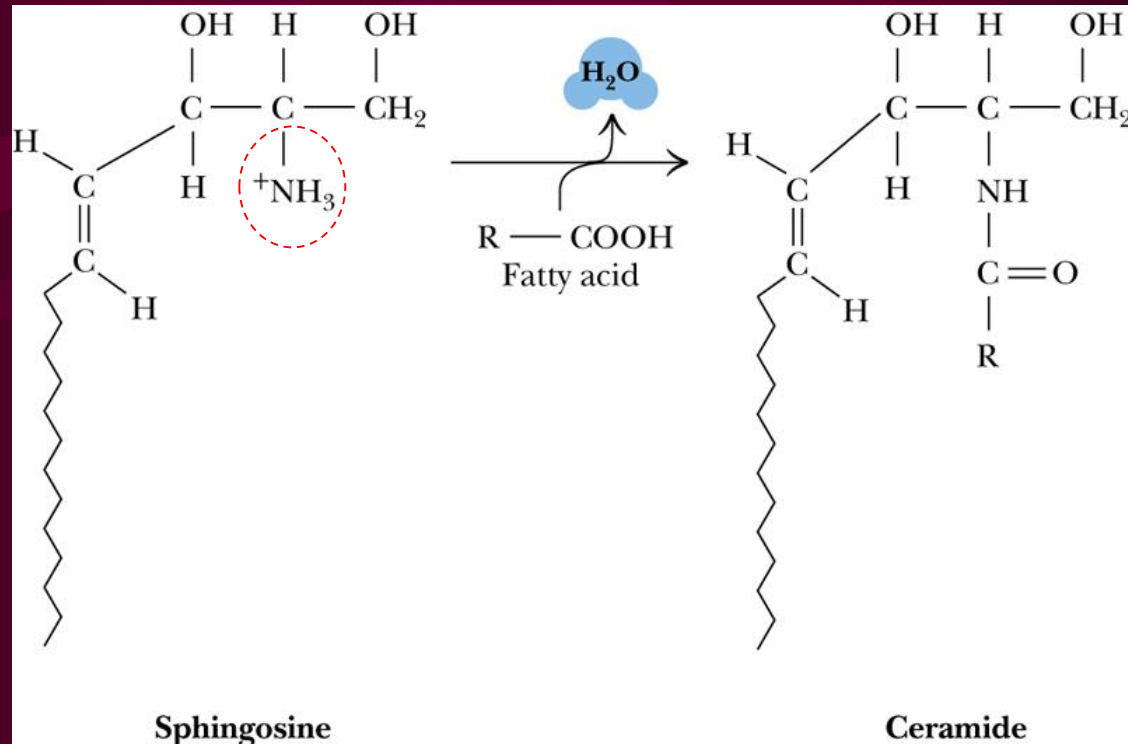
Plasmalogens are not only structural membrane components and a reservoir for second messengers but may also be involved in membrane fusion, ion transport, and cholesterol efflux.

Plasmalogens may also act as antioxidants, thus protecting cells from oxidative stress.

The Neuroscientist, Vol. 7, No. 3, 232-245 (2001)

What are Sphingolipids, and how are they important for higher animals?

Sphingolipids: Sphingosine and ceramide derivatives, frequently found in biological membranes



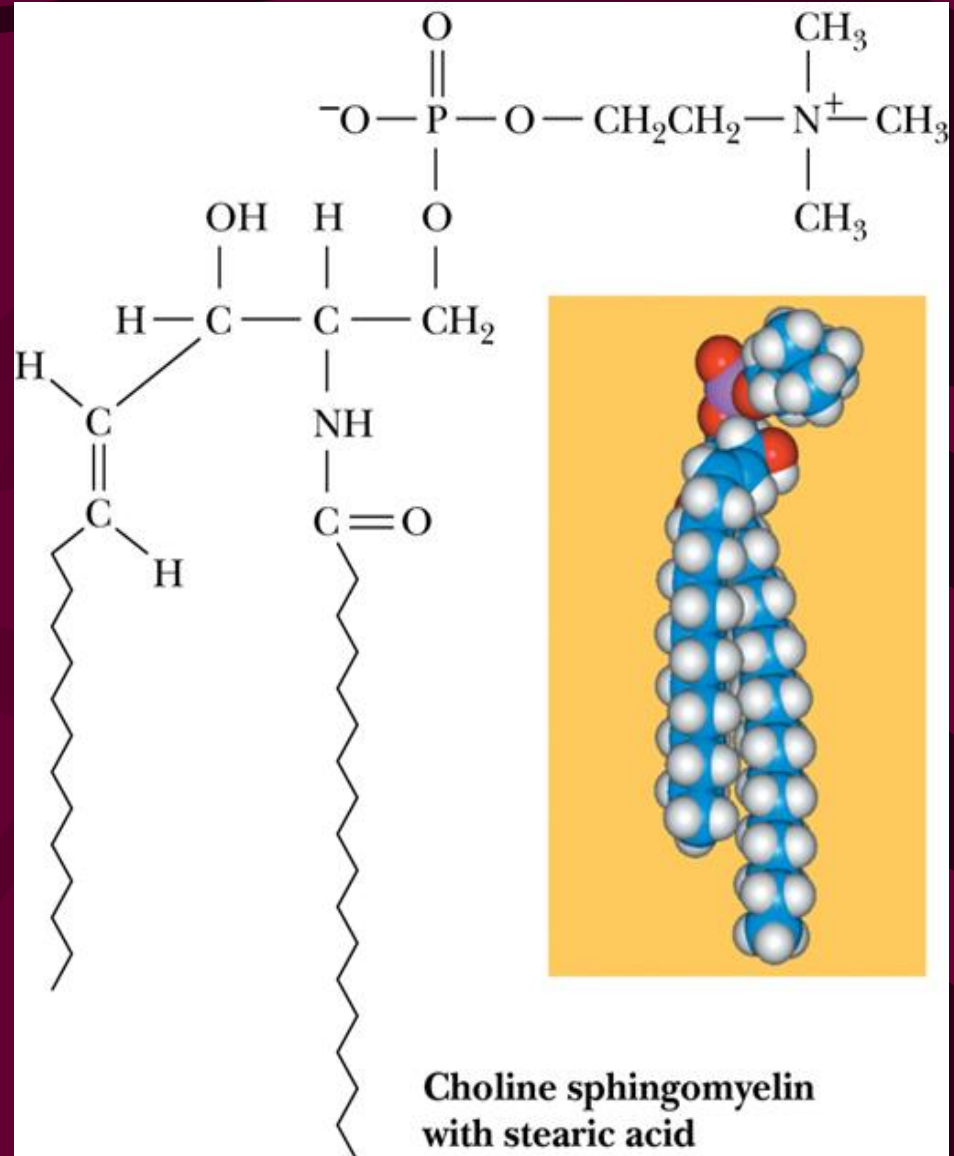
Sphingosine: 18C amino alcohol; **Ceramide:** fatty acid (amide linkage)

Sphigomyelins: especially important in the nervous tissue of higher animals.

C1 of Ceramide:

Phosphorylethanolamine

Phosphorylcholine



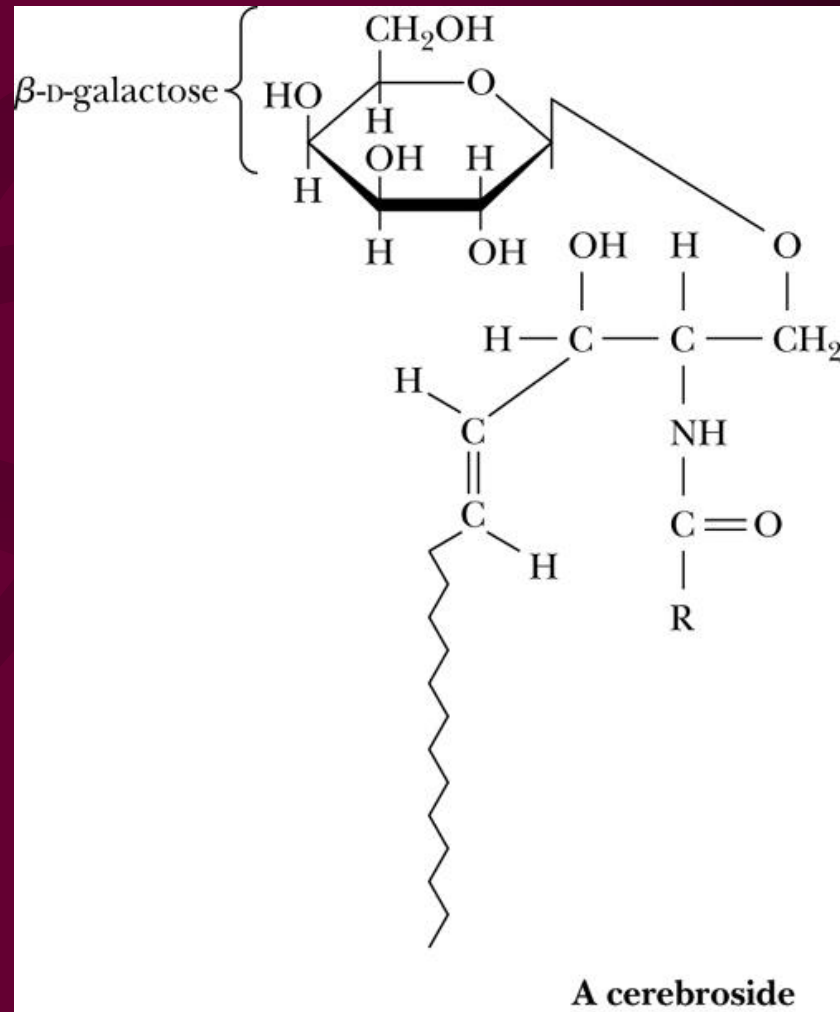
Glycosphingolipids: another class of ceramide-based lipids, in muscle and nerve membranes in animals.

Cerebroside

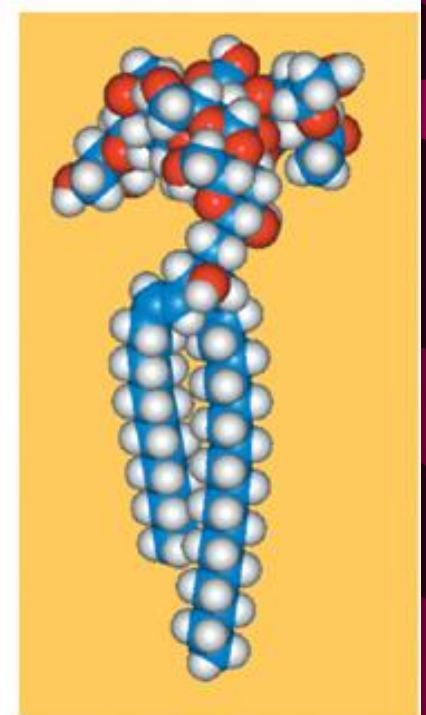
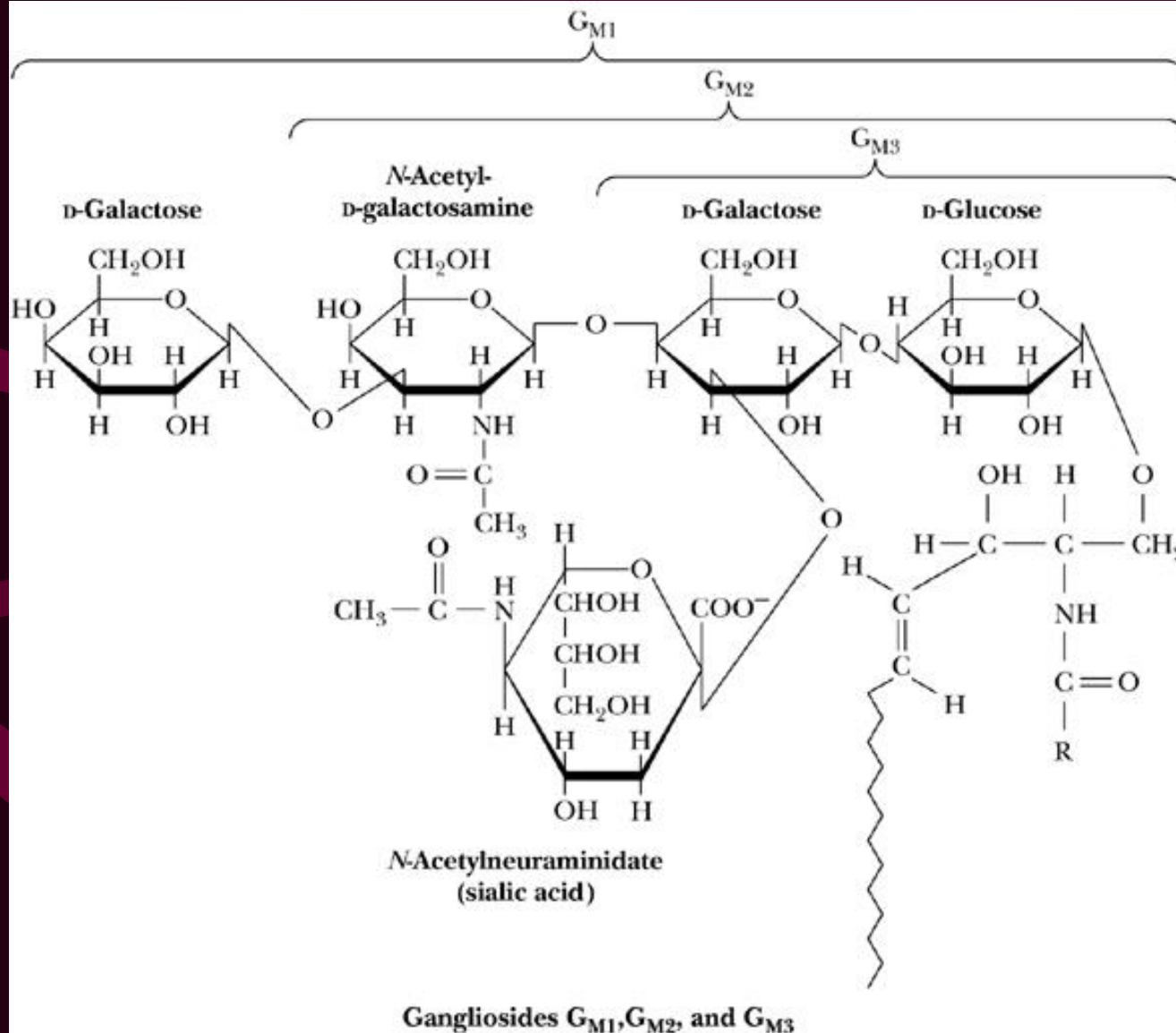
C1 of Ceramide:

One or more sugar residues in a β -glycosidic linkage;

Functions: at cell surfaces determine certain elements of tissue and organ specificity (cell-cell recognition, tissue immunity)



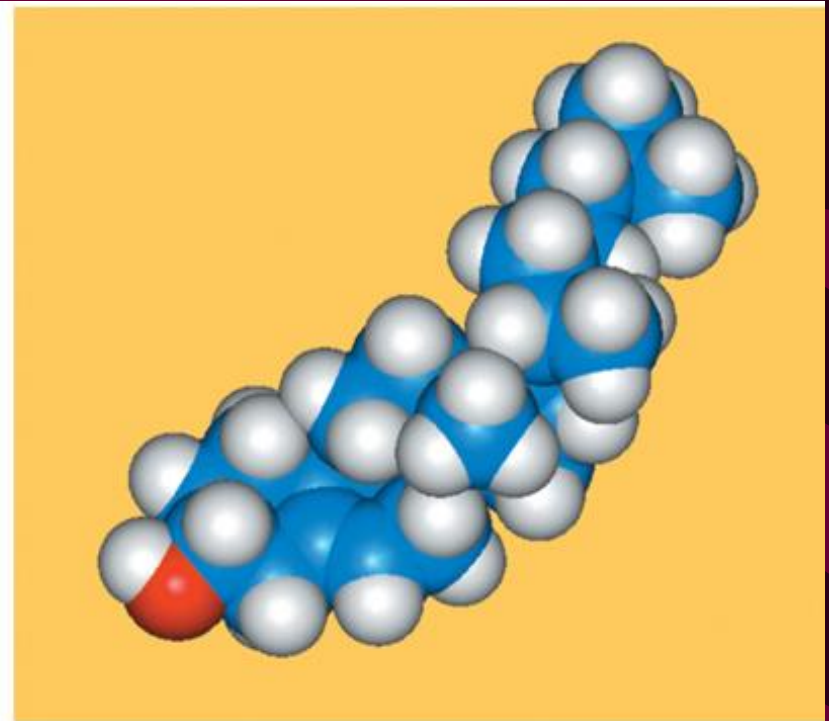
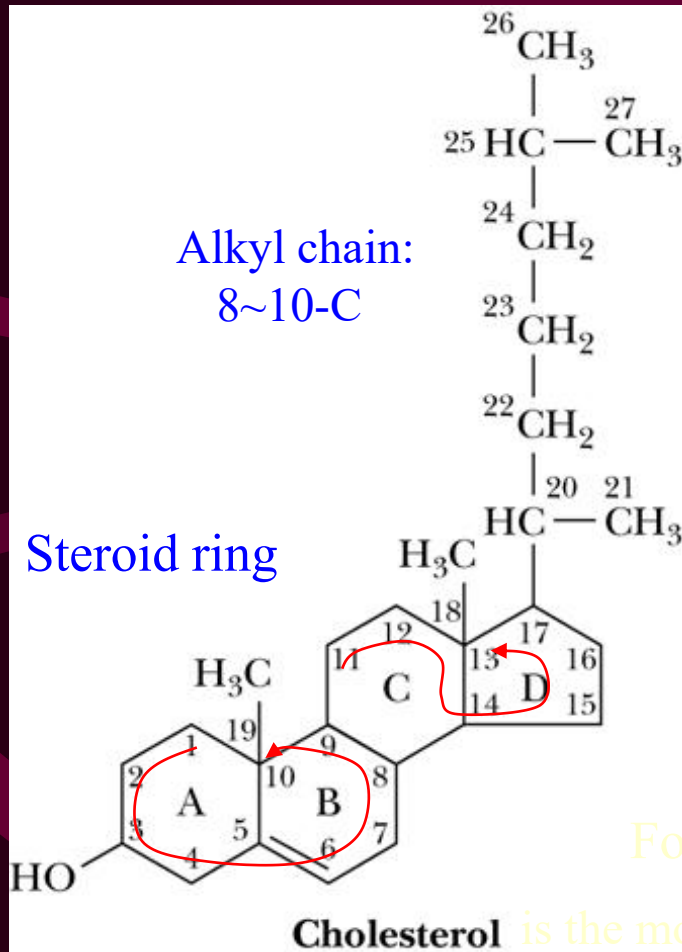
Gangliosides: in nerve endings, important in nerve impulse transmission.



What are Steroids, and their cellular functions?

Cholesterol

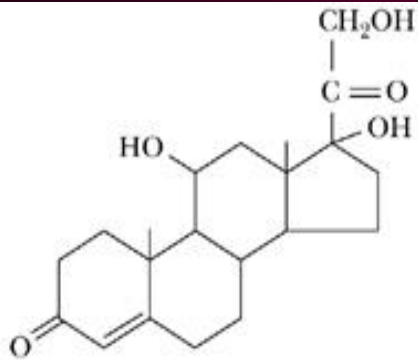
Terpene-based lipids



Found in membrane and lipoproteins of blood

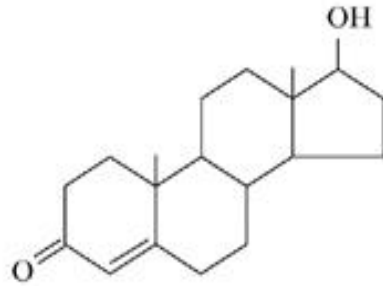
is the most common steroid in animals and the precursor for all other steroids

Steroid hormones are derived from cholesterol



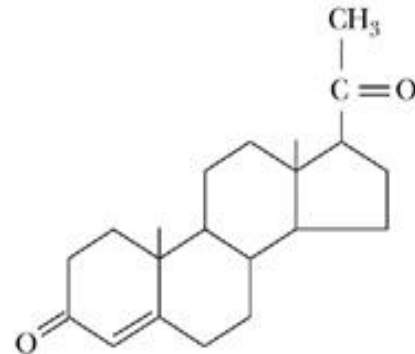
Cortisol

Glucocorticoids



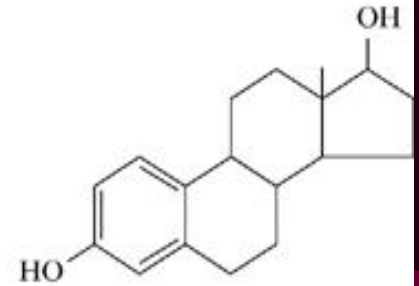
Testosterone

Androgen



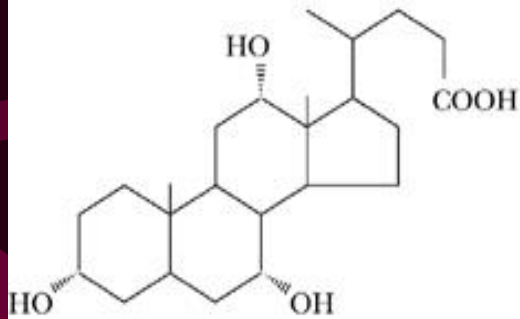
Progesterone

Progestin

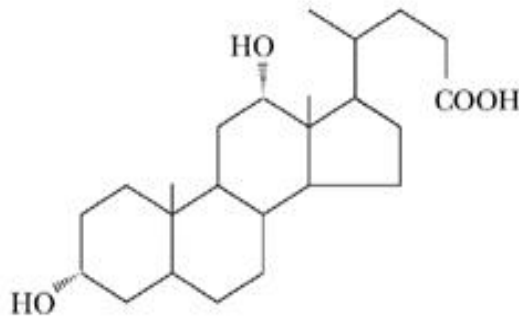


Estradiol

Estrogen



Cholic acid



Deoxycholic acid

Bile acids

Key points:

- Structure of Fatty acid, Triglycerides.
- Structure of Glycerophospholipids and Sphingolipids.
- Structure of Cholesterol and Steroids.