Advanced Cell Biology. Lecture 5

Alexey Shipunov

Minot State University

January 24th, 2011

Outline

Outline

Polysaccharides

Fatty acids and lipids

- Storage lipids: oils and fats
- Membrane lipids
- Signal lipids: sterols and others
- Lipid vitamins

Previous final question: the answer

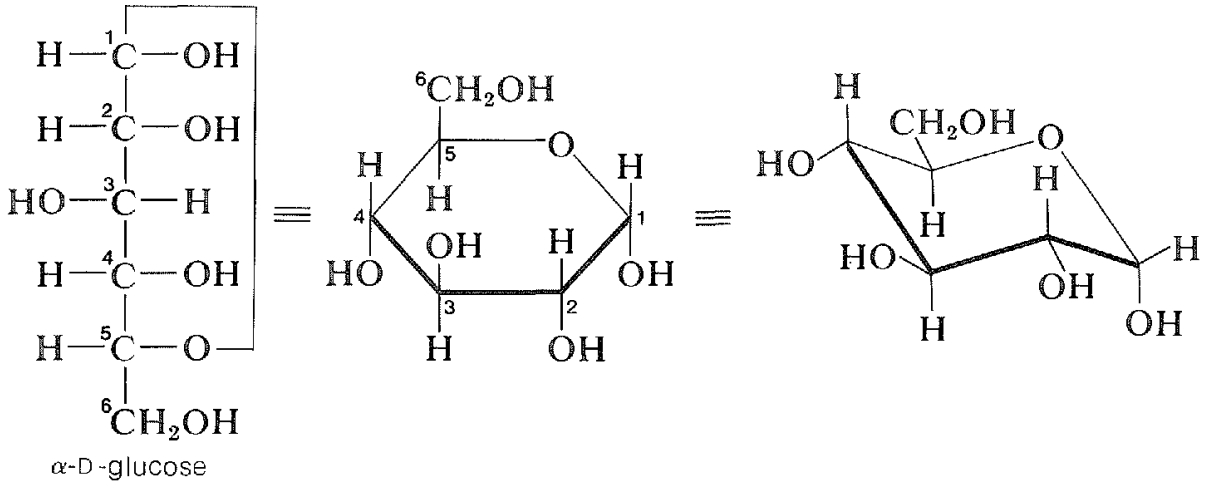
What is the difference between α- and β- glucose?

Previous final question: the answer

What is the difference between α- and β- glucose?

Orientation of rightmost –OH group

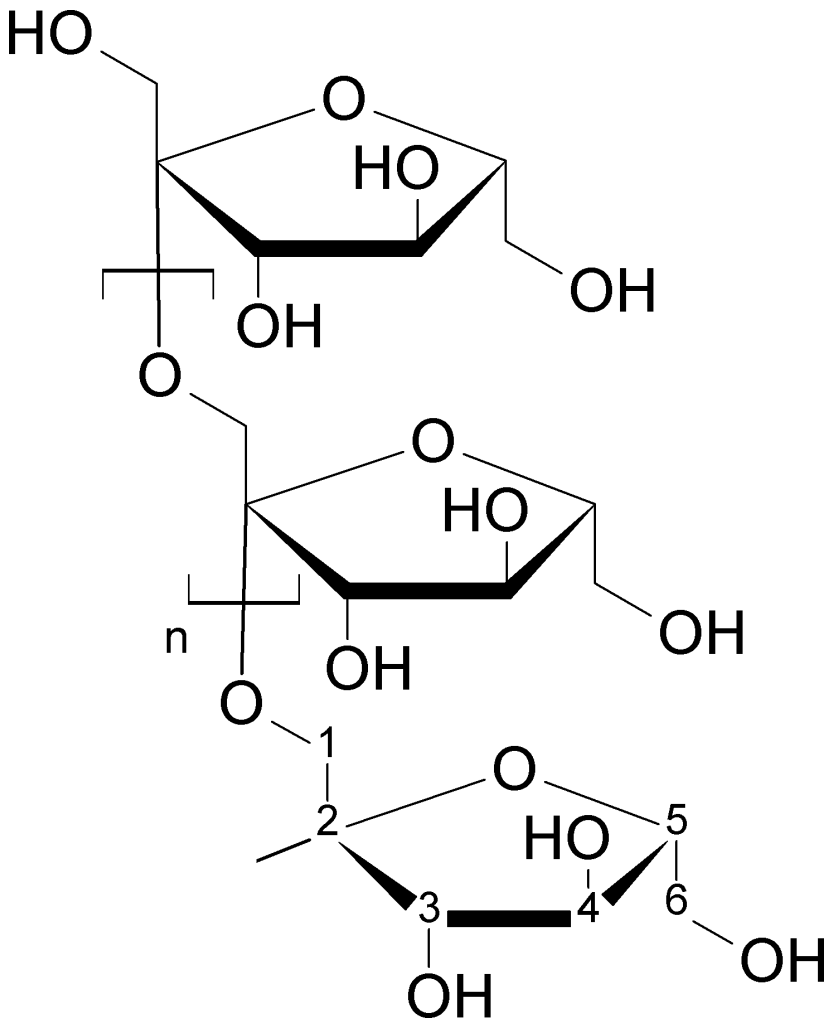
α- and β- glucose (again)



Inulin

- Polymer of fructose, often has a fibrous structure
- Typically, occurs in many plants of sunflower family (e.g., *chicory*, *dandelion* or *Jerusalem artichoke*)

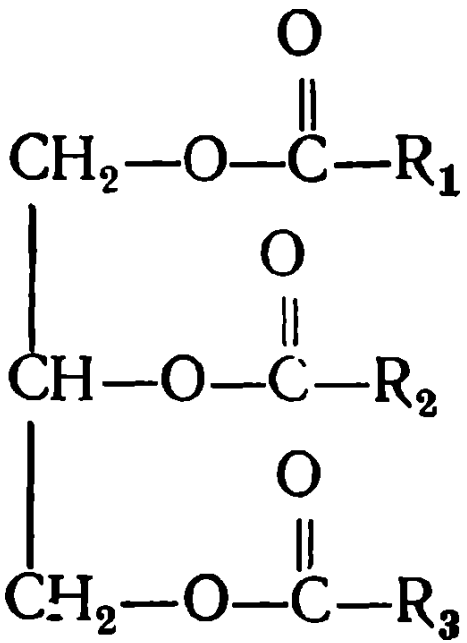
Inulin structure



Storage lipids: oils and fats

- Fatty acids are massive (C > 15) hydrocarbon acids
- Oils and fats are esters (complex ethers) of glycerol and (often different) fatty acids: **triacylglycerols**, or **triglycerides**
- Stable, hydrophobic and high-energetic molecules

Ttiacylglycerols (triglycerides)



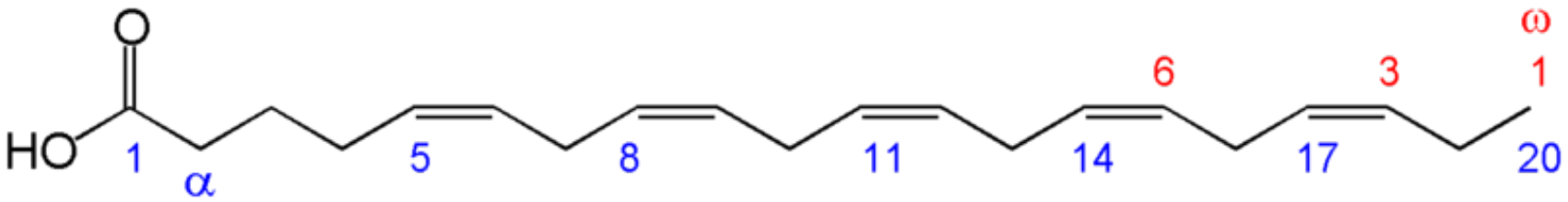
Diversity of fatty acids

- Saturated: contain only single bonds between carbons
- Unsaturated: contain also double bonds
- Unsaturated typically have bend chain, and much lower melting temperature
- Trans fats contain hydrogenated unsaturated oils

Examples of fatty acids

- *Palmitic* acid (C_{15}): from animal fats
- *Stearic* acid (C_{17}): from animal fats
- *Oleic* acid ($C_9 = C_8$): from olive
- *Linoleic* acid ($C_6 = C_3 = C_8$): from flax
- *Omega-3* fatty acids are considered now as important health factors

EPA, eicosapentaenoic acid

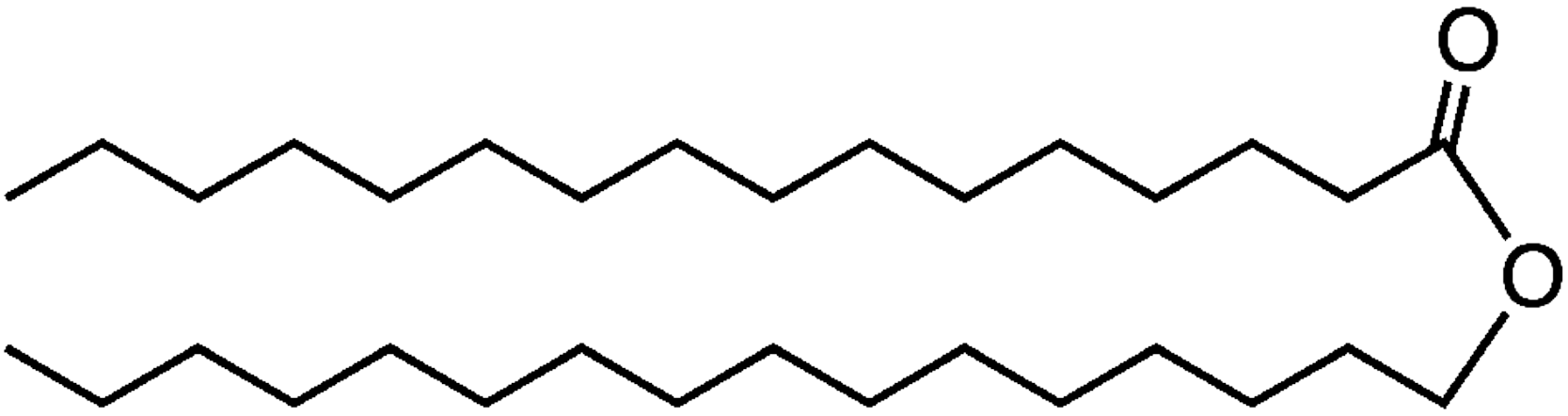


Produces statistically insignificant decrease in human depression

Waxes

- Waxes are esters of fatty acids and fatty alcohols (alcohols with long chains)
- Have high melting temperatures
- Use as structural and protective molecules, both in animals and plants

Cetyl palmitate wax

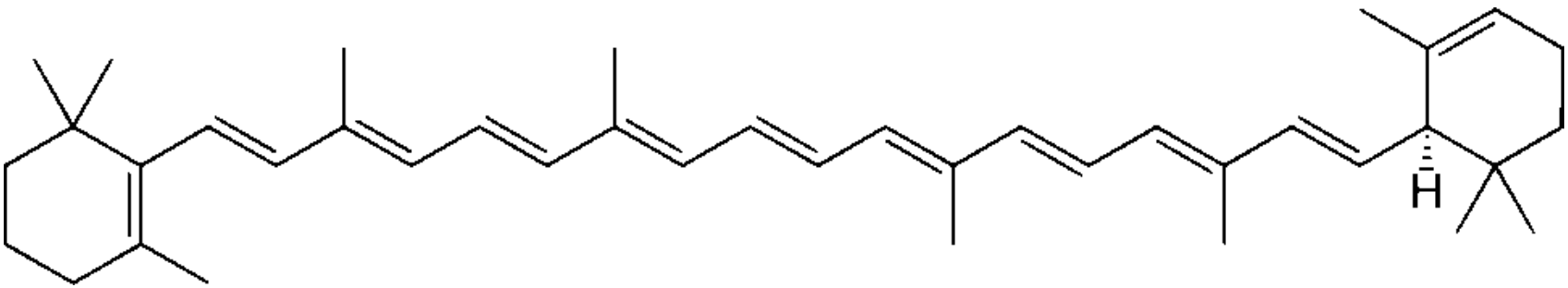


Primary constituent of spermaceti, the wax found in the skull of sperm whales

Plant lipids: isoprenoids

- Derivatives of isoprene, $CH_2{=}CH(CH_3){=}CH_2$
- Simple polyisoprenoids (*terpenes*) form some aroma compounds
- Complex polyisoprenoids (*terpenoids*) are carotenes and other plant pigments, and also components of latex

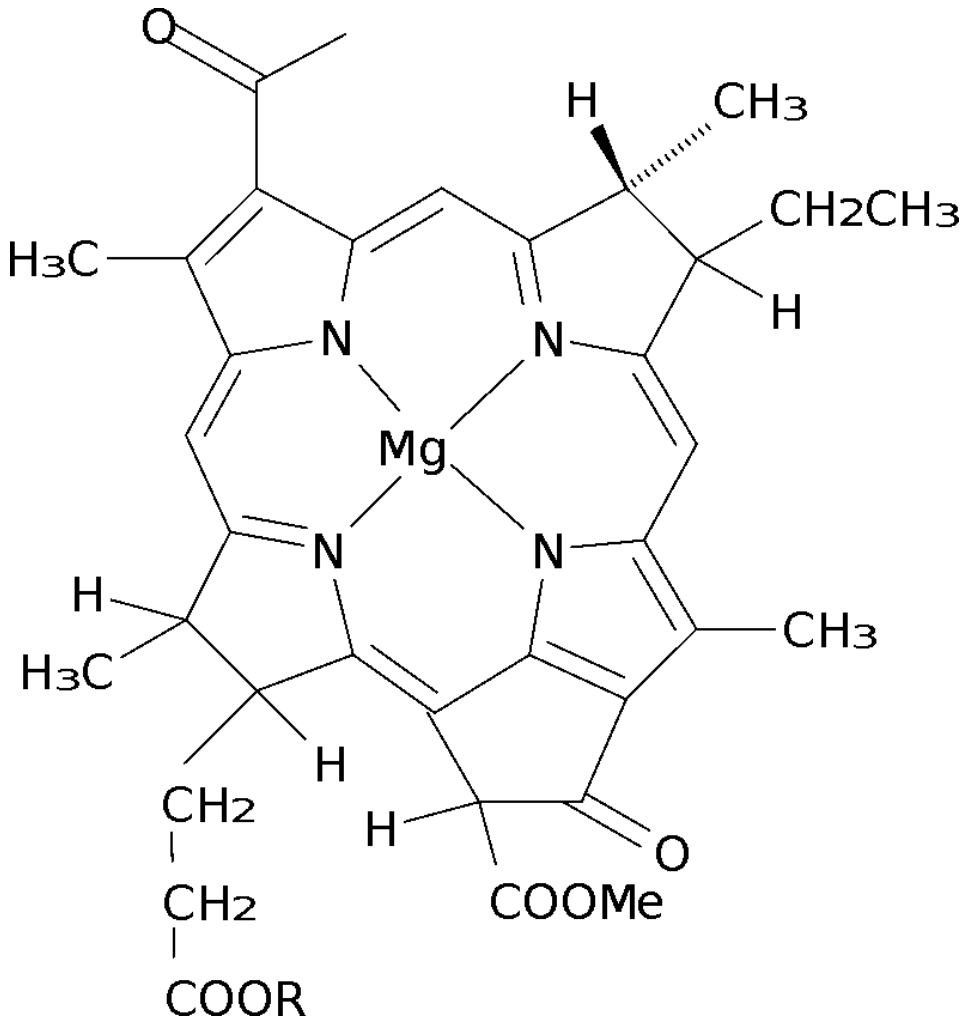
α-carotene



Porphyrins

- Occur in plants and animals
- Easily form complexes with metals and gases
- *Chlorophyll* and *heme* (red blood pigment) are examples of porphyrins

Bacteriochlorophyll *a*



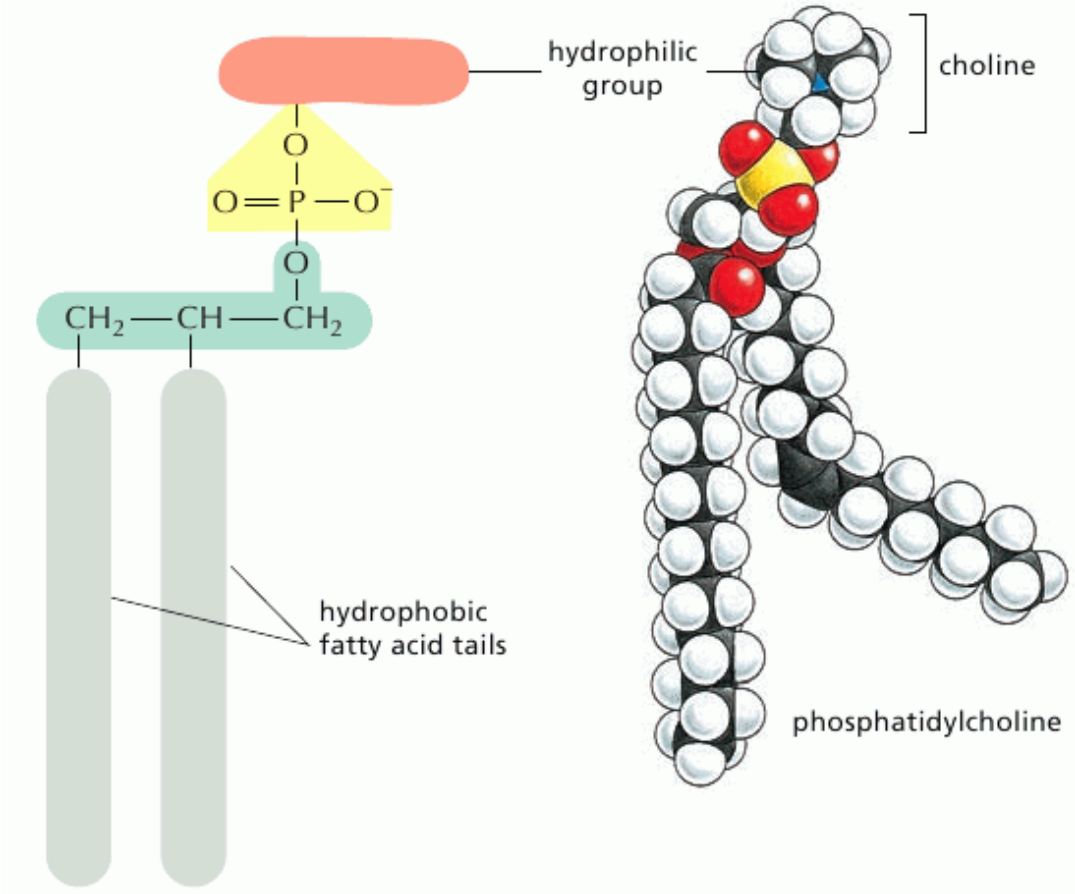
Membrane lipids

- Membrane lipids are structural units of membrane double layer
- Their chemical structure is similar to triacylglyceroles (fats) but one of fatty acids is replaced with other molecule

Phospholipids

- Phospholipids are esters of glycerol (or sphingoside), fatty acids and phosphorous acid
- Head + two tails structure
- Glycerol + phosphate head is hydrophilic whereas fatty acid tail is hydrophobic

Phospholipids

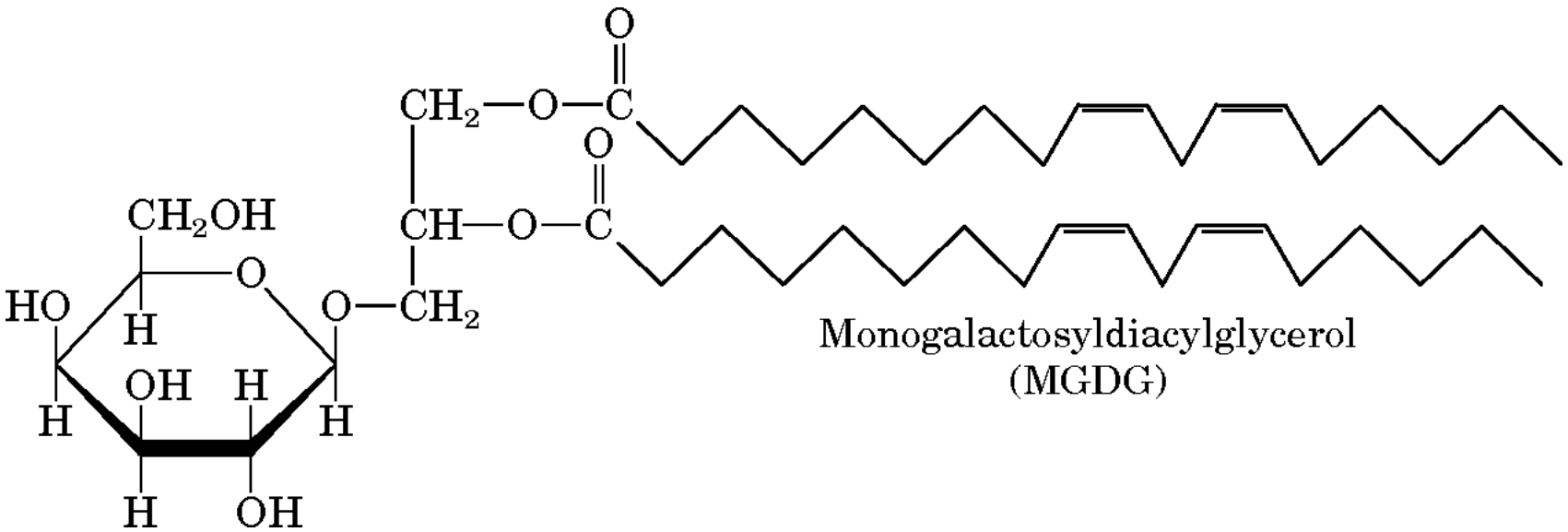


general structure of a phospholipid

Glycolipids

- Glycolipids have two hydrocarbon tails and sugar head
- Often occur in plant cells, especially in chloroplasts

Glycolipids

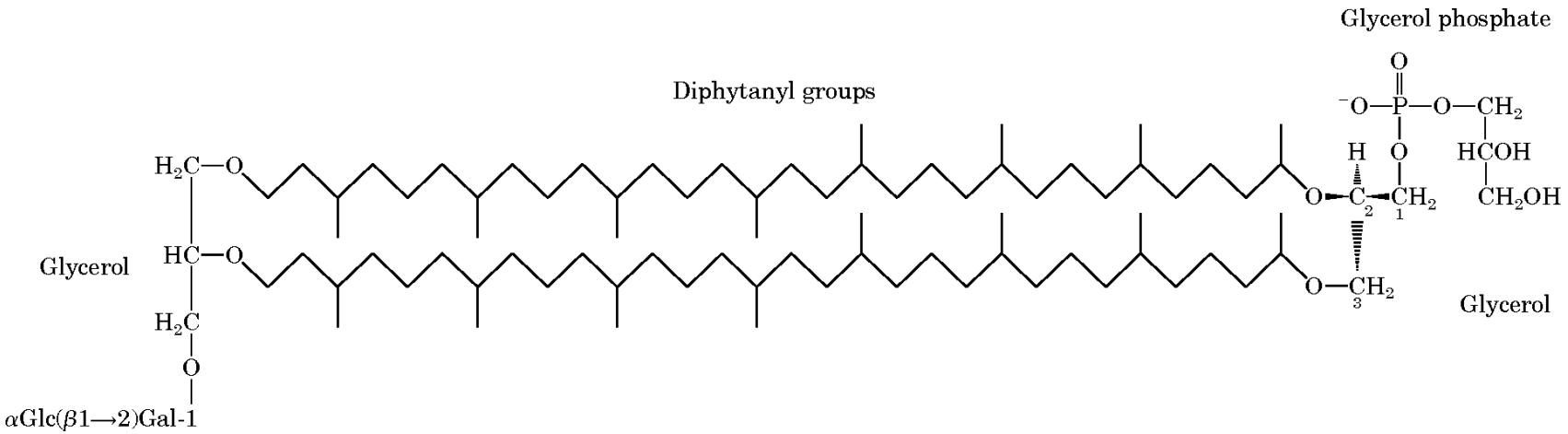


Monogalactosyldiacylglycerol
(MGDG)

Archaea membrane lipids

- Archaea (or archebacteria) have highly specific biochemistry
- Their membranes contain glycerol dialkyl glycerol tetraethers (GDGTs) which are double esters (have glycerol from both ends) and span the whole membrane
- These membranes are much more stable to high temperatures and low pH

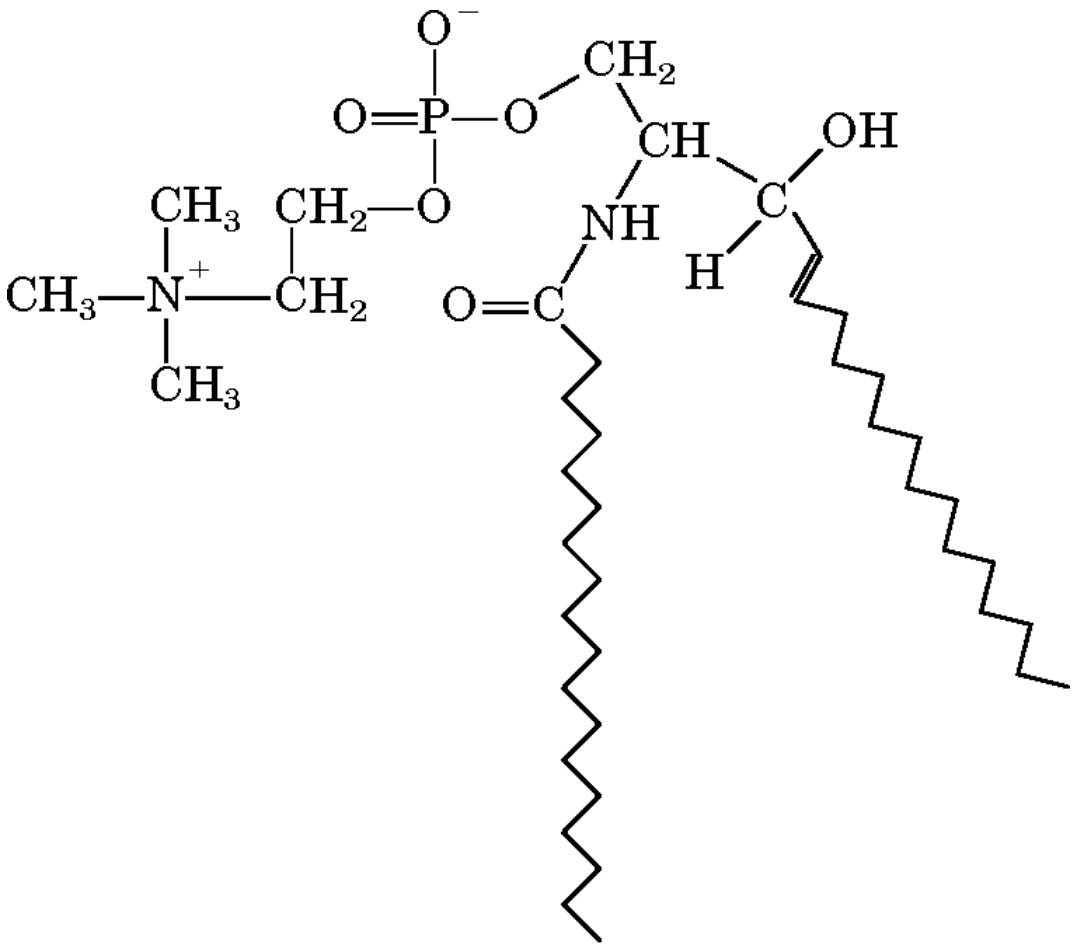
Glycerol dialkyl glycerol tetraethers (GDGTs)



Sphingolipids

- Sphingolipids are composed of one *sphingosine* (long chain amino-alcohol), one polar head and one fatty acid
- Again, head + two tails structure
- Sphingolipids in the membrane are important sites of biological recognition; nervous cells are especially rich of sphingolipids

Sphingomyelin

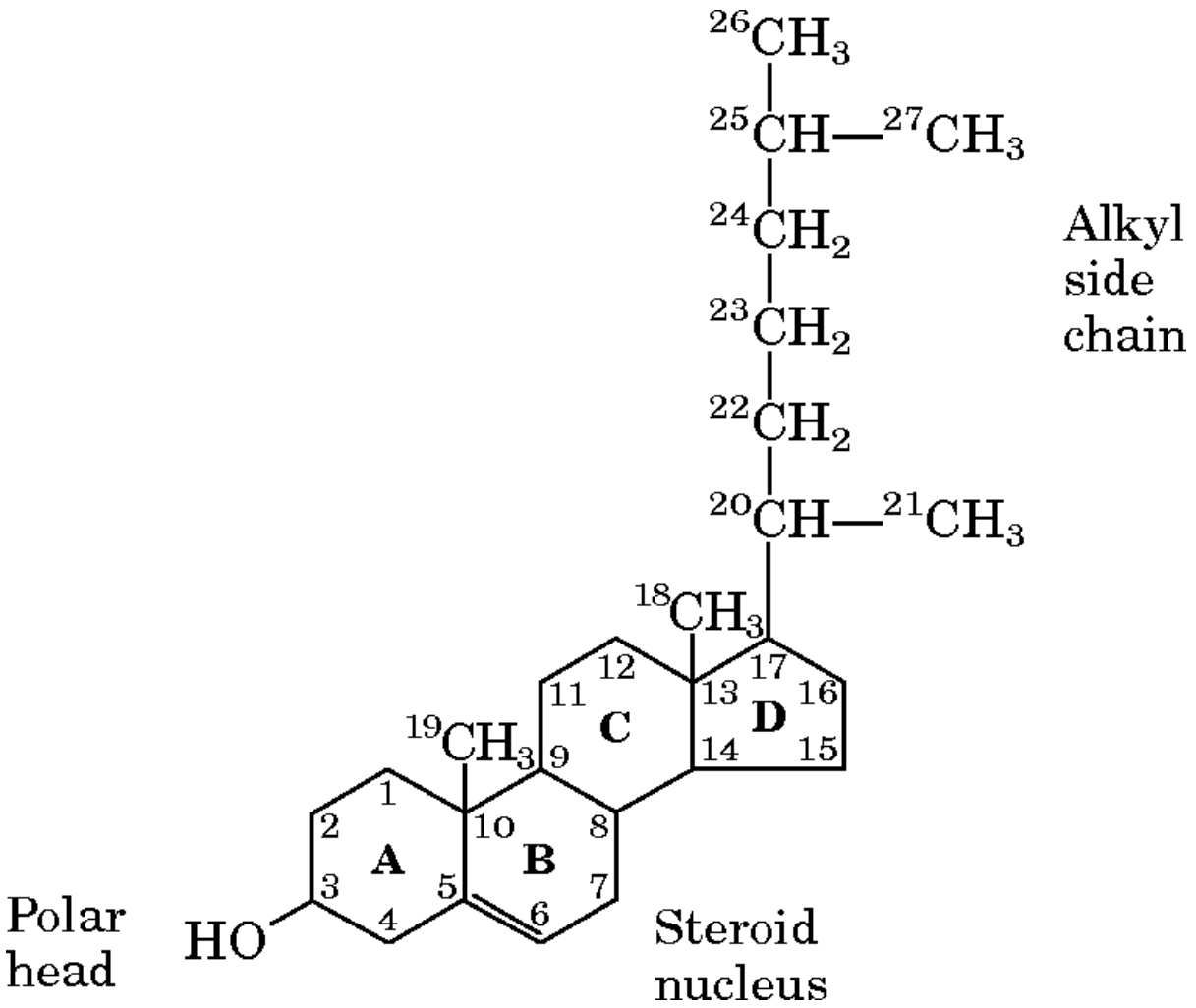


Sphingomyelin

Cholesterol

- Cholesterol is a *sterol*: molecule with four fused carbon rings
- One of main components of membrane, and also precursor to steroid hormones and other molecules
- Coronary disease is directly connected with cholesterol metabolism

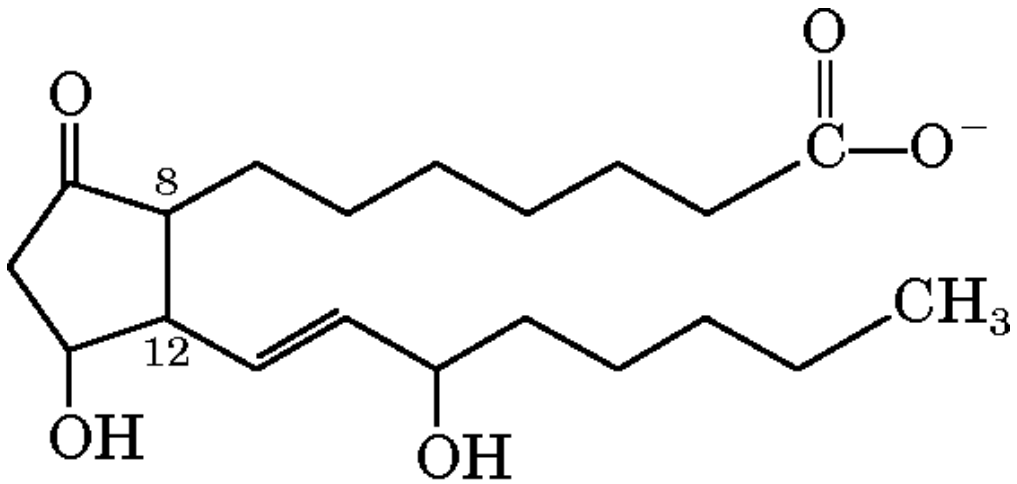
Cholesterol



Eicosanoids: derivatives of fatty acids

- *Eicosanoids* are hormones—biochemical signals
- They are structurally similar to membrane lipids
- Some of them, e.g., *prostaglandins*, play important physiological roles

Prostaglandin, one of eicosanoids

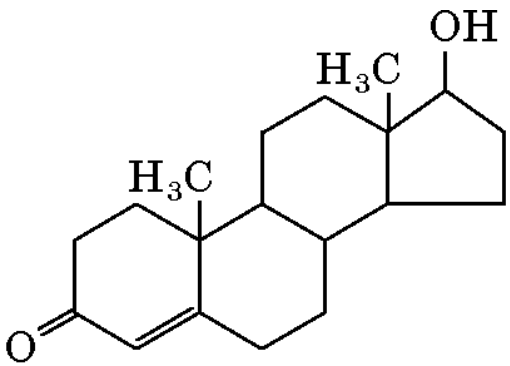


Prostaglandin E_1
(PGE_1)

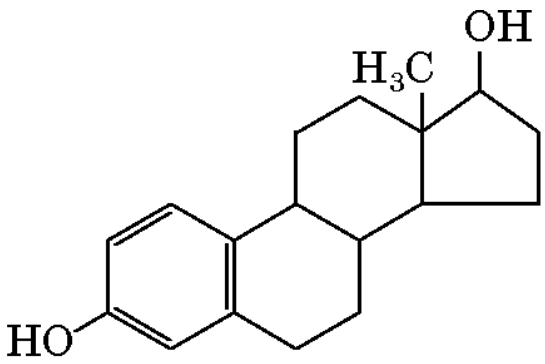
Steroids

- *Steroids* are derivates of *sterols* (mostly cholesterol)
- Occur both in plants and animals
- Have high specificity to receptors and therefore are producing in small quantities
- In vertebrates, play a role of sex hormones

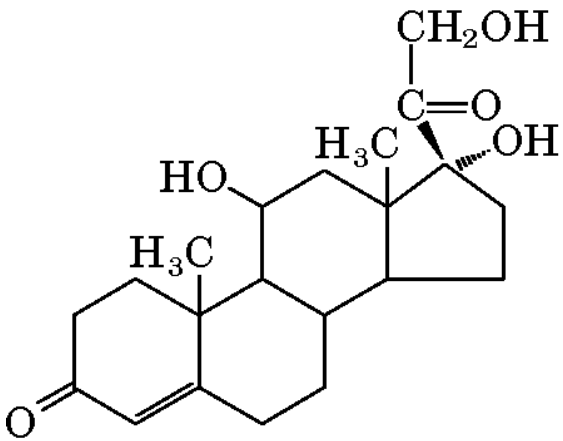
Steroids



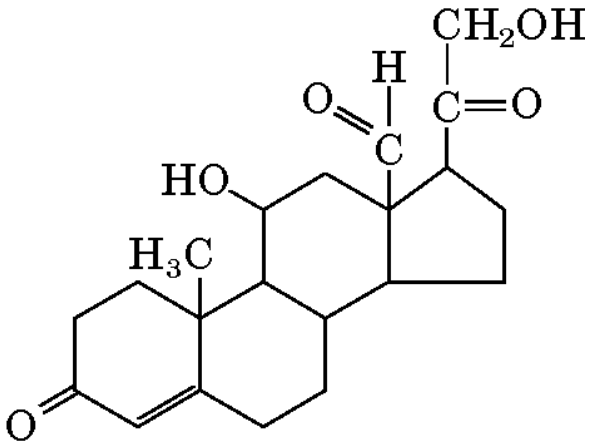
Testosterone



Estradiol



Cortisol

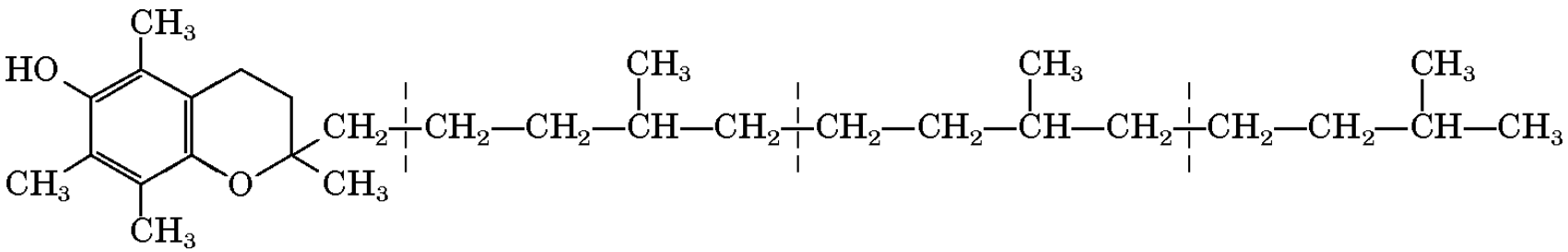


Aldosterone

Lipid vitamins

- Vitamin **D** (close to sterols) transforms into hormone regulating calcium uptake
- Vitamin **A** (retinol) transforms into retinal which is a main light response pigment of eye
- Vitamin **E** (tokoferol) assists in numerous biosynthetic processes

Vitamin E, tokoferol



Final question (2 points)

Final question (2 points)

Which role in the cell lipids do NOT play?

Summary

- Lipids are extremely diverse; the only character uniting them is their hydrophobic behavior

For Further Reading

A. Shipunov.
Advanced Cell Biology [Electronic resource].
2011—onwards.
Mode of access: `http://ashipunov.info/shipunov/school/biol_250`

B. Alberts et al.
Essential Cell Biology. 3rd edition.
Garland Science, 2009.
Chapter 2: Molecules in cells, Panel 2-4.