

Lipids

Lipids

Lipids are organic compounds formed from alcohol and fatty acids combined by ester linkage.

Roles in body:

- **Energy reserves** (particularly fatty acids, lipids with long hydrocarbon chains) - There is a large energy yield upon oxidation of these highly reduced hydrocarbons.
- As **lipid bilayers**, main components of biological membranes.
- Intra- and intercellular **signaling**.
- Etc...

CLASSIFICATION OF LIPIDS

BASED ON COMPOSITION

SIMPLE LIPIDS

- Fats
- Waxes

COMPLEX LIPIDS

- Phospholipids
- Non-Phosphorylated lipids
- Lipoproteins
- Sulfolipids

DERIVED LIPIDS

- Isoprenoids
- Fat soluble vitamins
- Steroids
- Ketone bodies
- Fatty acids

BASED ON FUNCTIONS

STORAGE LIPIDS

- Fats
- Oils

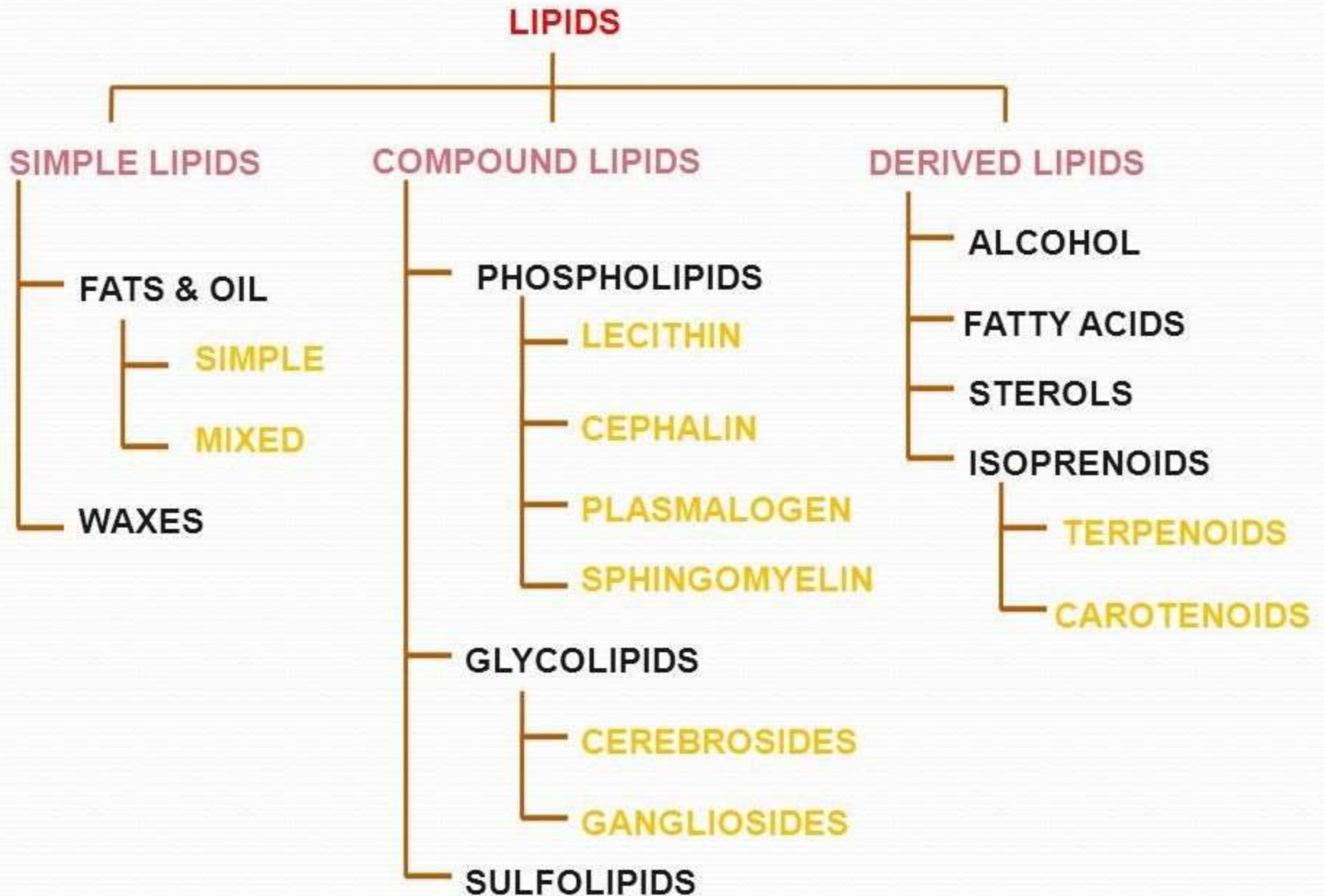
STRUCTURAL LIPIDS

- Phospholipids
- Non-Phosphorylated lipids

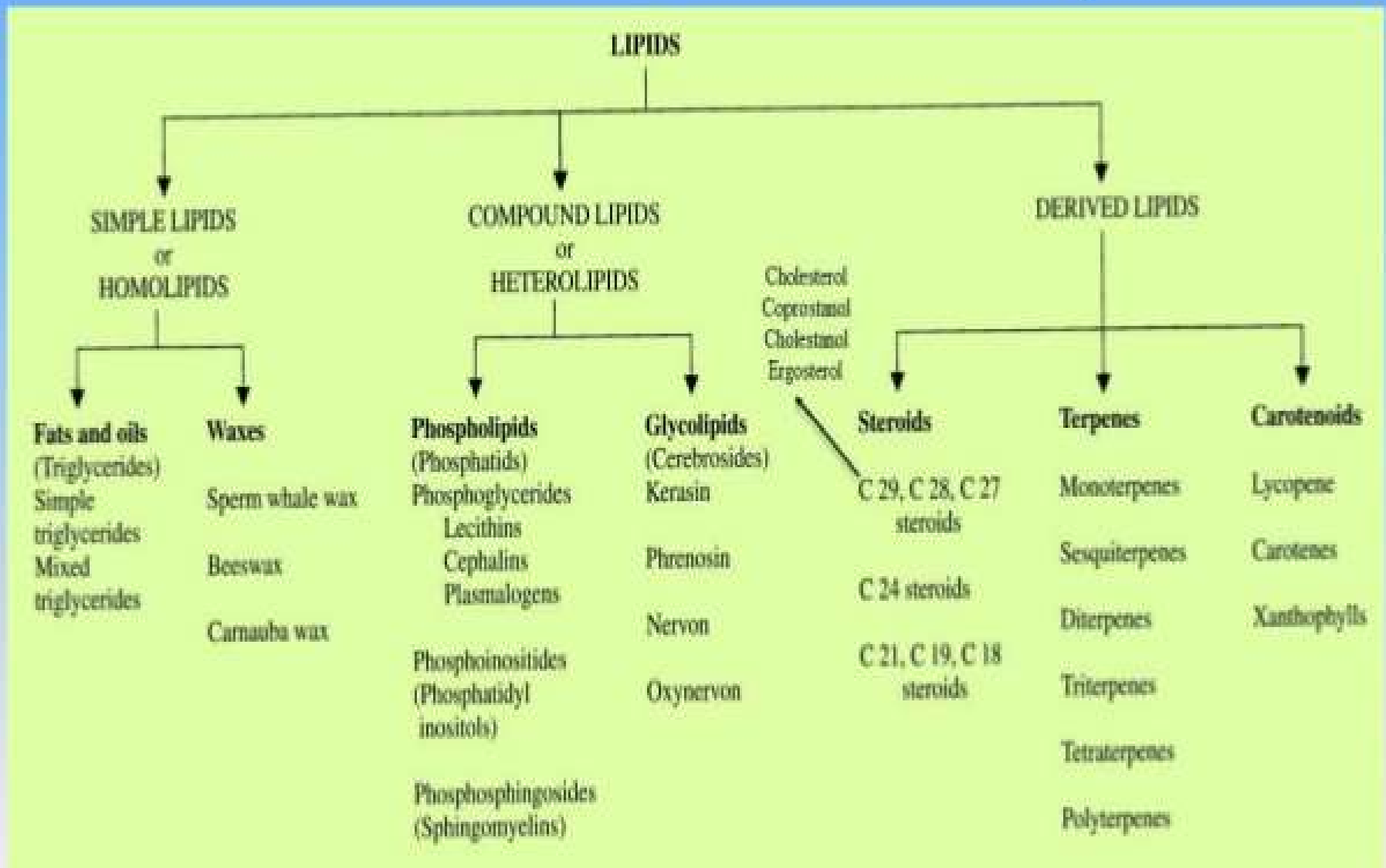
LIPIDS AS SIGNALS, COFACTORS AND PIGMENTS

- Phosphatidylinositol
- Eicosanoids
- Steroid hormones
- Fat soluble vitamins
- Lipid quinines
- Dolichols

CLASSIFICATION OF LIPIDS



Classification Of Lipids



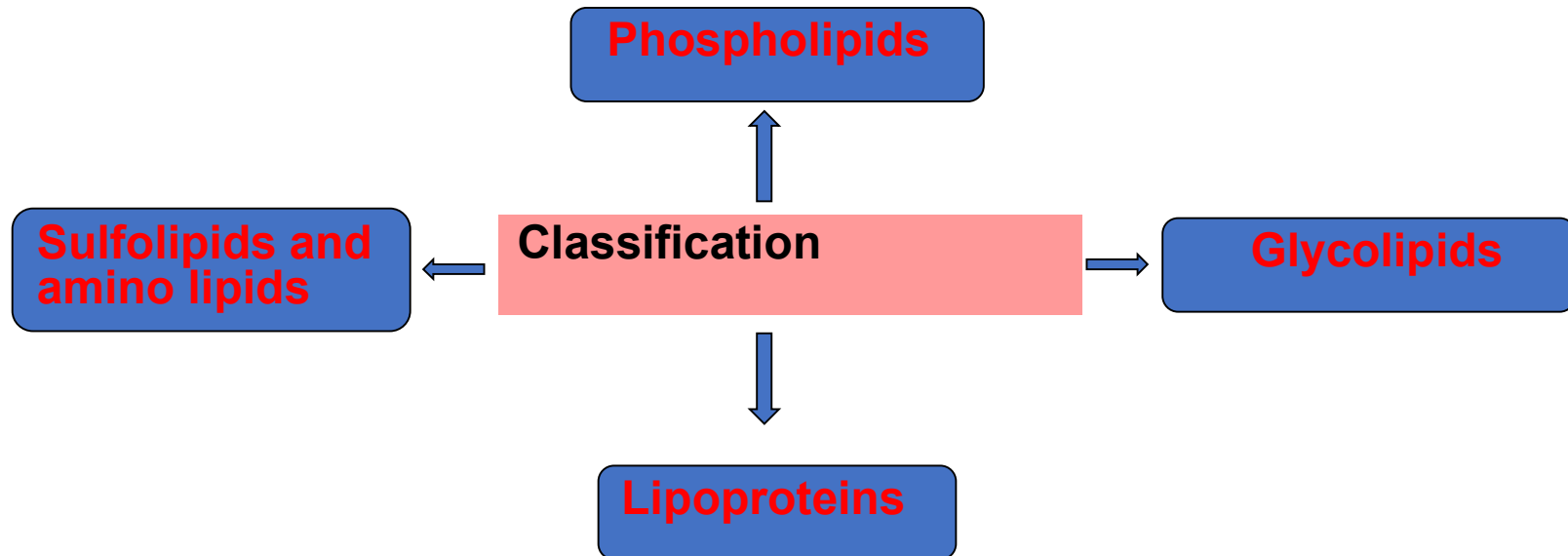
Simple Lipids

Fats and oils (Triglycerides)

- ❖ They are called neutral fats and are the most abundant lipids in nature.
- ❖ They are esters of glycerol with various fatty acids.
- ❖ Esterification of glycerol with one and 2 molecules of fatty acid gives **monoglyceride and diglyceride**, respectively.

2-Compound Lipids/ Conjugated Lipids

They are lipids that contain sulfur, phosphorus, amino group, carbohydrate, or proteins beside fatty acid and alcohol.

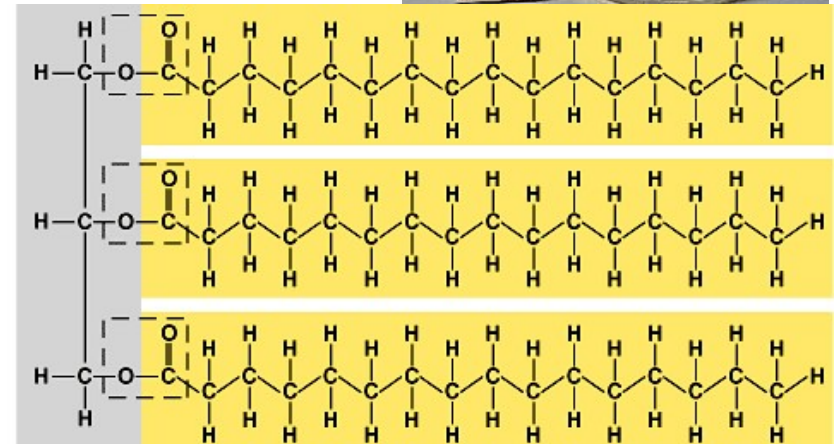


Derived Lipids

- ❖ **These are the derivatives obtained on the hydrolysis of simple and compound lipids which possess the characteristics of lipids.**
- ❖ **These include glycerol and other alcohol, fatty acids, mono- and diacylglycerols, fat soluble vitamins, steroid hormones.**

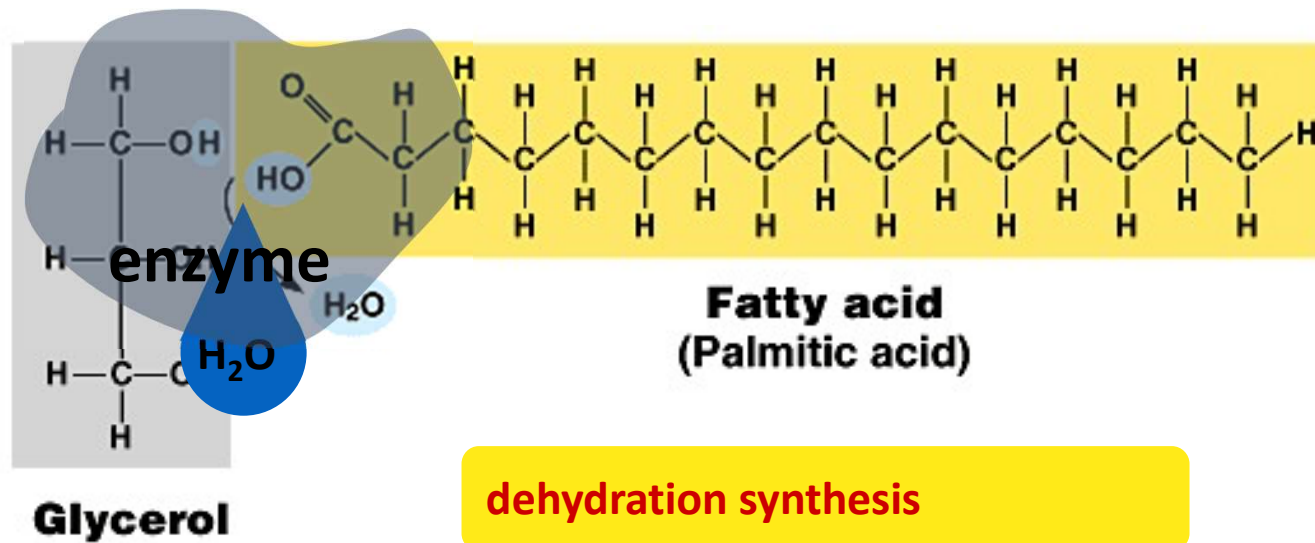
Lipids

- Lipids are composed of C, H, O
 - long hydrocarbon chains (H-C)
- “Family groups”
 - fats
 - phospholipids
 - steroids
- Do not form polymers
 - big molecules made of smaller subunits
 - not a continuing chain



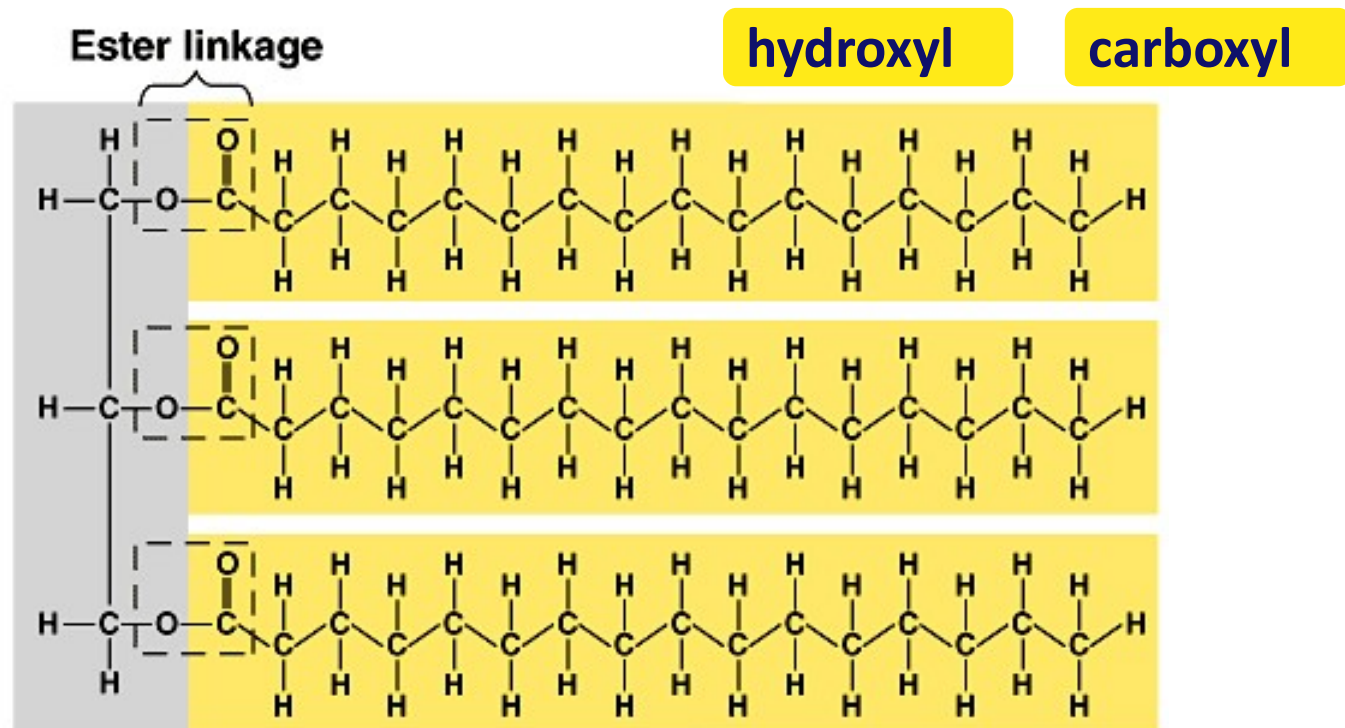
Fats

- Structure:
 - glycerol (3C alcohol) + fatty acid
 - fatty acid =
long HC “tail” with carboxyl (COOH) group “head”



Building Fats

- Triacylglycerol
 - 3 fatty acids linked to glycerol
 - ester linkage = between OH & COOH

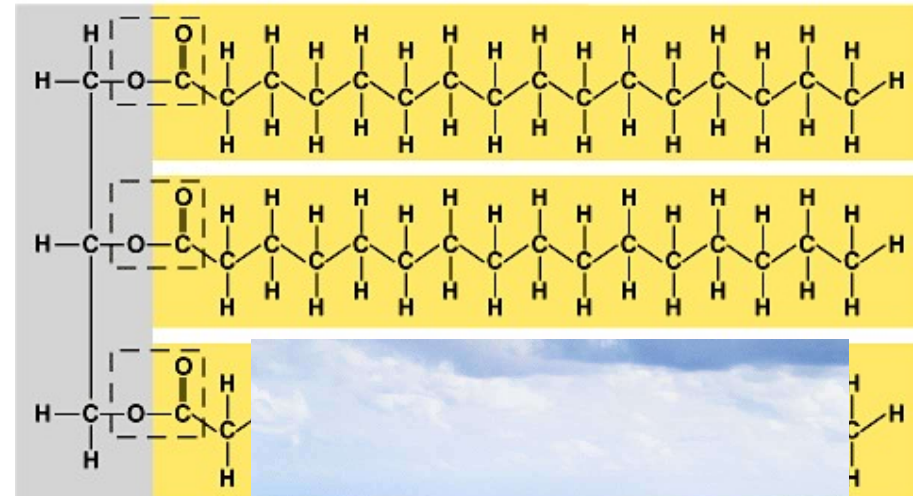


(b) Fat molecule (triacylglycerol)

Fats store energy

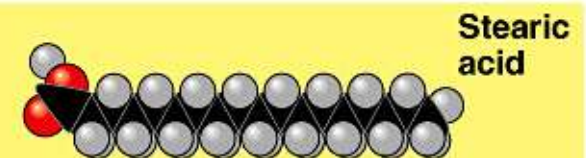
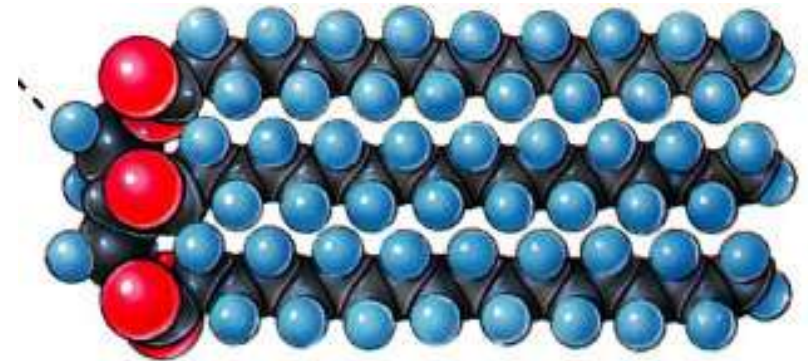
- Long HC chain
 - polar or non-polar?
 - hydrophilic or hydrophobic?
- Function:
 - energy storage
 - concentrated
 - all H-C!
 - 2x carbohydrates
 - cushion organs
 - insulates body
 - think whale blubber!

Why do humans like fatty foods?



Saturated fats

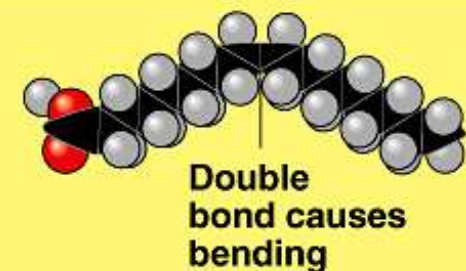
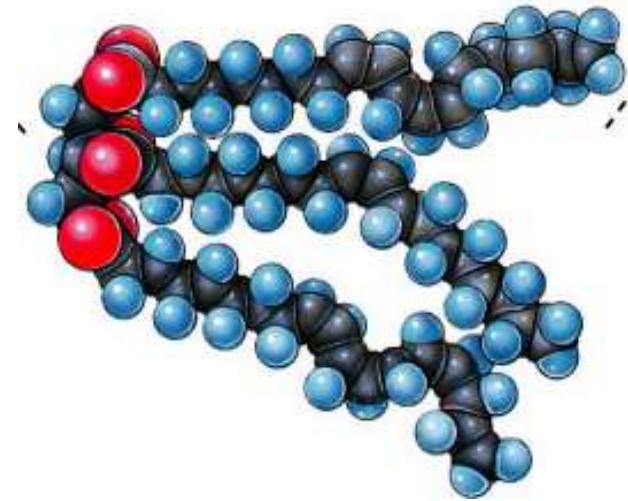
- All C bonded to H
- No C=C double bonds
 - long, straight chain
 - most animal fats
 - solid at room temp.
 - contributes to cardiovascular disease (atherosclerosis)
= plaque deposits



(a) Saturated fat and fatty acid

Unsaturated fats

- C=C double bonds in the fatty acids
 - plant & fish fats
 - vegetable oils
 - liquid at room temperature
 - the kinks made by double bonded C prevent the molecules from packing tightly together



Oleic acid

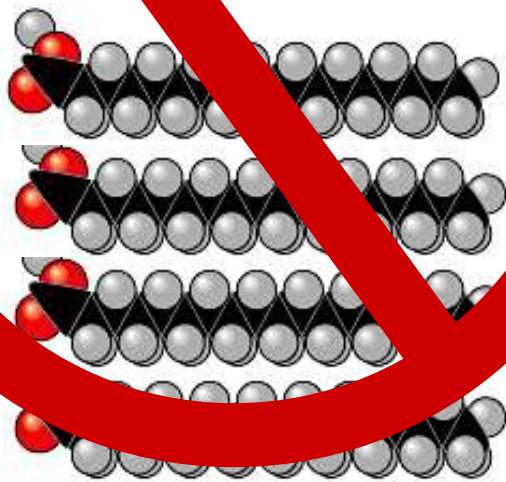
Double bond causes bending

(b) Unsaturated fat and fatty acid

mono-unsaturated?
poly-unsaturated?

Saturated vs. unsaturated

saturated



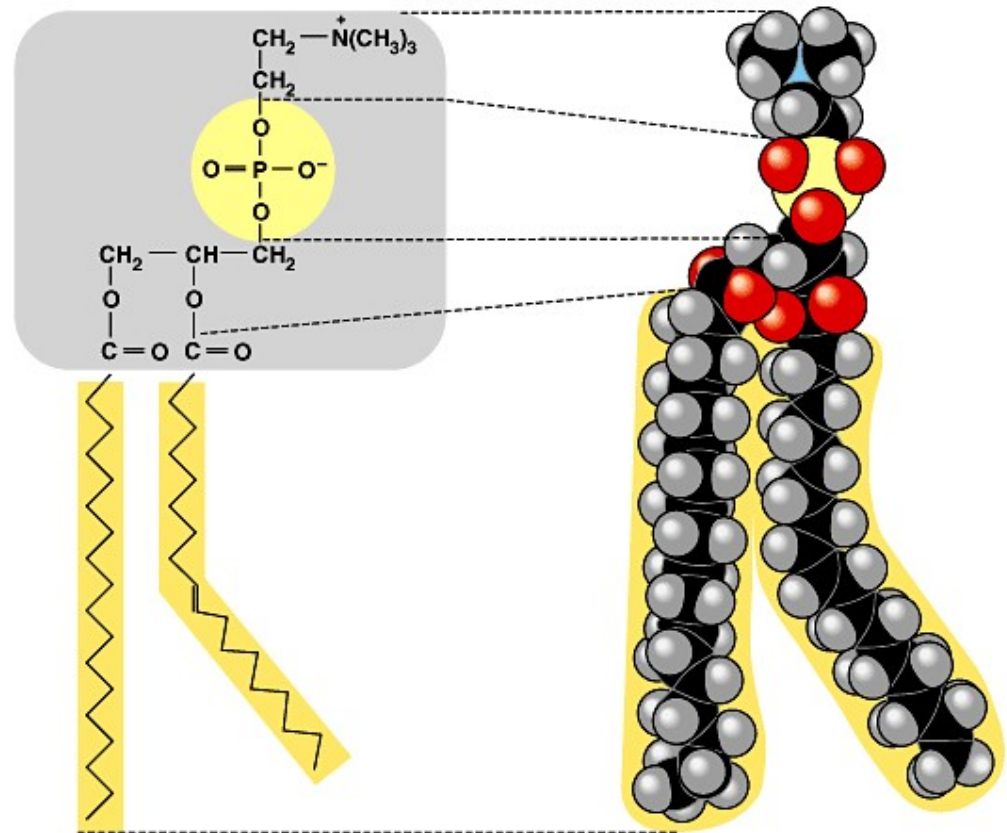
unsaturated



Phospholipids

- Structure:
 - glycerol + 2 fatty acids + PO_4
 - PO_4 = negatively charged

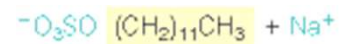
It's just like a penguin...
A head at one end
& a tail
at the other!



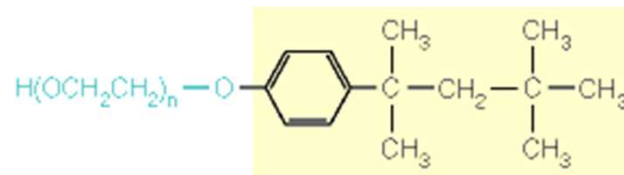
Soaps and Detergents

- Hydrolysis of fats with alkali such as NaOH or KOH yields soaps (saponification), salts of ionized fatty acids.
- Synthetic detergents:

Sodium dodecyl sulfate



Triton X-100



Phospholipids

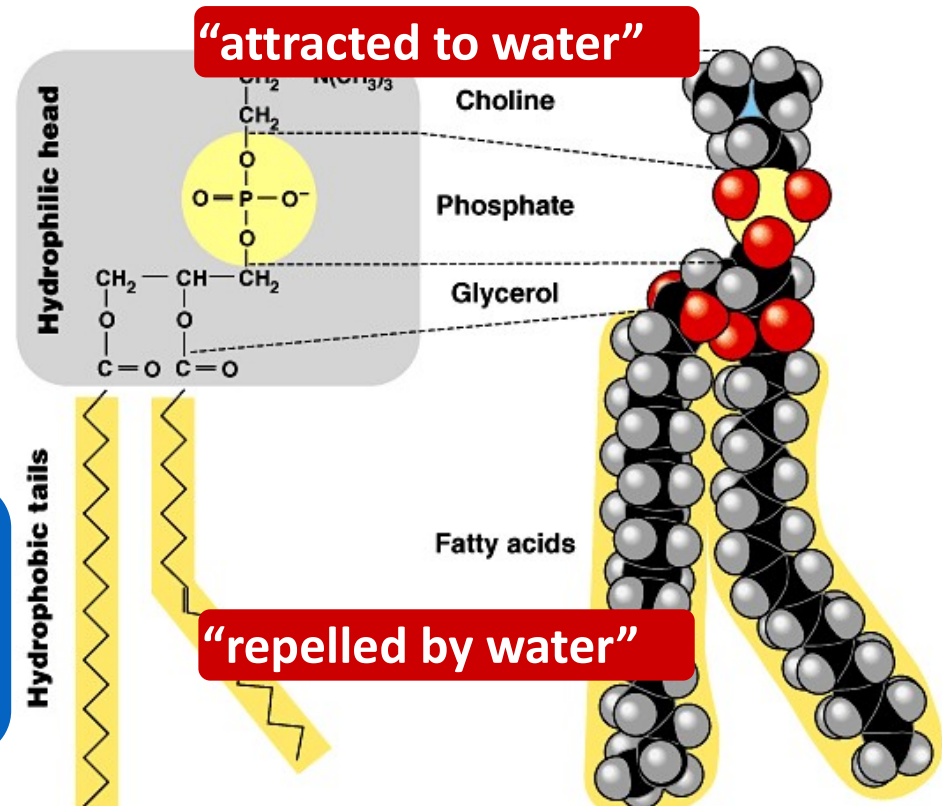
- Hydrophobic or hydrophilic?
 - fatty acid tails =
 - PO_4 head =
 - split “personality”

hydrophobic

hydrophilic

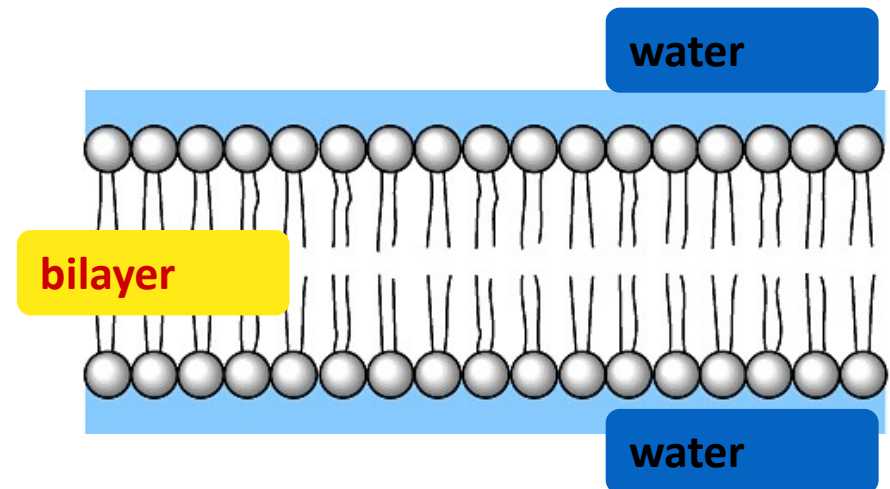
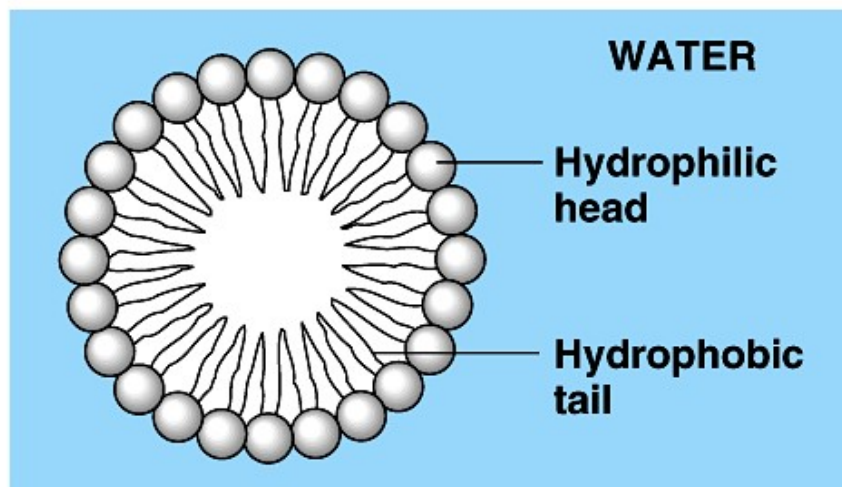
Come here,
No, go away!
Come here,
No, go away!

interaction with H_2O is complex
& very important!



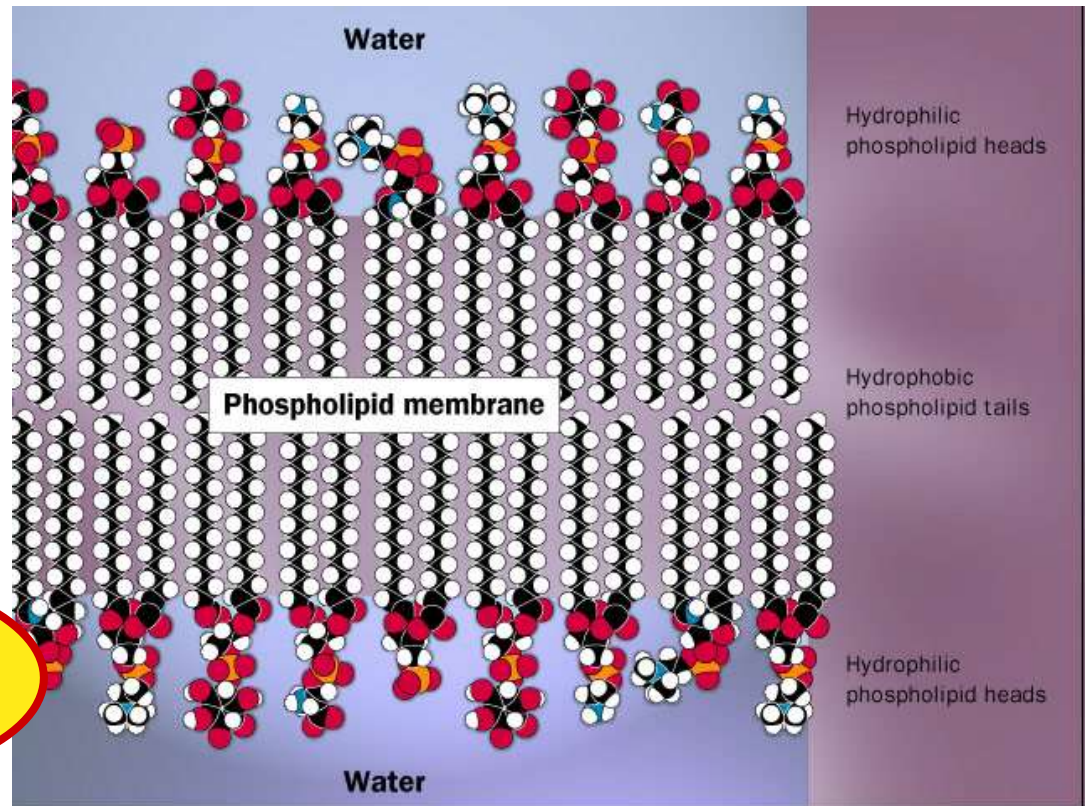
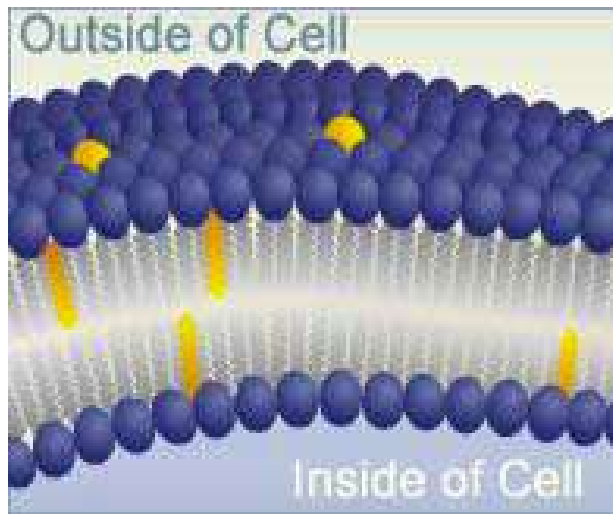
Phospholipids in water

- Hydrophilic heads “attracted” to H₂O
- Hydrophobic tails “hide” from H₂O
 - can self-assemble into “bubbles”
 - bubble = “micelle”
 - can also form a phospholipid bilayer
 - early evolutionary stage of cell?



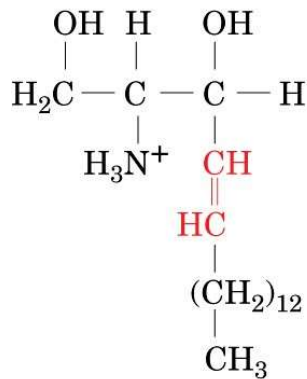
Why is this important?

- Phospholipids create a barrier in water
 - define outside vs. inside
 - they make cell membranes!



Tell them
about soap!

Sphingolipids: Another Major Class of Lipids Found in Biological Membranes

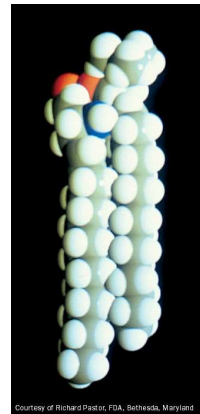


Sphingosine

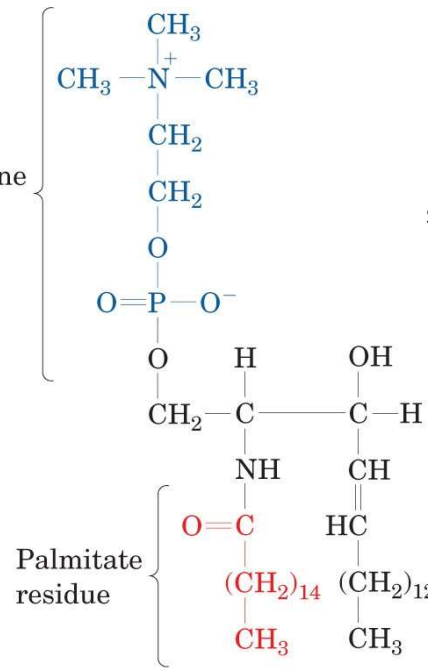
Sphingosine = amino alcohol with a long hydrocarbon chain.

Ceramide = sphingosine with a fatty acid linked by an amide bond to the amine to form an *N*-acyl chain.

Sphingomyelin = ceramides with a phosphocholine head group.



Phosphocholine head group



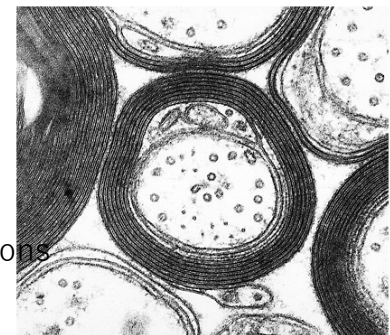
Palmitate residue

A sphingomyelin

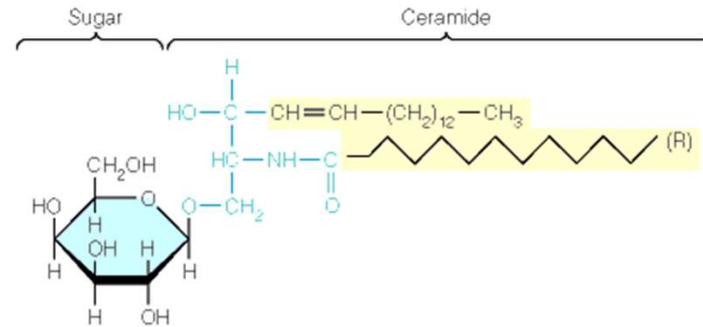
Black = sphingosine
 Black + red = a ceramide
 Black + red + blue = a sphingomyelin

Ceramide

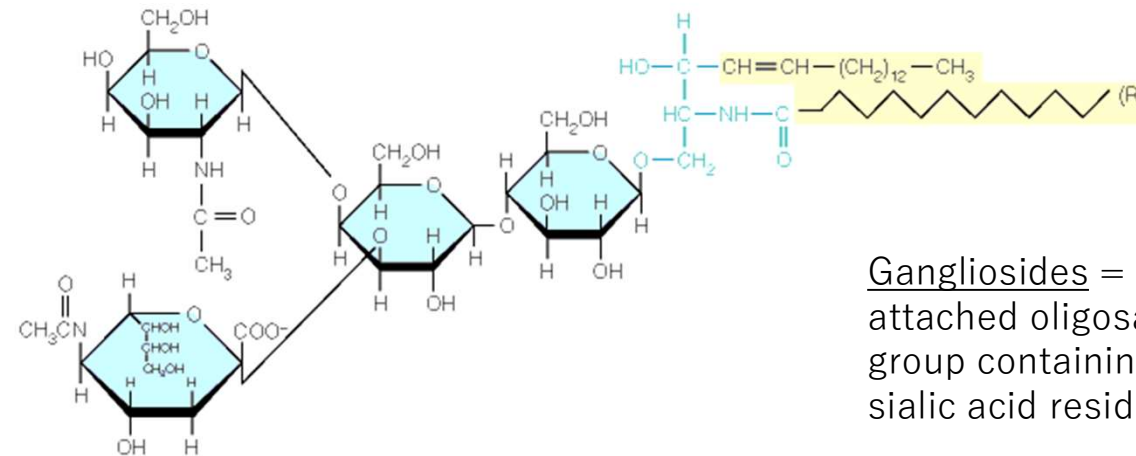
The myelin sheath that surrounds and electrically insulates many nerve cell axons is rich in sphingomyelin.



Glycosphingolipids



(a) Galactosylceramide



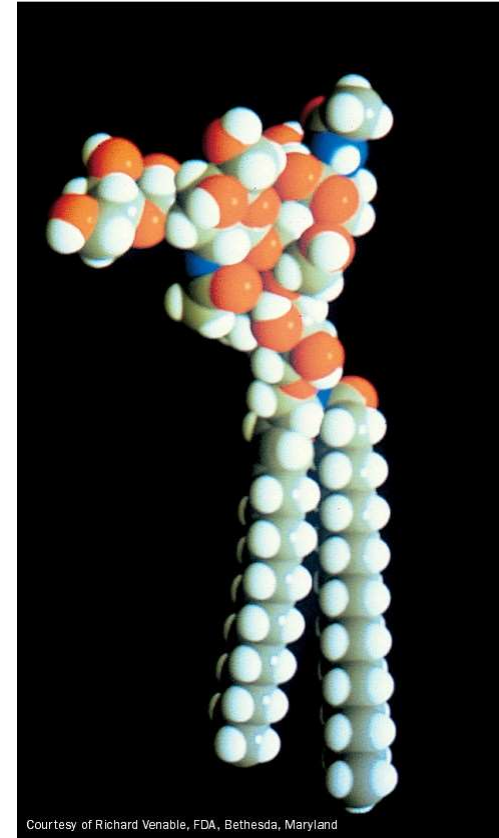
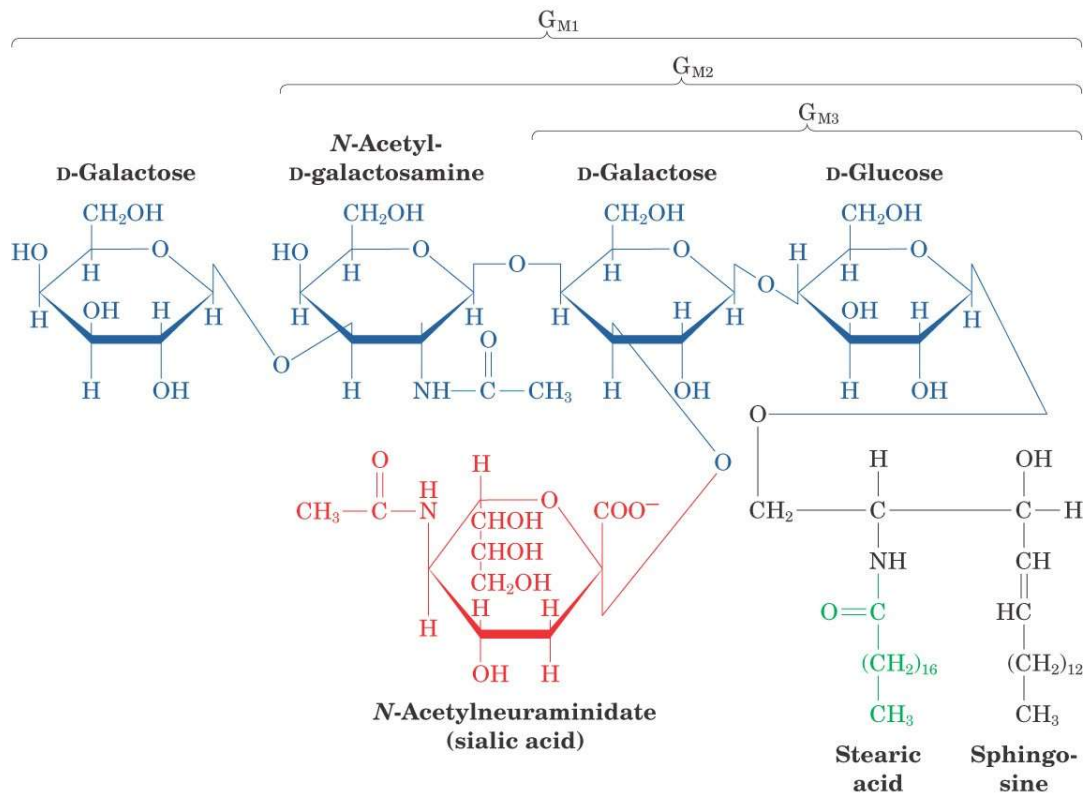
(b) GalNAc β (1 \rightarrow 4)Gal β (1 \rightarrow 4)Glc β (1 \rightarrow 1)ceramide



Cerebrosides = ceramides with a single sugar residue as head group.

Gangliosides = ceramides with attached oligosaccharide as head group containing at least one sialic acid residue.

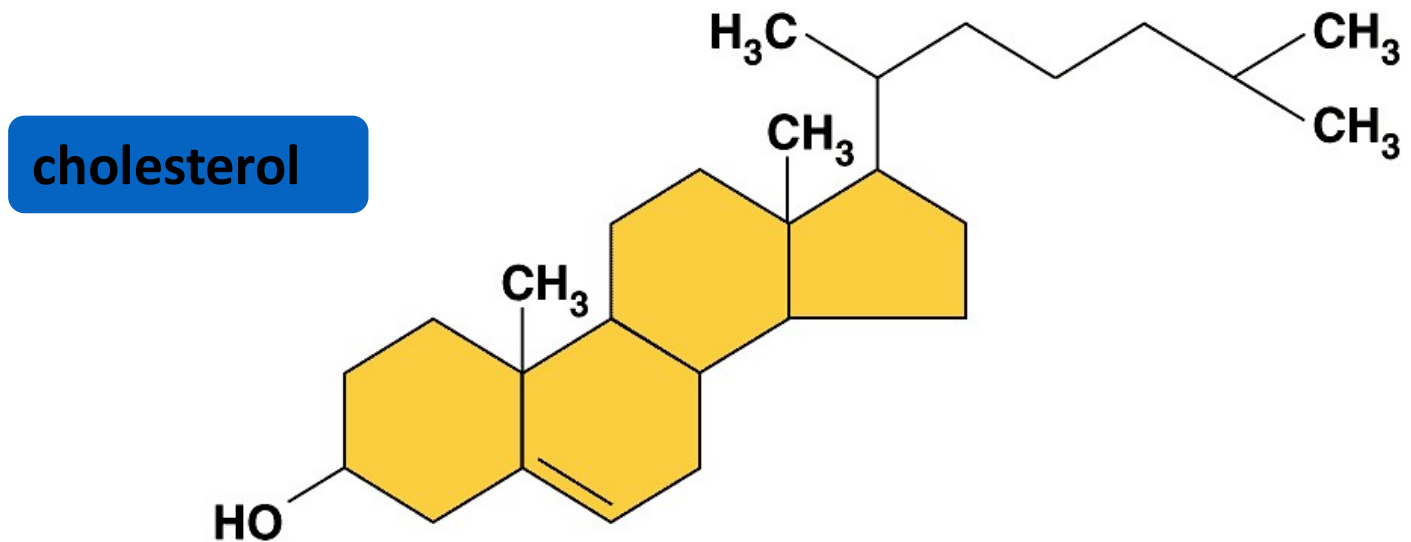
Gangliosides



Gangliosides constitute a significant fraction (~6%) of brain lipids. The ABO blood group antigens are also examples of gangliosides.

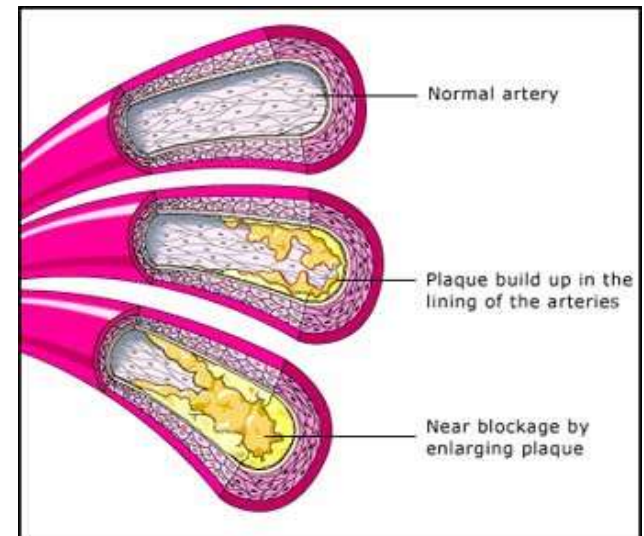
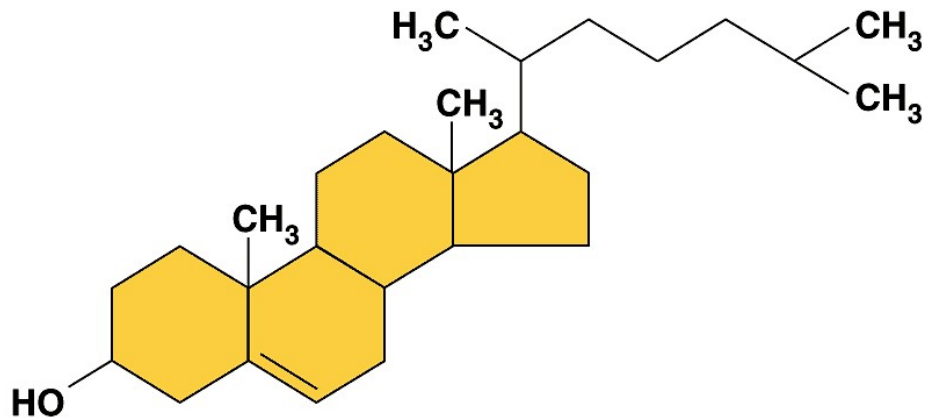
Steroids

- Structure:
 - 4 fused C rings + ??
 - different steroids created by attaching different functional groups to rings
 - different structure creates different function
 - examples: [cholesterol](#), [sex hormones](#)



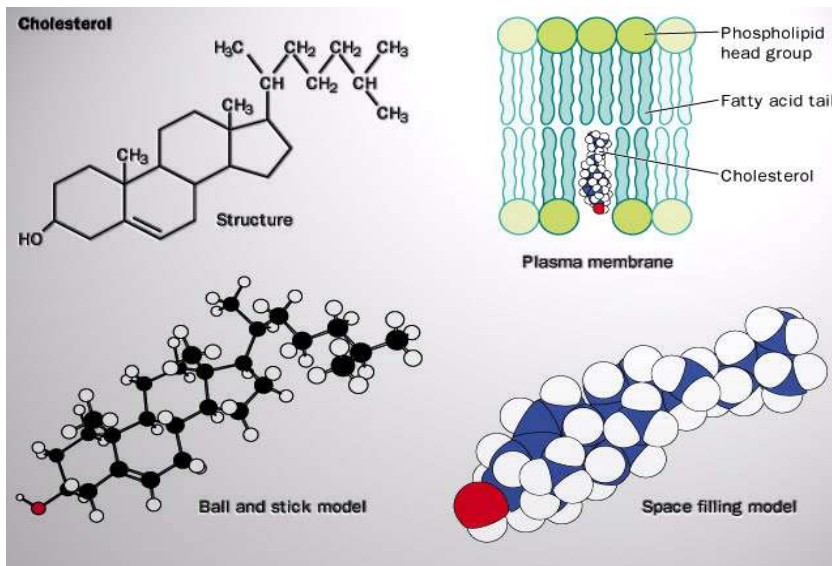
Cholesterol

- Important cell component
 - animal cell membranes
 - precursor of all other steroids
 - including vertebrate sex hormones
 - high levels in blood may contribute to cardiovascular disease



Cholesterol

Important component of cell membrane

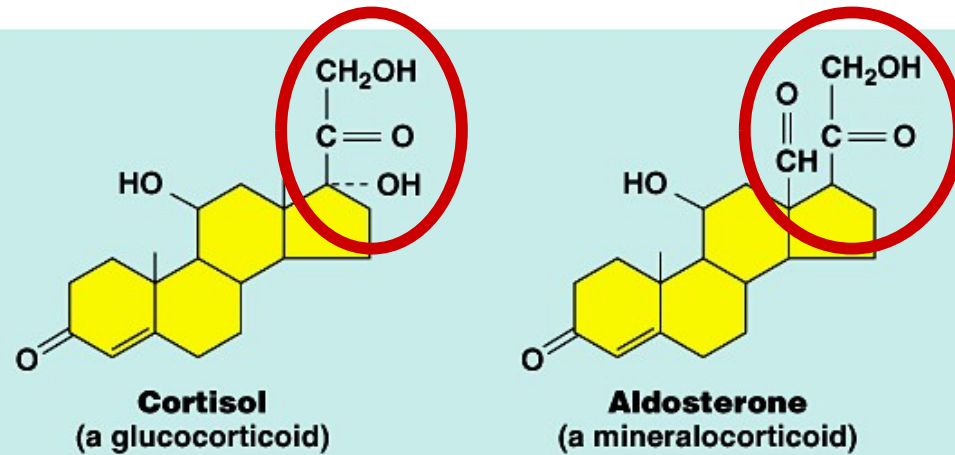


helps keep
cell membranes
fluid & flexible

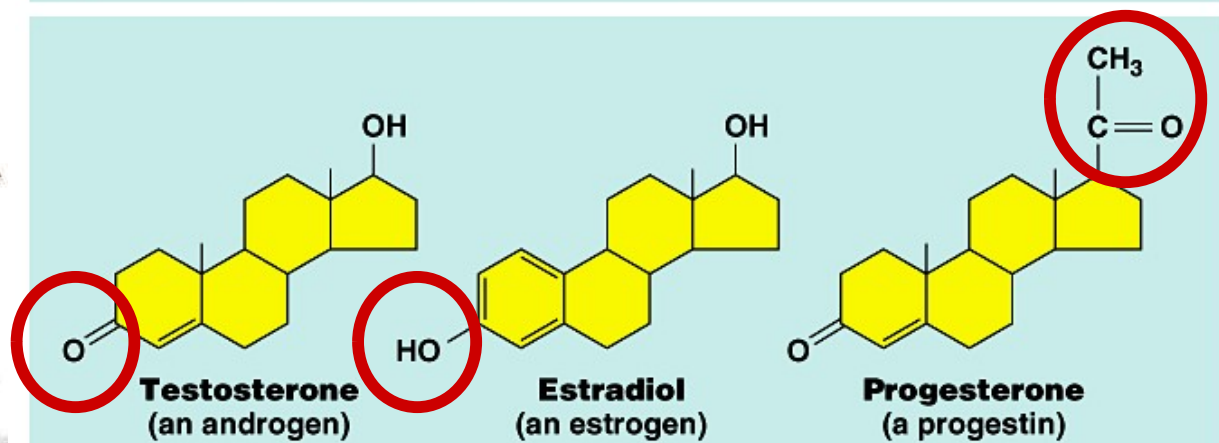
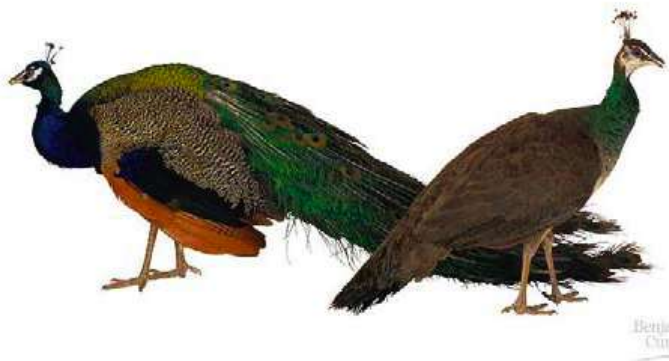
Prostaglandin

From Cholesterol → Sex Hormones

- What a big difference a few atoms can make!



(a) Steroid hormones made in adrenal cortex



(b) Steroid hormones made primarily in gonads

Vitamins

Vitamin A

Vitamin D

Vitamin E

Vitamin K

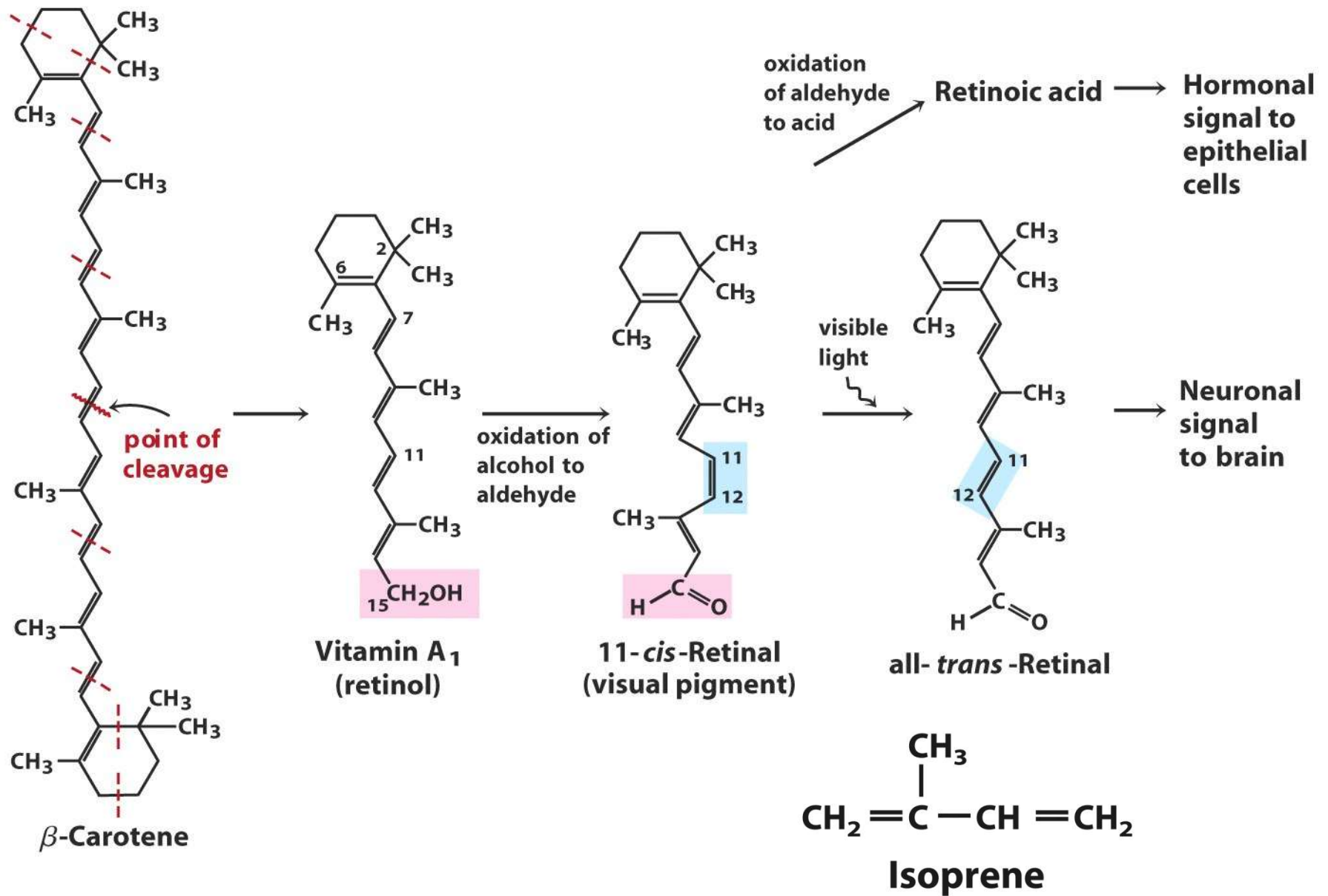


Before vitamin D treatment

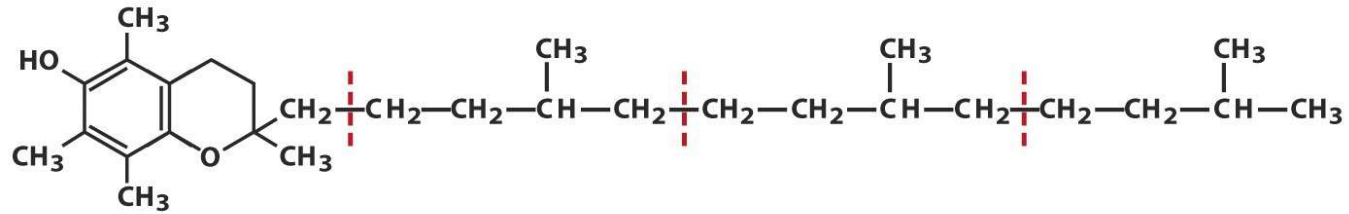
After 14 months of vitamin D treatment

A child who began life in a closet

Retinal Comes from Carotene

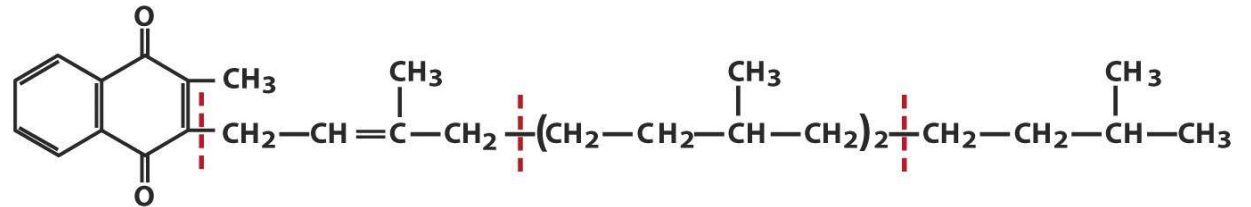


Isoprene Vitamins



(a)

Vitamin E: an antioxidant

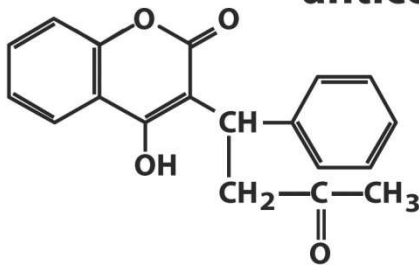


(b)

Vitamin K₁: a blood-clotting cofactor (phylloquinone)

(c)

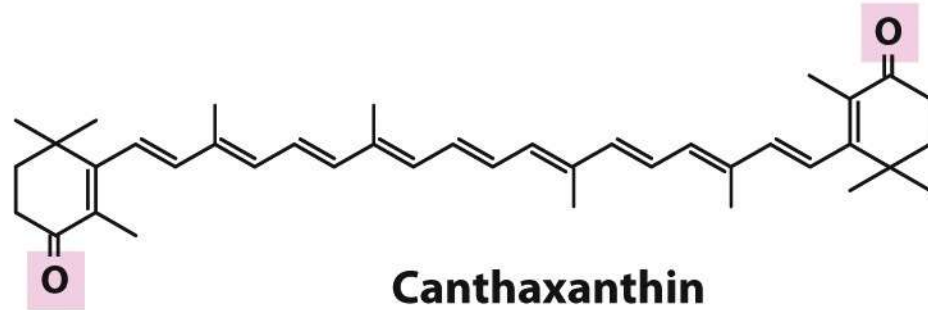
Warfarin: a blood anticoagulant



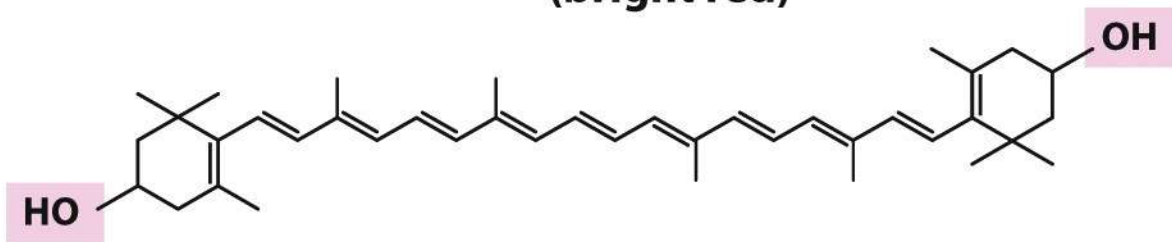
Miscellaneous Lipids

- ❖ This include a large number of compounds possessing the characteristics of lipids
- ❖ Eg. Carotenoids, Squalene, terpenes, Waxes etc.

Carotenoids



Canthaxanthin
(bright red)



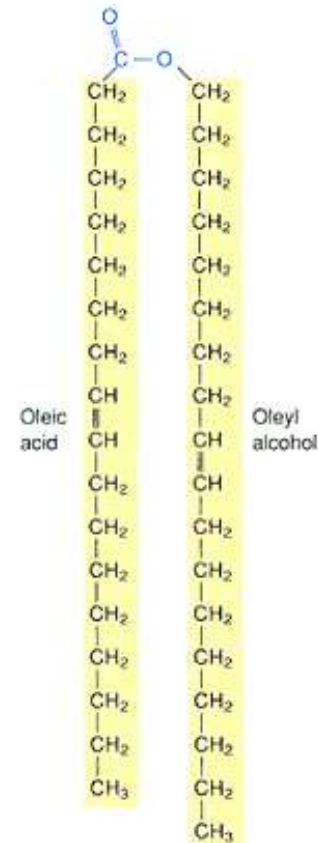
Zeaxanthin
(bright yellow)



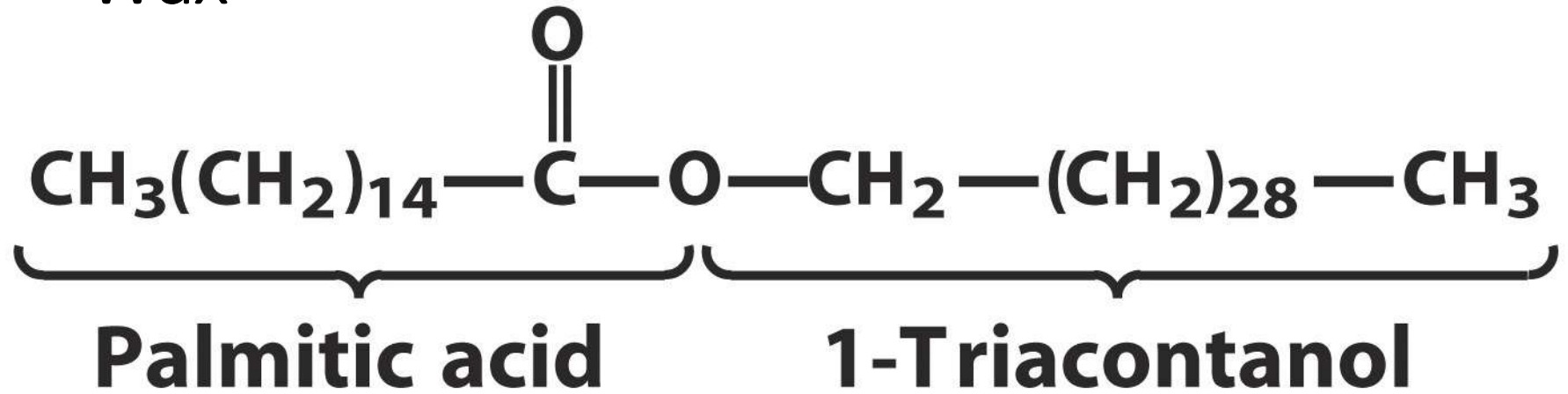
Figure 10-23
Lehninger Principles of Biochemistry, Fifth Edition
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Waxes

- Formed through esterification of fatty acid and long-chain alcohol
- Completely water-insoluble
- Water-repellent protective coating in some animals and plants
- Energy storage in some microorganisms



Wax



Ear Wax (Cerumen) is Not Wax

The primary components of ear wax are shed layers of skin:

60% of the earwax consisting of keratin

12–20% saturated and unsaturated long-chain fatty acids, alcohols and squalene,

6–9% cholesterol

