Lipids

Structure & Function

Types

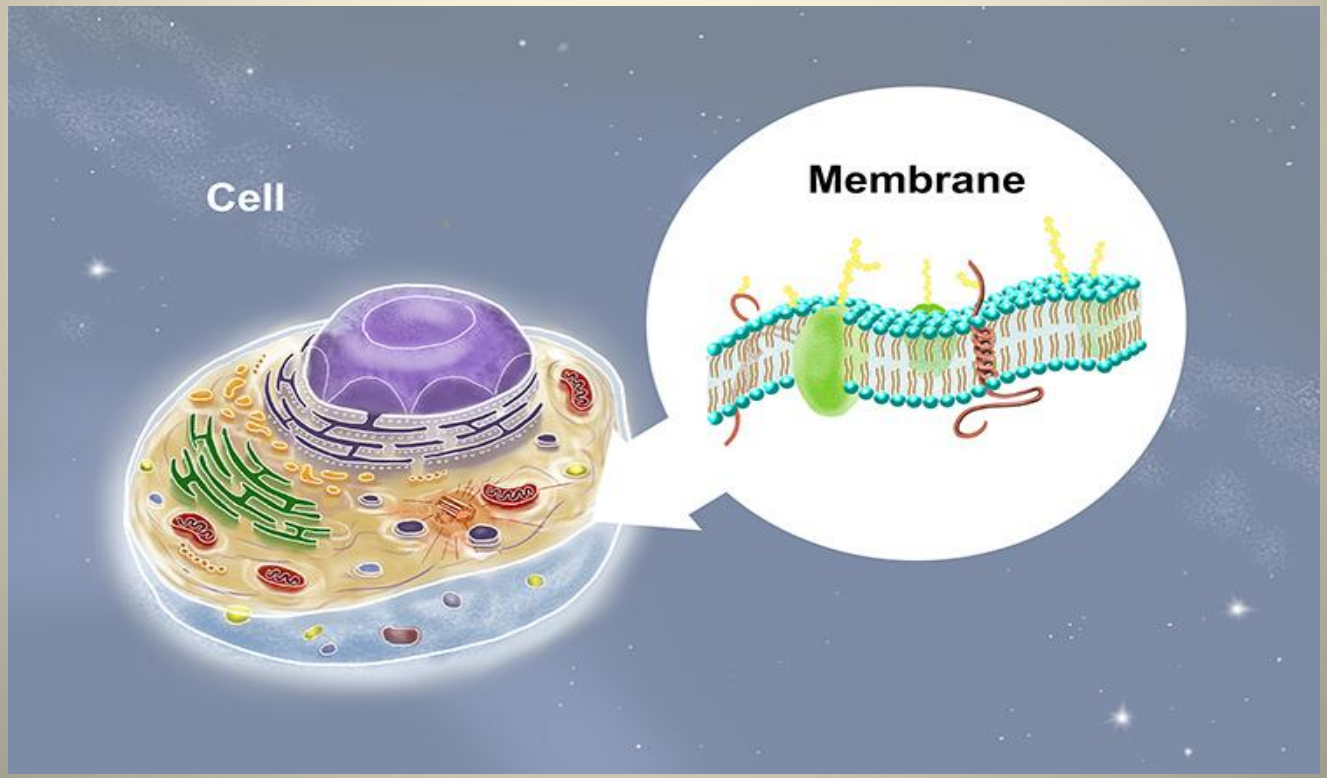
Lipid Function

1. Long-term energy storage (fat)
2. Form cell membrane (phospholipids)
3. Messaging (hormones)
4. Insulation
5. Cushioning of Internal Organs

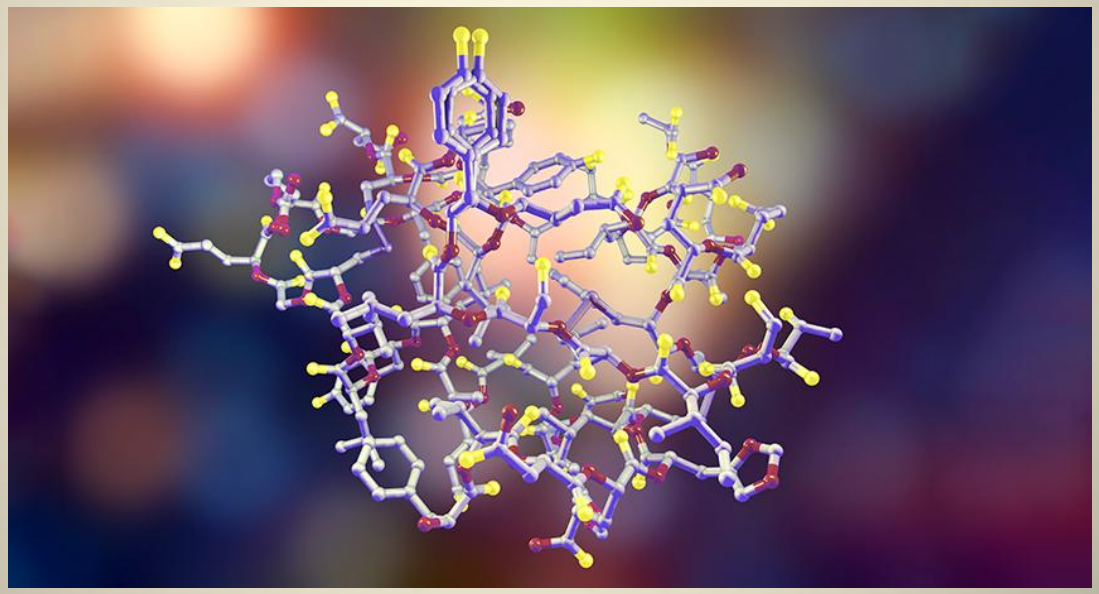
Why are lipids well suited for long term energy storage?

- Contain many high energy bonds between carbon and hydrogen
- Contain twice as much energy per gram than carbohydrates (very concentrated)
- Thus a much more compact form of storage than carbohydrate
- Animals store fats in adipose cells

- Membrane of cells, organelles etc. (phospholipid)

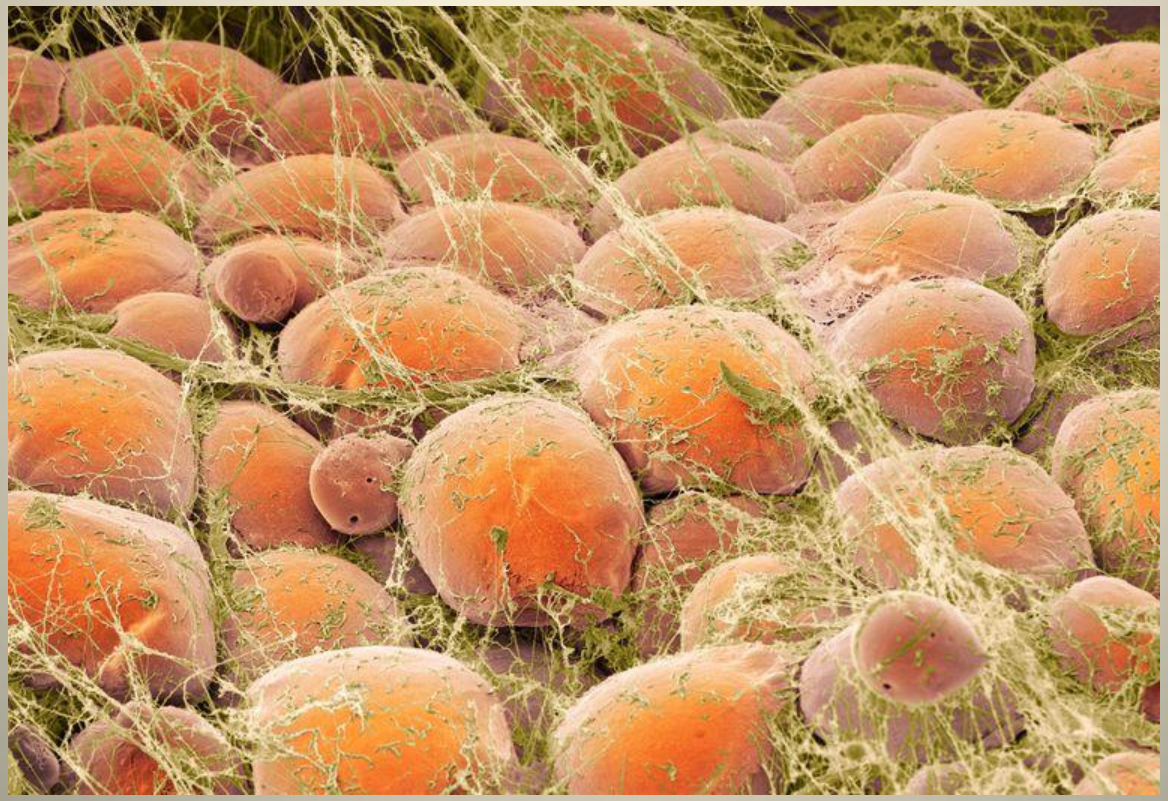


- **Messaging – Hormones**



- **Insulation**

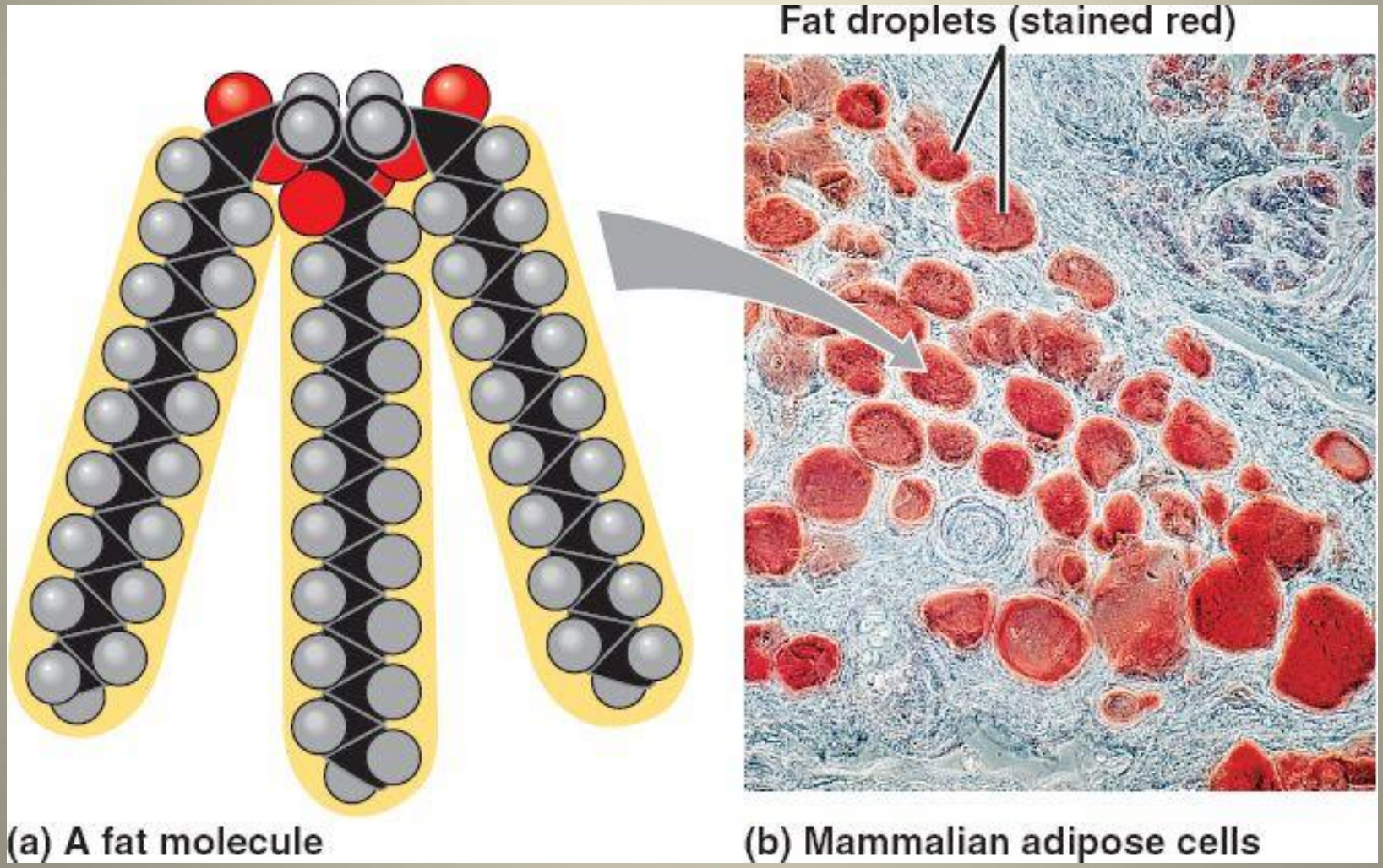
- **Cushioning of internal organs**



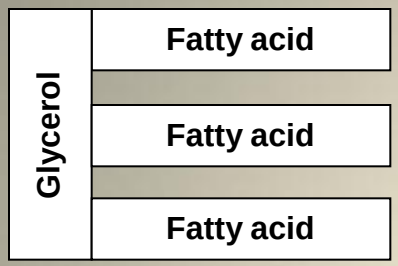
Types of Lipid

1. Fat (triglycerides)
2. Phospholipid
3. Steroid
4. Wax
5. Carotenoid

1. Fats - triglycerides

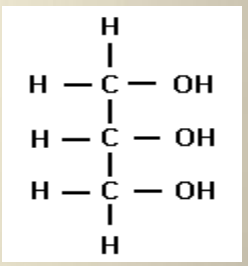


Triglyceride/triacylglycerol Structure



Consists of 1 glycerol backbone and 3 fatty acid chains

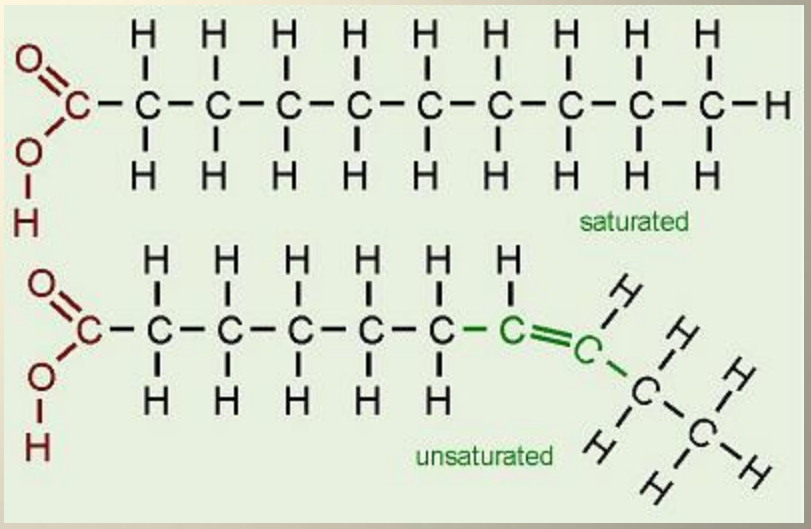
- Glycerol:
  - 3 carbon molecule
  - each carbon has a hydroxyl group attached
  - the alcohols are sites for condensation reactions
- Fatty acid:
  - unbranched chain of carbons
  - Has a carboxyl group at one end



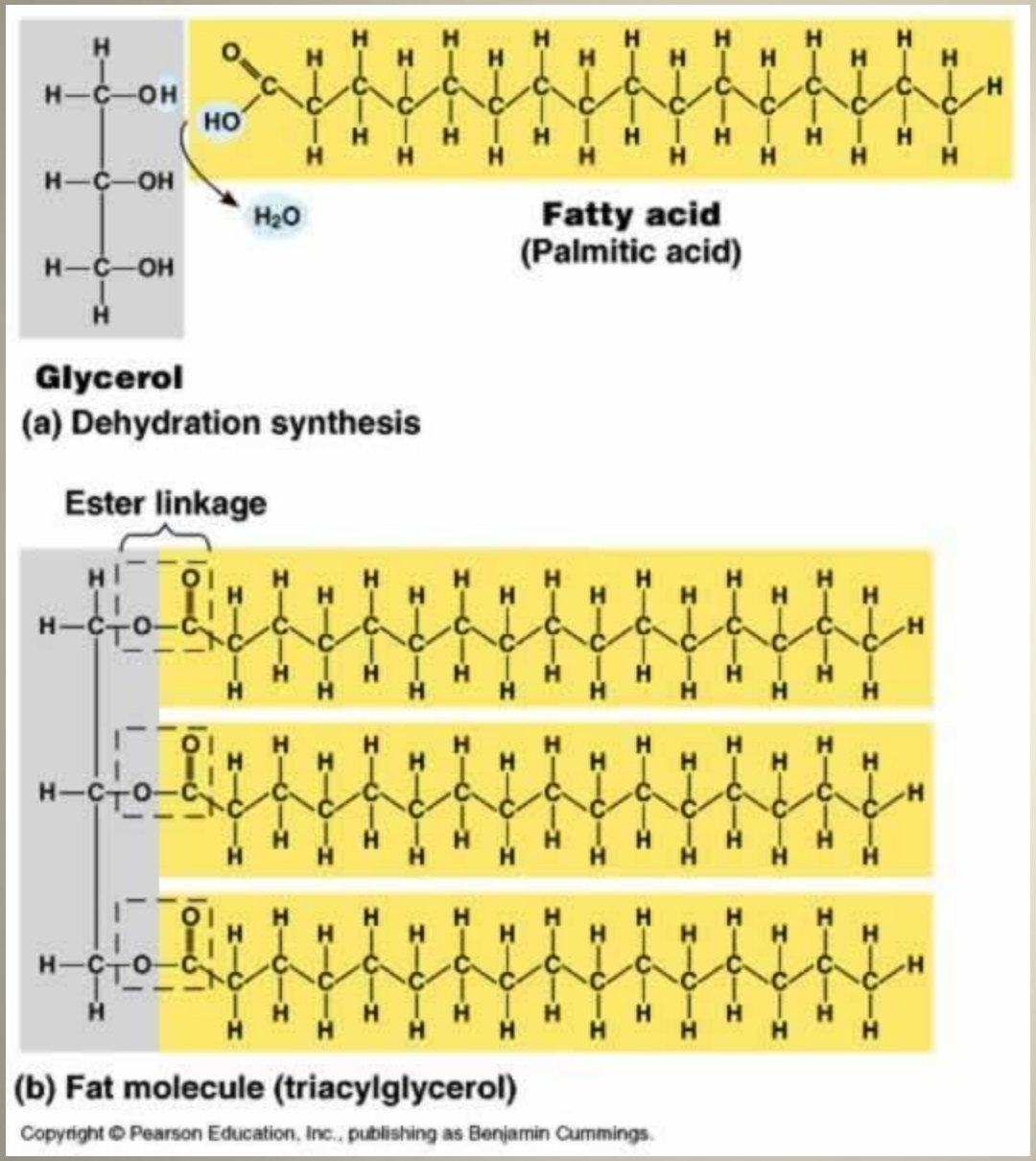
Fatty acid structure

Fatty acids differ in two ways:

1. In length: 4-24 carbons
2. Saturation:
   - Saturated
   - Unsaturated



Forming a triacylglycerol



- Condensation reaction between:
  - Hydroxyl on glycerol
  - Carboxyl on fatty acid
- Results in an ester bond
- Fig 5.10

Unsaturated Fats

- One or more double bonds, formed by the removal of hydrogen atoms from the carbon skeleton.
- The kinks where the double bonds are located prevent the molecules from packing together and prevent it from solidifying at room temperature.

Properties of Fatty acids

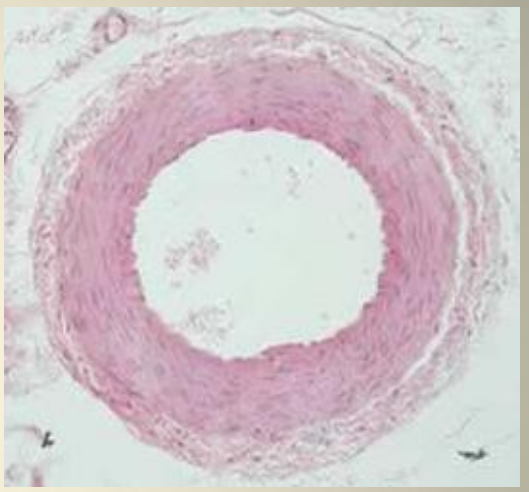
	Saturated	Unsaturated
Structure	Single bonds	Double bonds kink
State at room temperature	Solid	liquid
Origin	Animals	Plants
Examples	Butter, lard	Olive oil, essential fatty acids (omega 3/6 fish oil)

Hydrogenated Oil

- Unsaturated fats that were synthetically converted to saturated fats by adding hydrogen
- E.g. margarine

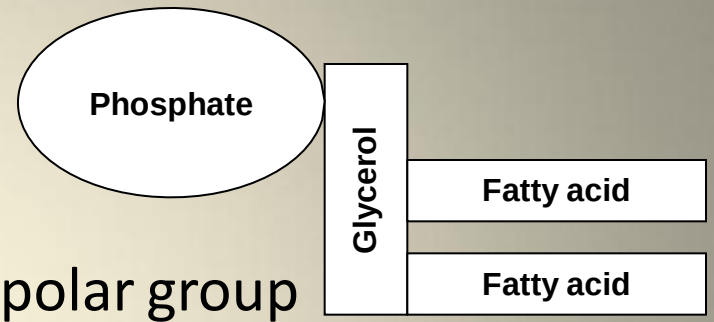
Atherosclerosis

- Cardiovascular disease
- Deposits of plaques form on inner lining of blood vessels
- Blocks blood flow
- Reduces elasticity of vessels

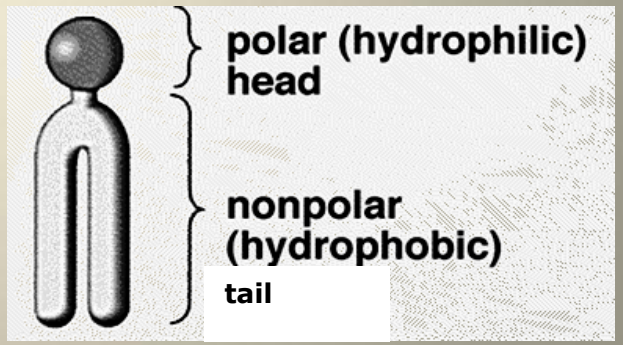


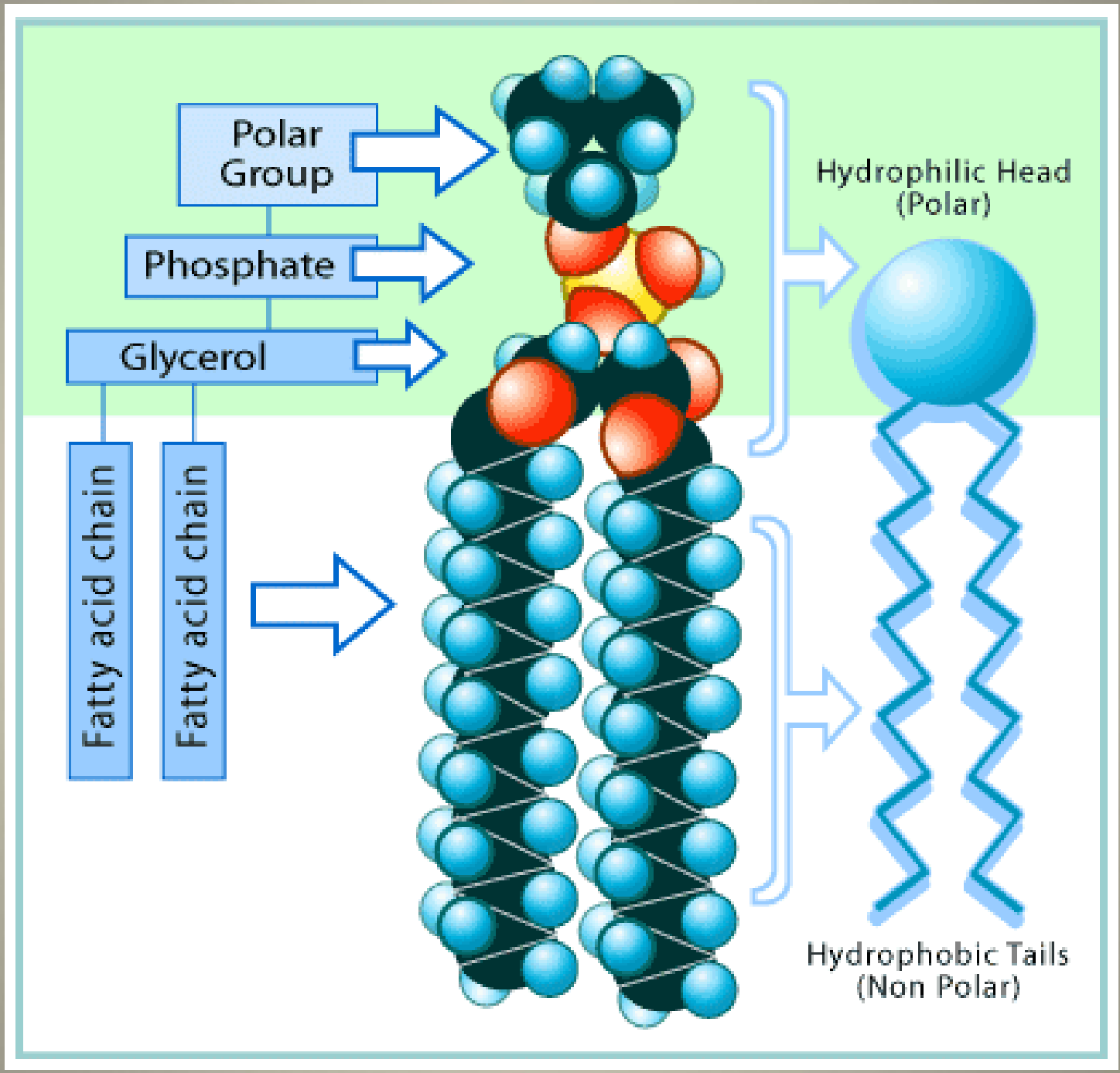
Triacylglycerol model

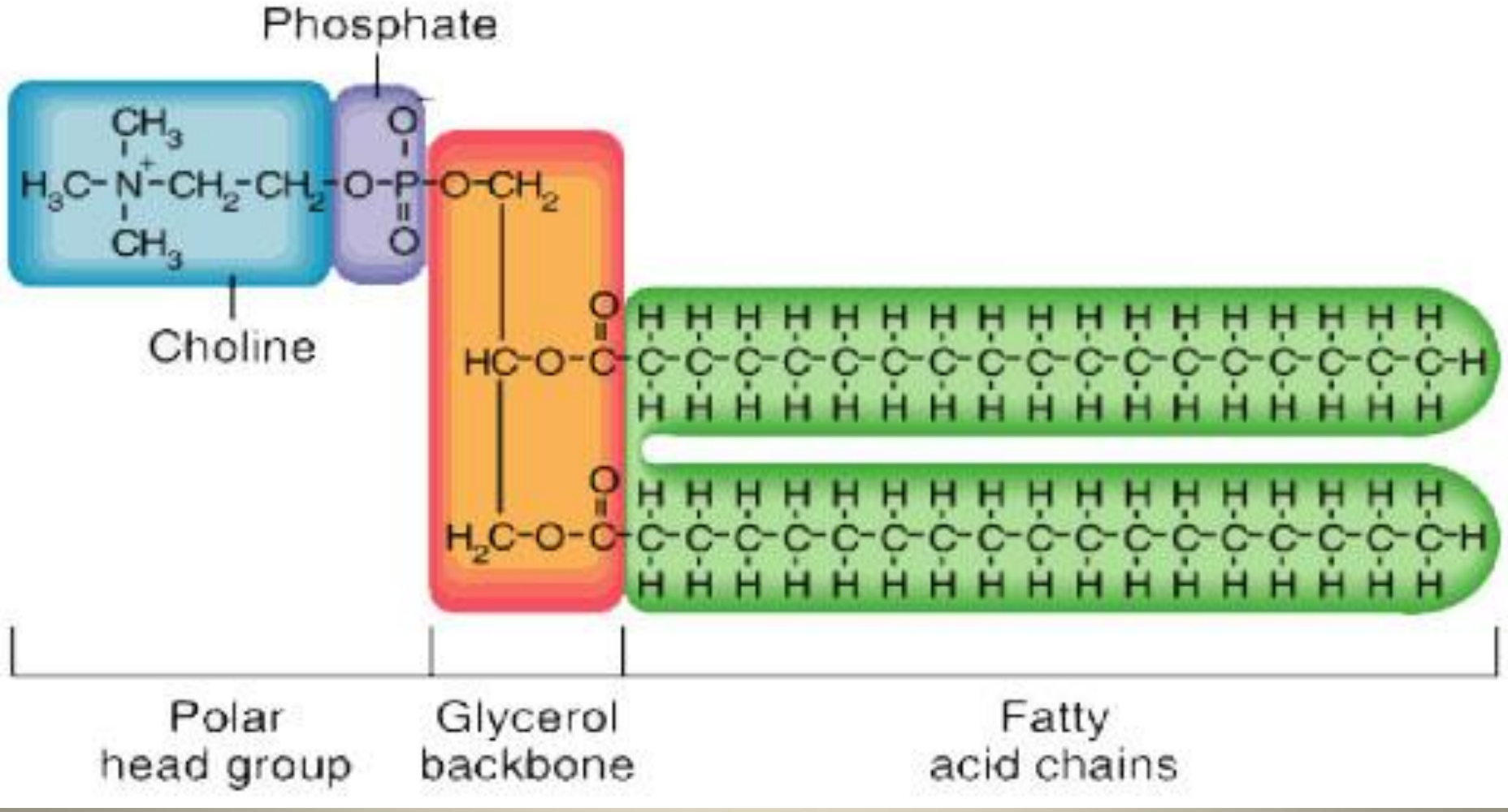
2. Phospholipid structure



- Glycerol + 2 fatty acids + phosphate/polar group
- Polar head: negatively charged, hydrophilic
- Nonpolar tails: fatty acids, hydrophobic
- Amphipathic: exhibiting both hydrophilic and hydrophobic properties

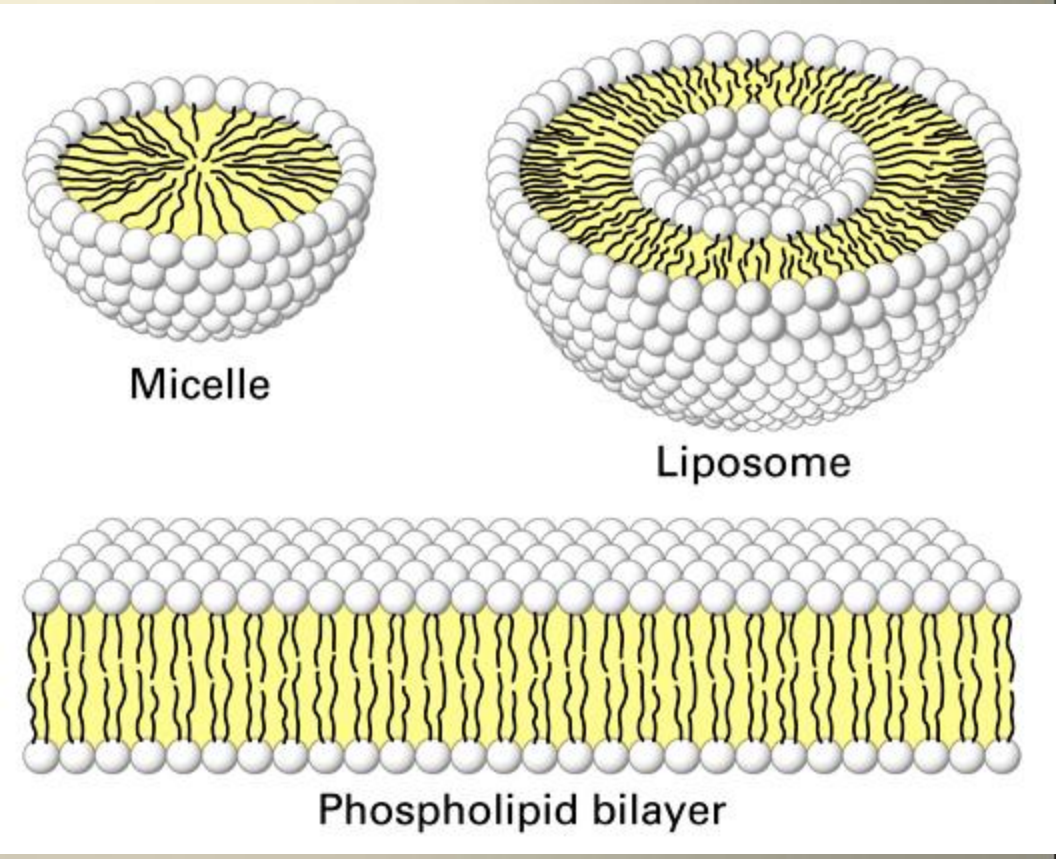



Polar Group
Phosphate
Glycerol
Fatty acid chain
Fatty acid chain
Hydrophilic Head (Polar)
Hydrophobic Tails (Non Polar)


Phosphate
Choline
Polar
head group
Glycerol
backbone
Fatty
acid chains

Self-assembly of phospholipid

- Condition: in water (aqueous)
- Self-assembly = spontaneous aggregate
- Micelle: single layer of phospholipid with polar head facing out, nonpolar tails facing inward
- Phospholipid bilayer

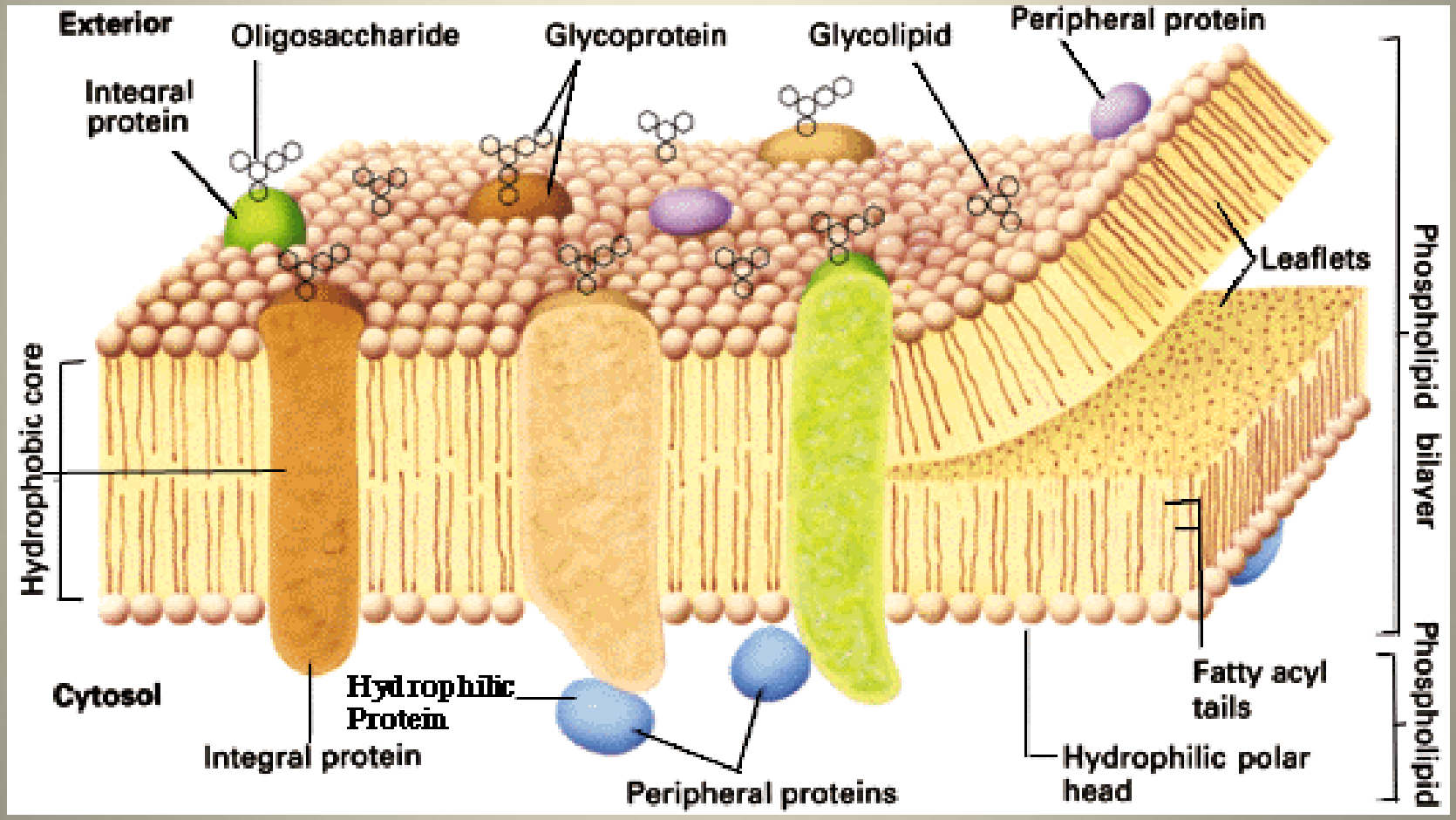


http://www.bio.miami.edu/~cmallery/255/255chem/mcb2.20.micelle.jpg

- Phospholipid bilayer have a double layer of phospholipids where the non-polar tails aggregate forming a hydrophobic core
- This is the basic structure of the plasma membrane

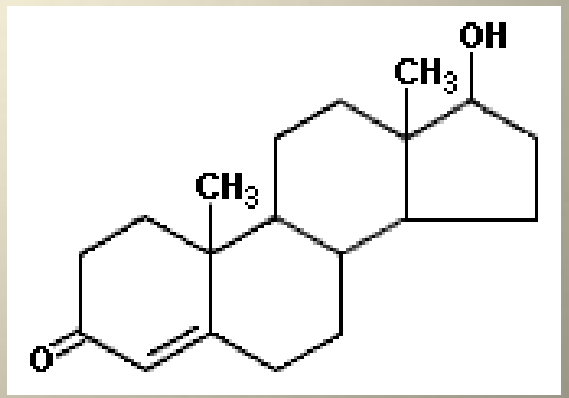
Phospholipid Bilayer

- Membranes are made of a bilayer of phospholipids.



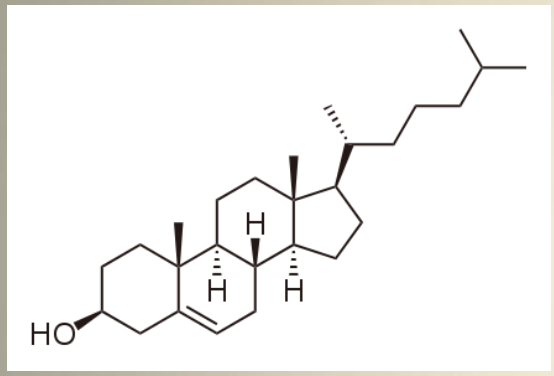
3. Steroid

- Carbon skeleton, 4 fused rings
- Three 6C rings, one 5C ring
- E.g. cholesterol – high levels may contribute to atherosclerosis.
- E.g. hormones – estrogen, testosterone

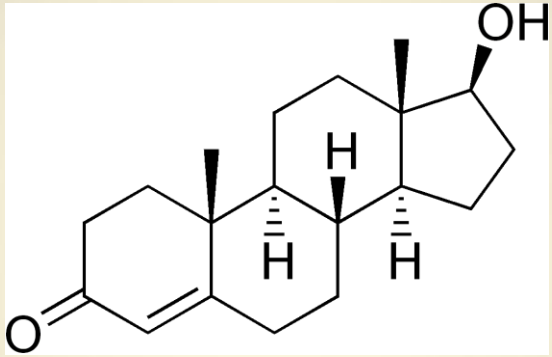


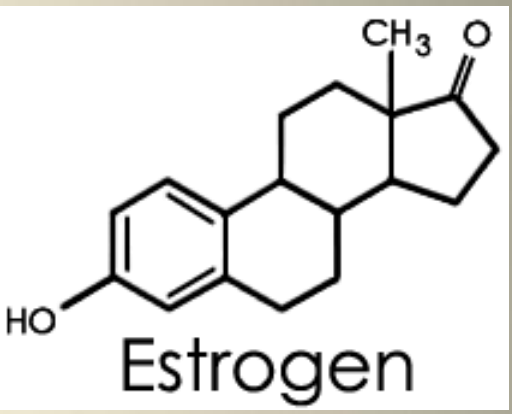
Steroid

Cholesterol

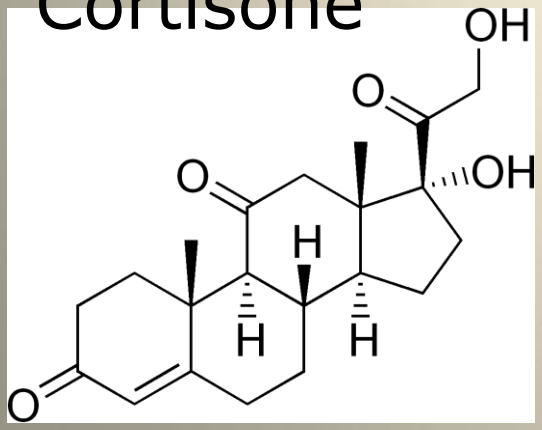


Testosterone

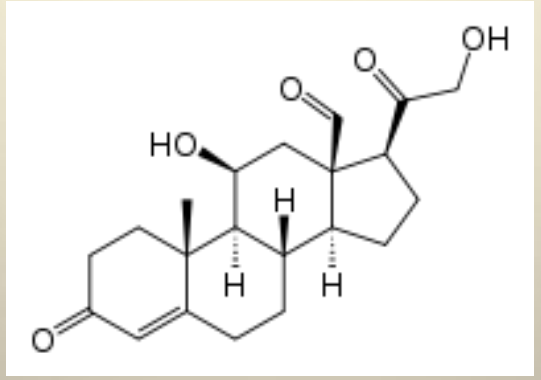


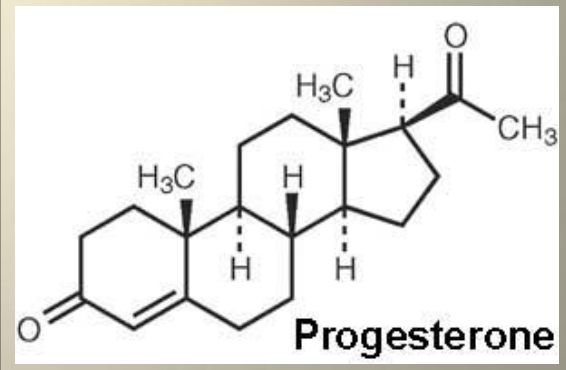


Cortisone



Aldoesterone

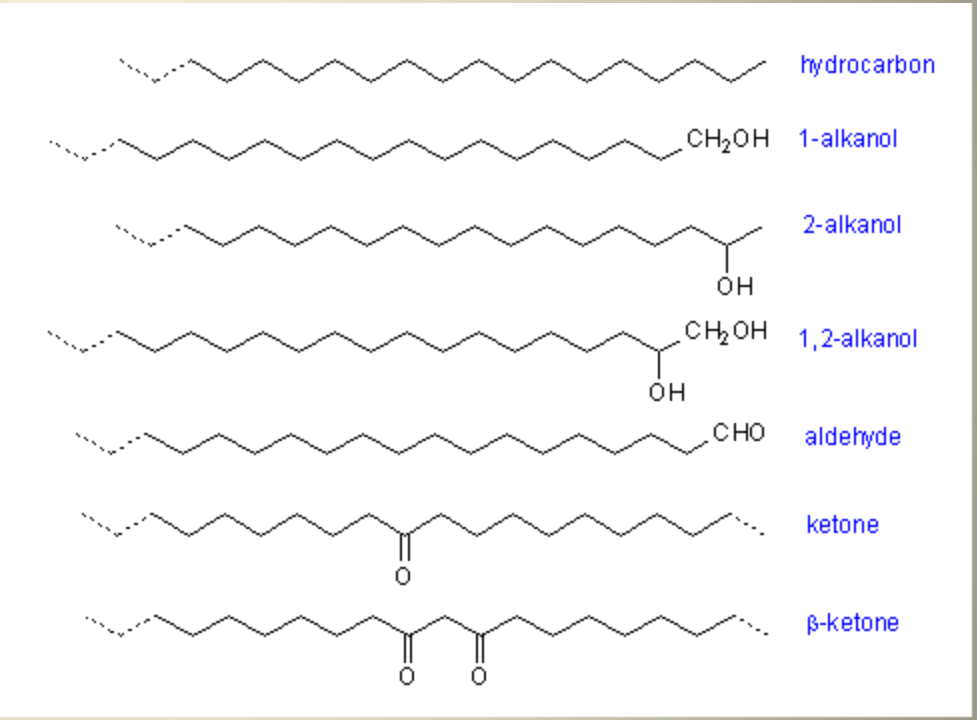


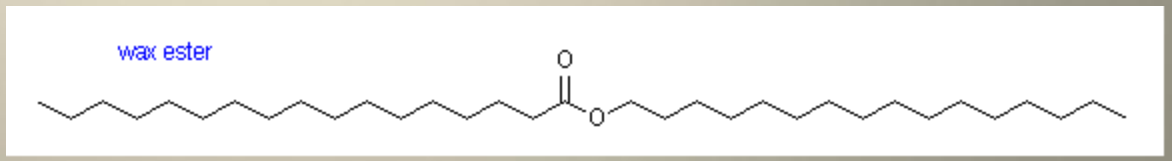


4. Wax Structure

Long chain hydrocarbons

- Primarily wax esters: a long chain hydrocarbon with an ester group that is not a triglyceride
- Could also involve alcohol, aldehyde & ketone groups





http://www.lipidlibrary.co.uk/Lipids/waxes/index.htm

Properties of Wax

- Solid at room temperature
- Becomes liquid when melted
- has **plastic** properties: deforms under pressure without application of heat
- **thermoplastic** is a polymer that turns to a liquid when heated and freezes to a very glassy state when cooled sufficiently

Examples

Natural

- Animal wax: beeswax, lanolin, shellac
- Vegetable waxes: soy, jojoba, carnauba
- Mineral waxes: petroleum (paraffin) from fossil fuels

Synthetic

- Polypropylene, Polyethylene

5. Carotenoids

- Natural fat-soluble pigment
- Backbone: 40 carbon polyethylene chain with alternating single and double bonds
- terminated by cyclic end-groups

Carotenoid: Plant Pigment

- Found in plants, algae, photosynthetic bacteria
- Pigment needed for photosynthesis

e.g. beta-carotene in carrot

Carotenoid: use in animals

- Detecting light: e.g. retinal absorbs light in retina
- Serves as antioxidant: double bonds absorb excess energy from other molecules, protecting cells and tissues from damaging effects of free radicals
- Source for vitamin A

What is common to all lipids?

- The 5 forms of lipids studied are not built upon any common monomer. What unified these lipids so that they are all classified under the ‘lipid’ category?
- In other words, what makes a lipid, a lipid?