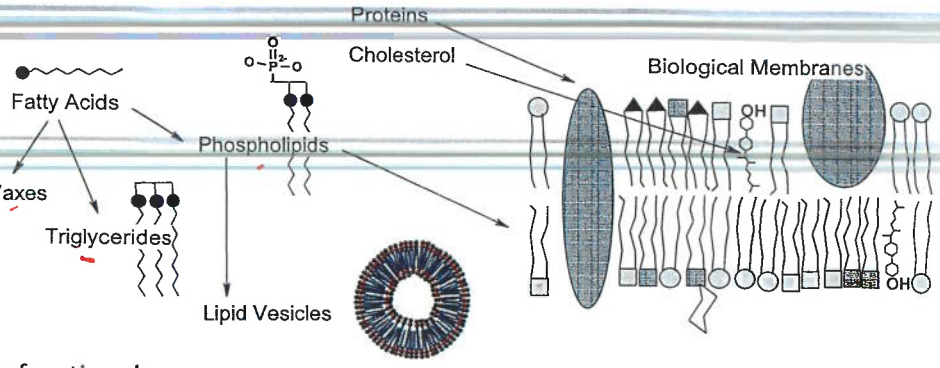
Lecture 25: Lipids



A diverse group of molecules that are generally insoluble in water.

- Mostly hydrocarbon with a small number of polar functional groups.
- Self-assembly of larger structures without the formation of covalent bonds.

Goals:

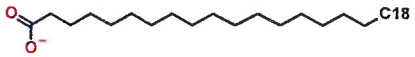
- Recognize chemical structure of fatty acids, waxes, triglycerides, phospholipids.
- Use correct nomenclature for fatty acids.
- Predict CMC of fatty acids from chemical structure.
- Structure and nomenclature of phospholipids.
- Understand the role of the hydrophobic effect in assembly of membranes
- Predict permeability properties of compounds through membranes.
- Predict osmotic effects, given internal and external salt concentrations.

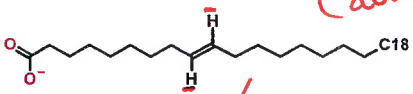
A. Fatty Acids:

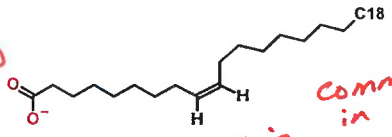
Structure:

Nomenclature for fatty acids:

# Carbons	Name
12	Lauric acid
14	Myristic acid
16	Palmitic acid
18	**Stearic acid**
20	Arachidic acid
18:1 cΔ9 ($C_9 = C_{10}$)	**Oleic**



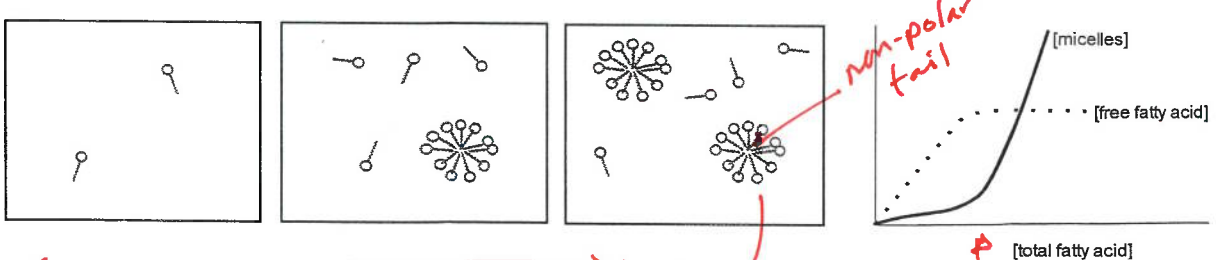




When fatty acids are part of larger molecules, they are named by their root name + oyl, e.g. lauroyl. Root name is name minus "ic", e.g. lauric minus "ic" = laur.

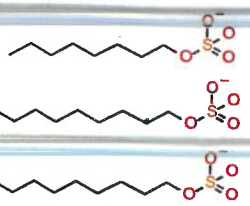
Interaction with water

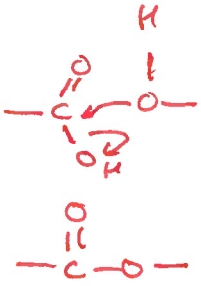
1. Fatty acid, as well as similar molecules, form **micelles**, aggregates of fatty acids with a polar (charged) surface and a hydrophobic, waterless, interior. The assembly of micelles is spontaneous and driven by the hydrophobic effect. Thermodynamics of formation: $\Delta G^0 \approx -T\Delta S^0$ (i.e. $\Delta H^0 \approx 0$)
2. The CMC (critical micelle concentration) is the highest concentration of *monomeric* fatty acids in solution.
3. The non-polar interior can dissolve hydrophobic compounds (oily 'dirt'), therefore, fatty acids and modified fatty acids (*e.g.* SDS) are the principal components of soaps.



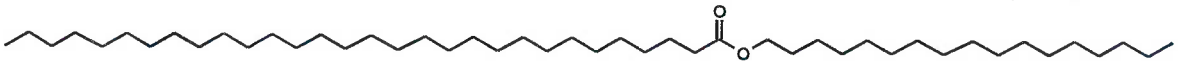
Detergent	CMC (mM)
$CH_3(CH_2)_7\text{-}OSO_3^-$ (C8)	100 mM
$CH_3(CH_2)_9\text{-}OSO_3^-$ (C10)	33 mM
$CH_3(CH_2)_{13}\text{-}OSO_3^-$ (C14)	10 mM

What do you expect for the order of CMC for the above?



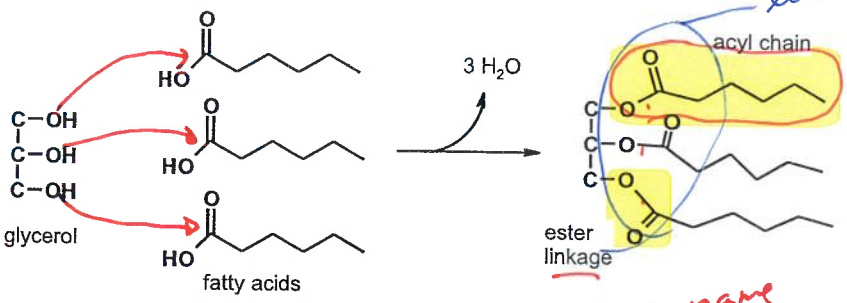


B. Waxes: Ester of a fatty acids and an alcohol, e.g. beeswax: $CH_3(CH_2)_{29}O\text{-}CO\text{-}(CH_2)_{14}CH_3$



C. Triglycerides (e.g. vegetable oils)

energy storage



Nomenclature:
If the fatty acid is the same, usually called tri *root*-oyl glycerol, e.g. tri-ole-oyl-glycerol.

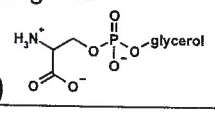
root name

3 same

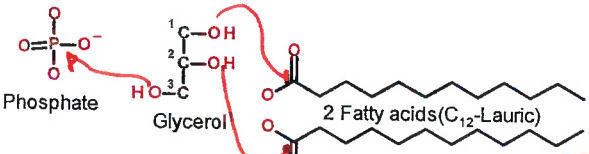
Triglycerides & water: Phase separation due to lower polarity of ester linkages versus carboxylic acid group on fatty acids – oil and water don't mix.

D. Phospholipids - Glycerophospholipids:

1. Head group + phosphate + glycerol + two fatty acids (**acyl chains**) of *various* types form a phospholipid.
2. Various **head groups** are attached to the phosphate, giving a diverse set of lipids.

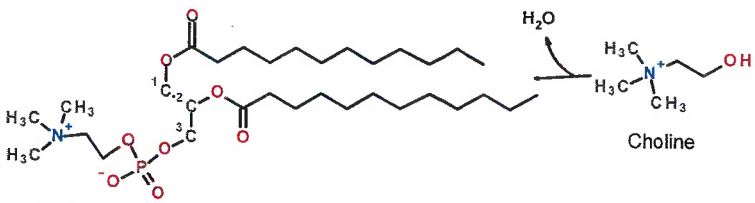
Head group(-X)	Name of Phospholipid	Net Charge
none	phosphatidic acid (PA)	-1
Choline (-C-C-$N^+(CH_3)_3$)	Phosphatidylcholine (PC), called lecithin	0 (zwitterion)
Serine (linkage via  sidechain)	Phosphatidylserine (PS)	-1

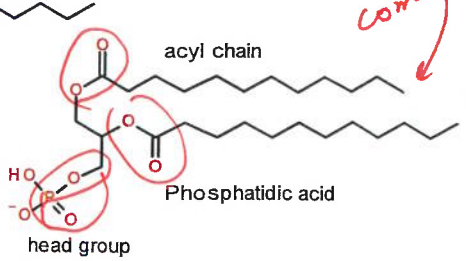
know these



1-lauroyl -2-lauroyl-3-phosphatidyl*choline*

(dilauroyl phosphatidyl choline, DLPC)





any combination

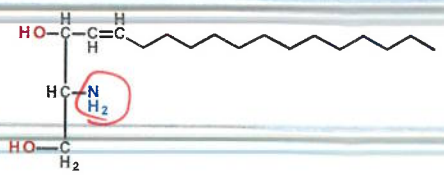
know -

Nomenclature: Fatty acid on 1st carbon of glycerol (*root*+oyl), Fatty acid on 2nd carbon of glycerol (*root*+oyl), Phosphatidyl + Headgroup.

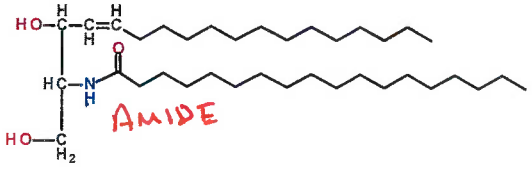
E. Sphingolipids:

Sphingosine:
(2-amino-4-trans-octadecene-1,3-diol)

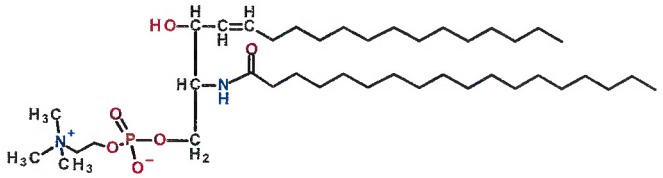
Know



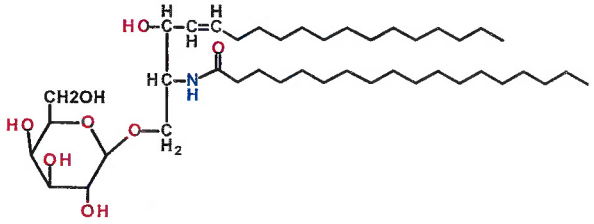
Ceramide = sphingosine + fatty acid (amide)



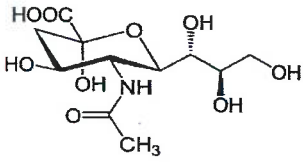
* * * Sphingomyelin = Sphingosine + fatty acid + phosphocholine



Cerebroside = sphingosine + fatty acid + sugar (glucose or galactose)



Gangliosides = sphingosine + fatty acid + multiple sugars (one is sialic acid, shown on right).



Physical Properties of Pure Lipid Bilayers:

1. Phospholipids self-assemble in water to form **bilayers** (two opposing layers of phospholipids). Bilayers are formed instead of micelles because the cross section of the head group is roughly equal to the cross section of the 2 fatty acid chains found in phospholipids.
2. In the case of liposomes, the bilayers form closed, water filled, vesicles with a 40-50 Å thick wall. The non-polar acyl chain width is about 30 Å. These can be used to carry polar drugs (in their center) or non-polar drugs (dissolved in the membrane).