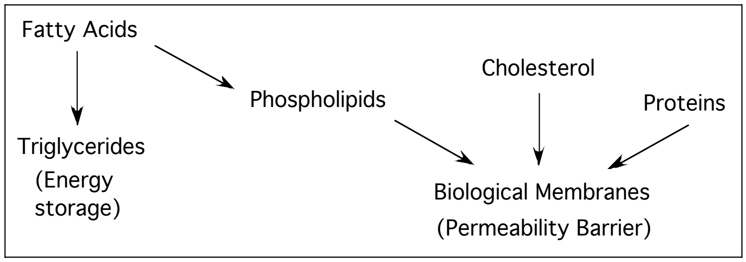
Lecture 23: Biological Membranes
Assigned reading in Campbell:
Chapter 8.3-8.6
Key Terms:

- **Phospholipids (PC, PS, PE, PI and PA)**
- **Peripheral & Integral membrane Proteins**
- **Membrane Fluidity**
- **Functions of Biological Membranes**



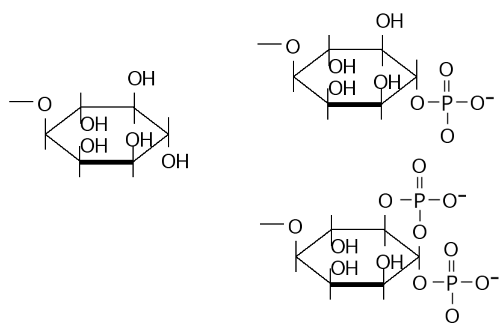
1. Phospholipids

A. Structure & Nomenclature

- Two fatty acids + glycerol + phosphate + a head group form a phospholipid.
- Various **head groups** are attached to the phosphate, giving a diverse set of lipids

Know the structure of either PC or PS as an example.

Head group(-X)	Name of Phospholipid	Net Charge
none	phosphatidic acid (PA)	-1
choline (-C-C-$N^+(CH_3)_3$)	Phosphatidylcholine (PC)	0 (zwitterion)
Serine (linkage via sidechain)	Phosphatidylserine (PS)	-1
ethanolamine (-C-C-NH_3^+)	Phosphatidyl-ethanolamine (PE)	0 (zwitterion)
inositol ($C_6H_6O_5$)	Phosphatidylinositol (PI)	-1



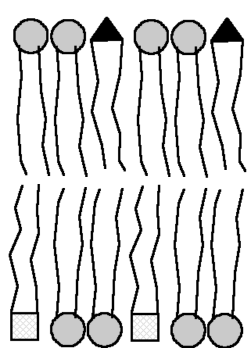
2. Membrane Proteins

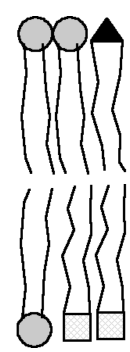
Peripheral Membrane Proteins:

- Loosely attached to membranes via electrostatic interactions – released with high salt.

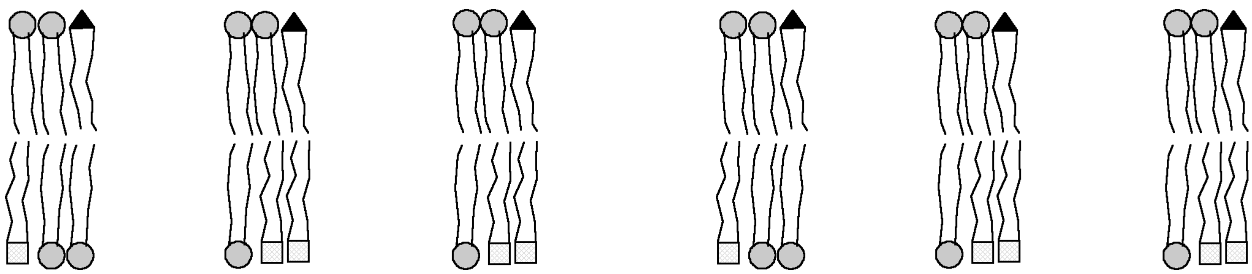
Integral Membrane Proteins:

- Largely contained within the membrane (solubilization requires disruption of the membrane by detergents).
- Often span the entire membrane.
- Stability energetics are similar to water soluble proteins, except that non-polar groups interact with acyl chains in the membrane. The rule here is: "hydrophobic outside - hydrophilic **or** hydrophobic inside", thereby matching the location.
- Asymmetry across the bilayer
  is required for most functions (both lipid and protein). No flip-flop!





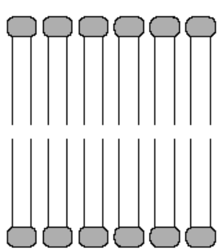
- Transport (*e.g.* of protons, metabolites, electrons)
  - ❖ Passive transport (no energy required, molecules go from high concentration to low)
  - ❖ Active transport (energy required, molecules are pushed from low to high concentration)

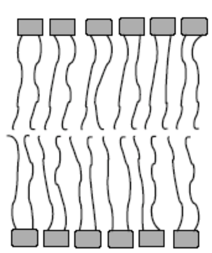


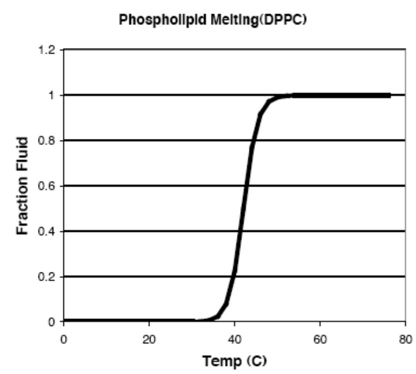
3. Cholesterol enhances membrane fluidity:

Lipid bilayers undergo a *highly cooperative* phase transition with a defined T_m:

- Below T_m the the acyl chains are tightly packed and the lipids exist as a solid-like *gel*; .
- Above T_m the acyl chains are disordered and the lipids are in a liquid-like *liquid crystal phase*.
- Rapid lateral diffusion of lipids and proteins occurs in the plane of the membranes above but not below $T_{m.}$



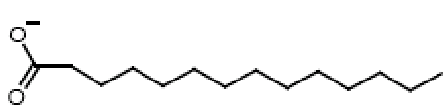


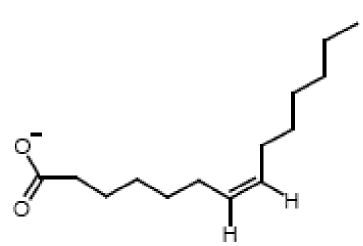


❖ Membrane fluidity is essential for the biological function of membranes. Therefore organisms go to great lengths to maintain a fluid membrane bilayer (eg, bacteria regulate acyl chain length).

❖ Lipid bilayers can be made more fluid (higher T_m) *either* by decreasing fatty acyl chain length *and/or* increasing the degree of unsaturation. (Chain length and the presence of cis-double bonds can greatly affect T_m and fluidity through affecting the extent of van der Waals packing)

DMPC (C_{14}) = 23 C
DPPC (C_{16}) = 41 C
DSPC (C_{18}) = 58 C
DOPC ($C_{18:1}$) = -22

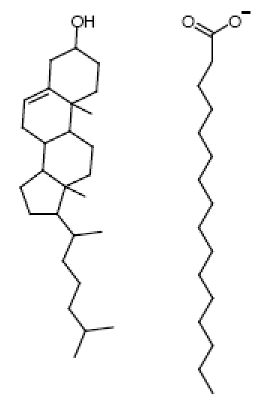


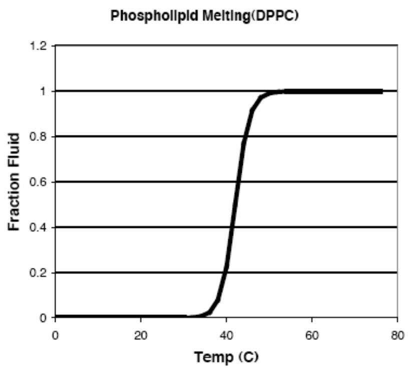


❖ But simply increasing the degree of unsaturation can compromise the integrity of the cell membrane. Animals cells have another way of increasing membrane fluidity:

Cholesterol:

- Is a natural steroid, you produce about 1 g/day!
- About the same length as a C_{16} fatty acid; therefore it reaches across *half* of the bilayer.
- *Essential* component of most mammalian membranes (~20% of cell membrane lipid)
- Destroys the phase transition of pure lipid membranes, thereby keeping the membranes fluid below the phase transition and more rigid above the phase transition. Often referred to as a membrane plasticizer.





Fluid mosaic model of Biological Membranes

- Lipids, membrane proteins, glycolipids, etc… float in a 2-D fluid membrane.
- Rapid lateral diffusion of components (~1 μm/sec!).
- Different types of lipids – composition varies (type & acyl chain) by organism, tissue type, and temperature.
- The membrane completely encloses the cell (or intracellular organelle) and therefore *defines cellular topology* (*i.e.* an inside and an outside).
  * Transport of molecules and ions occurs across membranes.
  * Generation of a concentration difference across the membrane can be used to produce energy.
  * Signal transduction occurs across the membrane.