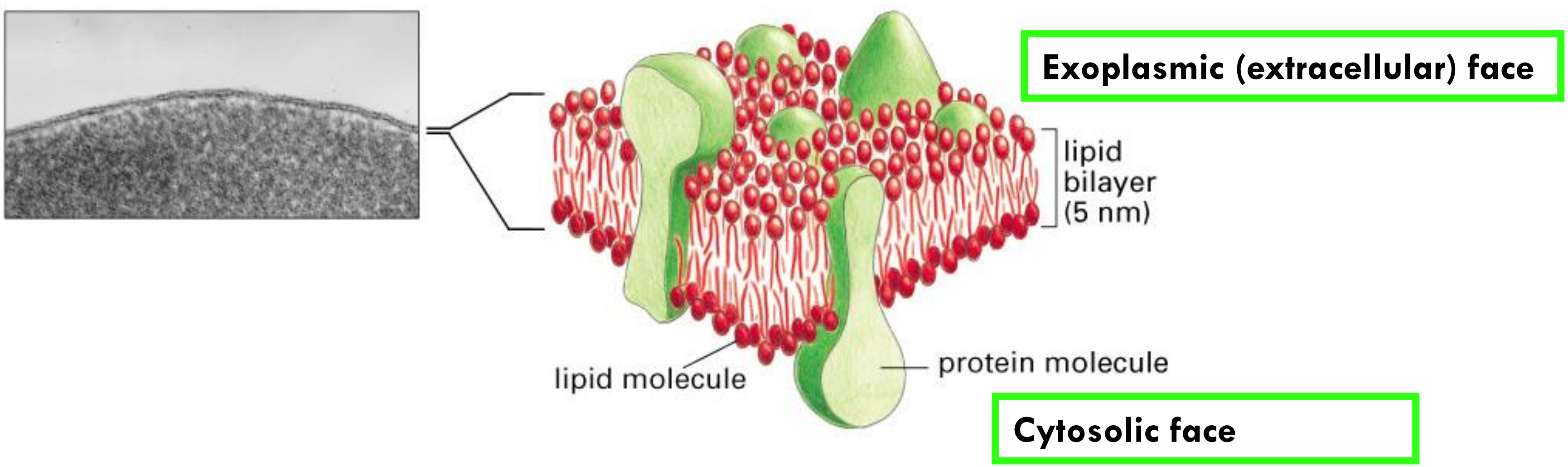
# Cell Membranes: Lipids (Ch 10)

Fluid mosaic model of biomembrane

- lipid bilayer (5 nm) with proteins
- Fluid--sea of lipids
- Mosaic--proteins floating around
- Biomembrane is composed of lipids, proteins, and carbohydrates



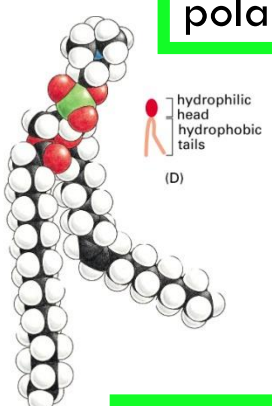

http://multimedia.mcb.harvard.edu/anim_innerlife.html

# Lipids

## Lipids are amphipathic

- A lipid has a hydrophilic polar head and 2 hydrophobic tails.
- It is amphipathic, meaning that it has dual solubility
- Heads like water and Tails don’t.
- Usually, one tail has 1-3 cis-double bond (s) (unsaturated)

polar head




2 hydrophobic tails

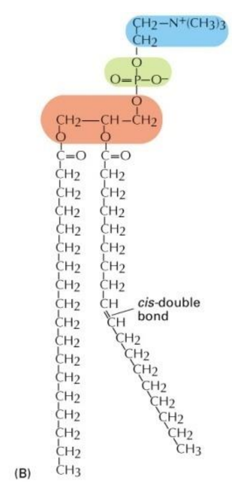



Figure 10–2 part 2 of 3. Molecular Biology

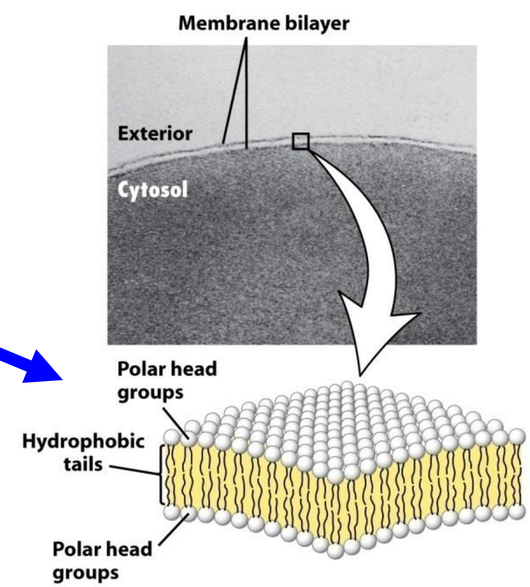



Figure 10-6ab
*Molecular Cell Biology, Sixth Edition*

# Biomembranes

Biomembranes of a typical cell contains 500-1000 different lipid species.

- Amphipathic/composition of lipids - barrier, compartmentalize, budding, fission, fusion, aggregate, disperse, fluid, gel-like
- used in signaling - PI, DAG, sphingosine, ceramide
- lipid for energy storage - triacylglycerol & steryl esters

Fortunately, they can be put into three principal classes of lipids: Phosphoglycerides, Sphingolipids and Sterols.

**Table 10–1 Approximate Lipid Compositions of Different Cell Membranes**

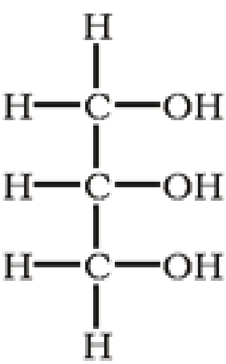
| | PERCENTAGE OF TOTAL LIPID BY WEIGHT | | | | | |
|---|---|---|---|---|---|---|
| LIPID | LIVER CELL PLASMA MEMBRANE | RED BLOOD CELL PLASMA MEMBRANE | MYELIN | MITOCHONDRION (INNER AND OUTER MEMBRANES) | ENDOPLASMIC RETICULUM | *E. COLI* BACTERIUM |
| Cholesterol | 17 | 23 | 22 | 3 | 6 | 0 |
| Phosphatidylethanolamine | 7 | 18 | 15 | 28 | 17 | 70 |
| Phosphatidylserine | 4 | 7 | 9 | 2 | 5 | trace |
| Phosphatidylcholine | 24 | 17 | 10 | 44 | 40 | 0 |
| Sphingomyelin | 19 | 18 | 8 | 0 | 5 | 0 |
| Glycolipids | 7 | 3 | 28 | trace | trace | 0 |
| Others | 22 | 13 | 8 | 23 | 27 | 30 |

Table 10.1

# Phosphoglycerides

## Phosphoglycerides: the predominant lipid in animal membranes

- Polar head: Phosphorylated alcohol or amino acid attached to a hydroxyl group of the glycerol.
- Hydrophobic tails: Hydrocarbon tails  with 14-24 carbons, one saturated and one unsaturated (1-3 double bonds) linked to the hydroxyl groups of the glycerol by two ester linkages.



glycerol

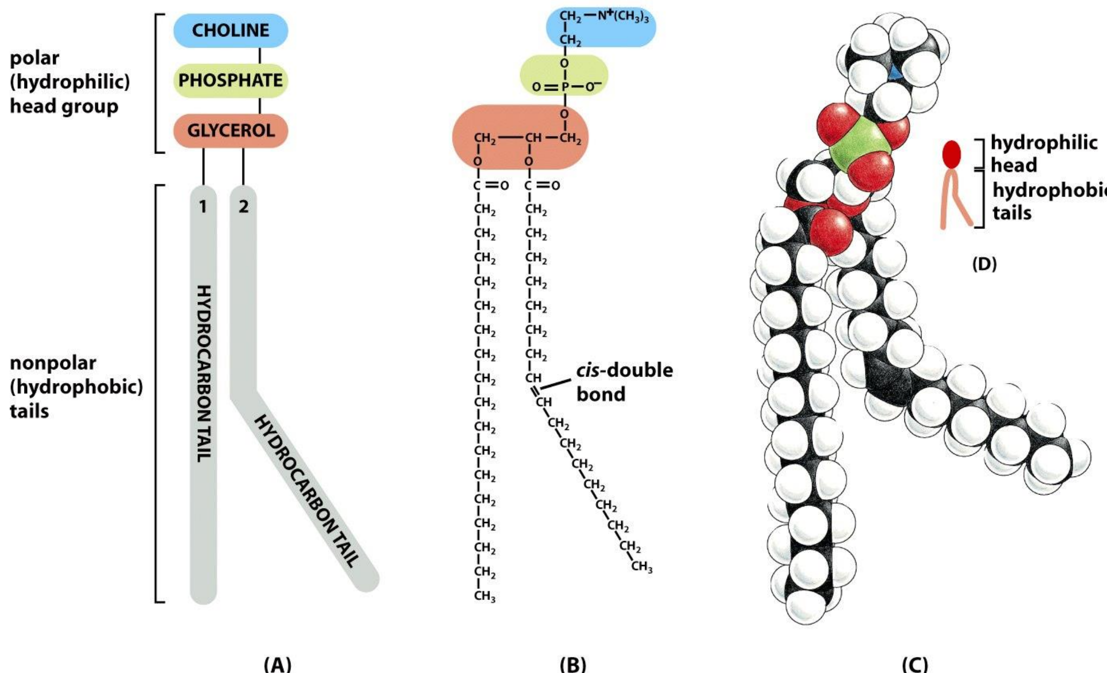
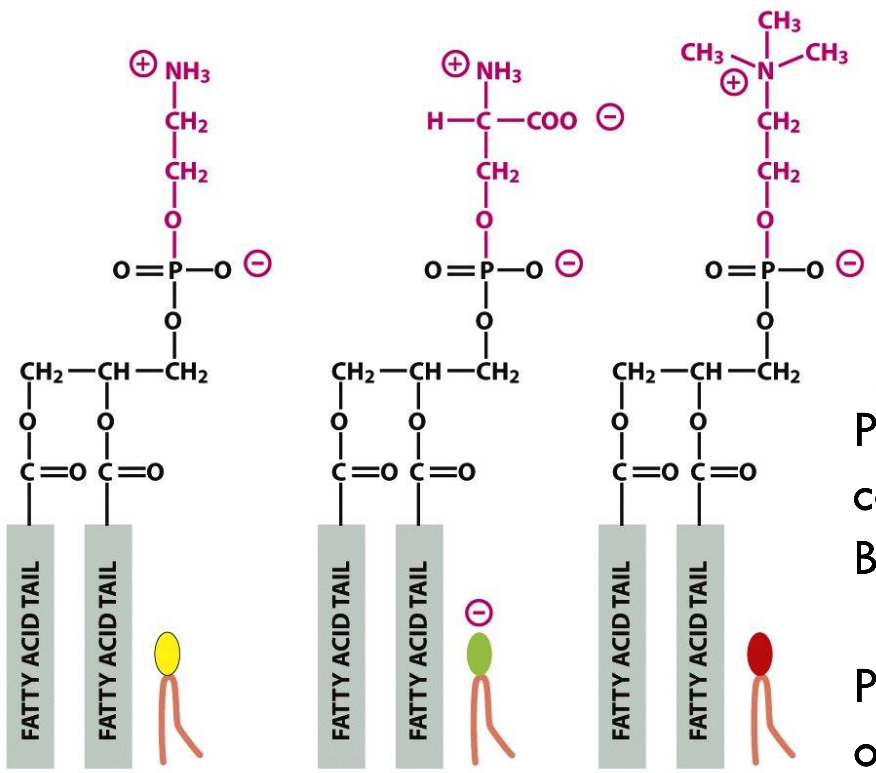



Figure 10-2 *Molecular Biology of the Cell* (© Garland Science 2008)

# Major Phosphoglycerides




**phosphatidyl-ethanolamine (A)** PE

**phosphatidyl-serine (B)** PS

**phosphatidyl-choline (C)** PC

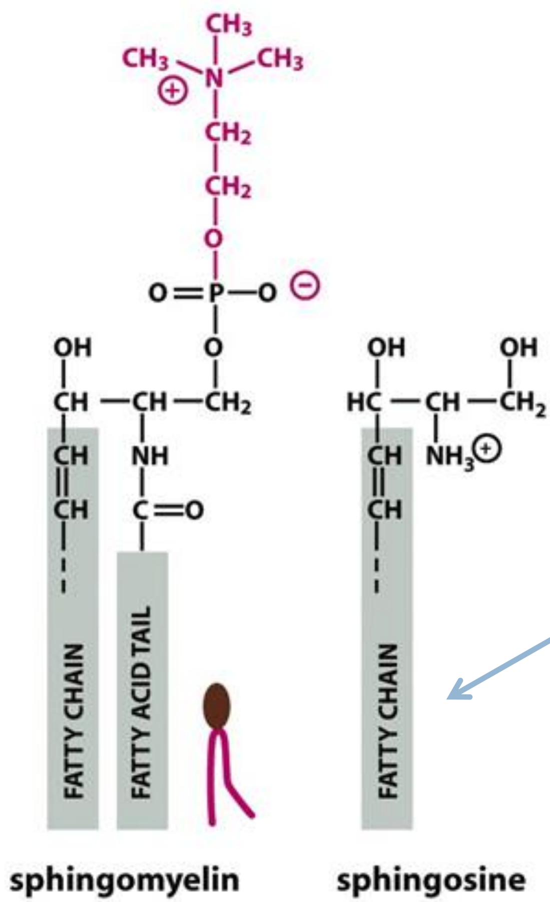
PS: Usually cytosolic face in healthy cells. Also negatively charged. Becomes exoplasmic when cells die.

PE: Found in all membranes but mostly on cytosolic face

PC: Common on extracellular face.

Figure 10-2 *Molecular Biology of the Cell* (© Garland Science 2008)

# Sphingolipids:




Serine

15 carbon unsaturated hydrocarbon tail

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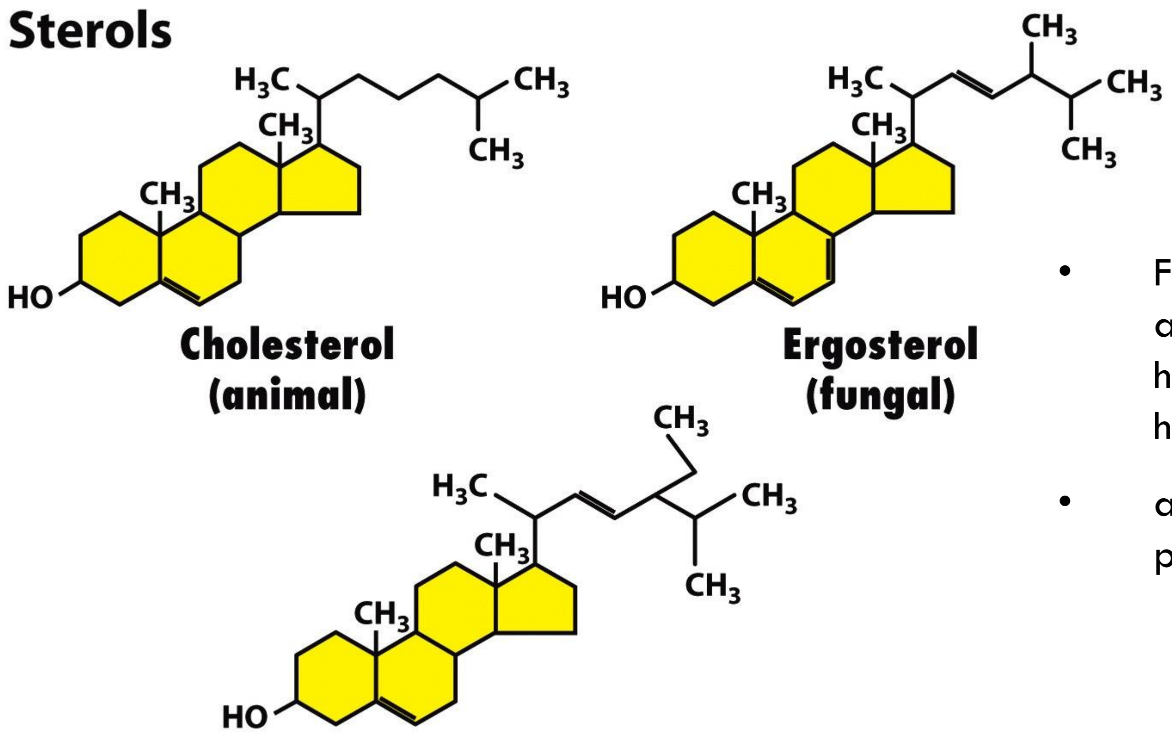
# Sterols




- Four-ring hydrocarbon (rigid and planar) and a short hydrocarbon chain form the hydrophobic tail
- a single OH group form a polar head

- Cholesterol is essential for animal cells.  Mutant cells that are unable to synthesize cholesterol lyse and die.
- None found in bacteria or low level in mitochondria.

Figure 10-5c
*Molecular Cell Biolo*

# Lipids and Proteins

- Spontaneous formation (Non-covalent assembly) of lipids and proteins
- Mix lipids with water in the container, artificial membrane bilayers assemble spontaneously
- Thermodynamically stable = no energy necessary
- Because lipids are amphipathic, polar heads toward water and hydrophobic tails bind tails

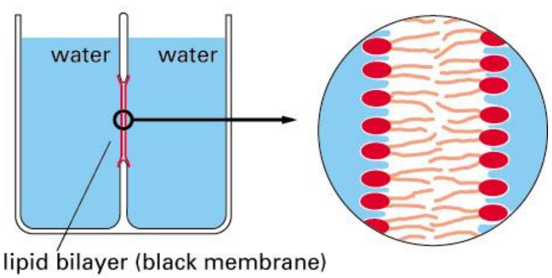
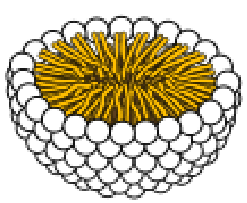
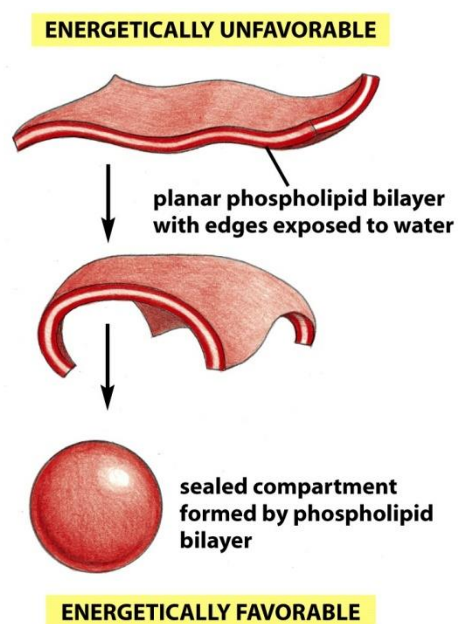
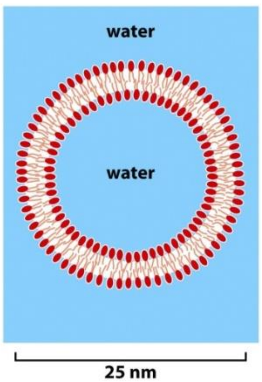



Figure 10–7. Molecular Biology of the Cell, 4th Edition.

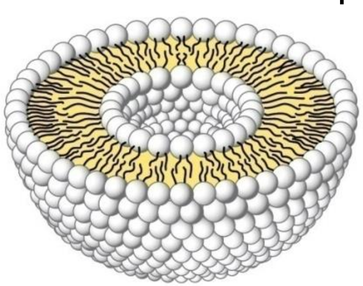


Micelle



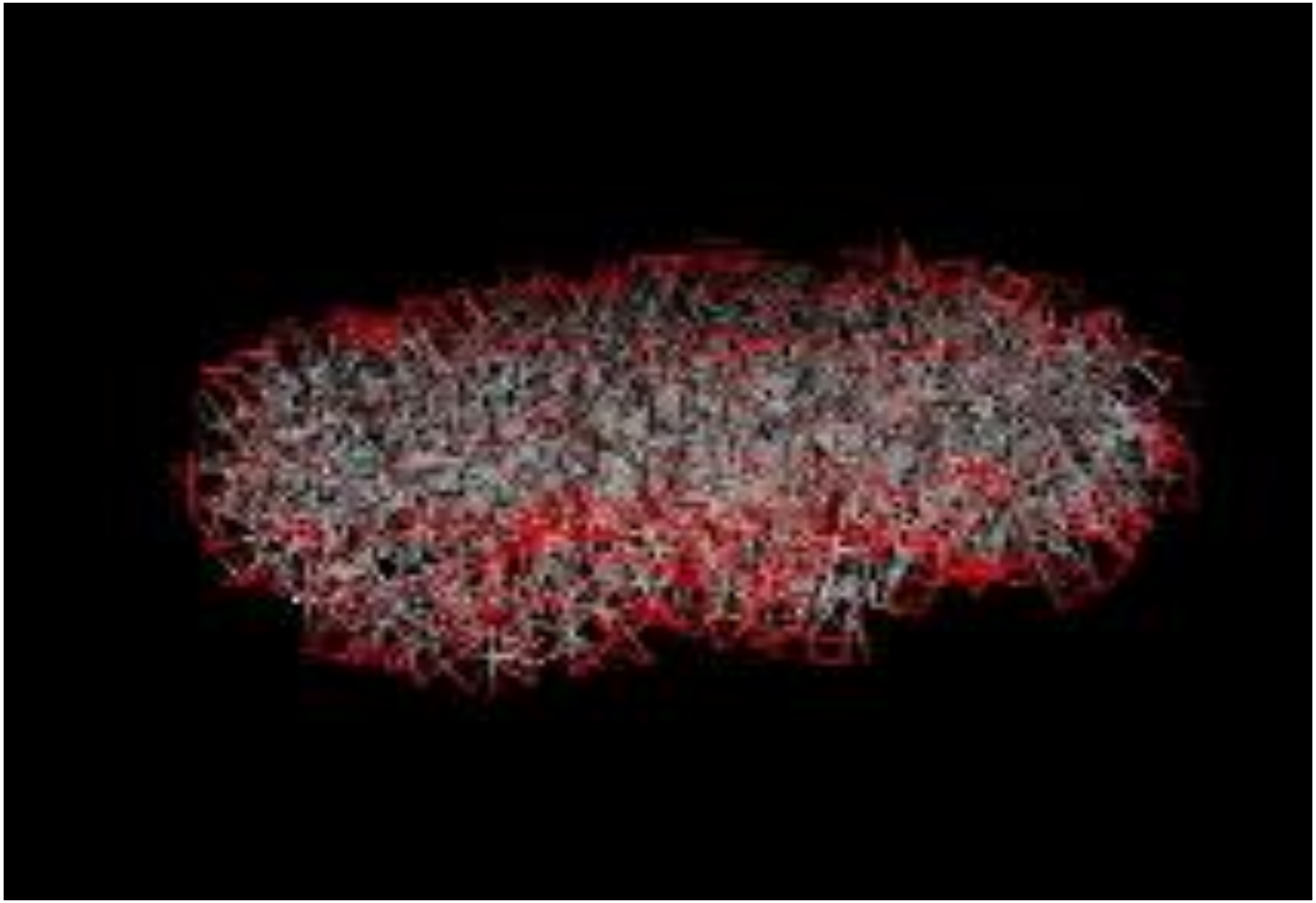




Liposomes can deliver drugs, DNA, etc to cells



**Liposome**

# Simple Principles Govern Lipid Organization



SoftSimu: www.softsimu.org
http://www.apmaths.uwo.ca/~mkarttu/dpd.shtml

# Biomembranes

- Biomembranes are dynamic fluids
- Membrane can expand (grow, fuse), shrink (fragment), change composition, change shape, change fluidity, etc.
- 4 types of lipid movement
  - Lateral diffusion of lipids: 2 micron per second
  - Rotation
  - Flexing
  - Flip-flop, needs phospholipid translocator enzymes (scramblase or flippase). Rarely occurs without enzymes.

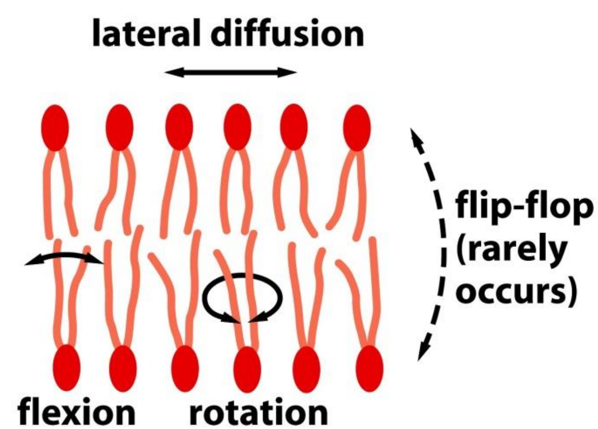
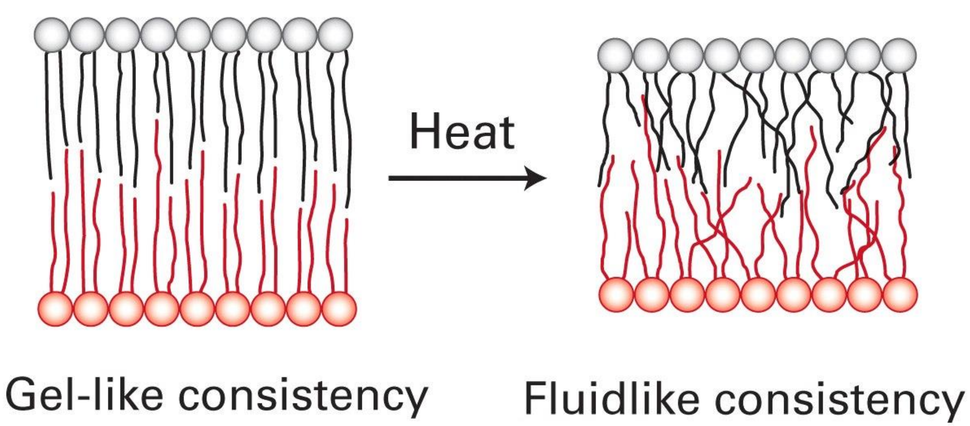



Figure 10-11b *Molecular Biology of the Cell* (© Garland Science 2008)

# Mebrane Fluidity is regulated by temperature

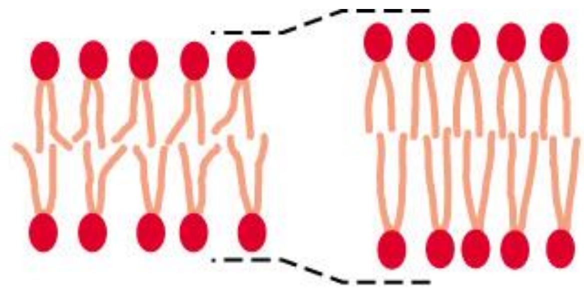
- Temperature can change membrane fluidity
  - Low temperature: gel-like
  - High temperature: fluid-like
- Phase transition temperature (Tm): temp at which half of the membrane is in the gel phase or half of the membrane is in the fluid phase.



# Fluidity of a Lipid Bilayer

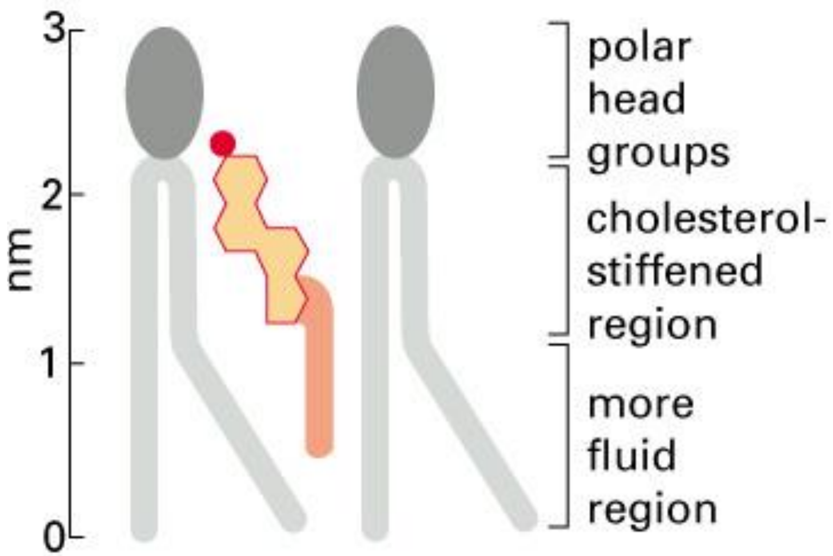
Fluidity of a lipid bilayer partly depends on double bonds in the hydrocarbon chain and the length of the hydrocarbon chains

- Disordered region of lipid bilayer
- Unsaturated hydrocarbon chains - more fluid-like
- Thinner
- Shorter the hydrocarbon tail, more fluid-likeOrdered region of lipid bilayer
- Saturated hydrocarbon chains - less fluid-like
- Thicker
- Longer the hydrocarbon tail, less fluid-like



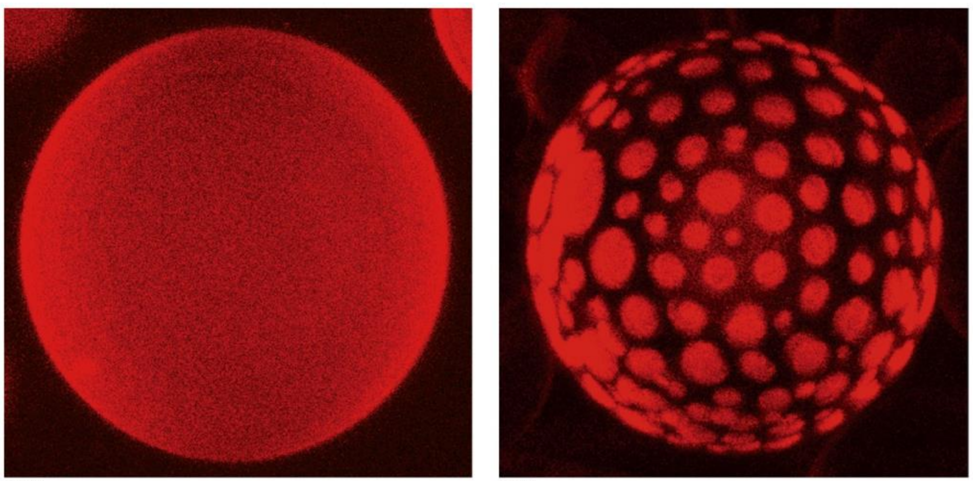
# Cholesterol

- Cholesterol regulates membrane fluidity; Cholesterol has a dual role
- Insertion of cholesterol into a membrane makes it less permeable and less fluid by filling spaces created by unsaturated lipids
- The rigid sterol rings inhibits close packing of lipids, thereby inhibiting gel formation. This shifts the phase transition temperature lower.



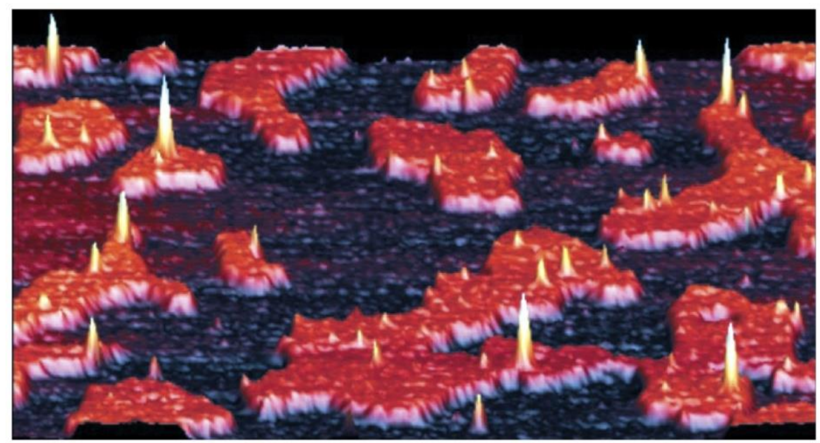
# Lipid Bilayers

- Lipid bilayers can form microdomains of different lipid composition -lipid phase boundary (behavior)



(A) 10 μm
1:1::PC:SM

(B) 5 μm
1:1:1::PC:SM:C



Lipid rafts

500 nm

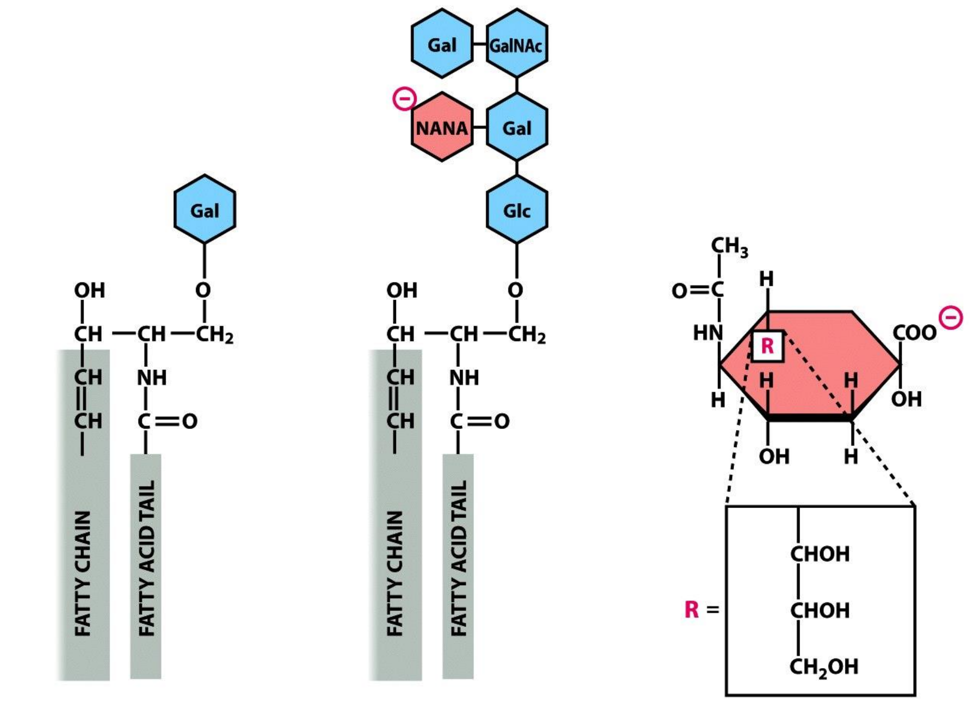
Figure 10-13, Figure 10-14 *Molecular Biology of the Cell* (© Garland Science 2008)

# Membrane Fluidity is Regulated

1. Temperature can change membrane fluidity
   - Phase transition temperature (Tm): temp at which half of the membrane is in the gel phase or half of the membrane is in the fluid phase
2. Lipid composition can change membrane fluidity
   - Shorter hydrophobic tails, more fluid-like
   - More unsaturated lipids, more fluid-like
3. Dual role of cholesterol
   - Membranes are less permeable
   - Membranes are less fluid at high temps, but also gel at lower temps
4. Mixtures of lipids can form regional segregations known as rafts
   - Create functionally specialized domain

# Glycolipids

- Glycolipid s are present on the exoplasmic face of lipid membranes
- Cerebroside--galactose or glucose attached
- Ganglioside--complex sugars, at least one sialic acid (NANA) attached




(A) galactocerebroside (B) $G_{M1}$ ganglioside (C) sialic acid (NANA)

NANA =
N-acetylneuraminic acid
(sialic acid)

Figure 10-18 *Molecular Biology of the Cell* (© Garland Science 2008)

# Illustration with A,B,O Blood Group

- Antigens are oligosaccharide chain attached to glycolipids or glycoproteins expressed on the exoplamic side of the plasma membrane of human cells, e.g, red blood cells

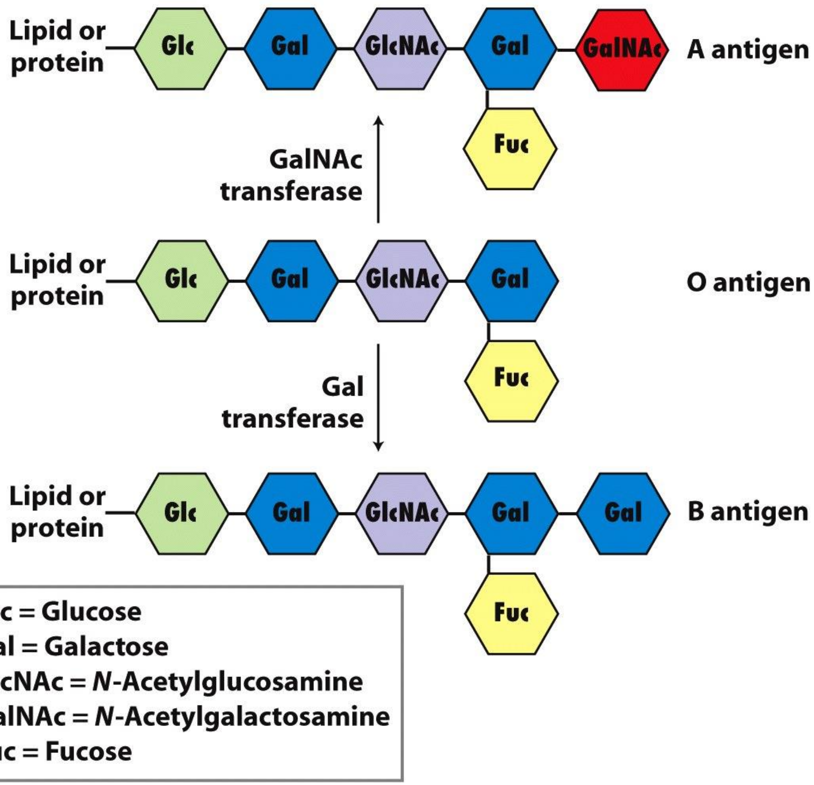


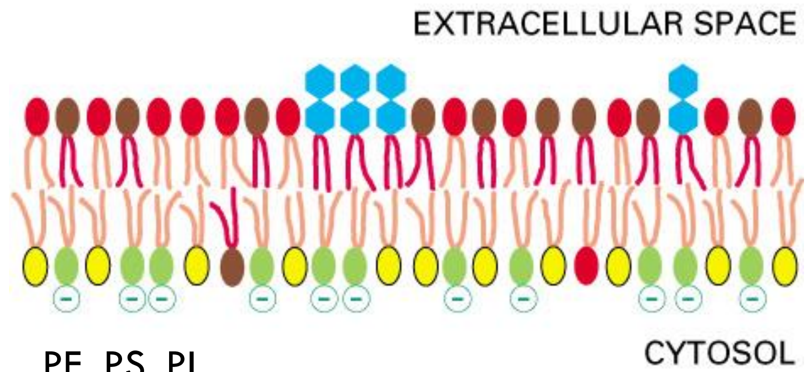

Figure 10-20
*Molecular Cell Biology, Sixth Edition*

# Lipid Bilayer

Lipid bilayer is asymmetrical: and this asymmetry is functionally important

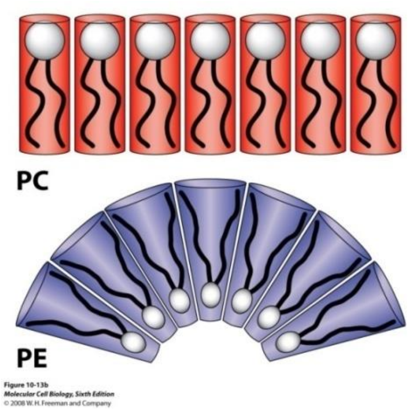
- PS (negatively charged) is exclusively on the cytosolic face.
- glycolipids and sphingomylin are exclusively on the exoplasmic face (e.g, blood group)
- Cholesterol is evenly distributed

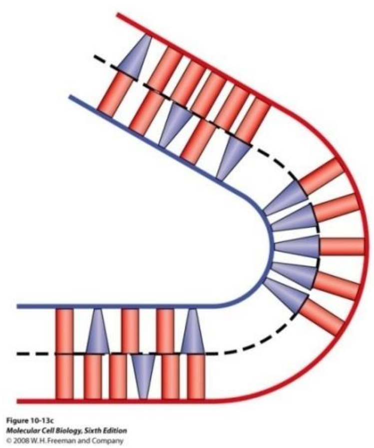
PC, sphingomyelin, glycolipids




PE, PS, PI

Figure 10–14. Molecular Biology of the Cell, 4th Edition.




- PE has a smaller head and the lipid has a conical shape.
- If PEs are on the cytoplasmic face and PCs are on the exoplasmic face, then membrane will curve