Membranes

STRUCTURE AND FUNCTIONS

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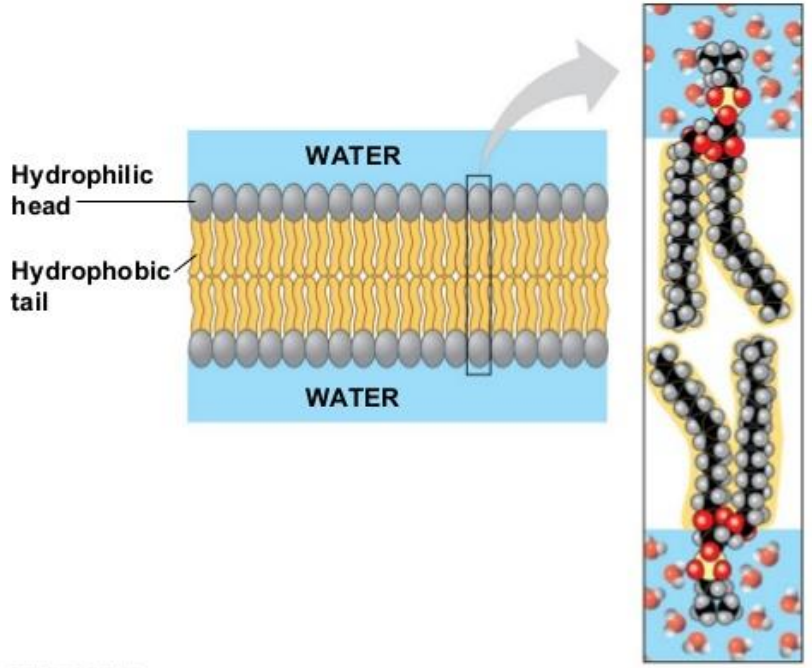
- Membranes define the external boundaries of cells and regulate the molecular traffic across that boundary
- Membranes are flexible, self-sealing, and selectively permeable to polar solutes
- they retain certain compounds and ions within cells and within specific cellular compartments, while excluding others.

The Composition and Architecture of Membranes

- Membranes have been chemically analyzed – made up of lipids and proteins
- Studies showed-phospholipid layer

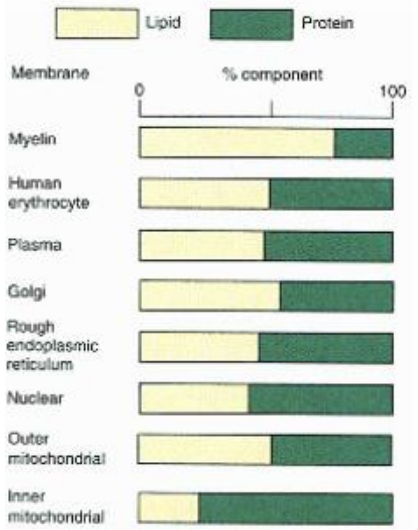
Figure 7.2



carbohydrates, present as part of glycoproteins and glycolipids.

Each Type of Membrane Has Characteristic Lipids and Proteins

- The myelin sheath consists primarily of lipids, whereas
- the plasma membranes of bacteria and the membranes of mitochondria and chloroplasts contain more protein than lipid
- Plasma membranes, are enriched in cholesterol and contain no detectable cardiolipin
- inner mitochondrial membrane of the hepatocyte: very low cholesterol and high cardiolipin.
- In a rod cell, more than 90% of the plasma membrane protein is rhodopsin
- erythrocyte has about 20 prominent types of proteins, mainly transporters



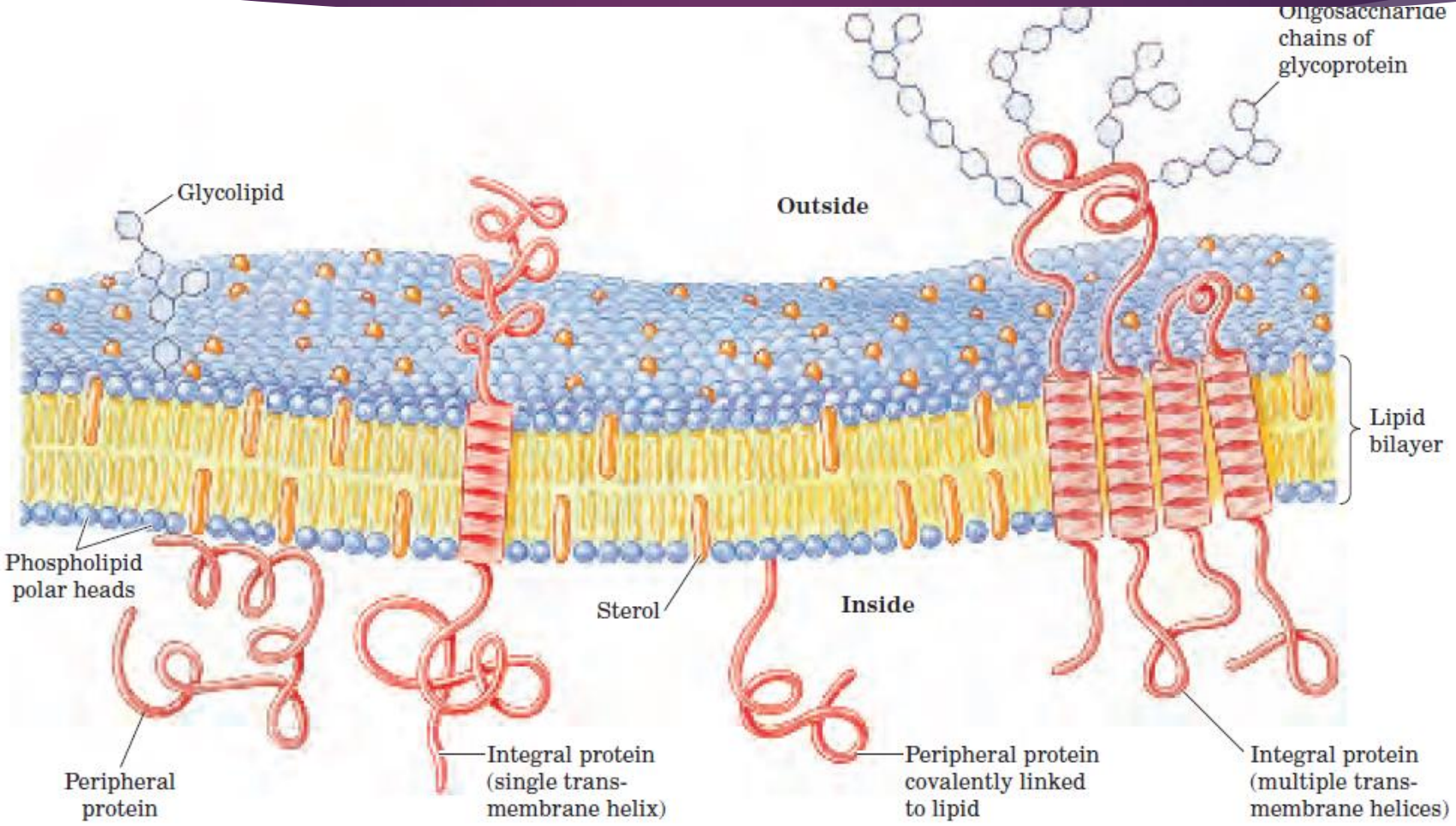
All Biological Membranes Share Some Fundamental Properties

- Membranes are impermeable to most polar or charged solutes, but permeable to nonpolar compounds
- **fluid mosaic model**

Membrane models

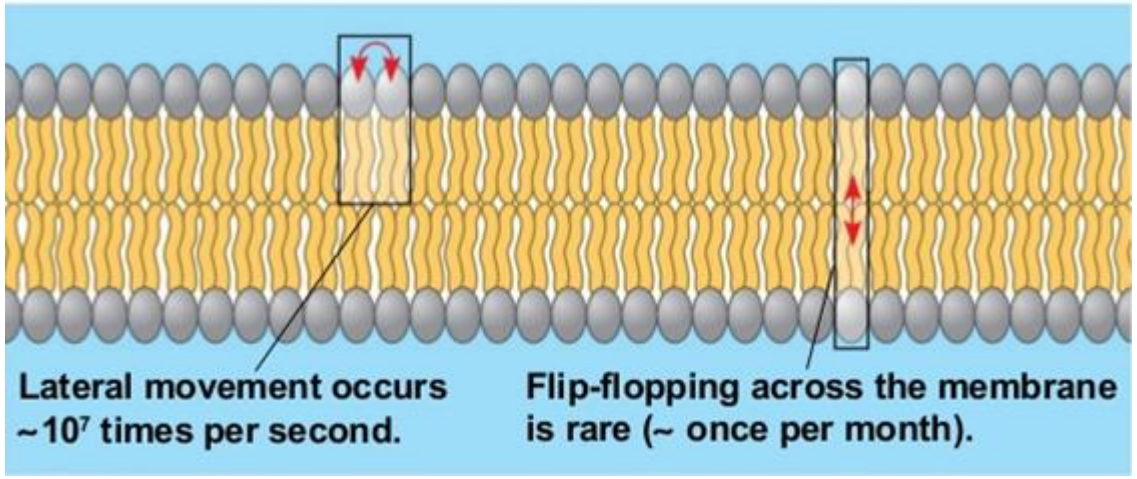
- In 1935, Hugh Davson and James Danielli proposed a sandwich model in which the phospholipid bilayer lies between two layers of globular proteins
- Later studies found problems with this model, particularly the placement of membrane proteins, which have hydrophilic and hydrophobic regions
- In 1972, S. J. Singer and G. Nicolson proposed that the membrane is a mosaic of proteins dispersed within the bilayer, with only the hydrophilic regions exposed to water

Fluid Mosaic model of membrane



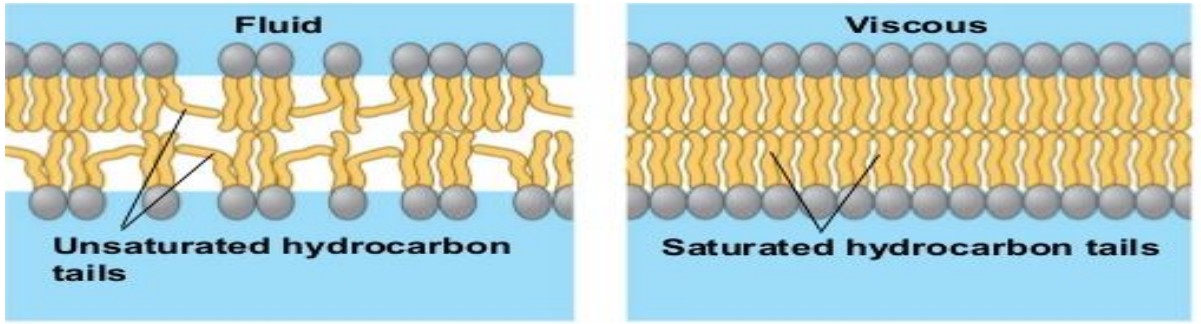
Fluidity of membrane

- Phospholipids in the plasma membrane can move
- Membranes Are Dynamic Structures
- Lipids and proteins drift laterally >flip/flop



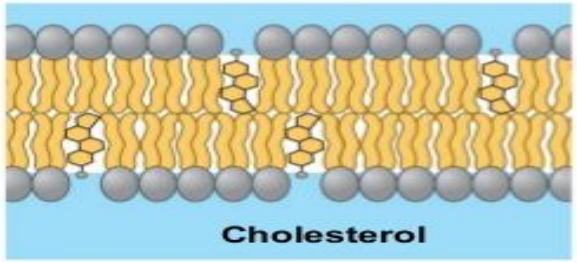
Fluidity of membrane

- At relatively low temperatures, the lipids in a bilayer form a semisolid **gel phase**
- At relatively high temperatures, **liquid-disordered state**, or fluid state

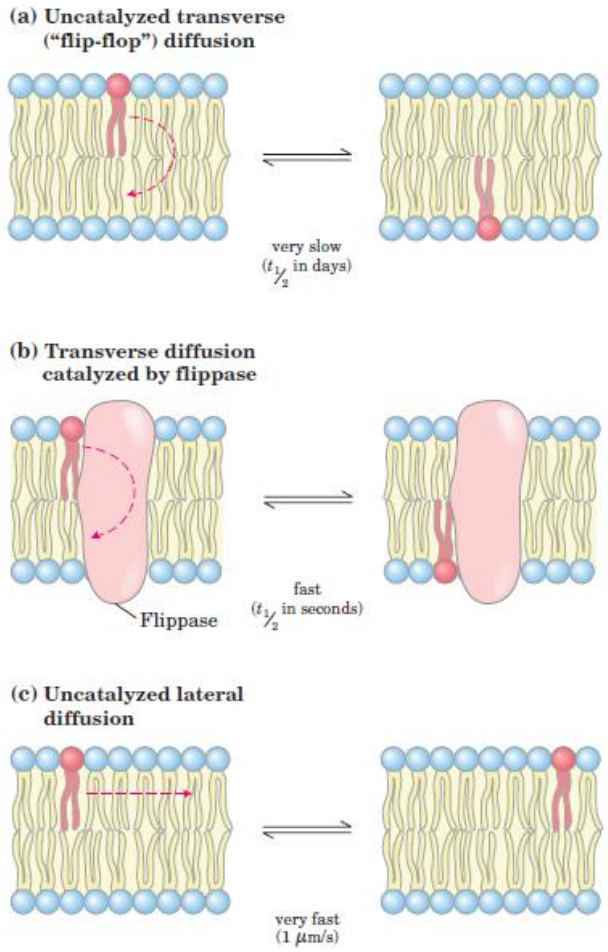


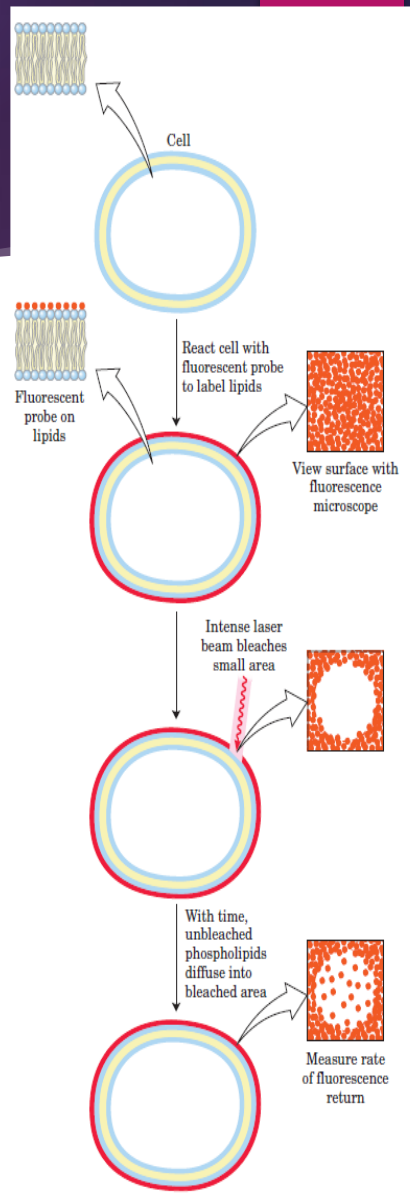
(a) Unsaturated versus saturated hydrocarbon tails

(b) Cholesterol within the animal cell membrane



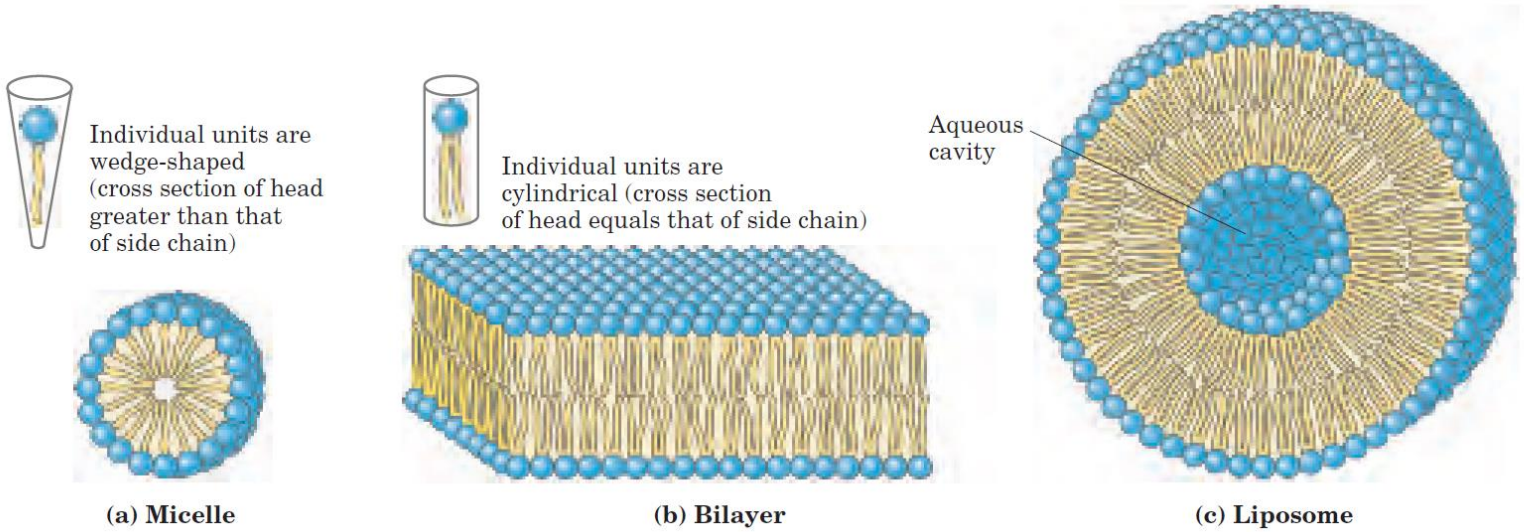
Transbilayer Movement of Lipids Requires Catalysis



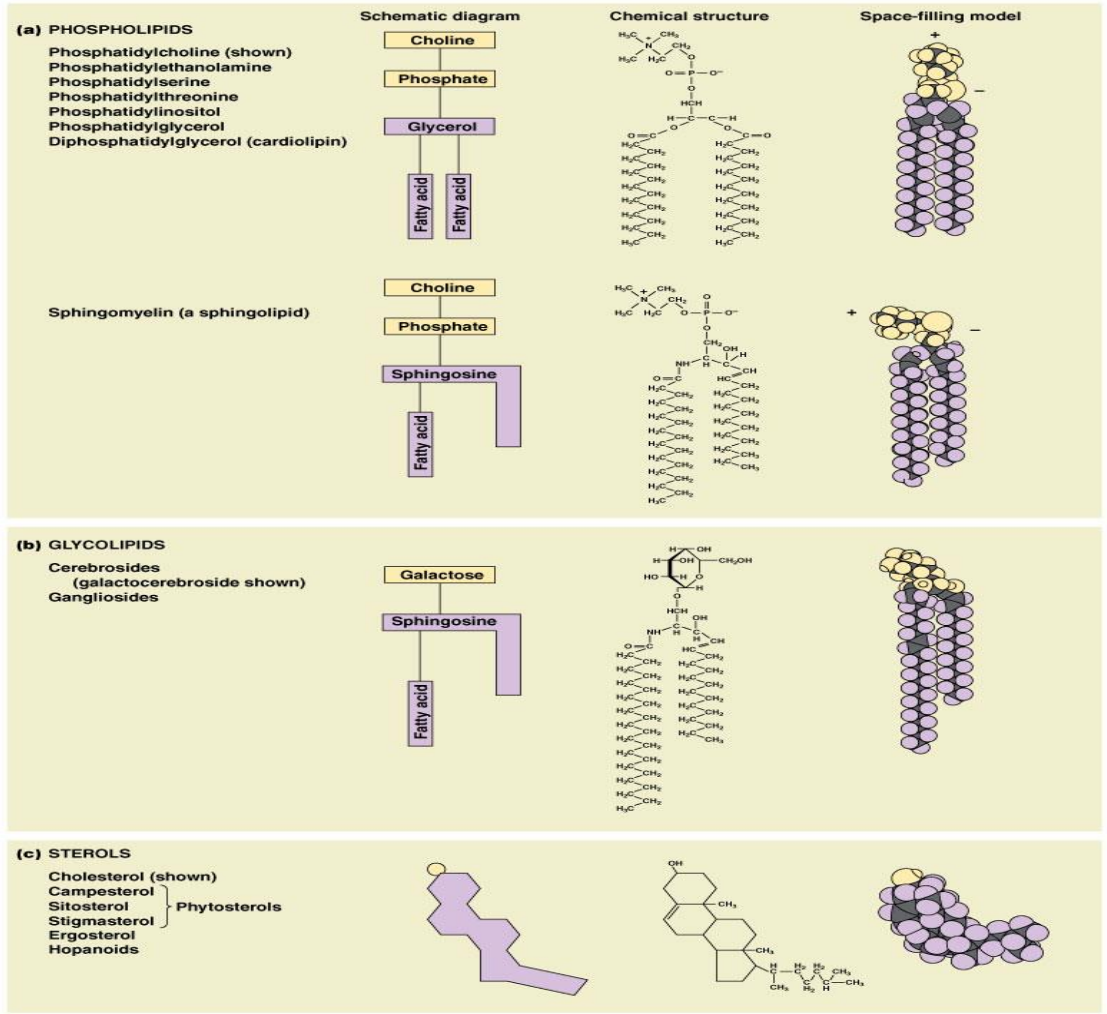


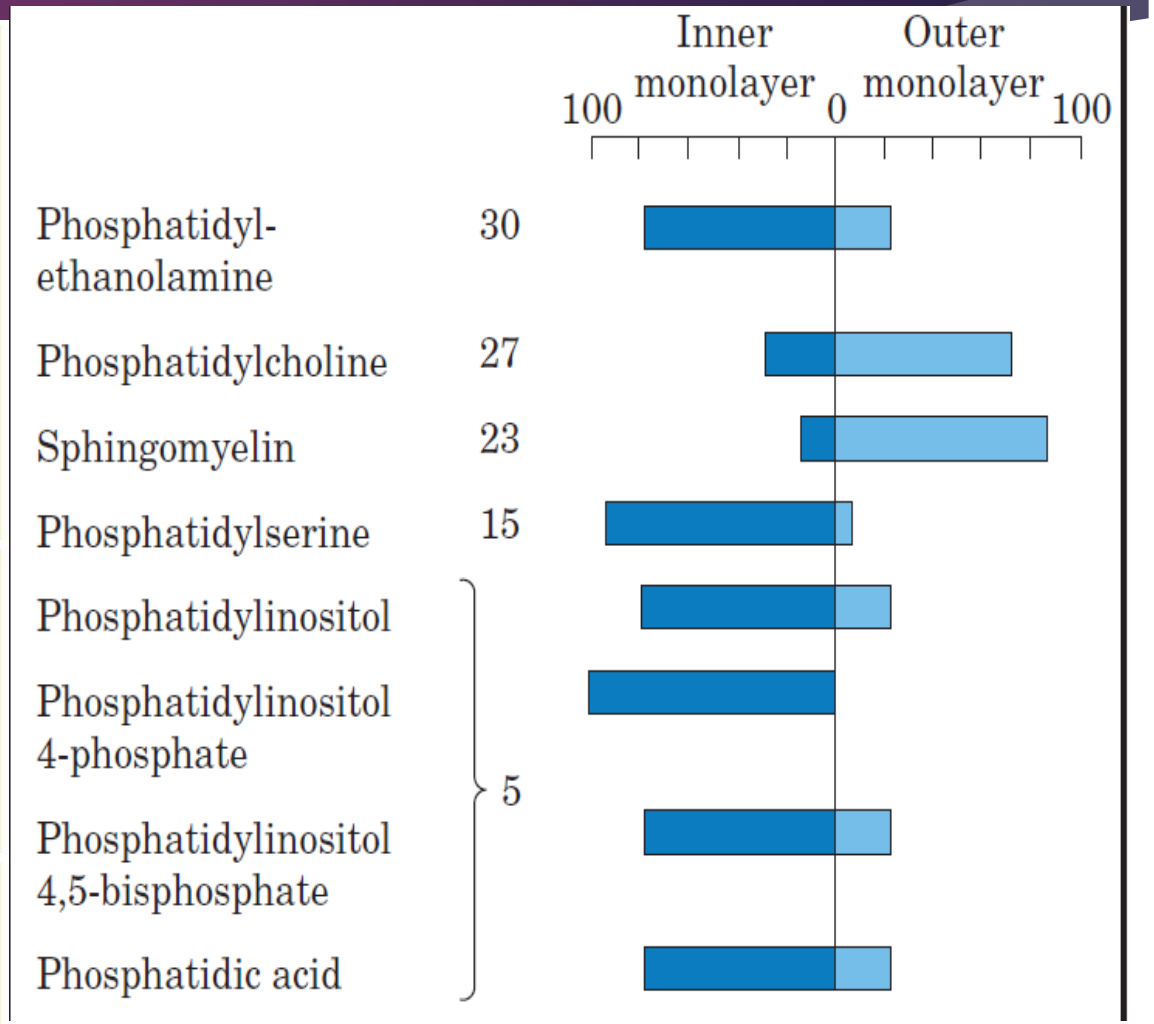
A Lipid Bilayer Is the Basic Structural Element of Membranes

- Glycerophospholipids, sphingolipids, and sterols are virtually insoluble in water
- **Amphipathic lipid aggregates that form in water**

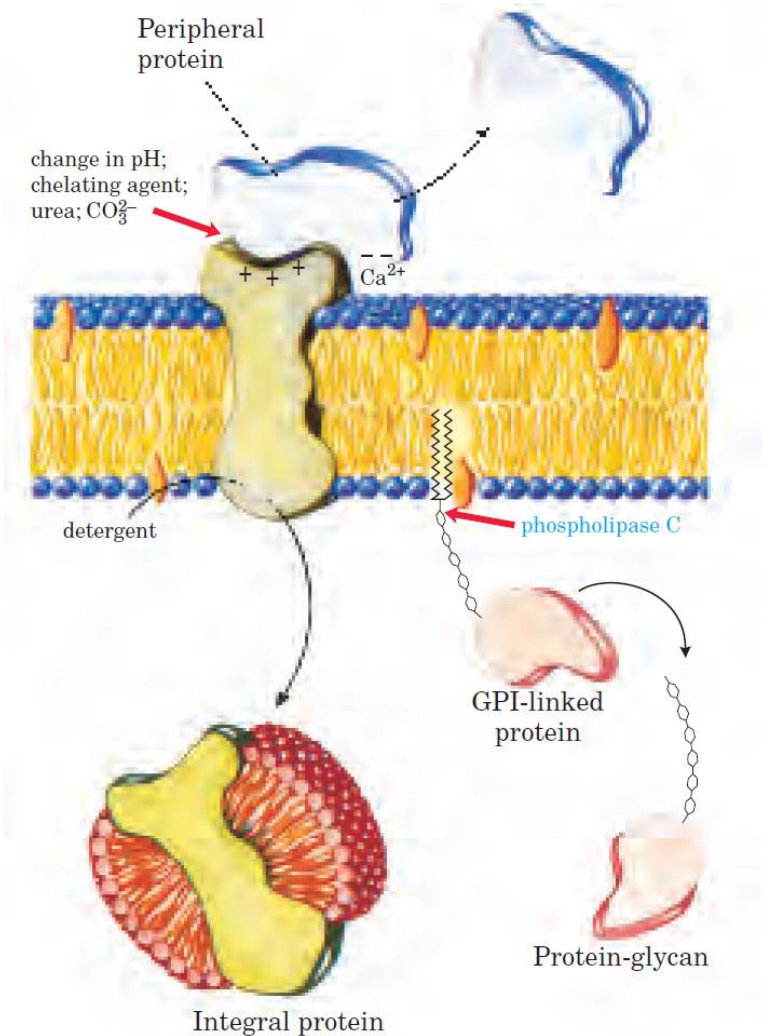


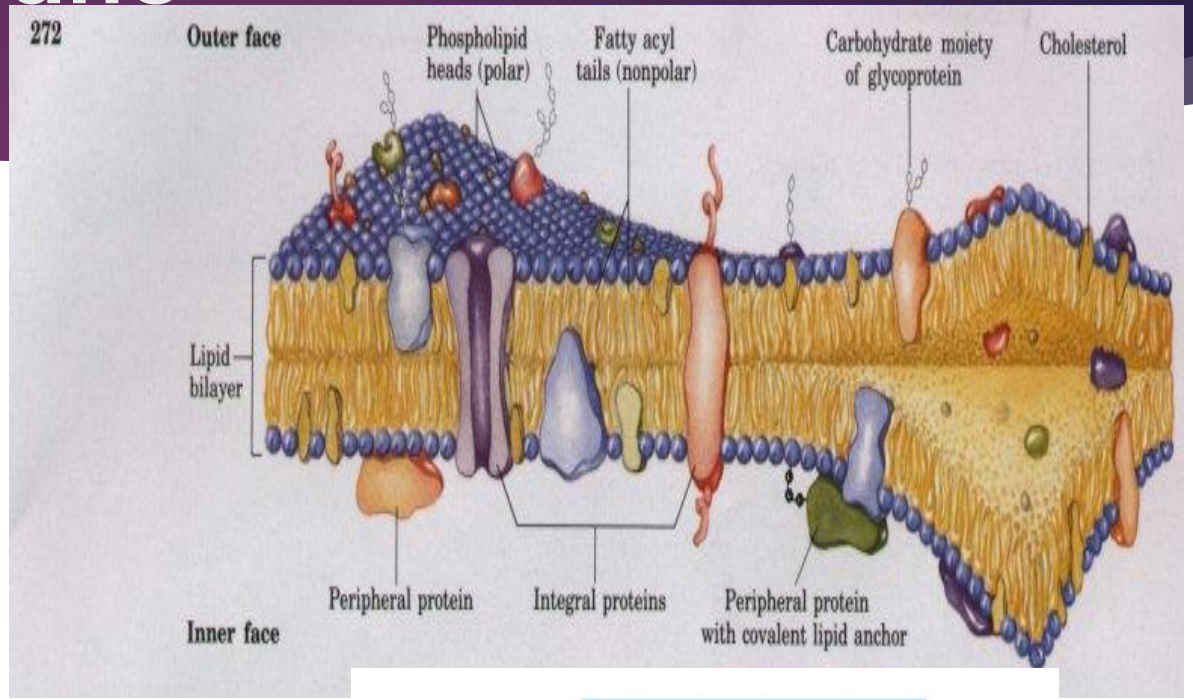
Lipid composition of membrane

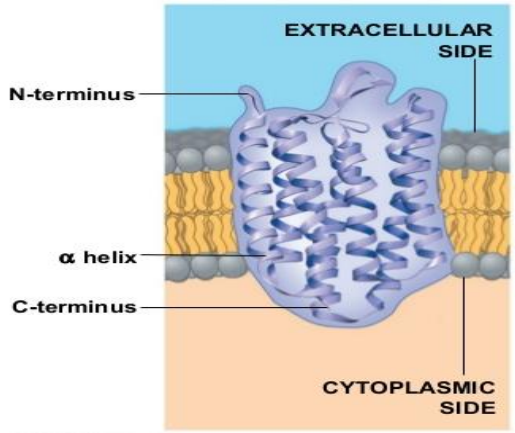




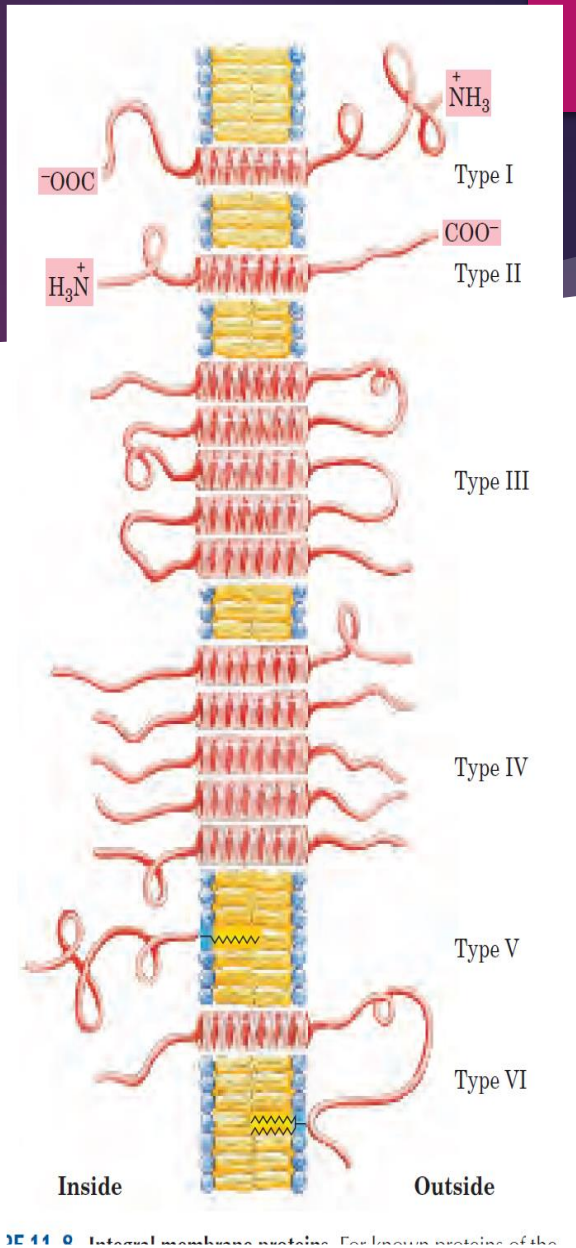
Proteins in Membrane



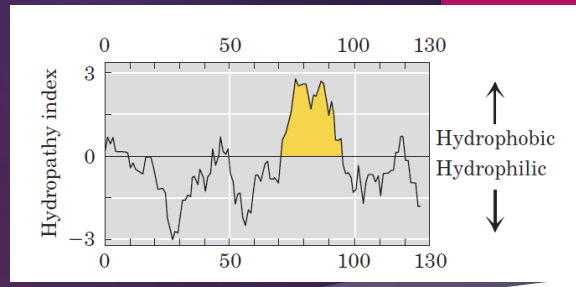




Classification of integral proteins



Integral Proteins Are Held in the Membrane by Hydrophobic Interactions with Lipids

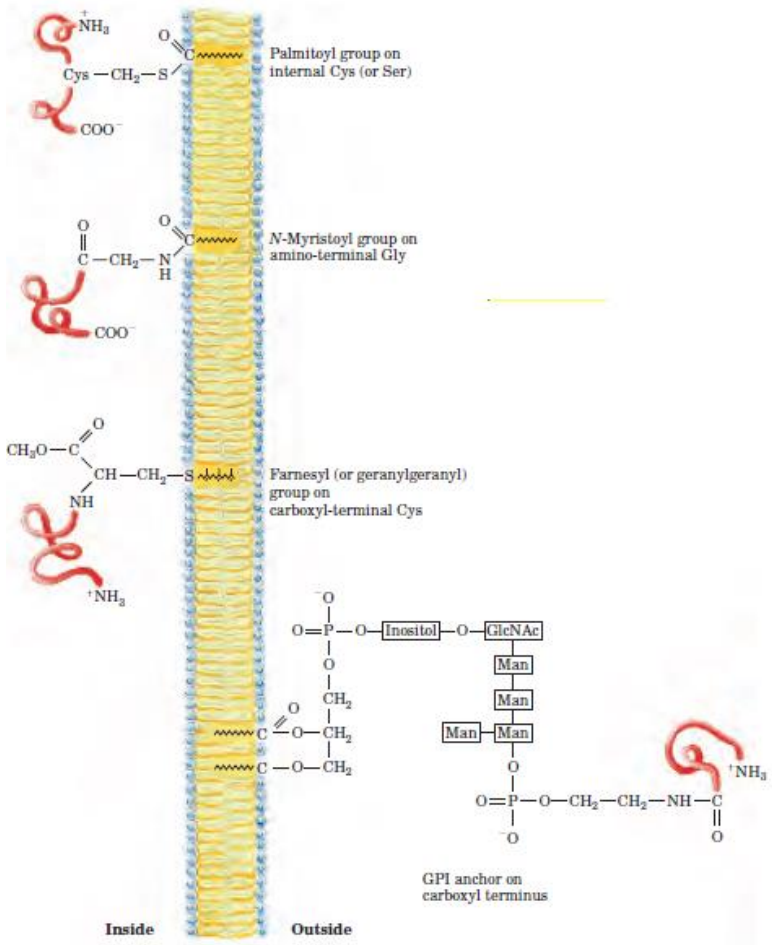


- Hydrophobic interactions between the nonpolar amino acids and the fatty acyl groups of the membrane lipids firmly anchor the protein in the membrane

- The presence of unbroken sequences of more than 20 hydrophobic residues in a membrane protein is commonly taken as evidence that these sequences traverse the lipid bilayer

- The overall hydrophobicity of a sequence of amino acids is estimated by summing the free energies of transfer for the residues in the sequence, which yields a **hydropathy index** for that region

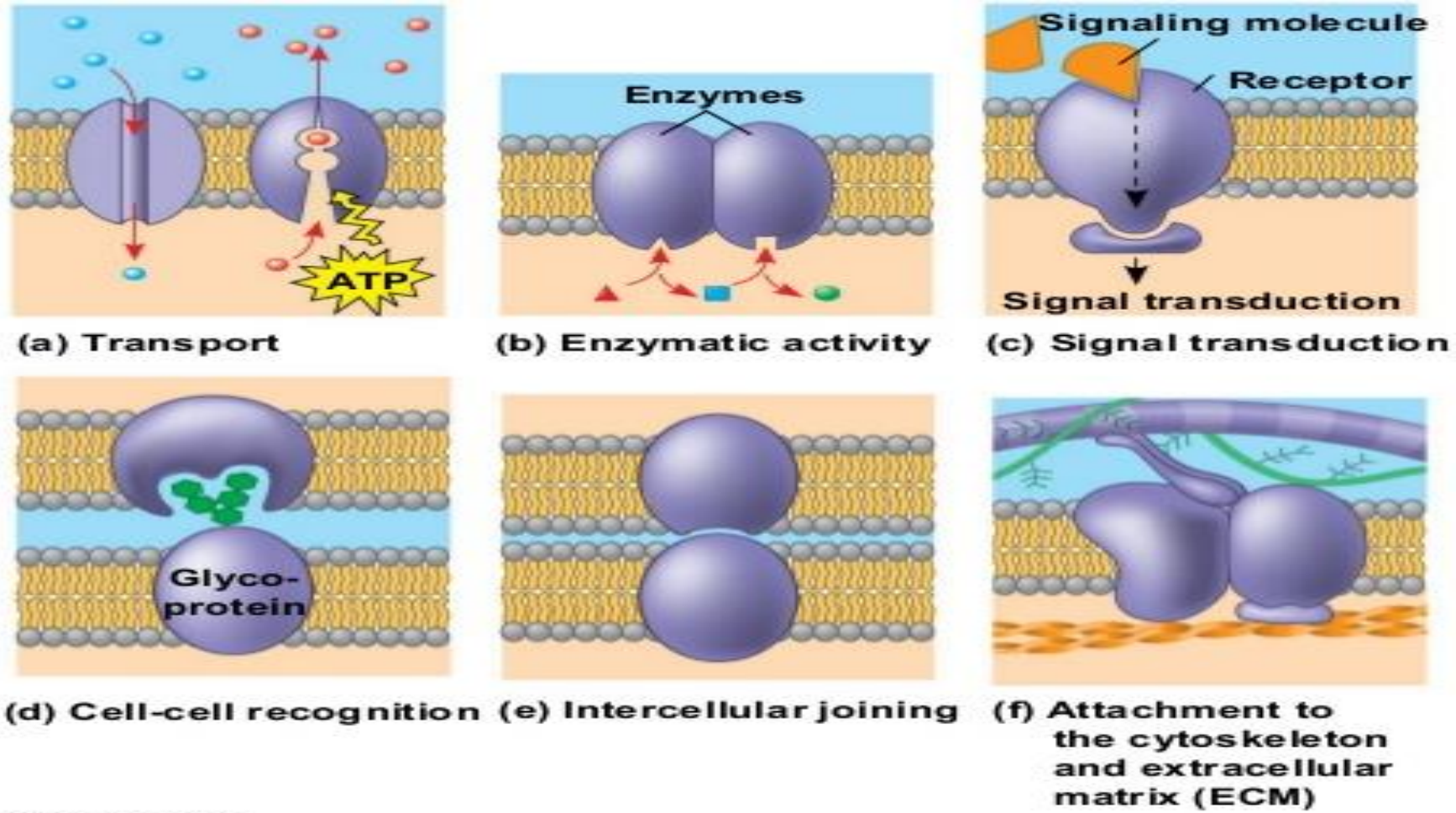
Lipid linked membrane proteins



- Alkaline phosphatase
- 5 -Nucleotidase

- Acetylcholinesterase
- Trehalase
- Renal dipeptidase
- Lipoprotein lipase
- Carcinoembryonic antigen
- Neural cell adhesion molecule
- Scrapie prion protein
- Oligodendrocyte-myelin protein

Proteins in membrane



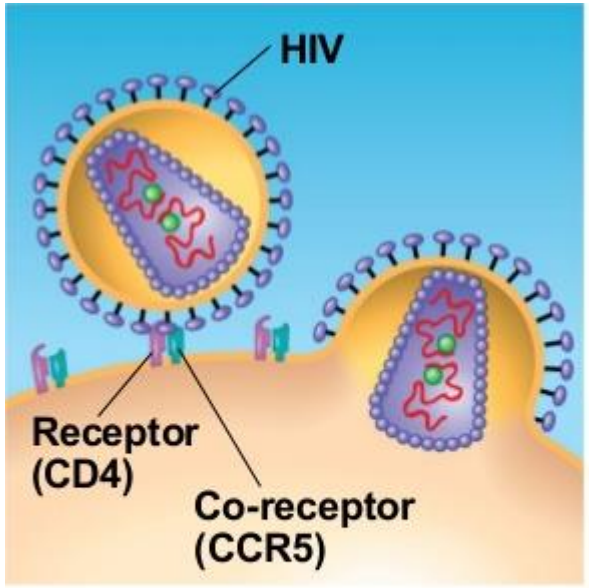
(a) Transport (b) Enzymatic activity (c) Signal transduction

(d) Cell-cell recognition (e) Intercellular joining (f) Attachment to the cytoskeleton and extracellular matrix (ECM)

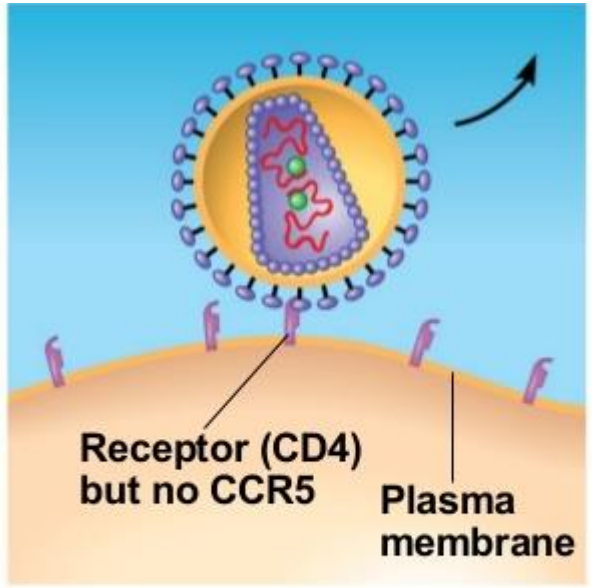
TABLE 40–2 Enzymatic Markers of Different Membranes

Membrane	Enzyme
Plasma	5′-Nucleotidase
	Adenylyl cyclase
	Na^+-K^+-ATPase
Endoplasmic reticulum	Glucose-6-phosphatase
Golgi apparatus	
Cis	GlcNAc transferase I
Medial	Golgi mannosidase II
Trans	Galactosyl transferase
Trans Golgi Network	Sialyl transferase
Inner mitochondrial membrane	ATP synthase

Role of glycoprotein in cell cell recognition



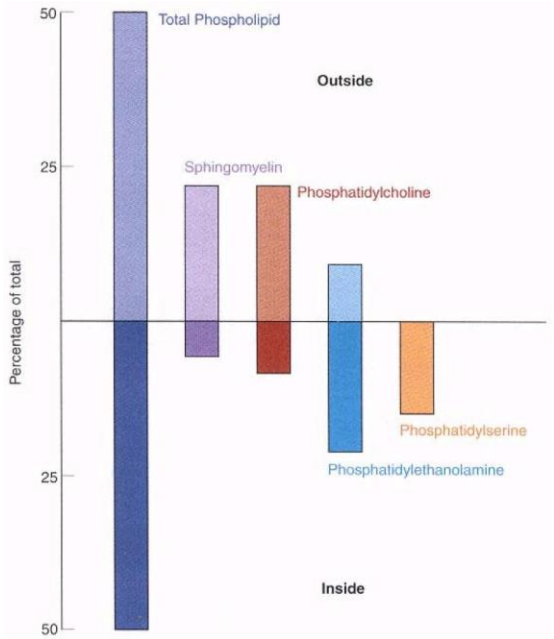
HIV can infect a cell that has CCR5 on its surface, as in most people.



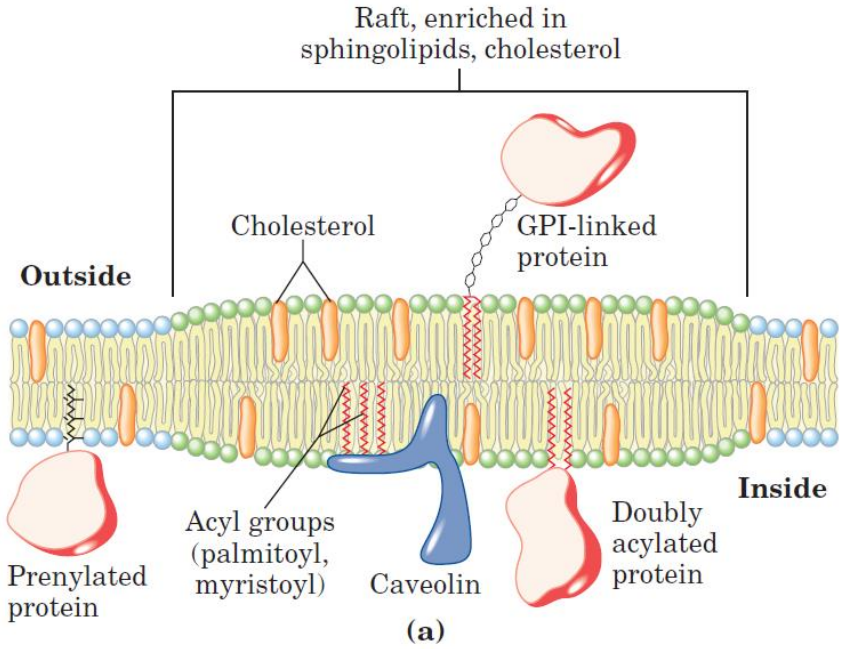
HIV cannot infect a cell lacking CCR5 on its surface, as in resistant individuals.

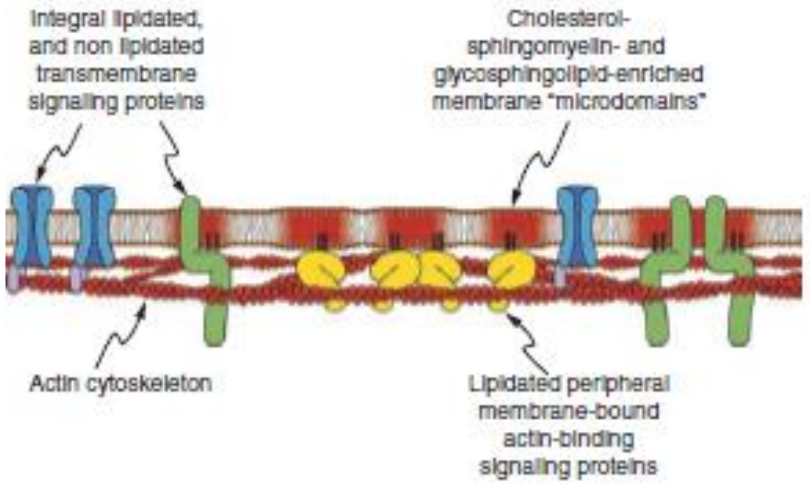
Membranes Are Asymmetric Structures

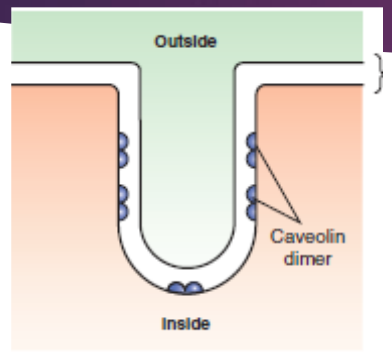
- outside surfaces different from the inside surfaces.
- regional heterogeneities: Gap junctions, tight junctions
- inside-outside asymmetry of the phospholipids:

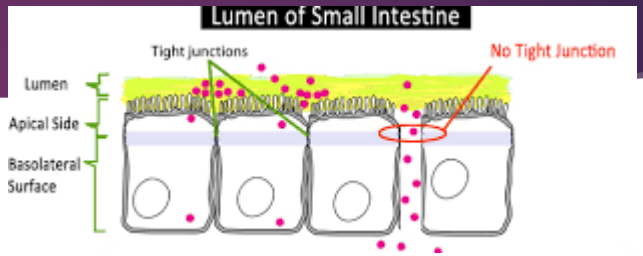


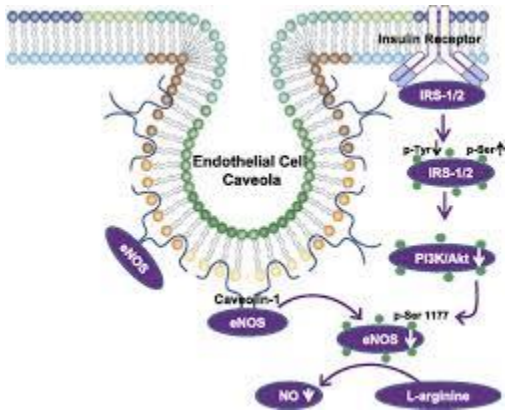
Lipid Rafts, Caveolae, & Tight Junctions Are Specialized Features of Plasma Membranes

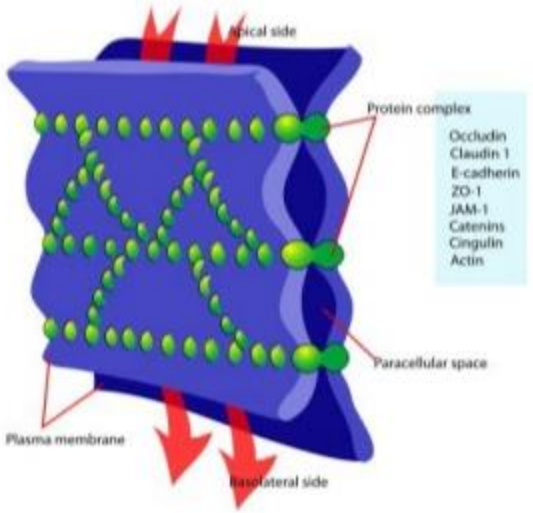





Outside
Caveolin dimer
Inside

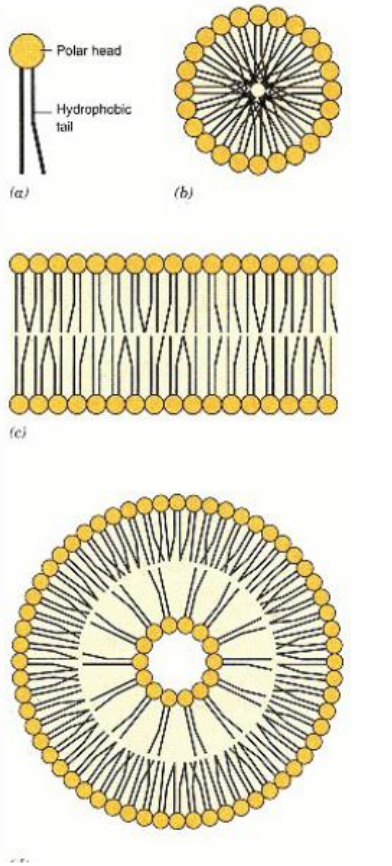

Lumen of Small Intestine
Tight junctions
No Tight Junction
Lumen
Apical Side
Basolateral Surface


Insulin Receptor
IRS-1/2
p-Tyr
p-Ser
IRS-1/2
Endothelial Cell
Caveola
eNOS
PI3K/Akt
Caveolin-1
eNOS
p-Ser 1177
eNOS
NO
L-arginine


Apical side
Protein complex
Occludin
Claudin 1
E-cadherin
ZO-1
JAM-1
Catenins
Cingulin
Actin
Paracellular space
Plasma membrane
Basolateral side

Aritificial membranes

- **Liposomes As Carriers of Drugs and Enzymes and DNA**



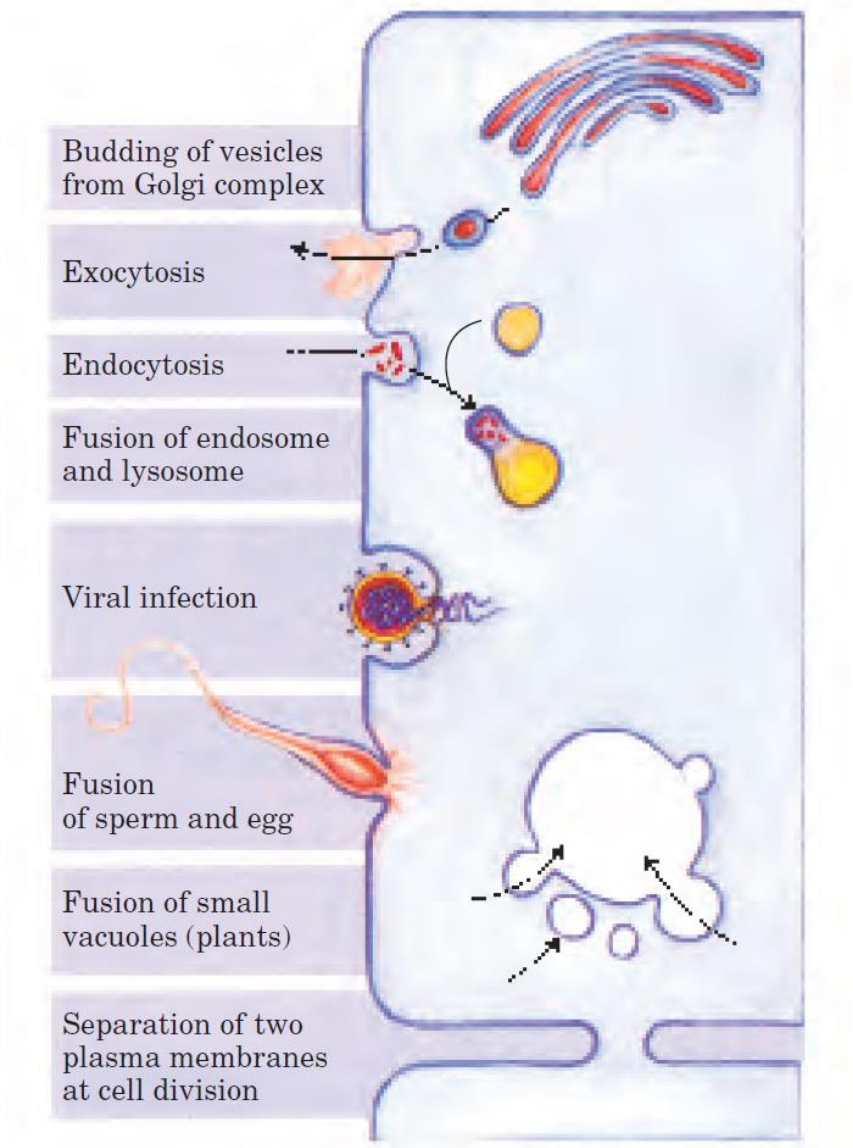


FIGURE 11–23 **Membrane fusion.** The fusion of two membranes is central to a variety of cellular processes involving both organelles and the plasma membrane.

TABLE 40–7 Some Diseases or Pathologic States Resulting From or Attributed to Abnormalities of Membranes[a]

Disease	Abnormality
Achondroplasia (OMIM 100800)	Mutations in the gene encoding the fibroblast growth factor receptor 3
Familial hypercholesterolemia (OMIM 143890)	Mutations in the gene encoding the LDL receptor
Cystic fibrosis (OMIM 219700)	Mutations in the gene encoding the CFTR protein, a Cl^- transporter
Congenital long QT syndrome (OMIM 192500)	Mutations in genes encoding ion channels in the heart
Wilson disease (OMIM 277900)	Mutations in the gene encoding a copper-dependent ATPase
I-cell disease (OMIM 252500)	Mutations in the gene encoding GlcNAc phosphotransferase, resulting in absence of the Man 6-P signal for lysosomal localization of certain hydrolases
Hereditary spherocytosis (OMIM 182900)	Mutations in the genes encoding spectrin or other structural proteins in the red cell membrane
Metastasis of cancer cells	Abnormalities in the oligosaccharide chains of membrane glycoproteins and glycolipids are thought to be of importance
Paroxysmal nocturnal hemoglobinuria (OMIM 311770)	Mutation resulting in deficient attachment of the GPI anchor (see Chapter 46) to certain proteins of the red cell membrane