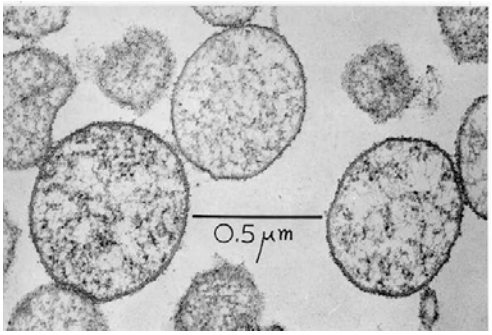
Chapter 9 - Biological Membranes



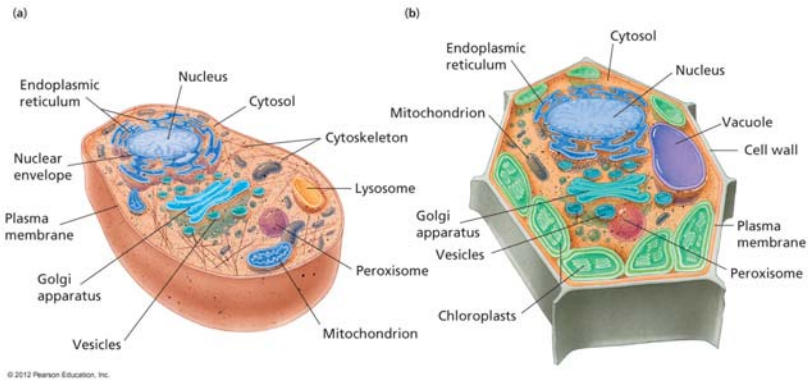
www.gsbs.utmb.edu/ microbook/ch037.htmMycoplasma

Membranes form a semi-permeable boundary between a cell and its environment.

Membranes also permit subcellular organization and segregation of metabolic pathways.

Membrane-bound Organelles

Mitochondrion
Endoplasmic Reticulum
Nucleus
Peroxisome
Vacuole
Lysosome
Golgi Apparatus
Secretory Vesicle
Chloroplast



Composition: Lipids, Proteins, Sterols, Carbohydrates.

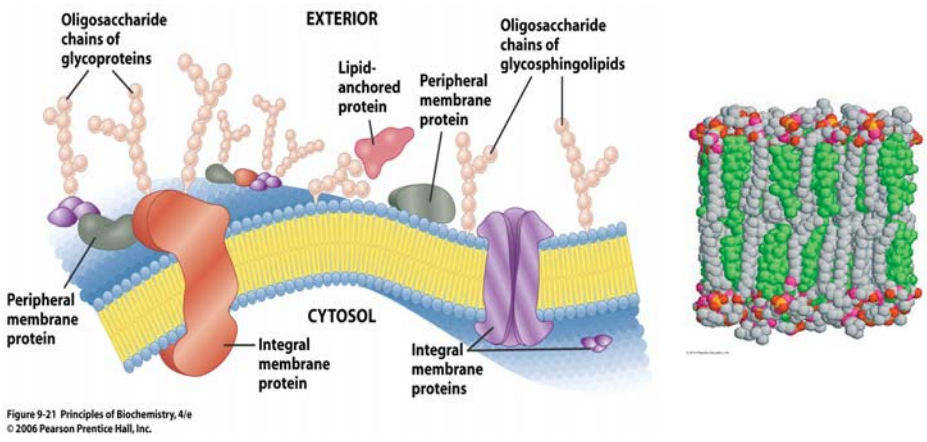
Myelin Sheath is mostly lipid. Mitochondrial membrane is mostly protein so there is lots of variety in composition.

Lipid composition depends on Kingdom, species, organelle, leaflet.

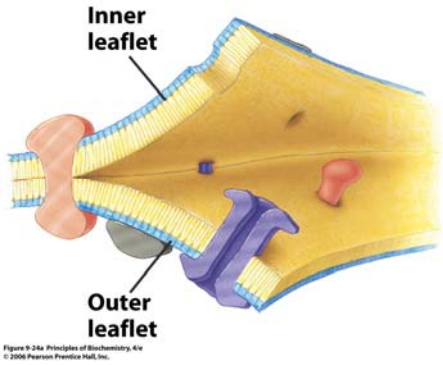
	Outer	Inner
P-Choline	22%	9%
P-Ethanolamine	7%	24%
P-Serine	0%	9%
Sphingomyelin	20%	7%

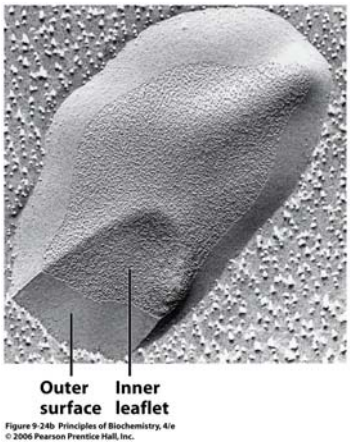
Carbohydrates are abundant on plasma membrane but rare on intracellular membranes.

Fluid Mosaic Model



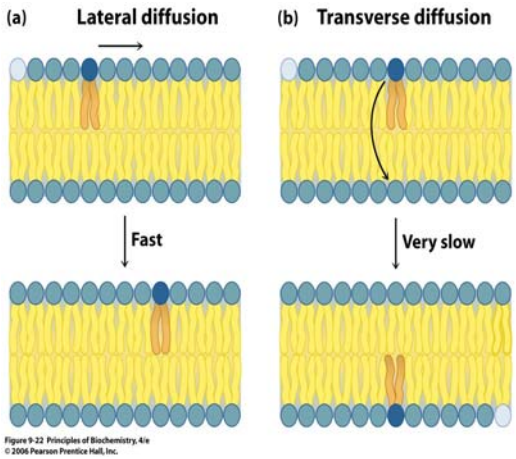
A lipid bilayer, 5-8 nm thick.





Lipid can diffuse laterally – in a red blood cell circumnavigation takes a few seconds.

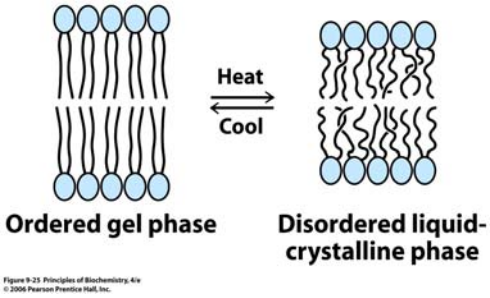
Transbilayer diffusion (flip-flop) is rare.



Special enzymes, **flipases,** exist to assist this process.

Bilayers undergo a phase transition:

Gel	Liquid Crystal
Low T	High T
FA tails rigid & packed	FA tails mobile



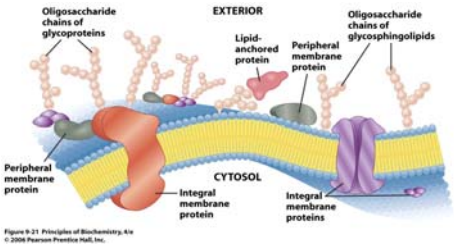
In living cells the phase transition is broad and may be between 10^{o} and 40^{o}C.

The fluidity of a membrane depends on the amount of saturated and unsaturated lipid, and the amount of sterol present.

Membrane Proteins:

1. **Peripheral Membrane Proteins** associate with the surface of the bilayer.

They are held in place by weak interactions (H-bonds, van der Waal's, electrostatic) or covalent attachment to the lipid.



High salt concentrations may release them from membrane.

An example is Cytochrome c.

2. **Integral Membrane Proteins** span the bilayer.

Their external surfaces are **hydrophilic.**

They are in contact with water in the cytoplasm or outside the cell.

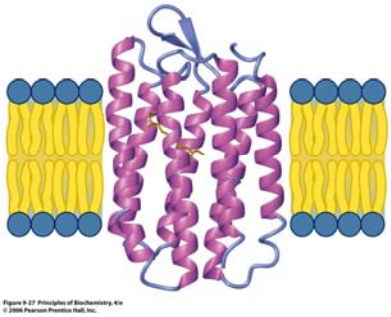
Their internal surfaces are **hydrophobic**, in contact with lipid.

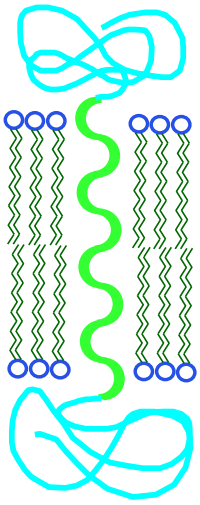
Removal from the membrane is usually by detergent extraction.

Classes Of Integral Membrane Proteins

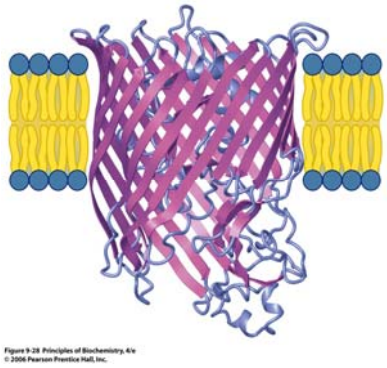
a. Traverse membrane as a single α-helix.

b. Traverse membrane as 4-16 α-helices.





c. Traverse membrane as 8-16 β-strands forming a giant β-barrel – **Porins**

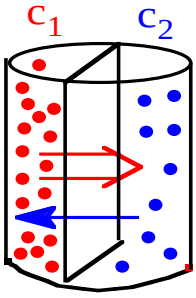


Some membrane proteins can diffuse laterally in the plane of the bilayer – others are anchored to the cytoskeleton.

Membranes are tough, but flexible. They can change shape in growth and movement, and are able to seal temporary leaks.

Transport Across Bilayers

The 2nd law of thermodynamics states that systems tend to the greatest entropy, disorder.



Diffusion across a semipermeable membrane occurs in both directions, but net diffusion is from **1** → **2** until $c_1 = c_2$.

CH_4, O_2, N_2, H_2O, NO, CO cross membranes freely, equalizing their concentrations on both sides of the membranes.

NO and CO are **second messengers**.

This is called "**Simple *Diffusion***" and is governed by thermodynamics.

When solute concentrations are different on 2 sides of a membrane there must also be a H_2O concentration gradient.

H_2O crosses the membrane until the **osmotic strength** is equal on both sides.

Some cells, *e.g.* kidney and lung, use integral membrane proteins called **aquaporins** to increase the rapid transport of water across membranes. They form a pore that permits rapid diffusion of the water down its concentration gradient. This is called:

Facilitated Diffusion:

Many large polar molecules, including carbohydrates, and amino acids are transported this way.

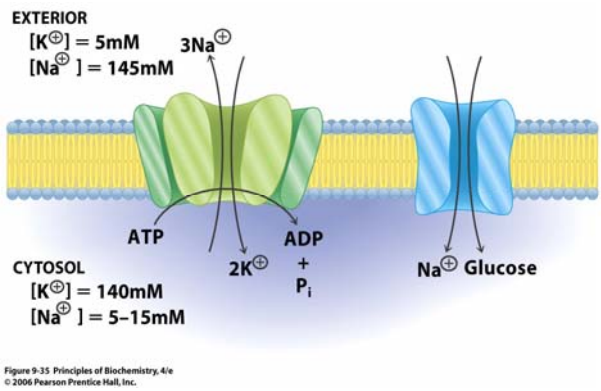
The transport proteins are called **permeases**.

e.g. Red Blood Cell Glucose Permease

M_r ~ 45,000 Da 12 α-helices form a pore that transports glucose 50,000 times faster than simple diffusion through the membrane.

Active Transporters can pump solute **against** a concentration gradient.

e.g. The $Na^+ – K^+$ ATPase uses energy from the hydrolysis of ATP to pump 2 K^+ into a cell and 3 Na^+ out of the cell.



For most animal cells: $[Na^+]_{in} < [Na^+]_{out}$ and $[K^+]_{in} > [K^+]_{out}$

There is a net movement of positive charge out of the cell, which then becomes negatively charged.

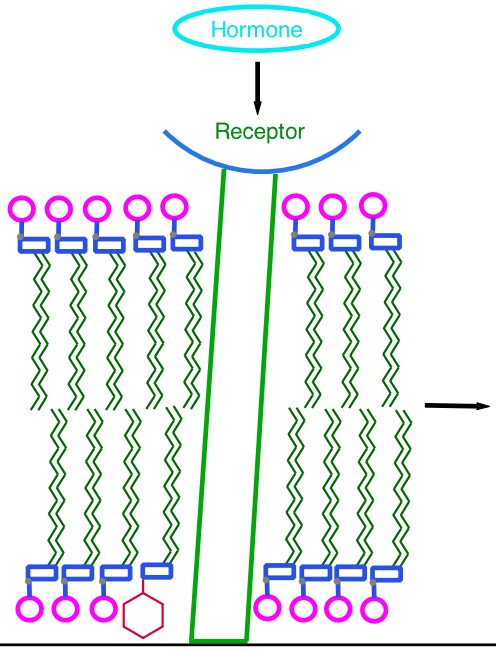
The transmembrane electrical potential is:

$\Delta\Psi$ = 50 – 70 milliVolts

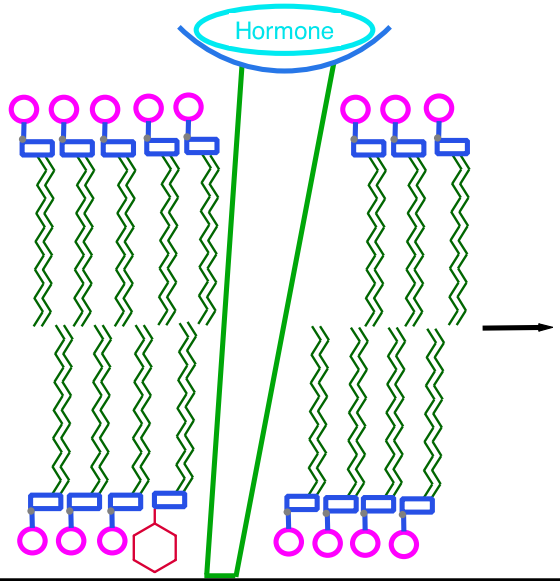
Up to 25% of the resting metabolic energy of a cell is used to maintain this gradient.

Transmission of Information Across Membranes

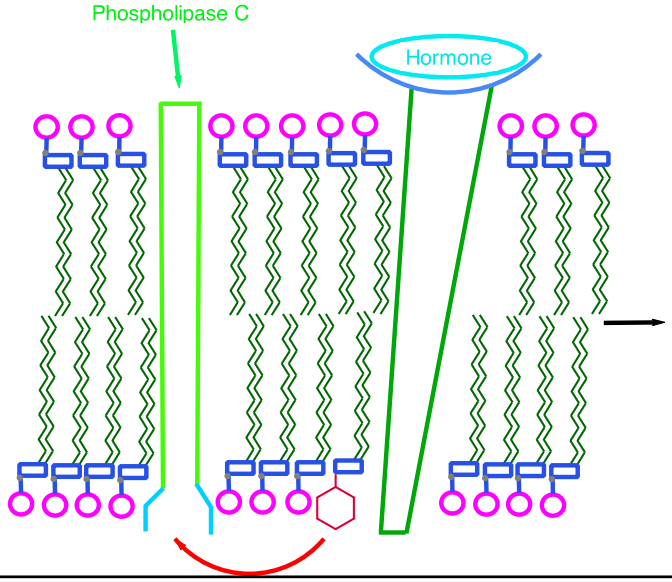
Many hydrophilic peptide hormones and hydrophobic steroid hormones are secreted by cells into the extracellular fluid and bind to membrane **receptors** on target cells.



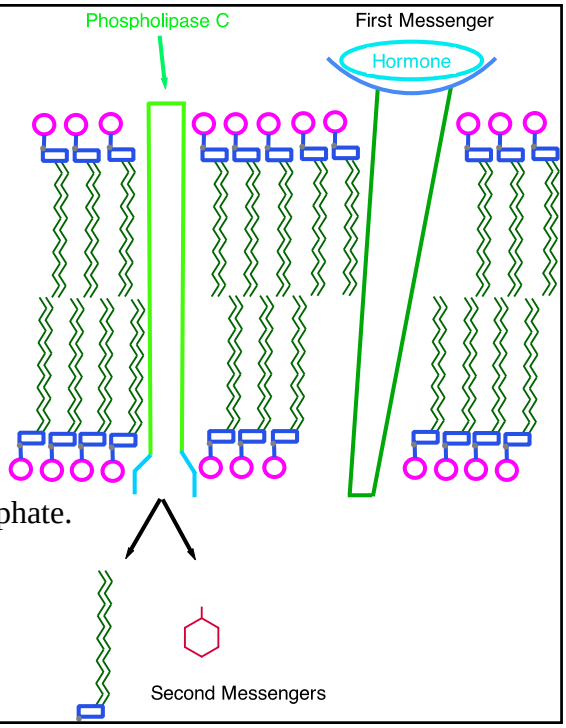
A conformational change in the receptor transmits a signal across the membrane activating a **second messenger** system.



For example, the hormone epinephrine (adrenaline) binds to adrenergic receptors activating phospholipase C an integral membrane protein enzyme.



It acts on phosphatidyl inositol-4,5 bisphosphate releasing diacylglycerol and inositol-1,4,5,trisphosphate.



Both are intracellular **Second Messengers** that regulate enzyme activity and metabolism in **cell signalling** aka **signal transduction**.

Another example: Insulin binds to the insulin receptor and activates an enzyme cascade that leads to changes in sugar and lipid metabolism.