Membrane Structure and Function

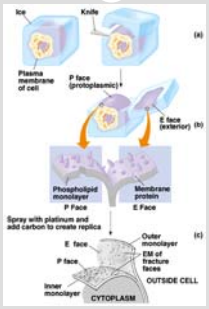
Membrane Structure

- Plasma membrane is a boundary that separates the living cell from it's non-living surroundings.
  - @ 8 nm thick
  - Controls chemical traffic
  - Selectively permeable.
  - Unique structure.

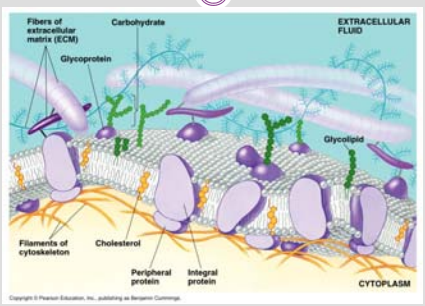
Singer and Nicolson Fluid Mosaic Model

- Proteins imbedded in membrane
- Hydrophilic and Hydrophobic regions will be stable.
- Membrane is a mosaic of proteins bobbing in a fluid bilayer of phospholipids.
- Freeze fracture gives clear evidence.

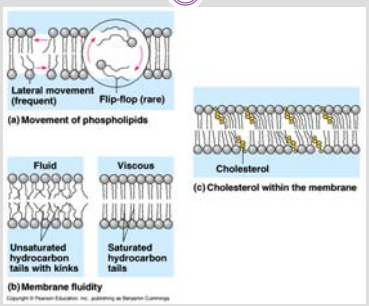
Freeze Fracture



Fluid Mosaic Model



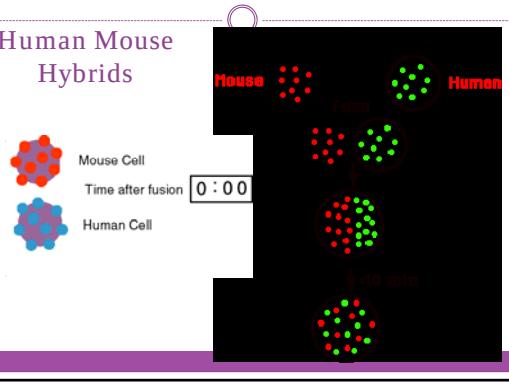
Fluid Mosaic Model



Fluidity of Membranes

- 1970 Mouse/Human Hybrid cells
- Labeled with two different fluorescent dyes.
- After a couple of hours they were evenly distributed.

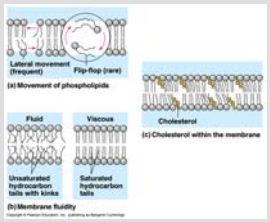
Human Mouse Hybrids

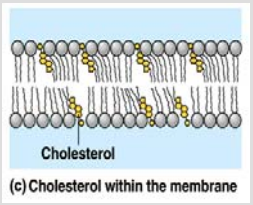


Fluidity of Membranes

- Unsaturated tails enhance fluidity
- More saturated the membrane phospholipids the easier it is to solidify.
- Cholesterol in eukaryotes modulates fluidity
  - less fluid in warmer temp by restraining phospholipid movement
  - More fluid in colder temp by preventing close packing of phospholipids.

Membrane Viscosity

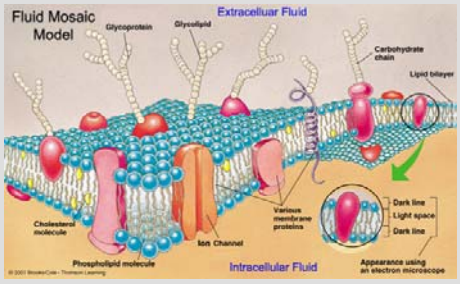


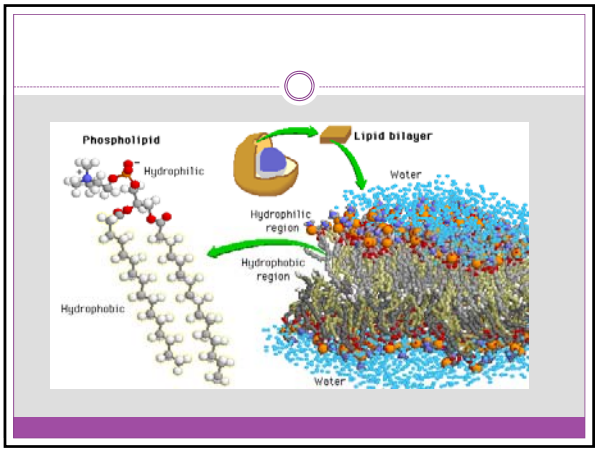


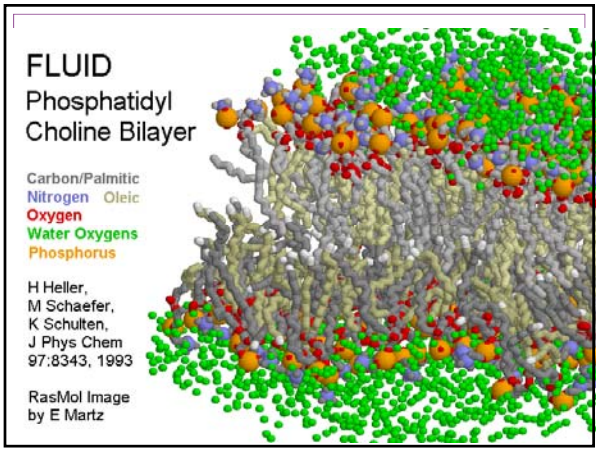
Mosaic of Structure

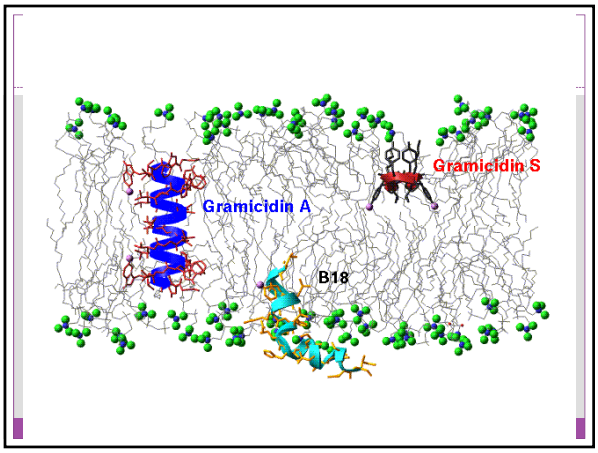
- Integral proteins
  - Generally transmembrane
- Peripheral proteins
  - not embedded but attached to the membrane surface.
  - May be attached to integral proteins or held by fibers of ECM (Extra Cellular Matrix).
  - On cytoplasmic side may be held by cytoskeleton.

Integral vs. Peripheral




Phospholipid
Hydrophilic
Hydrophobic
Lipid bilayer
Water
Hydrophilic region
Hydrophobic region
Water


FLUID
Phosphatidyl Choline Bilayer
Carbon/Palmitic
Nitrogen Oleic
Oxygen
Water Oxygens
Phosphorus
H Heller, M Schaefer, K Schulten, J Phys Chem 97:8343, 1993
RasMol Image by E Martz


Gramicidin S
Gramicidin A
B18

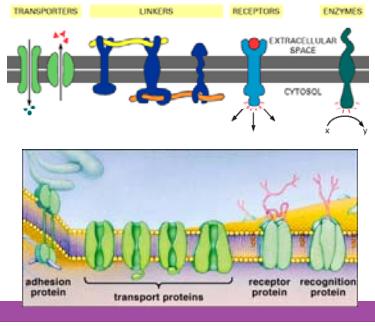
Bifacial Nature

- Carbohydrates when present are on the outer surface.
- ER, Golgi and vesicles contribute to membrane
- Six major kinds of functions by proteins of plasma membrane.

Function of Membrane Proteins

- Transport
- Enzymatic activity
- Signal Transduction
- Intercellular joining
- Cell-Cell recognition
- Attachment to cytoskeleton

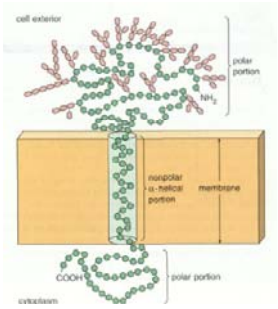
Membrane Proteins Functions



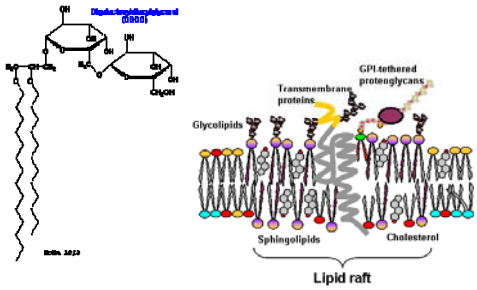
Membrane Carbohydrates

- Cell Cell Recognition
  - Sorting embryonic cells into tissues and organs
  - Rejecting foreign cells
  - Usually branched Oligosaccharides
  - Covalently bonded to lipids (Glycolipids)
  - Most covalently bonded to proteins (Glycoproteins)
  - Lots of variety

Glycoprotein



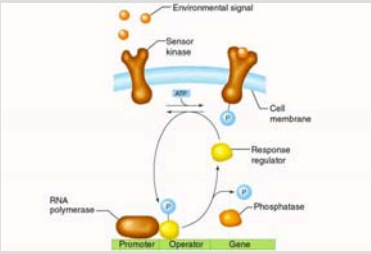
Glycolipids



Movement Across Membranes

- Selectively Permeable
  - Types of membrane proteins
  - Nature of the substance
- Non polar Molecules
  - Dissolve in the membrane
  - smaller move faster than larger
- Polar molecules
  - small polar uncharged go right between the phospholipids

Polar vs Non Polar Entry



Movement Across Membranes

- Polar molecules
  - Larger molecules need a transport protein
  - Ions also need transport help.
- Protein transport
  - Transport Proteins – Specific molecules or ions can pass through integral proteins
    - May have a tunnel (due to hydrophilic amino acids)
    - May bind and physically move it across membrane
    - Are specific for the substance they transport.

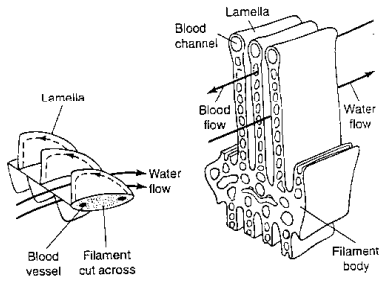
Passive Transport

- Concentration Gradient
  - Change of concentration over a given distance.
- Net directional movement
  - overall movement away from center of concentration
  - Diffusion- net movement from high to low concentration.
    - Due to kinetic energy, random molecular movement
    - Continues until dynamic equilibrium.

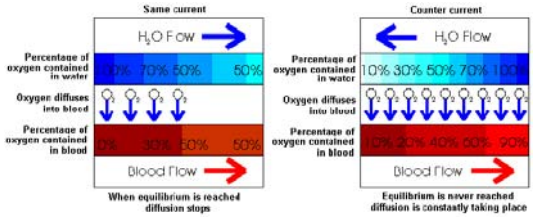
Passive Transport

- Diffusion of a substance across a biological membrane.
  - No energy required.
  - Concentration gradient drives it
  - Rate regulated by permeability, concentration
    - How do you get the most efficient diffusion?
      - Steep gradient
      - Short Distance

Counter Current Exchange



Counter Current Exchange



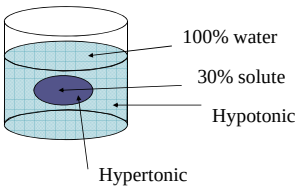
Osmosis

- Osmosis is the passive transport of water across a membrane. (from high to low concentration)
  - Hypertonic – A solution with a greater concentration of solute.
  - Hypotonic – A solution with a lower concentration of solute
  - Isotonic – A solution with an equal amount of solute.

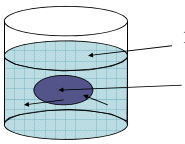
Solute and Water

- Solute- What is dissolved in the solvent
- Solvent- the medium in which molecules are being distributed.
  - Hypertonic- More solute as compared to another location.
  - Hypotonic- Less solute as compared to another location.
  - Isotonic- equal solute as compared to another location

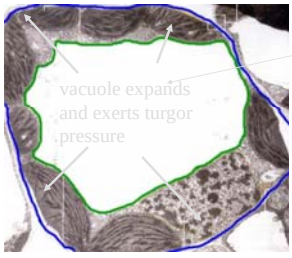
Water movement due to solute concentration



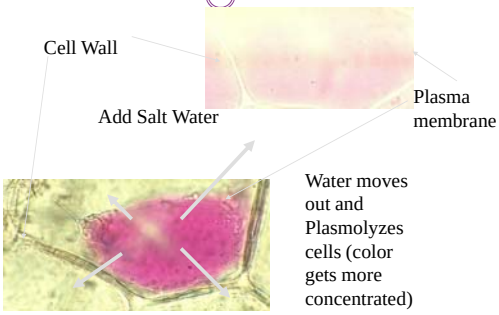
Water movement due to solute concentration



Cells with Walls



Plasmolysis



Lysis

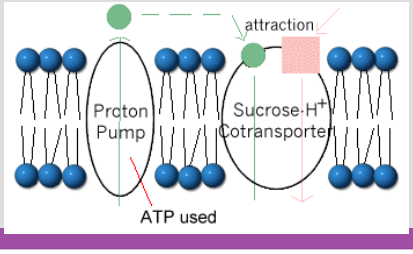
- When water rushes in, cells that don't have cell walls can Lyse.
- Bursting due to too much osmotic pressure.

Protein and Facilitated Diffusion

- Facilitated Diffusion: Diffusion across a membrane with the help of transport proteins.
  - Passive
  - Helps polar molecules and ions that are slowed down by the membranes lipid nature.
  - They are like enzymes because
    - have active sites
    - Max rate can be reached.
    - Can be inhibited.

Transport

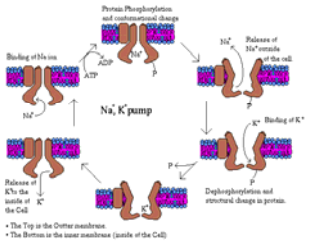
- ATP powered pump helps transport another substance as it moves back with the gradient.



Active Transport

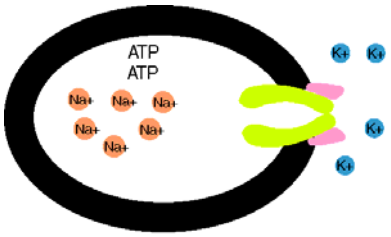
- Energy is required to go against the gradient.
- $+\Delta G$
- Requires energy
- Helps maintain steep gradients
- Transport proteins work with ATP to provide energy necessary.

Sodium Potassium Pump



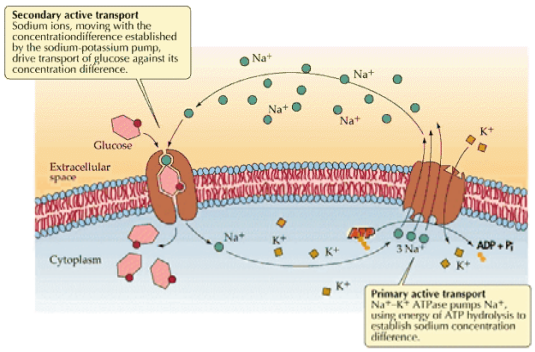
Three sodium are pumped out for every two potassium pumped in. Each is being pumped against the concentration gradient.

Na/K Pump

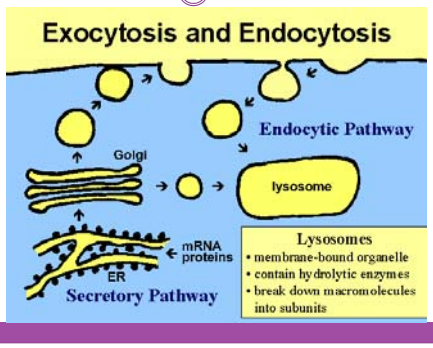


Electrogenic Pumps

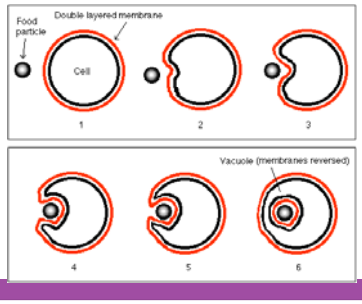
- Na/K ATPase: Main electrogenic pump in animal cells
- Proton pumps: plants, bacteria, and fungi and Chloroplasts, Mitochondria.
- Pumps are used to do work in organisms.
  - contract muscles
  - Make ATP
  - Conduct Nerve Impulses



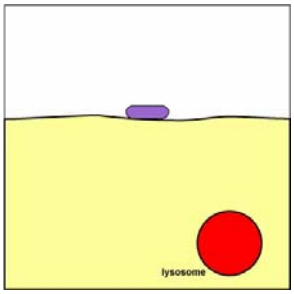
Exocytosis



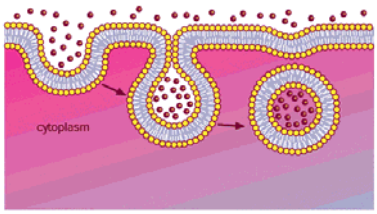
Endocytosis



Phagocytosis



Pinocytosis



Receptor Mediated Endocytosis