Biological Membranes

Inside cell

Outside cell

Plasma membrane

Model of Membrane Structure

• Fluid mosaic model
  • Singer & Nicholsen, 1972
  • Cell membrane is a fluid with proteins embedded or attached to the edge of membrane
  • Proteins & lipids can freely move about

Membrane Fluidity: Frye & Edidin (1970)

• Separately labeled mouse & human cells w/ red & green fluorescent antibodies
• Fuse the differently colored cells
• Colors mix in ~ 30 minutes; see with fluorescence microscope
Protein & lipid mobility

- Lateral movement of lipids/proteins is quick
- Lipids & proteins rarely flip across the lipid bilayer

The **fluid mosaic model today**

Organelles - Endomembrane System

- Biological membranes easily seal to form closed compartments
- Membranous compartments form vesicles, which travel to & fuse with other compartments
  - Carrying lipid & protein from one compartment to another
- Provide special sites for biological chemistry
  - Nucleus
  - Endoplasmic reticulum
  - Golgi apparatus
  - Lysosomes
  - Numerous vesicles
Functions of Membrane Proteins

- Cell junctions: hold cells together & pass molecules between cells
- Cell anchors: hold cells to substrate
- Passive transport: channels allow molecules to diffuse across membrane
- Active transport: pump molecules in/out of cell using ATP to power the process

Functions of Membrane Proteins

- Enzymes: catalyze reactions
- Cell receptors: identify molecules on invading cells
  - Cell markers on surface of bacteria
- Transduce signals of hormones: extracellular molecules can generate a signal in the interior of the cell

Membrane proteins in action
Membrane Permeability

- Biological membranes are **selectively permeable**
  - Small molecules & lipids readily pass through the membrane
  - Larger & charged/polar molecules cannot pass through without help
  - Proteins allow movement of charged/polar molecules

Diffusion

- Groups of molecules vibrate
  - Tend to spread apart over time = diffusion
  - Center of distribution does not change position
  - Center concentration & the position of the edge of the distribution does change

**Diffusion**

- **Concentration gradient**: a difference in concentration of a substance over distance
- **Diffusion** = net movement of particles from a region of high to low concentration
  - Down a concentration gradient
  - **change in a gradient of concentration over time**
  - Gradient becomes more gradual in nature with time
- At equilibrium (after a long time of diffusion), particles are uniformly distributed.
- **What factors affect diffusion rates?**
Osmosis

• *Osmosis* = diffusion of water across a membrane
• Since cells have membranes, osmosis is important to cells

Membranes & Osmosis

• Tank w/ *semipermeable* membrane: water may pass, solute cannot
• At first the concentration of solute is very high on the left
• But over time, the water moves across the semipermeable membrane & dilutes the solute

![Diagram of osmosis](image)

Osmotic Pressure

• Water builds up on the side of the solute
  • Flow will stop when it comes to equilibrium
• If the water were allowed to flow until it stopped, we would see that the water had risen
• We could alternatively apply a piston to the top of the water on the solute side & apply pressure
• In either case, the pressure needed to stop the water flow is called the *osmotic pressure*. 
Osmotic Vocabulary

<table>
<thead>
<tr>
<th>[Solute] in A</th>
<th>[Solute] in B</th>
<th>Tonicity</th>
<th>Direction of water flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater</td>
<td>Less</td>
<td>A hypertonic to B</td>
<td>B to A</td>
</tr>
<tr>
<td>Less</td>
<td>Greater</td>
<td>B hypertonic to A</td>
<td>A to B</td>
</tr>
<tr>
<td>Equal</td>
<td>Equal</td>
<td>A &amp; B are isotonic</td>
<td>No net movement</td>
</tr>
</tbody>
</table>

Animal Cells & Osmotic Pressure

- Hypotonic solutions produce osmotic pressure that produces turgor pressure
  - Turgor = "tight or stiff owing to being very full"
  - Keeps plant upright; hypertonic conditions plants wilt

Plant Cells & Osmotic Pressure
Facilitated diffusion

- Involves membrane proteins "helping" solutes move down gradient
- A transport protein can be a carrier or channel protein
- Movement is powered by a concentration gradient.

Facilitated diffusion using a channel protein
Active Transport

• Energy (from ATP) is used to move solutes across the membrane, UP a gradient
  • Low to high
  • Na/K pump

• Here, two gradients are formed, one for each ion.
  • Gradients have opposite orientation
  • Sodium is high outside, low inside
  • Potassium is high inside, low outside

Movement of large molecules OUT of a cell

• Exocytosis shown
• Very energy-expensive
  • Source of energy?
• Release of solutes/particles:
  • Wastes
  • Signaling molecules such as neurotransmitters or hormones

Endocytosis: Phagocytosis

• Uptake of particles
• Cell “eating” (bacteria, viruses, etc)
• Food particles are digested by fusion of the uptake vacuole with lysosomes
Endocytosis: Pinocytosis

- Cell "drinking" of watery fluids
- Not extremely specific or targeted

Receptor-Mediated Endocytosis

- Receptor on the surface of cell binds specific molecule
- Receptors & transported molecules are taken into the cell
- Here, cholesterol uptake by the LDL receptor

Cell Junctions

- Cells are connected by special junctions
  1. Desmosomes
  2. Tight junctions
  3. Gap junctions
  4. Plasmodesmata
Desmosomes

- Desmosomes hold cells together
- Kind of like velcro!
- Intermediate filaments hold desmosomes in cell

Tight Junctions

- Tight junctions hold cells very tightly together
- Solute cannot pass around cells
- Common in intestine cells

Gap Junctions: Transmembrane Channels

- Allow small ions to pass b/n cells
- Heart cell communication
Plasmodesmata

- Large channels b/n plant cells
- Allow movement of big molecules across membrane & cell wall