Molecules Movement in a Cells

- Passive Transport
- Active Transport

Passive Transport

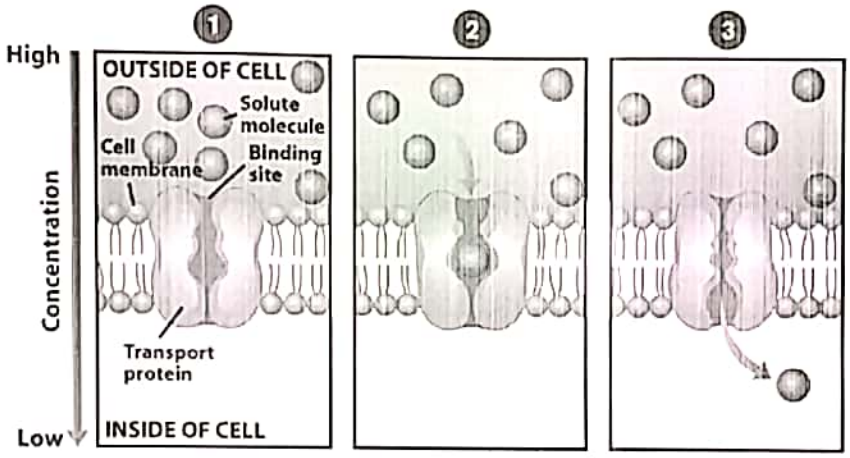
- No energy required
- Move due to gradient - differences in concentration, pressure, charge.
  Move to equalize gradient - High moves toward low

Types of Passive Transport

1. Diffusion
2. Osmosis
3. Facilitated diffusion

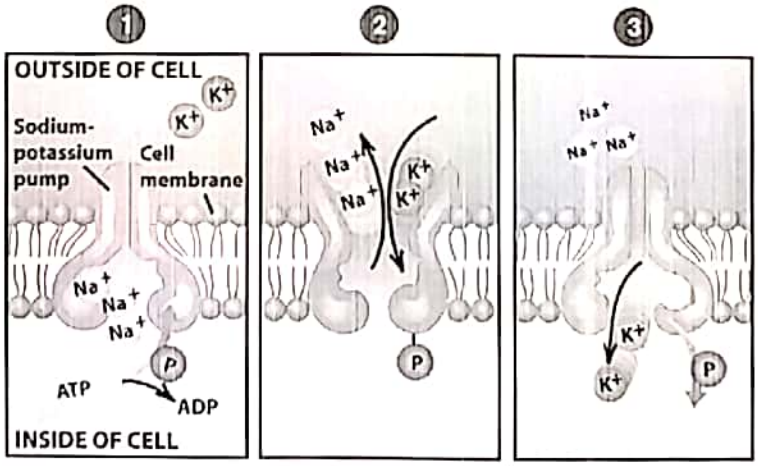
Process of Facilitated Transport

- Protein binds with molecule
- Shape of protein changes
- Molecule moves across membrane



Active Transport

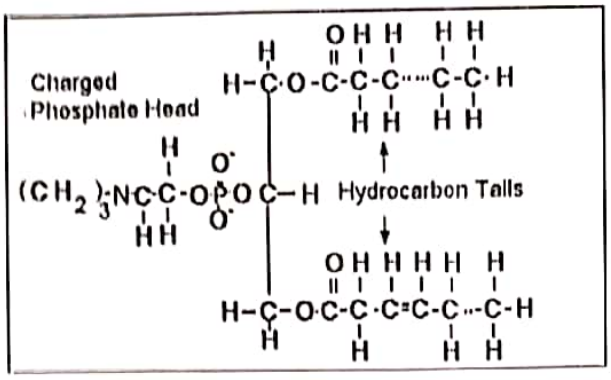
- Molecular movement
- Requires energy (against gradient)
- Example is sodium-potassium pump

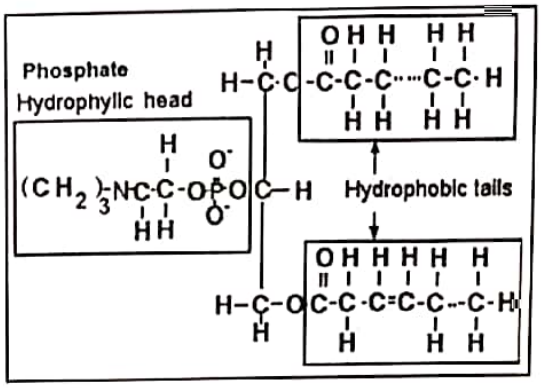


Cell Membrane

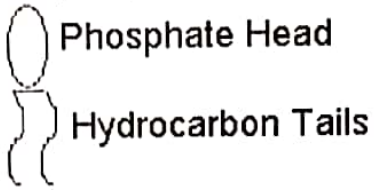
- The cell membrane is a dynamic and intricate structure that regulates material transported across the membrane.
- The membrane is selectively permeable (or semi-permeable) meaning that certain molecules can cross the membrane and others cannot.

All cells have plasma membranes and many of their organelles also have membranes. All membranes are made from a bilayer of phospholipids.





Phospholipids have hydrophilic heads and hydrophobic tails.



The cell membrane has two layers of phospholipids as shown below. The hydrophilic heads are facing an aqueous environment and the hydrophobic tails are facing one another.
Membranes are more fluid when they contain more unsaturated fatty acids within their phospholipids. More unsaturated fatty acids result in increased distance between the lipids making the layer more fluid.

Cholesterol

Cholesterol is found in the cell membranes of animals but not plants. It affects the fluidity of the membrane.

Cholesterol Functions in 3 ways

1. It can weakly bind to hydrocarbon tails making it more difficult for smaller molecules to cross membrane.
2. If the phospholipids are saturated, it prevents them from being packed too closely, making the membrane more fluid.
3. However - if the phospholipids are unsaturated there are kinks in the tails where the cholesterol molecules can fill in and anchor them making the membrane less fluid.

Proteins in Fluid Mosaic Model

- Proteins are "stuck" in the membrane like a mosaic.
- Proteins can be on just the surface (peripheral) or embedded in the membrane (intrinsic). Proteins that span the entire membrane are called "transmembrane"
- It is the different proteins that are responsible for the uniqueness of different membranes (plasma, eukaryotic, prokaryotic, organelle etc.)

- Transport proteins
- Function of Membrane Proteins
- 1. Transport proteins transport molecules across the membrane. Aquaporins are special protein channels used to move water across the membrane.

- A transport protein is specific for the substance it translocates (moves), allowing only a certain substance (or substances) to cross the membrane.

Types of transport proteins

1. Channel proteins – function by having a hydrophilic channel that certain polar molecules or ions use as a tunnel
   - Ex. Aquaporins
   - Carrier proteins – function by holding onto their passengers and change shape in a way that shuttles them across the membrane
2. Channel proteins would only allow for passive transport (down the concentration gradient) while carrier proteins can allow for passive or active (up the concentration gradient) transport
3. Enzyme-Some proteins in the membrane may expose their active site to speed up a chemical reaction.
4. Receptor site-Ex. Insulin never goes into a cell but binds to a receptor site on the cell membrane
5. Cell to cell recognition (glycoproteins).
6. Intercellular joining (adhesion)
7. Attachment to the cytoskeleton (intracellular) and extracellular matrix (only in animal cells)

Donnan equilibrium

- Also known as Gibbs–Donnan effect, Donnan's effect, Donnan law, Donnan equilibrium, or Gibbs–Donnan equilibrium.
- It is a name for the behaviour of charged particles near a semi-permeable membrane that sometimes fail to distribute evenly across the two sides of the membrane.
- The usual cause is the presence of a different charged substance that is unable to pass through the membrane and thus creates an uneven electrical charge.
- Such as the large anionic proteins in blood plasma are not permeable to capillary walls. Because small cations are attracted, but are not bound to the proteins, small anions will cross capillary walls away from the anionic proteins more readily than small cations.
- Some ionic species can pass through the barrier while others cannot.
- The solutions may be gels or colloids as well as solutions of electrolytes, and as such the phase boundary between gels, or a gel and a liquid, can also act as a selective barrier.
- The electric potential arising between two such solutions is called the Donnan potential.
- The effect is named after the American physicist Josiah Willard Gibbs and the British chemist Frederick G. Donnan.
- The Donnan equilibrium is prominent in the triphasic model for articular cartilage proposed by Mow and Lai, as well as in electrochemical fuel cells and dialysis.
- The Donnan effect is extra osmotic pressure attributable to cations (Na^+ and K^+) attached to dissolved plasma proteins.

Membrane Potential

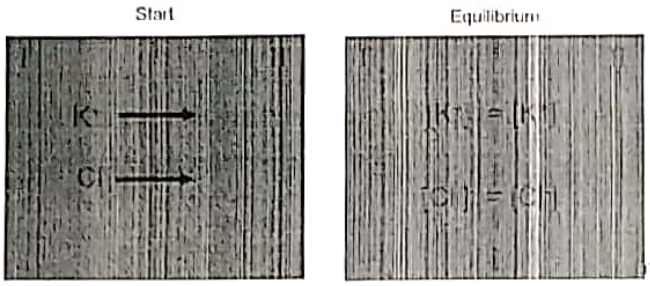
- Inside of cell is negative compared to outside
- Depends on:
  - High concentration K+ inside
  - Selective permeability of membrane

What causes the different ion distributions in cells?

1. Passive distribution – Donnan equilibrium
2. Active Transport

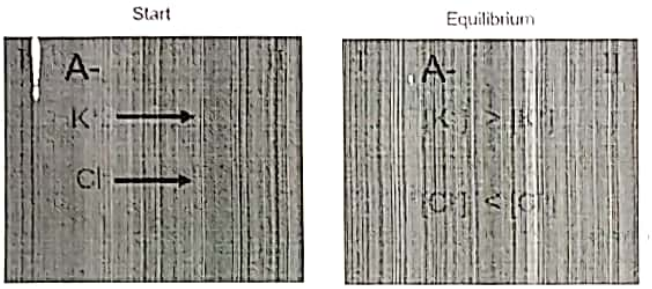
Passive distribution – Donnan equilibrium

- The ratio of positively charged permeable ions equals the ratio of negatively charged permeable ions



$$\frac{[K^+]_I}{[K^+]_{II}} = \frac{[Cl^-]_{II}}{[Cl^-]_I}$$

- Another way of saying the number of positive charges must equal the number of negative charges on each side of the membrane.
- BUT, in real cells there are a large number of negatively charged, impermeable molecules (proteins, nucleic acids, other ions)
- call them A^-



$[K^+]_I = [A^-]_I + [Cl^-]_I$

$[K^+]_{II} = [Cl^-]_{II}$

If $[A^-]_I$ is large, $[K^+]_I$ must also be large

- The presence of impermeable negatively charged molecules requires more positively charged molecules inside the cell.

Let Initial Concentrations

I	II
A^- = 100	A^- = 0
K^+ = 150	K^+ = 150
Cl^- = 50	Cl^- = 150

$$\frac{[K^+]_I}{[K^+]_{II}} = \frac{[Cl^-]_{II}}{[Cl^-]_I}$$

Let X be the amount of K+ and Cl- that moves

$$\frac{150+X}{150-X} = \frac{150-X}{50+X}$$

Are these ions in electrochemical equilibrium?
No,
E_{K^+} = 0 mV
E_{Cl^-} = -27 mV

Solve for X, $7500 + 200X + X^2 = 22500 - 300X + X^2$
X=30

Therefore Final Concentrations are

I	II
A^- = 100	A^- = 0
K^+ = 180	K^+ = 120
Cl^- = 80	Cl^- = 120

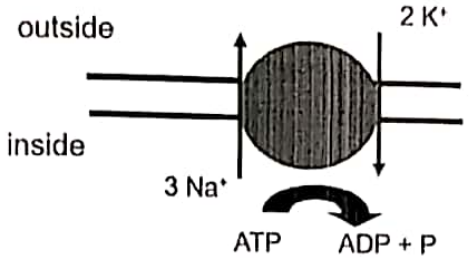
space-charge neutrality

Are these ions in electrochemical equilibrium?
Yes,
E_{K^+} = -10 mV
E_{Cl^-} = -10 mV

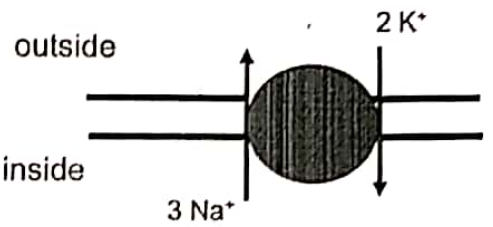
Active Transport

- **ATP-powered pumps - Proteins that are capable of pumping ions from one side of the cell membrane to the other.**
- **Use energy**

•Na⁺ - K⁺ pump

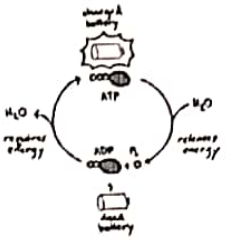


•Na⁺ - K⁺ pump



•Na⁺ - K⁺ pump
- –3 Na⁺ move out
- –2 K⁺ move in
- –Hydrolyzes ATP

•Maintains the concentration gradient



➢Electrogenic
- net loss of 1 positive charge from inside
- Inside becomes more negative
- contributes a few mV to resting potential

- **Na^+/K^+ pump is required**
  - **Due to low permeability for Na^+ to leak into the cell**
  - **Without pump,**
    - → **Gradual accumulation of +'ve charge inside**
    - → **Eventually lose the membrane potential**