Cell (plasma) membranes and transport

Fluid mosaic model

Singer and Nicholson proposed this model for the structure of the cell membrane in 1972.

Fluid - because the phospholipid molecules within a layer can move relative to each other.

Mosaic- because the proteins within the phospholipid layer are of different sizes and shapes and form different patterns.

Permeability

Cell membranes are **selectively permeable**. They only allow certain molecules through.

Permeability can be increased by:

- **Temperature** - increases above 40°C increase vibrations of phospholipids, moving them further apart.
- **Organic solvents** - dissolve phospholipids.

Lipid soluble substances (vit A) and small molecules (O^2 and CO^2) can dissolve and move **directly through the phospholipid bilayer.**

Water soluble substances (glucose, ions, all polar molecules) cannot pass through the hydrophobic fatty acid tails and so **must use intrinsic proteins to pass though.**

Phospholipid bilayer

The **hydrophilic phosphate heads** of the phospholipids form the outer and inner surface of the cell membrane.

The **hydrophobic fatty acid tails** of the phospholipids point towards each other.

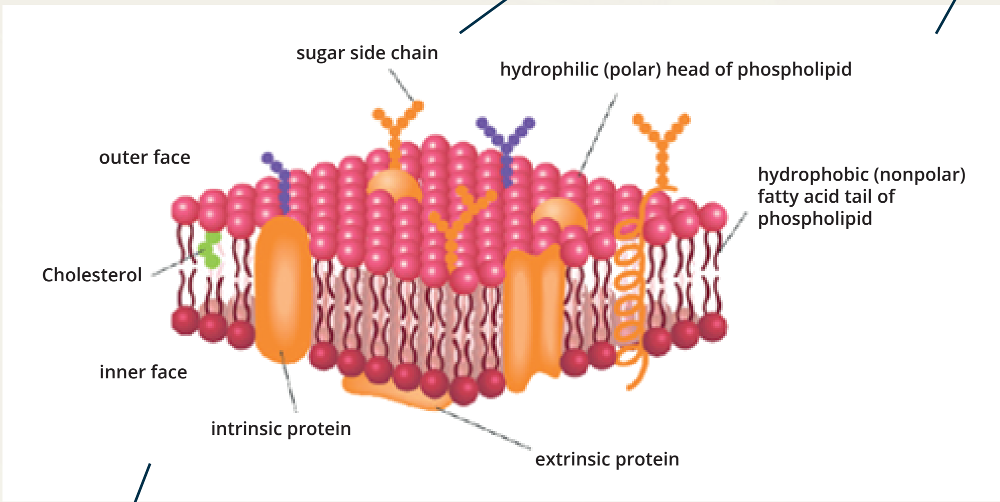
Extrinsic proteins

Found on **either outer surface** of the bilayer.

Those with sugars attached **(glycoproteins)** form the glycocalyx layer of the membrane which has a role in **cell to cell recognition** or **hormone receptor sites.**

Cholesterol

Found between the phospholipids making it more rigid and stable.



Intrinsic proteins

These proteins span the whole phospholipid bilayer and can form:

Channel proteins - pores lined with polar (hydrophilic) groups that allow charged ions through, e.g. Na+

Carrier proteins - allow larger polar molecules through, such as water-soluble **sugars** and **amino acids**. Binding of the molecules changes the shape of the protein moving the substance into or out of **the cell.**

The polarity of proteins determines if they sit on the membrane (extrinsic) or through it (intrinsic).

Water potential (ψ)

0 Pure water

-300 Some dissolved solutes

-800

The more solute in solution the more negative the water potential

Osmosis

The diffusion of water from a region of high water potential to low water potential across a selectively permeable membrane.

Water potential (ψ) is the tendency of water molecules to move. The solute potential is the osmotic strength of the solution. As shown to the left, the water potential of pure water is 0 and becomes more negative as the concentration of the solution increases.

In plant cells: $\psi = \psi p + \psi s$

Turgid(firm) cells - in **a hypotonic** (less concentrated solution) cells take up water by osmosis. The pressure potential of the cell increases as the cytoplasm pushes on the cell wall.

Incipient plasmolysis - A cell in this state has lost enough water for the cell membrane to start being drawn away from the cell wall. This lowers the pressure potential to 0.

Plasmolysed - Cells in hypertonic (more concentrated) solutions become **flaccid** (floppy).

<u>**In animal cells**</u>: It is important animal cells are in an **isotonic** solution (same concentration of dissolved solutes inside and outside cell) as they lack a cell wall. Cells can **burst** in hypotonic and **shrink** in hypertonic solutions due to osmosis.

Cell (plasma) membranes and transport

Diffusion

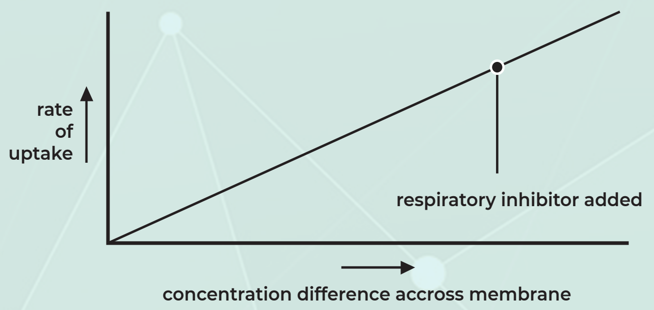
Simple diffusion

Diffusion is the movement of molecules from a region of high concentration to a region of low concentration down a concentration gradient. It is a **passive process** and so requires no energy. **Simple diffusion occurs through the phospholipid bilayer.**

Diffusion rate is increased by:

- higher concentration gradient
- thinner membrane/shorter diffusion distance
- larger surface area
- smaller molecules
- being non-polar or fat soluble
- increased temperature.

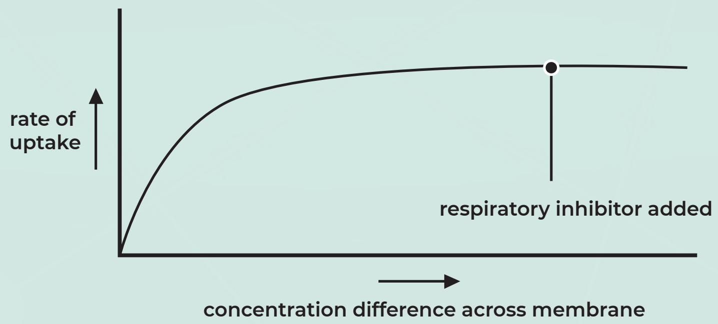
The graph shows that as the concentration on one side of the membrane increases there is a directly proportional increase in the rate of diffusion. Respiratory inhibitors like cyanide (leading to lack of energy) has no effect on the rate of diffusion.

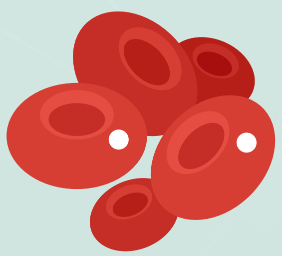


Facilitated diffusion

This is the process of diffusion but for polar molecules or ions that cannot pass directly though the phospholipid bilayer.

All of the **same rules apply as for diffusion**, the only difference is that substances enter the cell through **protein channels.** The effect of this is shown in the graph below. A continuing increase in the concentration will eventually lead to a maximum rate being reached due to the limiting effect of the number of channels available. This is a **passive process, therefore**, the **respiratory inhibitor has no effect.**

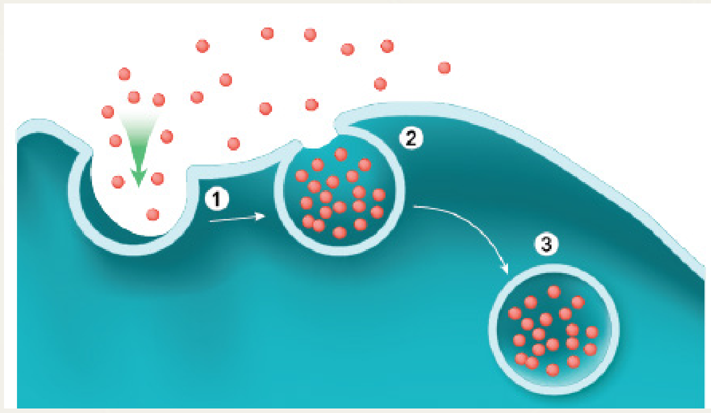




Co-transport

This is a type of facilitated diffusion where two different substances use the same carrier protein at the same time.

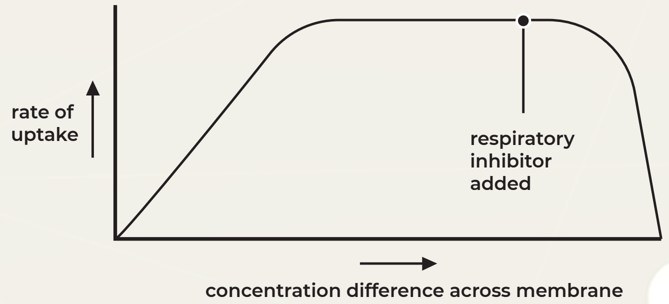
E.g. a molecule of glucose and 2 sodium ions attach to a carrier protein on the outer side of the membrane. This changes the shape of the protein sufficiently to flip them to the inside of the membrane. They can then diffuse separately through the cell.



Active transport

This moves molecules against a concentration gradient, i.e. from where they are in lower concentration to where they are already at a higher concentration. This process requires energy in the form of ATP from respiration. The ATP activates carrier proteins to move molecules across the cell membrane.

As this relies on ATP the addition of a respiratory inhibitor or lack of oxygen will also prevent transport as there will be no ATP available.



Bulk transport

Endocytosis - 2 main types

- **Phagocytosis** - solids enter the cell.
- **Pinocytosis** - liquids enter the cell.

1 Plasma membrane folds inwards

2 Plasma membrane engulfs the material.

3 Vesicle formed from plasma membrane enters the cell.

Exocytosis

3 Vesicle formed from the golgi moves towards the plasma membrane.

2 Vesicle fuses with plasma membrane

1 Vesicle contents empty out of cell.