4.3 Transport across plasma membrane

The internal composition of the cell is maintained because the plasma membrane is a selectively permeable structure. The plasma membrane forms a barrier that blocks the free exchange of molecules between the cytoplasm and the external environment of the cell.

Most biological molecules are unable to diffuse through the protein-free phospholipid bilayer (or synthetic lipid bilayer). Small non-polar molecules, such as O_2 and CO_2, readily dissolve in synthetic lipid bilayers and therefore diffuse rapidly across them. Small uncharged polar molecules, such as water or urea, also diffuse across a synthetic lipid bilayer. By contrast, synthetic lipid bilayers are highly impermeable for charged molecules (as shown in the figure 4.8).

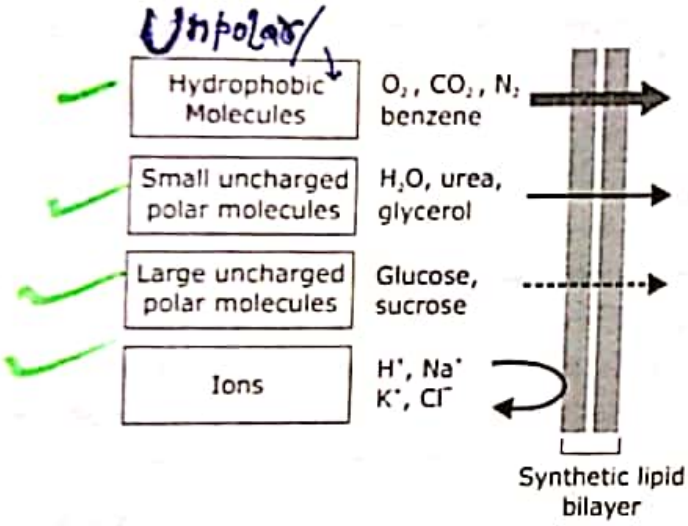

Figure : 4.8
The relative permeability of different classes of molecules across synthetic lipid bilayer. Bilayer is permeable to small hydrophobic molecules and small uncharged polar molecules, slightly permeable to water and urea, and essentially impermeable to ions.

However the plasma membrane unlike synthetic lipid bilayer allow the passage of various polar molecules such as ions, sugars, amino acids and others. Special classes of transport proteins (carrier and channel) are responsible for transferring such solutes across cell membranes. Thus the transport across plasma membrane can occur either through the lipid bilayer or through the transport proteins. The characteristics of lipid-phase diffusion and protein mediated transport are basically different. Transport across the plasma membrane is of two types:

1. **Passive transport**

   It occurs along the concentration gradient and without the use of metabolic energy. It may be-

a. **Simple diffusion**

During simple diffusion, a molecule simply dissolves in the phospholipid bilayer, diffuses across it. No membrane proteins are involved and the direction of transport is determined simply by the relative concentrations of the molecule inside and outside of the cell.

The relative diffusion rate of any substance across a *pure* phospholipid bilayer is proportional to its *concentration gradient* across the layer and to its *hydrophobicity* and *size*. The hydrophobicity of a substance is measured by its *partition coefficient*. It is the equilibrium constant for partition of the molecule between oil and water. The higher the substance partition coefficient, the more lipid soluble it is.

Movement of solutes by diffusion is always from a higher to a lower concentration, and the rate is described by *Fick's law of diffusion*.

$$J = -D\left(\frac{\Delta c}{\Delta x}\right)$$

Where J is the flux per unit area, D is the *diffusion coefficient* (usually expressed as cm^2/sec), and Δc is the difference in concentration between two regions separated by a distance Δx (membrane thickness in case of membrane transport). The negative sign accounts for the fact that diffusion is towards the lower concentration.

Simple diffusion is a *nonselective* process by which any molecule able to dissolve in the phospholipid bilayer is able to cross the plasma membrane and equilibrate between inside and outside of the cell. The rate of diffusion of the molecule will be proportional to its hydrophobicity. Gases (such as O_2 and CO_2), hydrophobic molecules (such as benzene), and small polar but uncharged molecules (such as H_2O and ethanol) are able to diffuse across the plasma membrane.

b. Facili... determined

b. **Facilitated diffusion**

Facilitated diffusion, like passive diffusion, involves the movement of molecules in the direction determined by their relative concentrations inside and outside of the cell. However, the passage is mediated by transport protein called **permease** and is selective in nature.

The rate of transport of the molecule across the membrane is far greater in facilitated diffusion as compare to simple diffusion. Facilitated diffusion allows polar and charged molecules, such as carbohydrates, amino acids, nucleosides, and ions, to cross the plasma membrane.

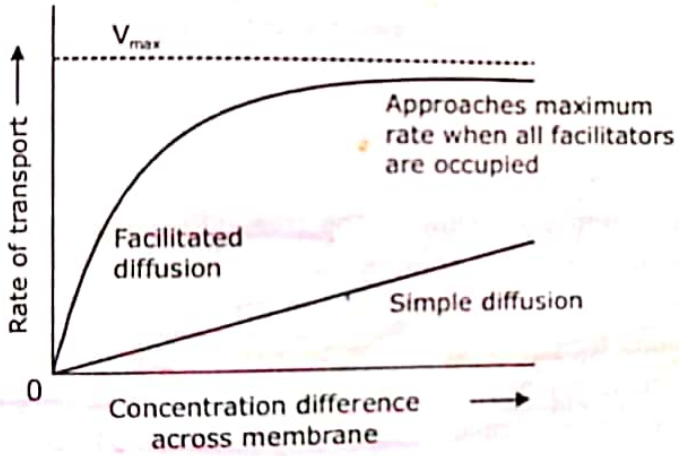

Figure : 4.9
Facilitated and simple diffusion.

2. Active transport

Active transport occurs against the concentration gradient and is mediated by carrier proteins. Metabolic energy is used to move ions or molecules against a concentration gradient. Active transport results in the accumulation of solute on one side of membrane. Active transport is different from carrier proteins mediated facilitated diffusion. Comparison of facilitated and active transport is given in the following table.

Table 4.3 : Comparison of facilitated diffusion and active transport

Facilitated diffusion	*Active transport*
Selective	Selective
Passive	Active
Occurs along the concentration gradient	Occurs against the concentration gradient
Transport protein involved	Transport protein involved
Saturable	Saturable
Entropy increases	Entropy decreases

Active transport is of two types: Primary active transport and secondary active transport