Course- B.Sc. (Honours), Part -3

Subject- Botany, Paper-V

Group-A, Plant Physiology

Topic- Diffusion

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Binod Kumar Pandey

Assistant Professor & HOD, Botany Department,

Ram Ratan Singh College, Mokama, Patna.

E.mail- binodkp14@gmail.com

Diffusion

The movement of the molecules of gases, liquids and solids from the region of higher concentration of the region of lower concentration is known as Diffusion. It may occur between gas and gas, liquid and liquid, or solid and liquid.

Diffusion may also be defined as movement of molecules from regions of higher partial pressure to regions of lower partial pressure as a result of their inherent kinetic energy. For example, when a cube of sugar is dropped in a beaker containing water, the sugar slowly dissolves and its molecules move, without being carried by current, from surface of the cube to other parts of the water in the beaker.

After sometime, the sugar cube disappears and the sugar particles become uniformly distributed throughout the water (Fig. 1.1). Similar is the case with gases—two gases liberated within a closed chamber soon diffuse throughout the whole available space and become thoroughly mixed. Its operation is familiar in respect to odor.

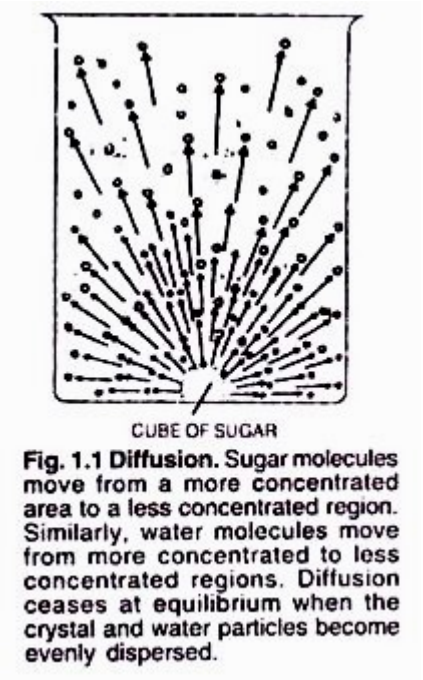

Fig. 1.1 Diffusion. Sugar molecules move from a more concentrated area to a less concentrated region. Similarly, water molecules move from more concentrated to less concentrated regions. Diffusion ceases at equilibrium when the crystal and water particles become evenly dispersed.

Diffusion of molecules or ions through a membrane are of two types:

(a) Simple diffusion:

Diffusing molecules or ions do not combine with the constituents of the membrane.

(b) Facilitated diffusion:

Diffusing molecules move through the membrane with the help of transport protein or carrier proteins.

Diffusion Pressure (DP):

The term was coined by Meyer (1938) to denote the potential ability of the molecules or ions of any substance to diffuse from an area of their higher concentration to that of their lower concentration. Diffusion pressure is directly proportional to the number of diffusing particles. Therefore, more the concentration of diffusing molecules in a system, their diffusion will also be greater. Pure water (solvent) would have more diffusion pressure than sugar solution.

Factors Affecting Diffusion:

The force of diffusion of molecules is their kinetic energy (i.e, chemical potential). The phenomenon of diffusion is, therefore, considered to be due to the differences in the chemical potential or the free energy of the components of a system. All the factors that alter the chemical potential of molecules will ultimately influence the rate of diffusion.

Some of the important factors are given below:

(A) Diffusion Pressure Gradient (DPG):

The rate of diffusion of any substance is directly proportional to the difference in concentration of its molecules or ions in the two regions, and inversely proportional to the distance between these two regions. Thus, the differences in diffusion pressures determine the rate and direction of diffusion.

(B) Temperature:

Temperature greatly influences the rate of diffusion. If the temperature is raised, diffusion is accelerated because the velocity of the diffusing particles is increased.

(C) Density:

Concentration of the diffusing particles and the density of the liquid or gas through which the diffusion occurs markedly influences the rate of diffusion. Density of the diffusing gas itself determines the rate of diffusion. Lighter the gas, greater will be the rate of its diffusion. According to the law of diffusion of gases, the rate of diffusion is inversely proportional to the square root of the density of gas.

$$D \propto \frac{1}{\sqrt{d}}$$ ('D' is diffusion, 'd' is density of diffusing substance).

According to the density the diffusion of substances takes place in following manner:

Gas > Liquid > Solid.

Importance of Diffusion in Plants:

1. The exchange of gases through stomata (for example, CO_2 intake and O_2 output during photosynthesis, and CO_2 output and O_2 intake during respiration takes place by the principal of independent diffusion.
2. Transpiration involves the process of diffusion.

3. The ions are absorbed by the simple diffusion during pas

4. Diffusion is an effective means of transport of substances helps in the translocation of food material.

5. Aroma in the vicinity of flowers is nothing but the diffusion of the volatile aromatic compounds. Thus, the diffusion helps to attract insects and other animals for pollination.

6. Diffusion keeps the cell walls of the internal plant tissues moist.

7. It is a means of spreading of ions and other substances throughout the protoplast.

Significance of Diffusion:

1. The process of diffusion is involved in the transpiration of water vapours.

2. Gaseous exchange during the process of respiration and photosynthesis takes place with the help of diffusion.

3. During passive salt uptake the ions are absorbed by the process of diffusion.

4. It also helps in translocation of food materials.

5. Gas exchange in submerged hydrophytes takes place by general body surface (epidermis) through diffusion.

6. Aroma of flowers is due to diffusion of volatile aromatic compounds to attract insects.

Permeability and Membranes:

Permeability is the degree of diffusion of gases, liquids and dissolved substances through a membrane. The ability of a substance to pass through a membrane is also called as permeability A membrane may be freely permeable for one substance, moderately permeable for the second one and may be completely impermeable for the third one.

On this basis following types of membranes have been recognized:

1. Freely permeable membrane:

This type of membrane allows free movement (passage) of various substance, such as water, other solvents, various ions and dissolved solutes, e x – Cell wall.

2. Impermeable membrane:

This type of membrane does not allow any kind of movement through it., e.g., – cultinized cell wall.

3. Semi-permeable membrane:

This type of membrane allows only solvent particles to pass through it. It does not allow the movement of solute particles, e.g., egg membrane, animal bladder, parchment membrane. These can be prepared artificially also.

4. Selectively permeable membrane or differentially permeable membrane:

These membranes allow only some selected molecules (of solute and solvent) to pass through it. Most of the biological membranes, such as cell membrane, tonoplast (vacuolar membrane) and the membrane surrounding the sub-cellular organelles are selectively permeable These membranes give a differential treatment to different kinds of molecules. Some molecules move very rapidly, some move very slowly, while rest other do not move at all. A nonliving selectively permeable membrane is cellophane.