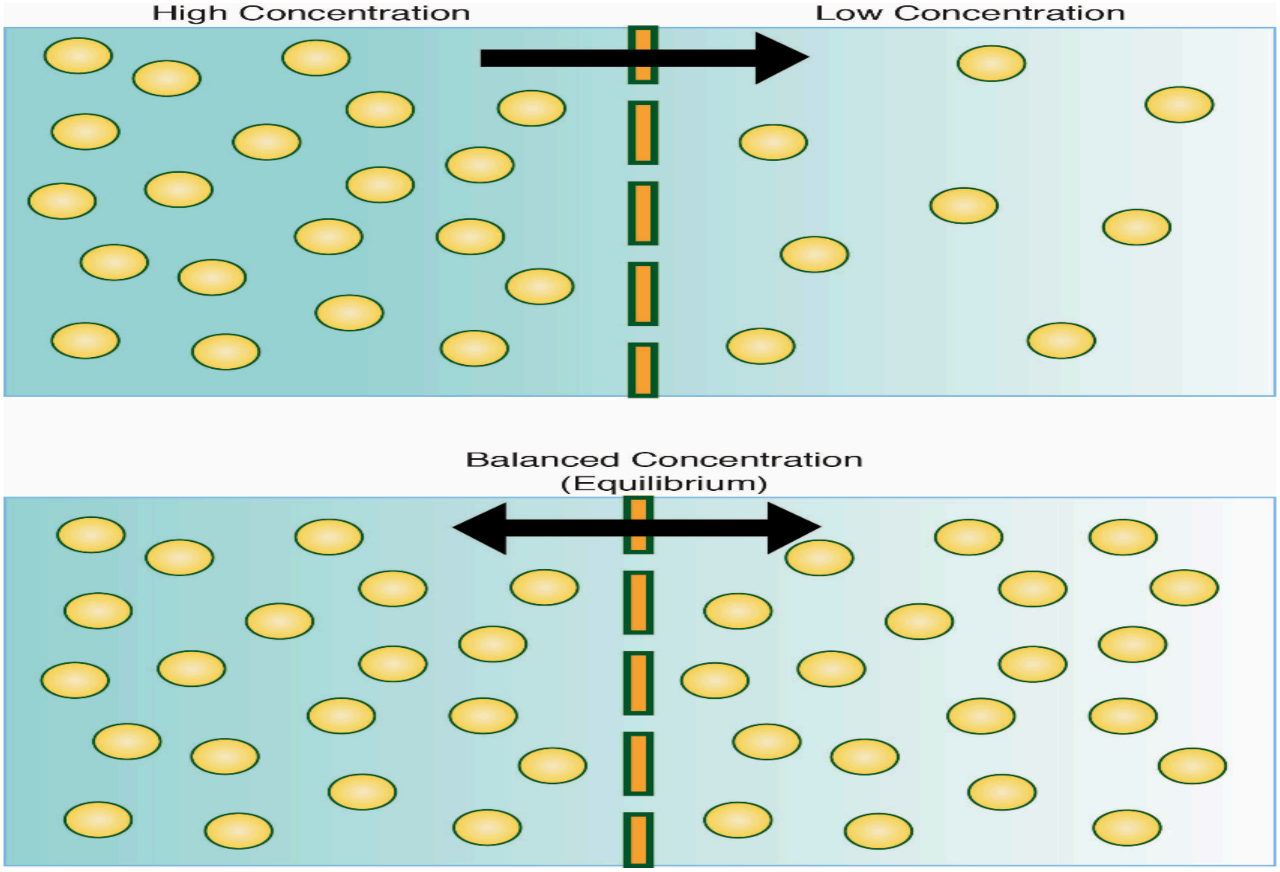
5.2.1

Simple Diffusion

Diffusion is a process that results from the fact that molecules are constantly in a state of random movement. They move in a straight line until they collide with another molecule, causing them to bounce off in a different direction. If there is an initial, unequal distribution of the molecules (i.e. more concentrated in one area than another), the constant random movement and collisions cause them to eventually become equally distributed. This process of gradual movement from where they are more concentrated to where they are less concentrated is called *diffusion*. We refer to the concentration difference as the **concentration gradient**.

Therefore, substances diffuse down their concentration gradients (from high to low concentration). Once the molecules are evenly distributed, we say that we have reached a state of **diffusion equilibrium**, and even though the molecules are still moving, there is no longer any net change in concentration. You can observe this phenomenon by carefully placing a drop of food coloring into a glass of water. The dye gradually moves through the liquid until it is evenly dispersed in the water. In the body, if the material in question can pass through the cell membrane without the aid of a membrane protein, we refer to the process as **simple diffusion**. Solutes that cross the membrane by simple diffusion tend to be hydrophobic. Examples of substances that cross the membrane by simple diffusion are the gasses CO2 and O2. The following video demonstrates the process of diffusion and explores some of the factors that influence the rate of diffusion. See if you can answer the questions posed in the video before reading the next section.

https://books.byui.edu/-bNsc (Transcription Available)



Simple Diffusion: Process of Moving from High to Low Concentration to Reach Equilibrium.
Image created by BYU-Idaho student, Hannah Crowder 2013.
The top panel shows the diffusion of solute from left (high concentration) to the right (low concentration) until an equilibrium is established. Once a diffusion equilibrium exists, there will no longer be any net movement of solute (lower panel).

Factors That Affect the Rate of Diffusion

The rate at which the solute diffuses is affected by several factors.

Concentration gradient: The greater the difference between the concentrations on the two sides of the membrane, the faster the rate of diffusion.

Temperature: The higher the temperature, the faster molecules move. Therefore, as temperature increases, the rate of diffusion increases.

Size of molecule: Smaller molecules tend to travel further before colliding with other molecules, so diffusion rates are faster for smaller molecules.

Viscosity of the medium: The viscosity is a measure of the "thickness" of the solvent. An increase in viscosity decreases the rate of diffusion.

Membrane permeability: Since we are talking about the movement of solutes into and out of the cell, the permeability of the membrane to the solute will affect how fast solutes diffuse across the cell membrane. For example, ions and other charged molecules that are hydrophilic do not readily cross the membrane due to the hydrophobic core of the bilayer. Conversely, oxygen and carbon dioxide, both nonpolar molecules, can readily diffuse through the membrane.

Surface area: The greater the surface area of the membrane, the faster the rate of diffusion is across the membrane. Areas in our bodies, where diffusion is especially important, typically employ structural modifications that increase the available surface area. For example, in the lungs, the hundreds of millions of small alveoli have a total surface area of nearly 70 square meters for gas exchange! This is approximately the same size as a typical two-bedroom apartment in Rexburg.

Distance: Diffusion is quite rapid over short distances but gets slower the further it goes. The time it takes for something to diffuse is proportional to the square of the distance. Therefore, if it takes one second to diffuse one centimeter, it would take 100 seconds to diffuse 10 cm and 10,000 seconds to diffuse 100 cm. So, to go 100 times further takes 10,000 times longer. In the body, diffusion is quite sufficient to cross the thin cell membrane, but to travel long distances by diffusion would be very slow. This is why we have other mechanisms, like the blood circulation and motor proteins along microtubule networks for moving substances long distances.