Diffusion and Osmosis

Diffusion and osmosis are terms concerned with movement of molecules in solutions.

Diffusion – this is the movement of 'non-water' molecules from a region where there is a large number of these molecules to a region where there is less.

Osmosis – this is the movement of water molecules from a region where there are a lot of water molecules to a region where there aren't as many.

These two processes happen in opposite directions and tend to result in the molecules being evenly spread throughout the solution so that the concentration is the same everywhere.

What exactly happens at a molecular level in order to cause the movement of the molecules?

We all know that to make a solution involves dissolving something (a solute) in a solvent (normally water) and this then mixes so that it is evenly spread throughout the water. But in terms of the molecules involved what happens to achieve this even spread?

The molecules in the water are in constant motion even though we normally can't see it (it's known as Brownian motion and is driven by heat from the surroundings). Now say you were to place a teaspoon of solute, say sugar, gently down in the bottom of a container full of water as shown in the diagram. The result of this constant movement of water molecules is that it has the same effect as stirring your tea - it will cause the molecules of the solute and water to be mixed around and both eventually will be evenly distributed throughout the solution. It should be noted that the effect is increased by the water molecules sticking slightly to the sugar molecules (due to attractive forces) and as the water molecules move they carry the sugar along with it until there are equal numbers of sugar and water molecules everywhere.

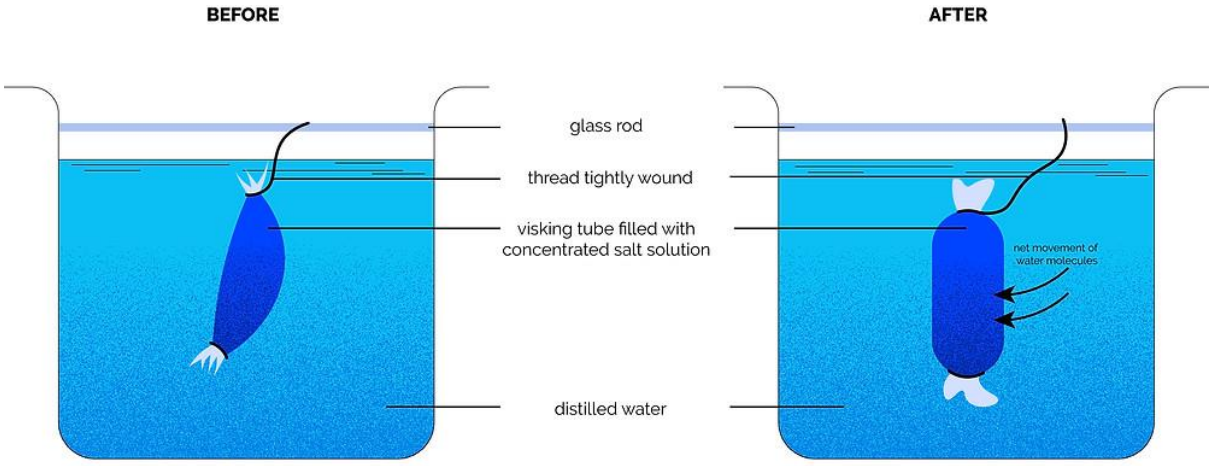
As far as the molecules ***inside*** the teaspoon of solute are concerned they are in a region of low numbers of water molecules while obviously the water molecules in the container which are outside the teaspoonful of solute are in a region of a large number of water molecules. So at the start, just after the solute is placed in the container, the solute molecules move (due to the Brownian motion) from a place where there are little numbers of water molecules into a region where there is a large number of water molecules (the rest of the container) i.e. the solute *diffuses* into the water. They move as a result of being carried along by the movement of the water molecules. As regards the water molecules themselves they will move in the reverse direction - from the region where there are lots of water molecules into the region where there are few water molecules ie the water travels by *osmosis* into the solute.

Solutions and semi-permeable membranes

Ok, so that's how molecules in a solution tend to move. Note that this Brownian motion continues even after the solution is evenly mixed and this serves to keep it homogenous. But what happens when you introduce a semi-permeable membrane into the scenario? Well such a membrane only allows *some* molecules like water to flow freely though the pores while others are too large which interferes with the spread of the solute molecules

throughout the whole scenario. Why do we care? Well this has a lot of importance in biology.

Imagine having a concentrated salt solution in a container made from a semipermeable membrane such as visking tube. This is then placed in water as shown in the diagram. We can see that the tube will swell after a time due to water.



So in terms of molecules what has happened? Well just like with our teaspoon of sugar the salt particles want to move out of the tube until its concentration is the same everywhere and the water will want to move into the tube until its 'concentration' is the same everywhere. However, because the tube is semipermeable it means the water can move freely into and out of the tube but the salt can't move out. If the salt wasn't there then the movement of water molecules into the tube would equal the movement out and the tube wouldn't swell. When the salt is added any water molecules that move in tend to 'stick' to the salt particles which reduces the movement of water molecules back out of the tube. Since the water molecules outside are still constantly moving you get more water molecules moving in than out and so the tube swells and with continue to do so until either it bursts (lyses) or the pressure inside the tube becomes so great that it is able to prevent more water coming in (which happens in plant cells due to the cellulose cell wall)

In biology the cell membrane around cells is semipermeable. The cytoplasm has salts, sugars, etc dissolved in it so if the cell is placed in water the inside of the cell is more concentrated than the outside and so water will move in faster than it moves out with the result that the cell will burst (unless it has a cellulose cell wall). If the cell is placed in a solution which is more concentrated outside than the inside then the water will move out of the cell faster than it moves in and the cell will shrink which could affect the normal functioning of the cell.