Transport across a membrane

Transport across a membrane occurs by one of two opposite means, actively or passively. Active transport requires the cell to utilise cellular energy in the form of ATP, in order to employ protein pumps or engage in the activity of endo / exocytosis. Passive transport therefore occurs with no energy expenditure by the cell, where molecules exit or enter the cell using kinetic energy, or protein channels. To this effect passive transport encompasses, osmosis, diffusion of a solute across a membrane, facilitated diffusion and transport of an ion down an electrochemical gradient. The reasoning for this is outlined below.

Intrinsic homeostasis at a cellular and molecular level is achieved when the cell is in an isotonic environment where the internal solute concentration of a cell is in equilibrium with the external, extra cellular environment, solute concentration and there is no net movement of water in any direction. A change in concentration of solute, initiates transport across the membrane in order to achieve equilibrium once again. The cell membrane is a structure designed in such a way to allow passage of molecules and ions in and out of the cell, to and from the extracellular fluid, whilst keeping essential components such as organelles and ribosomes within its boundary. It is comprised of a phospho lipid bi-layer, in which are embedded a variety of carrier and channel proteins. The lipid bi-layer acts as a barrier to molecules in both directions and the proteins allow entrance and exit of select molecules. (www. faculty. weber. edu/jclark1/mem%20 Permeability. PDF 25. 11. 09)

Some chemicals will traverse the membrane, such as water, carbon dioxide, oxygen, small polar molecules and lipids and others such as ions, amino acids, large polar and macromolecules will not and the membrane is effectively selectively permeable. (www. staff. jccc. net/PDECELL/cells/transport. html 25. 11. 09) The most basic category of passive transport is that of diffusion of a solute across a membrane. Molecules that move across the membrane in this manner are more soluble in oil than in water and hence effortlessly ‘ dissolve in and spontaneously cross the non polar lipid core of the membrane bi layer' Examples of these molecules are steroid hormones, Oxygen and Carbon Dioxide (www. Biologyreference. com/Ma-MO/membrane-Transport. html 26. 11. 09) during the process of diffusion, ‘ molecules move from an area of high concentration to an area of low concentration down the concentration gradient' in order to achieve equilibrium. This is achieved by kinetic energy of the molecules which are in Brownian motion. An increase in temperature causes the rate of diffusion to increase causing equilibrium to be achieved more quickly as kinetic energy increases. Size and type of molecule also has a bearing on the rate as the smaller the molecule the faster it will diffuse. Osmosis is purely ‘ the diffusion of water molecules across a partially permeable membrane from a region of higher water potential to an area of lower water potential'(www. biologymad. com/resources-getting in and out of cells 25. 11. 09) In an isotonic surrounding there is no net movement of water molecules in either direction as there is no concentration gradient, however in a hypertonic solution where the concentration of solutes is higher and hence the water potential is more negative than the cell, water molecules from within the cell will move down the ‘ water potential gradient' to the extracellular fluid in order to achieve equilibrium. This can be shown in laboratory conditions by placing red blood cells in a hypertonic solution and observing them. Over time the cells will crenate as the water molecules exit the cell. Similarly if cells are in a hypotonic solution where the concentration of solutes is lower, the water potential is higher and hence the cells now have a more negative water potential and water will be taken into the cell by osmosis down the water potential gradient. Red blood cells left in a hypotonic solution and observed will show nothing under the microscope over time, as the cells eventually undergo cytolysis. (www. biologymad. com/resources-getting in and out of cells 25. 11. 09).

Unfortunately most molecules cannot cross the membrane by straightforward diffusion alone as they are either too large, insoluble in lipid or they carry a charge which is repelled by the surface of the membrane. They therefore undergo facilitated diffusion, a mechanism by which passive transport still occurs without energy expenditure of the cell, but where the molecules are assisted across by groups of proteins inherent to the membrane. Facilitated diffusion still occurs down the concentration gradient but is specific to the molecule being facilitated. A carrier protein is specific to a particular molecule or class of molecules,(www. users. rcn. com/jkimball. ma. ulyranet/biologypages/d/diffusion. html#facilitated 26. 11. 09) where the molecule binds to the protein which in turn changes shape to enable the molecule to cross the membrane. An example of this being the transport of glucose into the cell. Once inside the cell glucose phosphate is manufactured for which there is no carrier protein and hence glucose cannot pass back out of the cell. In this case equilibrium will never be reached. . (www. biologymad. com/resources-getting in and out of cells 25. 11. 09). In the case of transport of an ion down the electrochemical gradient, Ions transit from an area of high concentration to an area of low concentration again through facilitated diffusion with the aid of intrinsic proteins called ion channels. Without these channels charged molecules such as K+ Na+ would be repelled by the charge on the membrane. Transmembrane channels that allow facilitated diffusion, can be permanently open, or can be closed and opened as in neurones, and as such are known as ‘ gated', they open or close in reaction to a ligand, a signalling molecule which can be either extracellular or intracellular. It is the gated mechanism that allows a nerve impulse to pass along a neurone.

Sometimes however it is necessary for cells to transport molecules against the gradient by the use of carrier proteins, known as protein pumps. They are akin to those of facilitated diffusion, except they are working against the gradient and therefore energy in the form of ATP is expended by the cell in the doing so. This process is known as Active Transport.

In all the cases outlined above the objective of passive transport has been to transport molecules across the semi permeable membrane down a concentration gradient, without expenditure of energy to the cell, and, passive transport can be demonstrated by diffusion of a solute, osmosis, facilitated diffusion and transport of an ion down an electrochemical gradient.