

Cells: cellular compartment, transport system and fluid movements

Cells are the structural and functional units of all living organisms. Some organisms, such as bacteria, are unicellular, consisting of a single cell. Others, such as humans, are multi cellular, cells have their own function and activities . These activities include cellular growth, metabolism and reproduction. Each cell can take in nutrients, convert these nutrients into energy, carry out specialized functions and reproduce as necessary.

The cell consists of three basic parts:

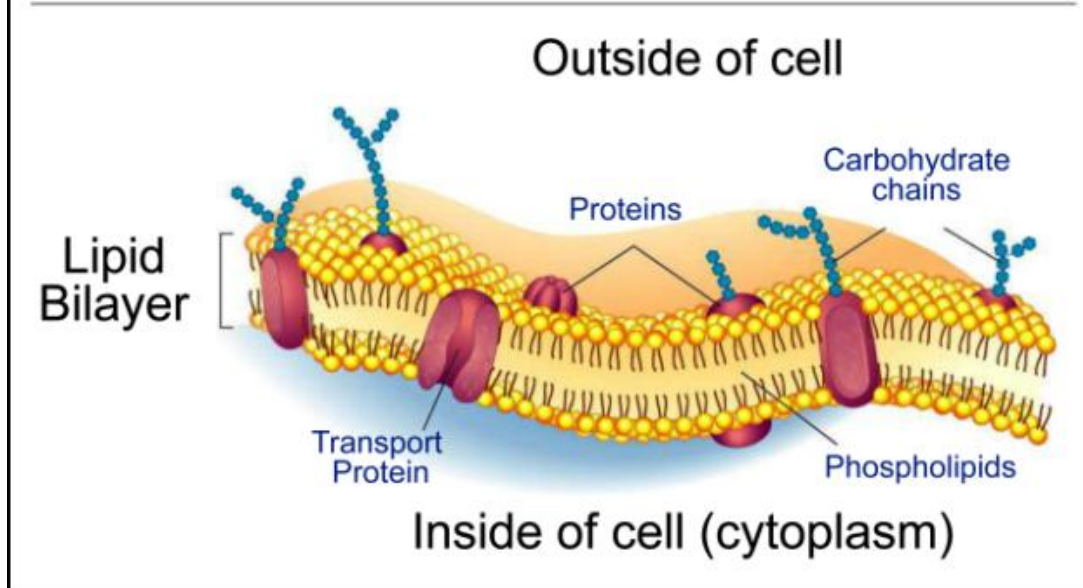
- 1• Cell membrane
- 2• Cytoplasm
- 3• Nucleus

Substances such as water, electrolytes and nutrients move in and out of a cell utilizing the transport system. The cell membrane is semi - permeable to water and solutes. It regulates the movement of water, nutrients and waste products into and out of the cell.

Cell membrane

The cell membrane is thin and forms the outermost layer of a cell; it is also called the plasma membrane. This membrane ensures the integrity of the cell and its contents and separate them from the surrounding environment. The cell membrane are involved in many cellular functions such as cellular communication and cellular transport. The cell membrane is made up of a double layer (bilayer) of phospholipid (fatty) molecules with protein molecules interspersed between them , The phospholipid bilayer consists of a polar ‘ head ’ which is hydrophilic (water - loving) and fatty acid ‘ tails ’ which are hydrophobic (water - hating).

Structure of the Cell Membrane



Functions of the cell membrane

Cell membranes serve several important functions. They:

- 1• Anchor the cytoskeleton (a cellular 'skeleton' made of protein and contained in the cytoplasm) and gives shape to the cell.
- 2• Attach the cell to the extracellular matrix so that the cells group together to form tissues.
- 3• Transport materials needed for the functioning of the cell organelles. The cell membrane is semi-permeable and controls the in and out movements of substances. Such movement of substances may be either at the expense of cellular energy or passive, without using cellular energy.
- 4• The protein molecules in the cell membrane receive signals from other cells or the outside environment and convert the signals to messages, which are passed to the organelles inside the cell.
- 5• In some cells, the **protein** molecules in the cell membrane **form enzymes**, which carry out metabolic reactions near the inner surface of the cell membrane.
- 6• The proteins in the cell membrane also help very small molecules to be **transported** through the cell membrane, provided the molecules are travelling from a region with lots of molecules to a region with less number of molecules.

Some of the proteins embedded in a cell membrane **provide structural support to the cell**. Some membrane proteins **regulate water-soluble**

substances through pores in the cell membrane; others are receptors for hormones and other substances such as neurotransmitters act. Other important cell membrane proteins are glycoproteins and they play an important role in cell-cell recognition.

Cellular compartments and their functions

- a- Nucleus / Contains genetic information.**
- b- Cytoplasm: it is located between plasma membrane and the nucleus ,contain cellular organelles such as :**
 - 1- Cytoskeleton / three types of proteins which Provides support ;cell movement; Provide conducting channels through which various substances can move through the cytoplasm and Helps to determine the shape of the cell .These proteins are Microfilaments ;intermediate filaments and Microtubules.
 - 2- Endoplasmic reticulum / Many functions, including site for protein synthesis and synthesis of lipids and steroids
 - 3- Golgi complex / Packages proteins for modification and secretion.
 - 4- Lysosomes/ Break down and digest harmful substances.
 - 5- Mitochondria / Energy - producing site of the cell.
 - 6- Peroxisomes/ Carry out metabolic reactions. Site for the destruction of hydrogen peroxide. Protects the cell from harmful substances .
 - 7- Centrioles/ Cellular replication.
 - 8- Cilia / Moves fluid or particles over the surface of the cell.

However, for the cells to survive and function, substances need to enter and leave the cells and this is provided by special proteins, such as integral and peripheral membrane proteins. The integral trans-membrane proteins are attached to the cell membrane and they can form channels which allow for the transportation of materials into and out of the cell and Peripheral membrane proteins may interact with other proteins or directly with the lipid bilayer.

Transport systems

Cells utilize two processes to move substance in and out of the cell: the passive and active transport systems. When molecules pass in and out of a cell membrane without the use of cellular energy, it is called passive transport system. This includes:

- Simple diffusion
- Facilitated diffusion
- Osmosis

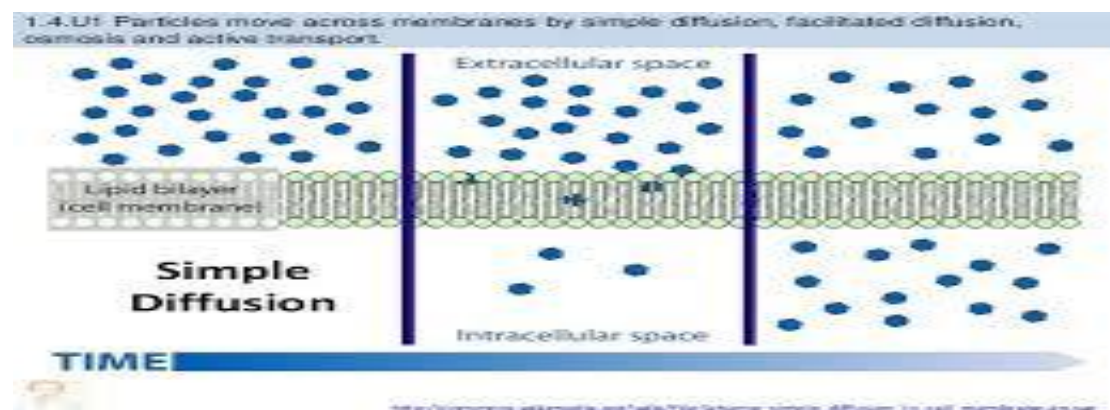
On the other hand, the active transport system requires energy to move substances in and out of a cell.

Simple diffusion

The term simple diffusion refers to a process whereby a substance passes through a membrane without the aid of an intermediary such as an integral membrane protein. Water, oxygen, carbon dioxide, ethanol and urea are examples of molecules that readily cross cell membranes by simple diffusion. They pass either directly through the lipid bilayer or through pores created by certain integral membrane proteins. Small, non-polar substances can diffuse directly through the plasma membrane. One example of simple diffusion is the exchange of respiratory gases between the cells of the alveolar sac and the blood in the lungs.

The rate of diffusion depends on several factors:-

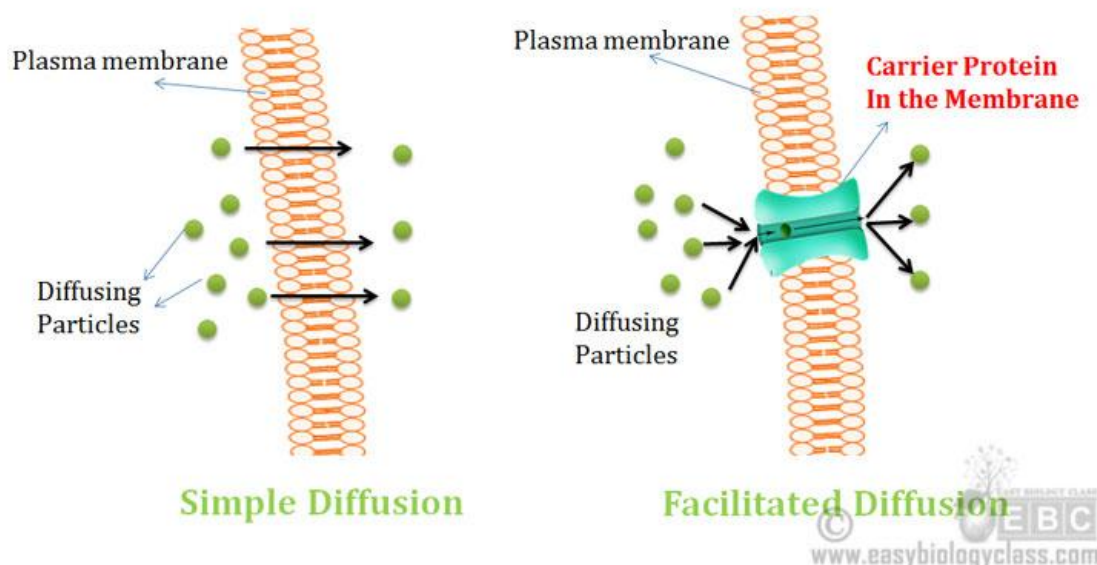
- 1• Gases diffuse rapidly and liquids diffuse more slowly
- 2• In high temperature the rate of diffusion is much faster
- 3• Smaller molecules such as glycerol diffuse much faster than larger molecules like fatty acids.
- 4• The solubility of the molecule
- 5• The concentration gradient.



Facilitated diffusion

Larger molecules, such as amino acids, cannot pass the cell membrane and therefore they use a process called facilitated diffusion . No direct cellular energy is used in this process. Glucose, sodium and chloride ions are just a few examples of molecules and ions that must efficiently get across the plasma membrane. Their transport must therefore be ‘ facilitated ’ by proteins that span the cell membrane and provide a passageway for these substances. Like simple diffusion, facilitated diffusion transports substances from an area of high concentration to an area of low concentration.

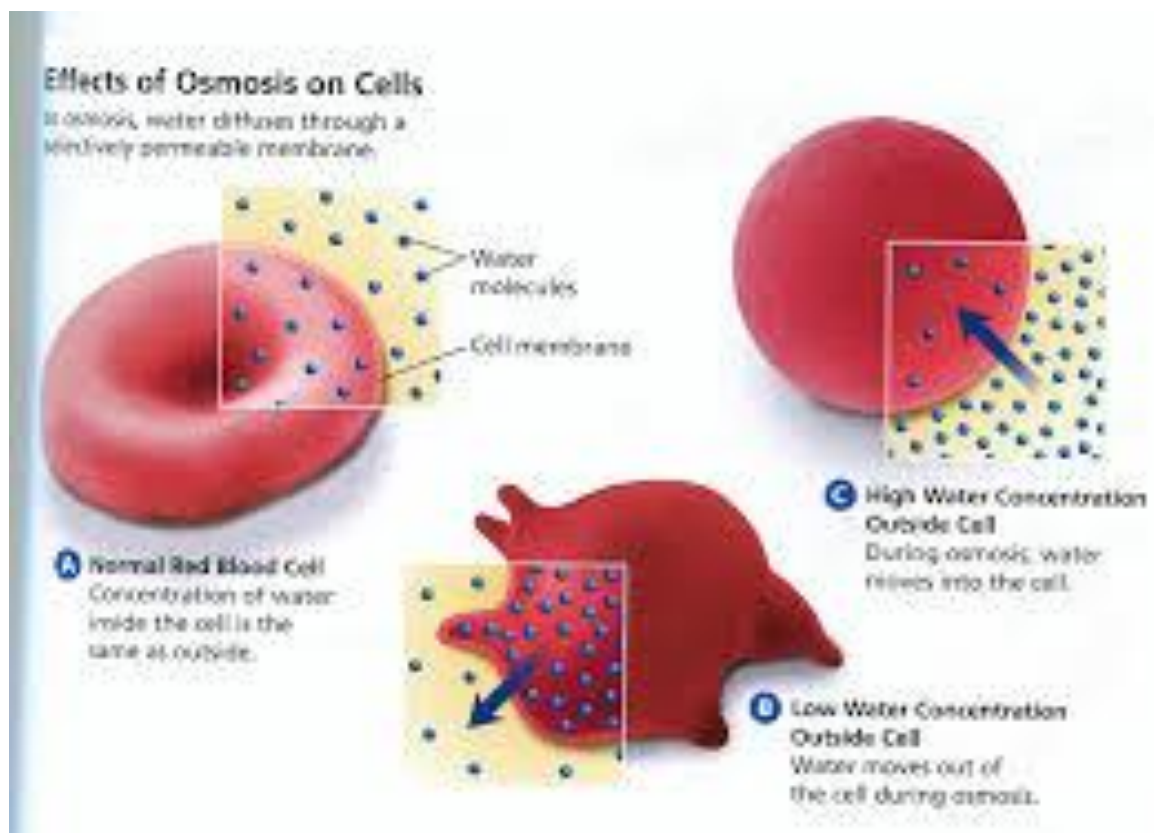
Simple Diffusion vs Facilitated Diffusion



Osmosis

Osmosis is a process whereby water moves from an area of high volume to an area of low volume through a selective permeable membrane. A selective permeable membrane is one that allows the unrestricted passage of water, but not solute molecules or ions. The relative concentrations of water are determined by the amount of solutes dissolved in the water. For example, a higher concentration of salt on one side of the cell membrane means that there is less space for water molecules. Water then will move from the side where there is a greater number of water molecules through the cell membrane to the other side of the cell where there are fewer water molecules. This is known as osmotic pressure. The osmotic pressure can be sufficient to damage the cell membrane and therefore it is

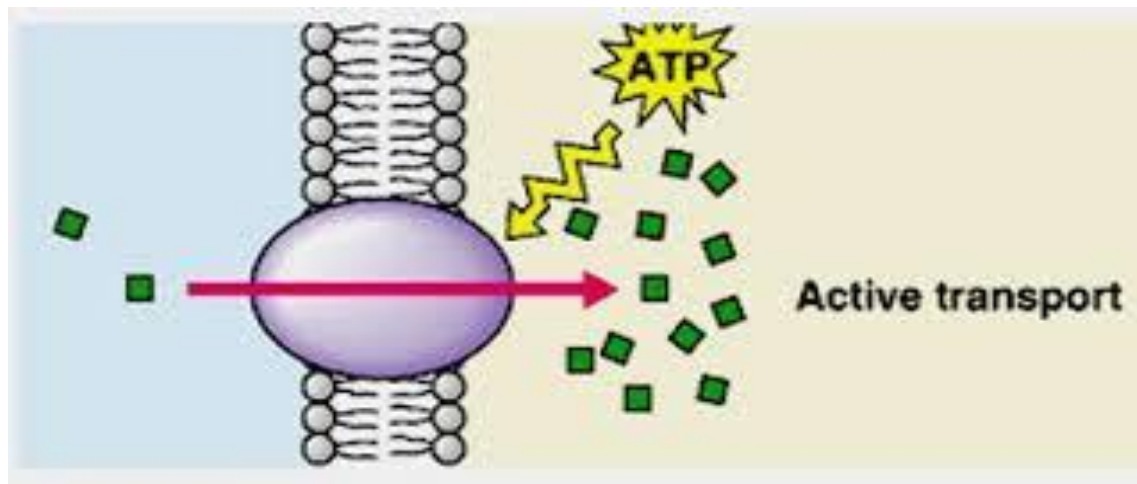
important for the cell to have a relatively constant pressure between the internal and external environment. If the osmotic pressure on one side of the cell is greater than that on the other side, changes to the cell could take place, resulting in cell damage. A red blood cell placed in a solution with less concentration of solute will undergo hemolysis and if placed in a fluid with high concentration of solutes the red blood cell will crenate. On the other hand, if the red blood cell is placed in a solution with a relatively constant osmotic pressure between the internal and external environment, the red blood cell does not undergo any changes.



Active transport

An active process is one in which substances move against a concentration gradient from an area of lower to higher concentration in which the cell must expend energy.

An example of active transport in the human body is The sodium-potassium pump.



Transport by Vesicles

Cells also have the ability to move large particles or numerous molecules at once through the plasma membrane. In this process, which also requires energy, the cell membrane creates a vesicle to transport the matter either into the cell or out of the cell

A-Endocytosis

Endocytosis is the process by which cells take in molecules such as proteins from outside the cell by engulfing them with their cell membrane. It is used by all cells of the body because most substances important to them are polar and consist of big molecules, and thus cannot pass through the hydrophobic plasma membrane. During endocytosis only a small section of the cell membrane plays a part to form a fold and a new intracellular pod is formed containing the substance.

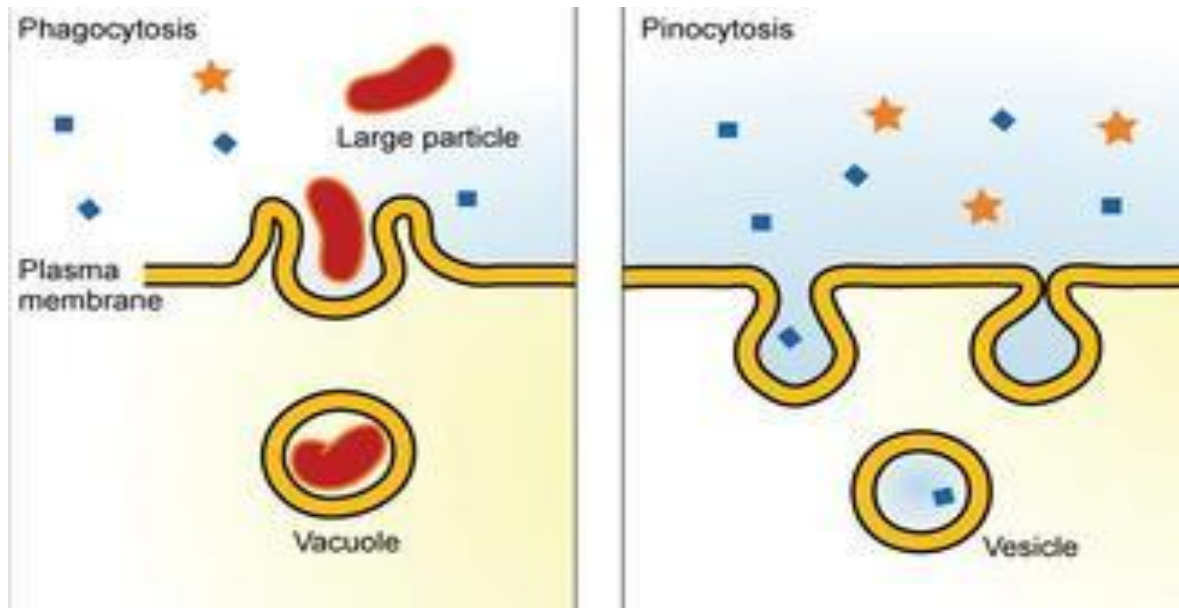
There are three types endocytosis:

1• Pinocytosis .

In pinocytosis the molecule engulfed is relatively small molecules with amount of fluid , occurs in all cells.

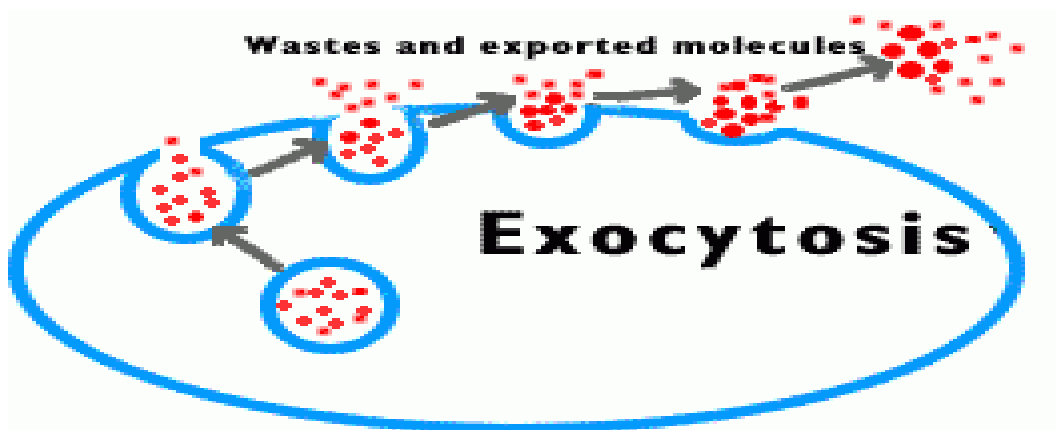
2.phagocytosis

results in the ingestion of particulate matter (e.g. bacteria) from the extracellular fluid ,the endosome is so large that it is called a phagosome or vacuole and occurs only in certain specialized cells (e.g. neutrophils, macrophages)



B-Exocytosis

Exocytosis is a process for moving items from the cytoplasm of the cell to the outside. The intracellular vesicle with its ingested substances fuses with the cell membrane to discharge the unwanted substance from the cell.



Body Fluid compartments

The two principal body fluid compartments are intracellular and extracellular. The intracellular compartment is the space inside a cell and the fluid inside the cell is called intracellular fluid (ICF).

The extracellular compartment is found outside the cell and the fluid outside the cell is called extracellular fluid (ECF). However, the

extracellular compartment is further divided into the interstitial and the intravascular compartments. Two thirds of body fluid is found inside the cell and one third outside the cell.

Intracellular fluid (ICF)

- The ICF is primarily a solution of potassium and organic anions, proteins, etc.
- The cell membranes and cellular metabolism control the constituents of this ICF

Extracellular fluid (ECF)

- The ECF primarily consists of NaCl and NaHCO₃ solution.
- The ECF is further subdivided into three compartments:
 - 1• Interstitial fluid (ISF) surrounds the cells, but does not circulate.
 - 2• Plasma circulates as the extracellular component of blood.
 - 3• Transcellular fluid is a set of fluids that are outside of the normal compartments. These include digestive juices, mucus, etc.

Composition of body fluid

Body fluid is composed of water and dissolved substances such as electrolytes (sodium, potassium and chloride), gases (oxygen and carbon dioxide), nutrients, enzymes and hormones. Water is essential for the body as it :

- 1-It is the major component of the body ' s transport systems. The blood transports nutrients, oxygen, glucose and fats to various tissues and cells. Also, the waste products of cellular metabolism.
- 2-It is needed for regulation of body temperature at 37 ° C. When body temperature starts to rise, blood vessels near the surface of the skin dilate to release some of the heat; the reverse happens when body temperature starts to drop . Also , when body temperature rises, sweat glands secrete sweat, which is 99% water. As the sweat evaporates, heat is removed from the body.
- 3-Provides an optimum medium for the cells to function.
- 4-There are chemical reactions in the body which require water.
- 5-Provides lubrication for the joints as it is a component of synovial fluid to provide lubrication .