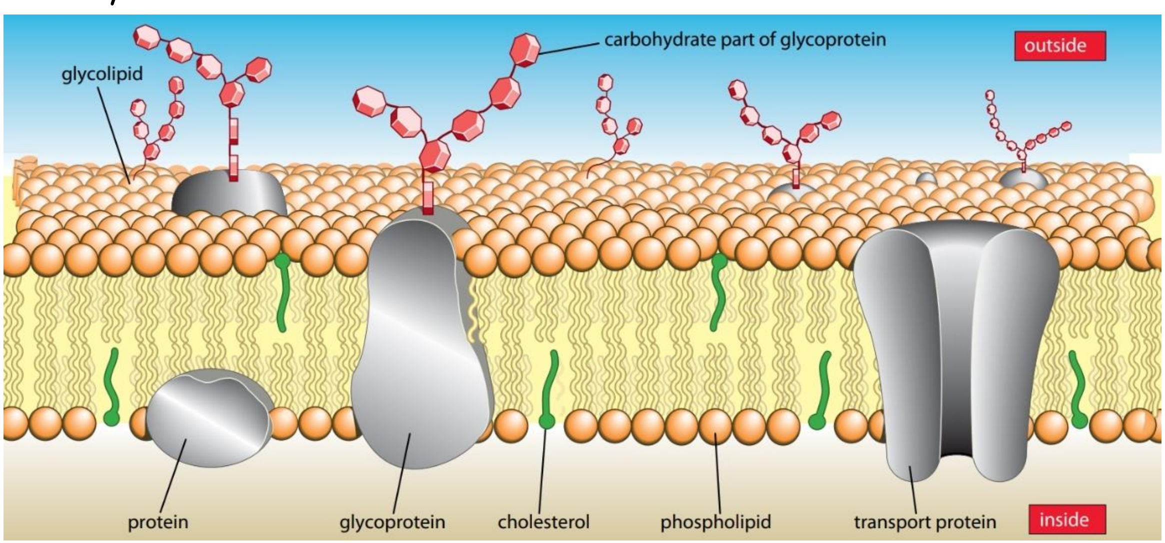
Cell Membranes & Transport

4.1 Fluid Mosaic Membranes

Cell Membranes:

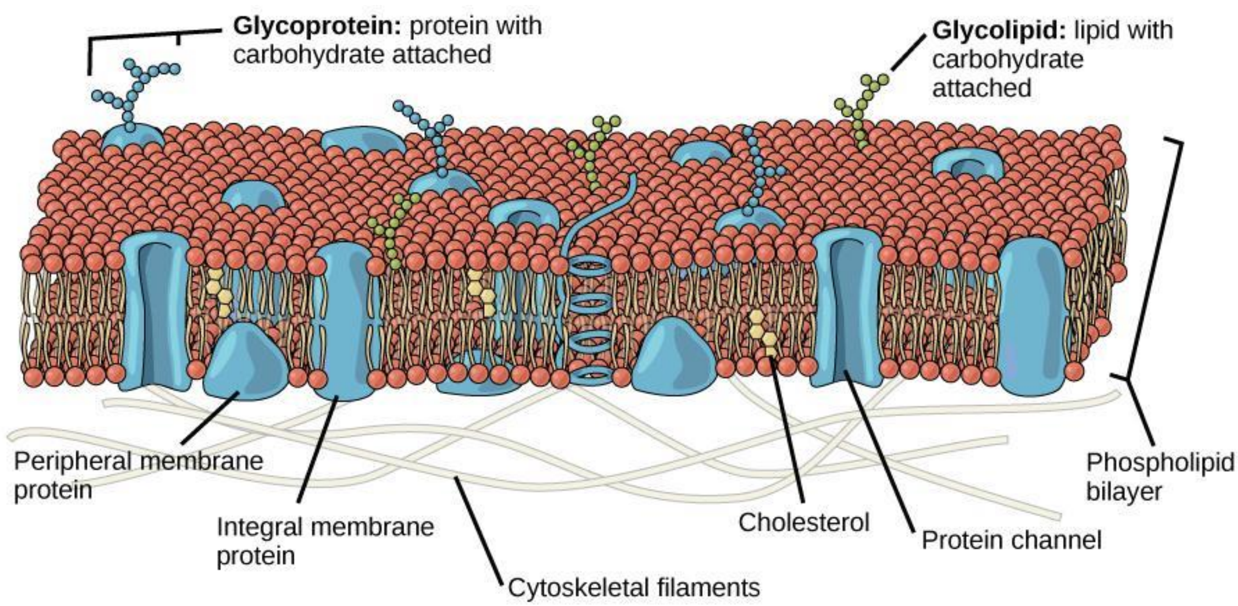
- Partially permeable layer controlling essential nutrients in and toxic waste substances out of cells.
- All cells are surrounded by a cell surface membrane and forms the boundary between the cytoplasm and the environment.
- It separates the inside of cells from their surroundings.
- Both eukaryotic and prokaryotic cells have an outer plasma membrane.
- Cell surface membranes control the exchange of materials between the internal cell environment and the external environment.
- The membrane is described as being partially permeable as it allows the passage of some substances and not others.
- The cell surface membrane/plasma membrane is extremely thin (about 7nm).
- However, at very high magnifications, at least x100 000, it can be seen to have 3 layers, described as trilaminar appearance.
- This consists of 2 dark lines (heavily stained) either side of a narrow pale interior.
- The membrane is partially permeable and controls exchange between the cell and its environment.
- Cells are surrounded by a plasma membrane formed from a phospholipid bilayer.



The Fluid Mosaic Model of Membranes:

- Membranes are vital structures found in all cells.

- The cell surface membrane creates an enclosed space separating the internal cell environment from the external environment, & intracellular membranes form compartments within the cell such as the nucleus, mitochondria and RER membranes do not only separate different areas but also control the exchange of material across them, as well as acting as an interface for communication.
- Membranes are partially permeable.
- Substances can cross membranes by:
  - Diffusion
  - Osmosis
  - Active transport
- Cellular membranes are formed from a bilayer of phospholipids which is roughly 7nm wide and therefore just visible under an electron microscope at very high magnifications.
- The fluid mosaic model also helps to explain:
  - Passive and active movement between cells and their surroundings.
  - Cell-to-cell interactions.
  - Cell signalling.



Hydrophobic:

- Having an aversion to water; tending to coalesce and form droplets in water.
- Hydrophobic is a term used to describe how molecules react with water.
- Molecules that are hydrophobic have an aversion to water and are often referred to as "water fearing".

Hydrophilic:

- Having an affinity for water.
- Hydrophilic is a term used to describe how molecules react with water. Molecules that are hydrophilic have an affinity for water. Hydrophilic is often referred to as "water loving".

Phospholipid: Phospholipids are similar to lipids except that one of the fatty acid molecules is replaced by a phosphate molecule. Whereas fatty acid molecules repel water (are hydrophobic), phosphate molecules attract water (are hydrophilic).

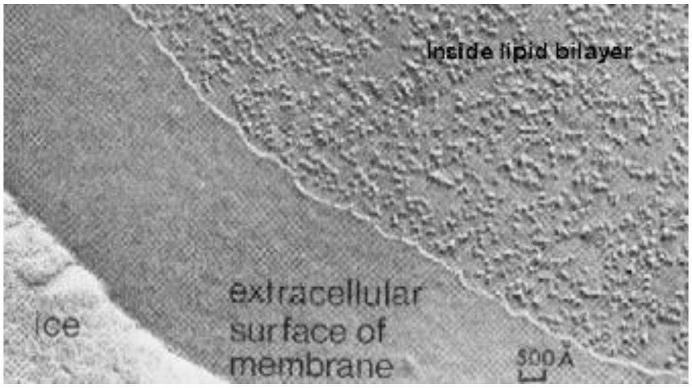
- A molecule that is a constituent of the inner bilayer (2 layered structures in the form of sheets) of biological membranes, having a polar, hydrophilic phosphate head and a non-polar, hydrophobic fatty acid tail.
- If phospholipids are mixed or shaken with water, they form spheres with heads facing out towards the water and tails facing towards each other, called a micelle.
- A phospholipid molecule is composed of glycerol, a 3-carbon compound with two fatty acids joined to two carbons and a phosphorylated alcohol molecule.

Glycerol + 2 Fatty Acids + Phosphoric Acid ⇌ Phospholipid

Singer-Nicholson Model:

- In 1972, two scientists, Singer and Nicolson, proposed a hypothesis for membrane structure called the fluid mosaic model.
- It is described as 'fluid' because both the phospholipids and the proteins can move about by diffusion. The 'mosaic' describes the pattern produced by the scattered protein molecules when the surface of the membrane is viewed from above.
- This theory remains the current accepted model of the plasma membrane. It is known as the fluid mosaic model and while the arrangements of the phospholipids remain the same, it is the location of the proteins that differs.

- This model shows them embedded in the bilayer as either integral or peripheral proteins.



This image was a turning point for the model of the plasma membrane. It shows the bumps and grooves on the inside of the membrane. These bumps and grooves are the membrane proteins. The **freeze-fracture** technique consists of physically breaking apart (**fracturing**) a frozen biological sample; structural detail exposed by the **fracture** plane is then visualized by vacuum-deposition of platinum-carbon to make a replica for examination in the transmission **electron microscope**.

Phospholipid Bilayer:

- Phospholipid bilayers can form compartments - the bilayer forming the cell surface membrane establishing the boundary of each cell.
- Internally, membrane bound compartments formed from phospholipid bilayers provide the basic structures of organelles, allowing for specialisation of processes within the cell.
- An example of a membrane bound organelle is the lysosome, each containing many hydrolytic enzymes that can breakdown many different kinds of biomolecules. These enzymes need to be kept compartmentalised otherwise they would breakdown most of the cellular components.

<u>Phospholipid formed by layers in water due to the amphipathic properties of phospholipid molecules:</u>

- The heads of the phospholipids are hydrophilic. The fatty acid tails are hydrophobic.
- Phospholipids are considered amphipathic molecules due to the fact that they both have a hydrophilic and hydrophobic region.
- The phospholipid molecules are arranged in the plasma membrane due to the way they react with water.
- Because the border heads of the molecules are hydrophilic, they are arranged so that they are always basically internal and external fluid environment of the cell.
- Due to the fact that the fatty acid tails are hydrophobic, they face inwards towards each other and away from the fluid environment.

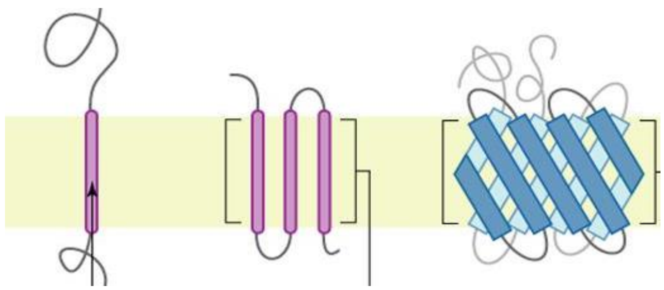
- The fatty acid tails in the centre of the membrane are attracted to each other and the phosphate heads are attracted to the surrounding water and this makes the structure of the plasma membrane very stable.

Proteins:

- Membrane proteins are diverse in terms of structure, position in the membrane and function. There are many different types of membrane proteins. They occupy different positions in the plasma membrane depending on the structure and function.
- Two types of protein are recognised according to their position in the membrane. Proteins that are embedded within the membrane are called intrinsic proteins (or integral proteins). Intrinsic proteins may be found in the inner layer or most commonly, spanning the whole membrane, in which case they are known as transmembrane proteins.
- In transmembrane proteins, the hydrophobic regions which cross the membrane are often made up of one or more α-helical chains. The hydrophobic regions completely span the hydrophobic interior of the membrane.
- Transport proteins create hydrophilic channels to allow ions & polar molecules to travel through the membranes. There are 2 types, channel (pore) proteins & carrier proteins.
- Each transport protein is specific to a particular ion or molecule.
- Transport proteins allow the cell to control which substances enter or leave.

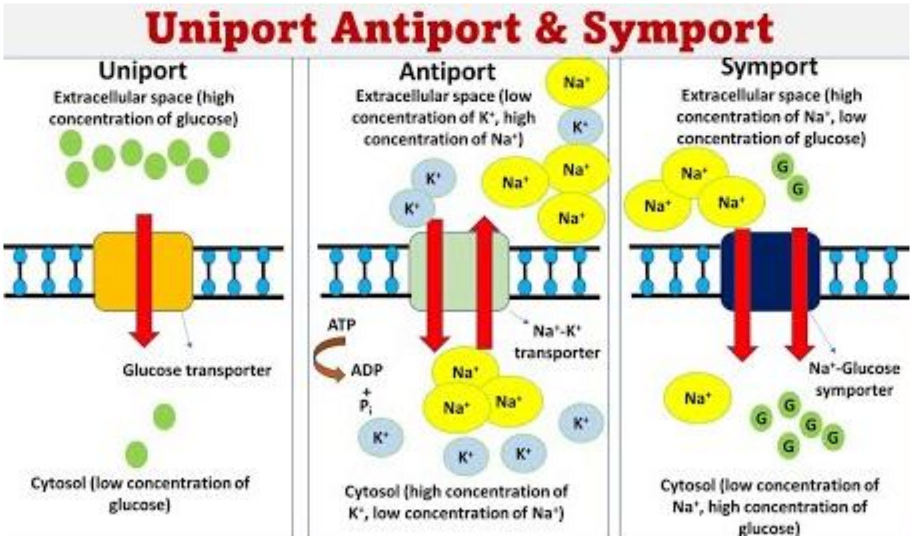
Intrinsic (Integral) Protein	Extrinsic (Peripheral) Protein
• Intrinsic proteins have hydrophobic and hydrophilic regions. They stay in the membrane because the hydrophobic regions made from hydrophobic amino acids are next to the hydrophobic fatty acid tails and are repelled by the watery environment either side of the membrane. • Typically, a transmembrane protein with hydrophobic regions that completely spans the hydrophobic interior of the membrane. • The integral proteins in the plasma membrane penetrate the lipid bilayer from one side to the other.	• A second type of protein molecule is the extrinsic protein (or peripheral protein). These are found on the inner or outer surface of the membrane. Many are bound to intrinsic proteins. Some are held in other ways- for example, by binding molecules inside the cell, or to the phospholipids. • A protein appendage loosely bound to the surface of a membrane and not embedded in the lipid bilayer. • The protein molecules are not fixed in one spot of the membrane and they actually float in the fluid phospholipid bilayer or are attached to an integral protein.

• These proteins control the entry and exit of specific molecules from the cell. They also have a hydrophobic and hydrophilic region which helps keep them in place in the membrane. • Integral membrane proteins may have one or more α-helices that span the membrane or they may have β-sheets that span the membrane.	• Peripheral proteins are known as glycoproteins because they have a carbohydrate attached. The function in immune responses and are involved in cell-to-cell recognition.



Membrane Proteins:

Functions	Descriptions
Hormone Binding Sites	A site exposed on the outside of the membrane allows one specific hormone to bind based on shape. A signal is then transmitted to the inside of the cell.
Immobilized Enzymes	Enzymes located in membranes either catalyze reactions inside or outside the cell, depending on whether the active site is on the inner or outer surface. Grouped so that a metabolic pathway may occur.
Cell Adhesion	Proteins from adjacent cells may hook together to provide either permanent or temporary connections. These form junctions referred to as gap junctions and tight junctions.
Cell-to-Cell Communication	The proteins involved in cell-to-cell communication have an attached molecule of carbohydrate which provides an identification label for the cell (glycoproteins).
Channels for Passive Transport	Channels are passages through the center of membrane proteins. Each channel allows one specific substance to pass through from high concentration to low concentration.
Pumps for Active Transport	Pumps release energy from ATP and use it to move specific substances across the plasma membrane. The energy is used to change the shape of the protein.



Channel Proteins	Carrier Proteins
Channel proteins transport ions.	Carrier proteins transport molecules.
Position is fixed.	Flip between 2 conformations.
Solute molecules diffuse through the pores.	Solute molecules are bound to one side and released from the other side.
Have high transport rates.	Have low transport rates.
Do not bind with solute molecules it transports.	Consist of alternative solute-bound conformations.
Lipoproteins.	Glycoproteins.
Synthesized in the Rough Endoplasmic Reticulum.	Synthesized in the free ribosomes in the cytoplasm.
Only transports water-soluble molecules.	Transport both water molecules & insoluble molecules.
Facilitated diffusion.	Both facilitated diffusion & active transport.

Cholesterol:

- Cholesterol molecules also have hydrophobic tails and hydrophilic heads.
- Cholesterol fits between phospholipid molecules and orientated the same way (head out, tail in).
- It is only found in eukaryotic membranes; it is absent in prokaryotes membranes & plant cells. Plant cells contain related compounds (sterols) that fulfill a similar function.
- Animal cell membranes contain cholesterol which plays a role in stabilizes and maintains the integrity of the plasma membrane.
    - Cholesterol is another amphipathic molecule involved in the cell membrane. The hydroxyl group of the cholesterol molecule lines up

with the polar heads of the phospholipid molecules. The rest of the molecule tucks in with the fatty acid tails.

- Cholesterol regulates the fluidity of the membrane. Cholesterol molecules sit in between the phospholipids, preventing them from packing too closely together or solidifying when temperatures are low; this prevents membranes from freezing and fracturing.
- Interaction between cholesterol and phospholipid tails also stabilizes the cell membrane at higher temperatures by stopping the membrane from becoming too fluid.
- Cholesterol molecules bind to the hydrophobic tails of phospholipids, stabilizing them and causing phospholipids to pack more closely together.
- Cholesterol also contributes to the impermeability of the membrane to ions and increases mechanical strength and stability of membranes. Without cholesterol, membranes would break down, which would cause cells to burst.
- Membranes become less fluid when there is:
    - An increased proportion of saturated fatty acid chains as the chains pack together tightly and therefore there is a high number of intermolecular forces between the chains.
    - A lower temperature as the molecules have less energy and therefore are not moving as freely which causes the structure to be more closely packed.
- Membranes become more fluid when there is:
    - An increased proportion of unsaturated fatty acid chains as these chains are bent, which means the chains are less tightly packed together and there are less intermolecular forces.
    - At higher temperatures, the molecules have more energy and therefore move more freely, which increasing membrane fluidity.

Carbohydrates:

- Many of the lipid molecules on the outer surfaces of cell surface membranes, and probably all of the protein molecules, have short carbohydrate chains attached to them.
- These 'combination' molecules are known as glycolipids and glycoproteins, respectively. The carbohydrate chains project like antennae into the watery fluids surrounding the cell, where they form hydrogen bonds with the water

molecules and so help to stabilise the membrane structure. The carbohydrate chains form a sugary coating to the cell known as the glycocalyx.

- The carbohydrate chains also help the glycoproteins and glycolipids to act as receptor molecules, which bind with particular substances at the cell surface.
  - Signaling receptors for hormones and neurotransmitters.
  - Receptors involved in endocytosis.
  - Receptors involved in cell adhesion and stabilization (as the carbohydrate part can form hydrogen bonds with water molecules surrounding the cell).
  - Some act as cell markers or antigens, for cell-to-cell recognition (E.g. the ABO blood group antigens are glycolipids and glycoproteins that differ slightly in their carbohydrate chains).
- <u>Glycolipids:</u> These are lipids with carbohydrate chains attached. These carbohydrate chains project out into whatever fluid is surrounding the cell.
- <u>Glycoproteins:</u> These are proteins with carbohydrate chains attached. These carbohydrate chains also project out into whatever fluid is surrounding the cell. A glycoprotein is a membrane protein that is covalently attached to a carbohydrate. They are used for cell-to-cell recognition and play an important role in immunity.

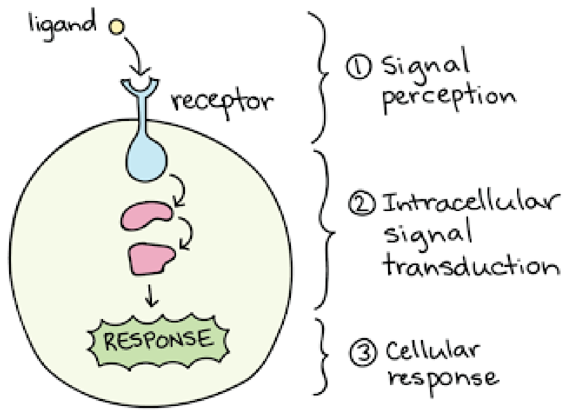
Cell Signaling:

- Cell signaling is the process by which messages are sent to cells.
- Cell signaling is very important as it allows multicellular organisms to control/ coordinate their bodies and respond to their environments.
- Cell signaling pathways coordinate the activities of cells, even if they are large distances apart within the organism.
- The basic stages of a cell signaling pathway are:
  - A stimulus or signal is received by a receptor.
  - The signal is converted to a 'message' that can be passed on – this process is known as transduction.
  - The 'message' is transmitted to a target(effector).
  - An appropriate response is made.
- Transmission of messages in cell signaling pathways requires crossing barriers such as cell surface membranes.
- Cell surface membranes are therefore very important in signaling pathways because the membrane controls which molecules (including cell signaling

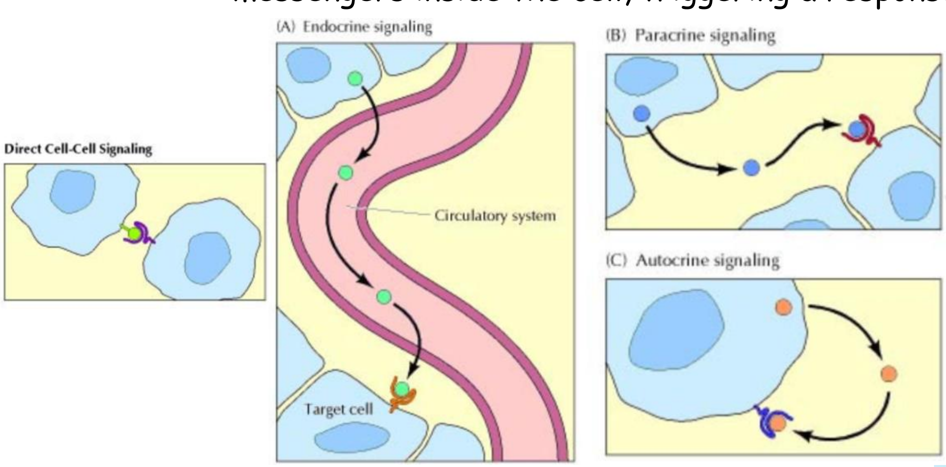
molecules) can move between the internal and external environments of the cell.

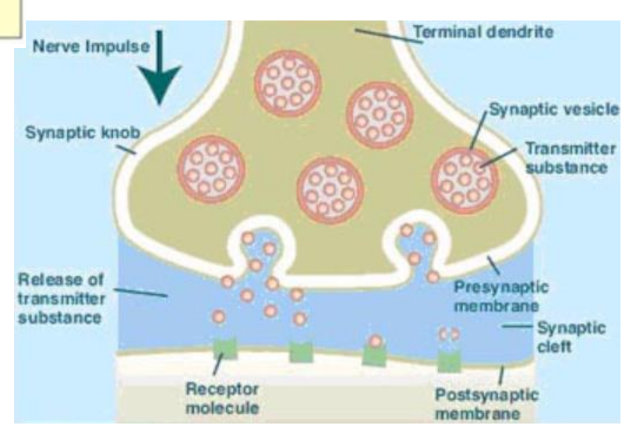
- Signaling molecules are usually very small for easy transport across cell membranes.
- Typically, in cell signaling pathways, signaling molecules need to cross or interact with cell membranes.

<u>Ligands:</u>



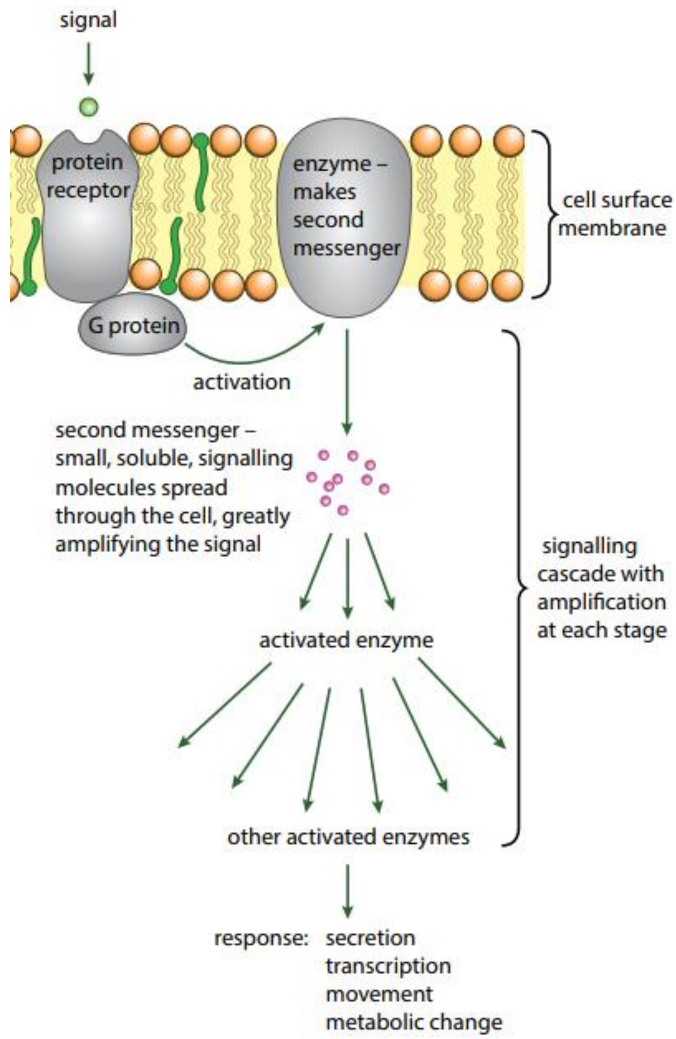
- Signaling molecules are often called ligands.
- Ligands are involved in the following stages of a cell signaling pathway:
    - ➢ Ligands are secreted from a cell (the sending cell) into the extracellular space.
    - ➢ The ligands are then transported through the extracellular space to the target cell.
    - ➢ The ligands bind to surface receptors (specific to that ligand) on the target cell. These receptors are formed from glycolipids and glycoproteins.
- The message carried by the ligand is relayed through a chain of chemical messengers inside the cell, triggering a response.

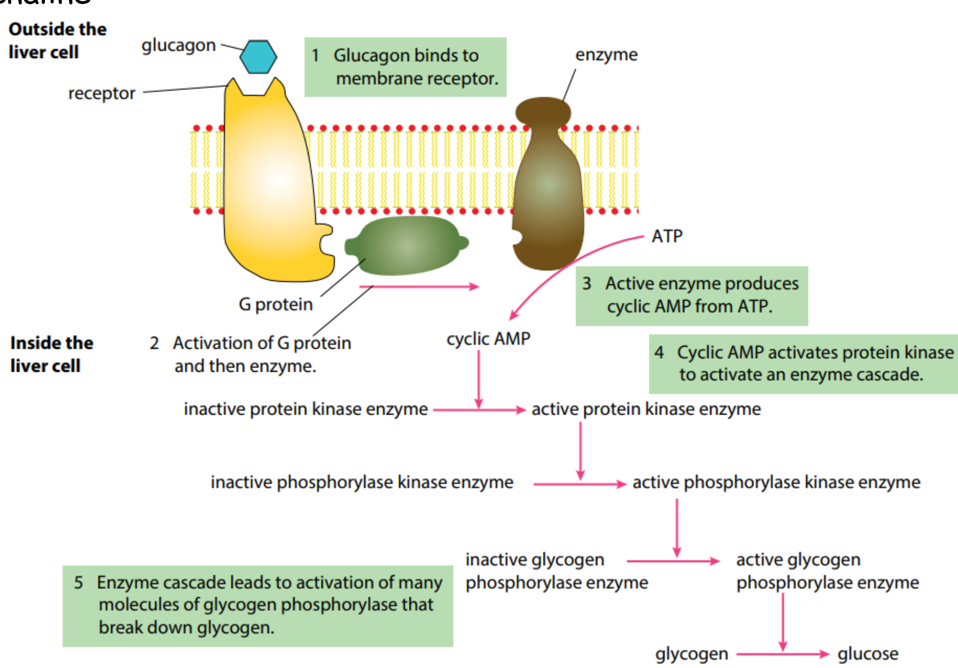




G-Protein Linked Receptor:

- 'G protein' acts as a switch to bring about the release of a 'second messenger', a small molecule which diffuses through the cell relaying the message.
- G proteins are so-called because the switch mechanism involves binding to GTP molecules.
- GTP is similar to ATP, but with guanine in place of adenine.
- Many second messenger molecules can be made in response to one receptor molecule being stimulated.
- This represents an amplification (magnification) of the original signal, a key feature of signalling.
- The second messenger typically activates an enzyme, which in turn activates further enzymes, increasing the amplification at each stage.
- Finally, an enzyme is produced which brings about the required change in cell metabolism.
- The sequence of events triggered by the G protein is called a signalling cascade.
- E.g. Glucagon and Adrenaline





4.2 Movement Into & Out of Cells

The exchange of materials between the cell occurs in several ways.

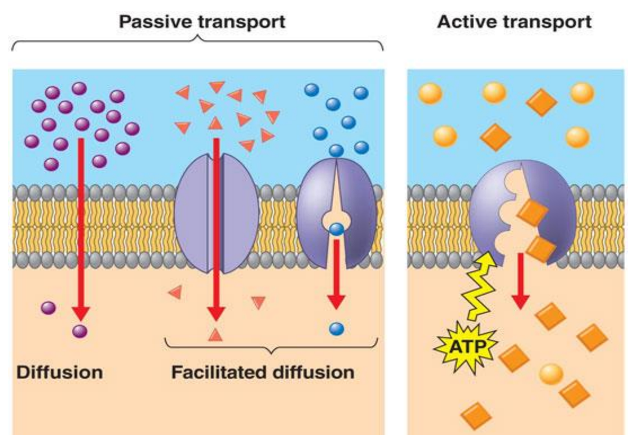
1. Diffusion
2. Facilitated diffusion
3. Osmosis
4. Active transport
5. Co-transport (Secondary Active Transport)

Cell must maintain homeostasis to live. It is a process by which a constant internal environment is maintained despite changes in the external environment. Cells need to bring in food, water, oxygen and eliminate wastes to maintain homeostasis. To do this, cells need the transport of molecules in and out, across the plasma membrane (which acts as a barrier).

<u>A concentration gradient</u> can be defined as an increase or decrease in the density of a chemical substance in an area. Cells often maintain concentration gradients of ions across their membranes.

In other words, it is the difference of concentration (high or low) of a substance on either side of the plasma membrane.

Passive Transport: Passive transport is the diffusion (facilitated or non-facilitated) of substances across a biological membrane. This occurs without the use of cellular energy.



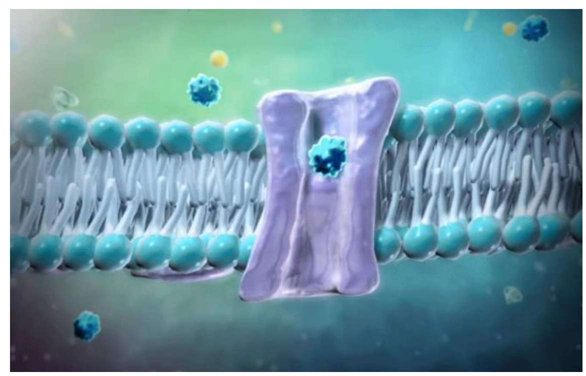
Diffusion: is the net movement of molecules and ions from a regional for higher concentration to a region of a lower concentration in down the concentration gradient due to the random motion of particles & the existence of a concentration gradient.

- Diffusion is a passive process of transport.
- Direct diffusion of molecules through a cell membrane is called simple diffusion.
- The rate of diffusion across internal and external cell membranes can change.
- Some cells display adaptations for rapid transport through their membranes.
- If there's a concentration gradient of a substance across a cell membrane and the membrane is freely permeable to the substance then molecules and ions will be entering exit by diffusion.

<u>Factors that influence the rate of diffusion:</u>

- S.A: The larger the surface area of a membrane means more area is exposed to the molecule and ions resulting in a faster rate of diffusion. ↑Surface area = ↑Rate
- Heat: At a greater temperature the particles convert heat into kinetic energy making the particles move faster increasing the diffusion rate. ↑Temperature = ↑Rate
- Concentration Gradient: When there is a greater difference in the concentration gradient, the rate of diffusion increases. ↑Difference in concentration = ↑Rate
- Distance: The shorter the distance to be moved by a substance, the faster the rate of her reaction. This is because the surface area does not increase at the same rate as a cell's volume, which is why a shorter distance would increase the rate of diffusion. ↑Distance= ↓Rate
- Thickness of plasma membrane: ↑Thickness = ↓Rate
- Solubility: Non-polar/lipid soluble materials = ↑Rate
- Solvent density: ↑Density = ↓Rate
- Mass of the molecules diffusing: Heavy molecules = ↓Rate

Facilitated Diffusion:

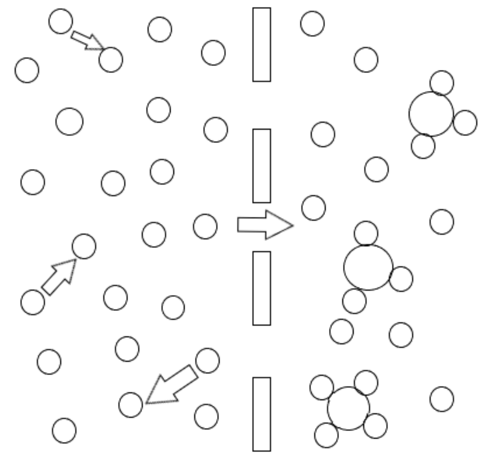


- Certain larger molecules like glucose and amino acids will diffuse very slowly across the phospholipid bilayer because they're too big.
- Charged particles like polar molecules and ions will also diffuse slowly because they're water soluble and the bilayer has a hydrophobic centre.
- In order to make things fast, charged or large particles diffuse through channel proteins or carrier proteins in the membrane instead of the phospholipid bilayer. This is called facilitated diffusion.
- Just like diffusion, facilitated diffusion also moves particles according to a concentration gradient (high to low).
- Facilitated diffusion is a passive process of transport.

Factors that influence the rate of facilitated diffusion:

- The number of carrier or channel proteins: ↑Number= ↑Rate
- The concentration gradient: ↑Gradient= ↑Rate

Osmosis: is the net movement of water molecules from a region of a higher water potential to a region of a lower water potential through a partially permeable membrane.



- The water potential of a solution measures the concentration of water molecules in that solution.
- The water potential of a solution measures the concentration of water molecules in that solution. The opposing force to the movement of water molecules from areas of high-water potential to areas of lower water potential is osmotic pressure.
- Equilibrium is reached when there are an equal amount of particles moving across a membrane in both directions.
- Also known as water balance, osmotic balance is obtained when there are as many water molecules moving into an area as there are moving out.
- Osmotic balance is a form of dynamic equilibrium.
- Ψ = 0kPa, 0 is the highest water potential.

Factors that influence the rate of osmosis:

- Water potential gradient: ↑Gradient= ↑Rate
- Thickness of the exchange surface: ↓Thickness= ↑Rate
- Surface area of the exchange surface: ↑Surface area= ↑Rate

Solute Potential:

- There are two factors that determine the water potential of a solution:
  - the concentration of the solution
  - the pressure applied to it.
- The contribution of the concentration of the solution to water potential is called solute potential.
- Solute potential is the extent to which the solute molecules decrease the water potential of the solution. The more solute there is, the lower the tendency for water to move out of the solution.
- Just like water potential, solute potential is 0 for pure water and has a negative value for a solution.
- Adding more solute to a solution decreases its water potential.
- The greater the concentration of the solute, the more negative the value of the solute potential. The psi symbol can be used to show the solute potential, but this time with the subscript $_s$ – ψ_s.
- As pure water is composed solely of water molecules, it has the highest possible water potential which is quantified at 0kPa. When solute molecules

are added to pure water, the relative number of water molecules in the resulting solution changes and the water potential decreases.

- The more solute molecules in a solution, the lower the water potential and the more negative the value. Therefore, a solution with a water potential measured at -800kPa has a lower water potential than a solution with a water potential measured at (-1 to -799) kPa.

<u>Pressure Potential:</u>

- The contribution of pressure to the water potential of a solution is called pressure potential.
- Increasing the pressure on B increases the tendency of water to move out of it – that is, it increases its water potential. Pressure potential can be shown using the symbol ψ_p.

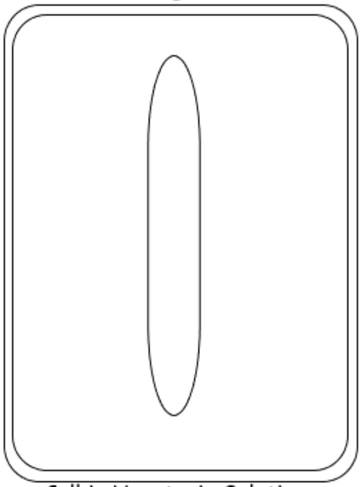
<u>Osmotic Pressure:</u>

- Animal cells cannot withstand a high amount of osmotic pressure and the plasma membrane will burst.
- Osmotic pressure inside a plant cell is known as turgor pressure. Plant cells can stand up to the pressure due to the presence of the cell wall. Turgor pressure helps keep a plant cell rigid.

<u>Plant Cells and Osmosis:</u>

- If a cell is in a hypotonic solution, it is said to be a turgid cell.
  - Turgidity is important for a cell to keep its shape. Young stems and most leaves remain firm due to the turgor pressure in their cells.
  - In some cells, movement occurs due to a change in turgidity. For example, the opening and closing of the stomata occurs when the guard cells become more or less turgid.
  - If too much water leaves the cells due to evaporation, the plant wilts.
- When plant cells are placed in hypertonic solutions, water leaves the cell and the cell becomes flaccid.
  - It will become turgid again if placed in a hypertonic solution.

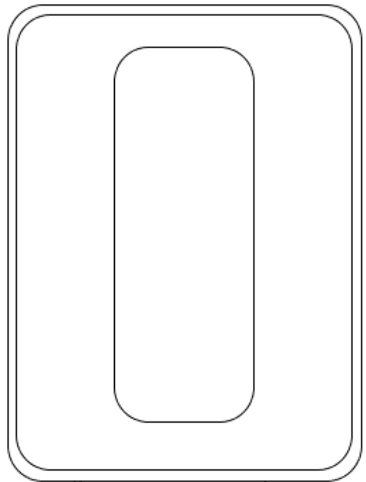
Turgid



Cell in Hypotonic Solution

In High water potential outside, the water will enter the cell by osmosis, making it swell up, and its cytoplsm pushes against the cell wall building an internal osmotic pressure allowing it to withstand the water pressure. It has expanded so much that no more water can enter making it fully turgid.

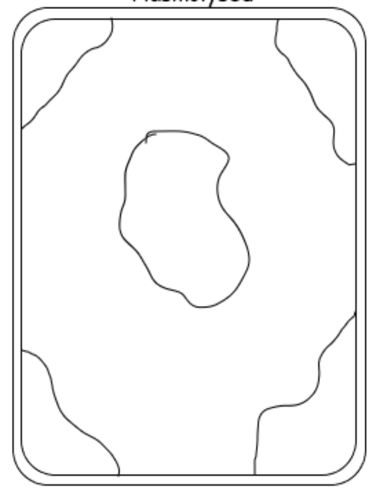
Flaccid



Cell in Hypertonic Solution

When a cell is placed in a hypertonic solution there is low water potential outside the cell so the cell loses water and deflates as the water exits by osmosis. The contents decrease in volume and the cytoplasm no longer pushes against the cell wall.

Plasmolysed



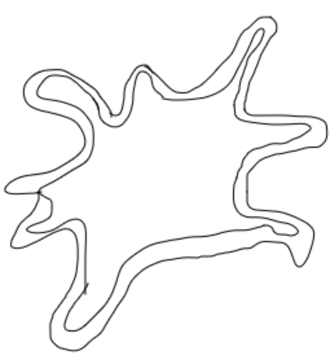
Cell in Hypertonic Solution

If left in a hypertonic solution, the contents of this cell will decrease in volume, so much so that the cytoplasm pulls away from the cell wall.

<u>Animal Cells and Osmosis:</u>

- When animal cells are placed in a hypotonic solution, they swell up.
  - As they don't have a cell wall, they burst as they aren't able to withstand the turgor pressure.
- When cell walls are placed in a hypertonic solution, water leaves the cell.
  - The cell shrinks and spikes form in a process known as cessation.
  - The cell will eventually die due to this.

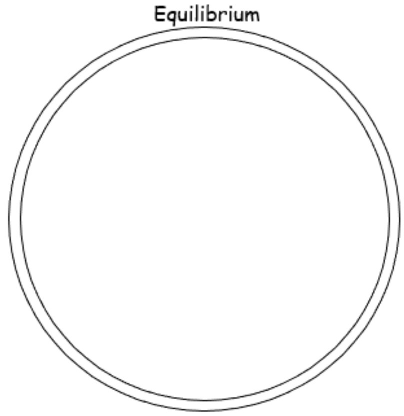
Crenated



Cell in a Hypertonic Solution

In a hypertonic solution where the outside has a low water potential so water moves from inside to out of the cell by osmosis. 3% salt solution is hypertonic to blood.

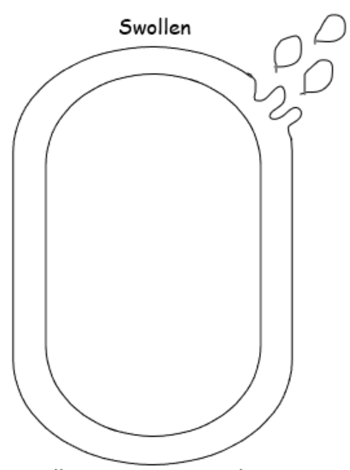
Equilibrium



Cell in an Isotonic Solution

Both sides, in and out had the same water potential one solution is said to be isotonic to the other solution. 0.85% salt solution is isotonic to blood.

Swollen



Cell in a Hypotonic Solution

In a hypertonic solution, where the outside has a higher water potential, water moves from out to inside of the cell. Pure water is hypertonic to blood.

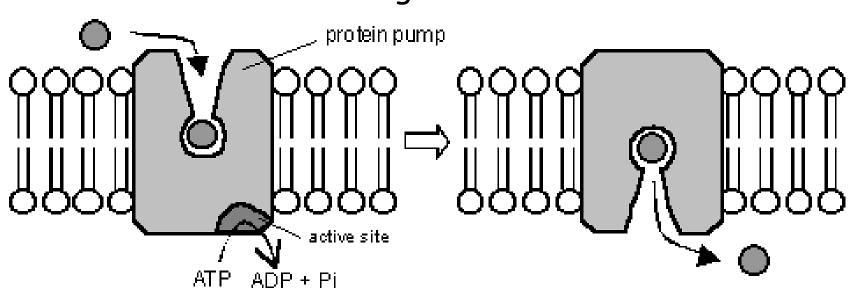
Active transport: is the movement of molecules ions into or out of a cell through the cell membrane from a region of their lower concentration to a region of their higher concentration against/ up a concentration gradient using energy from respiration in the form of ATP. Membrane proteins can be used as pumps in active transport. The process is almost the same as facilitated diffusion. When a molecule attaches itself to a carrier protein, the protein alters its shape and moves the molecule to release it onto the other side across the membrane.

Factors that influence the rate of active transport:

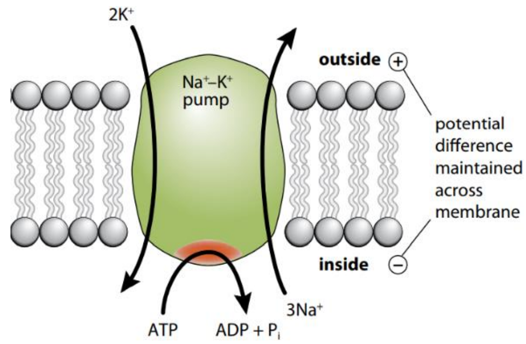
- Number of carrier proteins: ↑Proteins = ↑Rate
- Speed of individual carrier proteins: ↑Speed = ↑Rate
- Availability of ATP and the rate of respiration in the cell: No respiration = No active transport

Structure and function of sodium-potassium pumps for active transport and potassium channels for facilitated diffusion in axons:

- The cell can hydrolyze ATP and use the energy released to move substances across the plasma membrane and against the concentration gradient. The energy is used to change the shape of membrane protein "pumps".
- Each pump only transports particular substances.
- The particle will enter the pump on the side with a lower concentration and bind to a specific site for that type of particle.
- Energy from ATP is used to change the shape of the pump, the particle is released on the side of higher concentration, and the pump returns to its original shape.
- An example of this is the sodium-potassium pump in animal cells. There is a high concentration of potassium ions inside cells and a high concentration of sodium ions outside of the cells.
- The cell maintains these concentrations using the sodium-potassium pump; a membrane protein.



- The role of the Na+ – K+ pump is to pump three sodium ions out of the cell at the same time as allowing two potassium ions into the cell for each ATP molecule used. The ions are both positively charged, so the net result is that the inside of the cell becomes more negative than the outside – a potential difference is created across the membrane.



<u>The fluidity of membranes:</u> allows materials to be taken into cells by endocytosis or released by exocytosis. Vesicles move materials within cells.

- The phospholipid molecules which make up the plasma membrane are in a fluid state which allows them to change shape.
- This fluidity of the plasma membrane allows it to form vesicles that can be pinched off or ones that can fuse with it. During endocytosis and exocytosis these vesicles are formed without any damage to the plasma membrane.

<u>Importance of active transport in ion uptake by root hair cells:</u>

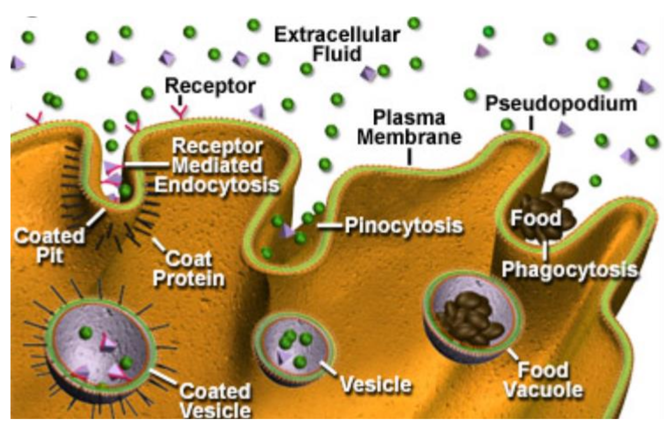
- Plants need to absorb minerals to stay healthy. They absorbed these ions from a region of low concentration to a region of a higher concentration, by active transport. Root hair cells have a large S.A:Vol and it present between the soil particle where there is a low concentration of ions unlike the cell which has a higher concentration and to absorb more, they follow the same pathway in a plant as water: cortex, Xylem.

<u>Another Example of Active Transport:</u>

- Glucose and amino acids are also absorbed by cells in the small intestine via active transport.

Endocytosis and Exocytosis:

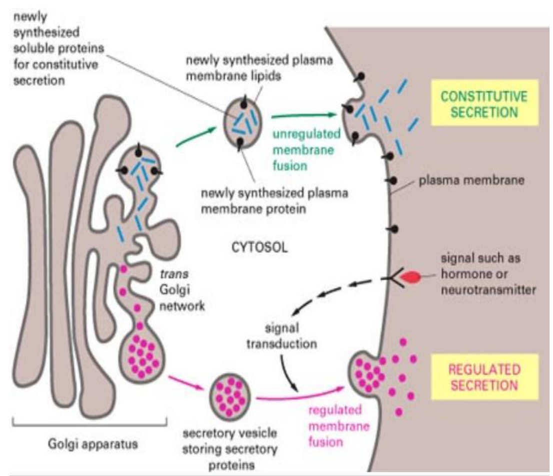
- If molecules are too large to move across a cell membrane via diffusion or osmosis, they need to be moved via a process called endocytosis or exocytosis.
- <u>Endocytosis:</u> In endocytosis, an outside molecule is engulfed by the cell membrane and brought inside the cell. The cellular uptake of macromolecules and particulate substances by localized regions of the plasma membrane that surround the substance and pinch off to form an intracellular vesicle. Cells can



bring in solids and liquids using this process. occurs when the plasma membrane is pulled inwards and will form a “pocket” around a particular substance. The substance will become enclosed in the vesicle which is then pinched off and begins moving through the cytoplasm. Cells can bring in solids and liquids using this process.

- Phagocytosis: A type of endocytosis involving large, particulate substances, accomplished mainly by macrophages, neutrophils and dendritic cells. This is the bulk intake of solid material by a cell. Cells that specialize in this process are called phagocytes. The vacuoles formed are called phagocytic vacuoles. An example is the engulfing of bacteria by phagocytic white blood cells.
- Pinocytosis: A type of endocytosis in which the cell ingests extracellular fluid and its dissolved substances. This is the bulk intake of liquids. If the vacuole (or vesicle) that is formed is extremely small then the process is called micropinocytosis.

- <u>Exocytosis:</u> In exocytosis, an inside molecule is fused with the plasma membrane and released outside the cell. The cellular secretion of macromolecules by the fusion of vesicles with the plasma membrane. Exocytosis is internal vesicles will fuse with the plasma membrane and the contents of the vesicle are released into the external environment of the cell. The cell can secrete substances they produced this way or excrete waste products.



<u>Vesicles are used to transport materials within a cell between the RER, Golgi apparatus and plasma membrane:</u>

- The ribosomes attached to the RER synthesize proteins and release them into the RER.
- The proteins travel through the RER and are then released from the RER in vesicles formed from the RER membrane.
- The vesicle travels through the cytoplasm and delivers the proteins to the Golgi apparatus which then modifies the proteins.
- The proteins are then sent off inside a vesicle formed from the membrane of the Golgi apparatus and are carried to the plasma membrane.

- The vesicle fuses with the plasma membrane and the contents are released outside the cell (exocytosis).

Differences between Facilitated Diffusion & Active Transport	
Facilitated Diffusion	**Active Transport**
In facilitated diffusion, solutes move from high to low concentration.	In active transport, it moves from low to high concentration.
Channel proteins are used in facilitated diffusion.	Channel proteins are not used in active transport.
facilitated diffusion does not need energy.	Active transport needs energy. • ATP is produced by respiration and its a common source of energy in cells. • When ATP splits into ADP & P1 during hydrolysis, energy is being released to facilitate the transport of solutes.

Co-transport (Secondary Active Transport): is a type of transport in which 2 substances are transported simultaneously across a membrane.

- This process is facilitated by symporters which could transfer 2 substances in the same direction. E.g. sodium-glucose symporter. This symporter uses the sodium ions to move glucose into the cell. The movement of sodium ions through the symporter provides the required energy for the glucose to move through the symporter as well.
- Absorption of sodium ions and glucose by cells lining the mammalian ileum takes place by co-transport.
- An electrochemical gradient, created by primary active transport, can move other substances against their concentration gradients, a process called co-transport or secondary active transport.