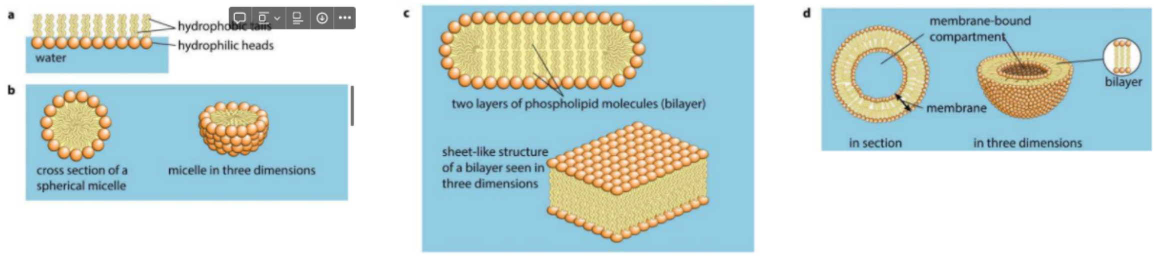
Chapter 4: Cell membranes and transport

▼ 4.1. Phospholipids



▼ 4.2. Structure of membranes

▼ Fluid mosaic model

The fluid mosaic model is the currently accepted model of the membrane structure, proposed by Singer and Nicolson in 1972, in which protein molecules are free to move about in a fluid bilayer of phospholipid molecules.

It is described as 'fluid' because both the phospholipids and the proteins can move about by diffusion.

The word mosaic describes the pattern produced by the scattered protein molecules when the surface of the membrane is viewed from the above.

The membranes are described to be **bilayer.**

▼ Intrinsic proteins / integral proteins

Intrinsic proteins are proteins that are embedded within the membrane. They have hydrophobic and hydrophilic regions.

Most intrinsic protein molecules float like mobile icebergs in the phospholipid layers, although some are fixed like islands to structures inside or outside the cell and do not move about.

▼ Extrinsic proteins

Extrinsic proteins are found on the inner or outer surface of the membrane. Many are bound to intrinsic proteins.

Many proteins and lipids have short, branching carbohydrate chains attached to that side of the molecule which faces the outside of the membrane, thus forming glycoproteins and glycolipids.

▼ Transmembrane proteins

Transmembrane proteins are proteins spanning the whole membrane.

▼ Roles of the components of cell membranes

There are 3 types of lipids; phospholipids, cholesterol and glycolipids.

There are 2 types of proteins; proteins and glycoproteins.

▼ Phospholipids and their functions

Phospholipids form a bilayer, which is the basic structure of the membrane. As the tails of phospholipids are non-polar, it is difficult for polar molecules, or ions, to pass through membranes, so they **act as a barrier to most water soluble substances.**

Some phospholipids **can be chemically modified to act as signaling molecules**. They move about in the bilayer activating other molecules such as enzymes, or they can **release water soluble small glycerol related molecules by hydrolization.** These diffuse through the cytoplasm and bind to specific receptors.

▼ Cholesterol and their functions

Small molecules that also have hydrophilic heads and hydrophobic tails. Animals have as much cholesterol as they have phospholipids, while plants have much less and non in prokaryotes.

At low temperatures, cholesterol increases fluidity of the membrane, preventing it from becoming too rigid. At high temperatures, prevents from becoming too fluid and basically **stabilizes cells.**

Also cholesterol is important for the **mechanical stability** as without it membranes quickly break and cells burst open. The hydrophobic regions of cholesterol molecules **help to prevent** ions or polar molecules from passing the membrane.

▼ Glycolipids, glycoproteins and proteins

Many of the lipid molecules on the other surfaces of cell membranes, and all the protein molecules have short carbohydrate chains attached to them like antennae. They form hydrogen bonds with the water molecules and so **help to stabilize the membrane structure.**

The carbohydrate chains help the glycoproteins and glycolipids to act as receptor molecules, which bind with particular substances at the cell surface. There are different receptors but the main three groups are:

▼ 1. Signaling receptors

They are part of a signaling system that coordinates the activities of cells. e.g. glucagon receptor in liver cells.

▼ 2. Receptors involved in endocytosis

They bind to molecules that are part of the structures to be engulfed by the cell surface membrane.

▼ 3. Receptors involved in binding cells to other cells(cell adhesion) in tissues and organs of animals.

Some glycolipids and glycoproteins **act as cell markers or antigens.** allowing cell-cell recognition. Each type of cell has its own type of antigen.

Many proteins act as **transport proteins**. They provide hydrophilic channels or passageways for ions and polar molecules to pass through the membrane. There are two types of transport proteins **channel proteins and carrier proteins.**

Other proteins may be enzymes that catalyze the hydrolysis of molecules such as disaccharides.

Some proteins inside of the membrane are attached to a **system of protein filaments**, known as **cytoskeleton** and help to maintain and decide the shape of the cell. They may also be **involved in changes of shapes** when they move.

What is glycocalyx

Glycocalyx is the carbohydrate chains that form the sugary coating of the cell, and for animals glycoproteins, and for plants glycolipids comprises the glycocalyx, mainly.

4.3. Cell signaling

What is the function is cell signaling

It helps to explain how living organisms control and coordinate their bodies by sending a message from one place to another to respond to their change in environments.

Transduction

Conversion of the original signal to a message that is then transmitted.

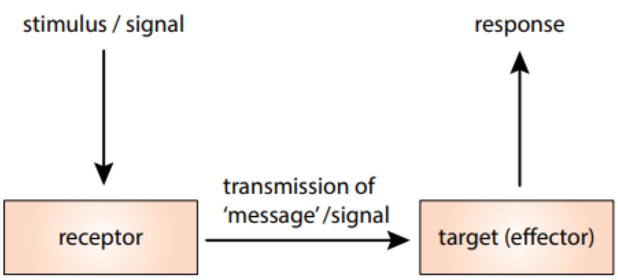


Figure 4.6 Basic components of a signalling pathway.

If the signaling distance is short the messages travel by diffusion, if long in blood for animals and phloem for plants.

Hydrophobic signals are less common and they can directly diffuse across the cell membrane and bind to receptors in the nucleus or cytoplasm.

G proteins

G proteins act as a switch to bring about the release of a 'second messenger', a small molecule which diffuses through the cell relaying the message.

Toggle cascade

The sequence of events triggered by the G protein.

Other ways in which a receptor can alter the activity of a cell.

1. Opening an ion channel, resulting in a change of membrane potential.
2. Acting directly as a membrane-bound enzyme.
3. Acting as an intracellular receptor when the initial signal passes straight through the cell surface membrane.

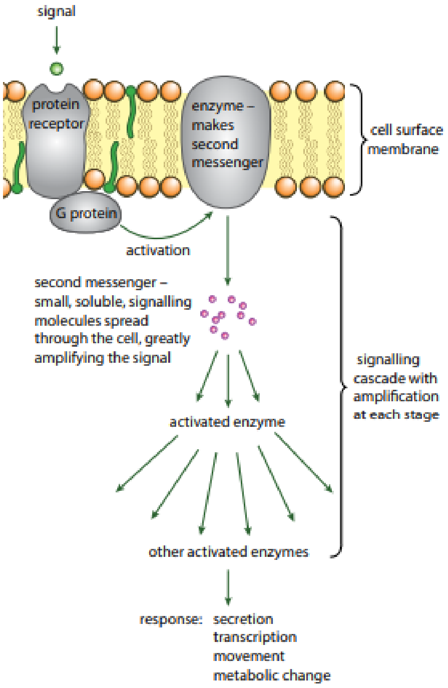


Figure 4.7 A simplified cell signalling pathway involving a second messenger.

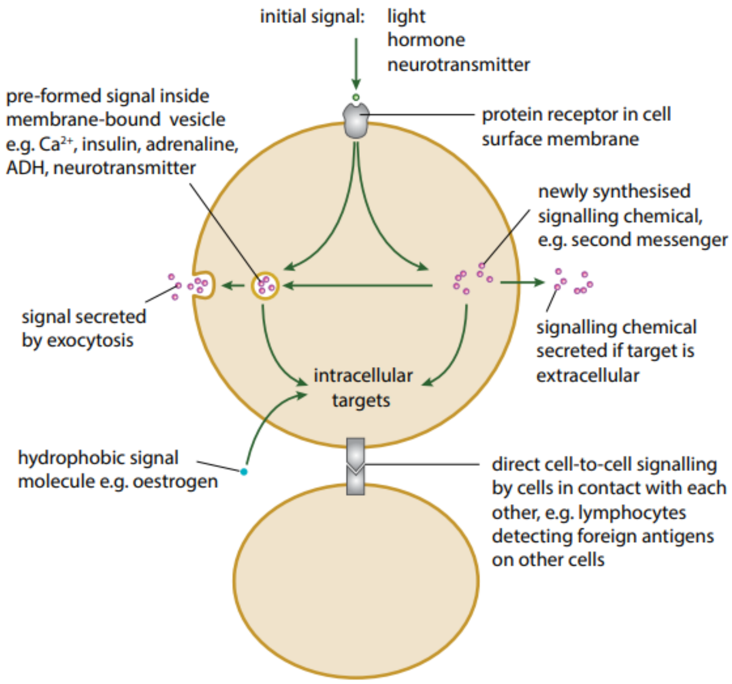


Figure 4.8 A few of the possible signalling pathways commonly found in cells. Note the role of membranes in these pathways.

▼ 4.4. Movement of substances into and out of cells

▼ What are the five basic mechanisms by which exchange is achieved

Diffusion, facilitated diffusion, osmosis, active transport and bulk transport.

▼ Diffusion

Diffusion is the net movement of molecules or ions from a region of higher concentration to a region of lower concentration down a gradient, as a result of the random movements of particles.

▼ The rate at which a substance diffuses across a membrane depends on a number of factors, (4)

1. **The 'steepness' of the concentration gradient -** that is, the difference in the concentration of the substance on the two sides of the surface. The greater the difference in concentration, the greater the difference in the number of molecules passing in the two directions, and hence the faster the rate of diffusion.
2. **Temperature -** molecules move faster with greater kinetic energy in high temperatures thus diffusion takes place faster.
3. **The surface area across which diffusion is taking place -** The greater the surface area, the more molecules or ions can cross it at any one moment, and therefore the faster diffusion can occur. The surface area of cell membranes can be increased by folding.

   The surface area: volume ratio decreases as the size of any three-dimensional object increases.

4. **The nature of the molecules or ions -** Large molecules require more energy to get them moving than small ones do, so large molecules tend to diffuse more slowly than small molecules.

   Non-polar molecules diffuse much more easily through cell membranes than polar ones, because they are soluble in the non-polar phospholipid tails.

   Oxygen and carbon diffuse easily because they are non-polar and uncharged.

   Water, even though it is polar, it is small so diffuses easily.

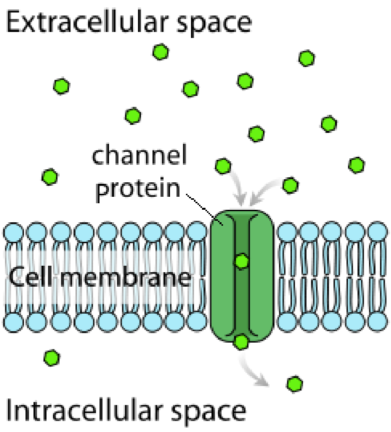
Facilitated diffusion

Facilitated diffusion is the diffusion of a substance through transport proteins in a cell membrane; the proteins provide hydrophilic areas that allow the molecules or ions to pass through the membrane which would otherwise be less permeable to them.

Channel proteins

Channel protein is a membrane protein of fixed shape which has a water-filled pore through which selected hydrophilic ions or molecules can pass with facilitated diffusion.

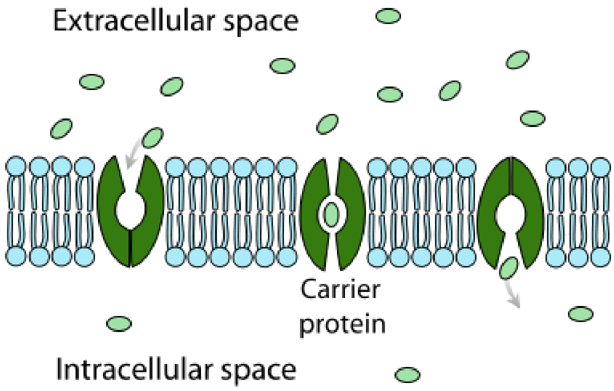
the rate at which this diffusion takes place is affected by how many channel or carrier protein molecules there are in the membrane.



Carrier proteins

Carrier protein is a type of membrane protein which changes shape to allow the passage into or out of the cell of specific ions or molecules by facilitated diffusion or active transport.

the rate at which this diffusion takes place is affected by channel proteins, on whether they are open or not.



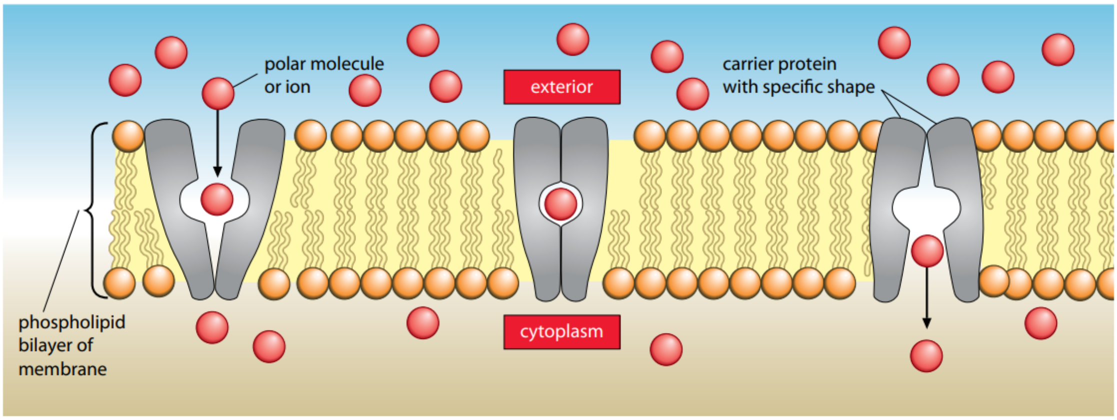


Figure 4.9 Changes in the shape of a carrier protein during facilitated diffusion. Here, there is a net diffusion of molecules or ions **into** the cell down a concentration gradient.

▼ Osmosis

Osmosis the net movement of water molecules from a region of higher water potential to a region of lower water potential, through a partially permeable membrane, as a result of their random motion (diffusion).

▼ Water potential

Water potential a measure of the tendency of water to move from one place to another; water moves from a solution with higher water potential to one with lower water potential; water potential is decreased by the addition of solute, and increased by the application of pressure; symbol is ψ or ψw

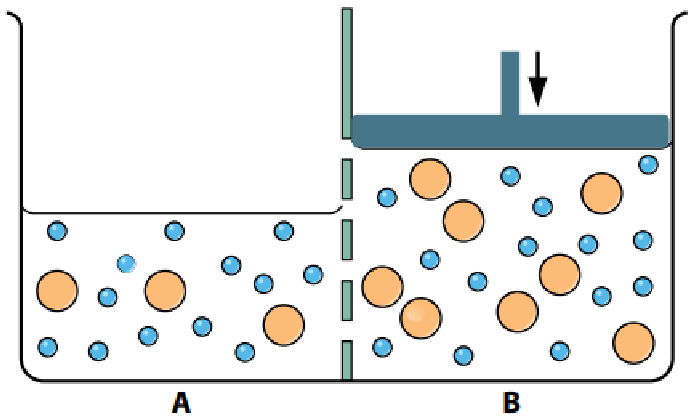


Figure 4.11 Applying pressure to a solution increases the tendency of water to move out of it – that is, it increases its water potential. Here, water molecules move from **B** to **A**.

▼ Solute potential and pressure potential

Solute potential (ψs) is the contribution of the concentration of the solution to water potential. There more solute there is, the lower tendency for water to move out of the solution.

The greater the concentration of the solute, the more negative the value of the solute potential.

Pressure potential (ψp) the contribution of pressure to the water potential of a solution.

▼ Osmosis in animal cells

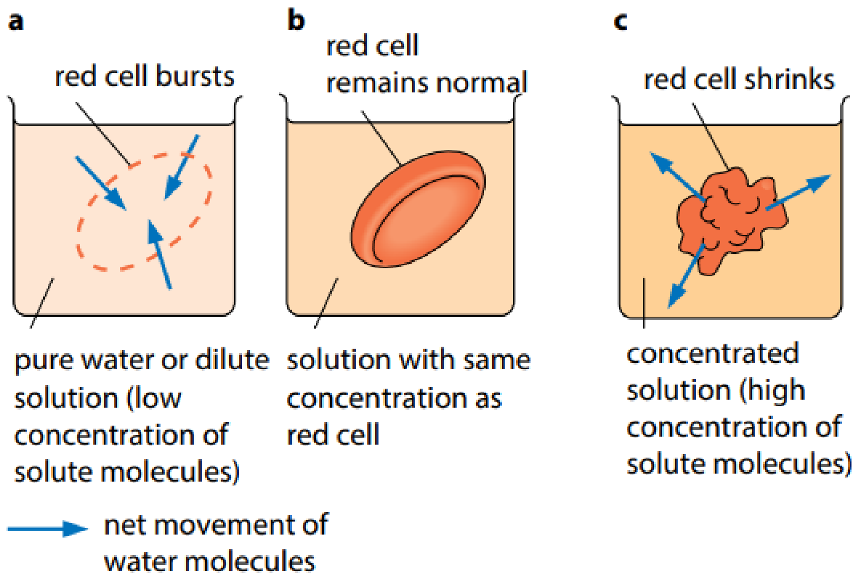


Figure 4.12 Movement of water into or out of red blood cells by osmosis in solutions of different concentration.

▼ Osmosis in plant cells

Just like in the animal cell, the volume of the cell increases, but in the plant cell the the cell wall pushes back against the expanding protoplast (the living part of the cell inside the cell wall), and pressure starts to build up rapidly.

For plant cells water potential is a combination of solute potential and pressure potential. This can be expressed in the following equation: $\psi = \psi s + \psi p$

The point at which pressure potential has just reached zero and plasmolysis is about to occur is referred to as incipient plasmolysis.

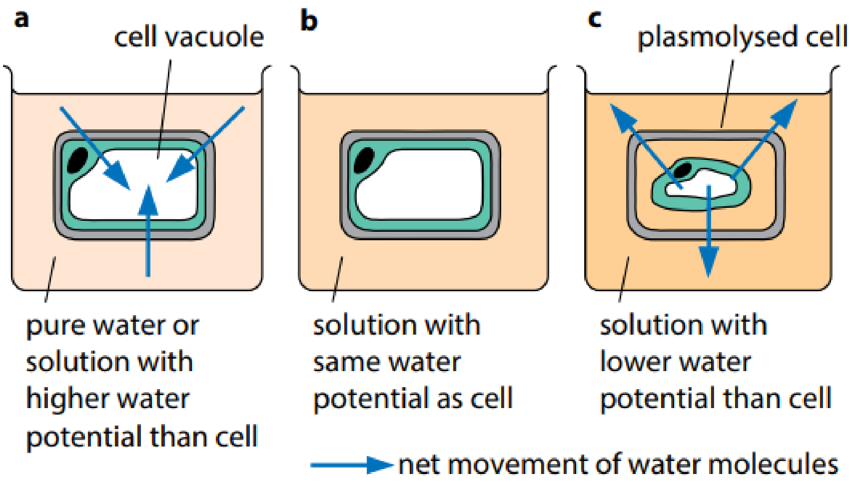


Figure 4.13 Osmotic changes in a plant cell in solutions of different water potential.

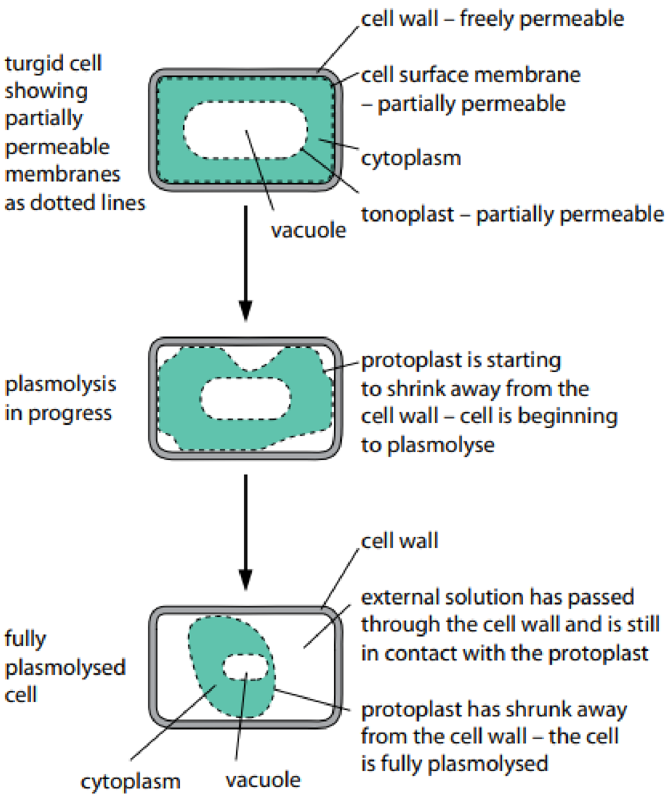


Figure 4.14 How plasmolysis occurs.

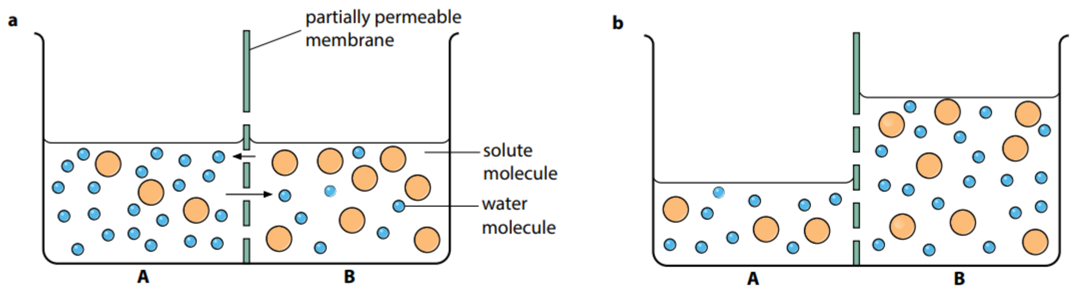


Figure 4.10 Two solutions separated by a partially permeable membrane. **a** Before osmosis. The solute molecules are too large to pass through the pores in the membrane, but the water molecules are small enough. **b** As the arrows show, more water molecules moved from A to B than from B to A, so the net movement has been from A to B, raising the level of solution in B and lowering it in A.

▼ Active transport

A**ctive transport** the movement of molecules or ions through transport proteins across a cell membrane, **against their concentration gradient,** using energy from ATP.

▼ Sodium-potassium (Na+ - K+) pump

Sodium–potassium pump a membrane protein (or proteins) that moves sodium ions out of a cell and potassium ions into it, using ATP.

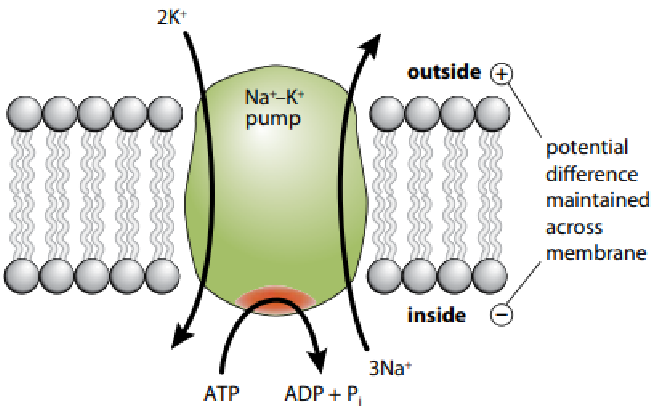


Figure 4.18 The $Na^+ - K^+$ pump.

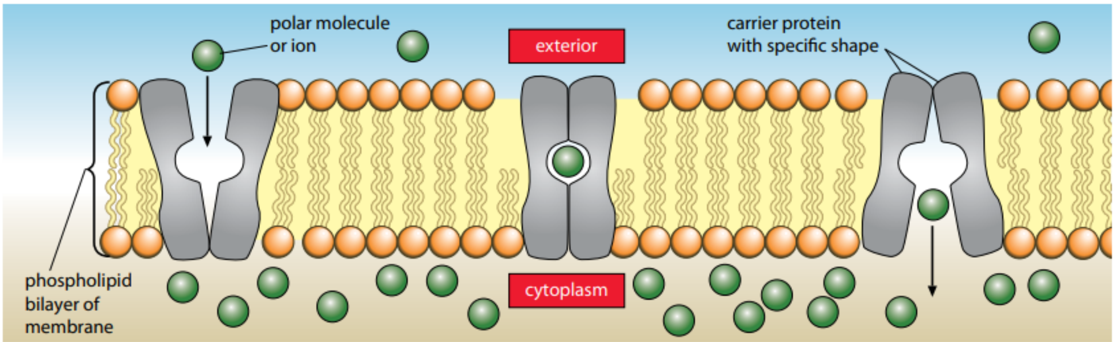


Figure 4.17 Changes in the shape of a carrier protein during active transport. Here, molecules or ions are being pumped into the cell **against** a concentration gradient. (Compare Figure 4.9.)

▼ Bull transport

Mechanisms also exist for the bulk transport of large quantities of materials into cells(endocytosis) and out of cells(exocytosis).

▼ Endocytosis

Endocytosis is the **bulk movement of liquids (pinocytosis**) or **solids (phagocytosis)** into a cell, by the infolding of the cell surface membrane to form vesicles containing the substance; endocytosis is an active process requiring ATP.

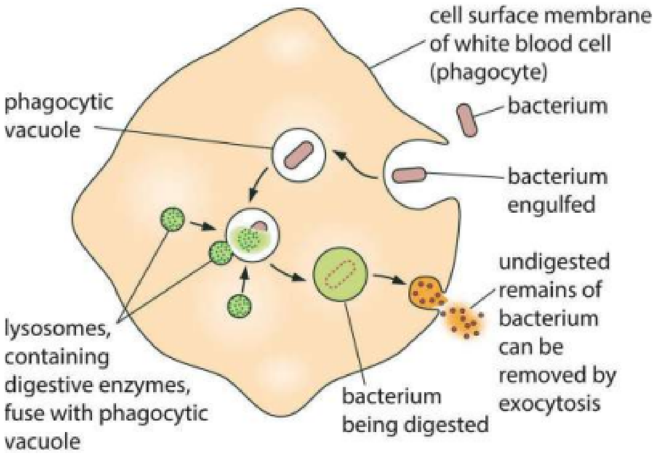


Figure 4.19 Stages in phagocytosis of a bacterium by a white blood cell.

▼ Exocytosis

Exocytosis the bulk movement of liquids or solids out of a cell, by the fusion of vesicles containing the substance with the cell surface membrane; exocytosis is an active process requiring ATP.

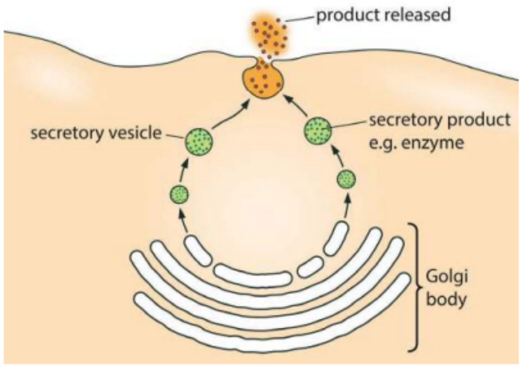


Figure 4.20 Exocytosis in a secretory cell. If the product being secreted is a protein, the Golgi body is often involved in chemically modifying the protein before it is secreted, as in the secretion of digestive enzymes by the pancreas.

Figure 4.21 Transmission electron micrograph of pancreatic acinar cell secreting protein. The outside of the cell is coloured green. Golgi (secretory) vesicles with darkly stained contents can be seen making their way from the Golgi body to the cell surface membrane.

▼ What are the most abundant molecules in the cell surface membranes of plant cells?

C phospholipids

▼ Where are the carbohydrate portions of glycolipids and glycoproteins located in cell surface membranes?

D the outside surface of the membrane

▼ The cells of the myelin sheath are wrapped in layers around nerve cell axons. Freeze-fractured preparations of the myelin sheath cell surface membranes show very few particles. This indicates that myelin membranes contain relatively few of which type of molecule?

D proteins

▼ **Prepare a table to summarize briefly the major functions of phospholipids, cholesterol, glycolipids, glycoproteins and proteins in cell surface membranes.**

Major functions of components of the cell membrane

Component	Function 1	Function 2	Function 3
Phospholipids	act as a barrier to most water soluble substances.	can be chemically altered to act as signalling molecule.	can release water soluble small glycerol related molecules by hydrolisation.
Cholesterol	Stabilises the cell in different temperatures.	Mechanical stability, as without it cells can easily burst.	the hydrophobic regions help to prevent ions or polar molecules from passing the membrane.
Glycolipids	forms hydrogen bonds with the water molecule so help to stabilise the membranes structure.	act as receptor molecules	act as antigens.
Glycoproteins	act as receptor molecules.		
Proteins	act as transport proteins (channel proteins & carrier)	some attached to the cytoskeleton and help to maintain or decide the shape of the cell.	may be involved in changes of shapes when they move.

If you have any questions reach out to**: 23C Chinguun.M, IG: @chinguun__0511, FB: Chinguun Tsetsgee.**
Or post questions on the discord server for help!