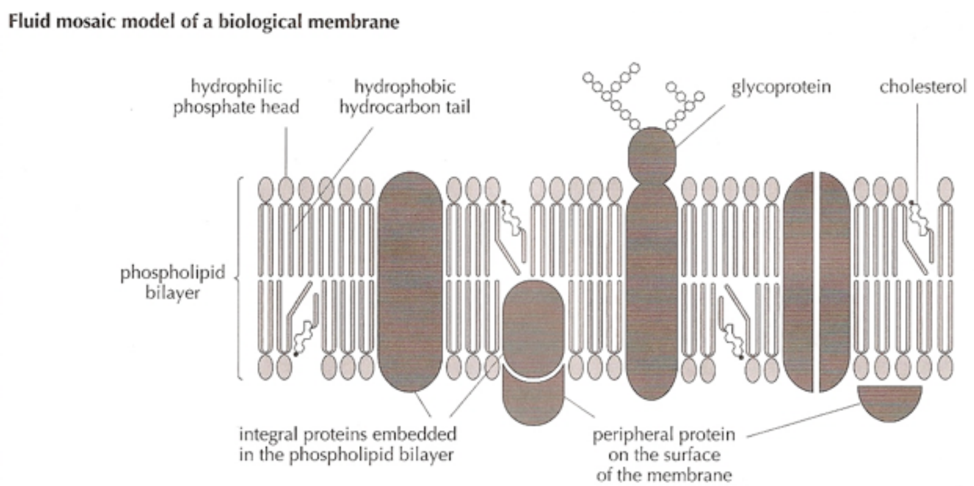
B2.1 Membranes and membrane transport



Phospholipids:

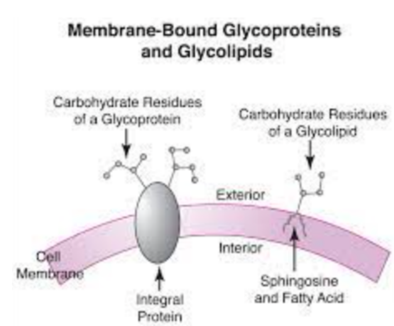
The attraction between the hydrophobic tails in the centre and between the hydrophilic heads and the surrounding water makes membranes very stable. This happens because hydrophobic molecules are not attracted to water but to each other. Substances with this property (i.e being hydrophilic and hydrophobic) are called **amphipathic**.

Cholesterol:

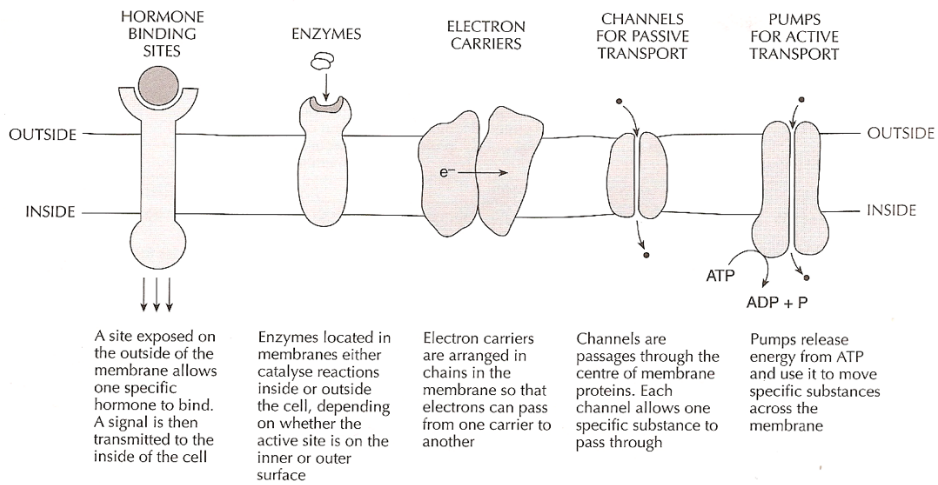
It is a component (20-40%) of animal cell membranes. In mammalian membranes cholesterol reduces membrane fluidity and permeability to some solutes. It also helps to maintain the necessary orderly arrangement of phospholipids. It stabilizes membranes at higher temperatures and helps ensure that the membrane will not solidify at lower temperatures.

Glycoproteins and glycolipids:

They are both used for cell adhesion and cell-to-cell recognition. They distinguish between self and non-self cells, so pathogens and foreign tissues can be recognized and destroyed.



Membrane proteins:



Transport across membranes

Membranes control the composition of cells by active and passive transport.

1) **Passive transport:** the movement of substances across membranes without the use of ATP

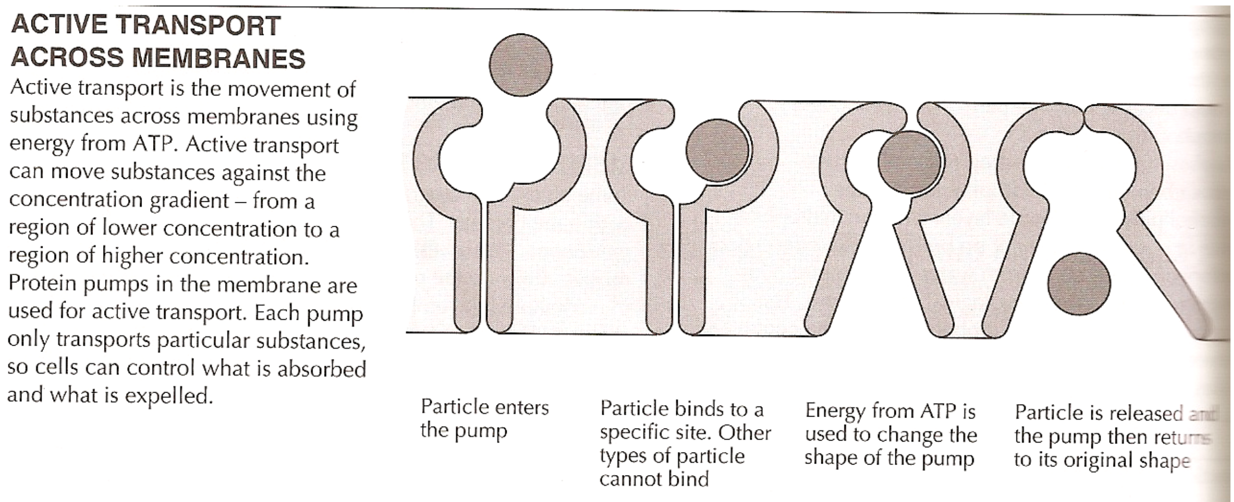
1a) **Diffusion**: the movement of molecules and ions across a partially permeable membrane (phospholipids) from a region of high concentration to a region of low concentration. simple diffusion is not selective and depends only on the concentration gradient, particle size and polarity or charge of molecules.
In some cases where selective permeability is required, substances need the use of **channel proteins** in order to pass in or out the cell. This is called **facilitated diffusion**

1b) **Osmosis:** The movement of WATER (only!) across a partially permeable from a region of low solute concentration to a region of high solute concentration.

Aquaporins are water channels in cells, which greatly increase membrane permeability to water. Kidney cells and hair root cells in plants are a typical example.

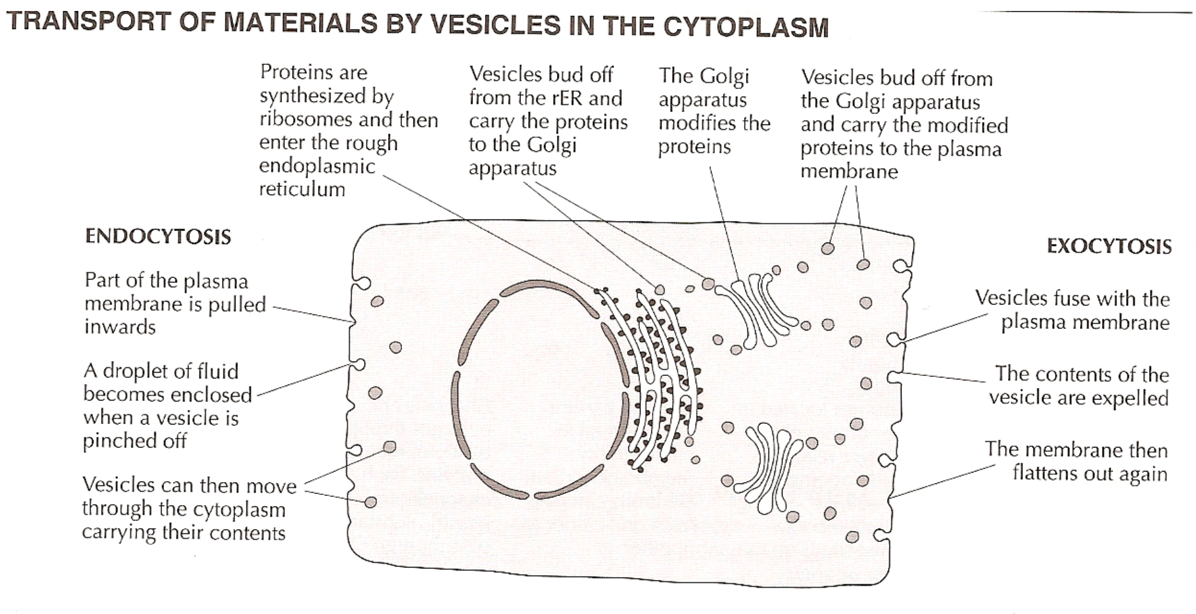
2) **Active transport:** The movement of substances across membranes from a region of low concentration to a region of high concentration with the use of ATP and pump proteins (against a concentration gradient).

Figure 1: Mechanism of active transport



Higher Level

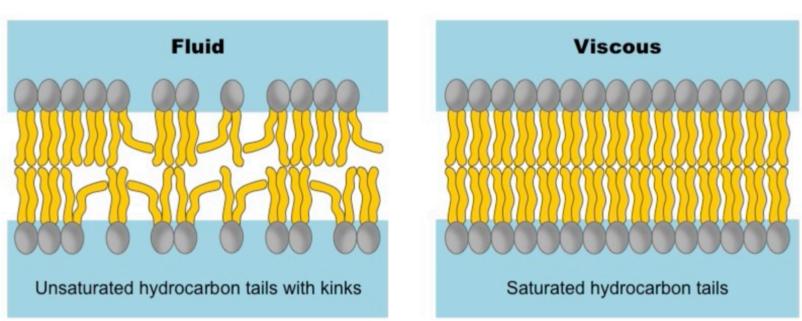
The use of vesicles in endocytosis and exocytosis



Endocytosis involves either pinocytosis (liquid substances) or phagocytosis (solid substances).

Relationships between fatty acid composition of lipid bilayers and their fluidity

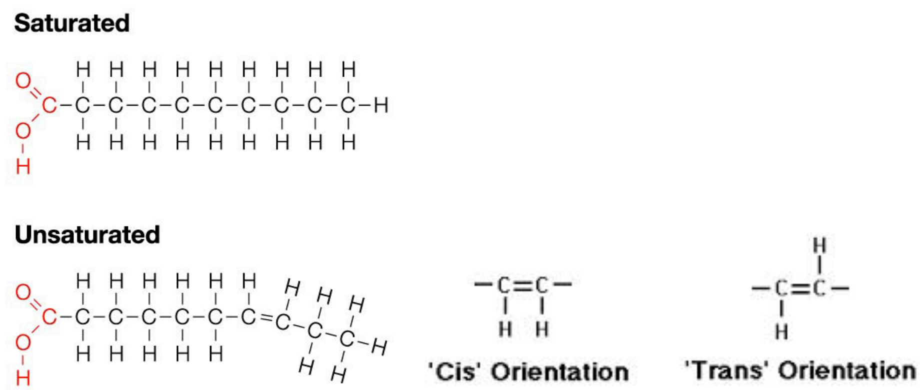
A membrane containing only saturated fatty acids (right) is thicker, more viscous, and has a higher density of phospholipids and a higher melting point than a membrane containing both saturated and unsaturated fatty acids (left).



Saturated fat consists of triglycerides containing only saturated fatty acids. *Saturated* fatty acids have no double bonds between the individual carbon atoms of the fatty acid chain. That is, the chain of carbon atoms is fully "saturated" with hydrogen atoms. Bad ones!

A fatty acid chain is monounsaturated if it contains one double bond, and polyunsaturated if it contains more than one double bond.

An **unsaturated fat** is a fat or fatty acid in which there is at least one double bond within the fatty acid chain. Cis-fatty acids are the ones where the hydrogen atoms, are always on the same side of the two carbon atoms that are double bonded. The alternative is for the hydrogen atoms to be on opposite sides – called trans – fatty acids. Good ones!



Adaptation in membrane composition in relation to habitat:

Fish from Antarctic waters have been found to have a higher percentage of unsaturated fatty acids in their membranes than fish from warmer waters.

Structure and function of sodium–potassium pumps for active transport in axons

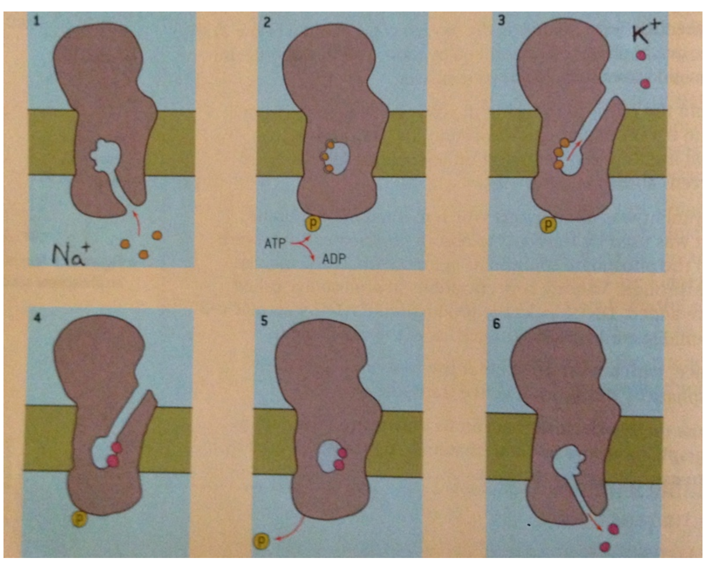
An axon is a part of a neuron. Their function is to convey messages rapidly from one part of the body to another in an electrical form called a nerve impulse.

A nerve impulse involves rapid movements of sodium and then potassium across the axon membrane. These movements occur by facilitated diffusion through sodium and potassium channels. They occur because of concentration gradients between the inside and the outside of the axon. The concentration gradients are built up by active transport, carried out by a sodium-potassium pump protein.

Three sodium ions are pumped out of the axon and two potassium ions are pumped in. One ATP is used per cycle.

Steps:

1. The interior of the pump is open to the inside of the axon. Three sodium ions enter the pump and attach to their binding sites
2. ATP transfers a phosphate group from itself to the pump. This causes the pump to change shape and the interior is then closed.
3. The interior of the pump opens to the outside of the axon and the three sodium ions are released
4. Two potassium ions from outside can then enter and attach to their binding sites
5. Binding of potassium causes release of the phosphate group. This causes the pump to change shape again so that it is again only open to the inside of the axon
6. The interior of the pump opens to the inside of the axon and the potassium ions are released. Sodium ions can then enter and bind to the pump again



The function of the **ligand-gated sodium cha**nnel in the postsynaptic cell membrane (AKA the nicotinic acetylcholine receptor).

→ Acetylcholine is a neurotransmitter in many of our nervous synapses
→ Both nicotine and acetylcholine bind to the receptors hence they are called nicotinic acetylcholine receptors
→ The binding on these receptors causes a conformational change and sodium ions can pass through, because this changes the voltage and sodium channels open.
→ The binding of acetylcholine is reversible and when it dissociates from the receptor, the conformational change is reversed and the pore closes.

Sodium-dependent glucose cotransporters as an example of indirect active transport.

Active transport involves the movement of materials *against* a concentration gradient and requires an expenditure of energy

This energy may be harnessed by one of two means:

- The direct hydrolysis of ATP (*primary active transport*)
- By coupling with the transport of another molecule moving along its electrochemical gradient (*secondary active transport or cotransport*)

The coupled transport of two distinct molecules is called co-transport (the movement of a single molecule is called uniport)

- If the two molecules are transported in the same direction it is called **symport**
- If the two molecules are transported in opposite directions it is called **antiport**

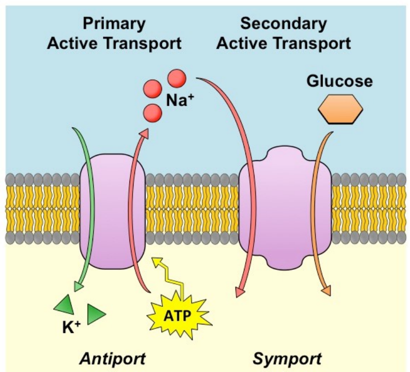
The sodium-potassium pump is an example of an antiporter as sodium and potassium are pumped in opposite directions.

- This is primary active transport as both molecules are pumped against their gradient and require ATP hydrolysis

Glucose uptake in the kidneys is an example of symport as its movement is coupled to the parallel transport of sodium

- This is secondary active transport as the sodium is moving passively down an electrochemical gradient

Types of Cotransport



Adhesion of cells to form tissues

Cell adhesion describes the attachment of cells to other surfaces via specialized membrane proteins called cell adhesion molecules (**CAMs**)

- Cells can either be directly attached to other cells or indirectly anchored to the extracellular matrix (a gel-like framework between cells)
- This is useful because cell adhesion molecules can play important roles in a variety of cellular processes including tissue development and forming a more complex structure