CELL MEMBRANES

Content Statements:

B2.1.11 Relationship between fatty acid composition of lipid bilayers and their fluidity

B2.1.12 Cholesterol and membrane fluidity in animal cells

B2.1.13 Membrane fluidity and the fusion and formation of vesicles

B2.1.14 Gated ion channels in neurons

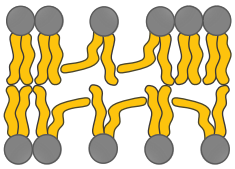
B2.1.15 Sodium-potassium pumps as an example of exchange transporters

B2.1.16 Sodium-dependent glucose cotransporters as an example of indirect active transport

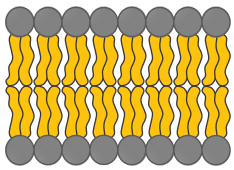
B2.1.17 Adhesion of cells to form tissues

MEMBRANE FLUIDITY

Cell membranes are fluid, meaning they are not fixed in position and they can adopt amorphous shapes. Membrane fluidity is affected by the composition of fatty acids within the phospholipid bilayer. **Unsaturated fatty acids** have double bonds within the lipid chain which results in a kinked hydrocarbon tail. This means the lipids are harder to pack together, lowering their viscosity (and increasing fluidity). These fatty acids will have lower melting points, so the membranes are more flexible at the temperatures normally experienced by a cell. **Saturated fatty acids** have no double bonds in the lipid chain which results in a straight hydrocarbon tail. This means the lipids are much easier to pack together, increasing their viscosity (and lowering fluidity). Saturated fatty acids have higher melting points, which make membranes stronger at higher temperatures.



Unsaturated

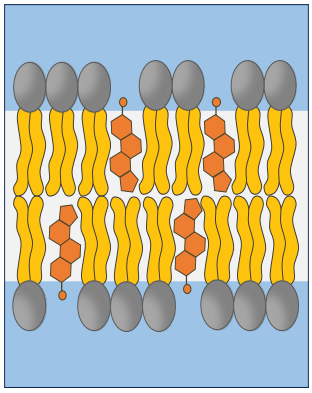


Saturated

Many organisms will adjust the composition of lipids in their membranes in order to regulate their fluidity. Fish living in cold Antarctic waters have a higher composition of unsaturated fatty acids. Similarly, caribou have more unsaturated fatty acids in the membranes of cells at their extremities than in the cells located around their core organs. Thermophiles tend to have a higher composition of saturated fatty acids in their membranes. Certain organisms that are subjected to pronounced temperature variations may also produce **desaturase enzymes** to increase the proportion of unsaturated fatty acids in their bilayers. In this way, the organism (e.g. bacteria) can adjust the fluidity of their membrane to suit the environmental temperatures.

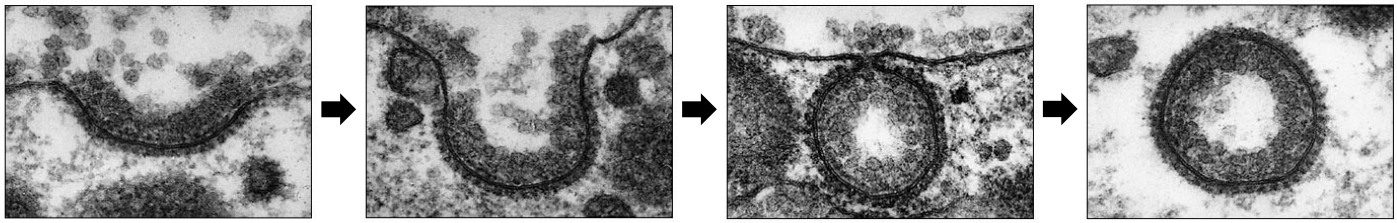
CHOLESTEROL

Cholesterol is an amphipathic molecule that is located in the plasma membrane of organisms lacking a cell wall. The hydrophilic hydroxyl group associates with the phosphate heads, while the hydrophobic carbon rings sit between the fatty acid tails. Cholesterol acts as a bidirectional modulator of fluidity according to temperature. At high temperatures it functions to stabilise the membrane and raises the melting point (lowering fluidity), while at lower temperatures it will intercalate between the phospholipids, preventing stiffening and crystallisation (increasing fluidity). Cholesterol will also make the membrane less permeable to small water-soluble molecules and can help to secure any peripheral proteins.



VESICULAR TRANSPORT

The fluidity of membranes allows them to spontaneously break and reform (creating or fusing to **vesicles**). This allows materials to enter or leave the cell without having to cross the membrane. This is an active form of transport that requires ATP hydrolysis. Vesicular transport can involve either endocytosis or exocytosis. **Endocytosis** involves the movement of materials into the cell via vesicular formation – a membrane forms an invagination around the material, which is then internalised in a vesicle. For solid materials, this process is called *phagocytosis* ('cell eating'), while ingestion of dissolved solutes is called *pinocytosis* ('cell drinking'). The movement of materials out of a cell is called **exocytosis** and involves vesicles (from the Golgi complex) fusing with the plasma membrane to expel the contents of the vesicle into the extracellular environment.

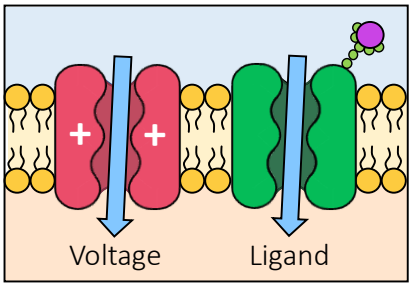


PROTEIN TRANSPORT

Membrane proteins can facilitate the passage of certain substances directly across the bilayer. Pumps move solutes against a gradient, while channels and carrier proteins move solutes along a gradient. The proteins can further be described according to the direction of solute movement (i.e. uniport, symport or antiport).

Uniport:

Neurons use ion channels to change membrane potential by moving the ions in a single direction (uniport). Potassium channels are **voltage-gated** and change between an open and closed conformation according to the voltage across membranes. In contrast, nicotinic acetylcholine receptors are **ligand-gated** and change conformation according to the binding of a chemical (ligand) – in this instance, the neurotransmitter (acetylcholine).

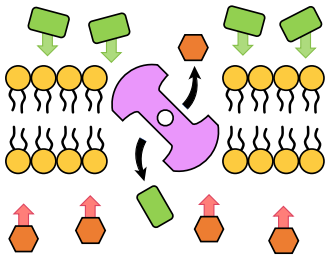


Symport:

Symport involves the movement of two molecules in the *same direction*. Cotransporters link the movement of an ion along its gradient to the movement of a solute against its gradient. This is an example of **indirect active transport**. An example is the absorption of glucose in the kidneys (co-transported with sodium ions).

Antiport:

Antiporters move two molecules in *opposite directions*. In neurons, the Na^+/K^+ pump functions as an antiporter. Three Na^+ ions bind to the pump, which then is phosphorylated by ATP. A **conformational change** moves the sodium across the membrane before two K^+ ions bind. The phosphate is released, returning the pump to its original configuration and translocating the potassium ions.



CELL ADHESION

Cell adhesion molecules (CAMs) join cells together or connect them to the extracellular matrix. Different types of cell-cell junctions exist based to the type of cell adhesion molecule involved. By linking together, cells can organise into tissues and form complex multicellular organisms capable of emergent properties.