In and out of cells

Cells, membranes and walls

All living organisms are made up of cells. Cells may be **eukaryotic** (in animals and plants) or **prokaryotic** (bacterial cells). They:

- absorb or produce food
- reproduce
- are sensitive to and respond to changes in their environment
- control the chemical reactions taking place inside them

In this way they have the properties that characterise life.

All eukaryotic cells have a **cell surface membrane** (also known as a **plasma membrane**). It is very fragile and its role is to hold the cell together and to help control what substances can get in and out. It is **partially permeable**, allowing only some substances to pass through it. The membrane has a complex structure consisting of a phospholipid bi-layer and different types of proteins.

Phospholipids

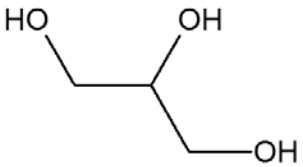
These layers are constantly moving, creating small pores which allow small particles to pass through by diffusion and osmosis.

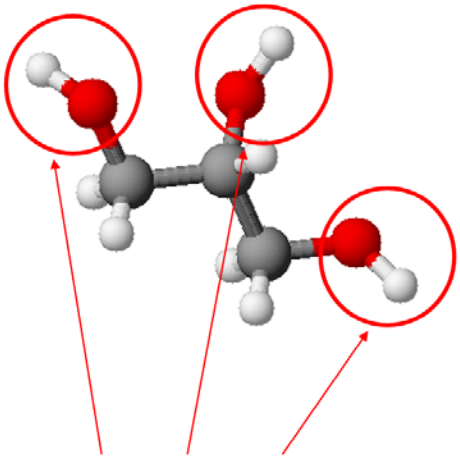
Some of the lipids in the cell surface membrane are **triglycerides**. These are molecules formed from glycerol by reaction with fatty acids, phosphoric acid or simple sugars. Each glycerol molecule has three hydroxyl groups.

Glycerol, $C_3H_8O_3$

Glycerol is a trihydric alcohol, in other words each molecule has three hydroxyl groups

Its skeletal formula is:





There is one hydroxyl (alcohol) group attached to each carbon atom in the chain

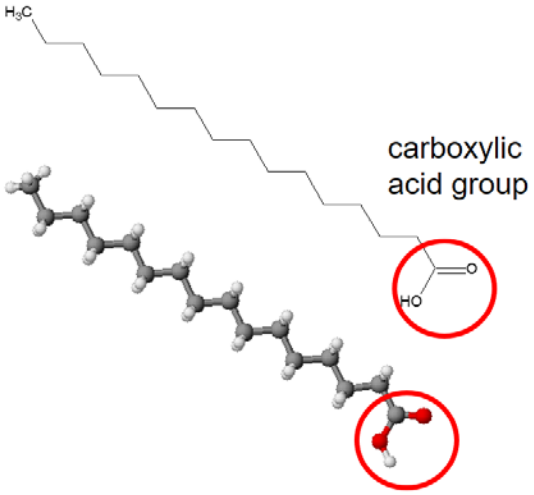
However, the majority of lipids in the membrane are phospholipids. In these, two hydroxyl groups of a glycerol molecule form esters with fatty acids.

Fatty acids

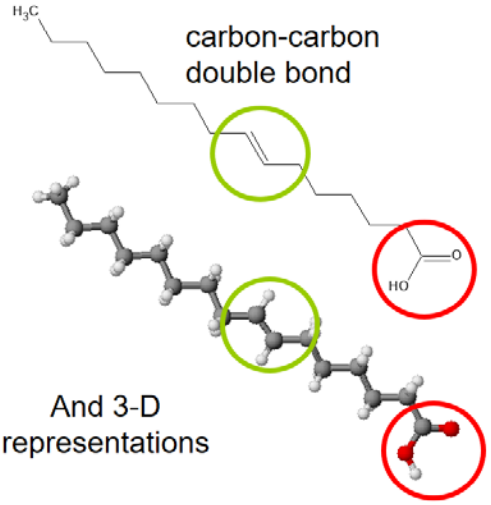
Fatty acids are carboxylic acids with a long hydrocarbon tail…

They may be saturated or unsaturated:

Here is the skeletal formula for a typical saturated fatty acid

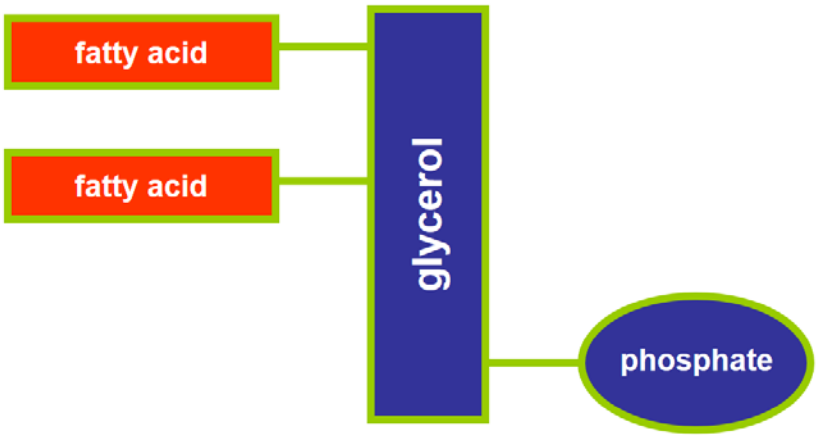


Here is the skeletal formula for a typical unsaturated fatty acid



The third hydroxyl group forms a phosphate.

Representation of a phospholipid

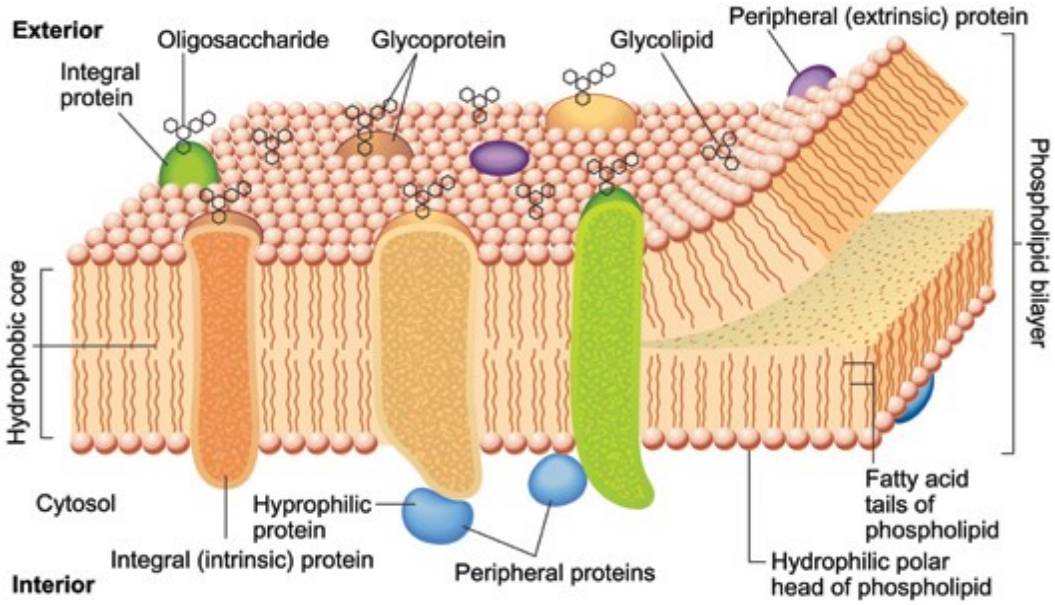


Hydrophobic part of the molecule: repels water

Hydrophilic part of the molecule: attracts water

A phospholipid molecule has one part that is attracted to water (it's said to be **hydrophilic**) and one part that repels water (it's said to be **hydrophobic**).

In the bi-layer, the hydrophilic parts are on the outside, attracted by the water in the cell and water in the fluid surrounding the cell. The hydrophobic parts are in the middle of the membrane.



Proteins

There are many different types of **proteins** associated with the phospholipid bi-layer. Some lie in just one of the phospholipids layers (**extrinsic proteins**) and some span both layers (**intrinsic proteins**).

These have a number of roles:

- some have pores in them allowing diffusion of small particles
- some play a role in facilitated diffusion
- some act as enzymes or receptors for hormones
- some allow cells to bind together

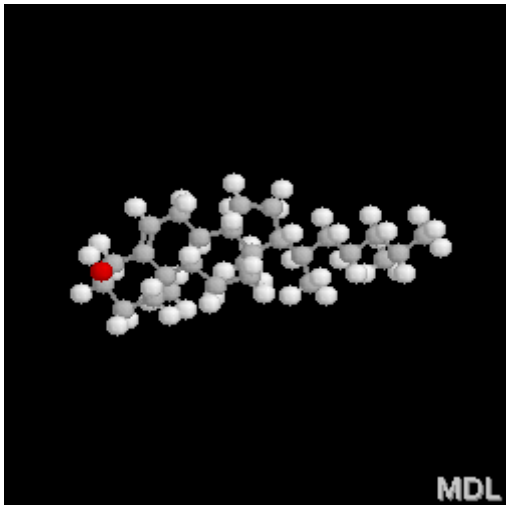
Carbohydrates form a minor part of the exterior membrane, but have an essential role. Some proteins have a polysaccharide attached to them. These are called **glycoproteins** and are important in cell recognition and essential to the immune response. Saccharides are also attached to some lipids, forming **glycolipids**.

Fluid mosaic model

The phospholipid bi-layer and associated proteins is called the **fluid mosaic model** of the membrane's structure. 'Fluid' because the positions of the constituents are always changing and 'mosaic' because the membrane is made from different types of molecules.

Cholesterol

Cholesterol helps to regulate the fluidity of the membrane. The more cholesterol, the more fluid the membrane is.



Cholesterol

Plant cell walls

Eukaryotic cells in plants also have a **cell wall**. It's made of cellulose, is much tougher than the cell surface membrane and is freely permeable.

Getting across the barrier

Cells need to obtain chemicals from the outside and to get rid of waste products from chemical reactions. Cell surface membranes control these processes.

Particles move naturally

Particles (molecules and ions) in solution move around colliding with one another constantly and the walls of the container holding the solution. The particles are said to have translational energy. The movement is random, but there is a net movement from regions where there are lots of particles to ones where there are fewer particles.

If this random movement results in particles passing through a cell membrane no energy is required and this is called **passive transport**. However, if cells do need to use energy to get particles through the cell membrane this is called **active transport**.

Passive transport

Passive transport: diffusion

Some substances pass through small holes in the surface cell membrane. This is called **diffusion** and does not require the cell to expend energy. Oxygen gets into a cell and carbon dioxide (the product of respiration reactions) leaves it this way. There are four main features of diffusion:

- diffusion only takes place if the concentration of the substance is different on either side of the membrane (we call this a concentration gradient)
- the substance moves from the more concentrated side to the less concentrated side
- the higher the concentration difference, the faster the rate of diffusion
- small particles (ions or molecules) diffuse more quickly than large ones

Passive transport: facilitated diffusion

Some particles are 'helped' through the membrane. This is known as facilitated diffusion. The 'facilitators' are **carrier proteins**. These have specific binding sites for the substances they transport. Randomly moving particles in solution come into contact with their specific binding site. Once they have become bound the protein changes shape and the particle is released on the other side of the membrane.

Passive transport: osmosis

Water enters and leaves a cell by **osmosis**. It's a specific example of diffusion. Imagine two solutions, one with more solute in it than the other. Usually we say the solution with most solute is the more concentrated, e.g. 100 g of solution containing 20 g of glucose in water is more concentrated than 100 g of solution containing 1 g of glucose in water. But we could look at it in a different way. There is less water in the concentrated sugar solution than the dilute one (because there is more solute).

Solution	Concentration of water / g / 100 g	Concentration of glucose / g / 100 g
(A) 100 g of solution containing 20 g of glucose in water	80	20
(B) 100 g of solution containing 1 g of glucose in water	99	1

Water molecules pass from the more dilute glucose solution (B) to the more concentrated glucose solution (A). This is osmosis.

It's the same when solutes other than glucose are present.

When water molecules hit the membrane they exert pressure on it. This is called **water potential** (ψ). Water potential is measured in units of pressure: pascals (Pa) or kilopascals (kPa). The more water molecules there are, the greater the number of collisions and the pressure exerted by them, and the higher the water potential. Pure water has a water potential of zero. Solute particles are surrounded by water molecules.

> See the topic about Some basic chemistry

This makes fewer water molecules available to collide with the membrane and so solutions have negative water potentials. The more solute the more negative the water potential. In osmosis water molecules move from a higher to a lower (or more negative) water potential.

Active transport

Some particles need to pass through a membrane against the concentration gradient, in other words from a low concentration to a high concentration. This cannot happen by passive transport (diffusion or facilitated diffusion). The cell must expend energy.

Some carrier proteins can do this. They bind the particles on their active sites and release them the other side of the membrane, but they only do this in one direction. The cell must provide energy to make this happen.

Endocytosis and exocytosis

Sometimes cells need to transport large quantities of substances, too much for passive and active transport to cope with in the time available. They use a process called **cytosis**. Vesicles, small 'bags'

made from the cell surface membrane itself, carry material into the cell (**endocytosis**) or out of the cell (**exocytosis**).

Test your knowledge

Take quiz on *In and out of cells*