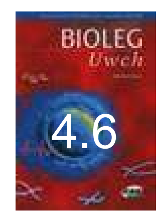
Plasma Membranes

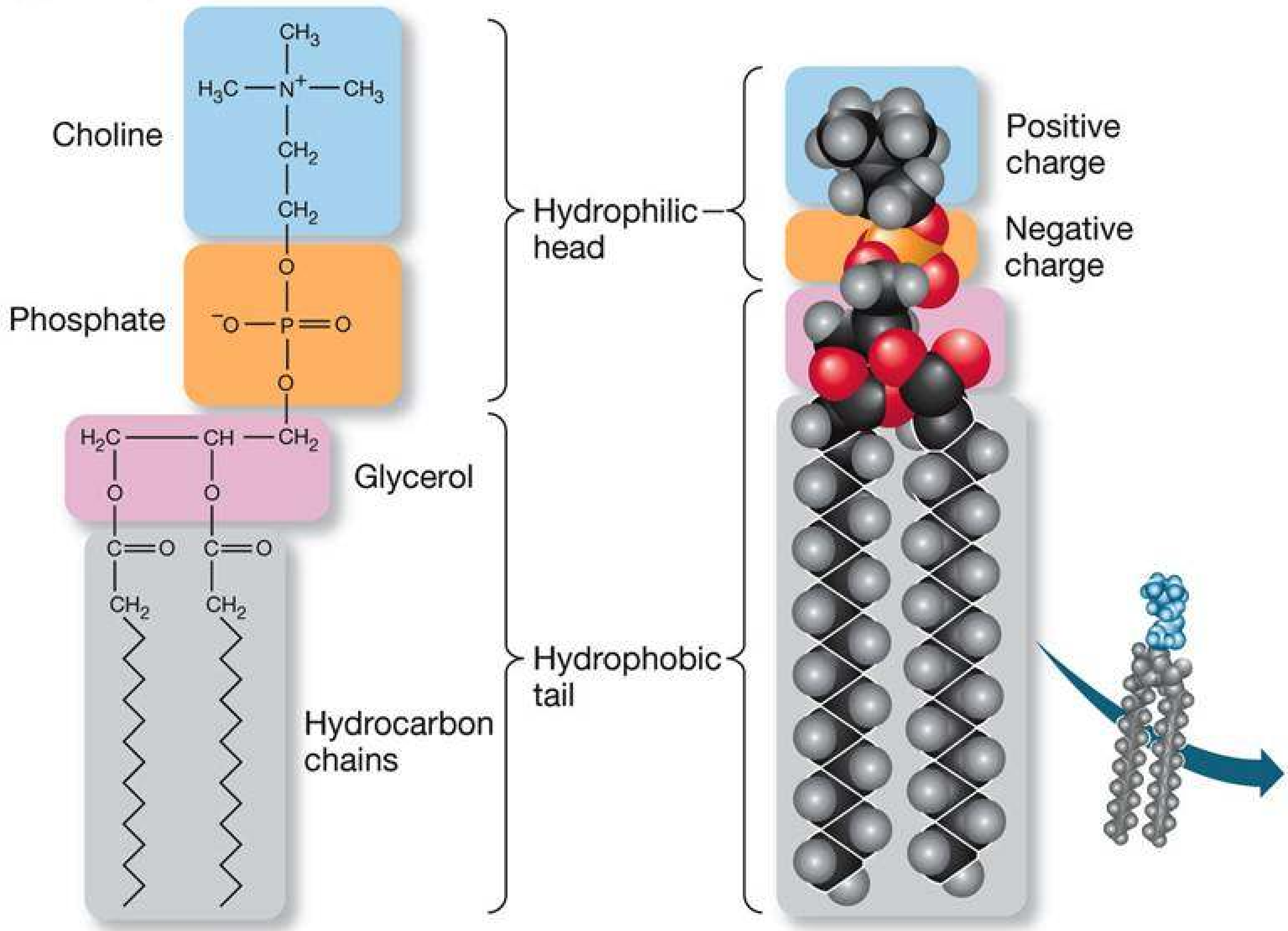
WJEC GCE BIOLOGY
Plasma Membranes



WJEC CBAC

WJEC GCE BIOLOGY
Plasma Membranes

(A) Phosphatidylcholine

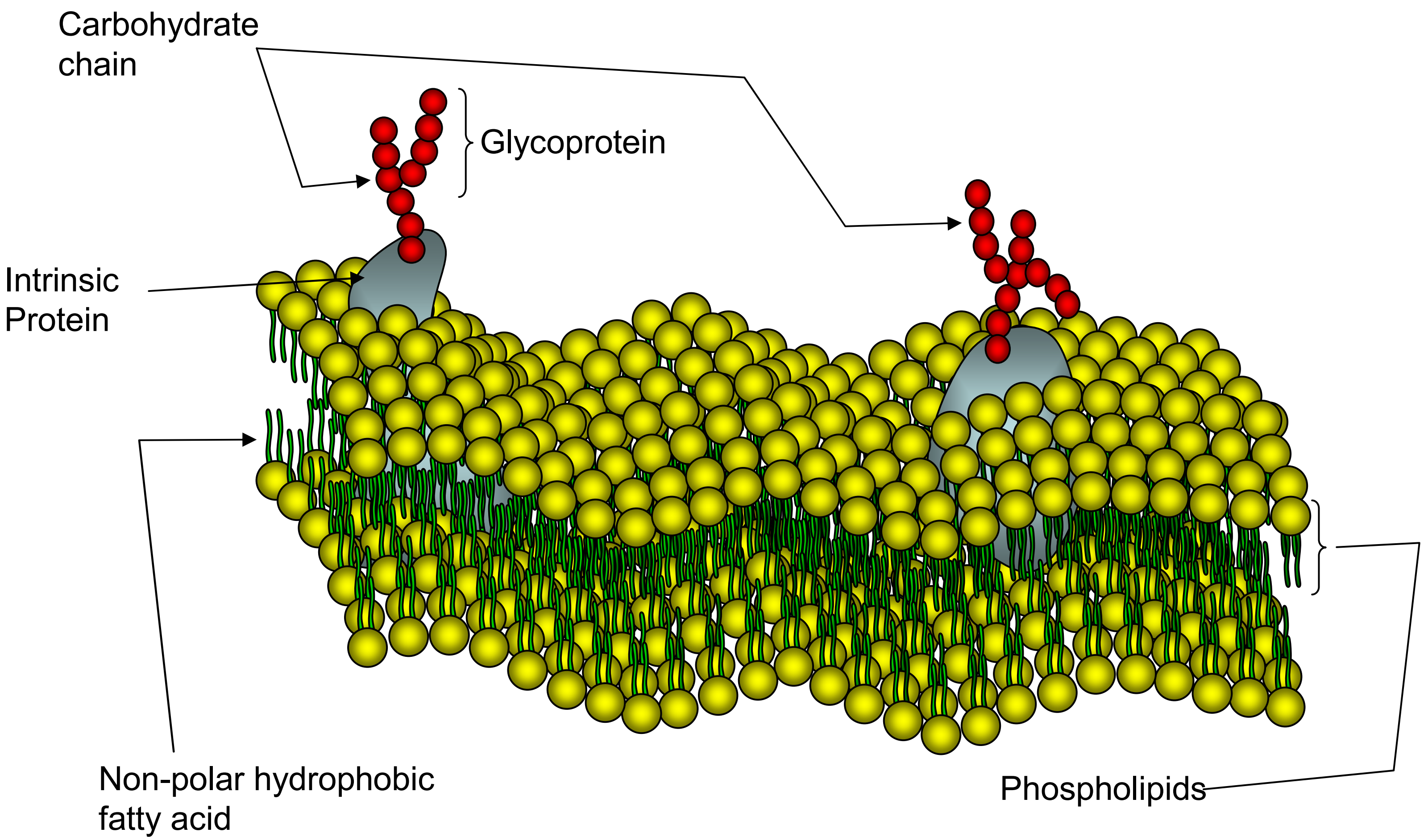


***LIFE* 8e, Figure 3.20 (Part 1)**

WJEC CBAC

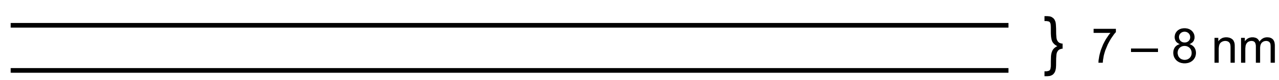
WJEC GCE BIOLOGY
Plasma Membranes

Fluid Mosaic Model of the Plasma Membrane



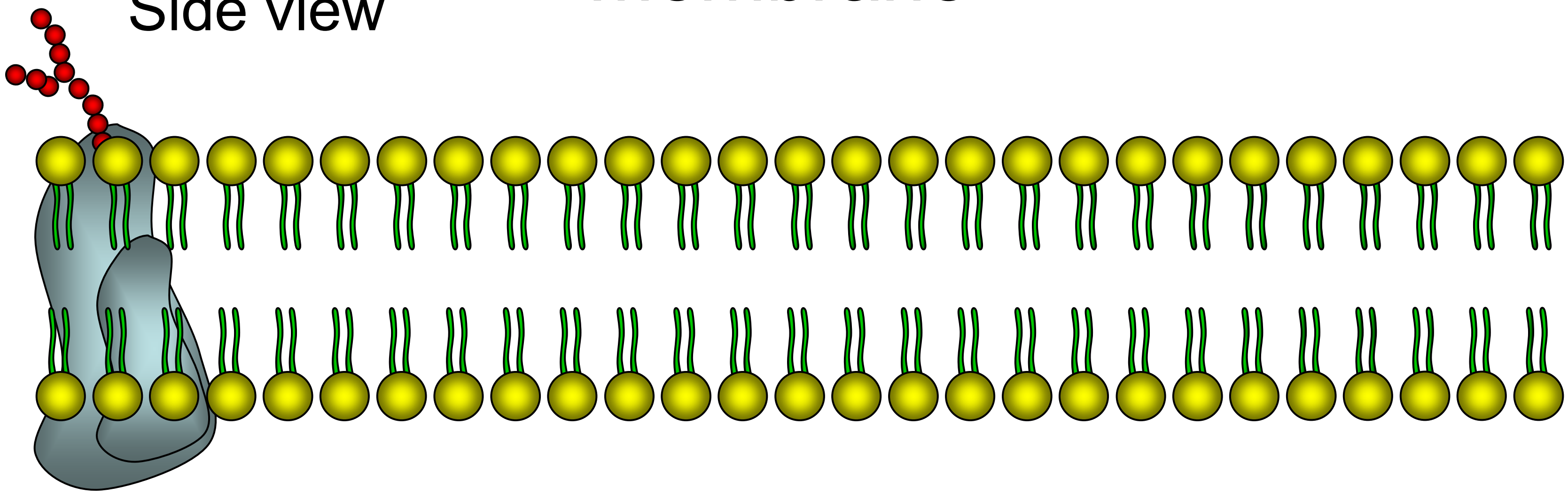
Appearance of the Cell Membrane

Seen using a light microscope, the cell membrane appears as a thin line, but with an electron microscope, it appears as a double line.

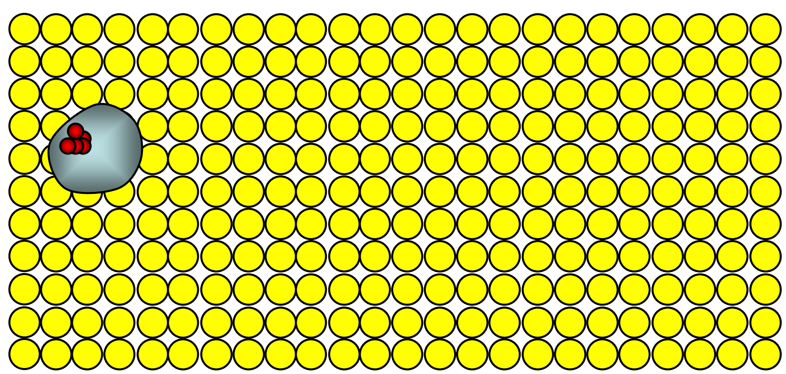


Biochemical Composition of the Plasma Membrane

Side view



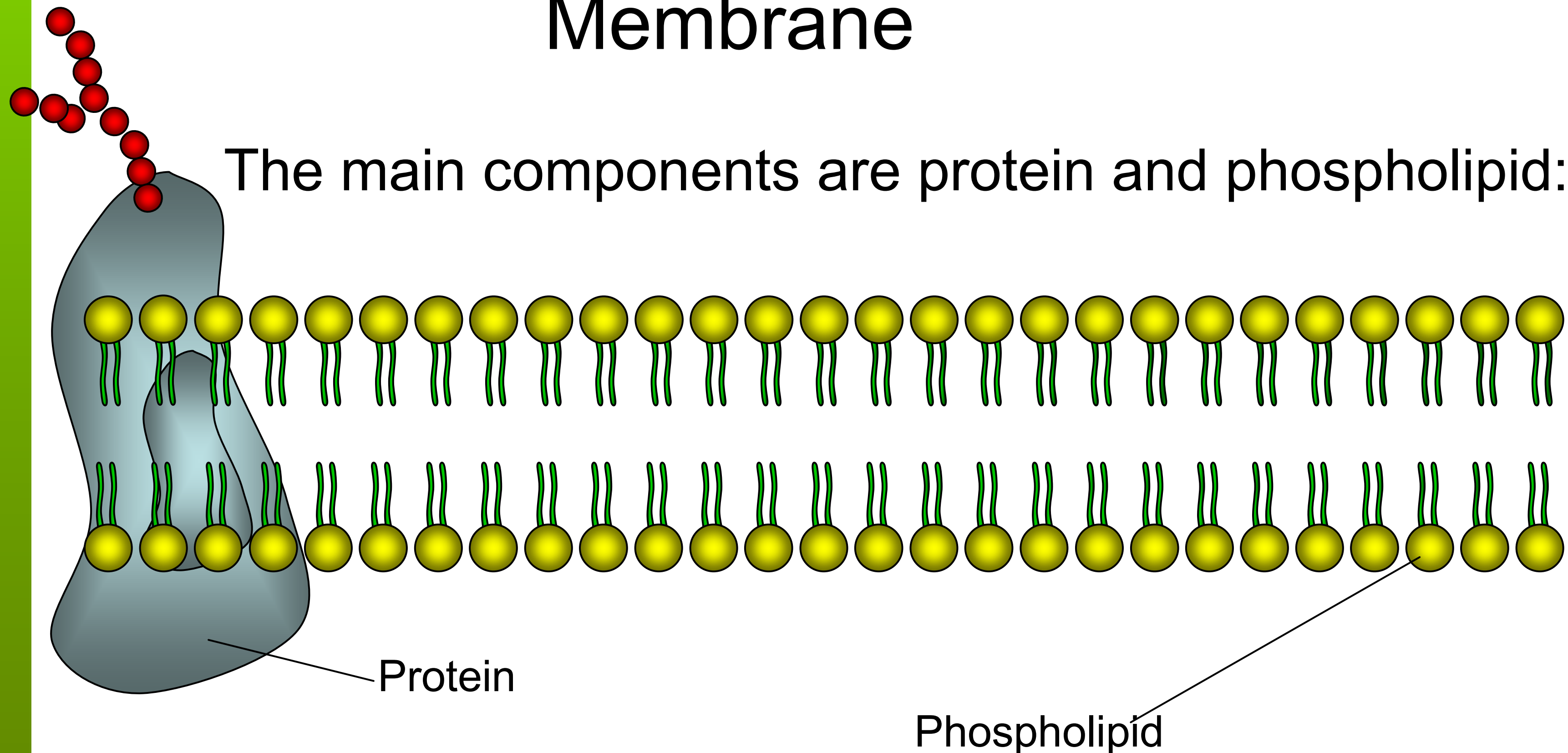
Surface view



WJEC GCE BIOLOGY
Plasma Membranes

Biochemical Composition of the Plasma Membrane

The main components are protein and phospholipid:

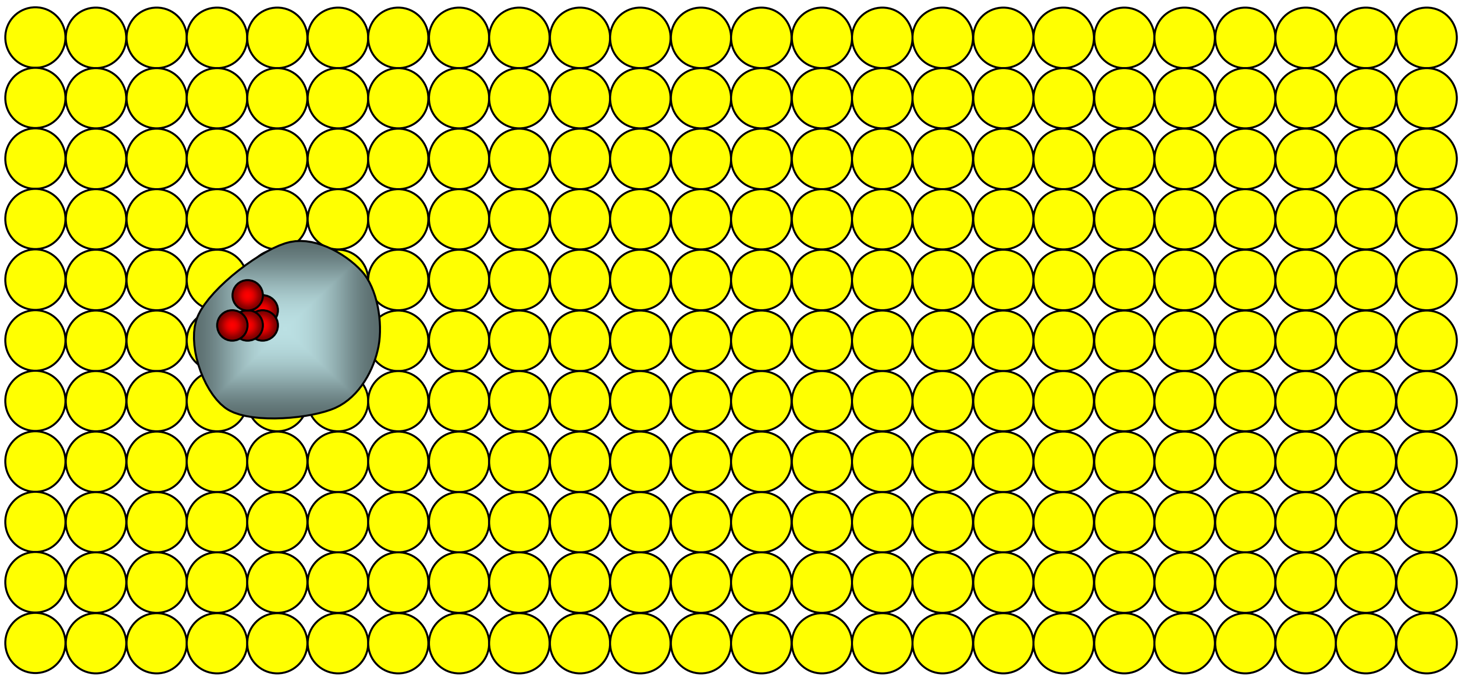


Side view

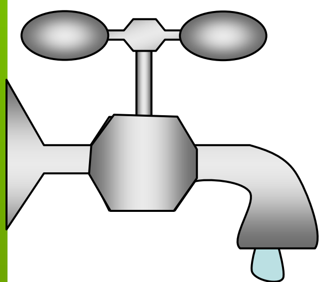
WJEC GCE BIOLOGY
Plasma Membranes

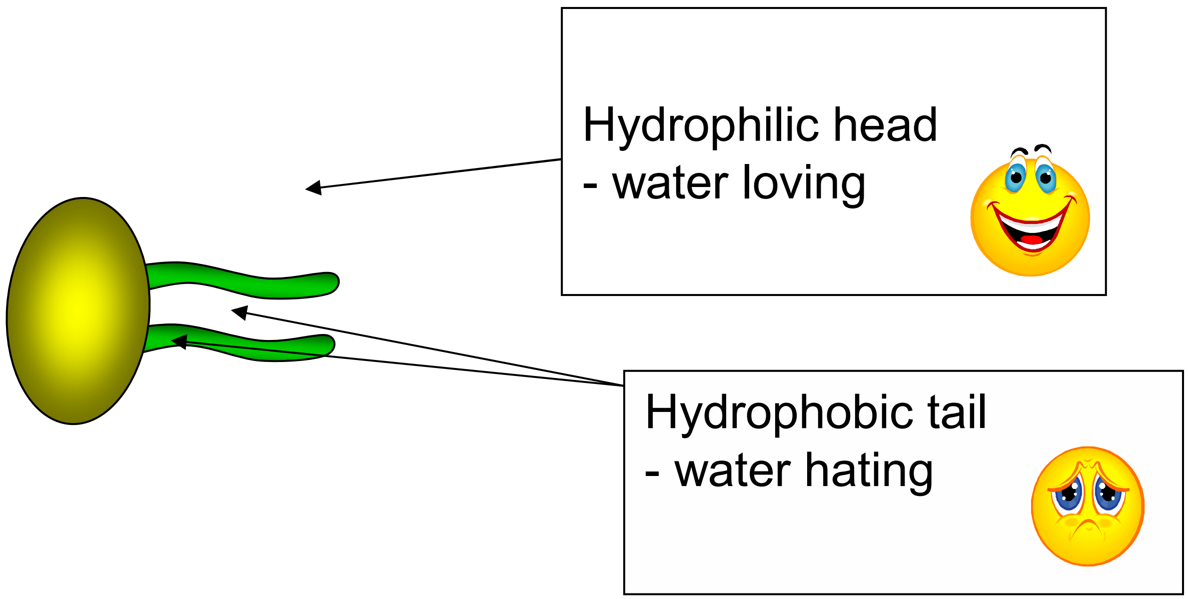
Surface view

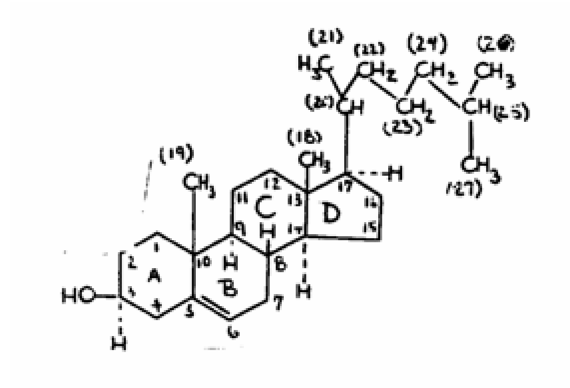
This model is referred to as the **‘fluid mosaic model’** because the components are free to move independently of each other.



Phospholipid







<u>Question</u>

Even though too much cholesterol is linked to heart disease, our cells would not be able to survive without a some supply of cholesterol. Referring to the fluid mosaic model, explain why cholesterol is so important in animal plasma membranes.

Permeability

Three factors affect the permeability of a cell membrane:

- heat
- ethanol
- pH

Try and explain how these factors affect the membrane, by referring to the fluid mosaic model.

Help

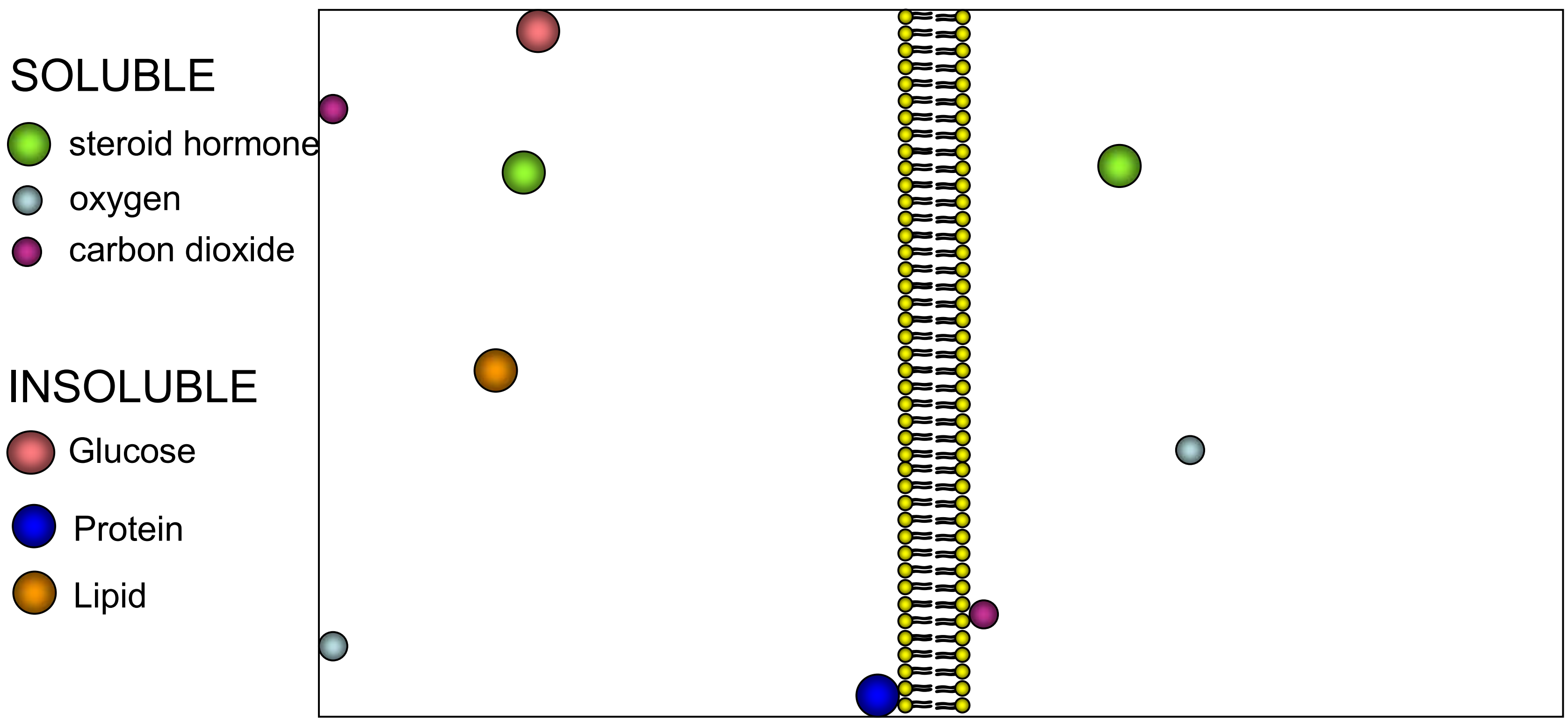
A temperature exceeding the optimum and pH levels beyond the normal range can denature the membrane's proteins. Ethanol dissolves the lipid components of the membrane.

This all makes the membrane far more permeable acting as if it is full of holes.

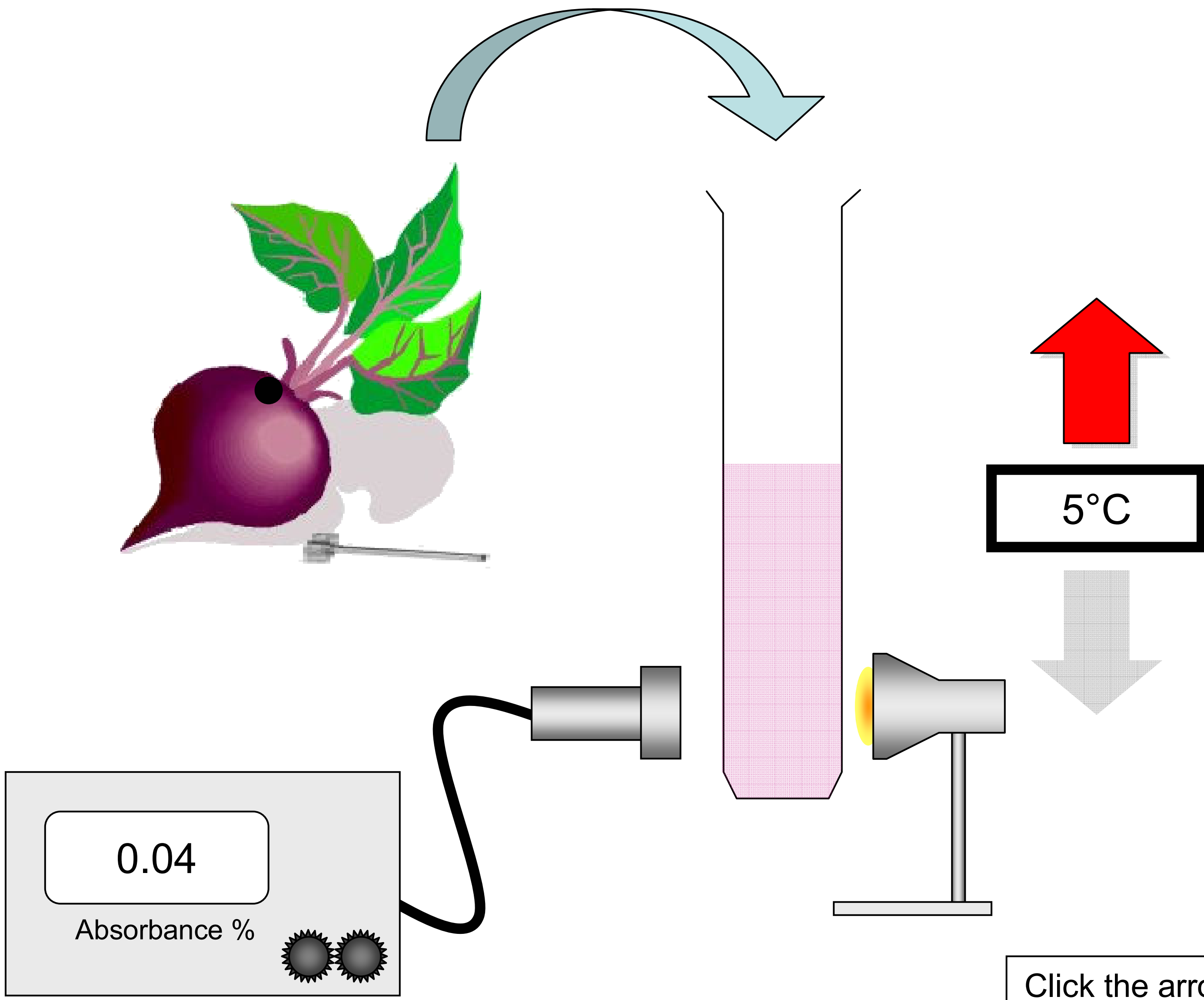
WJEC GCE BIOLOGY
Plasma Membranes

Membrane Permeability

Plasma membranes are semi-permeable – this means that some substances can pass through and others cannot. What is it that determines what substances pass through? The substance has to be very soluble in the oily phospholipid bilayer. Steroid hormones, oxygen and carbon dioxide are examples of such molecules.

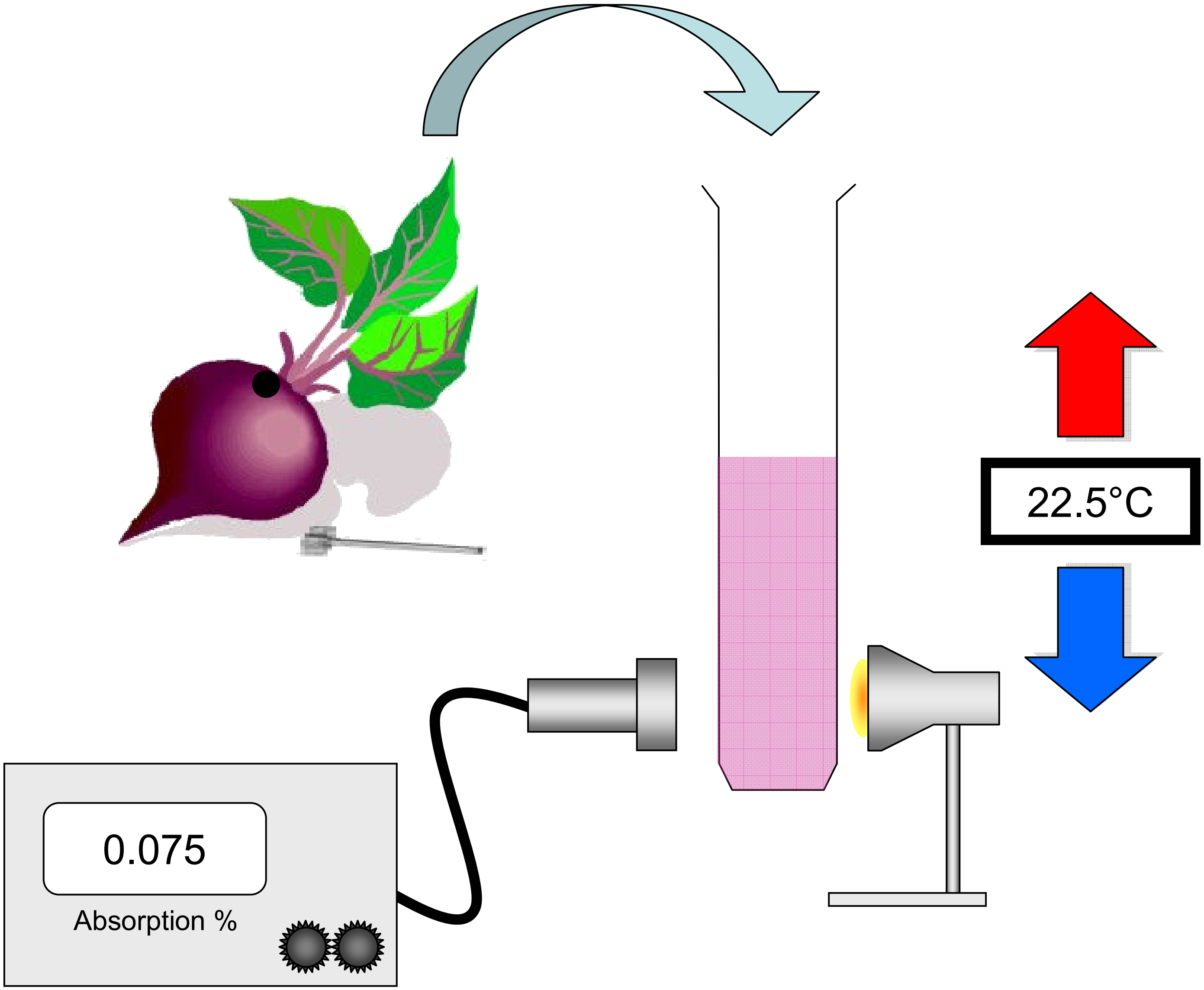


Experiment

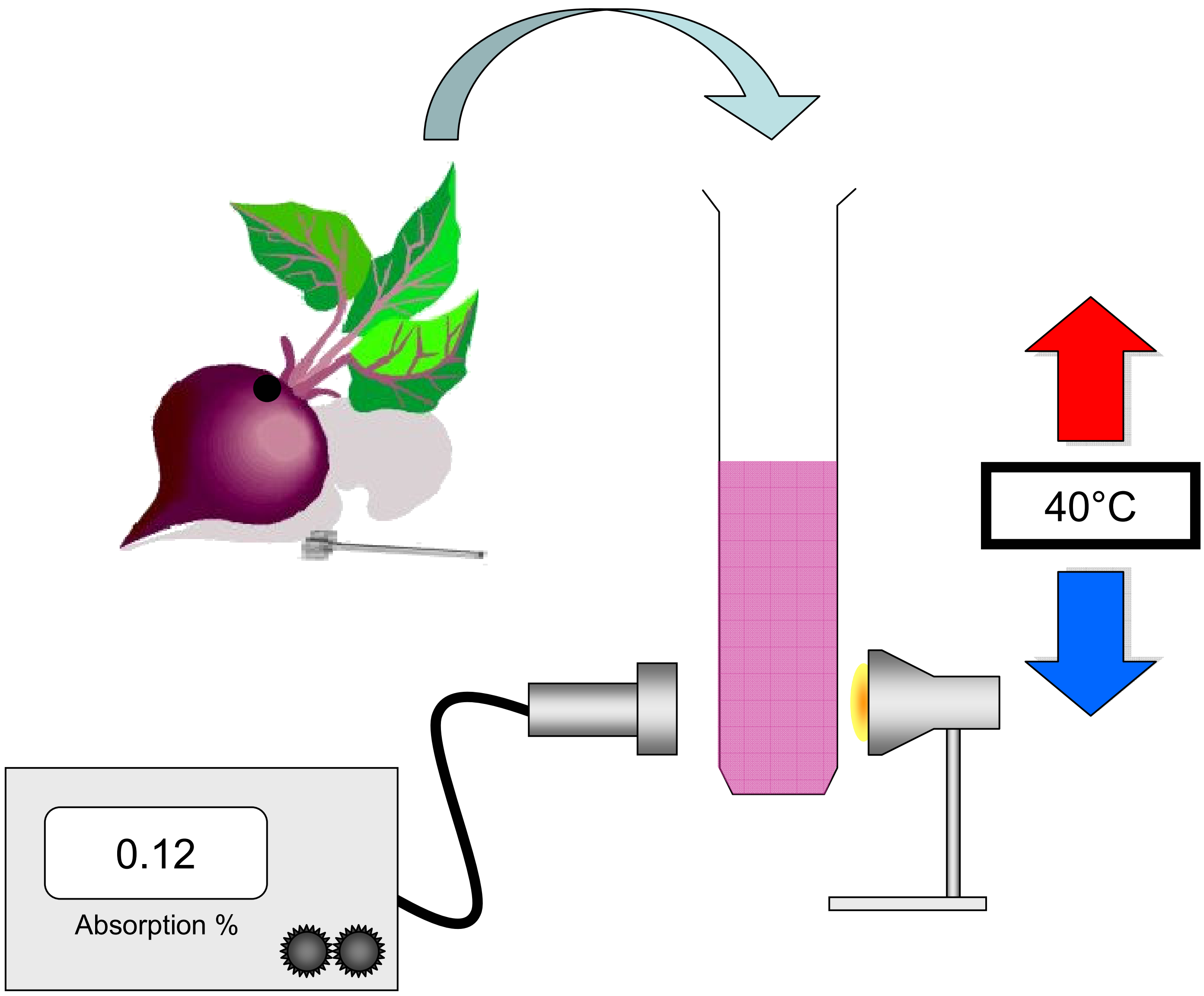


Click the arrows to adjust the temperature

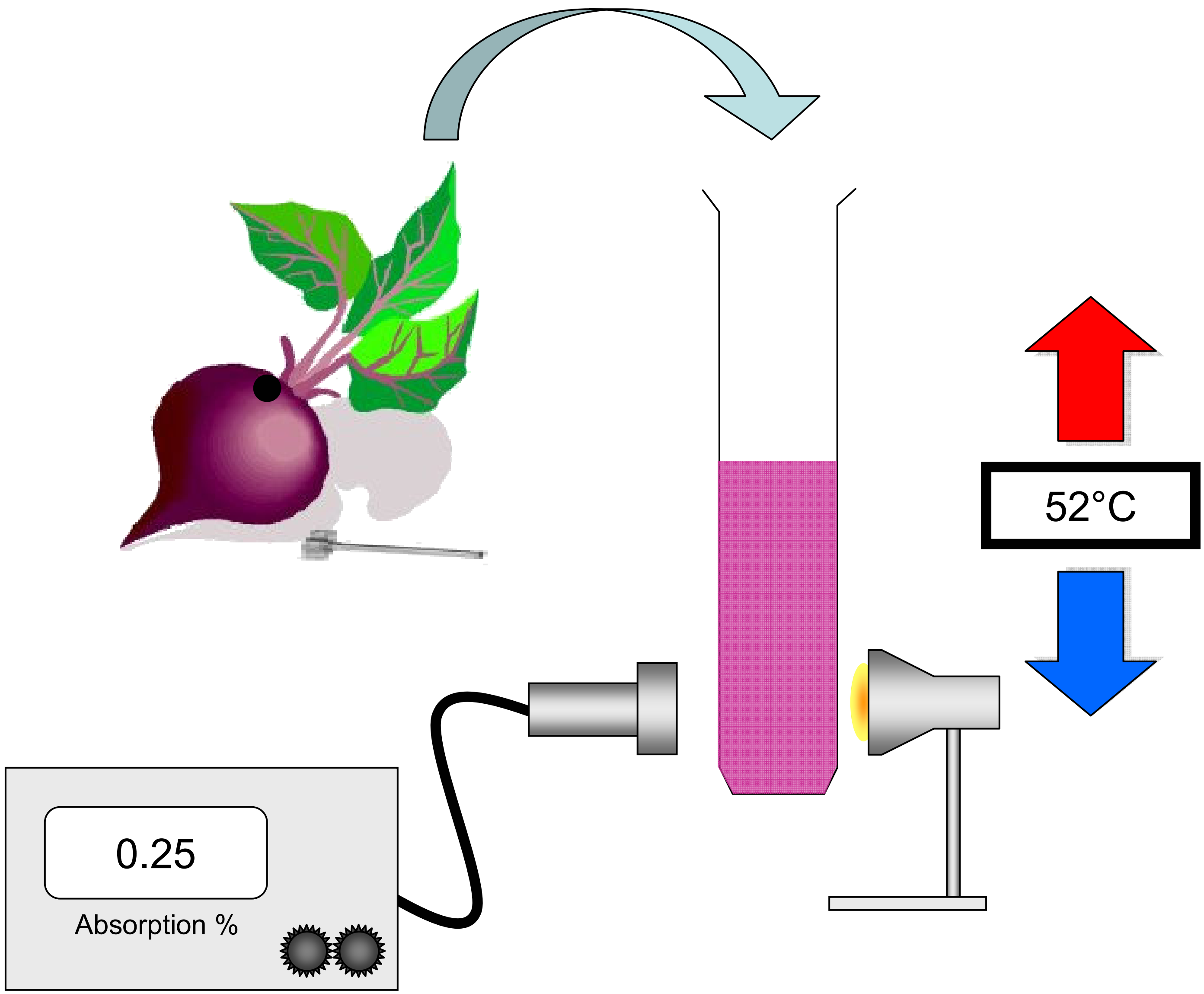
Experiment



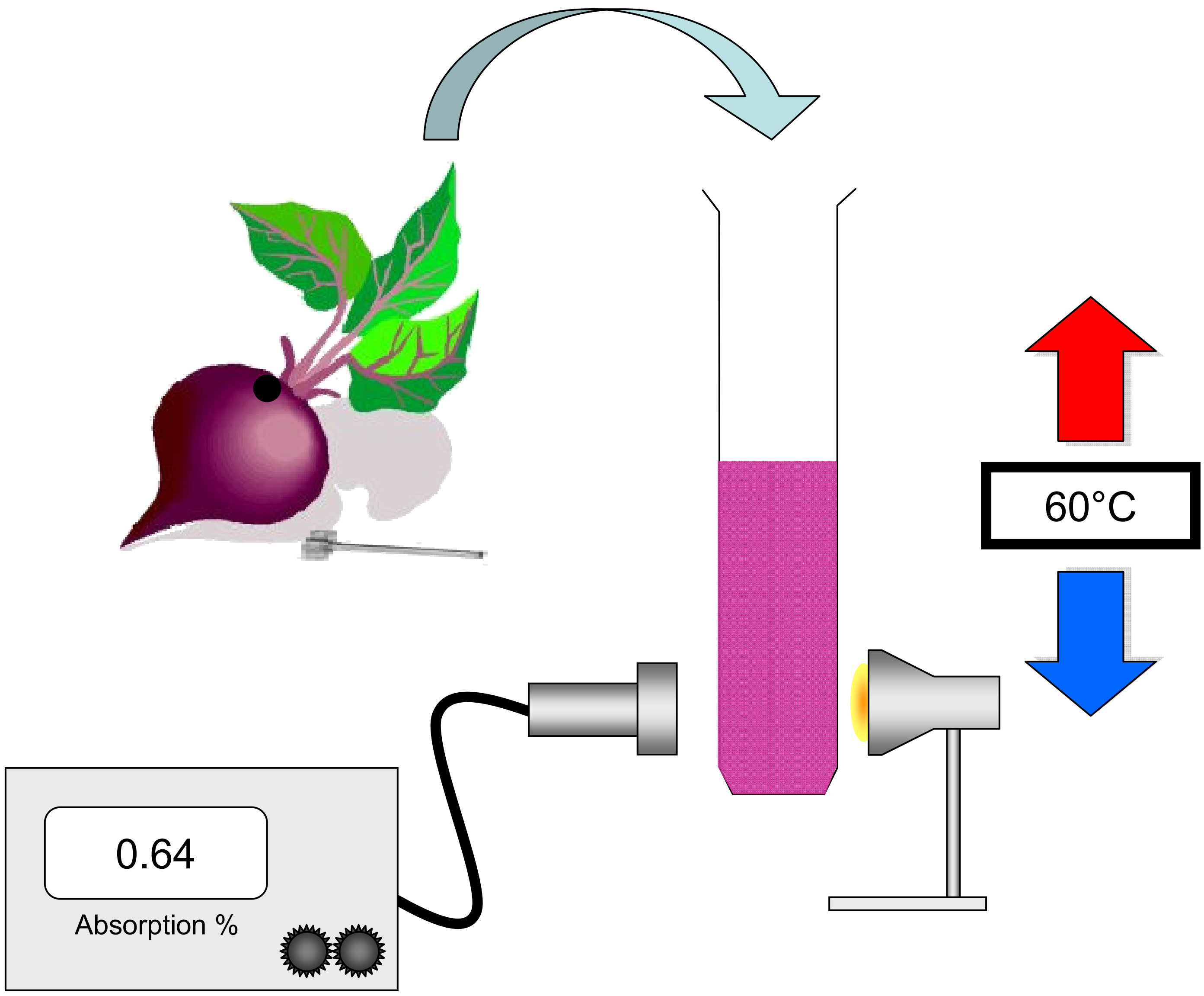
Experiment



Experiment

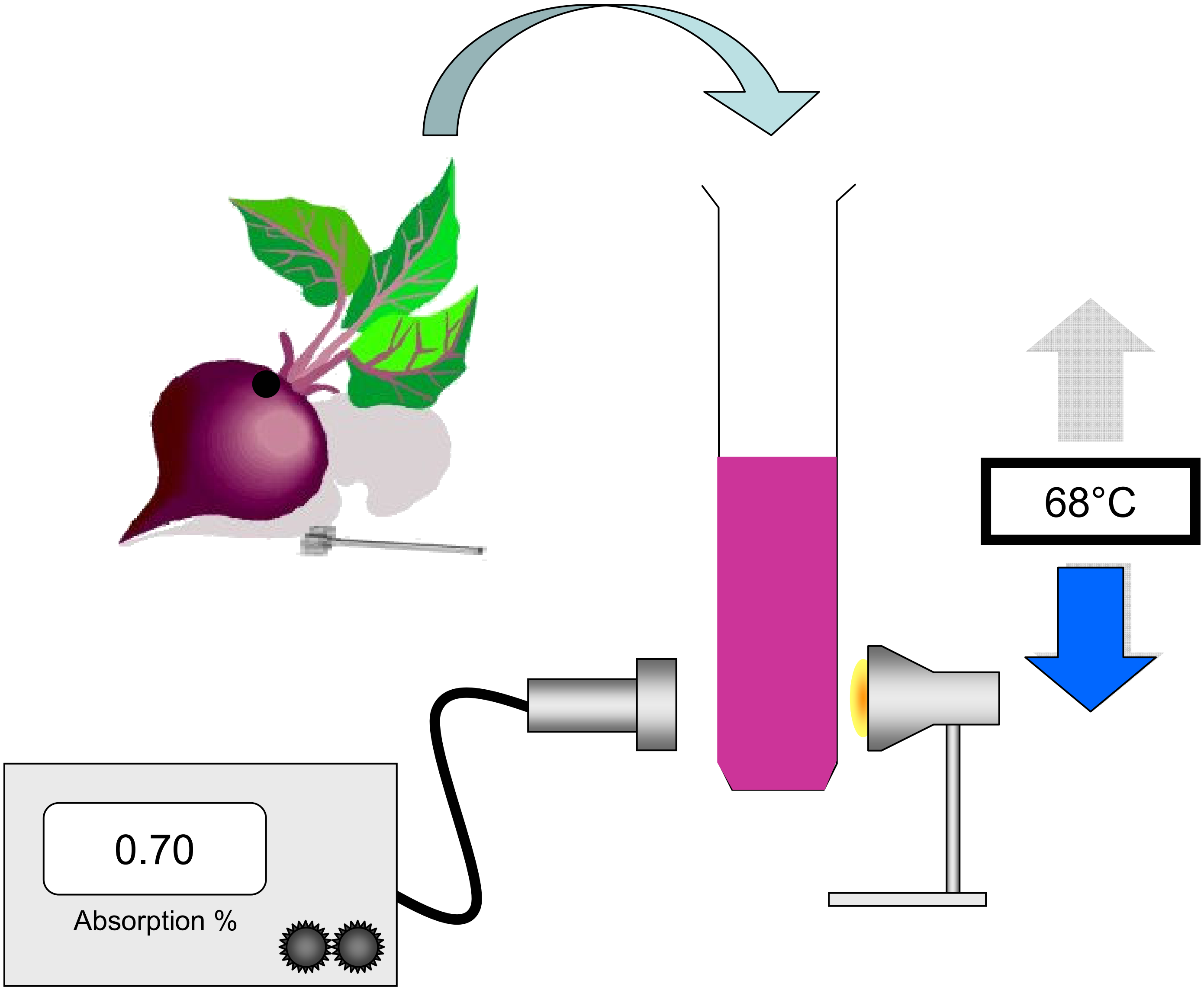


Experiment



WJEC GCE BIOLOGY
Plasma Membranes

Experiment



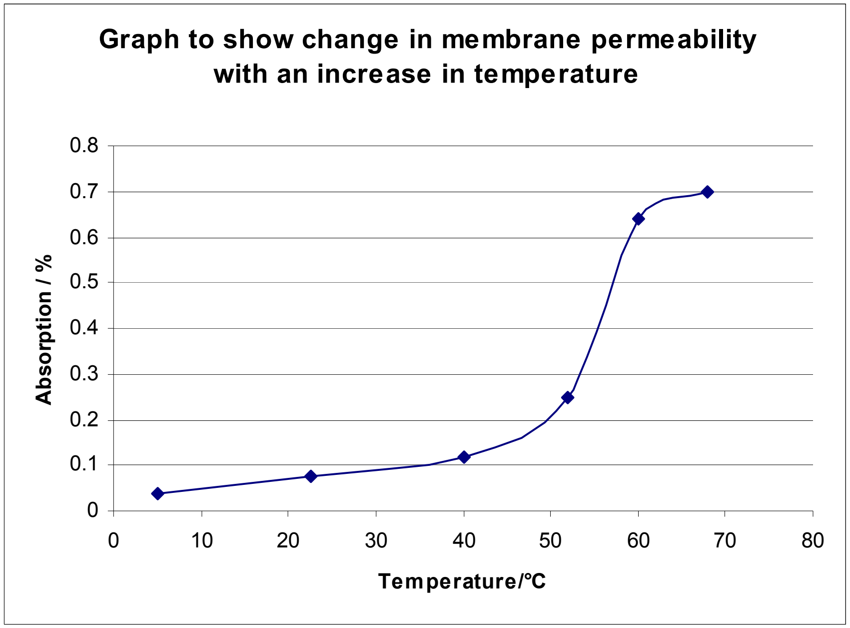
WJEC GCE BIOLOGY
Plasma Membranes

Results

Results Table

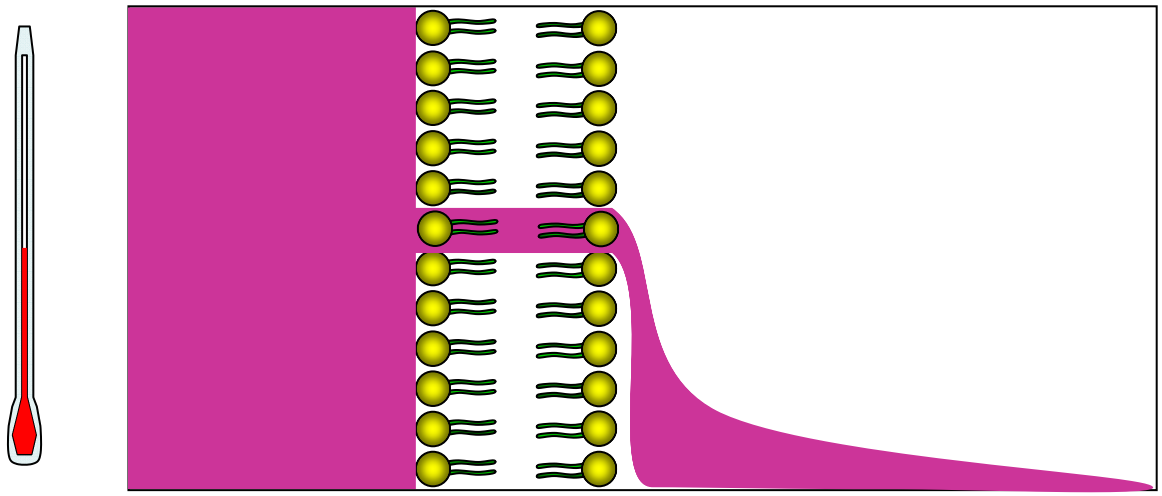
Temperature (°c)	**Absorption/ %**
5	0.04
22.5 (Room Temperature)	0.075
40	0.12
52	0.25
60	0.64
68	0.7

Graph

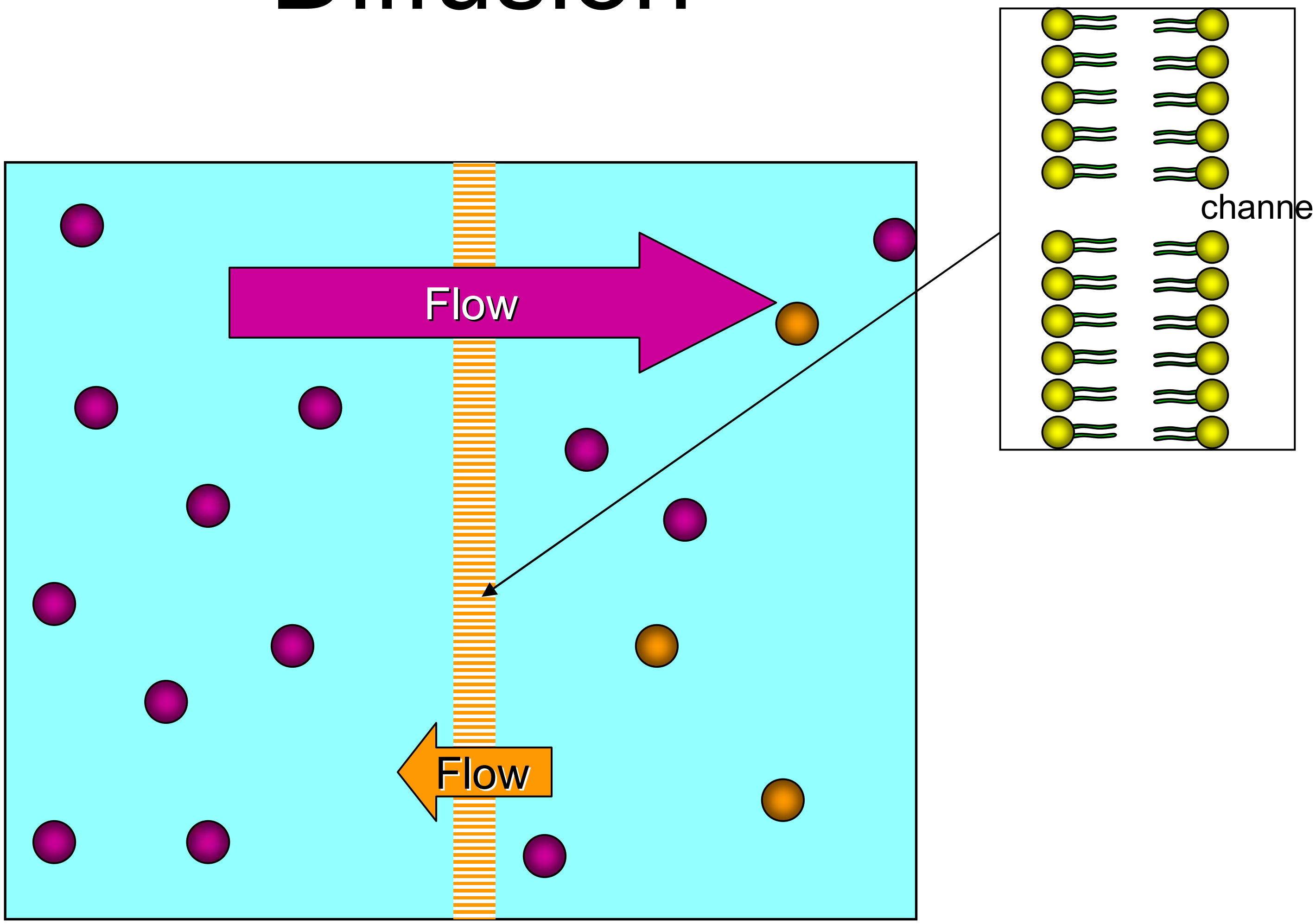


Conclusion

The increase in temperature causes the proteins in the membrane to denature and so its permeability increases, causing substances (purple dye in this case) to escape.



Diffusion



WJEC GCE BIOLOGY
Plasma Membranes

WJEC CBAC

Factors affecting the rate of diffusion

Fick's law notes that the rate of diffusion is in direct proportion to:

$$\frac{\text{surface area} \times \text{concentration difference}}{\text{Length of diffusion path}}$$

Factors affecting the rate of diffusion

Fick's law notes that the rate of diffusion is in direct proportion to:

$$\frac{\text{surface area} \times \text{concentration difference}}{\text{Length of diffusion path}}$$

The higher the surface area to volume ratio, the faster diffusion occurs.

Factors affecting the rate of diffusion

Fick's law notes that the rate of diffusion is in direct proportion to:

$$\frac{\text{surface area} \times \text{concentration difference}}{\text{Length of diffusion path}}$$

By maintaining a steep concentration gradient, diffusion rate increases.

Factors affecting the rate of diffusion

Fick's law notes that the rate of diffusion is in direct proportion to:

$$\frac{\text{surface area} \times \text{concentration difference}}{\text{Length of diffusion path}}$$

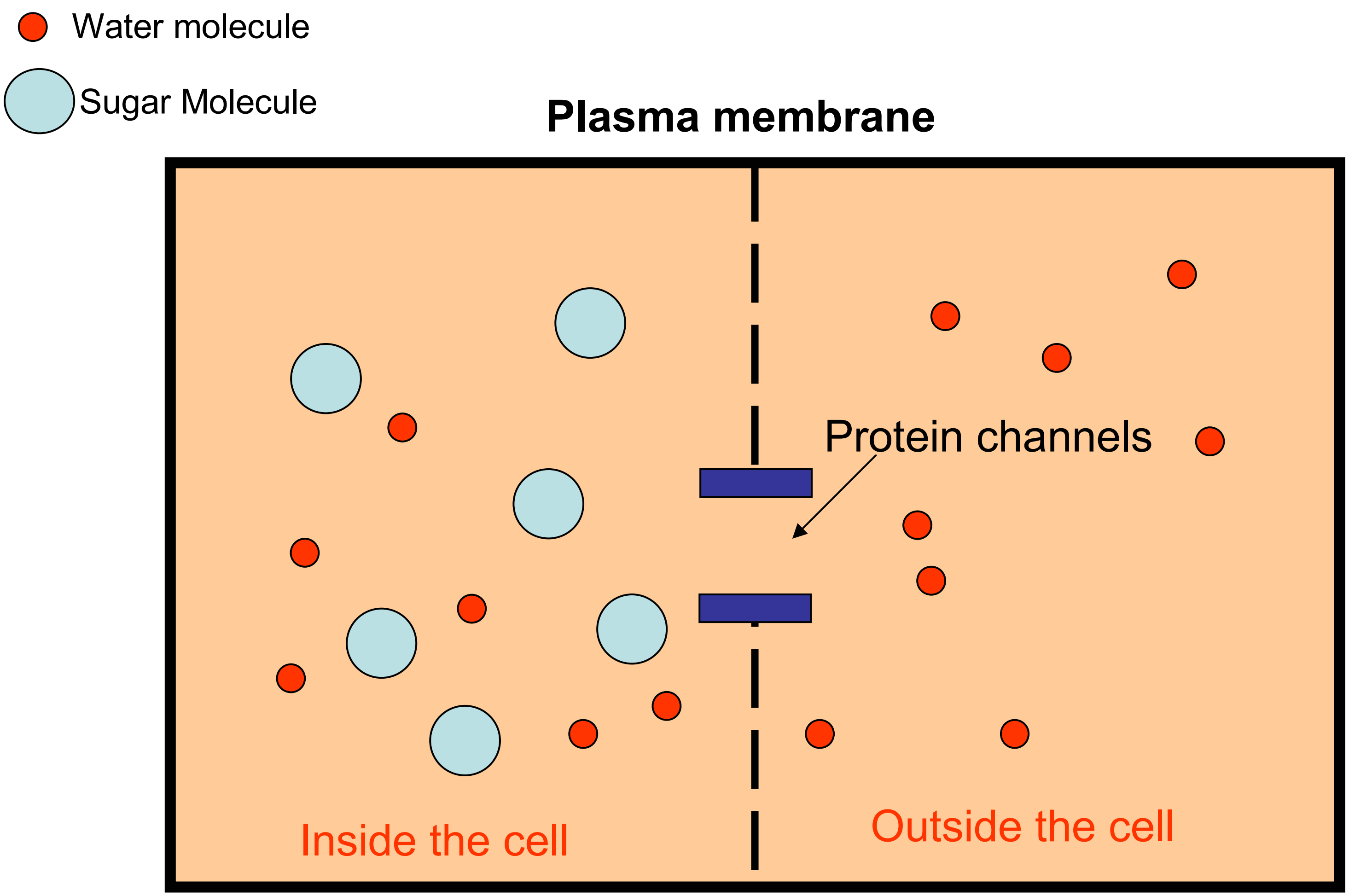
A thin membrane reduces the distance over which the substances diffuse, therefore diffusion happens quicker.

Facilitated Diffusion

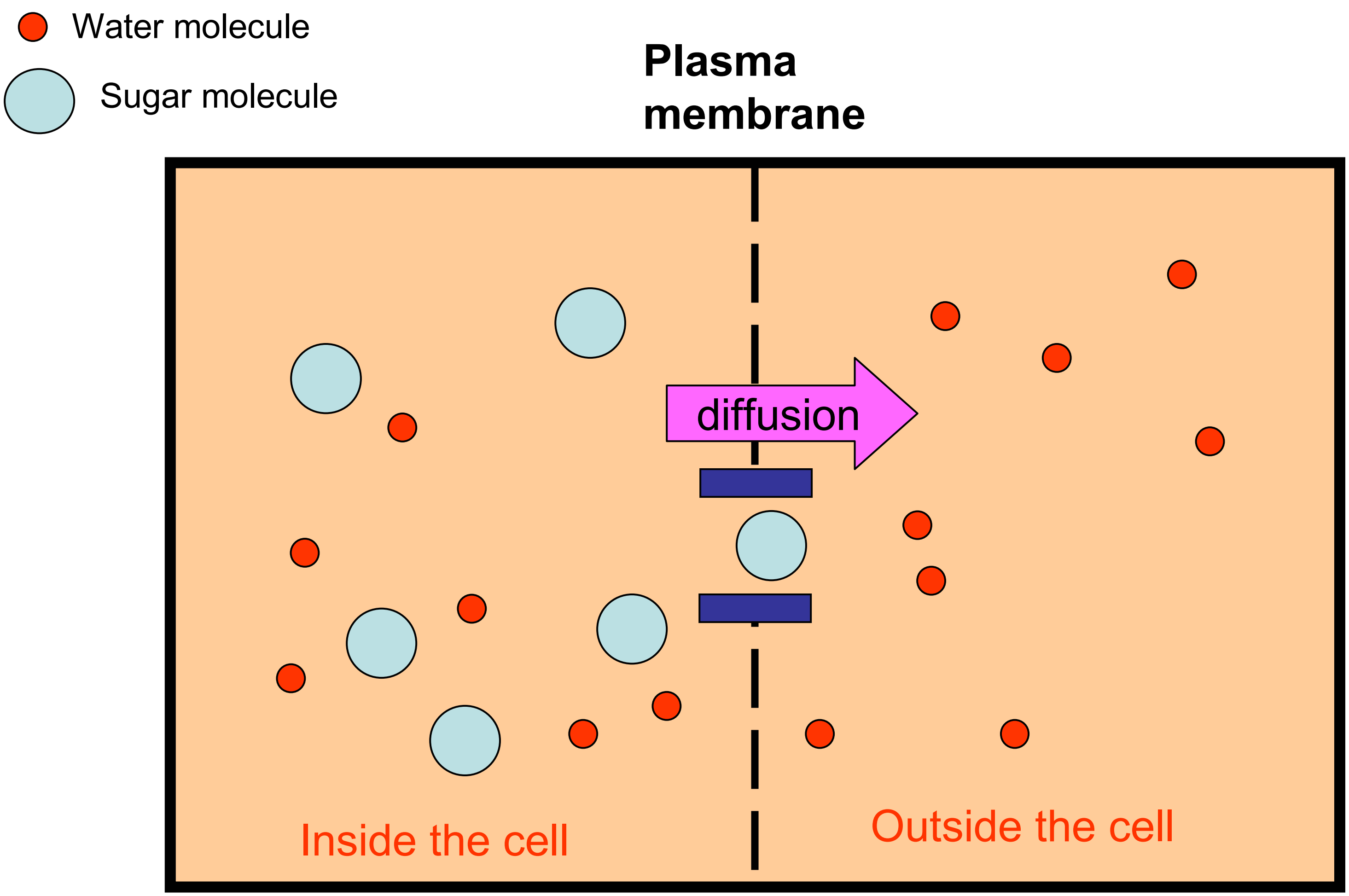
If substances that are insoluble in lipid cannot easily cross the membrane, how do they move in and out of cells through the double phospholipid layer in a membrane?

The next diagram shows how special transport proteins in the plasma membrane help the transport across the membrane of these insoluble molecules, such as glucose, amino acids and nucleic acids:

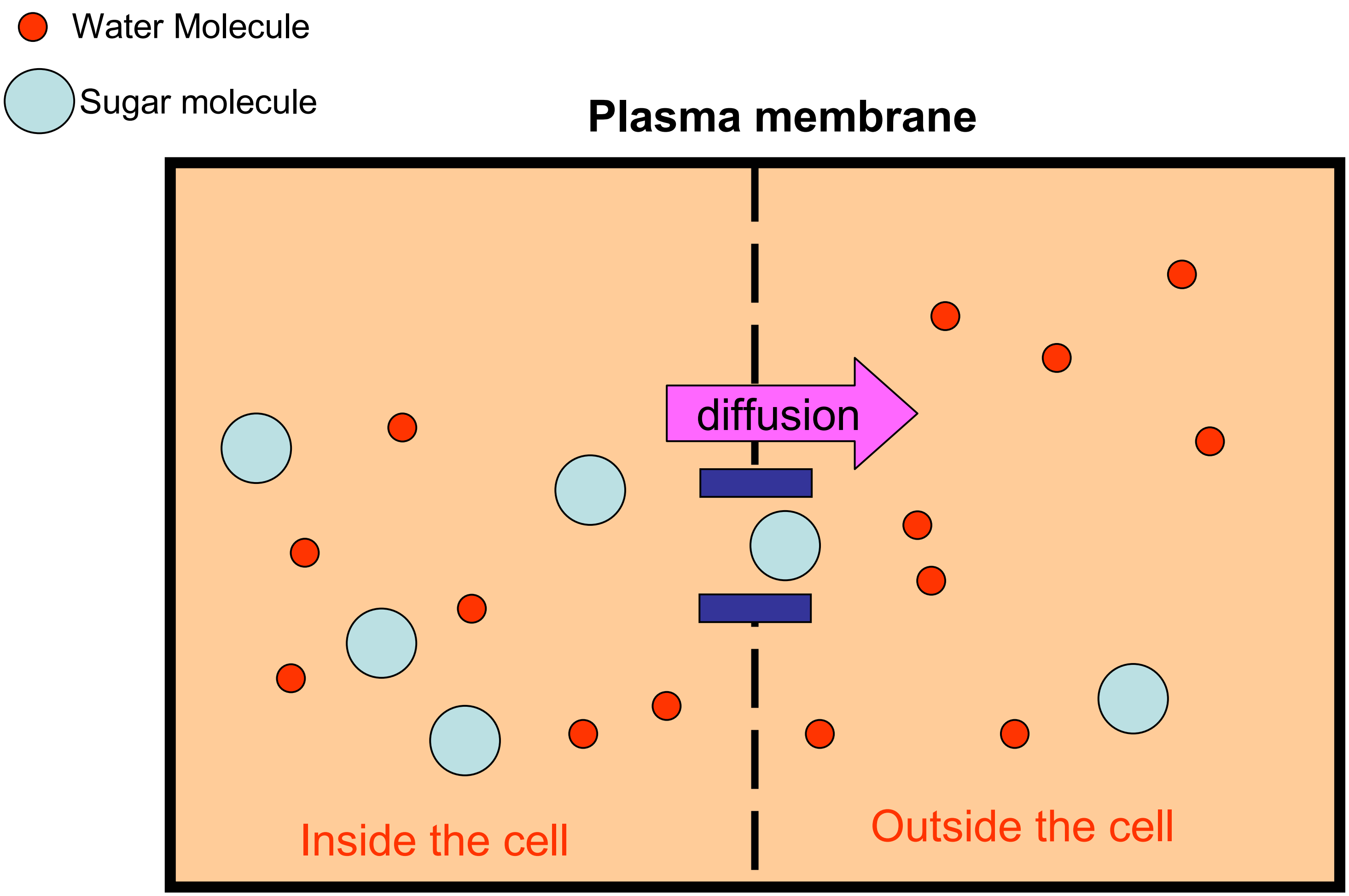
Facilitated Diffusion



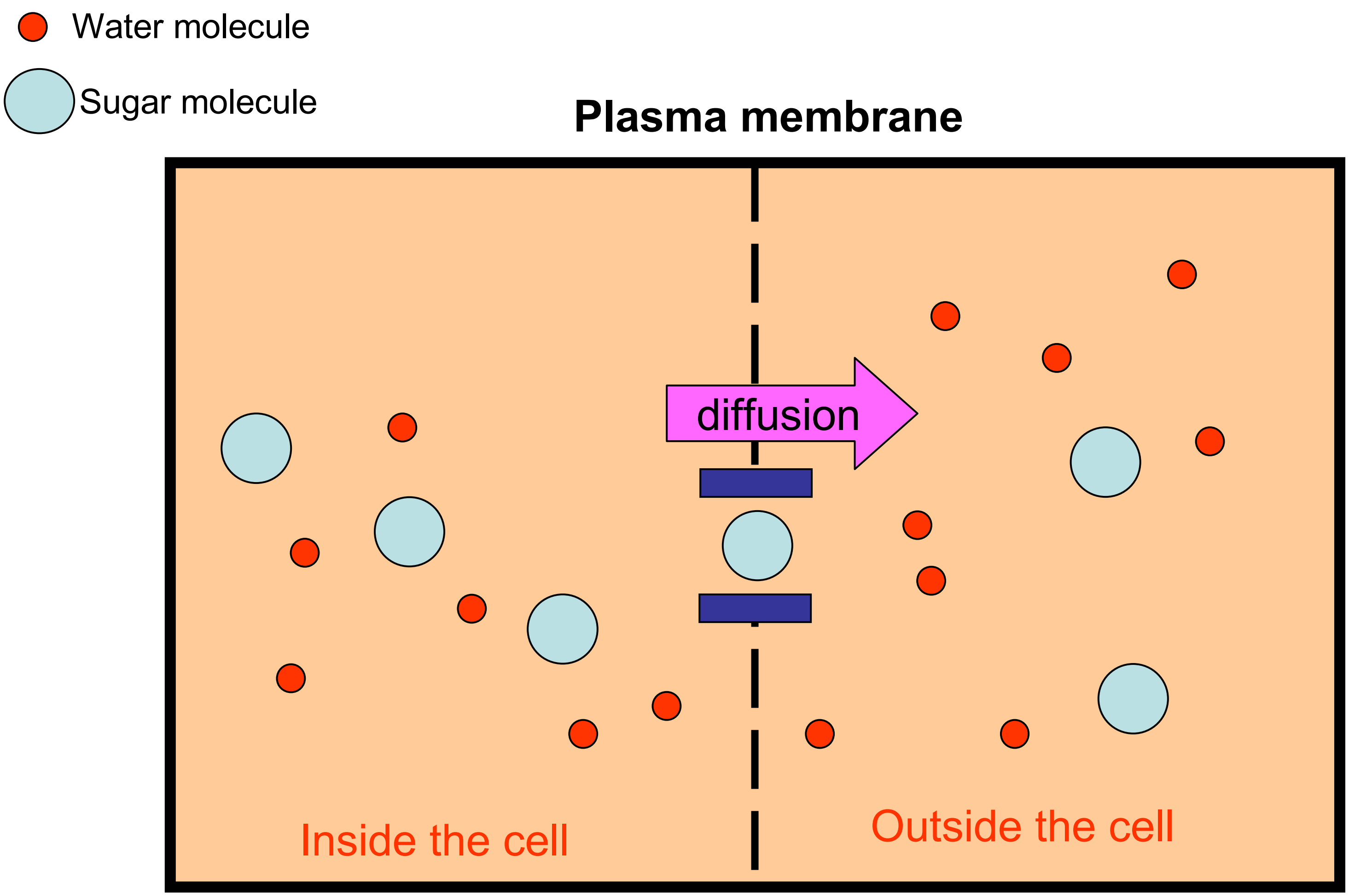
Facilitated Diffusion



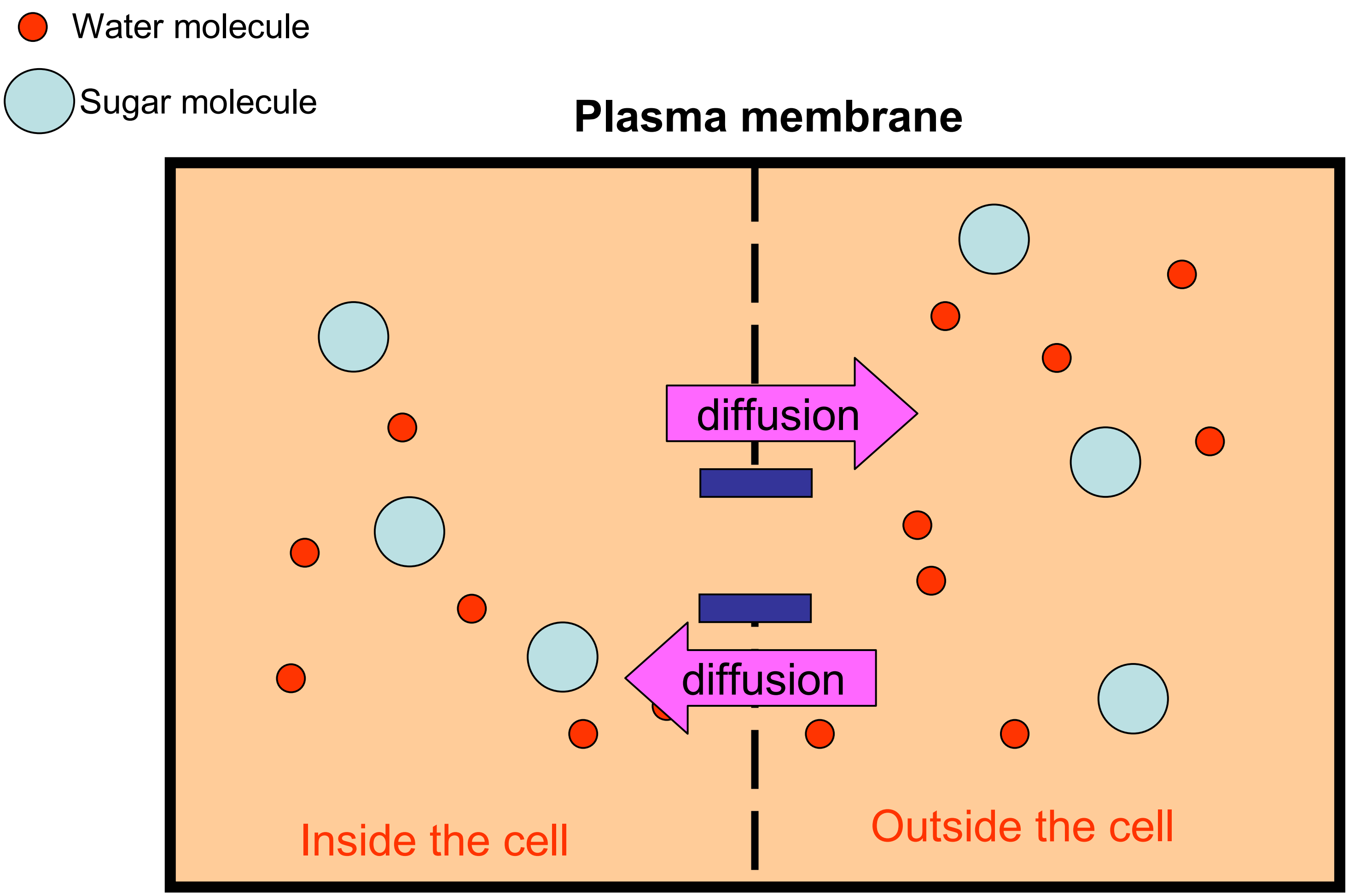
Facilitated Diffusion



Facilitated Diffusion



Facilitated Diffusion



EQUILIBRIUM

WJEC GCE BIOLOGY
Plasma Membranes

Osmosis

Osmosis is the process used by cells to exchange water with their environment. It is a passive process similar to diffusion but it is water molecules that move. A standard definition of osmosis is:

a net movement of water molecules from a region of high concentration to a region where their concentration is low, through a selectively permeable membrane (a membrane permeable to water and specific solutes).

Water Potential

Water potential is the pressure exerted by water molecule that are free to move in a system – it is measured in **Kilopascals (kPa)**. Conventionally, pure water has a water potential of 0 kPa. A solution with a high water potential has a large number of water molecules that are free to move.

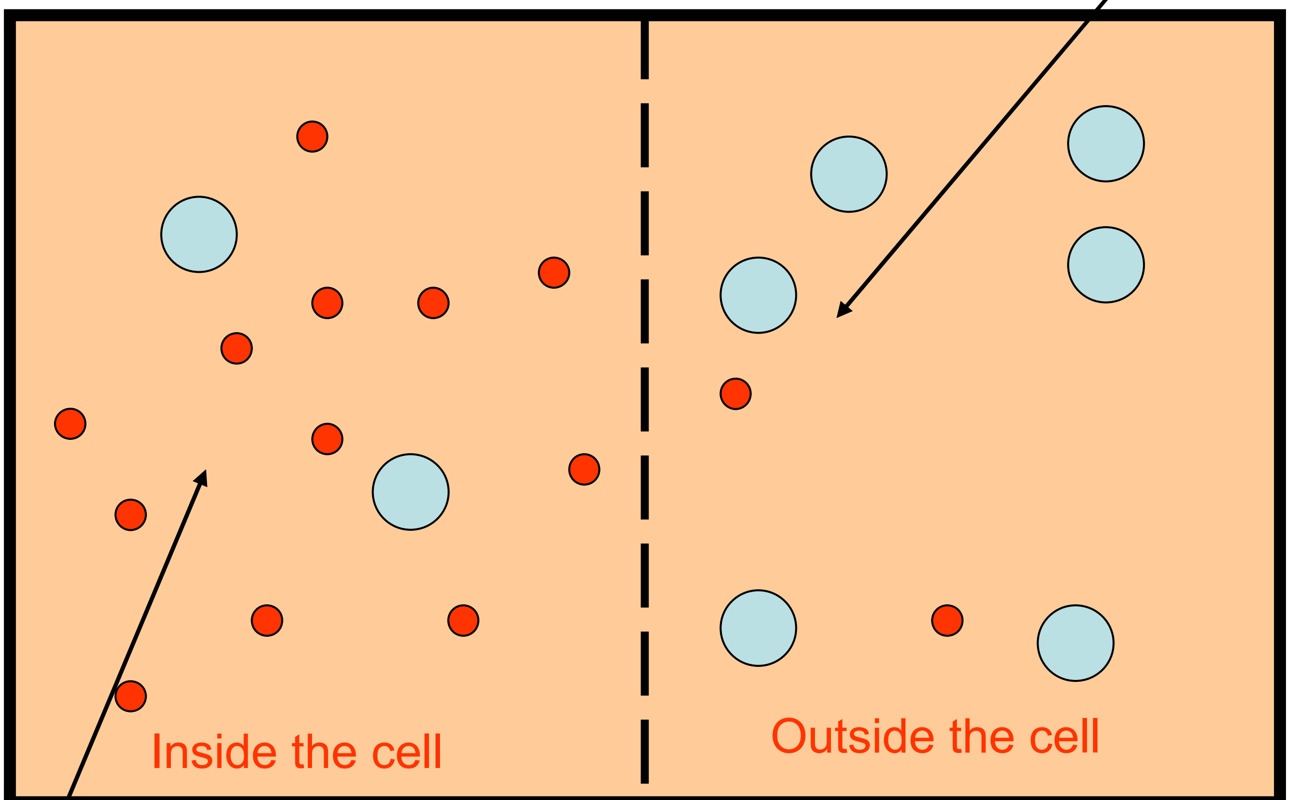
Osmosis

Water molecule

Sugar molecule

Semi-permeable membrane

VERY LOW concentration of water. LOW water potential.



WEAK SOLUTION

STRONG SOLUTION

VERY HIGH concentration of water molecules. HIGH water potential.

WJEC GCE BIOLOGY
Plasma Membranes

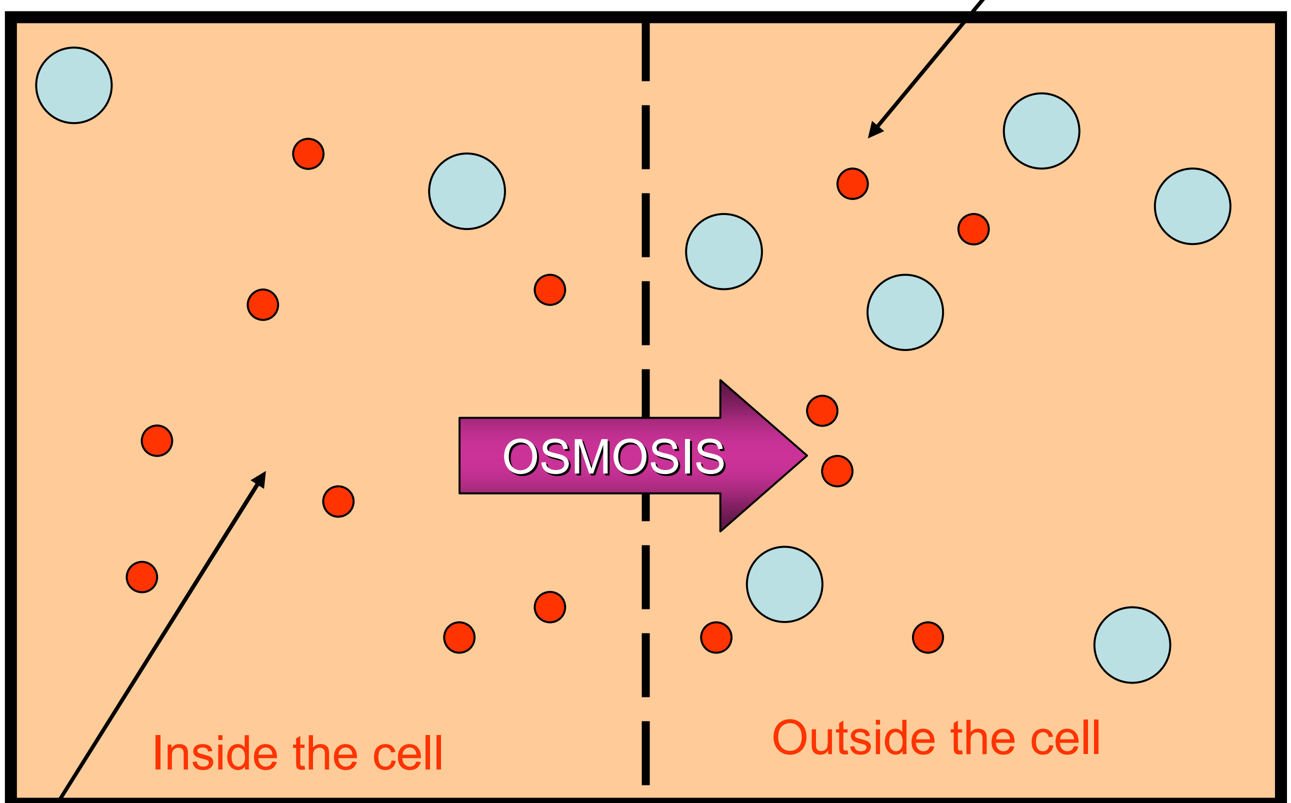
Osmosis

Water molecule

Sugar molecule

Semi-permeable membrane

LOW concentration of water molecules. LOW water potential.



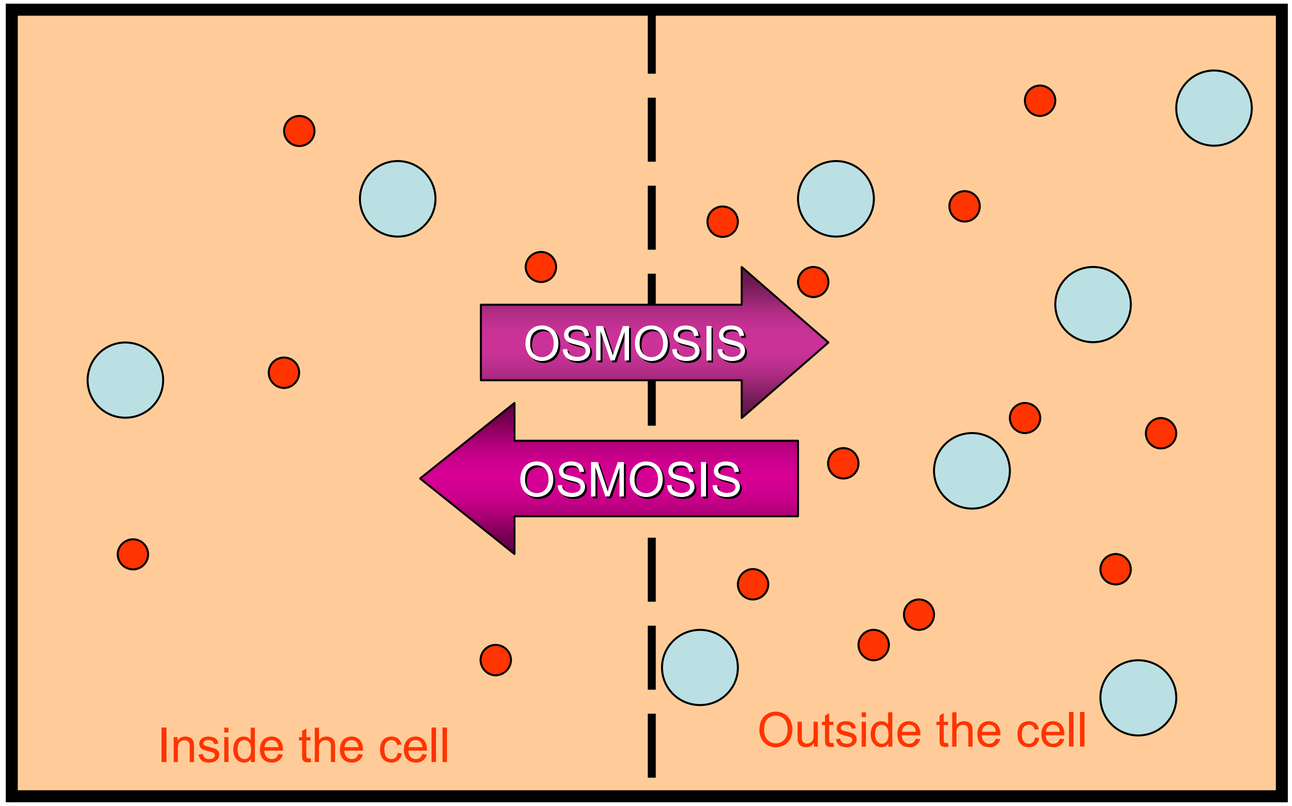
HIGH concentration of water molecules. HIGH water potential.

Osmosis

Water molecule

Sugar molecule

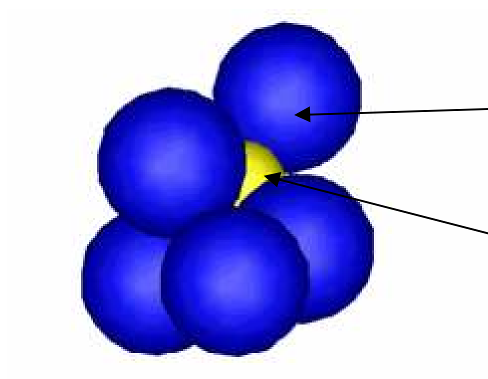
Semi-permeable membrane



EQUILIBRIUM. An equal concentration of water on two sides of the membrane. A position of equal water potential has been reached. There is no net movement of water.

Remember

A solution's water potential will fall as solutes are added because water molecules will cluster around the solute molecules.



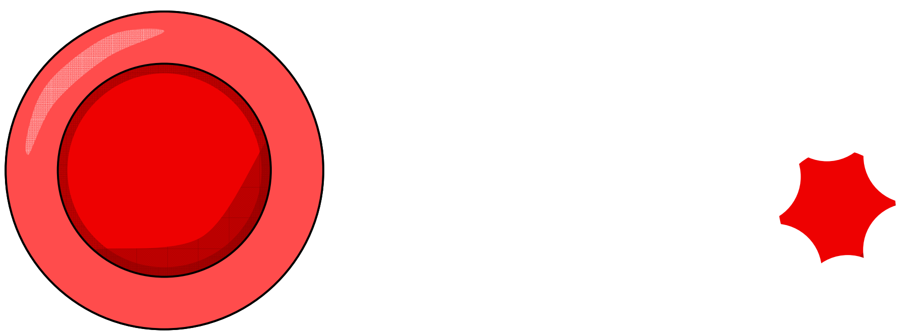
Solute Potential

A solute's contribution to the water potential is called the solute potential.

As it always reduces the water potential, the solute potential will always be negative.

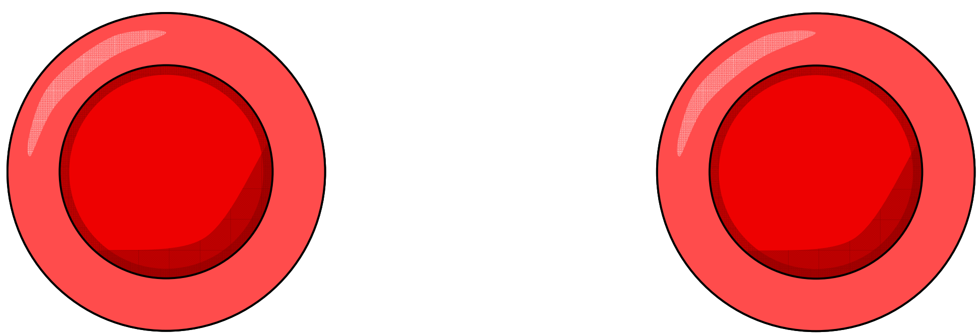
It becomes more negative as more solute is added to the system.

Osmosis in an animal cell



Osmosis in an animal cell

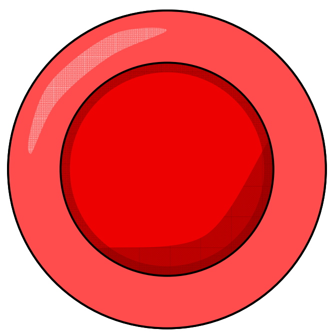
If this cell is placed in a solution that's **hypotonic** to its cytosol, then water will move into the cell causing it to expand.

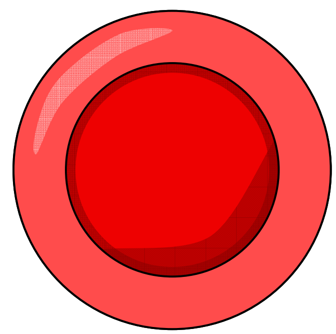


WJEC GCE BIOLOGY
Plasma Membranes

Osmosis in an animal cell

If this cell is placed in a solution that's **isotonic** to its cytosol, then the same amount of water enters the cell as moves out of it, so the cell is not damaged.





Osmosis in a plant cell

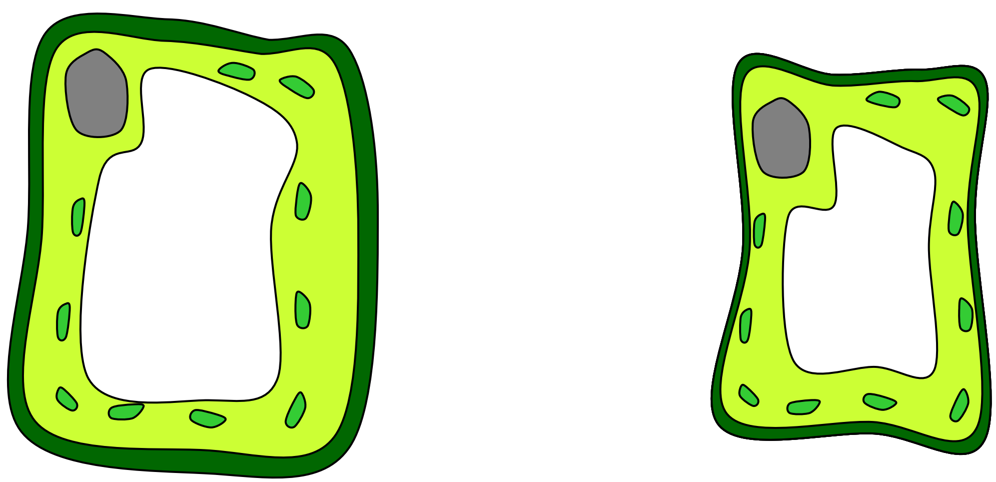
Plant cells behave in the same way as animal cells when placed in an isotonic solution: they don’t gain or lose water.

But the cell wall is inflexible and causes plant cells to behave differently in a hypertonic and hypotonic solution.

Osmosis in plant cells

In a hypotonic solution water will enter the cell and fill the vacuole. The plasma membrane will push against the cell wall making the cell very inflexible. It is said that cells in this state are **turgid**.

In a hypertonic solution the cell loses water and goes flaccid because the vacuole becomes flaccid and the cytoplasm stops pushing against the cell wall. This state is called **plasmolysis**. A cell at this stage is said to be in plasmolysis.



Pressure Potential

A cell's water potential can be calculated using the following formula:

$$\Psi_{cell} = \Psi_s + \Psi_p$$

Pressure potential will always be positive if the cell is turgid, but when the cell is flaccid the pressure potential is 0kPa.

Pressure Potential

The water potential equation can be used to predict the movement of the water flow in this example:

$$\Psi_{cell} = \Psi_s + \Psi_p$$

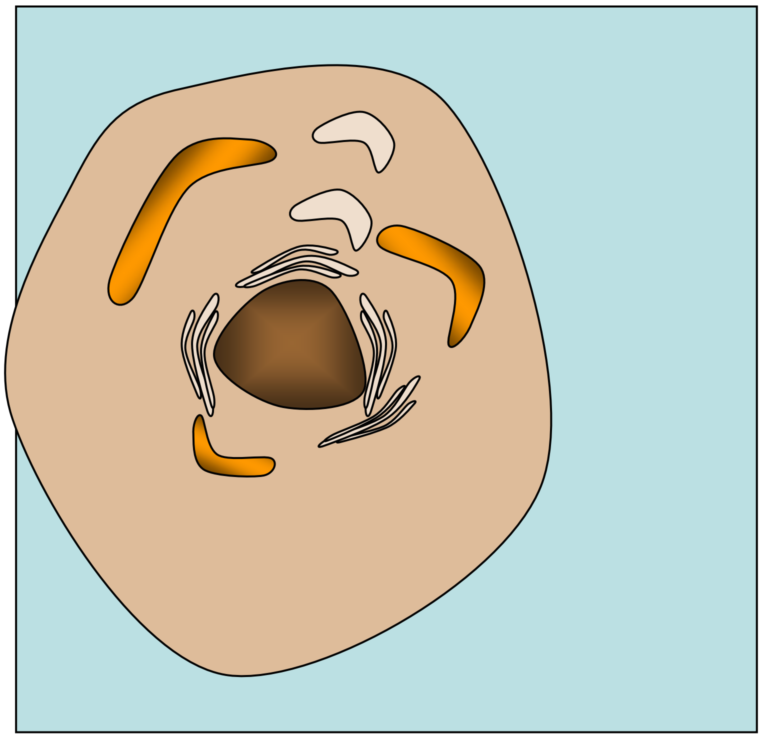
Plant A has a solute potential of -300kPa and a pressure potential of 200kPa. Cell B is directly adjacent to this cell and has a solute potential of -400kPa and a pressure potential of 100kPa.

The water potential of cell A is therefore -100kPa [-300 + 200] and the water potential of B is -300kPa [-400 +100]. Therefore, water moves from A to B as there is more concentration of water in A that in B.

Further example:

a) Calculate the water potential of this cell showing your calculations.

b) Will water move in or out of this cell?



Ψ_p = 350 kPa

Ψ_{cell} = -800 kPa

Ψ_s = -1500 kPa

Click to check your answer

Answer

a) $\Psi_{cell} = \Psi_s + \Psi_p$

$\Psi_{cell} = 350 + (-800)$ kPa

$\Psi_{cell} = -450$ kPa

b) As the water potential is lower (more negative) outside the cell; water moves from a high water potential to a lower one, down a concentration gradient. Therefore water will move out of the cell.

Active Transport

This is the movement of substances **against a concentration gradient** (from a region of low concentration to a region of higher concentration) across a plasma membrane. This process requires **energy**.

This energy is provided by mitochondria in the form of ATP and cells performing active transport on a large scale contains numerous mitochondria.

How does Active Transport work?

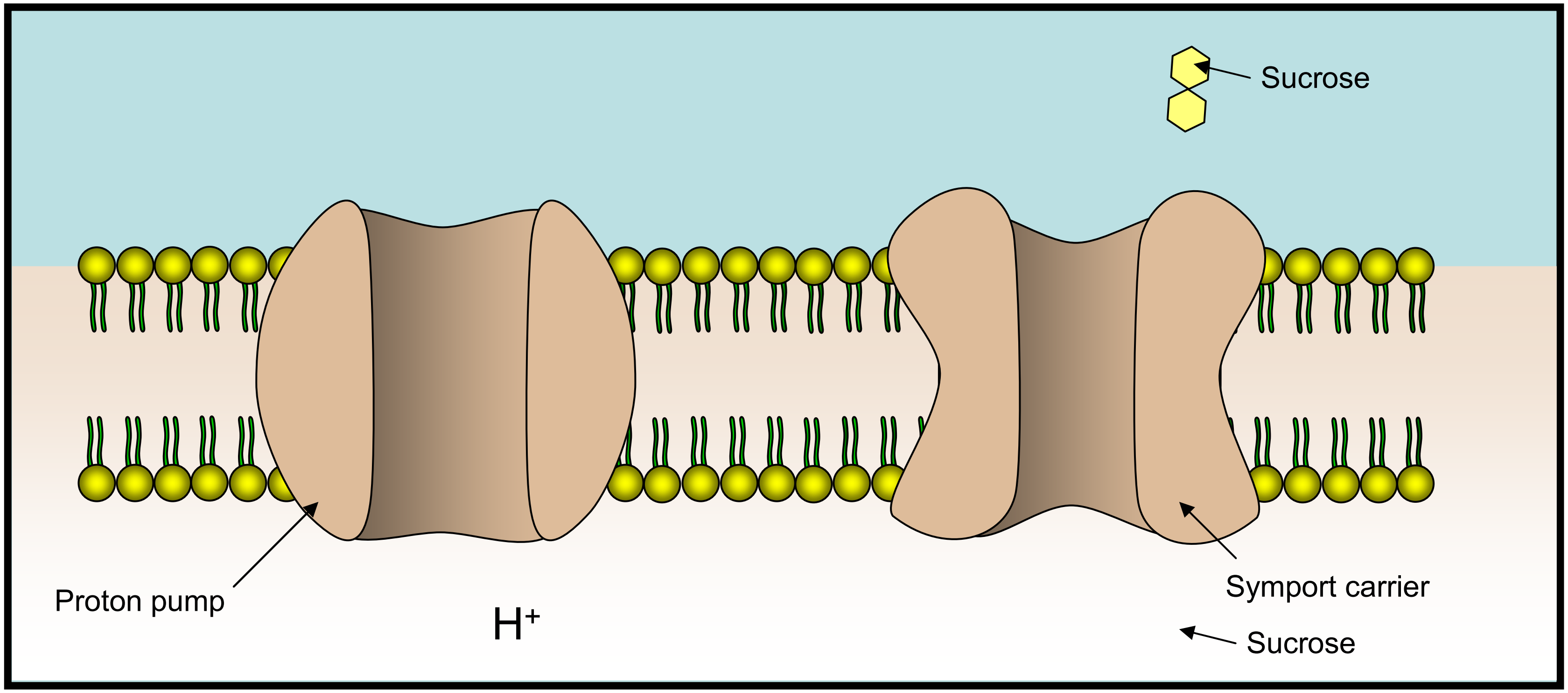
Active transport depends on proteins in the cell membrane to transport specific molecules or ions. These can move. These carriers can move:

i) one substance in one direction (uniport carriers)
ii) two substances in one direction (symport carriers
iii) two substances in opposite directions (antiport carriers)

The exact mechanism of active transport is unclear. Here are two hypotheses:

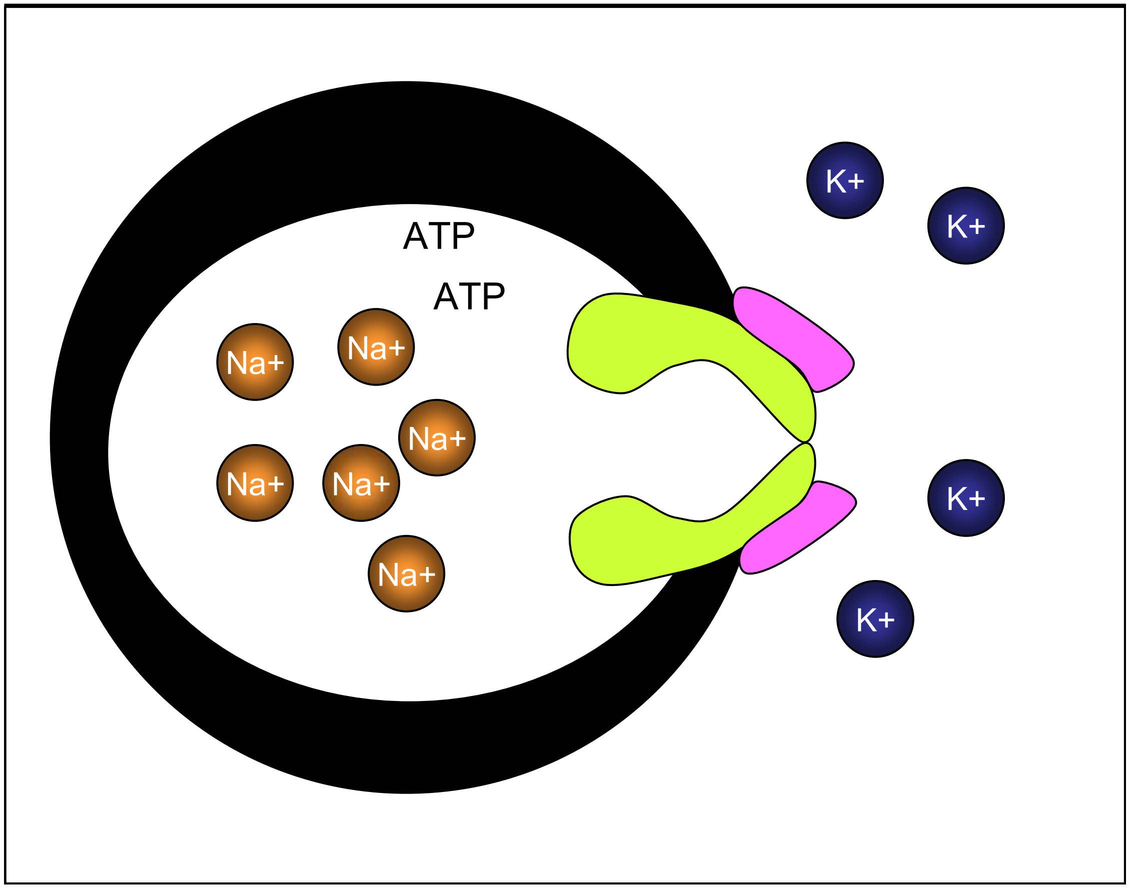
Cotransport Hypotheses

Sucrose movement in glucose storing cells in a plant.



Here the process of pumping protons drives sucrose transport in a plant cell. A pump using ATP as an energy source drives protons out of the cell, as they diffuse back into the cell, sucrose in this case is transported at the same time across a symport carrier.

Another Hypothesis



This hypothesis suggests that one protein molecule changes its shape in order to transport solutes across a membrane.

As ATP is hydrolysed to ADP to release energy for the process, ADP binds to the protein and changes its shape.

A sodium-potassium pump is an example of this. These pumps are vital in order to generate impulses in nerve cells.

Cytosis

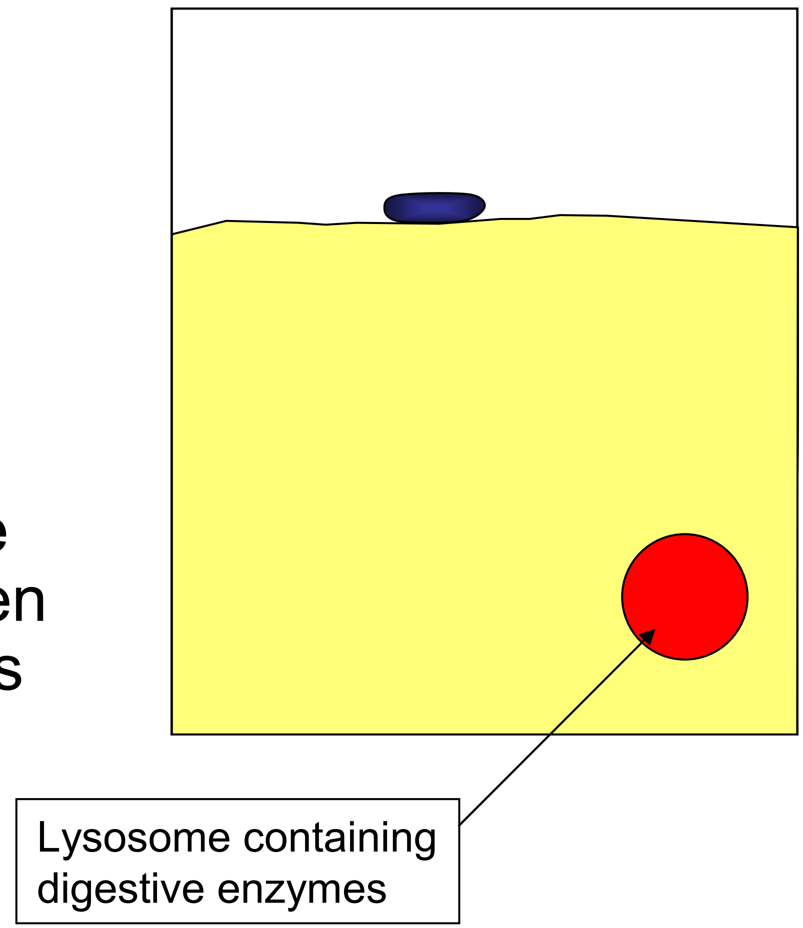
This process is active transport where parts of the plasma membrane form infoldings or outfoldings.

Cytosis can lead to transporting materials **into** a cell (**endo**cytosis) our **out** of it (**exo**cytosis).

Endocytosis

1. **Phagocytosis (cell eating)**

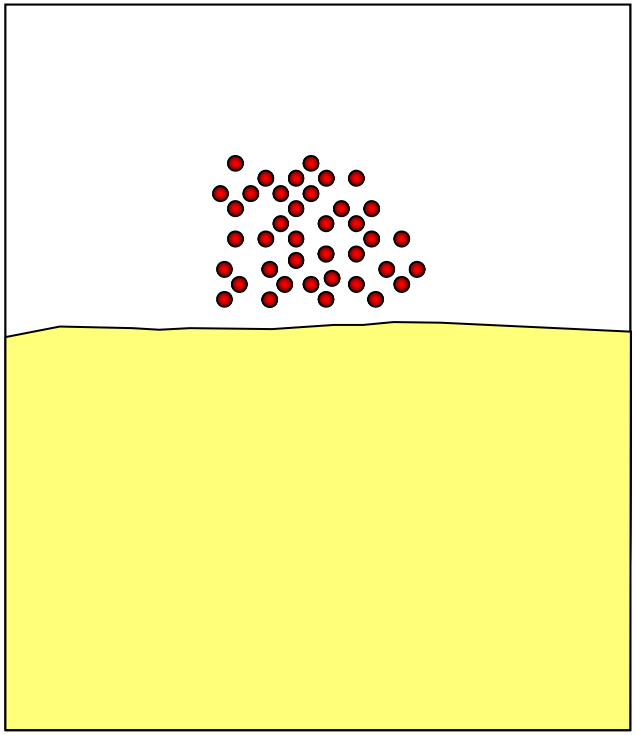
   Solid substances, sometimes whole organisms, are taken into a cell through infolding of the surface membrane. This is seen in an amoeba and cells such as white blood cells.



Endocytosis

2. Pinocytosis (cell drinking)

This process is similar to phagocytosis, but here the infoldings in the membrane are much smaller. Liquids or large micromolecules are taken in through small vesicles.

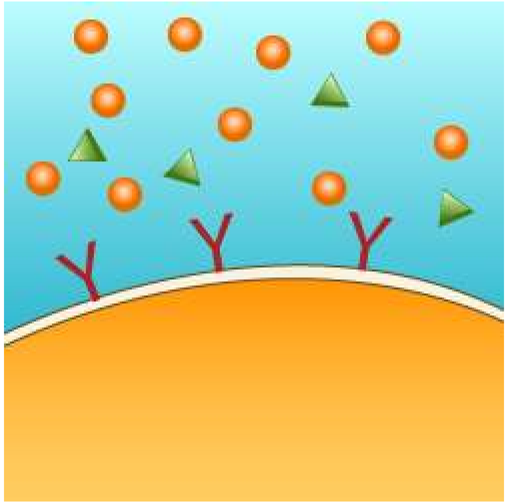


Endocytosis

3. **Receptor mediated endocystosis.**

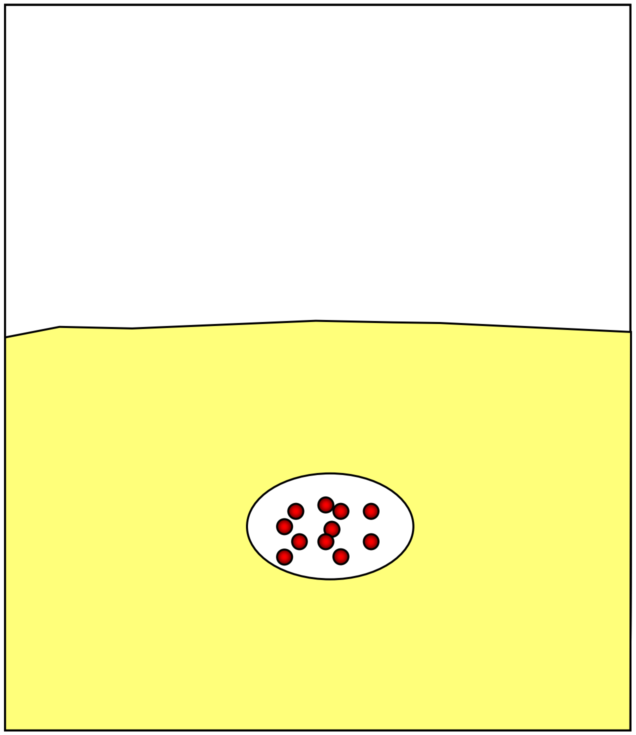
This is the third process:

We see the receptors on the surface membrane adhering to specific substrates (e.g. cholesterol) from the extracellular environment. As the receptor sites fill up, the surface folds inwards to form a vesicle and separates from the surface membrane.



Exocytosis

This is the reverse of endocytosis i.e. vesicles and vacuoles move towards the surface membrane, fuse with it, and release their content outside the cell.



The effect of cyanide

Cyanide is a strong poison. It works as a respiratory inhibitor. The enzyme cytochrome oxidase catalyses the reaction

$$ADP + P \longrightarrow ATP$$

If the enzyme is inhibited, ATP is not produced and the organism quickly dies.