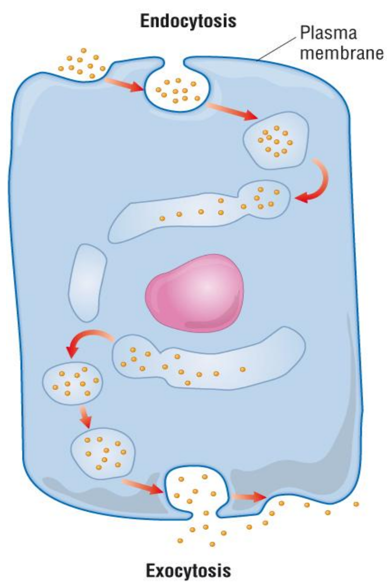
Name:…………………………………………….



Movement Across Cell Membranes

How to use – answer all questions. Use textbooks, revision guides and the internet. Read and highlight note. Annotate text.

Learning Outcomes

- Describe and explain what is meant by passive transport (diffusion and facilitated diffusion).

- Describe the role of membrane proteins in passive transport.

- Describe and explain what is meant by active transport, endocytosis and exocytosis.

- Explain what is meant by osmosis, in terms of water potential.

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- Recognise and explain the effects of solutions of different water potentials on plant and animal cells.

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Movement across Cell Membranes

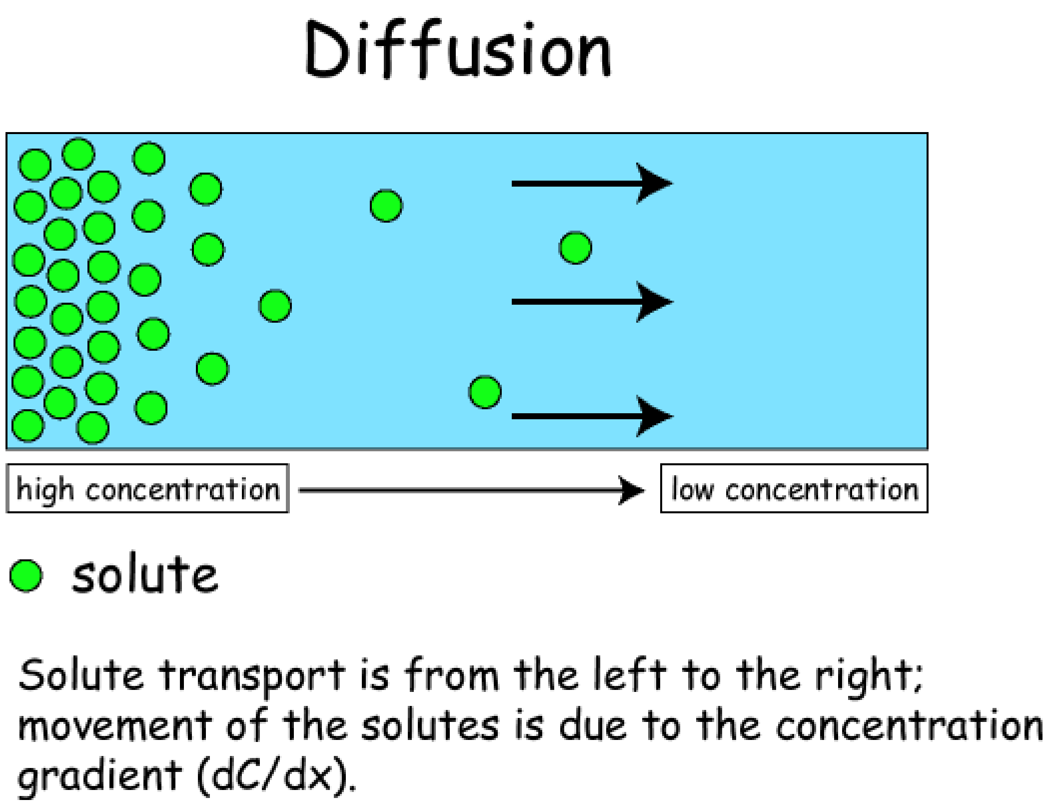
Many substances move into and out of cells through their plasma membranes. Some of these substances move passively – that is, the cell does not have to use energy to make them move.

Passive processes include **diffusion**, **facilitated diffusion** and **osmosis**.

Other substances are actively moved by the cell, which uses energy to make them move up their concentration gradients. This is called **active transport**.

Diffusion

Definition – "the net movement of molecules or ions from a region of their high concentration to a region of their lower concentration"



Particles are constantly moving around randomly. They hit each other and bounce off in different directions. Gradually, this movement results in the particles spreading evenly throughout the space within which they can move. This is **diffusion**.

If there are initially more particles in one place than another, we say there is a **concentration gradient** for them.

Diffusion is affected by:

- Surface area
- Length of diffusion path
- Difference in concentration

Diffusion across cell membranes is also affected by:

- the permeability of the membrane
- the size and type of molecule/ion diffusing through it

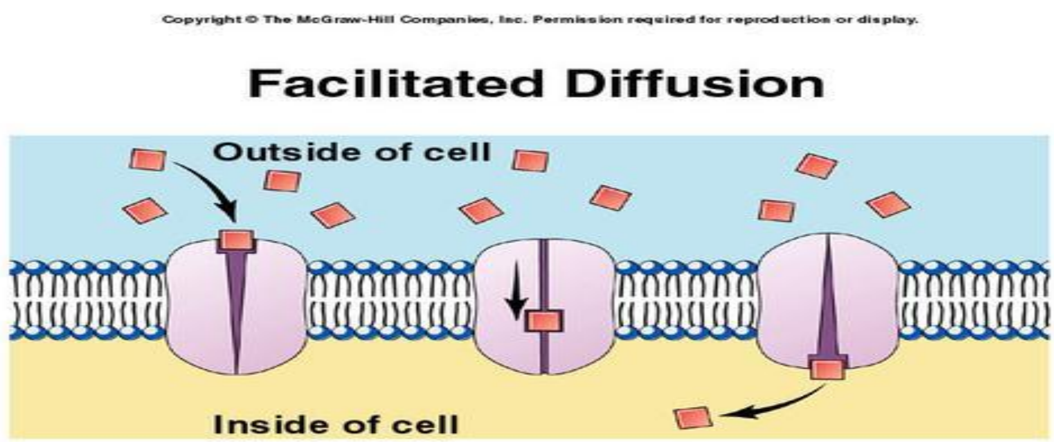
There are usually a large number of different kinds of particles bouncing around the inside and outside of a cell, on both sides of the plasma membrane. Some of these particles hit the plasma membrane. If they are small – like oxygen and carbon dioxide molecules – and do not have an electrical charge, they can easily slip through the phospholipid bilayer.

Facilitated Diffusion

Oxygen and carbon dioxide have small molecules with no electrical charge, and can easily pass through the phospholipid bilayer. However, many other molecules or ions may be too biog, or too highly charged to do this. E.g. chloride ions Cl^- have an electrical charge and cannot pass through the phospholipid bilayer.

Cells therefore need to provide special pathways through the plasma membrane which will allow such substances to pass through. Proteins provide such pathways.

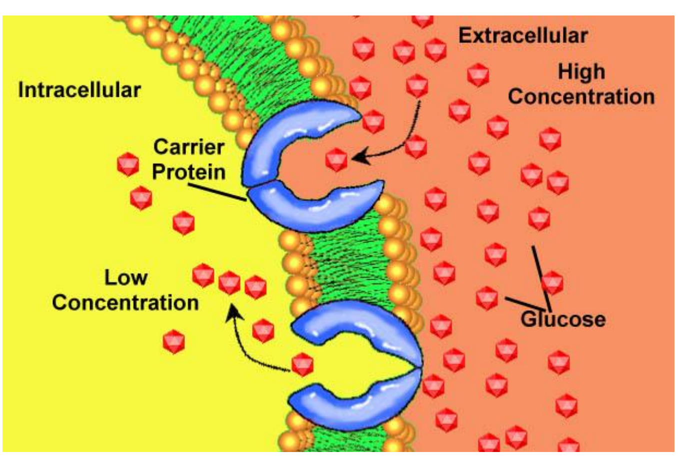
Channel Proteins



Channel proteins form pores in the membrane for charged particles to diffuse down the concentration gradient. They are also SPECIFIC and each channel will only allow a certain ion or molecule to pass through.

These proteins lie in the membrane, stretching from one side to the other, forming a hydrophilic channel; through which ions can pass.

Carrier Proteins

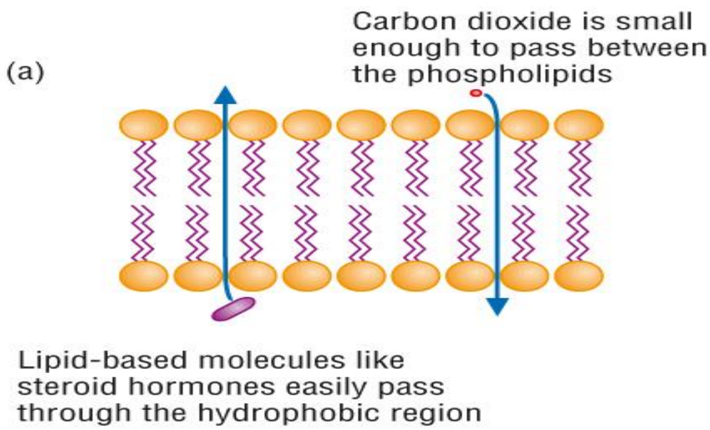


Carrier proteins move large molecules into or out of the cell, down the concentration gradient. Different carrier proteins facilitate the diffusion of different molecules – they are SPECIFIC.

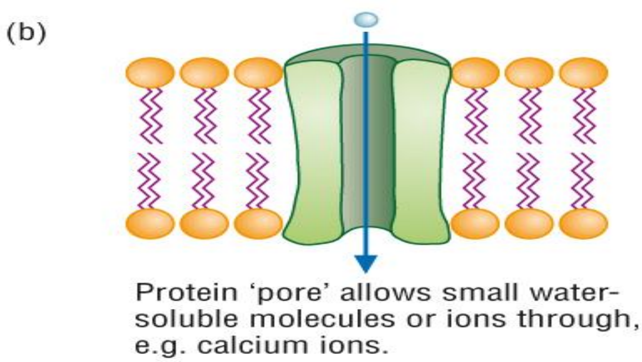
~ large molecule attaches to carrier protein in cell membrane

~ the protein changes shape

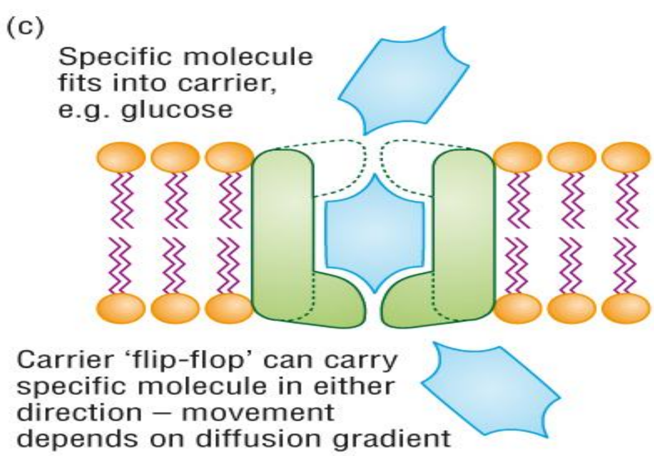
~ this releases the molecule on the other side of the membrane



(a) Simple diffusion



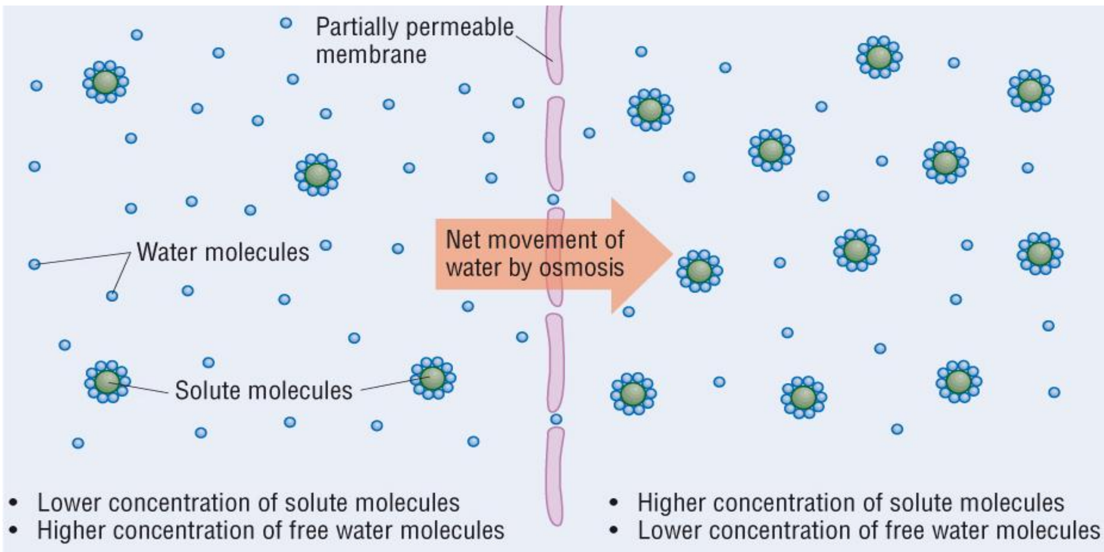
(b) Facilitated diffusion using a channel protein



(c) Facilitated diffusion using a carrier protein

Osmosis

Water molecules, although they carry a small charge are able to pass through the lipid bilayer by diffusion. This movement of water molecules down their diffusion gradient, through a **partially permeable** membrane is call **osmosis**.



It is not correct to use the term concentration to describe the amount of water there is in something. Concentration refers to the amount of solute present. Instead, the term **water potential** is used.

- The pressure exerted by freely moving water molecules in a system is the WATER POTENTIAL (measured in kilopascals, kPa).

- The water potential of pure water is 0kPa.

- A solution with a high water potential has a high number of freely moving water molecules.

- The water potential of a solution falls when a solute is added because water molecules cluster around the solute molecules.

- The more solute is added, the lower the water potential falls.

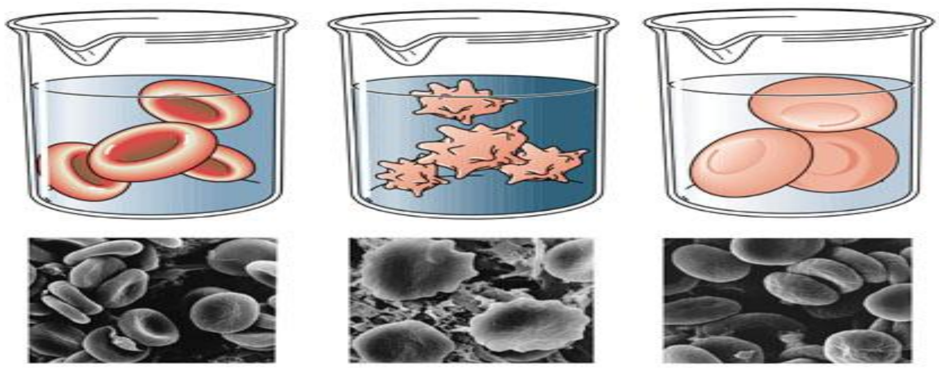
Definition

The net movement of water molecules from a region of high water potential to a region of lower water potential, through a partially permeable membrane, as a result of their random movement.

Effect of Water Potential on Animal Cells

The cells in your body are bathed in a watery fluid. If there is a water potential gradient between the contents of a cell and the watery fluid then water will move wither in or out. If a lot of water moves like this, the cell can be damaged.

Tobin/Dusheck, Asking About Life, 2/e
Figure 4.20



A. Isotonic solution (equal concentration of ions in solution and cell)

B. Hypertonic solution (higher concentration of ions in solution than in cell)

C. Hypotonic solution (lower concentration of ions in solution than in cell)

The red blood cells show what happens to animal cells in solutions of different water potentials.

Describe the water potential in the following solutions:

Isotonic - ……………………………………………………………………………………

Hypertonic -……………………………………………………………………………………

Hypotonic – …………………………………………………………………………………….

- In a hypotonic solution, the animal cell will take on water until it bursts – this is called CELL LYSIS.

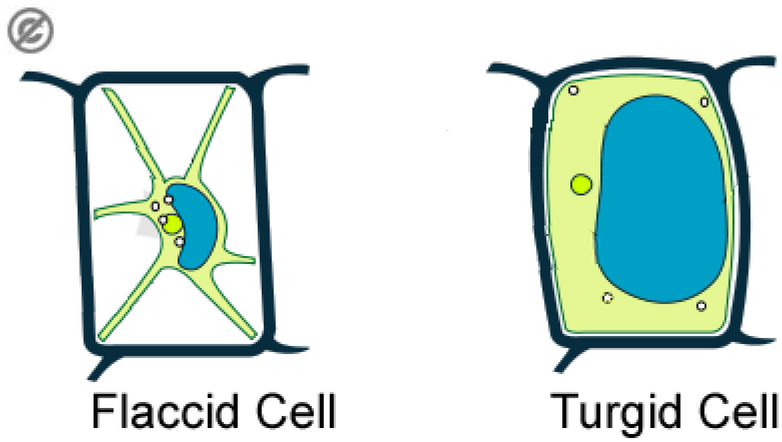
- In a hypertonic solution, the animal cell will shrink and shrivel as water is drawn out of the cell, sometimes becoming 'star-shaped', described as being '**crenated**'.

Effect of Water Potential on Plant Cells

Plant cells behave the same way in an isotonic solution, i.e. they do not lose or gain water.

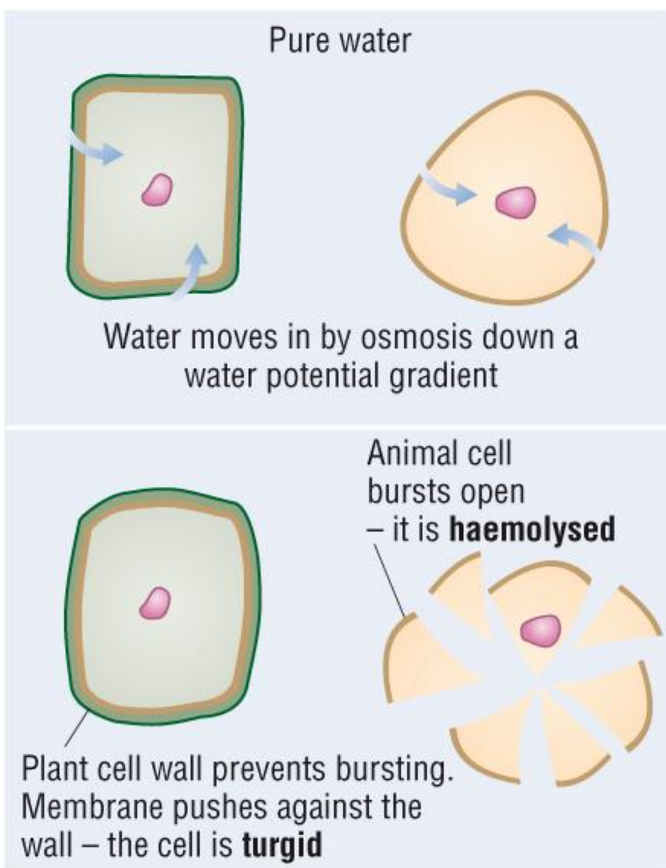
In a hypertonic solution the plant cell loses water, the vacuole shrinks and the cell membrane is pulled away from the cell wall. The cell is **FLACCID** because the contents no longer push against the cell wall. A cell in this condition is **PLASMOLYSED.**

In a hypotonic solution the plant cell takes on water until the vacuole is full and the cell contents are pushed against the cell wall.
The cell is very rigid, it is **TURGID.**

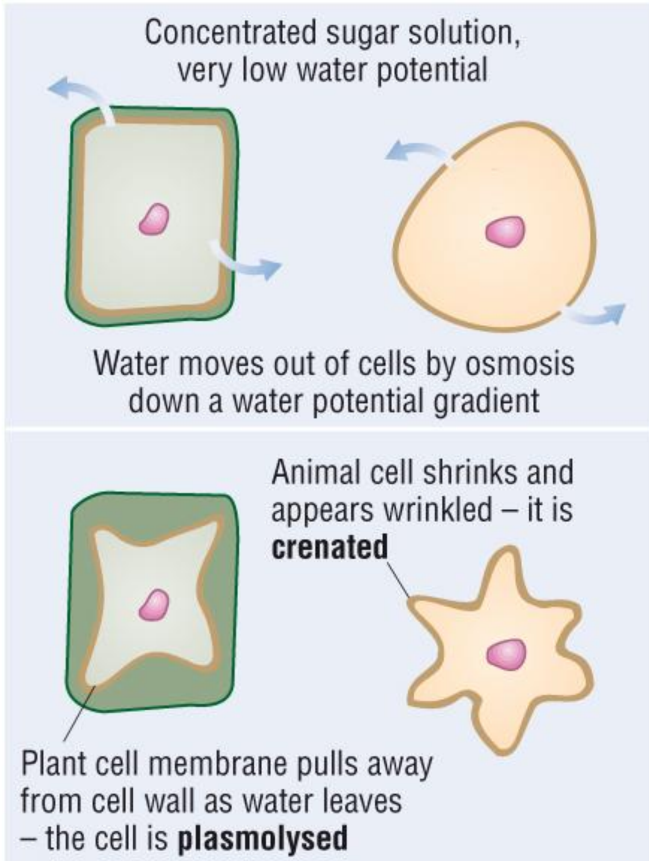


There is no danger of the cell bursting because the pressure of the cell wall on the contents prevents further inflow of water.

Plant and animal cells in solutions of high water potential - before and after



Plant and animal cells in solutions of low water potential - before and after



Required practical: Investigating water potential of a plant tissue

Procedure

1. Prepare a series of six sucrose solutions using 1.0 M sucrose and distilled water to give a range of 0.0-0.1 M as shown in the figure.
2. Measure 25 cm^3 of each sucrose concentration into separate boiling tubes and label with the appropriate molarity.
3. Cut six cylinders from a swede using the cork borer. Trim to remove any skin and cut to the same length (approximately 5 cm).
4. Dry the swede cylinders by rolling in paper towel – the same number of times for each cylinder. For each of the six sucrose bathing solutions, weigh a cylinder on the balance. In a suitable table, record its mass against the appropriate solution molarity.
5. Using forceps, place each cylinder into the correct sucrose concentration and insert the bung.
6. Leave the swede cylinders in the tubes for one hour.
7. Remove each cylinder from the tubes in the same order that they were put in. Roll each cylinder in paper towel – the same number of times as in step 4. Reweigh and record the new mass in your table against the correct bathing solution.
8. Calculate the change in mass for each cylinder.
9. Draw a graph of your processed results showing the intercept. Now work out the water potential value using a calibration table or curve. Join the points with straight lines and do not extrapolate.

If you use 0.1 M sucrose solution you will notice a change in the previously observed trend. There will be a gain in mass from the one at 0.5 M. This is not an anomalous result but it happens because the cells are so plasmolysed and the space between the walls and membrane fills with sucrose solution (the cell walls are fully permeable and 0.1 M sucrose is dense).

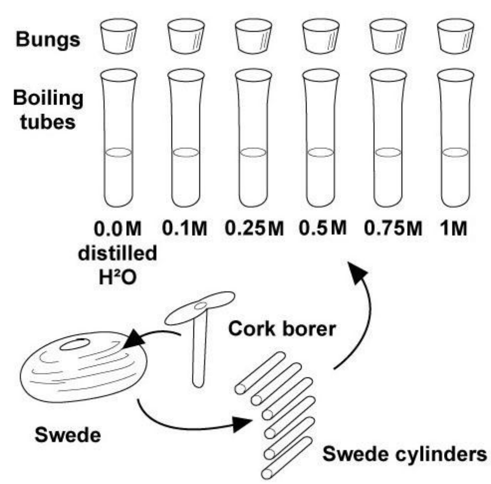
Objective

- To make up different water potential solutions
- To determine water potential of plant tissue
- To draw graphs of the data showing an intercept

Equipment/materials

- Plant tissue such as swede
- 1 M sucrose solution
- Distilled water
- Boiling tubes
- Cork borer size No. 5 or 6
- Scalpel, white tile and ruler
- Boiling tube rack to hold six tubes
- Measuring cylinders
- 10 cm^3 syringes
- Chemical balance
- Tweezers
- Labels or Chinagraph pencil / OHP pen
- Bungs to fit boiling tubes
- Paper towel for blotting

Diagram



From the examiner

- The point where the solution and the plant cells are at equilibrium is the intercept.

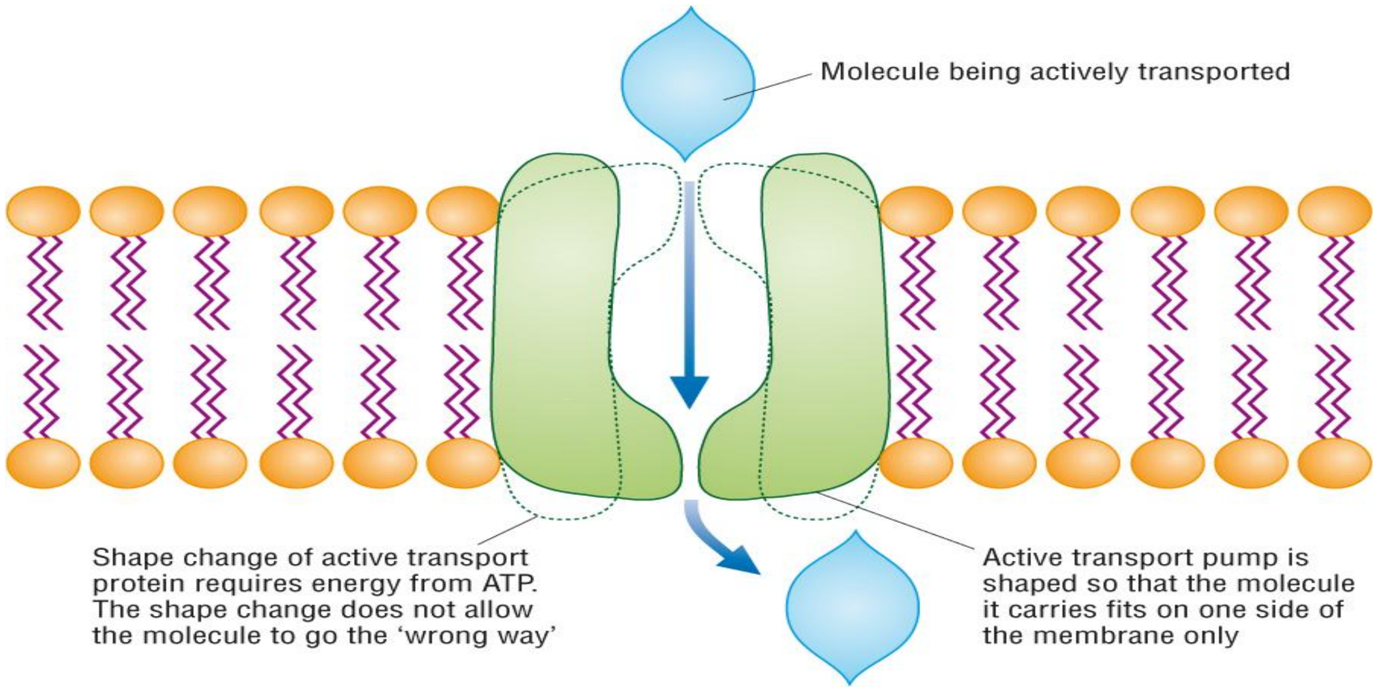
Safety

- Take care with glassware and cutting equipment.

Questions

1. Explain the importance of drying the swede cylinders before and after soaking in the bathing solution.
2. Why is it important to remove the cylinders from the bathing solution in the same order that they were put in?
3. After working out the change in mass, what additional calculation would help eliminate any differences between the cylinders and give a more accurate result?
4. How would you assess the reliability of the results?
5. What are the limitations of this investigation? How sure can you be that the water potential value is accurate?
6. Why were bungs placed in the tubes?

Active Transport



There are many instances where a cell needs to take up or get rid of a substance whose concentration gradient is in the wrong direction. This is done by active transport.

Active transport is carried out by transporter proteins in the plasma membrane, working in close association with ATP which supplies the energy. The ATP is used to change the shape of the transporter proteins.

SUMMARY

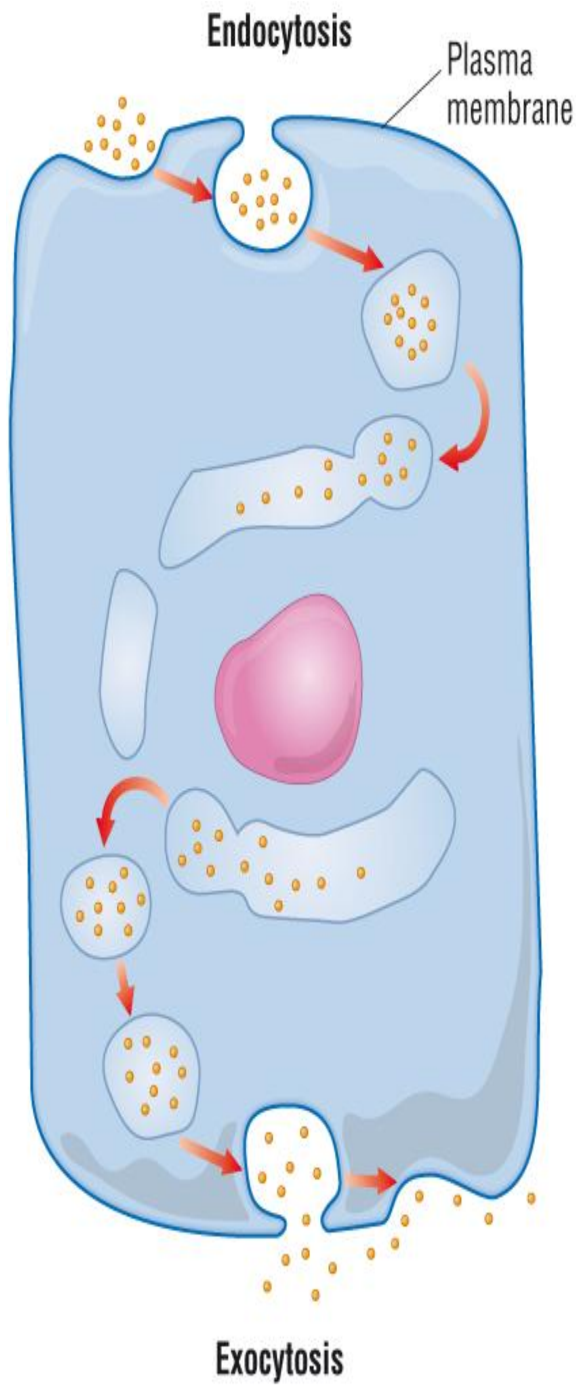
- Energy is used
- Transport against a concentration gradient
- Protein pumps change their shape
- May transport two molecules at once

Active transport includes:

- Ca2+ pumps in muscles

- Active reabsorption in nephrons
- Absorption of the products of digestion
- Sugar loading into phloem

Endocytosis and Exocytosis

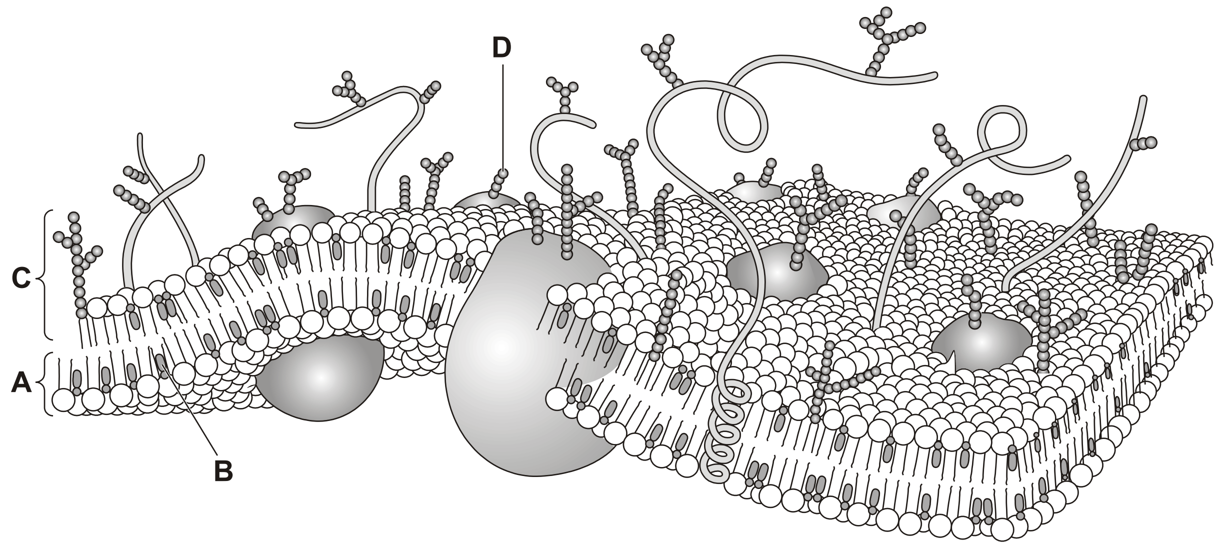


ENDOCYTOSIS – a cell surrounds a substance with a section of it's cell membrane. The membrane pinches off to form a vesicle inside the cell.
Phagocytes use endocytosis to ingest and digest bacteria and dead cells.

- **Pinocytosis** is the movement of liquids.
- **Phagocytosis** is the movement of solids.

EXOCYTOSIS – vesicles containing substances for secretion are pinched off the Golgi apparatus and move towards the cell membrane. The vesicle fuses with the membrane and releases the substances outside the cell (or membrane proteins are inserted directly into the bilayer).

1. The diagram below represents the structure of the plasma (cell surface) membrane.



(i) State the name given to the model of membrane structure shown in the diagram.

....

[1]

(ii) Name the parts labelled **A** to **D**.

A ....

B ....

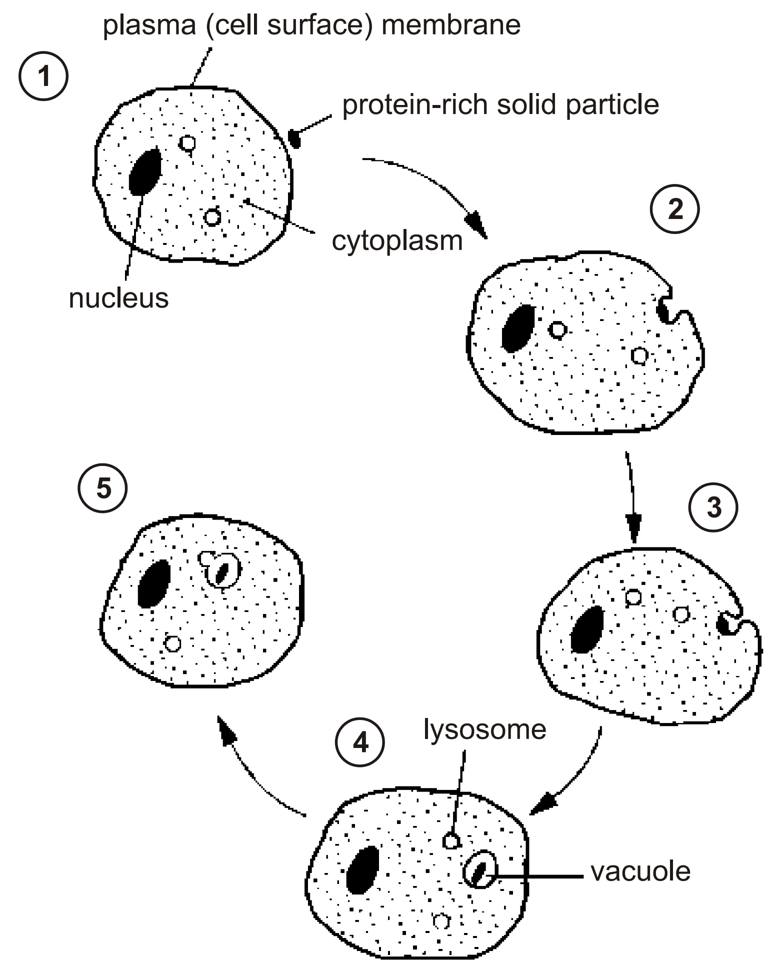
C ....

D ....

[4]

[Total 5 marks]

2. The figure below is a diagram showing the transport of a protein-rich solid particle into an animal cell.



(i) Name the method of transport shown in stages 1 to 4 in the figure.

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[1]

(ii) Describe what happens within the vacuole after it fuses with the lysosome.

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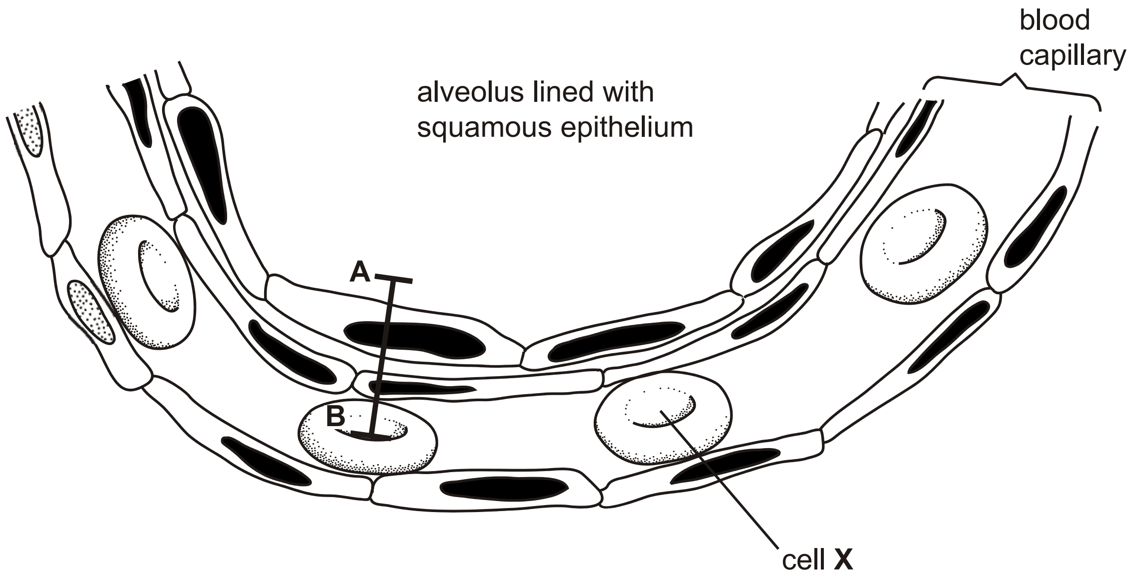
[3]

[Total 4 marks]

3. The diagram below is a drawing of an alveolus together with an associated blood capillary.



In this question, one mark is available for the quality of spelling, punctuation and grammar.

When passing from the alveolus to cell **X**, oxygen diffuses through cell membranes.

Describe how other molecules or ions cross a plasma (cell surface) membrane by **active transport** and **facilitated diffusion**.

You should refer to the structure of the plasma (cell surface) membrane in your answer.

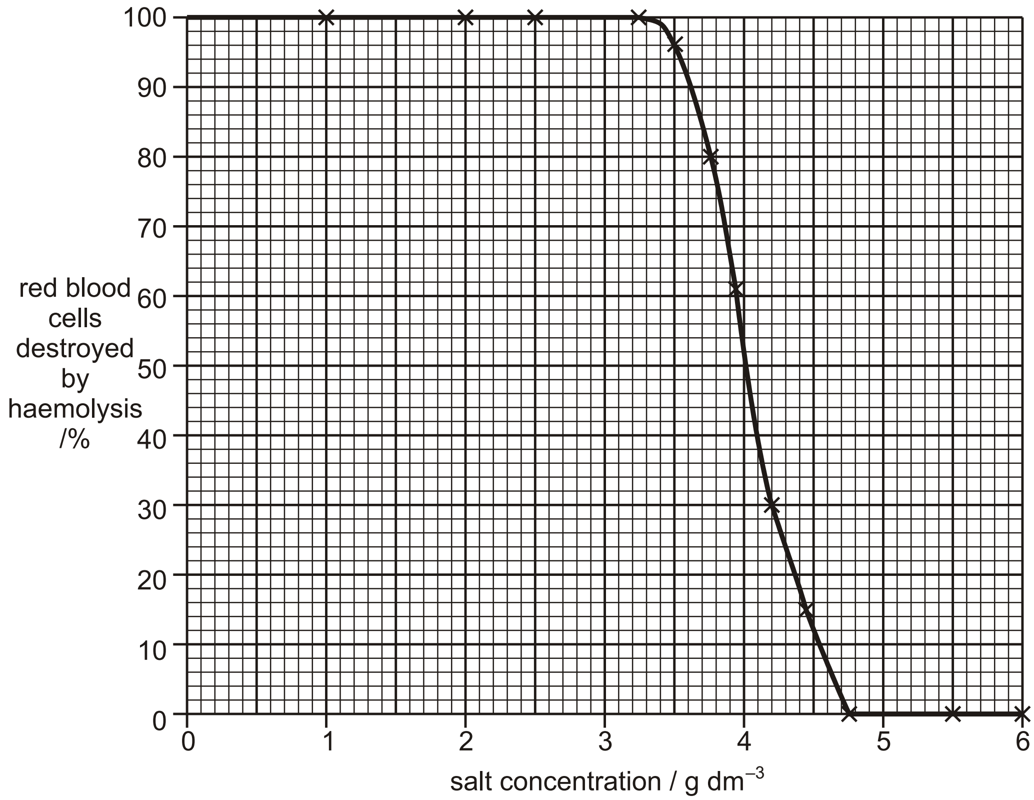
(Allow one lined page).

[7]

Quality of Written Communication [1]

[Total 8 marks]

4. An experiment was carried out in which red blood cells were placed in salt solutions of different concentrations. The percentage of cells which were destroyed by haemolysis was recorded. The results are shown in the graph below.



The graph shows that the red blood cells do not all haemolyse at the same salt concentration.

(i) Using the graph above, state the salt concentration at which the percentage of haemolysed red blood cells is equal to those that are not haemolysed.

.... g dm^{-3}

[1]

(ii) Suggest why different red blood cells haemolyse at different salt concentrations.

....

....

[1]

[Total 2 marks]

5. Explain why it is important that red blood cells are stored in a solution with a suitable water potential.

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[Total 2 marks]