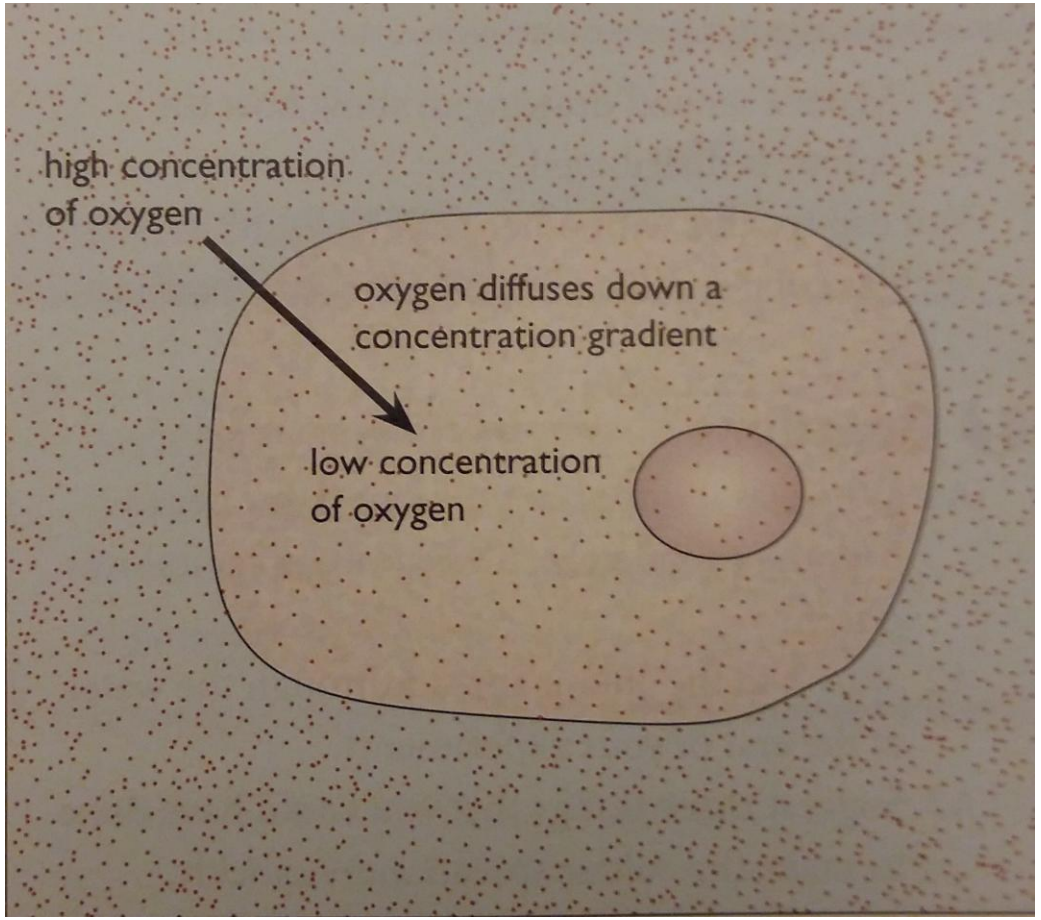
Chapter 3

Movement in and out of cells

Diffusion

Diffusion is the net movement of molecules and ions from a region of their higher concentration to a region of their lower concentration down a concentration gradient, as a result of their random movement,



Diffusion of oxygen into a cell. The red dots represents oxygen molecules.

Examples of diffusion in plants

- The movement of carbon dioxide during photosynthesis.
- The movement of water vapour during transpiration.

Examples of diffusion in animals

- The movement of oxygen through the walls of alveoli into the blood.
- The movement of carbon dioxide from respiring cells, through tissue fluid, into the blood in capillaries.

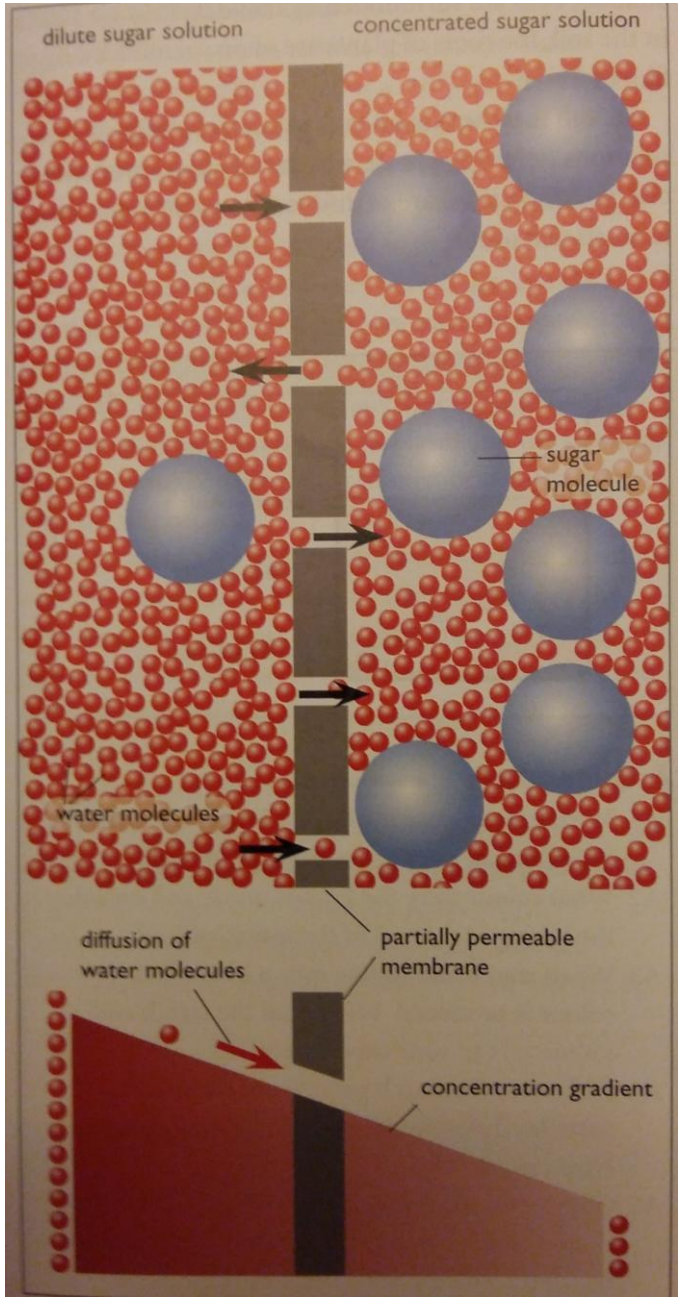
Rate of diffusion

The speed with which a substance diffuses through a cell wall or a cell membrane depends on:

1. **Temperature and pressure,** the higher the temperature/pressure the faster the rate of diffusion.
2. **Thickness of cell membrane or cell wall:** the thicker the wall/membrane the slower the rate of diffusion.
3. **Concentration gradient or diffusion gradient:** the bigger the difference in concentration of a substance on either side of a membrane, the faster it will tend to diffuse.
4. **Size of particle:** the larger the molecules or ions, the slower they diffuse.
5. **Surface area:** the greater the surface area, the faster is the total diffusion.

Osmosis

- ***Osmosis*** is the diffusion of water molecules from a region of higher water potential to a region of lower low water potential, through a partially permeable membrane.
    - ***Dilute*** *solutions, which have a relatively large number of water molecules, are said to have a high water potential.*
    - ***Concentrat****ed solutions, with fewer water molecules, are said to have a low water potential.*



Special property of cell membrane

- The cell membrane is a partially permeable membrane. It contains lipids and proteins.
- Heat denatures proteins and destroys cell membranes.
- Cell membranes lose their partial permeable property and cells die.

Osmosis and animal cells

Case 1, *animal cells in pure water*

If animal cells are placed in pure water, water enters them by osmosis.

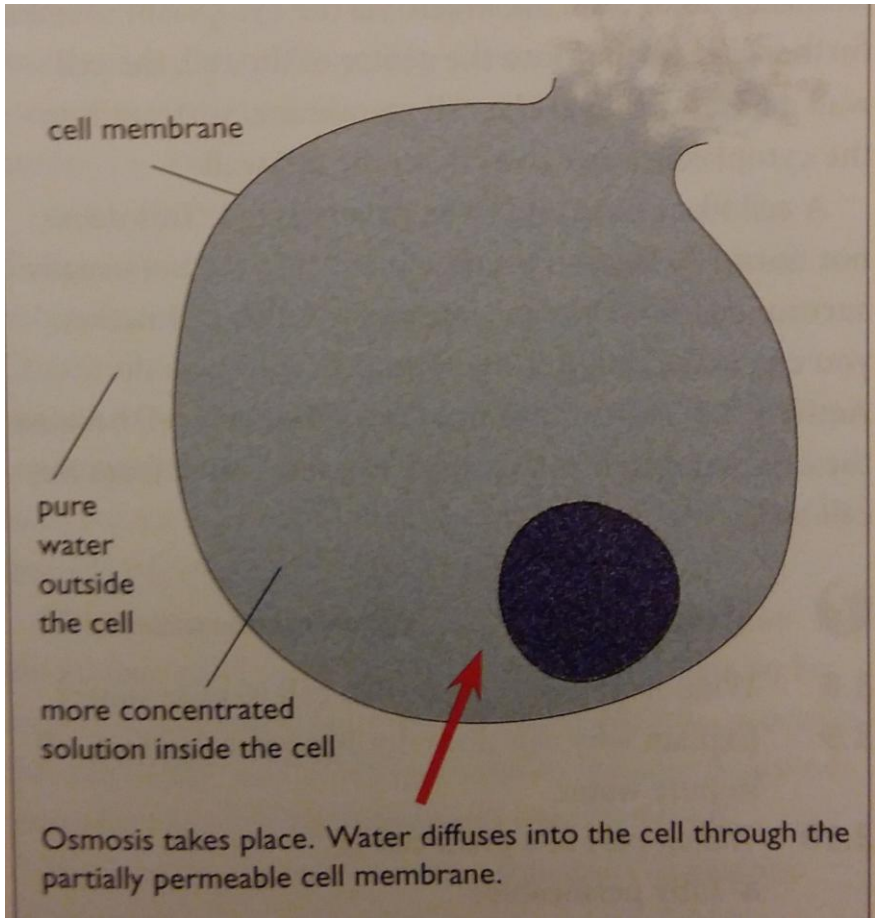
Description

Cells swell, the cell membrane stretches as the cell gets bigger, until eventually the strain is too much, and the cell bursts. ***Why?***

Animal cells do not have cell walls to protect them.

Explanation

Osmosis takes place, water molecules move down their concentration gradient from the outside region, pure water, of high water potential into the cytoplasm of low water potential through the cell membrane which is partially permeable.



Animal cells burst in pure water.

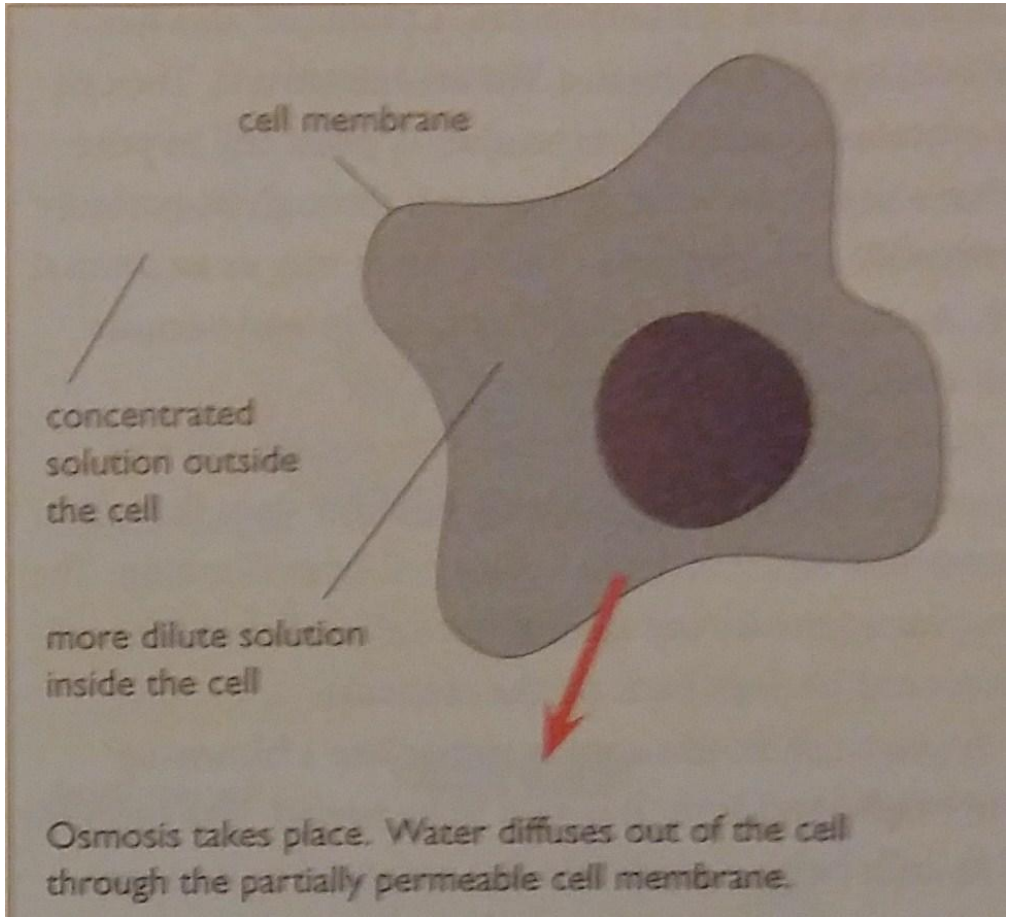
Case 2,*animal cells in a concentrated solution*

Description

If animal cells are surrounded by a solution, which is more concentrated than the cytoplasm, water will diffuse out of cells by osmosis through the cell membrane, the cytoplasm ***shrinks***. The cell shrivels up.

Explanation

Osmosis takes place, water molecules move down their concentration gradient from the cytoplasm, a region of higher water potential, out of the cell, a region of lower water potential through the cell membrane which is partially permeable.



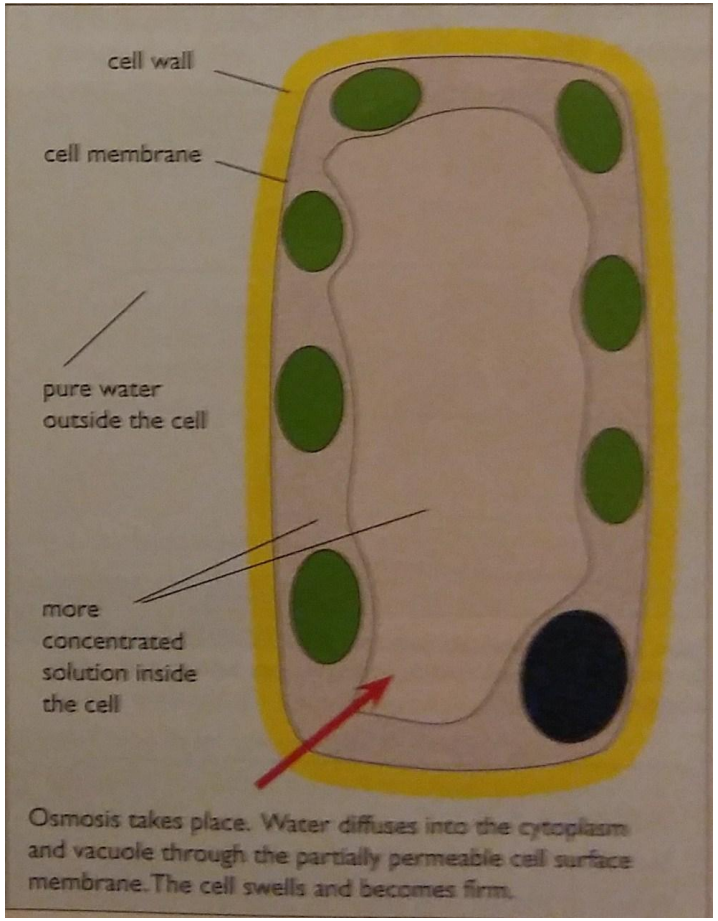
Animal cells shrink in a concentrated solution.

Osmosis and plant cells

Turgidity
If plant cells are placed in pure water, water enters them by osmosis. Cells swell up and said to be turgid (firm).

Features of turgid cells
The vacuole is expanded and pressed outwards on the cytoplasm and cell wall.
The cell membrane is in contact with cell wall.

The turgidity of its cells helps a plant (its stem) that has no wood in it to stay upright, and keeps the leaves firm.



Plant cells become swollen and firm in pure water.

- ***Explanation***

Osmosis takes place, water molecules move down their concentration gradient from the outside region, pure water, of high water potential into the cytoplasm and vacuole of lower water potential through the cell membrane which is partially permeable.

Why plant cells do not burst?

- Plant cells have a very string cell wall around them.
- The cell wall is much stronger than the cell membrane and it stops the plant cell from bursting.
- The cytoplasm presses out against the cell wall, but the cell wall resists and presses back on the contents (this turgor pressure).

Plasmolysis

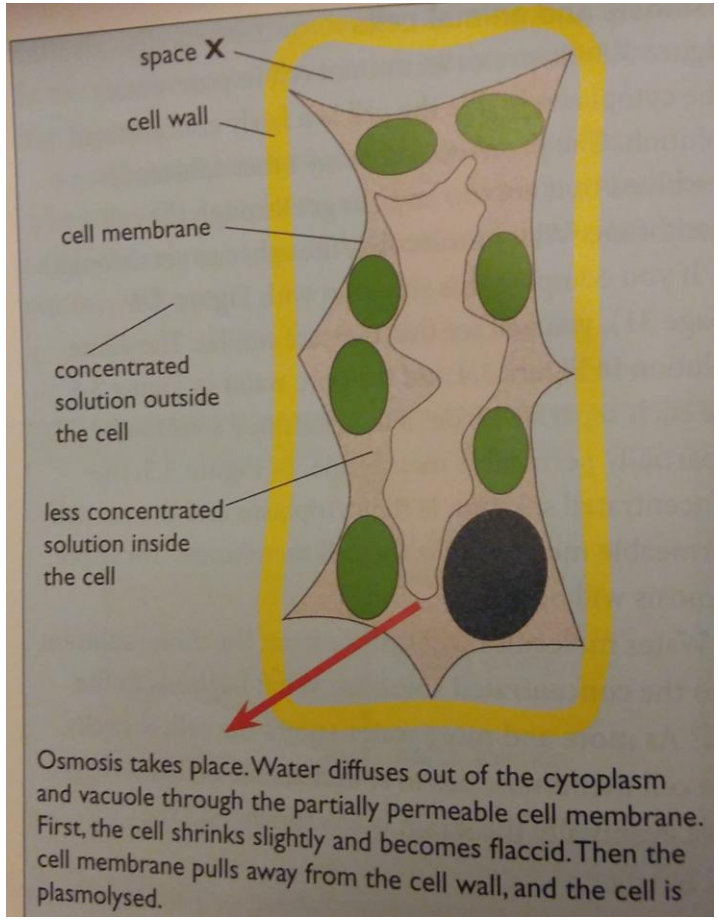
If plant cells are placed in concentrated sugar solution, water leaves them by osmosis and the cells are said to be plasmolysed.

Features of plasmolysed cells

The vacuole and the cytoplasm have lost water by osmosis, the cytoplasm shrunk and cell membrane pulled away from the cell wall.

The cell becomes floppy and said to be ***flaccid***.

The plant loses its firmness and begins to wilt.



Plant cells become faccid and may plasmolyse in a concentrated solution.

Explanation

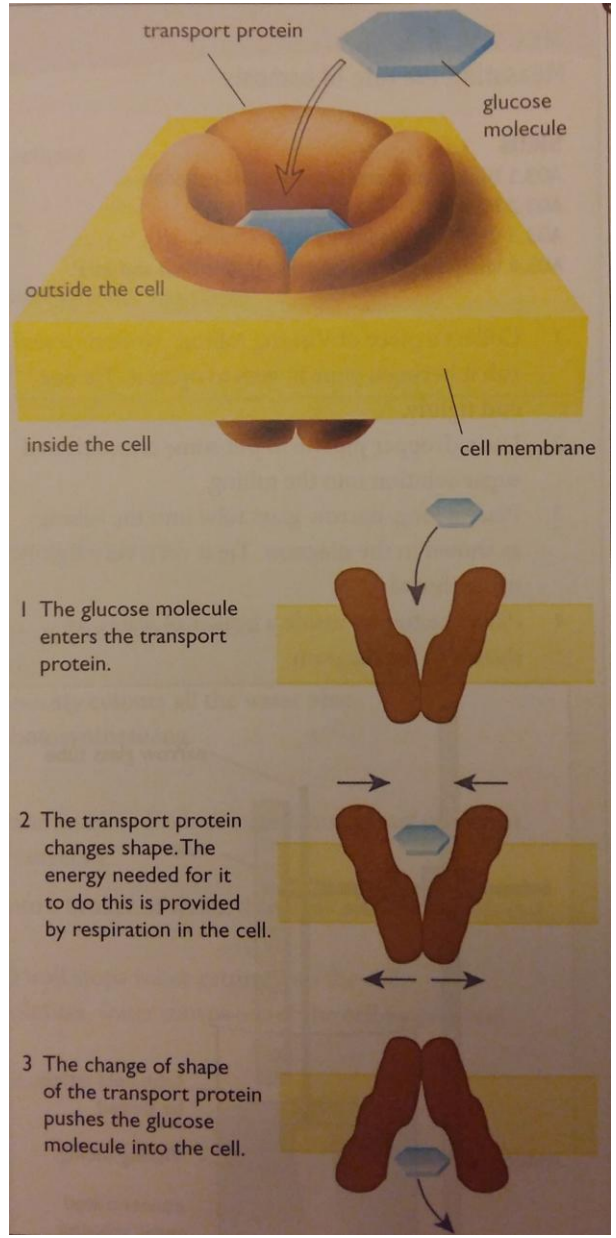
Osmosis takes place, water molecules move down their concentration gradient from the vacuole and cytoplasm, a region of higher water potential, out of the cell, a region of lower water potential through the cell membrane which is partially permeable.

Active transport

- Active transport is the movement of molecules and ions in or out of a cell through the cell membrane against a concentration gradient, using ATP energy from respiration.
- Examples:
  - Root hair cells take nitrate ions in against their concentration gradient;
  - Movement of glucose from the lumen of the small intestine into the cells of the villi;
  - In kidney tubules, glucose is actively transported out of the tubules and into the blood.

Why is ATP energy needed during active transport?

ATP is needed to produce the shape change in the transport protein.



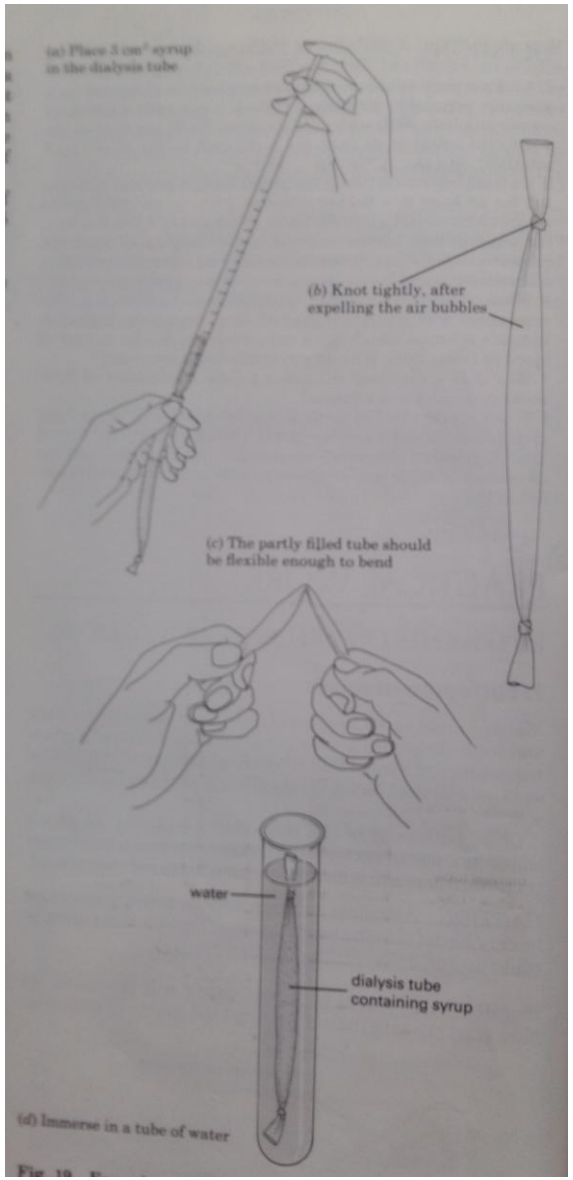
Practical work

Dialysis tubing: is a partially permeable, allowing water molecules to pass through freely, but stopping the passage of others to varying extent.

1- Osmosis and turgor
Place a dialysis tubing containing few ml of sugar solution (partly filled) in a test tube of water for 45 minutes and look for any changes for the dialysis tubing.

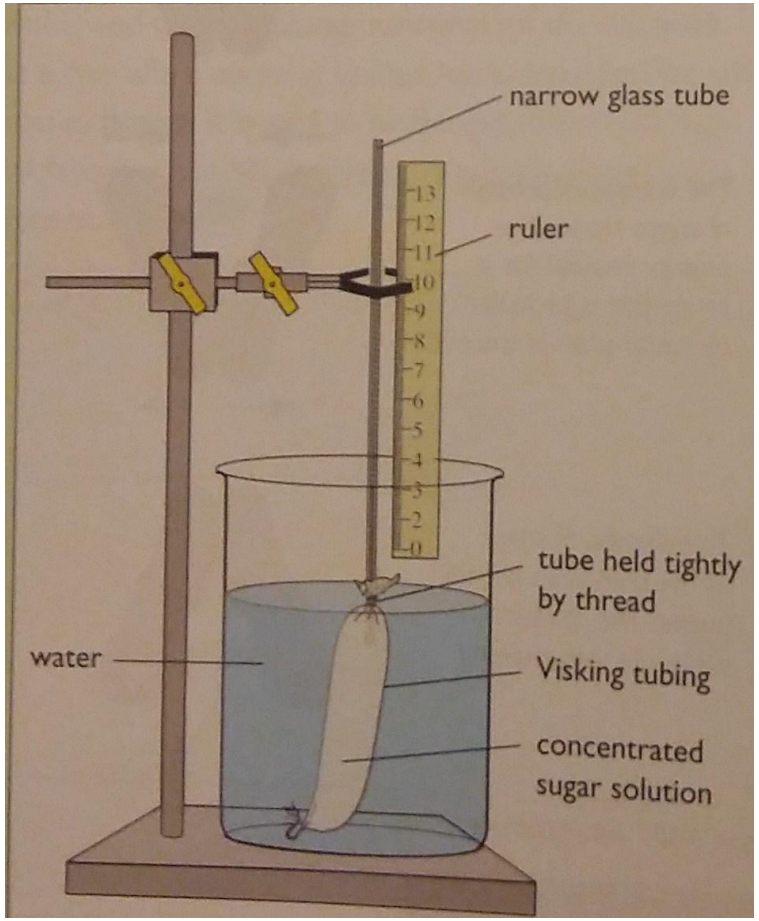
Result
The tubing will be firm and bulged.
It resembles a plant cell when it becomes turgid.

Explanation
The dialysis tubing is partially permeable.
Water molecules move though it by osmosis
from outside of high water potential to the solution inside,
which has lower water potential (fewer water molecules).



2- Osmosis and water flow

- In this experiment, fill the dialysis tubing
- with sugar solution and fit it over the end
- of a long capillary tube
- (make sure that the capillary tube touches
- the solution). Then place the dialysis tubing
- in a beaker of water as shown below.



Result

The level of liquid in the capillary tube will be seen to rise.

Explanation

Water must be passing by osmosis into the sugar solution (a region of low water potential) from the beaker (a region of high water potential).
This process partially shows how water moves from the roots to the stem of a plant.

3- Turgor in potato tissue

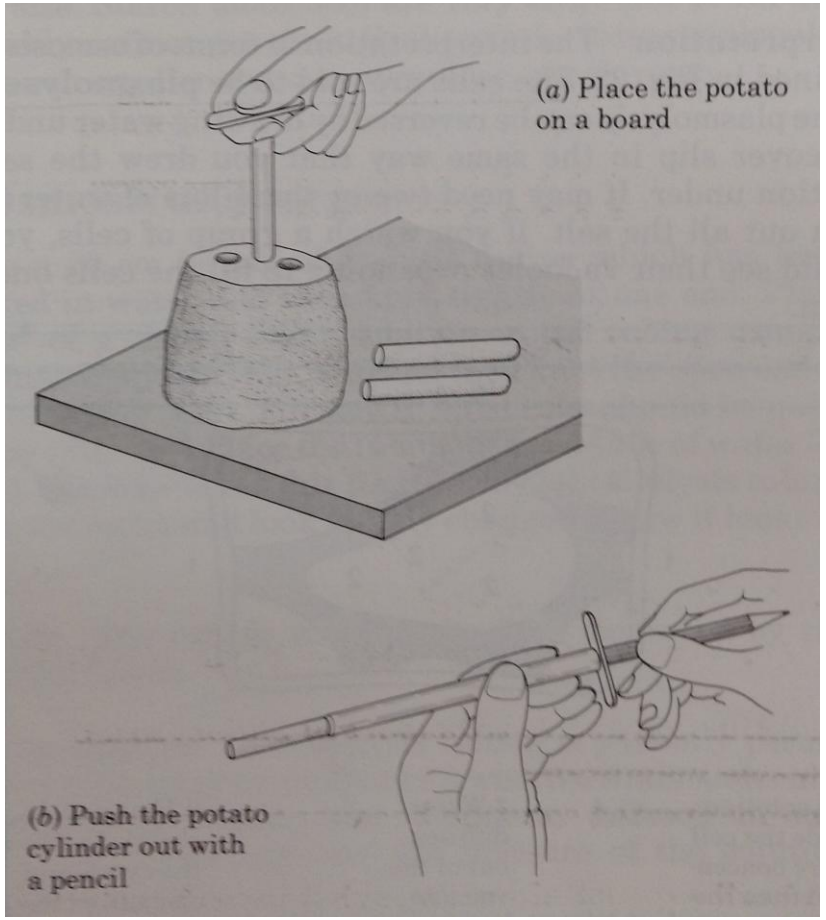
Use a cork borer to obtain potato cylinders of 100 mm long.
Label two beakers A and B and place a potato cylinder in each.
Cover the potato cylinder in A with water and B with strong sugar solution.
Leave the beakers for a day.
Remove the cylinders and measure them.

Result

The cylinder from beaker A should be about 102 mm long and feel firm.
The cylinder from beaker B should be about 98 mm long and feel flabby.

Explanation

Potato cylinder from beaker A was not fully turgid and must be taking up water by osmosis and cause an increase in length, this because the cell sap and cytoplasm have lower water potential than the outside medium.
Potato cylinder from beaker B will lose water by osmosis, because the sugar solution has lower water potential than the cell sap of potato cells.



Obtaining cylinders of potato tissue

4- Partial permeability (dialysis)

Place a dialysis tubing containing 1 per cent starch solution in a test tube of dilute iodine solution.
Leave for 15 minutes.

Result

The starch inside the dialysis tubing goes dark blue but the iodine outside stays yellow/brown.

Explanation

The results show that iodine molecules (small molecules)
have passed through the dialysis tubing into the starch but
the starch molecules (very large) have not moved out into the iodine.
This is because the dialysis tubing is partially permeable.