UNIVERSITY OF SWAZILAND
FACULTY OF EDUCATION
DEPARTMENT OF CURRICULUM AND TEACHING
SUPPLEMENTARY EXAMINATION QUESTION PAPER, JULY 2014

TITLE OF PAPER	:	CURRICULUM STUDIES IN BIOLOGY I
COURSE CODE	:	EDC 278
STUDENTS	:	BEd. II, PGCE
TIME ALLOWED	:	THREE (3) HOURS

INSTRUCTIONS: 1.This examination paper has five (5) questions. Question 1 is compulsory. Then answer any three (3) questions.

2. Each question has a total of 25 points.

3. There is an attachment (IGCSE Biology, McKean, D. G., 2002, pages 26-34) for one question

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Question 1 is compulsory.

1. a) J. B. Conant offers us two views of science. Briefly, describe each one. **[5]**

   b) Scientific models are constituted by empirical and theoretical objects and processes in which they participate. Provide examples of theoretical objects and processes in the Meiotic and Simple Dominance Models. **[5]**

   c) Briefly explain the common elements in the Science Statement of Policy, 1999 and the Swaziland Education and Training Sector Policy, 2011. **[5]**

   d) Inquiry and discovery learning in the science classroom can be justified on the basis of the following factors: *intellectual potency and intrinsic rather than extrinsic motives.* Explain what this means. **[5]**

   e) Explain how a test specification grid provides important information about the contents of a test. **[5]**

Choose any 3 questions below.

~~2. a) Explain why Peter Medawar and Karl Popper are against the use of induction and in favour of deduction in scientific discoveries. **[10]**~~

   b) A scientific paradigm, when it is viable, is a very powerful tool for the scientific community. Elaborate on this assertion. **[15]**

3. a) The following are the skills senior secondary school leavers should have developed as a consequence of engaging in laboratory activities: manipulative skills, creative skills, acquisition skill, organizational skills and communication skills. Choose any three skills and explain what each entails. **[15]**

   b) For the topic, **Movement in and out of Cells,** the SGCSE Biology Syllabus 6884 for the November 2013 and 2014 examinations is as follows:

Core	**Extended**
Diffusion - Define diffusion as the movement of molecules from a region of their higher concentration to a region of their lower concentration, down a concentration gradient - Describe the importance of gaseous exchange and solute diffusion, and of water as a solvent	

Active transport	- Define active transport as an energy consuming process by which substances are transported against a concentration gradient, eg, ion uptake by root hairs and uptake of glucose by epithelial cells of villi
Osmosis - Define osmosis as the passage of water molecules from a region of their higher concentration to a region of their lower concentration, through a partially permeable membrane. - Describe the importance of osmosis on the uptake of water by plants, and its effects on plant and animal tissues	- Describe the importance of a water potential gradient in the uptake of water by plants

You may use the attached and your own knowledge of the topic to perform the following tasks.

i) Write 2 divergent questions on osmosis that would address the **extended** objective of the syllabus. **[2x2]**

ii) Write 1 objective in the psychomotor domain on diffusion that would address any of the **core** objectives. **[2]**

c) Non-behavioural objectives have a place in the Science classroom. Explain. **[4]**

4. a) Laboratory work is an integral part of learning experiences in Science. Describe the procedure(s) you would use to evaluate a biology practical activity. State the reasons for your choice of method(s). **[15]**

b) Content validity is important in Science assessment since it can be determined by teachers. Discuss the validity of this statement. **[10]**

5. a) It has been observed that the curiosity of learners about the natural world diminishes the longer they study Science especially as they progress to higher grade levels. Discuss the strategies you would employ to increase and maintain the curiosity of a Form IV biology class. Use concrete examples to illustrate your strategies. **[15]**

b) Describe the attributes of an effective Science teacher **[10]**

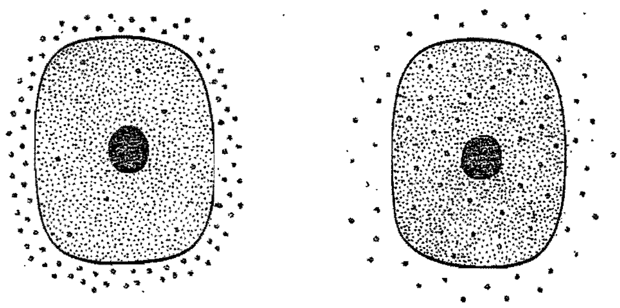
4 How substances get in and out of cells

Diffusion
Explanation. Diffusion into and out of cells. Rate of diffusion. Controlled diffusion. Surface area. Endo- and exocytosis.
Active transport

Osmosis
Definition. Explanation. Artificial partially permeable membranes. The cell membrane. Water potential. Osmosis in animal and plant cells.
Practical work
Experiments on diffusion, osmotic flow, plasmolysis, selective permeability (dialysis), turgor in potato tissue.

Cells need food materials which they can oxidize for energy or use to build up their cell structures. They also need salts and water which play a part in chemical reactions in the cell. Finally, they need to get rid of substances such as carbon dioxide, which, if they accumulated in the cell, would upset some of the chemical reactions and even poison the cell.

Substances may pass through the cell membrane either passively by diffusion, or actively by some form of active transport.

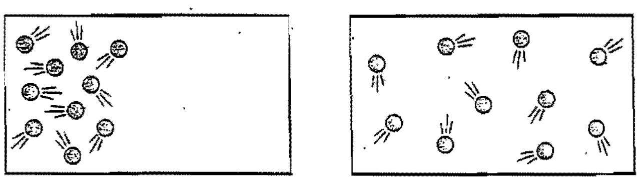


(a) greater concentration outside cell (b) concentrations equal on both sides of the cell membrane

Figure 4.2 Molecules entering a cell by diffusion

Diffusion

The molecules of a gas such as oxygen are moving about all the time. So are the molecules of a liquid, or a substance such as sugar dissolved in water. As a result of this movement, the molecules spread themselves out evenly to fill all the available space (Figure 4.1).



molecules moving about become evenly distributed

Figure 4.1 Diffusion

This process is called **diffusion**. One effect of diffusion is that the molecules of a gas, a liquid or a dissolved substance will move from a region where there are a lot of them (i.e. concentrated) to regions where there are few of them (i.e. less concentrated) until the concentration everywhere is the same. Figure 4.2a is a diagram of a cell with a high concentration of molecules (e.g. oxygen) outside and a low concentration inside. The effect of this difference in concentration is to make the molecules diffuse into the cell until the concentration inside and outside is the same (Figure 4.2b).

Whether this will happen or not depends on whether the cell membrane will let the molecules through. Small molecules such as water (H_2O), carbon dioxide (CO_2) and oxygen (O_2) can pass through the cell membrane fairly easily. So diffusion tends to equalize the concentration of these molecules inside and outside the cell all the time.

When a cell uses up oxygen for its aerobic respiration, the concentration of oxygen inside the cell falls and so oxygen molecules diffuse into the cell until the concentration is raised again. During tissue respiration, carbon dioxide is produced and so its concentration inside the cell goes up. Once again diffusion takes place, but this time the molecules move out of the cell. In this way, diffusion can explain how a cell takes in its oxygen and gets rid of its carbon dioxide.

Rates of diffusion

The speed with which a substance diffuses through a cell wall or cell membrane will depend on temperature, pressure and many other conditions including (1) the distance it has to diffuse, (2) its concentration inside and outside the cell and (3) the size of its molecules or ions.

- Cell membranes are all about the same thickness (about 0.007 μm) but plant cell walls vary in their thickness and permeability. Generally speaking, the thicker the wall, the slower is the rate of diffusion.

- The bigger the difference in concentration of a substance on either side of a membrane, the faster it will tend to diffuse. The difference is called a **concentration gradient** or **diffusion gradient** (Figure 4.3). If a substance on one side of a membrane is steadily removed, the diffusion gradient is maintained. When oxygen molecules enter a red cell they combine with a chemical (haemoglobin) which takes them out of solution. Thus the concentration of free oxygen molecules inside the cell is kept very low and the diffusion gradient for oxygen is maintained.

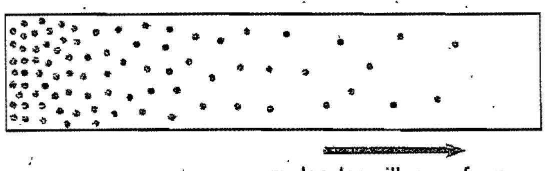


Figure 4.3 Diffusion gradient

- In general, the larger the molecules or ions, the slower they diffuse. However, many ions and molecules in solution attract water molecules around them (see p. 29) and so their effective size is greatly increased. It may not be possible to predict the rate of diffusion from the molecular size alone.

Controlled diffusion

Although for any one substance, the rate of diffusion through a cell membrane depends partly on the concentration gradient, the rate is often faster or slower than expected. Water diffuses more slowly and amino acids diffuse more rapidly through a membrane than might be expected. In some cases this is thought to happen because the ions or molecules can pass through the membrane only by means of special pores. These pores may be few in number or they may be open or closed in different conditions.

In other cases, the movement of a substance may be speeded up by an enzyme working in the cell membrane. So it seems that 'simple passive' diffusion, even of water molecules, may not be so simple or so passive after all, where cell membranes are concerned.

When a molecule gets inside a cell there are a great many structures and processes which may move it from where it enters to where it is needed. Simple diffusion is unlikely to play a very significant part in this movement.

Surface area

If 100 molecules diffuse through 1 mm^2 of a membrane in 1 minute, it is reasonable to suppose that an area of 2 mm^2 will allow twice as many through in the same time. Thus the rate of diffusion into a cell will depend on the cell's surface area. The greater the surface area, the faster is the total diffusion. Cells which are involved in rapid absorption, e.g. in the kidney or the intestine, often have their 'free' surface membrane formed into

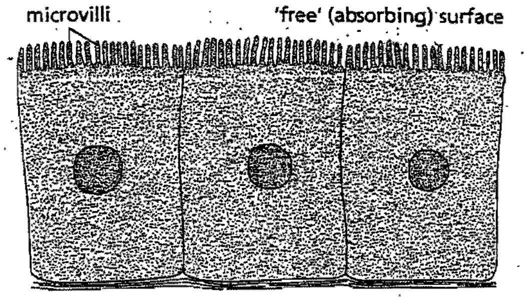


Figure 4.4 Microvilli

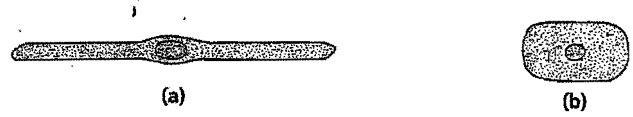


Figure 4.5 Surface area. The cells have the same volume but (a) has a much greater surface area

hundreds of tiny projections called **microvilli** (Figure 4.4) which increase the absorbing surface.

The shape of a cell will also affect the surface area. For example, the cell in Figure 4.5a has a greater surface area than that in Figure 4.5b, even though they each have the same volume.

Endo- and exocytosis

Some cells can take in (**endocytosis**) or expel (**exocytosis**) solid particles or drops of fluid through the cell membrane. Endocytosis occurs in single-celled 'animals' such as *Paramecium* (p. 268) when they feed, or in certain white blood cells (phagocytes, p. 108) when they engulf bacteria, a process called **phagocytosis** (Figure 4.6). Exocytosis takes place in the cells of some glands. A secretion, e.g. a digestive enzyme, forms vacuoles or granules in the cytoplasm and these are expelled through the cell membrane to do their work outside the cell (Figure 4.7).

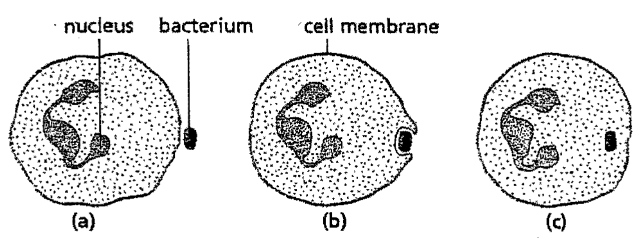


Figure 4.6 Endocytosis (phagocytosis) in a white blood cell

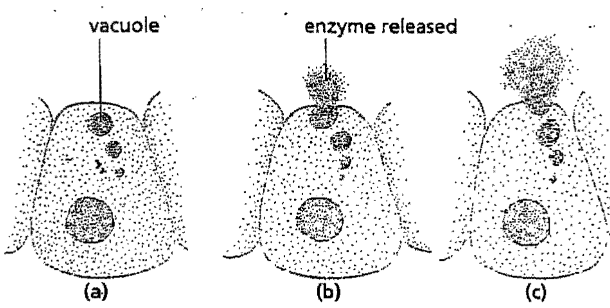


Figure 4.7 Exocytosis in a gland cell

Active transport

If diffusion were the only method by which a cell could take in substances, it would have no control over what went in or out. Anything that was more concentrated outside would diffuse into the cell whether it was harmful or not. Substances which the cell needed would diffuse out as soon as their concentration inside rose above that outside the cell. The cell membrane, however, has a great deal of control over the substances which enter and leave the cell.

In some cases, substances are taken into or expelled from the cell against the concentration gradient. For example, sodium ions may continue to pass out of a cell even though the concentration outside is greater than inside. The processes by which such reverse concentrations are produced are not fully understood and may be quite different for different substances but are all generally described as **active transport**. The cells lining the small intestine take up glucose by active transport (p. 102).

Anything which interferes with respiration, e.g. lack of oxygen or glucose, prevents active transport taking place (Figure 4.8). Thus it seems that active transport needs a supply of energy from respiration.

In some cases, a combination of active transport and controlled diffusion seems to occur. For example, sodium ions are thought to get into a cell by diffusion through special pores in the membrane and are expelled by a form of active transport. The reversed diffusion gradient for sodium ions created in this way is very important in the conduction of nerve impulses in nerve cells.

Plants need to absorb mineral salts from the soil, but these salts are in very dilute solution. Active transport enables the cells of the plant roots to take up salts from this dilute solution against the concentration gradient.

Questions

1 Look at Figure 12.3 on p. 109. If the symbol ○ represents an oxygen molecule, explain why oxygen is entering the cells drawn on the left but leaving the cells on the right.

2 Look at Figure 13.9 on p. 126 representing one of the small air pockets (an alveolus) which form the lung.
  a Suggest a reason why the oxygen and carbon dioxide are diffusing in opposite directions.
  b What might happen to the rate of diffusion if the blood flow were to speed up?

3 List the ways in which a cell membrane might regulate the flow of substances into the cell.

4 What is your interpretation of the results shown by the graph in Figure 4.9?

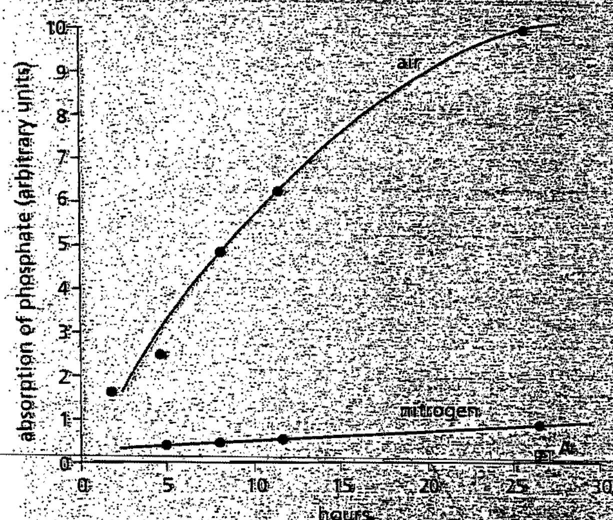
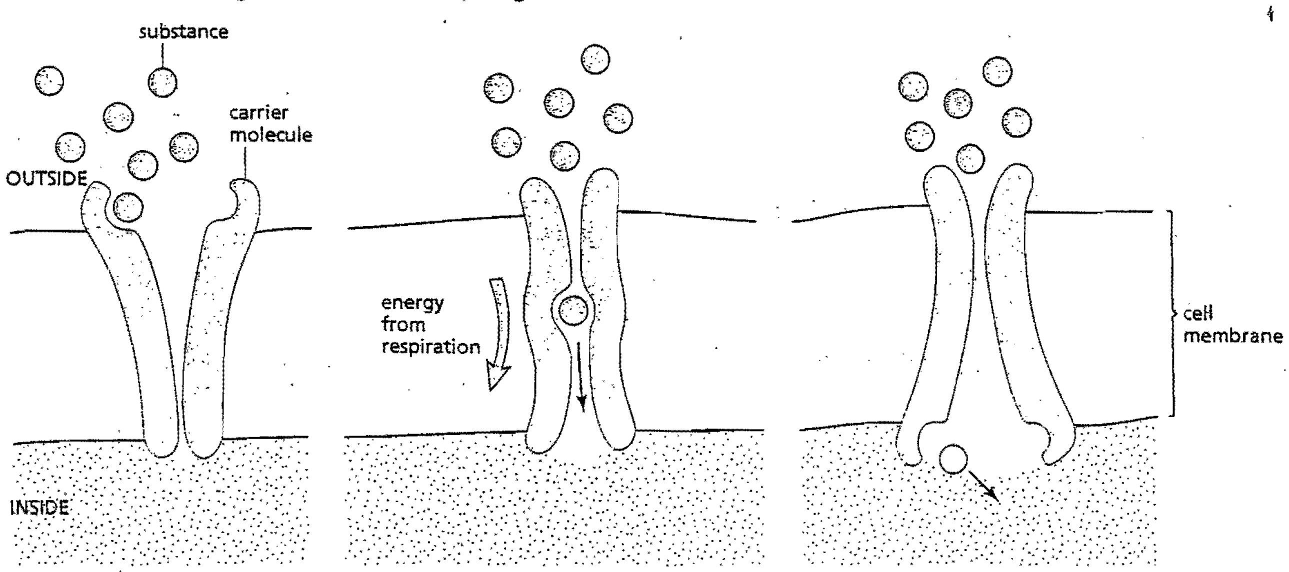


Figure 4.9 Absorption of phosphate ions in air and in nitrogen by roots of beech. A represents the concentration of phosphate in external solution



(a) substance combines with carrier molecule
(b) carrier transports substance across membrane using energy from respiration
(c) substance released into cell

Figure 4.8 Theoretical model to explain active transport

Osmosis

If a dilute solution is separated from a concentrated solution by a **partially permeable** membrane, water diffuses across the membrane from the dilute to the concentrated solution. This is known as **osmosis** (Figure 4.10).

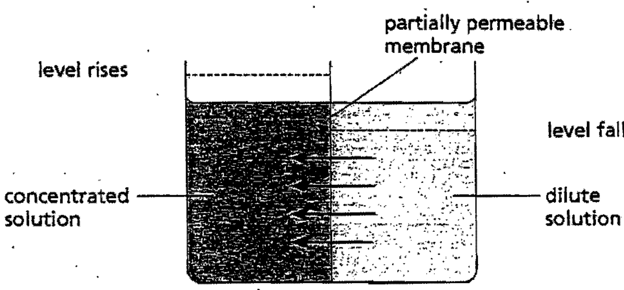


Figure 4.10 Osmosis. Water will diffuse from the dilute to the concentrated solution through the partially permeable membrane. As a result, the liquid level will rise on the left and fall on the right

A partially permeable membrane is porous but allows water to pass through it more rapidly than dissolved substances.

Since a dilute solution contains, in effect, more water molecules than a concentrated solution, there is a diffusion gradient which favours the passage of water from the dilute to the concentrated solution.

In living cells, the cell membrane is partially permeable and the cytoplasm and vacuole (in plant cells) contain dissolved substances. As a consequence, water tends to diffuse into cells by osmosis if they are surrounded by a weak solution, e.g. fresh water. If the cells are surrounded by a stronger solution, e.g. sea water, the cells may lose water by osmosis.

These effects are described more fully on p. 30.

Explanation of osmosis

When a substance such as sugar dissolves in water, the sugar molecules attract some of the water molecules and stop them moving freely. This, in effect, reduces the concentration of water molecules. In Figure 4.11 the sugar molecules on the right have 'captured' half the water molecules. There are more free water molecules on the left of the membrane than on the right, so water will diffuse more rapidly from left to right across the membrane than from right to left.

The partially permeable membrane does not act like a sieve, in this case. The sugar molecules can diffuse from right to left but, because they are bigger and surrounded by a cloud of water molecules, they diffuse more slowly than the water (Figure 4.12).

Artificial partially permeable membranes are made from cellulose acetate in sheets or tubes and used for **dialysis** (p. 34) rather than for osmosis. The pore size can be adjusted during manufacture so that large molecules cannot get through at all.

The **cell membrane** behaves like a partially permeable membrane. The partial permeability may depend on pores in the cell membrane but the processes involved are far more complicated than in an artificial membrane and depend on the structure of the membrane and on living processes in the cytoplasm (see p. 27). The cell membrane contains lipids and proteins. Anything which denatures proteins, e.g. heat, also destroys the structure and the partially permeable properties of a cell membrane. If this happens, the cell will die as essential substances diffuse out of the cell and harmful chemicals diffuse in.

Water potential

The **water potential** of a solution is a measure of whether it is likely to lose or gain water molecules from another solution. A dilute solution, with its high proportion of free water molecules, is said to have a higher water potential than a concentrated solution, because water will flow from the dilute to the concentrated solution (from a high potential to a low potential). Pure water has the highest possible water potential because water molecules will flow from it to any other aqueous solution, no matter how dilute.

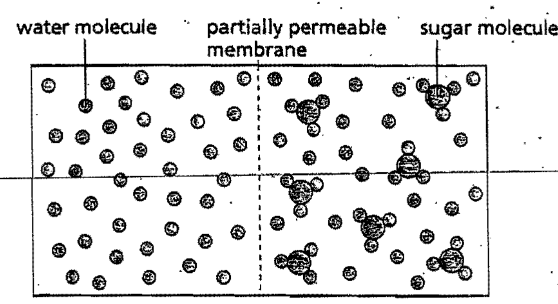


Figure 4.11 The diffusion gradient for water. There are more free water molecules on the left, so more will diffuse from left to right than in the other direction. Sugar molecules will diffuse more slowly from right to left

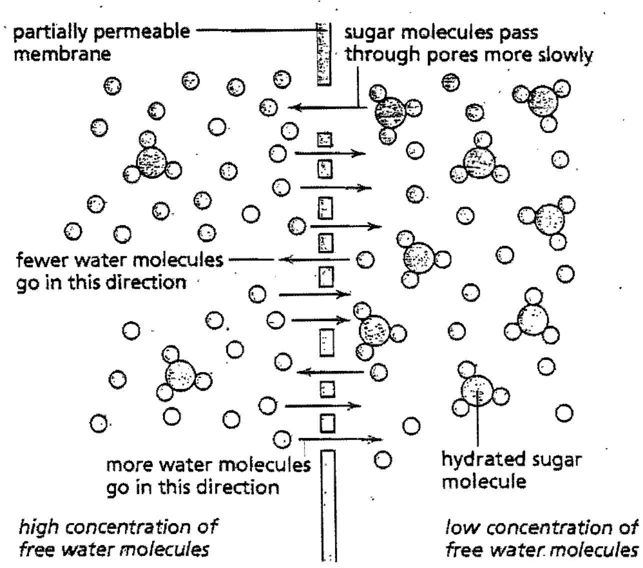
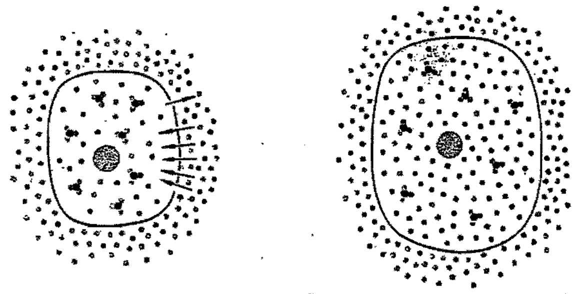


Figure 4.12 The diffusion theory of osmosis



(a) There is a higher concentration of free water molecules outside the cell than inside, so water diffuses into the cell.

(b) The extra water makes the cell swell up.

(Note that molecules are really far too small to be seen at this magnification.)

Figure 4.13 Osmosis in an animal cell

Animal cells

In Figure 4.13 an animal cell is shown very simply. The coloured circles represent molecules in the cytoplasm. They may be sugar, salt or protein molecules. The grey circles represent water molecules.

The cell is shown surrounded by pure water. Nothing is dissolved in the water; it has 100 per cent concentration of water molecules. So the concentration of free water molecules outside the cell is greater than that inside and, therefore, water will diffuse into the cell by osmosis.

The membrane allows water to go through either way. So in our example, water can move into or out of the cell.

The cell membrane is partially permeable to most of the substances dissolved in the cytoplasm. So although the concentration of these substances inside may be high, they cannot diffuse freely out of the cell.

The water molecules move into and out of the cell, but because there are more of them on the outside, they will move in faster than they move out. The liquid outside the cell does not have to be 100 per cent pure water. As long as the concentration of water outside is higher than that inside, water will diffuse in by osmosis.

Water entering the cell will make it swell up, and unless the extra water is expelled in some way the cell will burst.

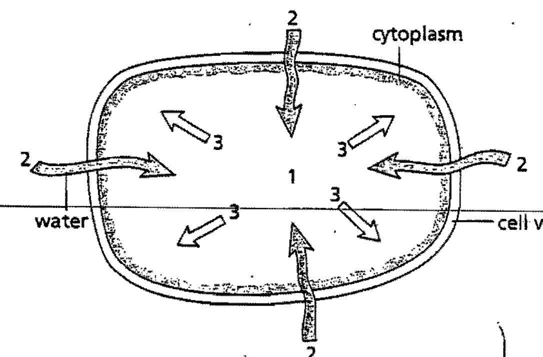
Conversely, if the cells are surrounded by a solution which is more concentrated than the cytoplasm, water will pass out of the cell by osmosis and the cell will shrink. Excessive uptake or loss of water by osmosis may damage cells.

For this reason, it is very important that the cells in an animal's body are surrounded by a liquid which has the same concentration as the liquid inside the cells. The outside liquid is called 'tissue fluid' (see p. 113) and its concentration depends on the concentration of the blood. In vertebrate animals the blood's concentration is monitored by the brain and adjusted by the kidneys, as described on p. 133.

By keeping the blood concentration within narrow limits, the concentration of tissue fluid remains more or less constant (see pp. 116 and 135) and the cells are not bloated by taking in too much water, or dehydrated by losing too much.

Plant cells

The cytoplasm of a plant cell and the cell sap in its vacuole contain salts, sugars and proteins which effectively reduce the concentration of free water molecules inside the cell. The cell wall is freely permeable to water and dissolved substances but the cell membrane of the cytoplasm is partially permeable. If a plant cell is surrounded by water or a solution more dilute than its contents, water will pass into the vacuole by osmosis. The vacuole will expand and press outwards on the cytoplasm and cell wall. The cell wall of a mature plant cell cannot be stretched, so there comes a time when the inflow of water is resisted by the unstretchable cell wall (Figure 4.14).



1 since there is effectively a lower concentration of water in the cell sap
2 water diffuses into the vacuole
3 and makes it push out against the cell wall

Figure 4.14 Osmosis in a plant cell

This has a similar effect to inflating a soft bicycle tyre. The tyre represents the firm cell wall, the floppy inner tube is like the cytoplasm and the air inside corresponds to the vacuole. If enough air is pumped in, it pushes the inner tube against the tyre and makes the tyre hard. A plant cell with the vacuole pushing out on the cell wall is said to be **turgid** and the vacuole is exerting **turgor pressure** on the cell wall.

If all the cells in a leaf and stem are turgid, the stem will be firm and upright and the leaves held out straight. If the vacuoles lose water for any reason, the cells will lose their turgor and become **flaccid** (Experiment 3, p. 32). A leaf with flaccid cells will be limp and the stem will droop. A plant which loses water to this extent is said to be 'wilting' (Figure 4.15).

Figure 4.15 Wilting

Questions

1 A 10 per cent solution of copper sulphate is separated by a partially permeable membrane from a 5 per cent solution of copper sulphate. Will water diffuse from the 10 per cent to the 5 per cent solution, or from the 5 per cent to the 10 per cent solution?

2 If a fresh beetroot is cut up, the pieces washed in water and then left for an hour in a beaker of water, little or no red pigment escapes from the cells into the water. If the beetroot is boiled first, the pigment does escape into the water. Bearing in mind the properties of a living cell membrane, offer an explanation for this difference.

3 When doing experiments with animal tissues they are usually bathed in Ringer's solution, which has a concentration similar to that of blood or tissue fluid. Why do you think this is necessary?

4 Why does a dissolved substance reduce the number of 'free' water molecules in a solution?

5 When a plant leaf is in daylight, its cells make sugar from carbon dioxide and water (see p. 35). The sugar is at once turned into starch and deposited in plastids. What is the osmotic advantage of doing this? (Sugar is soluble in water; starch is not. See p. 12.)

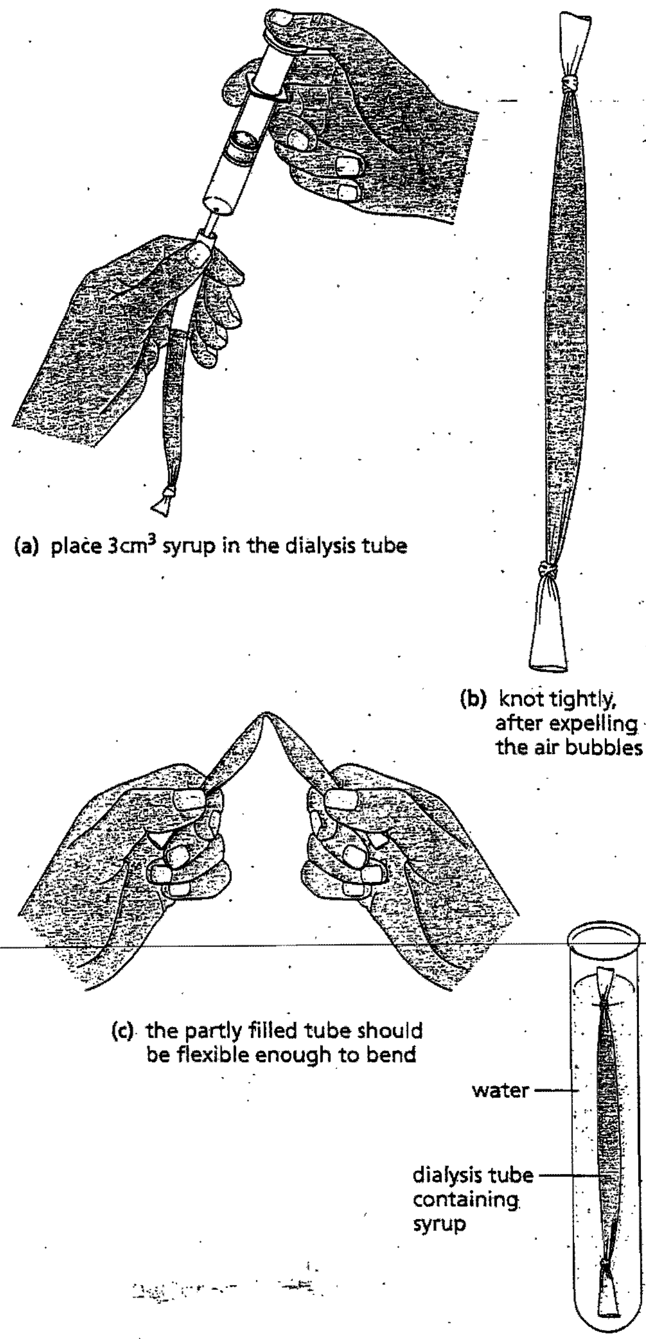


Figure 4.16 Experiment to illustrate turgor in a plant cell

Practical work

Experiments on osmosis and dialysis

Experiments 1, 2 and 5 use 'Visking' dialysis tubing. It is made from cellulose and is partially permeable, allowing water molecules to diffuse through freely, but restricting the passage of dissolved substances to varying extents. It is used in kidney dialysis machines because it lets the small molecules of harmful waste products (e.g. urea, p. 134) out of the blood but retains the blood cells and large protein molecules.

1 Osmosis and turgor

Take a 20 cm length of dialysis tubing which has been soaked in water and tie a knot tightly at one end. Place $3\,cm^3$ of a strong sugar solution in the tubing using a plastic syringe (Figure 4.16a) and then knot the open end of the tube (Figure 4.16b). The partly filled tube should be quite floppy (Figure 4.16c). Place the tubing in a test-tube of water for 30–45 minutes. After this time, remove the dialysis tubing from the water and look for any changes in how it looks or feels.

Result The tubing will now be firm, distended by the solution inside.

Interpretation The dialysis tubing is partially permeable and the solution inside has fewer free water molecules than outside. Water has, therefore, diffused in and increased the volume and the pressure of the solution inside.

This is a crude model of what is thought to happen to a plant cell when it becomes turgid. The sugar solution represents the cell sap and the dialysis tubing represents the cell membrane and cell wall combined.

2 Osmosis and water flow

Tie a knot in one end of a piece of soaked dialysis tubing and fill it with sugar solution as in the previous experiment but, this time, add a little coloured dye. Then fit it over the end of a length of capillary tubing and hold it in place with an elastic band. Push the capillary tubing into the dialysis tubing until the sugar solution enters the capillary. Now clamp the capillary tubing so that the dialysis tubing is totally immersed in a beaker of water as shown in Figure 4.17. Watch the level of liquid in the capillary tubing over the next 10 or 15 minutes.

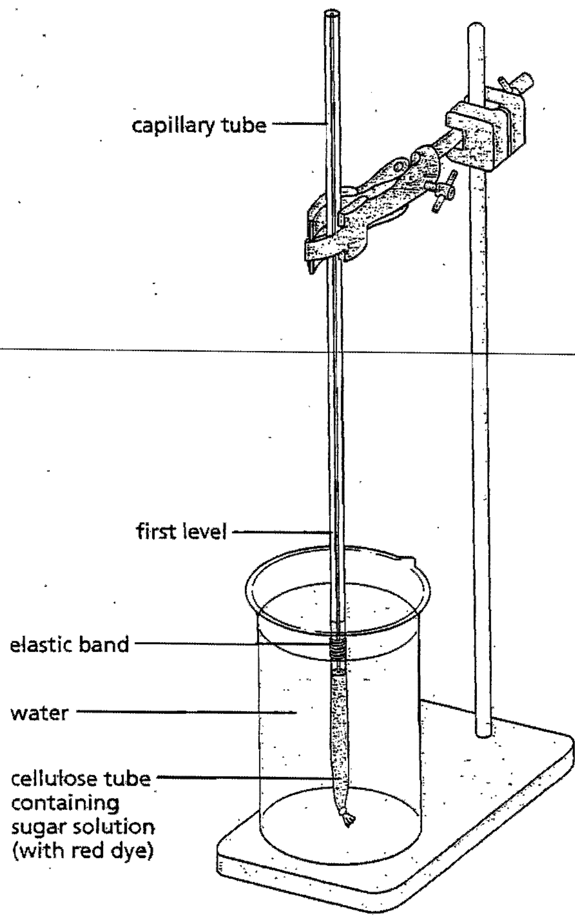


Figure 4.17 Demonstration of osmosis

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

Interpretation Water must be passing into the sugar solution from the beaker. This is what you would expect when a concentrated solution is separated from water by a partially permeable membrane. The results are similar to those in Experiment 1 but instead of the expanding solution distending the dialysis tube, it escapes up the capillary.

A process similar to this might be partially responsible for moving water from the roots to the stem of a plant.

3 Plasmolysis

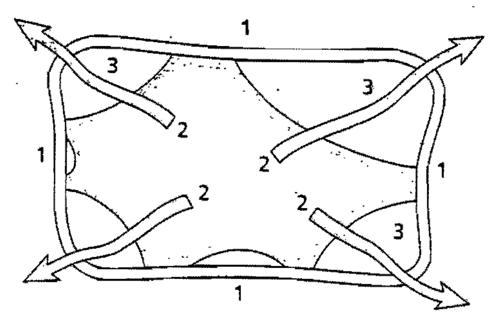
Peel a small piece of epidermis (outer layer of cells) from a red area of a rhubarb stalk (see Figure 1.15a, p.9). Place the epidermis on a slide with a drop of water and cover with a cover-slip (see Figure 1.15c, p.9). Place a 30 per cent solution of sugar at one edge of the cover-slip with a pipette and then draw the solution under the cover-slip by placing a piece of blotting-paper on the opposite side (Figure 4.18). As you are doing this, study a small group of cells under the microscope and watch for any changes in their appearance (Figure 4.20).

Figure 4.18 Changing the water for sugar solution

Result The red cell sap will appear to shrink and get darker and pull the cytoplasm away from the cell wall leaving clear spaces. (It will not be possible to see the cytoplasm but its presence can be inferred from the fact that the red cell sap seems to have a distinct outer boundary in those places where it has separated from the cell wall.)

Interpretation The interpretation in terms of osmosis is outlined in Figure 4.19. The cells are said to be **plasmolysed.**

The plasmolysis can be reversed by drawing water under the cover-slip in the same way that you drew the sugar solution under. It may need two or three lots of water to flush out all the sugar. If you watch a group of cells, you should see their vacuoles expanding to fill the cells once again.



1 the solution outside the cell is more concentrated than the cell sap
2 water diffuses out of the vacuole
3 the vacuole shrinks, pulling the cytoplasm away from the cell wall, leaving the cell flaccid

Figure 4.19 Plasmolysis

Rhubarb is used for this experiment because the coloured cell sap shows up. If rhubarb is not available the epidermis from a red onion scale can be used with results similar to those in Figure 4.20.

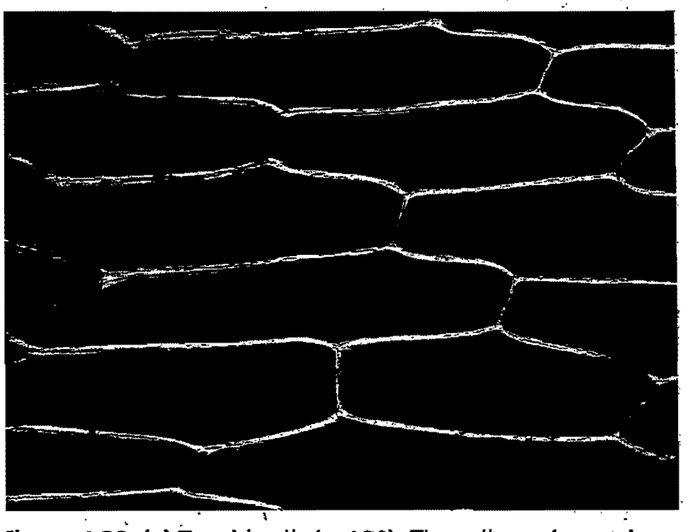
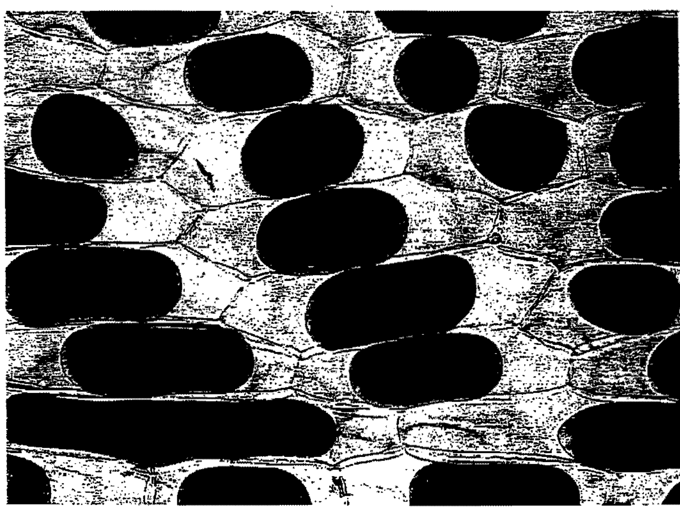


Figure 4.20 (a) Turgid cells (× 100). The cells are in a strip of epidermis from a red onion scale. The cytoplasm is pressed against the inside of the cell wall by the vacuole



(b) Plasmolysed cells (× 100). The same cells as they appear after treatment with salt solution. The vacuole has lost water by osmosis, shrunk and pulled the cytoplasm away from the cell wall.

4 Turgor in potato tissue

Push a No. 4 or No. 5 cork borer into a large potato. *Caution* Do not hold the potato in your hand but use a board as in Figure 4.21a.

Push the potato tissue out of the cork borer using a pencil as in Figure 4.21b. Prepare a number of potato cylinders in this way and choose the two longest (at least 50 mm). Cut these two accurately to the same length, e.g. 50, 60 or 70 mm. Measure carefully.

Label two test-tubes A and B and place a potato cylinder in each. Cover the potato tissue in tube A with water; cover the tissue in B with a 20 per cent sugar solution. Leave the tubes for a day.

After this time, remove the cylinder from tube A and measure its length. Notice also whether it is firm or flabby. Repeat this for the potato in tube B, but rinse it in water before measuring it.

Result The cylinder from tube A should have gained a millimetre or two and feel firm. The cylinder from tube B should be a millimetre or two shorter and feel flabby.

Interpretation If the potato cells were not fully turgid at the beginning of the experiment, they would take up water by osmosis (tube A), and cause an increase in length.

In tube B, the sugar solution is stronger than the cell sap of the potato cells, so these cells will lose water by osmosis. The cells will lose their turgor and the potato cylinder will become flabby and shorter.

An alternative to measuring the potato cores is to weigh them before and after the 24 hours' immersion in water or sugar solution. The core in tube A should gain weight and that in tube B should lose weight. It is important to blot the cores dry with a paper towel before each weighing.

Whichever method is used, it is a good idea to pool the results of the whole class since the changes may be quite small. A gain in length of 1 or 2 mm might be due to an error in measurement, but if most of the class record an increase in length, then experimental error is unlikely to be the cause.

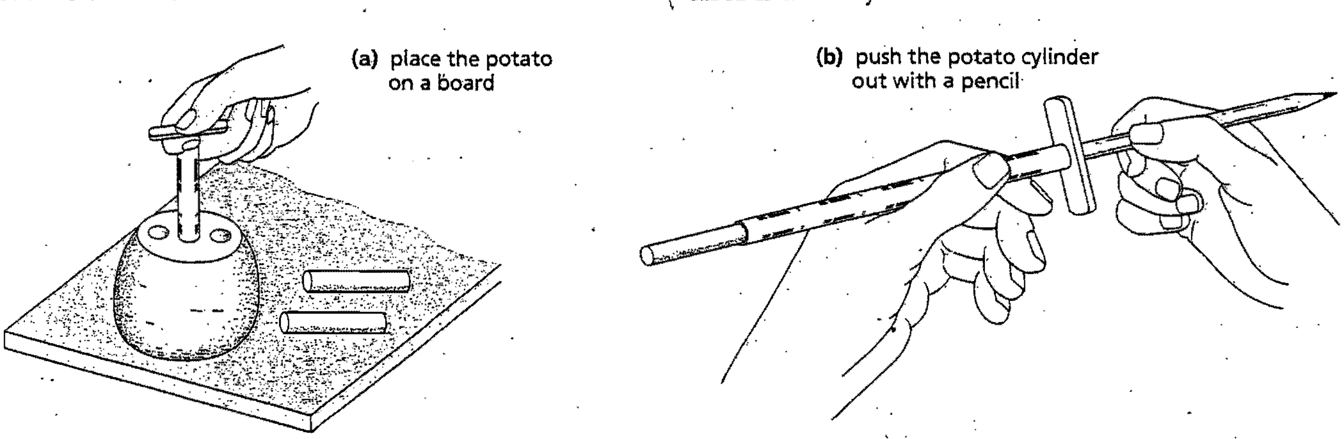


Figure 4.21 Obtaining cylinders of potato tissue

5 Partial permeability (dialysis)

Take a 15 cm length of dialysis tubing which has been soaked in water and tie a knot tightly at one end. Use a dropping pipette to partly fill the tubing with 1 per cent starch solution. Put the tubing in a test-tube and hold it in place with an elastic band as shown in Figure 4.22. Rinse the tubing and test-tube under the tap to remove all traces of starch solution from the outside of the dialysis tube.

Fill the test-tube with water and add a few drops of iodine solution to colour the water yellow. Leave for 10–15 minutes.

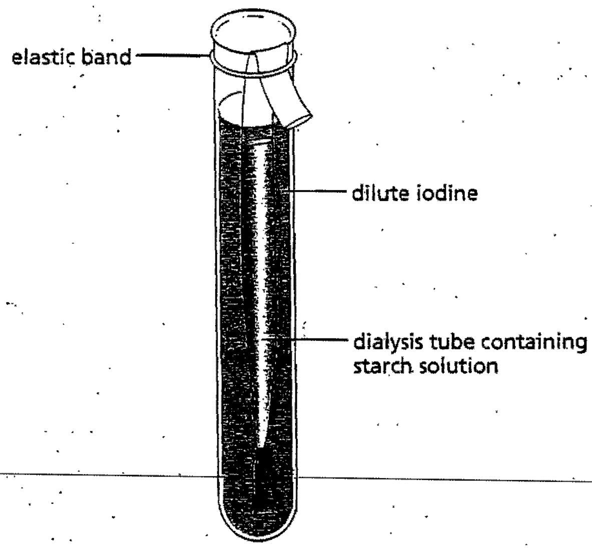


Figure 4.22 Dialysis

Result The starch inside the dialysis tubing goes blue but the iodine outside stays yellow.

Interpretation The blue colour is characteristic of the reaction which takes place between starch and iodine, and is used as a test for starch (see p. 95). The results show that iodine molecules have passed through the dialysis tubing into the starch but the starch molecules have not moved out into the iodine. This is what we would expect if the dialysis tubing were partially permeable on the basis of its pore size. Starch molecules are very large (see p. 12) and probably cannot get through the pores. Iodine molecules are much smaller and can, therefore, get through.

Note This experiment illustrates the process of dialysis rather than osmosis. The movement of water is not necessarily involved and the pore size of the membrane makes it genuinely partially permeable with respect to iodine and starch.

Questions

1 In Experiment 2 (Figure 4.17), what do you think would happen
  a if a much stronger sugar solution was placed in the cellulose tube?
  b if the beaker contained a weak sugar solution instead of water?
  c if the sugar solution was in the beaker and the water was in the cellulose tube?

2 In Experiment 1 (Figure 4.16), what might happen if the cellulose tube filled with sugar solution was left in the water for several hours?

3 In Experiment 3, Figure 4.19 explains why the vacuole shrinks. Give a brief explanation of why it swells up again when the cell is surrounded by water.

4 An alternative interpretation of the results of Experiment 5 might be that the dialysis tubing allowed molecules (of any size) to pass in but not out. Describe an experiment to test this possibility and say what results you would expect
  a if it were correct and
  b if it were false.

5 In Experiment 2 on p. 32, the column of liquid accumulating in the capillary tube exerts an ever-increasing pressure on the solution in the dialysis tube. Bearing this in mind and assuming a very long capillary, at what stage would you expect the net flow of water from the beaker into the dialysis tubing to cease?

Checklist

- Diffusion is the result of molecules of liquid, gas or dissolved solid moving about.
- The molecules of a substance diffuse from a region where they are very concentrated to a region where they are less concentrated.
- Substances may enter cells by simple diffusion, controlled diffusion, active transport or endocytosis.
- Osmosis is the diffusion of water through a partially permeable membrane.
- Water diffuses from a dilute solution of salt or sugar to a concentrated solution because the concentrated solution contains fewer free water molecules.
- Cell membranes are partially permeable and cytoplasm and cell sap contain many substances in solution.
- Cells take up water from dilute solutions but lose water to concentrated solutions because of osmosis.
- Osmosis maintains turgor in plant cells.