

SAMPLE TEXTBOOK ANSWERS

Chapter 4 Cells exchange materials

The following are sample answers only. Other answers to the same questions may also be correct.

Science inquiry

Activity 4.1 A model membrane

Answer: The model should show the following structures:

- a membrane made up of a phospholipid bilayer
- a bilayer consisting of (hydrophilic) heads on the outside and (hydrophobic) tails on the inside
- channel proteins (in the membrane) and other proteins that extend from one side of the membrane to the other
- cholesterol molecules embedded in the membrane
- carbohydrate molecules attached to the outside of the membrane.

Activity 4.2 Diffusion through a differentially permeable membrane

Studying your results

- 1 Do you have any evidence that any molecules passed from the beaker into the bag? Describe any such evidence.

Answer: Yes, because the starch in the bag has changed colour, and the level of liquid in the glass tube has risen.

- 2 Do you have any evidence that any molecules moved from inside the bag to the outside? Explain your answer.

Answer: No, because nothing has changed in the beaker, except that the water level has gone down a little.

- 3 Which has larger molecules, starch or iodine-potassium-iodide? Explain your answer. (You can estimate relative molecule size from the results of the experiment.)

Answer: Starch has larger molecules than iodine-potassium-iodide. The starch molecules did not/could not move out of the bag into the beaker through the semi-permeable membrane of the bag. We know that starch did not move out of the bag because there was no colour change outside the bag. Iodine moved into the bag because the molecules were smaller and could fit through the pores of the differentially permeable membrane. We know that iodine moved into the bag because it changed the colour of the starch solution.

- 4 Use the description of osmosis in this chapter to explain the changes that occurred in the experimental set-up.

Answer: Water moves from areas of high concentration of water to areas of low water concentration across a semi-permeable membrane. The bag had a concentrated starch solution in it, and therefore a low concentration of water, so the water moved into the bag from the beaker.

- 5 If the cellulose bag containing starch suspension were a model of a cell, which part of the cell would be represented by the cellulose bag itself?

Answer: The cell membrane

- 6 Predict what would happen if an isolated animal cell were placed in distilled water.

Answer: Water would move across the semi-permeable cell membrane into the cell and the cell would swell and perhaps burst.

Activity 4.3 Surface area and volume

What to do

- 2 Calculate the volume, surface area and SA:V ratio (surface area to volume ratio) of each 'cell' (volume = length \times width \times height; surface area = 6 \times area of one side). Record these in a suitable table.

Answer:

'Cell'	Volume V cm ³	Surface area SA cm ²	SA:V ratio
1 cm cube	$1 \times 1 \times 1 = 1$	$1 \times 1 \times 6 = 6$	6:1
2 cm cube	$2 \times 2 \times 2 = 8$	$2 \times 2 \times 6 = 24$	$24:8 = 3:1$
3 cm cube	$3 \times 3 \times 3 = 27$	$3 \times 3 \times 6 = 54$	$54:27 = 2:1$

Studying your results

Write a paragraph explaining what this activity has demonstrated about the relationship between surface area to volume ratio and the supply of materials to the cell. Why are cells so small?

Answer: The experiment should have shown that the smaller the 'cell' the greater the proportion of the 'cell's' volume that was reached by the sodium hydroxide.

Cells are very small so that they have a very large surface area in relation to their small volume. This allows for efficient exchange of materials between the cell's interior and the surrounding environment.

Review questions

- 1 a What is homeostasis?

Answer: Homeostasis is the maintenance of a constant internal environment/cellular environment.

- b What variables have to be kept relatively constant to achieve homeostasis of a cell's environment?

Answer: Cell temperature and the concentration of fluids around the cell, including oxygen, carbon dioxide, wastes and glucose

- 2 List the substances that:

- a are required by all cells

Answer: Oxygen and glucose

- b have to be removed from all cells.

Answer: Carbon dioxide, water and wastes other than CO₂

- 3 Describe the structure of a cell membrane.

Answer: The cell membrane is composed mainly of phospholipids and proteins. The lipid molecules are arranged into two layers (bilayer), with the proteins scattered throughout. The phospholipids have hydrophilic heads that are on the outside of the bilayer and hydrophobic tails that are on the inside.

- 4 What is diffusion? In your answer explain the term 'diffusion gradient'.

Answer: Diffusion is the movement of particles of a liquid or gas, so that they spread out and become evenly distributed over the available space. This means that there is net movement of particles from areas where they are more concentrated to areas where they are less concentrated. This difference in concentration that brings about diffusion is known as the diffusion gradient.

- 5 What is a differentially permeable membrane? How would such a membrane differ from one that is completely permeable?

Answer: Differentially permeable (semi-permeable, selectively permeable) membranes allow only certain substances to pass through, but restrict the movement of other substances.

A completely permeable membrane will allow all substances to move across it.

- 6 What is osmosis? In your answer explain what is meant by 'osmotic pressure'.

Answer: Osmosis is the movement of water from an area of higher water concentration to an area of lower water concentration across a differentially permeable membrane. The concentration of water is dependent on the amount of solute dissolved in it. Water moves across the membrane from the more watery to the less watery solution. This means that water moves into the more concentrated solution and the overall level of fluid rises on that side of the membrane. This results in osmotic pressure. The higher the concentration of solute in the water, the higher the fluid level rises and the higher the osmotic pressure.

- 7 What 'carriers' are involved in carrier-mediated transport? Explain the role of the carrier in this form of transport.

Answer: The carriers are special proteins. They are usually specific so only bind to certain ions or molecules, and they move the substance from one side of the membrane to the other by changing shape.

- 8 Explain the difference between facilitated diffusion and active transport.

Answer: Facilitated diffusion is a passive process that moves substances from a higher concentration on one side of a membrane to a lower concentration on the other side. It requires carrier proteins to enable the movement. Glucose is transported in this way.

Active transport requires energy to move substances against a concentration gradient across a membrane; that is, from an area of lower concentration to higher concentration. Amino acids are transported into the cell in this way.

- 9 a What is vesicular transport?

Answer: Vesicular transport is an active process in which materials move into or out of the cell enclosed as vesicles – bubble-like structures surrounded by a membrane. Large quantities of materials can be moved in this way.

- b Explain the difference between endocytosis and exocytosis.

Answer: Endocytosis occurs when a cell encloses some material from outside the cell and takes it inside in the form of a membrane-bound vesicle.

Exocytosis occurs when the contents of a vesicle are expelled from the cell to the outside through the cell membrane.

- c Explain the difference between phagocytosis and pinocytosis.

Answer: Phagocytosis is endocytosis where the material engulfed by the cell is solid particles.

Pinocytosis is endocytosis where the material engulfed by the cell is liquid.

10 a What is the difference between a passive process and an active process?

Answer: A passive process moves substances without using energy released by the cell. An active process uses energy obtained from cellular respiration.

b List the forms of transport described in this chapter in two columns, one for passive processes and one for active processes.

Answer:

Passive processes	Active processes
Diffusion	Active transport
Osmosis	Endocytosis – phagocytosis and pinocytosis
Facilitated diffusion	Exocytosis

Apply your knowledge

1 Explain how the structure of the cell membrane makes it permeable to some molecules but not to others.

Answer: The cell membrane is semi-permeable. The membrane is a phospholipid bilayer – a group of phospholipids (consisting of a phosphate head and two fatty-acid tails) arranged into a double layer, with the hydrophilic phosphate heads exposed to the water content outside and within the cell and the hydrophobic fatty-acid tails hidden in the inside. The phospholipid bilayer is most permeable to small, uncharged solutes. Protein channels float through the phospholipids. Collectively, this model is known as the fluid mosaic model. Substances that are too large, or in low concentrations compared with the inside of the cell, are transported across using energy. Carrier proteins are specific for certain substances, and unless the correct carrier proteins are present a particular substance cannot move across the membrane.

2 Explain why, in the lungs, oxygen diffuses from the air into the blood but carbon dioxide diffuses from the blood into the air.

Answer: The air in the lungs contains a greater concentration of oxygen than is in the blood (because fresh air is constantly being brought in from outside); thus, it moves from the area of higher concentration to the area of lower concentration by diffusion. The opposite is true for carbon dioxide, because the concentration is higher in the blood than in the air (because blood from around the body is constantly entering the lung capillaries).

3 A red blood cell placed in distilled water swells up and bursts, but a red blood cell placed in sea water (about 3% salt) shrivels. Explain why this happens.

Answer: The red blood cell has a concentration of approximately 0.9% salt; thus, the distilled water represents a very dilute solution with a very high concentration of water. This means that water will move across the cell membrane by osmosis into the cell, causing it to burst. Sea water is more concentrated than the contents of the red blood cell, so water moves out of the red blood cell into the sea water, causing the cell to shrivel.

4 Patients who have suffered severe blood loss or dehydration have to be given large volumes of fluid. A fluid that is often given is a 0.9% solution of sodium chloride, known as normal saline. Why is saline solution given rather than just plain water?

Answer: Cells in humans have a 0.9% salt concentration under normal conditions/homeostasis. If only plain water were introduced into the blood, body fluids would be diluted (and the water would be excreted). There would also be the risk that cells would swell and possibly burst as the water diffused across the membrane.

- 5 During digestion, the concentration of acid in the stomach rises to several times that found in the cells of the stomach lining. Explain which transport process would be responsible for this situation.

Answer: Active transport would be necessary, because energy is required to transport substances from areas of lower concentration to higher concentration.

- 6 The hormone insulin activates glucose carriers in the cell membrane of muscle cells, fat storage cells and many other types of cells. People who suffer from diabetes mellitus type 1 do not produce enough insulin. The amount of glucose in their blood can be abnormally high and they excrete glucose in the urine. Why would diabetes sufferers have abnormally high blood glucose levels?

Answer: Glucose normally travels from the blood (the area of higher concentration) into the cells, where there is relatively low concentration, by facilitated diffusion. If the protein carriers are not activated, as in people who suffer from diabetes, they would not carry the glucose across the membrane, so the glucose would stay in their blood.