

Nelson Biology VCE Units 3 & 4

Answers to Chapter Questions

Chapter 2

Review questions

- 1 All cells have an outer plasma membrane and contain genetic material and ribosomes. Prokaryotic cells lack internal membrane-bound structures, whereas eukaryotic cells have a membrane-bound nucleus and other membrane-bound structures that include the endoplasmic reticulum, mitochondria, vesicles and Golgi apparatus. Students should realise that eukaryotic cells are about 20 times larger than prokaryotic cells. This size difference requires specific structures to carry out specific functions and to facilitate the diffusion of molecules at the required concentrations.
- 2 An organelle is a structure within a cell that carries out a specific function. Both animal and plant cells have many organelles in common, such as the nucleus, mitochondria, vesicles, Golgi apparatus and ribosomes. However, plant cells also contain chloroplasts and other storage plastids, such as leucoplasts. In general, plant cells have larger vacuoles than animal cells. Plant cells also have a cell wall that is external to the plasma membrane.

Student responses could include:

 - ribosomes – site of polypeptide production
 - mitochondria – site of chemical reactions that produce energy for the cell
 - endoplasmic reticulum – membrane network that provides increased surface area and compartmentalisation of the cytoplasm for chemical reactions and the transport of materials
 - cytoskeleton – series of protein microtubules that provides an internal skeleton to support the cell and assists with the movement of organelles within the cell
 - chloroplasts – site of photosynthesis.
- 3
 - a Model organisms are used to investigate cell systems owing to their short reproductive cycles, ease of care and comparative simple nature. Such organisms include mice, bacteria and fruit-flies.
 - b Systems biology seeks to see all the activities of the cell as behaving as an integrated system.
 - c Bioinformatics is the application of information technology, statistics and mathematics to biological systems. Information technology can sort through vast amounts of information and produce global databases for use in biological research, as well as analyse and predict complex inter-relationships.
- 4 The significant discovery in the 20th century that began the current revolution in biological thought is that knowledge of a malfunction is not seen in isolation but rather as an event that is part of a biological system.
- 5 The plasma membrane not only forms the outer boundary of the cell but also controls and regulates the movement of substances across it. A simple student-annotated diagram should show that small molecules can pass across the plasma membrane and that larger ones may not pass through. It should also show the phospholipid bilayer. See Figures 2.5, 2.6, 2.10.
- 6 Selectively permeability implies that some substances can pass through freely, whereas other substances may need assistance or cannot pass through.

- 7 The term 'fluid' applies to the phospholipid bilayer as the phospholipid molecules are flexible and capable of lateral movement. The term 'mosaic' applies to proteins that are embedded in the phospholipid bilayer, where they form a mosaic pattern.
- 8 Glycoproteins are proteins with a sugar group attached. They form important receptors for the detection of chemicals on the outer surface of the plasma membrane. They also function as 'markers' on cells to identify a cell as 'self' (i.e. belonging to the organism).
- 9 The diagram of diffusion should show particles moving from a high concentration to a low concentration with an arrow indicating that the substance is moving along the concentration gradient from high to low. The diagram should note that it is a passive process.
- 10 Although water is a highly polar molecule it is very small in size – only three atoms. It is this size factor that allows it to diffuse freely across the plasma membrane.
- 11 The concentration gradient for oxygen is maintained because as soon as oxygen moves into the cell it is used up in respiration.
- 12 Student diagrams of the process of osmosis need to show two solutions of differing concentrations of solute separated by a semipermeable membrane with the solute too large to move across the membrane. The solvent water will move from an area of high concentration (low solute) across the membrane to an area of low concentration (high solute). The diffusion of water under these conditions is termed 'osmosis'.
- 13 A hypotonic solution contains little solute and a high concentration of water. The animal cell will have a relatively high solute concentration and a low concentration of water. Hence, water will move into the animal cell, resulting in rupture of the cell.
- 14 When water uptake is less than the water lost by a plant through transpiration, cells will lose turgor. The result of this is that the plasma membrane will no longer be pushed against the cell wall and the plants will lose firmness and 'droop'.
- 15 Many substances are too big or highly charged to pass through the plasma membrane unassisted. Facilitated diffusion is when substances such as glucose, amino acids and various ions bind to a protein molecule that can carry them across the plasma membrane, or pass through a channel formed by a channel protein.
- 16 Active transport requires an input of energy for the process to occur as substances are moved against their concentration gradient, whereas simple diffusion is a passive process requiring no energy input to move the substance along its concentration gradient.
- 17 Substances such as glucose and ions can enter a cell using facilitated diffusion, which is a passive process. However, when such substances are moved against the concentration gradient, the molecules bind to carrier proteins, which must be connected to a source of energy (mitochondria).
- 18 Substances that are secreted from cells are various but most relevant to Unit 3 are extracellular enzymes, hormones, extracellular products, such as mucus and waxes, milk proteins and antibodies.

- 19 Many substances are too large to enter or leave a cell by any form of diffusion. Such materials are carried in vesicles that are produced from the plasma membrane or fuse with the plasma membrane. This process is called cytos. Endocytosis is the movement of material into the cell by the plasma membrane engulfing the material and enclosing it in a vesicle that then moves into the cytoplasm. In exocytosis, vesicles form inside the cell and contain material that is to be secreted from the cell. These vesicles fuse with the plasma membrane, releasing their contents to the extracellular environment. Both processes are complementary in adding to or subtracting from the plasma membrane.
- 20 Cells that engulf material by the process of phagocytosis (endocytosis) are termed phagocytes. Macrophages are a type of white blood cell that carries out phagocytosis.
- 21 The nucleus is the information centre of the cell and controls all cellular activities through the production of proteins. The nucleus contains chromosomes that are made up of the genetic material DNA, and is also the site of production of mRNA and the components for making ribosomes.
- 22 The main molecules transported from the nucleus to the cytoplasm are mRNA and the subunits of ribosomes containing rRNA and proteins.
- 23 Within the nucleus DNA is coiled around proteins called histones and then supercoiled into linear structures called chromosomes, which are highly visible during cell division.
- 24 Ribosomes are made up of two subunits, one small and one larger subunit that assemble together as the site of protein synthesis within the cytoplasm. Ribosomes differ from other organelles in that they are not enclosed by a membrane.
- 25 Both the endoplasmic reticulum and the Golgi apparatus are made up of membranes that are folded into tube- and sac-like structures. The lumen of the endoplasmic reticulum is the site of the chemical modification of proteins produced by the attached ribosomes. These modified proteins are then transported in vesicles to the Golgi apparatus for packaging and finally for use in the cell or export from the cell. In the Golgi apparatus, protein and lipid molecules combine with carbohydrates to form glycoproteins and glycolipids.
- 26 Proteins are chemically modified in the lumen of the endoplasmic reticulum. Such proteins are used for membranes, stored in vesicles in the cell or secreted from the cell.
- 27 Cytotoxic proteins such as ricin are transported in an inactive form until they are deposited in the final storage vesicle. In this way the cell protects itself during their production.
- 28 Lysosomes are vesicles that contain powerful digestive enzymes that can break down macromolecules. Lysosomes fuse with other vesicles containing such materials that need to be broken down into products that can be recycled. The contents of old/damaged cells are engulfed by lysosomes.
- 29 Three functions of the cytoskeleton in eukaryotic cells are to maintain cell shape, assist in the movement of organelles within the cell and coordinate the movement of the cell. Microtubules are also involved in cell division.
- 30 Knowledge of the functions of the cytoskeleton has been gained from studies of various genetically inherited conditions and by the use of chemicals that can disrupt cell functioning.

- 31** The extracellular matrix (ECM) consists of various macromolecules that have been produced by specialist fibroblast cells in the ECM. In animal cells its structure consists of long, flexible fibres embedded in a matrix of glycoproteins and glycolipids. Its main function is in connecting cells together to form tissue (e.g. it provides many of the mechanical properties of tissues such as cartilage).

Apply understanding

- 1** The response requires an understanding of a protein secretory pathway and what organelles are involved. The passage of the radioactivity would be: ribosomes, endoplasmic reticulum, transport vesicles, the Golgi apparatus, secretory vesicles and release from the plasma membrane.
- 2** Students should compare the size of (i.e. number of atoms in) each molecule. Ethanol is a considerably smaller molecule than glucose and can freely diffuse across the plasma membrane.
- 3** The particle that has been engulfed by a cell is enclosed in a vesicle that is actually part of the plasma membrane. In effect, the particle has never crossed over the membrane.
- 4** Saline solution is isotonic with the contents of red blood cells. Hence, there is no net movement of water into or out of the red blood cell by osmosis so the cells are suspended. When red blood cells are placed in pure water, water moves into the cells and the cells rupture.
- 5** The wilting of plants is caused by loss of turgor of the plant cells. By soaking in cold water the cells take up water and become fully turgid.
- 6** Toxic products such as ricin are kept in an inactive form while being transported within the cell and are only activated when they reach their final destination, enclosed in an appropriate storage vesicle. The active form of ricin is found in the endosperm of the seed coat. Such substances are produced to deter other organisms from eating the seeds.
- 7** The formation of vesicles in endocytosis does remove parts of the plasma membrane but this is counterbalanced by exocytosis when arriving secretory vesicles fuse with the plasma membrane to release their contents. Overall, the plasma membrane size is maintained. Students should realise that it is a very dynamic and fluid structure.
- 8** Membrane-bound organelles serve as compartments that localise specific reactions and so maintain the concentration of reactants to enable reactions to occur at a rate that ensures the cell's survival. The abundance of membranous structures also increases the surface area upon which reactions may occur.