# 2018 Eukaryotic Cell Structure and Cell Membrane STQ MS

**2018 / H2 / ACJC PRELIM / P2 Q1**

**1** Cholesterol is synthesised in the smooth endoplasmic reticulum (SER) in liver cells by a series of enzyme-catalysed reactions. Cholesterol is then transported to the Golgi apparatus where they are packaged into vesicles and subsequently released into a membrane-bound duct of the liver.

Fig. 1.1 is an electron micrograph of a section of a liver tissue.

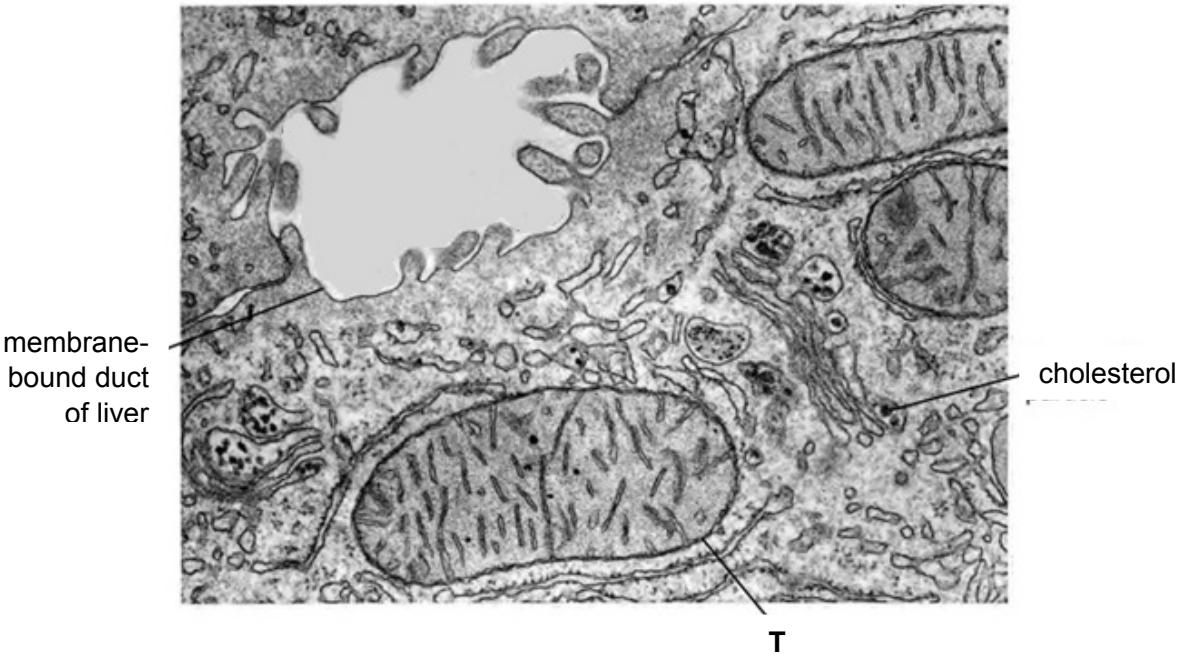


**Fig. 1.1**

**(a)** Name structure **T** in Fig. 1.1 and describe its role in liver cells.

1. **Structure T is the mitochondrion;**

2. **Site of ATP synthesis for synthesis of cholesterol/glycogen (or other liver-specific functions);**

[2]

**(b)** Both prokaryotes and structure **T** have membrane proteins to help them perform the role described in (a). Suggest how prokaryotes perform this role.

1. **Presence of electron carriers / ATP synthase;**

2. **Embedded in cell surface membrane;**
3. **Electron carriers use the energy from the transport of the electrons to pump $H^+$ across the membrane, generating a proton gradient/pool;**
4. **ATP synthase which uses the energy of the proton gradient/proton motive force/flow of protons for chemiosmotic synthesis of ATP;**
5. **AVP;**

[3]

**(c)** Describe the role of cholesterol in the cell surface membrane.

**Maintain fluidity of the membrane by preventing close packing of phospholipids at low temperature / prevent phospholipids from moving too far apart when temperature is high;**

[1]

**(d)** Suggest how cholesterol is transported from the Golgi apparatus to the membrane-bound duct of the liver.

1. **Secretory vesicles containing cholesterol pinch off the GA and move along microtubules to the cell surface membrane;**
2. **They fuse with the cell surface/duct membrane and discharge cholesterol outside the cell via exocytosis;**

[2]

[Total: 8]

**2018 / H2 / IJC PRELIM / P2 Q1**

**2** Fig. 1.1 shows an electron micrograph of a pancreatic cell that secretes large amounts of insulin that helps to regulate blood glucose level.

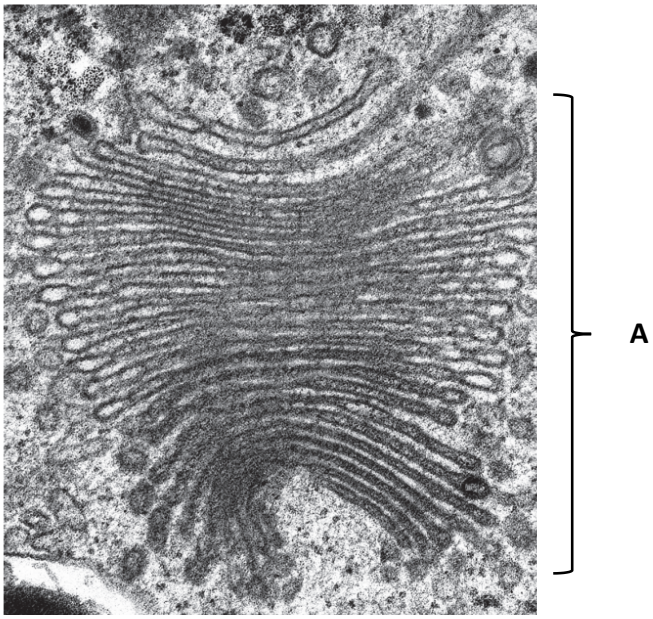


**Fig. 1.1**

**(a)** With reference to Fig. 1.1,

**(i)** identify organelle **A**;

***Golgi apparatus/ body;*** [1]

**(ii)** describe **two** identifying features of organelle **A** that allows its identification in **(a)(i)**.

***1. a stack of discrete, flattened, memb-bound sacs called cisternae;***

***2. distinct memb with 2 faces cis/ convex & trans/ concave);***

***3. vesicles pinching & joining from ends of each sac;*** ***(any 2)*** [2]

Fig. 1.2 shows a diagram of the molecular structures of tristearin (a triglyceride) and

phosphatidylcholine (a phospholipid).

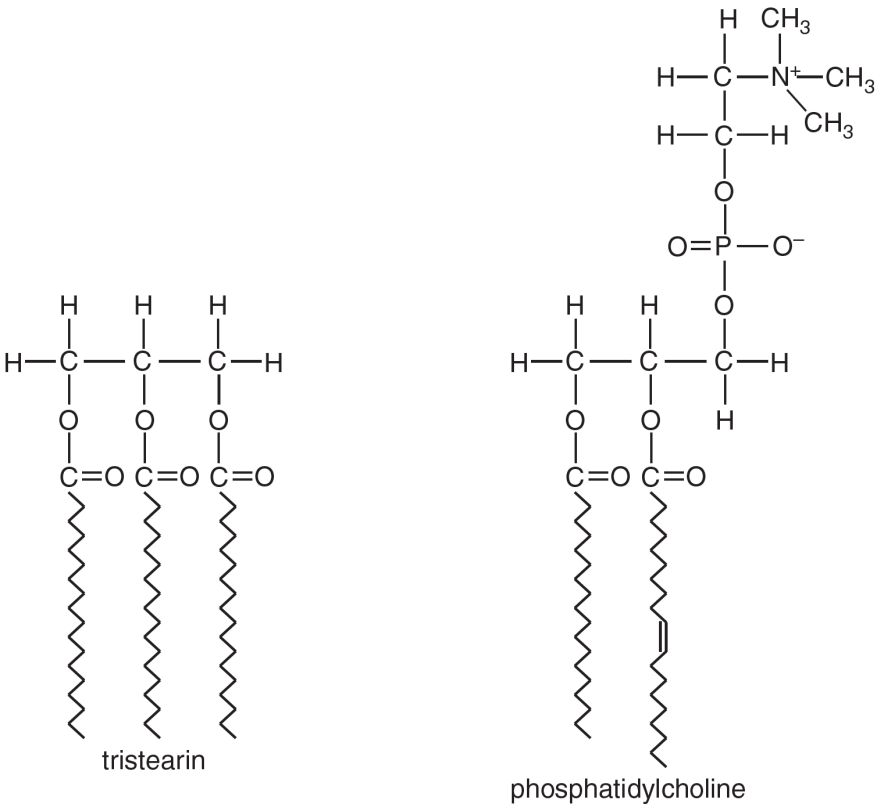


**Fig. 1.2**

**(b)** Table 1 shows a structural difference between the two molecules shown in Fig. 1.2.

Complete Table 1 with two further **structural** differences **other than** in numbers of different types of atoms.

**Table 1**

| structural feature | tristearin | phosphotidylcholine |
|---|---|---|
| length of fatty acid chain | all same length | different lengths |
| ***degree of saturation*** | ***all FA tails are saturated*** | ***1 FA tail is unsaturated / have C=C*** |
| ***functional grp*** | ***glycerol & carboxylic acid*** | ***glycerol, carboxylic acid & phosphate*** |
| ***presence of phosphate group*** | ***absent*** | ***present*** |

***no. of FA*** ***3*** ***3***

[2]

**(c)** Triglyceride is used as energy storage while phospholipids are membrane components. Explain why phospholipids are suitable membrane components but not triglyceride.

***1.*** ***amphipathic***

***has hydrophilic head and hydrophobic tail;***

***2.*** ***able to form bilayer***

***w hydrophilic heads interxt w aq medium in/s & o/s cell (while forming a hydrophobic core that prevents free movement of hydrophilic subst);*** [2]

Cells in the pancreas secrete enzymes, such as amylase and trypsin, into a duct. The enzymes are packaged in vesicles so that they can be exported from these cells as shown in Fig. 1.3.

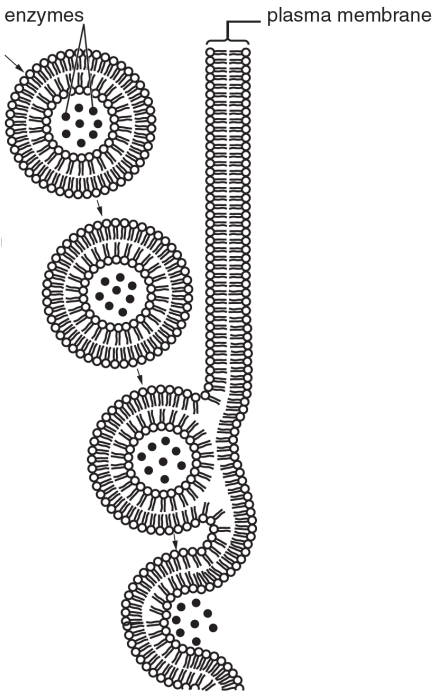


**Fig. 1.3**

**(d)** On Fig. 1.3, label the cytoplasm of the cell as '**cytoplasm'** and extracellular fluid as '**extracellular'**. [1]

**(d)** ***cytoplasm***

**d)** ***extracellular***

**(e)** With reference to Fig. 1.3,

**(i)** explain how enzymes that are secreted by cells in the pancreas are packaged into vesicles and exported, after their synthesis at the endoplasmic reticulum.

***1.*** ***enz packaged in tpt vesicles pinch off from surface of rER***

***pinch off from surface of rER;***

***2.*** ***tpt vesicles travel thru cytoplasm / or idea of transport***

***fuse with A/ Golgi apparatus at cis face;***

***3.*** ***protein modification occurs (adding phosphate grp/ adding, deleting, substituting sugar monomers)***

***modification results in molecular identification tag on enz;***

***4.*** ***vesicles containing enz pinch off***

***from trans face of A/ Golgi apparatus;***

***5.*** ***vesicles translocate towards CSM***

***via cytoskeleton (ATP req'd);***

***6.*** ***memb vesicle fuses with CSM***

***enz released out of cell via exocytosis;*** [6]

**(ii)** explain **one** property of the plasma membrane that allows vesicle formation.

***1.*** ***memb is fluid***

***allows <u>evagination</u> of memb to form vesicles;***

***2.*** ***phospholipid molecules are held by weak hydrophobic interxns***

***thus capable of lateral movement (within the monolayer);*** [2]

**(f)** Describe **two** advantages of having plasma membranes **within** the cell.

***1.*** ***allows compartmentalisation***

*to setup unique / optimum conditions for biochem rxns (e.g. acidic pH in lysosome);*

2. *regulates movement of subst in and out of cell / organelle*

*(by having prot trspters that only allows movement of specific subst);* [2]

[Total: 18]

**2018 / H2 / MJC PRELIM / P2 Q1**

**QUESTION 3**

Fig. 1.1 is an electron micrograph of part of a eukaryotic cell.

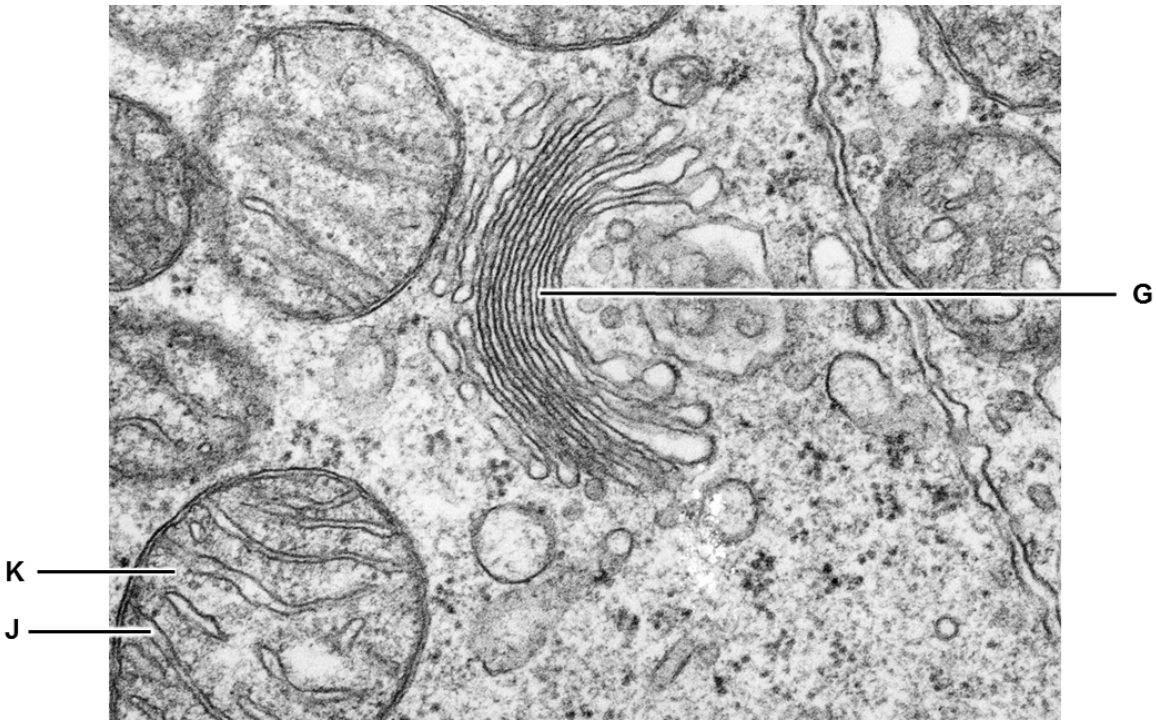


**Fig. 1.1**

**(a)** Identify the structures **J** and **K**. [2]

- **J**: Crista
- **K**: Mitochondrial matrix

**(b)** Describe two structural features shown in Fig. 1.1 that identify **G** as the Golgi apparatus and **not** the rough endoplasmic reticulum. [2]

- **G** has no ribosomes while the rough ER is attached with ribosomes
- **G** has flattened membranous sacs that are stacked / no connection between membranes while the rER membranes are interconnected

- **G** is not continuous with outer membrane of nuclear envelope while the rER is
- **G** has vesicles at ends of sacs / swellings at end of sacs (for vesicle formation) while there are no ends for vesicles formation in the rER
- **G** has a slight curvature compared to the rER

The Golgi apparatus is an organelle that is important for many functions. One example is the formation of lysosomes.

Before lysosomal hydrolases can function in the lysosome, they must be sorted from other proteins. Fig. 1.2 shows how a glycosylated lysosomal hydrolase is sorted at the trans face of the Golgi apparatus.

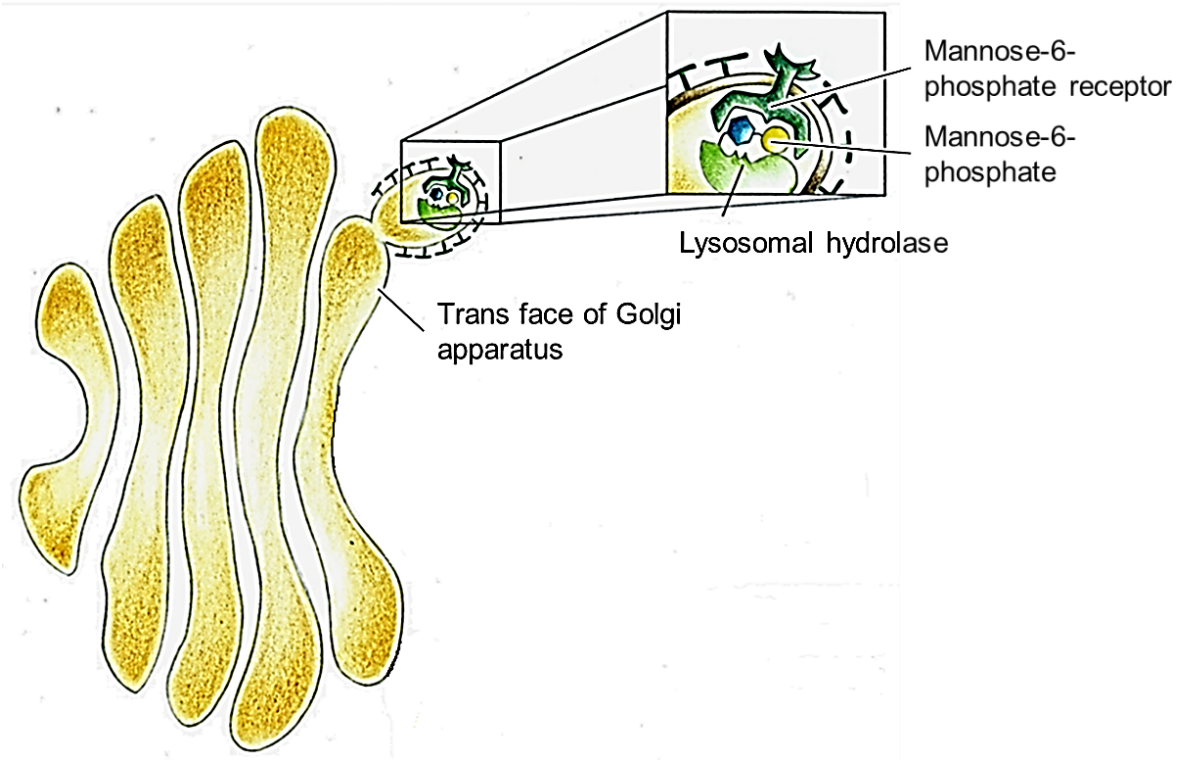


**Fig. 1.2**

**(c)** Outline the pathway taken by the lysosomal hydrolase from its site of synthesis to the trans face of the Golgi apparatus. [3]

- After being synthesised by the **ribosome** on the rER, the lysosomal hydrolase enters the **rER lumen**
- **ER vesicle** carrying lysosomal hydrolase **buds off** from rER and travels towards Golgi apparatus
- ER vesicle **fuses** with **cis face** of Golgi apparatus
- Repeated **budding and fusing of vesicles** transports hydrolase to the trans face

**(d)** With reference to Fig. 1.2, suggest how the Golgi apparatus is able to specifically sort the lysosomal hydrolase from other proteins. [2]

- *Idea that* Only the lysosomal hydrolase contains mannose-6-phosphate / other proteins are not glycosylated / not glycosylated with mannose-6-phosphate

Mannose-6-phosphate is **complementary** in shape to and **binds** to the **mannose-6-phosphate receptor**, allowing the lysosomal hydrolase to be packaged into the

**[Total: 9]**

**2018 / H2 / MJC PRELIM / P2 Q2**

**QUESTION 4**

**(a)** Contrast the processes of facilitated diffusion and active transport. [3]

- Facilitated diffusion involves transport of substances **down a concentration gradient** whereas active transport occurs **against a concentration gradient**.
- Facilitated diffusion **does not require ATP** whereas active transport **requires ATP**.
- Facilitated diffusion involves **channel or carrier proteins** whereas active transport only involves **protein pump**.

**(b)** A group of students investigated the uptake of chloride ions in barley plants. They divided the plants into two groups and placed their roots in solutions containing radioactive chloride ions.

- Group **A** plants had a substance that inhibited respiration added to the solution.
- Group **B** did not have the substance added to the solution.

The students calculated the total amount of chloride ions absorbed by the plants every 15 minutes. Their results are shown in Fig. 2.1.

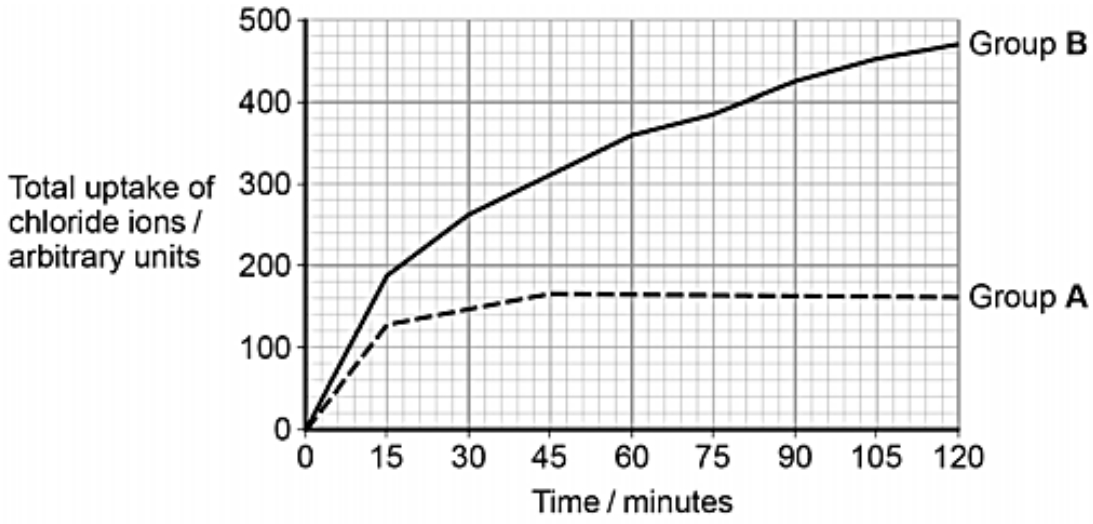


**Fig. 2.1**

**(i)** Calculate the ratio of the **rate** of uptake of chloride ions in the first hour to the **rate** of uptake of chloride ions in the second hour for group **B** plants. [2]

- rate of uptake in the first hour = 360 – 0

$$= \frac{60}{6 \text{ au min}^{-1}}$$

- rate of uptake in the second hour = $\frac{470-360}{60}$
  $= 1.83 \text{ au min}^{-1}$
- Ratio = 6/ 1.83 = **3.3 : 1**

**(ii)** Explain the results shown in Fig. 2.1. [4]

- In Group A, **from 0-15 mins**, the initial rate of uptake of chloride ions is slower as only **facilitated diffusion** occurred.
- In Group A, **from 45-120 mins**, the total uptake of chloride ions **levels off/plateaus** because the concentrations of chloride ions inside cells and outside cells is the **same/reached equilibrium**.
- In Group B, **from 0-15 mins**, the initial rate of uptake of chloride ions is faster as both **facilitated diffusion** and **active transport** occurred.
- In Group B, **from 15-120 mins,** the total uptake of chloride ions continued to increase because the uptake of chloride ions is **against concentration/did not reach an equilibrium**.
- In Group B, **from 15-120 mins**, the rate of uptake **slows down** as **fewer chloride ions in external solution/ respiratory substrate is used up**.

**[Total: 9]**

**2018 / H2 / NJC PRELIM / P2 Q1**

**Section A**

Answer the question in this section.

**1** Fig. 1.1 shows a section of a cell surface membrane.

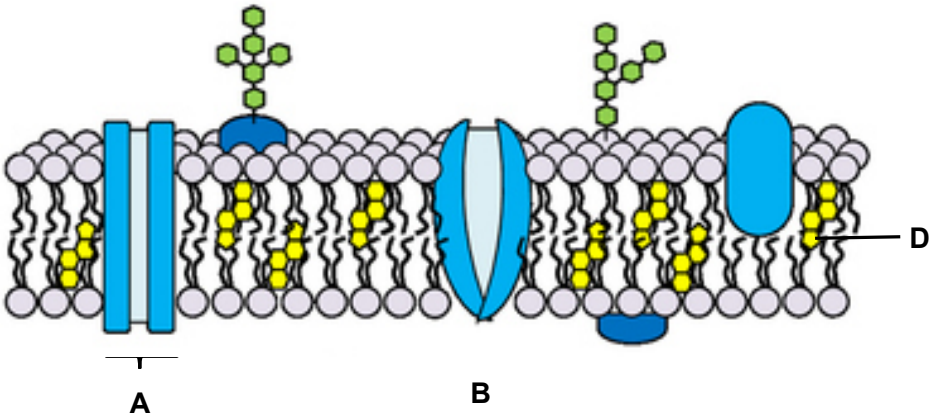

**Fig. 1.1**

**(a)** Name the structures labelled **A**, **B**, **C** and **D**.

(4 correct – 2 marks; 2 or 3 correct – 1 mark; 0 or 1 correct – 0 mark)

**A** **channel protein**
(Reject: transmembrane / integral / intrinsic membrane protein)

**B** **carrier protein**
(Reject: transmembrane / integral / intrinsic membrane protein)

**C** **oligosaccharide / sugars / carbohydrate**
(Reject: glycoprotein)

**D** **cholesterol** [2]

**(b)** Describe how structures **A** and **B** are held in the membrane.

1. **hydrophobic interactions between the non-polar hydrocarbon tails of the phospholipid bilayer and the hydrophobic R groups of the non-polar amino acids in the exterior surface of the proteins;**

2. **hydrophilic interactions between the phosphate heads of phospholipids in the bilayer and the polar and charged R groups of amino acids in the exterior surface of the proteins;** [2]

**(c)** For hydrophilic molecules to enter a cell, they require the help of either structure **A** or **B**.

State and explain which of the two structures allows a faster entry into the cell.

1. **Structure A (channel protein);**

2. **Hydrophilic molecules do not need to bind to the channel protein in order to enter the cell;**

3. **Channel protein does not need to undergo any conformational change to allow the entry of the hydrophilic molecules into the cell;**
4. **Carrier protein, on the other hand, requires the hydrophilic molecules to bind to it before it undergoes a conformational change that results in the transport of the hydrophilic molecules into the cell;**

[3]

**(d)** State **two** possible functions of structure **C**.

1. **increases the hydrophilic characteristics of lipids and proteins;**
2. **stabilises the conformation of many membrane proteins;**
3. **contributes to cell-cell recognition / communication;**
4. **contributes to cell-cell adhesion;**
5. **contributes to signal transduction;**
6. **used as antigens in the body's immune responses;**
7. **protects the cell membrane from mechanical damage;**
8. **AVP**

[2]

**(e)** Suggest why there seems to be a greater diversity in the molecular structures of **A** and **B** (proteins) than that of **C** (carbohydrates).

1. **greater variety of monomers – at least 20 different amino acids / variety due to side chains or R groups;**
2. **more types of bonds – hydrogen bonds, ionic bonds, disulphide bonds, hydrophobic interactions;**
3. **more levels of structure – primary, secondary, tertiary, quaternary;**

[2]

**(f)** The fluid mosaic model was first proposed by S.J. Singer and Garth L. Nicolson in 1972 to explain the structure of the cell surface membrane.

Explain why it is called fluid mosaic.

1. **fluid – phospholipids and proteins free to move laterally along the membrane;**
2. **mosaic – proteins embedded / studded / scattered in the phospholipid bilayer OR phospholipids and proteins distributed asymmetrically across the bilayer;**

[2]

**(g)** Comment on the significance of structure **D** in the cell surface membrane.

1. **maintains membrane fluidity when temperature changes OR provides mechanical stability;**
2. **prevents leakage of polar molecules;** [1]

[Total: 14]

**2018 / H2 / RVHS PRELIM / P2 Q1**

**6** Fig.1.1 shows a cell undergoing telophase and process **X** simultaneously.

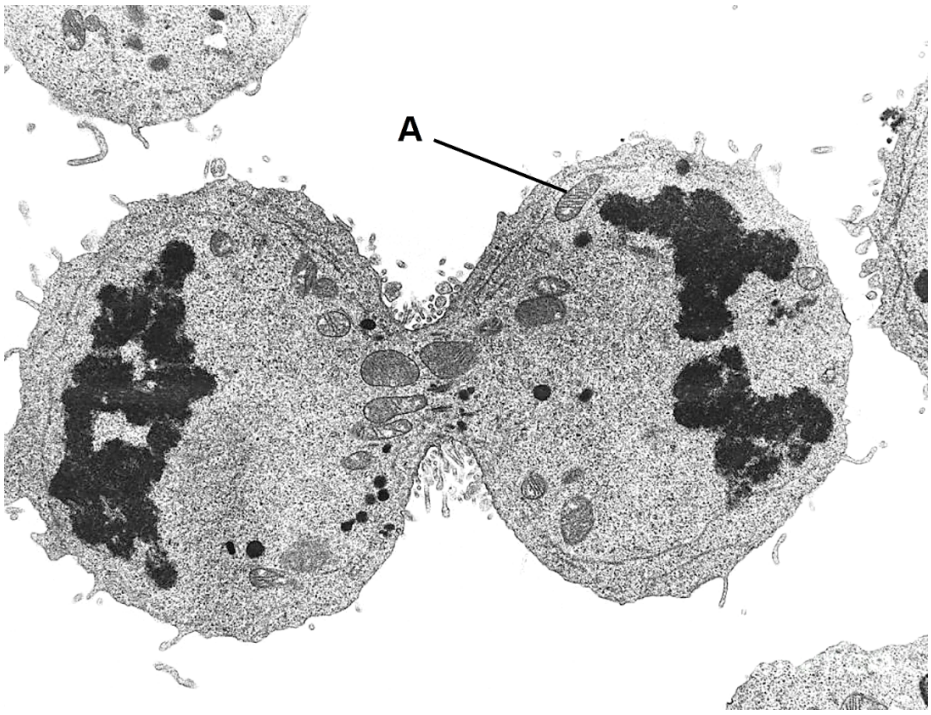


**Fig. 1.1**

*Source: David M. Phillips, 2014*

**(a)** Name structure **A**. [1]

**mitochondrion**

**(b)** Name process **X** and explain how it supports the cell theory. [2]

1. **Cytokinesis**
2. **The process shows that all cells come from pre-existing cells**

**(c)** Outline the role of **A** and explain its significance to process **X**. [3]

1. **(Site of) ATP synthesis;**
2. **during aerobic respiration**
3. **Provide energy**
4. **to form contractile ring of filaments**
5. **to form cleavage furrow**
6. **so as to separate the cell (into two)**

[Total: 6]

**2018 / H2 / TJC PRELIM / P2 Q1**

**7** Plants vary greatly in terms of size.

**(a)** Explain whether the cell theory is applicable to plants. [2]

1. **Applicable.**
2. **Plants are living organisms, which are composed of (many, different plant) cells,**
3. **which are basic/ smallest unit of life.**
4. **All plant cells come from pre-existing plant cells via cell division (e.g. mitosis or meiosis).**

Sugar molecules enter cells through transport proteins.

**(b)** Explain why transport proteins are required for the movement of sugar molecules, such as glucose and fructose, into cells. [2]

1. **Glucose and fructose are polar molecules.**
2. **They are unable to cross**
3. **the hydrophobic core of the phospholipid bilayer.**
4. **Transport proteins shield them from hydrophobic core of plasma membrane (e.g. channel proteins provide a hydrophilic channel for their movement across the membrane).**

Some plant cells convert fructose and glucose into sucrose for transport from the leaves to the roots. Sucrose is moved into phloem sieve tubes as shown in Fig. 1.1.

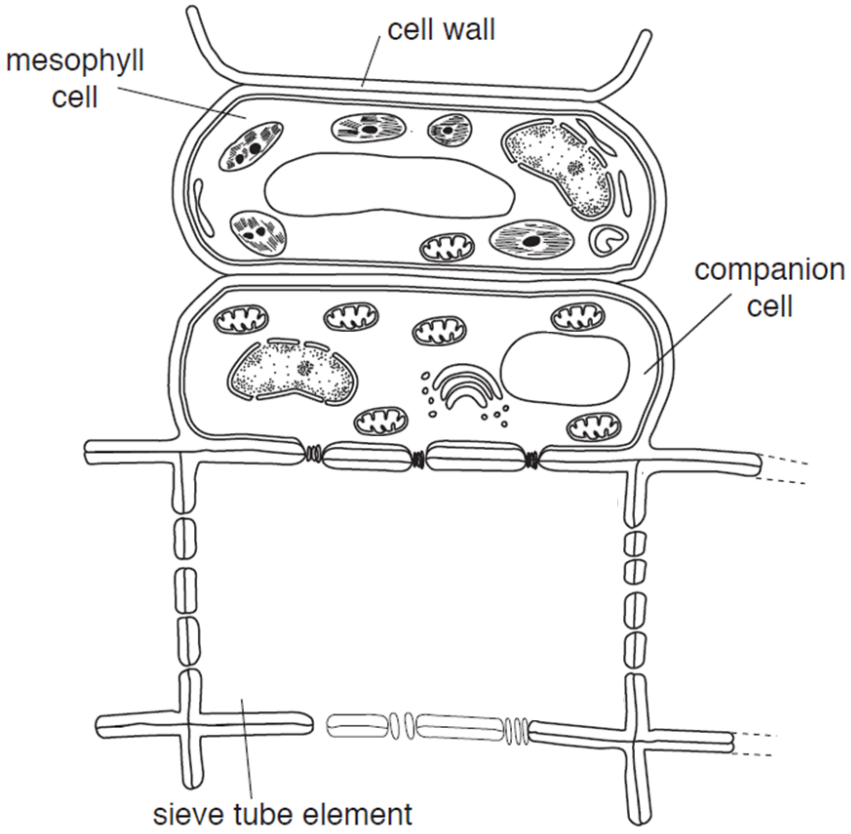


**Fig. 1.1**

Each cell has a specialized function.

**(c)** With reference to Fig. 1.1 and the information provided, state **one** difference between a mesophyll cell and companion cell. [1]

**1. Companion cells (6 mitochondria) have more mitochondria than mesophyll cells (1 mitochondrion). [1]**

**OR**

**Mesophyll cells (5 chloroplasts) have chloroplasts whereas companion cells have none. [1]**

Fig. 1.2 shows how sucrose is transported into the companion cell from the mesophyll cell.

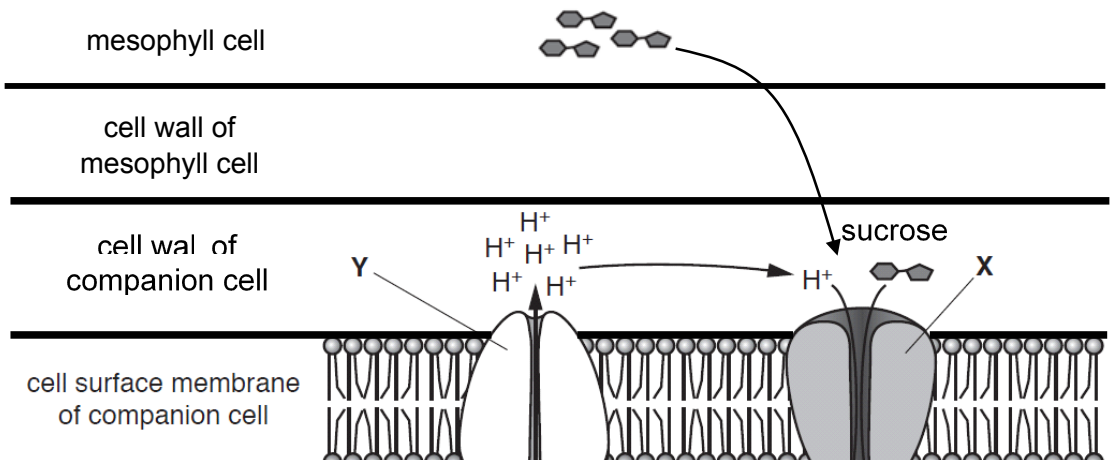

**Fig. 1.2**

**(d)** Using the information in Fig. 1.1 and Fig. 1.2, explain how sucrose moves into the companion cell. [3]

1. **Sucrose diffuses from mesophyll cell to the cell wall of companion cell.**

2. **Protons are actively pumped out from the cytoplasm of companion cell into its cell wall through carrier protein Y via active transport (hydrolysis of ATP). [1]**
   **[Reject: Diffuse]**

3. **Protons then diffuses from the cell wall of companion cells into the companion cell through transport protein X (cotransporter) via facilitated diffusion [1]**

4. **which is coupled with the transport of sucrose**
5. **against the sucrose concentration gradient.**

[Total: 8]

**2018 / H2 / VJC PRELIM / P2 Q1**

2 In eukaryotic cells, the degradation of mRNA is an essential part of the regulation of gene expression. It can be controlled in response to developmental, environmental, and metabolic signals. mRNA hydrolysis is catalysed by numerous types of nucleases, such as the endonuclease Ribonuclease A (RNAse A), shown in Fig. 1.1.

(a) Using a labelled and annotated diagram, illustrate the hydrolysis of the bond catalysed by RNAase. [3]
(A monomer has been drawn for you.)

- Accurate drawing of mRNA strand, at least 2 nucleotides (using symbols);;
- Accurate drawing of phosphodiester linkage + label;;
- Water;
- Hydrolysis ;
- Accurate drawing of correct number of nucleotides after hydrolysis;

Fig 1.1B shows two important catalytic residues within the active site of RNAse A, which are His12 and His119.

(b) Explain how these two histidines, which are in position 12 and 119 of the 124 amino acid sequence, are brought together in the active site of the enzyme. [3]

- Primary structure (number, type and sequence of amino acid )determines how the polypeptide chain folds upon itself;;
- interactions between R groups of amino acids not located close to one another on the primary structure ;
- To form the tertiary structure with a compact globular 3D structure;
- Bringing faraway amino acids together within the active site;

(c) Predict how the catalytic activity of RNAse would be affected if both histidines were replaced by phenylalanines. [2]

- Histidine has an R-group that is polar whereas phenylalanine has an R-group that is non-polar;;
- This causes the change in the interaction between the catalytic residues and the substrate at the active site; therefore; RNAase catalytic activity will be greatly reduced / lost;;