Civics Group	Index Number	Name (use BLOCK LETTERS)	H1

ST ANDREW'S JUNIOR COLLEGE
2021 JC1 Final Year Examination

H1 BIOLOGY **8876/2**

Paper 1 & 2:

Tuesday October 2021 1hr 45min

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A (Multiple Choice Questions)
Answer **all 10** questions.
For each question, there are four possible answers, A, B, C and D.

Choose the one you consider correct and record your choice in soft pencil on the separate multiple choice answer sheet (OTAS).

Sections B and C (Structured Questions + Essay)
Answer the **all 5** questions.
Write your answers in the blanks provided.

INFORMATION TO CANDIDATES
At the end of the examination,
1. Submit the OTAS and question paper separately.

Conceptual mistake (C)	Expression (E)	Data Quoting (D)	Misreading the question (Q)

For Examiner's Use	
Section A	/10
Section B	
1	/10
2	/10
3	/10
4	/10
Section C	
5	/10
Total	/60

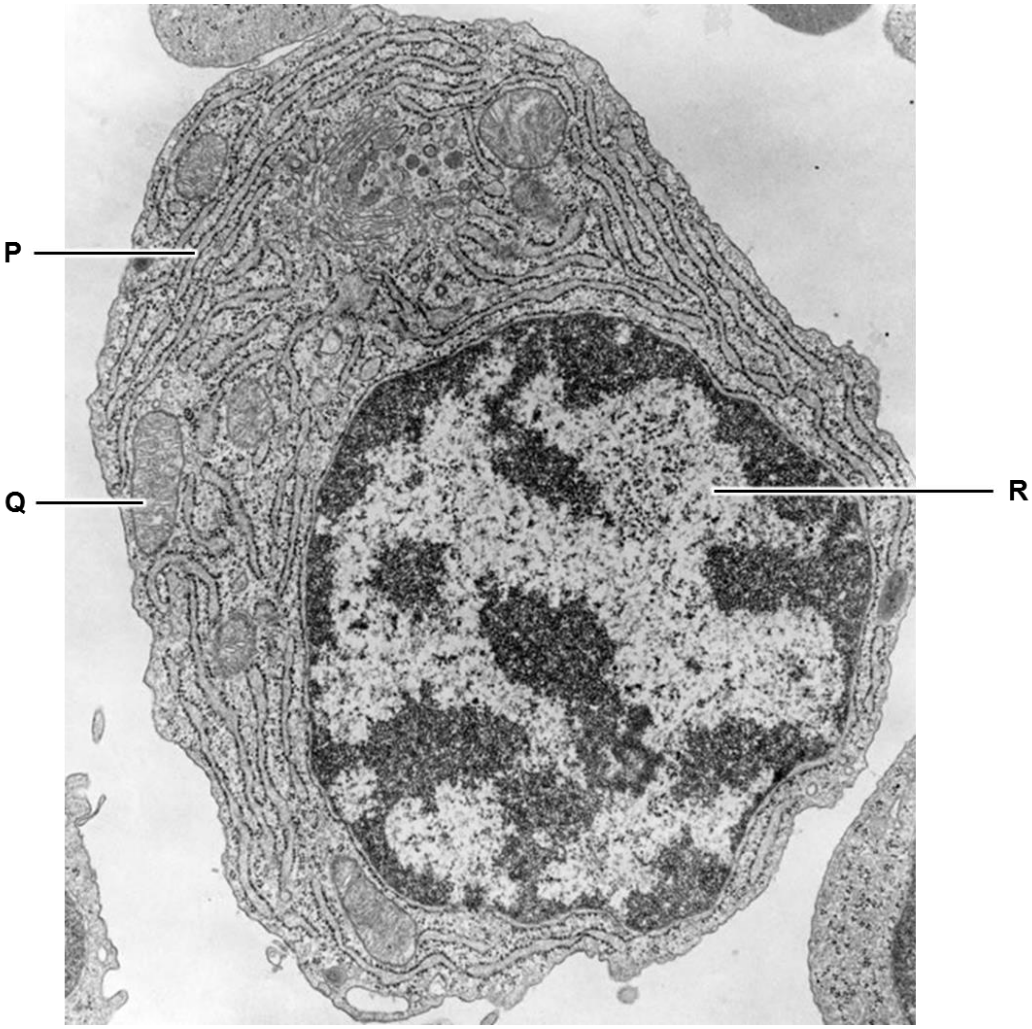
This document consists of **XX** printed pages.

[Turn over

Section A

Shade your answers in the OTAS provided.

1 The figure below shows an electron micrograph of a cell.



Which row correctly describes structures **P** – **R**?

	P (RER)	**Q (Mitochondrion)**	**R (nucleus)**
A	synthesis of ribosomes (X)	substrate level phosphorylation (true – Krebs cycle occurs in mitochondrion)	active replication of genes
B	provision of large surface area for attachment of ribosomes	formation of ATP from light energy (X)	active transcription of genes
C	synthesis of membrane proteins	oxidative decarboxylation	active transcription of genes

D	transport of proteins to Golgi apparatus	modification of mRNA transcripts (X) circular DNA in mitochondria, similar to bacterial genes, no post-transcriptional modifications	active replication of genes

2 The following are all observations about cell surface membranes.

1 Phospholipids labelled with radioactive phosphate groups change position over time. (√)

2 Proteins labelled with fluorescent dyes change position over time. (√)

3 Lectins are proteins that bind to polysaccharides. They only attach to the outside of membrane samples. (X) This only describes how the membrane is asymmetrical (i.e. inner surface not the same as outer surface).

4 Electron microscope images of membranes fractured by freezing show a large number of regularly arranged particles interrupted by larger particles. (√) demonstrates the scattered arrangement of proteins in the layer of phospholipids.

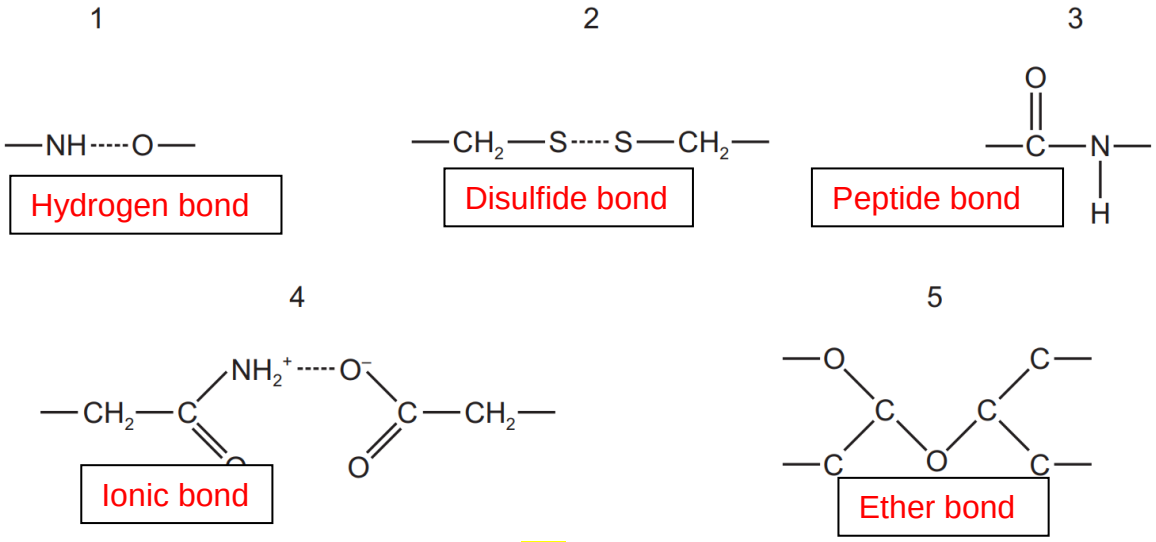
5 Some membranes contain more cholesterol and unsaturated fatty acid chains than other membranes. (X) This describes different compositions of membranes but not fluid mosaic.

6 Some proteins can only be separated from the membrane by disrupting the membrane with detergent. (X) This describes how proteins are embedded in the membrane by hydrophobic interactions between their non-polar R groups and the hydrocarbon chains of the phospholipid bilayer.

Which observations provide evidence for the fluid mosaic model of cell surface membranes? "Fluid" refers to phospholipids and proteins being able to move, and "mosaic" refers to the random, scattered arrangement of the proteins in the membrane.

A 1, 2 and 4
B 1, 2 and 6
C 3, 4 and 5
D 3, 5 and 6

3 The following diagram show different types of bond found in biological molecules.

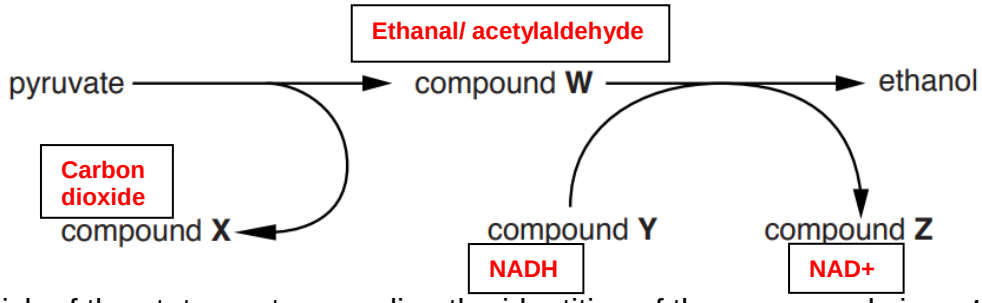


Which combination of bonds could not be found in a protein with a tertiary structure?

A 1, 2, 3 and 4
B 1, 2 and 4
C 3 and 5
D 5 only

Consists of hydrogen bond, ionic bond, disulphide bond, hydrophobic interaction (all found in tertiary structure) and peptide bond (found in primary structure)

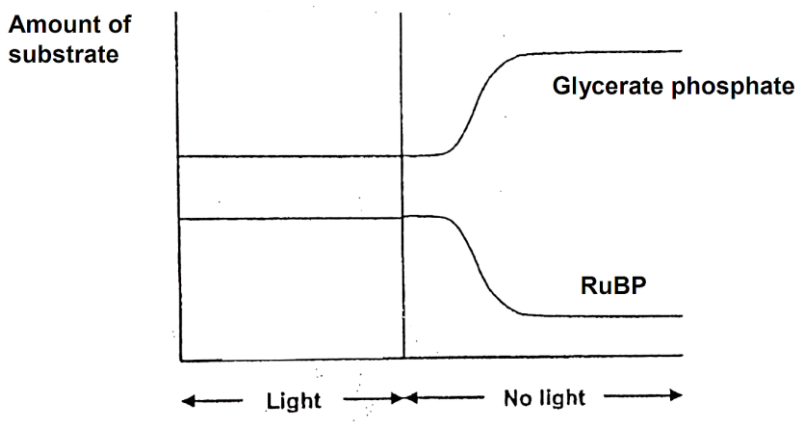
4 The flowchart outlines the process of anaerobic respiration in yeast cells.



Which of the statements regarding the identities of the compounds is **not** correct?

A Compound W can also be synthesised in the anaerobic respiration of plant cells.
B Compound X is a waste product.
C Compound Y is necessary for more rounds of glycolysis.
D Compound Z acts as an oxidising agent

5 The graph below shows the change in the concentration of RuBP and glycerate phosphate in the presence of light and when the light is switched off.



Which statement(s) is/are **true**?

1 In the dark, the amount of glycerate phosphate increased initially due to the lack of reduced NADP. Yes, in the dark no ATP and NADPH is produce for reducing step.

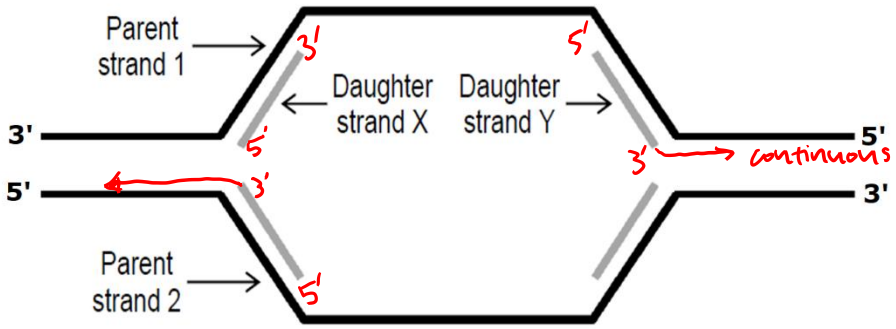
2 In the dark, the amount of glycerate phosphate increased initially as more RuBP is converted to glycerate phosphate. Yes, in the dark no ATP and NADPH is produce for reducing step but CO_2 fixation can still occur.

3 In the dark, the amount of RuBP decreased initially as it reacted with carbon dioxide. Yes, in the dark no ATP and NADPH is produce for reducing step but CO_2 fixation can still occur so RuBP decreased

4 In the light, the concentration of RuBP and glycerate phosphate were constant as RuBP that was used to form glycerate phosphate was regenerated. Yes, 10 out of 12 PGAL is used to regenerate RuBp while the other 2 forms glucose

A 1 and 2
B 1, 3 and 4
C 2, 3 and 4
D 1, 2, 3 and 4

6 A simplified representation of a replication bubble is shown in the figure below. Parental strands 1 and 2 and the growing daughter strands X and Y are indicated.



Which of the following statements about the synthesis of daughter strands **X** and **Y** is correct?

A Daughter strands **X** and **Y** are synthesised away from their respective replication forks. Strand Y is synthesised towards the replication fork due to the presence of a free 3' OH group.

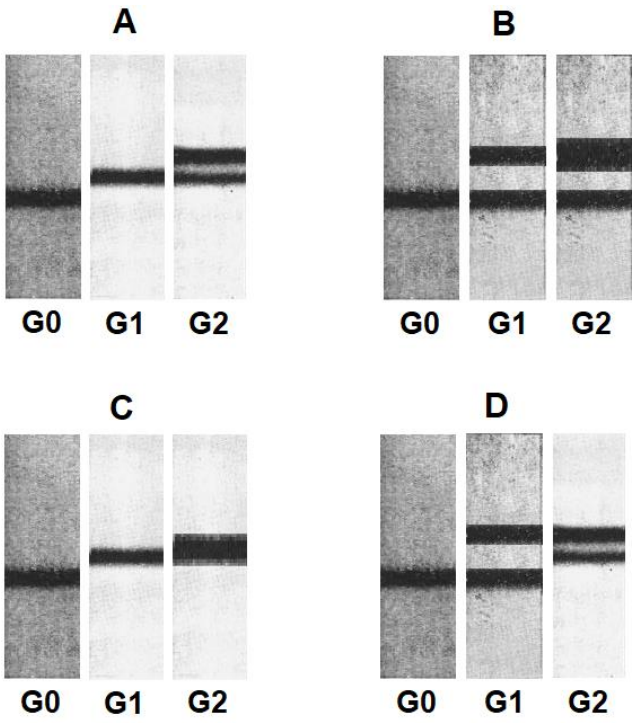
B Daughter strand **X** is synthesised continuously while daughter strand **Y** is synthesised in the form of Okazaki fragments. The opposite is true.

C Daughter strand **X** is synthesised in the 5' → 3' direction while daughter strand **Y** is synthesised in the 3' → 5' direction. Both strands are synthesised from 5' → 3' direction as DNA polymerase can only add new nucleotides to a free-3' OH group of an existing strand.

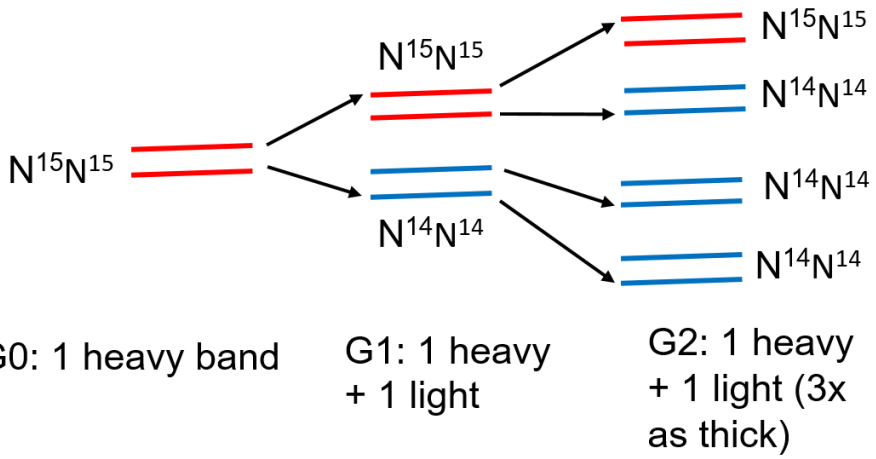
D To synthesise daughter strands **X** and **Y**, both parental strands 1 and 2 are read in the 3' to 5' direction.

7 Bacteria were cultured in a medium containing heavy nitrogen (^{15}N) until all the DNA was labelled. These bacteria (G0) were then grown in a medium containing only normal nitrogen (^{14}N) for two more generations (G1 and G2). At each generation, a sample is removed and the DNA is extracted and centrifuged in caesium chloride.

If DNA replicates according to the conservative model rather than the semi-conservative model, which of the following would be the expected results of the experiment? **ANSWER: B**



Explanation for conservative model:



8 Which of the following are not involved in transcription?

1 Helicase involved in DNA replication
2 Transcription factors
3 DNA polymerase involved in DNA replication
4 Deoxyribonucleotides involved in DNA replication

A 1 only
B 1 and 3
C 2 and 4
D 1, 3 and 4

9 The following table shows the mRNA codons for six different amino acids.

mRNA codons	amino acid
AAA AAG	lysine
AGA AGG CGG	arginine
GGU GGA GGC GGG	glycine
CCU CCA CCC CCG	proline
UGG	tryptophan
UAU UAC	tyrosine

The base sequence of mRNA coding for part of a polypeptide is shown below.

U	A	U	A	A	G	A	G	G	C	C	U	U	G	G
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

start reading

From the information provided, which of the predictions stated below is not true?

A The insertion of a nucleotide between positions 3 and 4 is expected to result in a greater change in the amino acid sequence than an insertion between positions 12 and 13. (√) Insertion between 3 and 4 results in frameshift for the rest of the polypeptide while between 12 and 13 is more towards the end.

B The deletion of a nucleotide at position 5 would result only in an alteration of the second amino acid in the chain. (x) deletion of 1 nucleotide causes a frameshift that affects all the amino acids coded for from the point of deletion.

C The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain. (√) Degeneracy of genetic code. Will still code for proline no matter the base at position 12.

D The substitution of a different nucleotide at position 13 would result in the alteration of one amino acid (√) UGG is unique code for tryptophan. Any change in the U (base 13) will cause it code for another amino acid.

10 Which of the following will not result in chromosomal aberration?

A Frameshift mutation at the beginning of a coding sequence. (x) this is gene mutation,not chromosomal aberration (which must affect more than one gene).

B Nondisjunction during anaphase II of meiosis.

C Non-equivalent crossing over of non-sister chromatids during prophase I.

D Deletion of telomeres

Section B

Answer **all** questions in the space provided.

QUESTION 1

(a) Fig. 1.1 shows part of the primary structure of the β–chain of haemoglobin S (HbS).

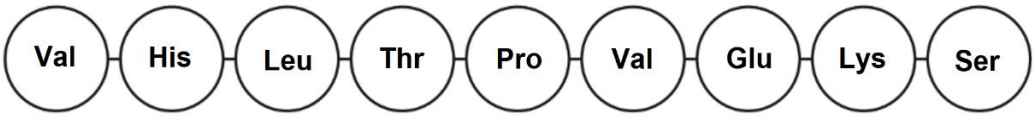


Fig.1.1

(i) State the difference between the primary structure of the β–chain of HbS and that of the normal haemoglobin, HbA.

..... [1]

Amino acid at 6th position is valine in HbS but glutamic acid in HbA.

Fig. 1.2 shows the molecular structure of the amino acid valine (val).

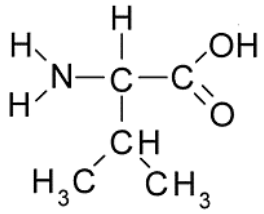


Fig. 1.2

Fig. 1.3**A** shows a polypeptide molecule during protein synthesis. A molecule of valine is shown just before it is added to the polypeptide.

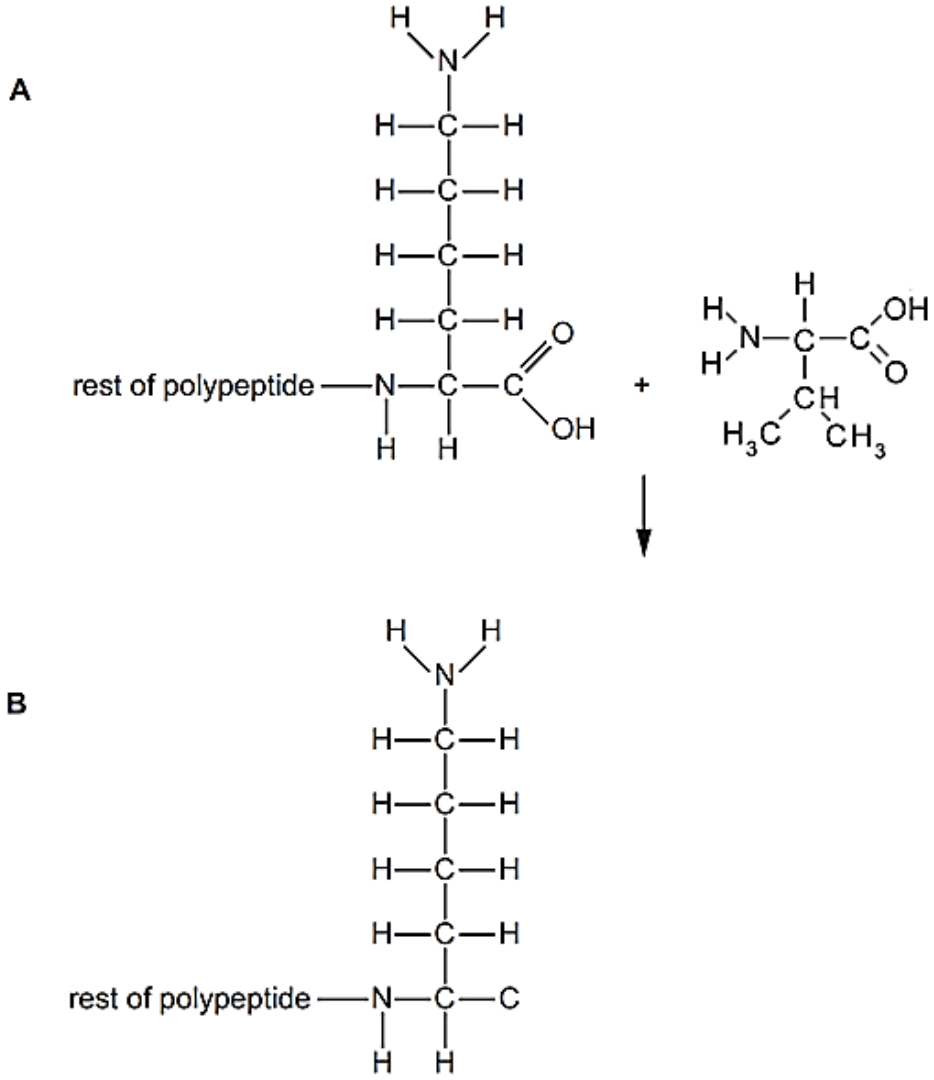
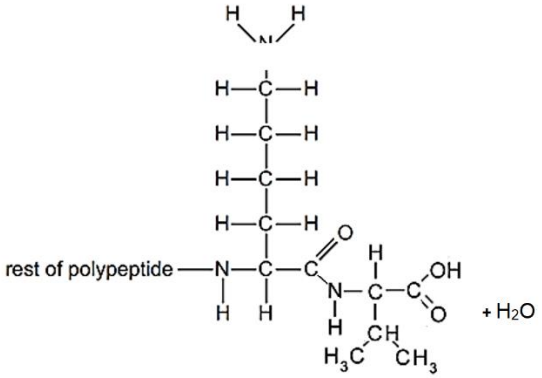


Fig. 1.3

(ii) Complete Fig. 1.3**B** to show how the molecule of valine is added to the end of the polypeptide. [2]



1 diagram shows bond between C (of polypeptide) and N (of valine) and double bond to O shown correctly ; valine drawn correctly;
2 H_2O included
[Reject : R group. Need to draw all bonds]

(b) Explain how the primary structure of HbS results in symptoms of sickle cell anemia.

…… [4]

1 Valine (at position 6) has a <u>non-polar R group</u> which forms <u>hydrophobic interactions</u> with valine R groups of other HbS molecules.
2 As a result, HbS **polymerises into long fibres** at low oxygen concentration.
3 This distorts the red blood cells into **sickle shaped** cells.
4 Which clump together and **clog blood capillaries**, **obstructing blood flow** to tissues/organs.
5 Sickled red blood cells have a **shorter life span**, hence leading to <u>anemia</u>.

Marker's comments: *Some candidates wrongly stated that "HbS becomes sickle shaped" rather than RBCs becoming sickle-shaped.*

(c) Instead of haemoglobin, horseshoe crabs' blood contain hemocyanins. Hemocyanins are hexameric proteins (i.e. consists of six identical subunits), which contain two copper ions instead of iron ion in each subunit.

Using your knowledge of haemoglobin and the information given above, describe how the structure of hemocyanin relates to its function.

…… [3]

1 Hemocyanins are **globular** proteins / have polar/charged/hydrophilic R groups on the surface of the protein, and hence are **soluble** in the aqueous medium of the blood.
2 The 6 subunits are held together by **ionic bonds, hydrogen bonds and hydrophobic interactions** between <u>R groups</u> of the <u>different</u> polypeptides. Binding of oxygen to the first subunit induces a conformational change in the remaining subunits, increasing affinity for oxygen binding / ref. **cooperativity**

3 The presence of the copper ions allow hemocyanins to **bind reversibly to oxygen**, allowing release of oxygen to cells that need it.

Marker's comments: *Some candidates did not emphasise on the ability of hemocyanins to bind REVERSIBLY with oxygen. Many candidates also did not directly relate a structural feature with the function.*

[Total: 10]

QUESTION 2

Fig. 2.1 shows the process of transcription and translation in Cell X.

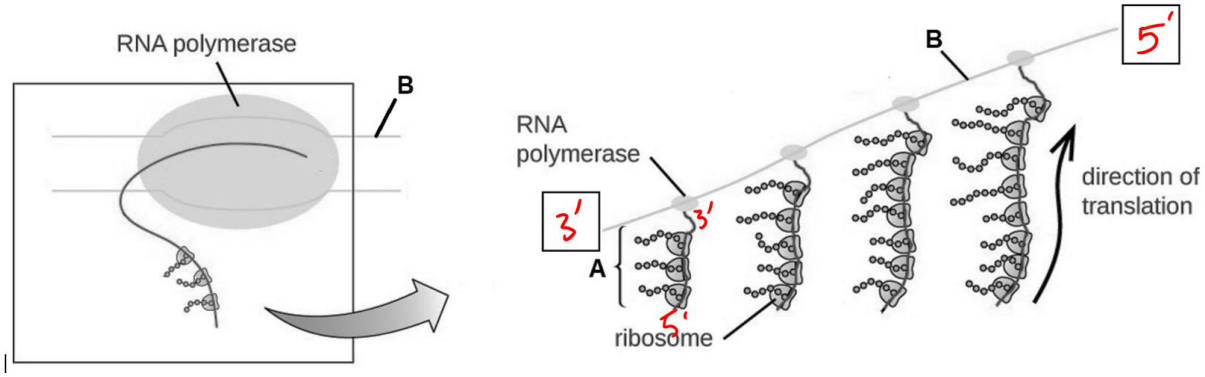


Fig. 2.1

(a) (i) With reference to Fig. 2.1, state and explain whether Cell X is prokaryotic or eukaryotic.

…… [2]

1 Prokaryotic
2 The processes of **transcription and translation occur simultaneously** due to the **absence of nuclear envelope**.

Marker's comments:
A small number of candidates wrongly stated that the cell is eukaryotic.

(ii) Name structures **A** and **B**.

…… [1]

A – polyribosome
B – DNA template [Reject DNA only]

Marker's comments:
A majority of candidates were unable to identify the polyribosome. No half mark marking is given for this question.

(iii) Outline the formation of structure A.

…… [3]

1 **Initiation factors** and the **initiator tRNA** which carries the amino acid **formylmethionine** associates with the **small ribosomal subunit** forming **a pre-initiation complex**.
2 The **Shine-Dalgarno sequence** binds to mRNA binding site on ribosome to indicate to the ribosome where to start translation.
3 The large ribosomal subunit then attaches to the small ribosomal subunit in the pre-initiation complex to form the translation initiation complex.
4 As the ribosome **translocates** downstream, another ribosome can assemble at the start codon, resulting in multiple ribosomes translating the mRNA at the same time.

AVP:
Anticodon of initiator tRNA **complementary base pairs** with **start codon** AUG on mRNA.
GTP is hydrolysed to GDP to provide energy required for assembly of translation initiation complex.

Marker's comments:
Many candidates wrote "methionine" instead of "formylmethionine" despite identifying Cell X as prokaryotic in (a)(ii). A significant proportion of students also mentioned components required in transcription instead (e.g. RNA polymerase, promoter, transcription factors).

(iv) Indicate, in the boxes provided in Fig., the 5' and 3' ends of structure **B**.

…… [1]

Left box – 3'; right box – 5'

Marker's comments:
A large proportion of candidates did not get this correct.

(b) Outline the differences between DNA replication and translation in eukaryotes.

…… [3]

Feature	DNA replication	Translation
Type of template used	DNA is used as template	mRNA is used as template
No. of strands of template	Both strands of DNA are used as template	Only one of the strands is used as template.
Type of product formed	DNA is produced	Polypeptide is produced
Type of monomers used	Deoxyribonucleoside triphosphates are used	(Activated) amino acids are used

	[Accept deoxyribonucleotides]	
Enzyme involved	DNA polymerases are used	Peptidyl transferase is the enzyme involved.
Type of bond formed	Phosphodiester bonds are formed.	Peptide bonds are formed
Location	Occurs in the nucleus	Occurs in cytoplasm

[Any two]

Marker's comments:
Candidates need to pick stronger points to compare, and to ensure that the comparison is a valid one (e.g. compare template vs template and not template vs product formed).

[Total: 10]

QUESTION 3

(a) State the initial reactant(s) and the products of glycolysis and linked reaction.

…… [2]

Glycolysis [1m]
Initial reactant: glucose
Products: pyruvate, NADH, ATP

Linked reaction [1m]
Initial reactant: pyruvate, Co-enzyme A
Products: acetyl-CoA, CO_2, NADH

Marker's comments:
Many candidates did not fully state all the reactants and/or products.

(b) A student investigated the effect of different types of carbohydrates on the rate of aerobic respiration in yeast. He incubated 2.0 cm^3 of glucose with 2.0 cm^3 of yeast culture for two minutes and collected the volume CO_2 produced.

He repeated the experiment using two other types of carbohydrate, sucrose and lactose. Table 3.1 shows the results of his experiment.

Table 3.1

Type of carbohydrate	Volume of CO_2 collected /cm^3
Glucose	9.53
Sucrose	4.79
Lactose	0.35

(i) Explain the rationale for measuring the volume of CO_2 for this investigation.

…… [2]

1 CO_2 is produced via oxidative decarboxylation during linked reaction and Krebs cycle.
2 The larger the volume of CO_2 collected, the faster the rate of respiration.

Marker's comments:
Most candidates missed out point 1, this is a failure to elaborate on why CO_2 was monitored in the experiment.

(ii) With reference to Table 3.1, describe and explain the effect of different types of carbohydrate on the rate of respiration in yeast.

…… [4]

1 [Quote data]: Volume of CO_2 collected was highest at 9.53 cm^3 when glucose was added to yeast, followed by 4.79 cm^3 in sucrose, and lowest at 0.35 cm^3 in lactose.
2 Rate of respiration in yeast is **fastest** in glucose because glucose can be used directly in glycolysis as a respiratory substrate.
3 Rate of respiration is slower in sucrose because yeast cells **need to hydrolyse the sucrose into glucose** and fructose before the glucose can be used as a respiratory substrate.
4 Rate of respiration is slowest / almost zero in lactose because yeast cells **do not have enzymes that hydrolyse lactose** into glucose and galactose / OVP.

Marker's comments:
Many candidates could describe the effect of type of carbohydrate, but were unable to explain why sucrose caused rate of respiration to be slower and why lactose gave the slowest rate.

(iii) Compare the Calvin cycle with Krebs cycle.

……..…..… [2]

Similarities

1 Both involve regeneration of an initial reactant (RuBP in Calvin cycle, oxaloacetate in Krebs).

Differences

2 Calvin cycle uses up ATP while Krebs cycle produces ATP.
3 Calvin cycle uses up CO_2 while Krebs cycle produces CO_2.
4 The coenzyme involved in Calvin cycle is NADP while the coenzymes involved in Krebs cycle are NAD and FAD.
5 Calvin cycle occurs in chloroplast stroma while Krebs cycle occurs in mitochondrial matrix.

Marker's comments:

Some candidates did not give any similarities.

[Total: 10]

QUESTION 4

Fig. 4.1 shows how different molecules can be transported across a cell membrane.

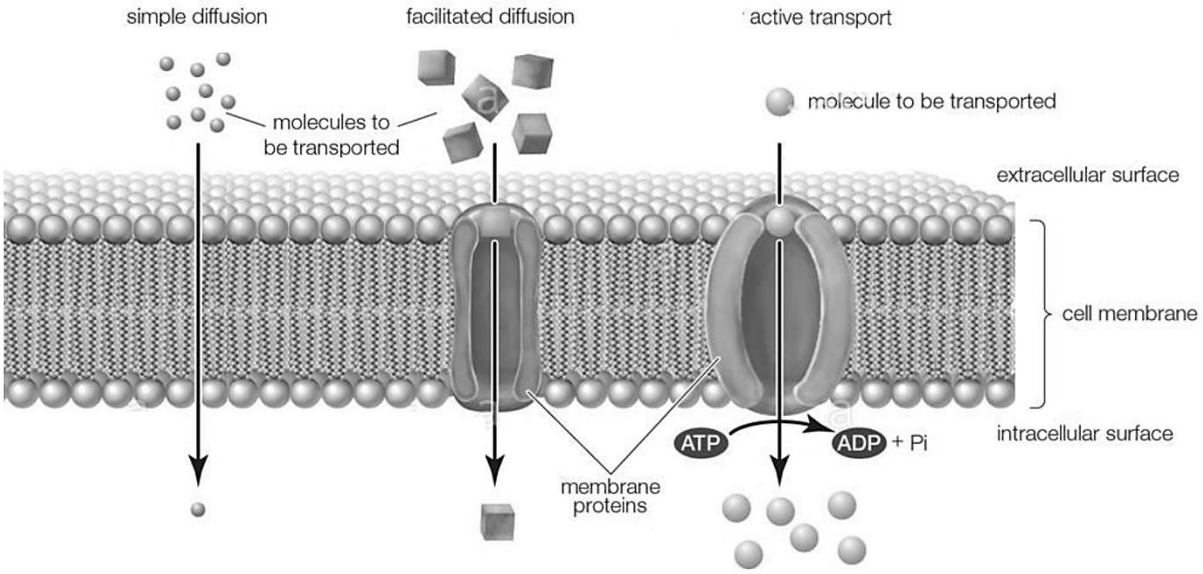


Fig. 4.1

(a) Molecules such as oxygen and carbon dioxide pass through the cell membrane via simple diffusion.

Explain why such molecules cannot pass through the cell membrane via facilitated diffusion.

……..…..… [2]

1 Molecules that can pass through via simple diffusion are **non-polar / hydrophobic**, but the **channel proteins** involved in facilitated diffusion have a channel that is lined by **polar/charged/hydrophilic R groups**.
2 The channel / carrier proteins involved in facilitated diffusion have binding sites that are only **complementary in shape to specific molecules** that they transport.

Marker's comments:
Most candidates did not consider the specificity of channel/carrier proteins such that not all molecules can pass through the membrane through them.

(b) With reference to Fig. 4.1, compare facilitated diffusion and active transport.

…… [3]

Similarities

1 Both involve transmembrane **transport proteins** to provide a hydrophilic channel for molecules to pass through.

Differences

2 Molecules **diffuse down a concentration gradient** in facilitated transport but molecules are transported **against their concentration gradient** in active transport.
3 ATP is hydrolysed to ADP and Pi in active transport, but not in facilitated diffusion.

Marker's comments:
This question was well done by most candidates.

(c) Glucose transporter 2 (GLUT2) are transmembrane proteins that allow the uptake of glucose into liver cells. Fanconi-Bickel syndrome (FBS) is a genetic disorder caused by defects in the GLUT2 proteins.

The partial sequence of the normal and mutant alleles coding for GLUT2 are shown below:

Normal allele: …..TCT AAG TAT ACC CGG ACC TAG…..

Mutant allele: …..TCT AAG TAT ATC CGG ACC TAG…..

(i) State the type of mutation that altered the gene coding for GLUT2 proteins.

…… [1]

Substitution

(ii) Explain how the mutation led to FBS.

…… [4]

1 When **C is substitute with T**,
2 created a nonsense mutation / created a stop codon, UAG.

3 This caused premature termination of translation of the mRNA, resulting in **truncated GLUT2 protein**.
4 The mutant protein folds into a **different 3D/tertiary structure** / forms different R group interactions, hence is no longer **complementary in shape** to glucose.

Marker's comments:
Most candidates did not realise that the mutation generated a new stop codon, and is a nonsense mutation. As a result they elaborated on missense or frameshift instead.

[Total: 10]

Section C

Answer the question.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

7	There are similarities and differences in how ATP is generated in chloroplasts and mitochondria. Compare the processes of ATP generation in both organelles.	**[10]**

No QwC mark.

PHOTOPHOSPHORYLATION vs OXIDATIVE PHOSPHORYLATION

Similarities (S1-S7) – Max 4

Both processes:

1 Involve the transport of electrons through an ETC
2 In both processes, the electron carriers are of progressively lower energy level.
3 In both processes, **energy released from electron transport** is used to create a proton gradient. The potential energy of the proton gradient is used for the synthesis of ATP from ADP and P_i.
4 In both processes **protons are unable to pass through the membrane** which allows the generation of a proton gradient.
5 Both ATP generated process requires protons to be **pump across membranes**.
6 Both involves the process of Chemiosmosis where hydrogen ions diffuse from **an area of high proton concentration to an area of lower proton concentration**
7 Both synthesize ATP using the enzyme ATP synthetase.

Differences (D1-D8) – Max 6

S/N	Features	Photophosphorylation	Oxidative Phosphorylation
1	Location	Occurs at the thylakoid membrane of chloroplast.	Occurs at the inner membrane of the mitochondrion.
2	Requirement for light	Light energy required for photolysis of water.	No light energy required.
3	Source of energy	Energy for ATP synthesis comes ultimately from light.	Energy for ATP synthesis comes from glucose oxidation.
4	Electron donors	Electron donor in non-cyclic pathway = water. Electron donor in cyclic pathway = PS I	Electron donors = NADH and $FADH_2$.
5	Final electron acceptor	Final electron acceptor in **non-cyclic pathway** = $NADP^+$ Final electron acceptor in **cyclic pathway** = PS I	Final electron acceptor = oxygen.
6	Pumping of H+	H^+ ions are pumped inwards from stroma into the thylakoid space.	H^+ ions are pumped outwards from matrix into the intermembrane space.
7	No. of Electron transport chain	Involves TWO electron transport chain. PSII to ETC to PSI and PSI to ETC to NADPH	Only involve ONE electron transport chain

8 In mitochondria, ATP can be generated by substrate level phosphorylation (in Kreb cycle) and Oxidative phosphorylation whereas in Chloroplast ATP can only be generated by photophosphorylation.

Marker's comments:
*Many students **DID NOT meet question requirement** and describe the entire processes in two separate long paragraphs **instead of comparing point by point** which can **result in NO marks awarded.***

*In this FE examination, marks are only awarded when there is **clear, explicit corresponding points** in the two paragraphs. QWC is not awarded if question requirements are not met.*

From 2020 Cambridge Examiner's Report
(b) Some misconceptions included the incorrect idea that oxidative phosphorylation occurs in chloroplasts as well as mitochondria and mis-naming the intermembrane space as the 'inner membrane space'. Weaker responses limited comparisons to differences and omitted consideration of features that

are common to chloroplasts and mitochondria. In some responses, the two parts of a difference description (one for chloroplasts and one for mitochondria) were widely separated so that the difference was largely obscured.

2008 Cambridge Comments
This question was well done by the vast majority of candidates.
[Similarity in ATP production] Marks were commonly gained for references to an electron transport chain, the generation of a proton gradient, the relevant membranes involved and the role of ATP synthetase. Some candidates incorrectly referred to ATPase in this context.
The question asks why there are similarities in ATP production in mitochondria and chloroplasts and therefore references to the fact they were once prokaryotes and their endosymbiotic origin were required.