Civics Group	Index Number	Name (use BLOCK LETTERS)	**H2**

ST. ANDREW'S JUNIOR COLLEGE
2024 JC2 PRELIMINARY EXAMINATIONS

H2 BIOLOGY **9744/2**

Paper 2 (Set A – Qn 1-5)

Friday **23rd August 2024** **2 hours**

Materials: Question Paper Set A and Set B

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.

Answer **all** questions.
Write your answers in the spaces provided on the question paper.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiners' Use	
1	/10
2	/10
3	/12
4	/10
5	/9
6	/10
7	/10
8	/10
9	/5
10	/4
Total	**/100**

This document consists of **15** printed pages and **0** blank page.

[Turn over

QUESTION 1

(a) Table 1.1 lists cell structures that can be found in eukaryotic cells or prokaryotic cells. Some of these cell structures can be found in both types of cell.

Complete the table using a tick (✓) to show that the cell structure can be present in a particular type of cell and a cross (✗) to show that the cell structure cannot be present.

Put a tick or a cross in every box.

The top row has been completed for you.

Table 1.1

Cell structure	eukaryotic cells	prokaryotic cells
Nucleus	✓	✗
Golgi body		
circular DNA		
70S ribosome		

[2]

(b) All cells have a cell surface membrane. Fig. 1.1 shows a transmission electron micrograph of part of two adjacent animal cells, cell 1 and cell 2.

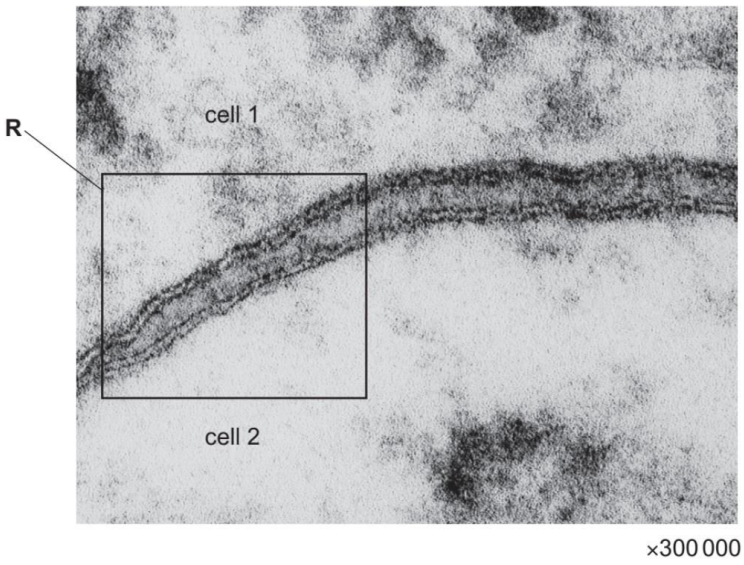

Fig. 1.1

In the space provided, draw a diagram of the region in the box labelled **R** in Fig. 1.1. Your diagram should show the four dark lines.

Label the diagram to identify what is shown by the dark lines and each of the three spaces between them.

R

[3]

Fig. 1.2 is a transmission electron micrograph of part of a hepatocyte showing some cell structures.

The peroxisome shown in Fig. 1.2 is a spherical organelle bound by a single membrane. It carries out a variety of enzyme-catalysed metabolic reactions, including detoxification. Some of these reactions require oxygen.

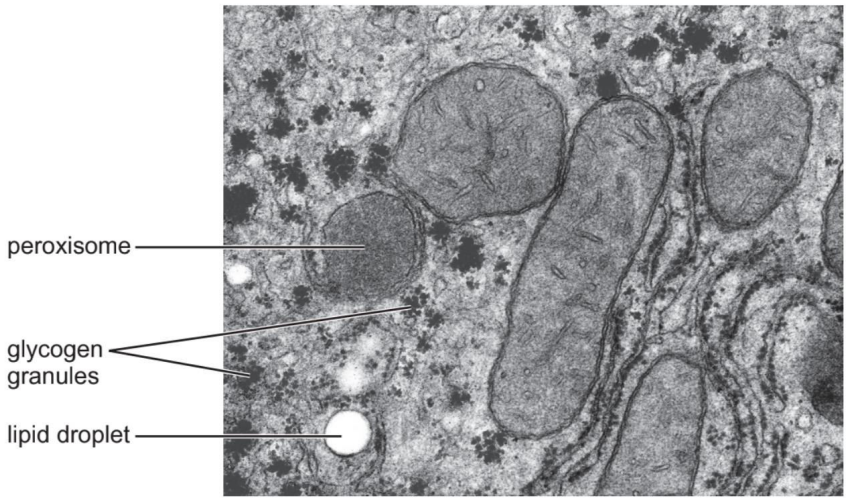

Fig. 1.2

(c) The mitochondria in Fig. 1.2 are larger than the peroxisome.

(i) State **one other** difference, **visible** in Fig. 1.2, between a peroxisome and a mitochondrion.

……

……[1]

Some of the enzymes used within mitochondria can be synthesised by the organelle.

Peroxisomes cannot synthesise any of the enzymes that they contain.

(ii) Suggest why a mitochondrion can synthesise enzymes, but a peroxisome cannot synthesise enzymes.

……

……

……

……

……

……[2]

(iii) One of the enzymes present in peroxisomes is catalase. This enzyme catalyses the breakdown of hydrogen peroxide to harmless products.

Suggest why it is useful to the cell for this reaction to take place within peroxisomes.

……

……

……

……

……[2]

[Total: 10]

Question 2

Fig. 2.1 outlines the first three stages of respiration in aerobic conditions.

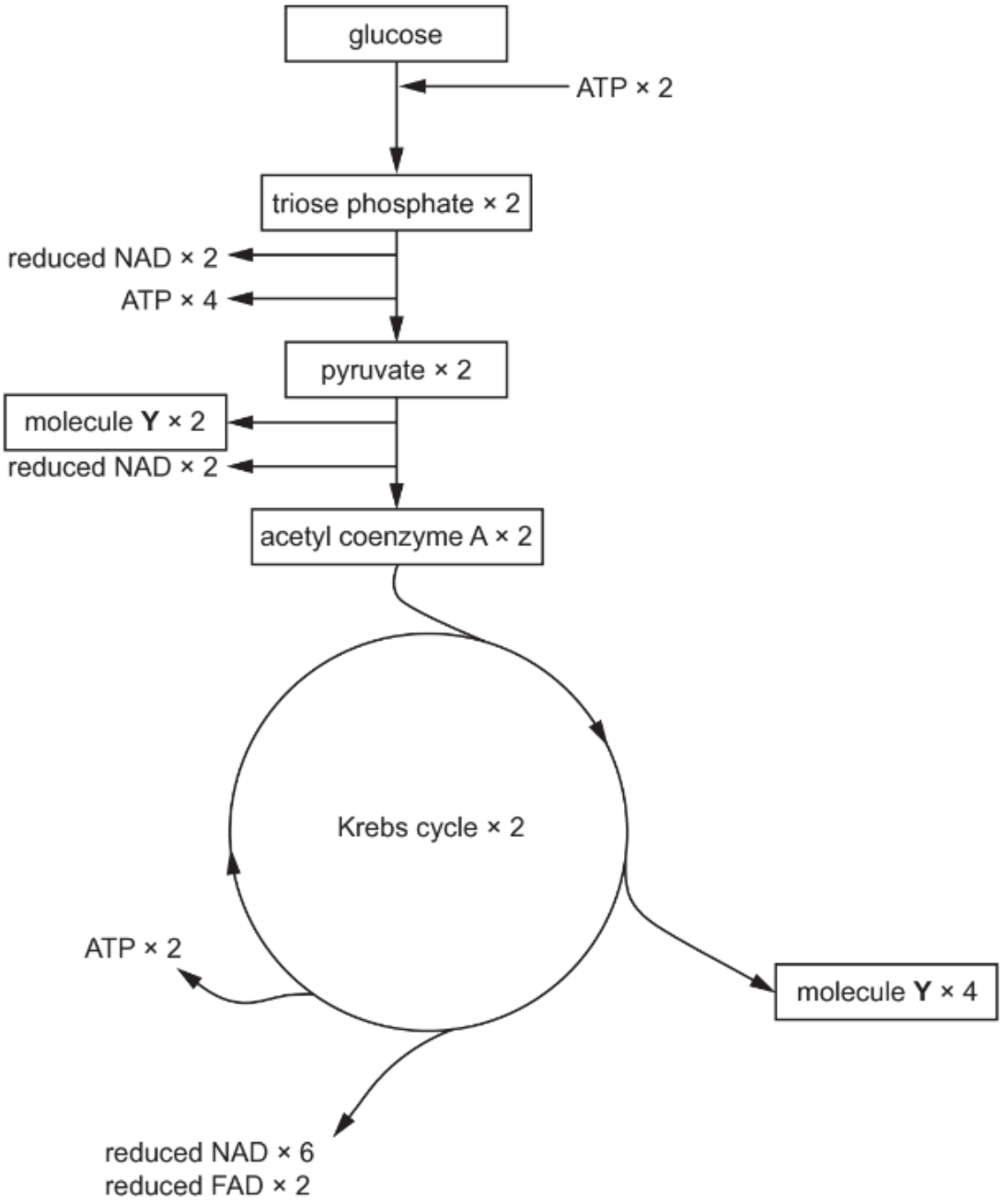

Fig. 2.1

(a) Name molecule Y in Fig. 2.1.

……[1]

(b) At one time it was thought that the oxidative phosphorylation of:

- one molecule of reduced NAD results in the synthesis of 2.5 ATP molecules
- one molecule of reduced FAD results in the synthesis of 1.5 ATP molecules.

Using Fig. 2.1, a theoretical value for the net number of ATP molecules that are synthesized for each molecule of glucose can be calculated. Modern research has shown that the actual net number of ATP molecules synthesised for each glucose molecule respired is much lower than this theoretical value.

(i) Using Fig. 2.1, calculate the theoretical value for the net number of ATP molecules that are synthesised for each molecule of glucose respired in all phosphorylation reactions.

Show your working.

answer = ... [2]

(ii) Suggest two reasons why the actual net number of ATP molecules synthesised is less than the theoretical number.

……

……

……

……

……

……

……[2]

(c) Outline the roles of NAD and FAD in aerobic respiration.

……

……

……

……

……

……

……[2]

(d) Rotenone is used as an insecticide. Rotenone kills insects by inhibiting the transfer of electrons in the electron transport chain of the mitochondrion. Explain how rotenone affects ATP synthesis in the mitochondrion.

……

……

……

……

……

……

……

……

……[3]

[Total: 10]

Question 3

The polymerase chain reaction (PCR) is used to produce large amounts of haemoglobin gene DNA from a very small original DNA sample. The main stages of a PCR are shown in Fig. 3.1.

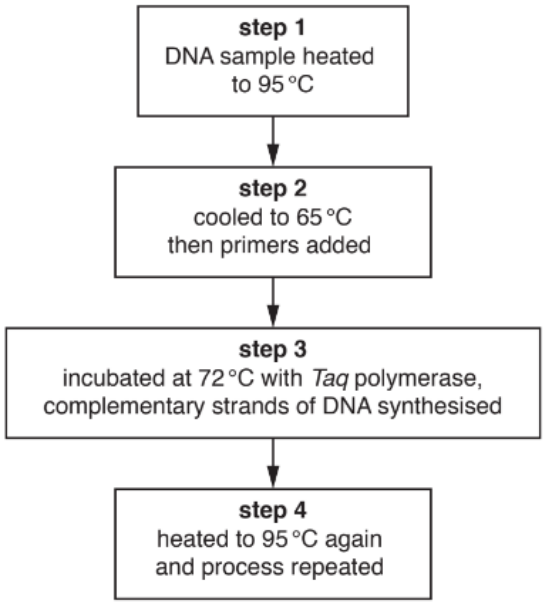

Fig. 3.1

(a) (i) Explain why the DNA sample is heated to 95°C in **step 1**.

……

……

……

……

……

……[2]

(ii) Explain why primers are added in **step 2**.

……

……

……

……

……

……[2]

(iii) Explain why the enzyme Taq polymerase is used in **step 3**.

……

……

……

……

……[2]

(b) Gel electrophoresis can be carried out to test individuals for the different versions of haemoglobin: Adult haemoglobin(HbA) , Sickle cell haemoglobin (HbS) and Fetal haemoglobin (HbF).

- A buffer with alkaline pH is used to make all haemoglobin molecules negatively charged.
- HbS molecules have an additional positive charge compared to HbA.
- Fetal hemoglobin (Hb F) accounts for about two thirds of the infant's haemoglobin while HbA acounts for the rest of the haemoglobin.

(i) Describe and explain how gel electrophoresis is used to diagnose sickle cell anaemia.

……

……

……

……

……

……

……

……

……

……[4]

(ii) Four individuals had their haemoglobin analysed by gel electrophoresis. One of the individuals was heterozygous for the HbA and HbS alleles and had a condition known as sickle cell trait (SCT). Some of the results are shown in Fig. 3.2. In Fig. 3.2, lane 1 and lane 5 are complete**.**

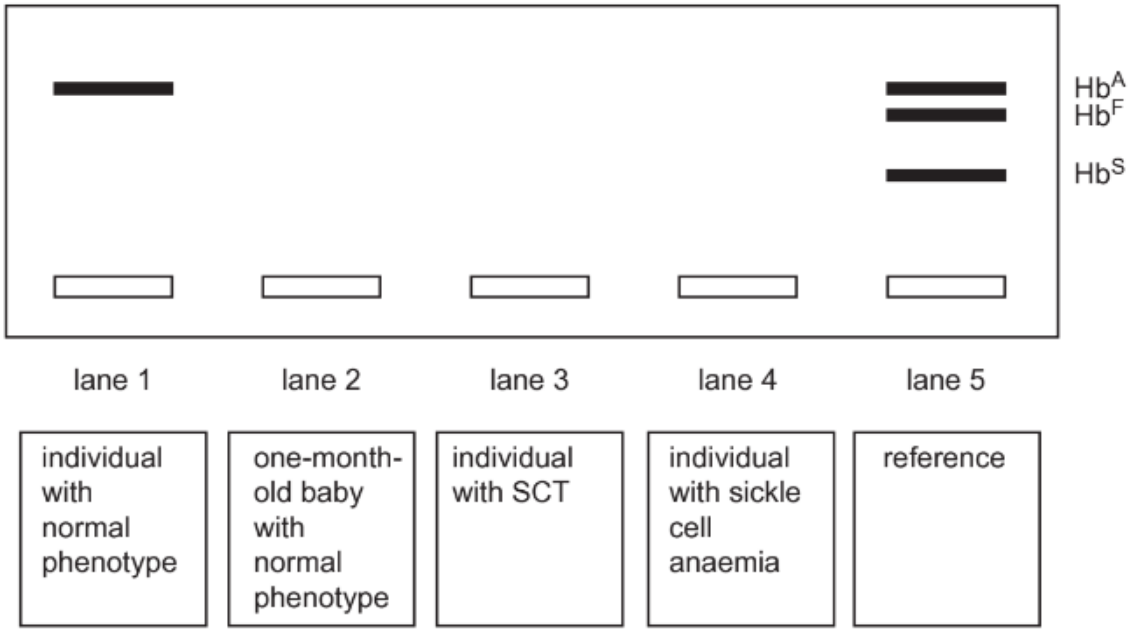

Fig. 3.2

Predict the results for the individuals analysed, by adding bands to lanes 2, 3 and 4 on Fig. 3.2.
[2]

[Total: 12]

QUESTION 4

The enzyme glucose 6-phosphate dehydrogenase (G6PD) is active in all types of cells, is involved in the normal processing of carbohydrates.

Scientists investigated the activity of two isoforms of G6PD, J and K, at different concentrations of substrate. K is a form of the enzyme that results from a mutation that changes one amino acid in the polypeptide. The results are shown in Fig. 4.1.

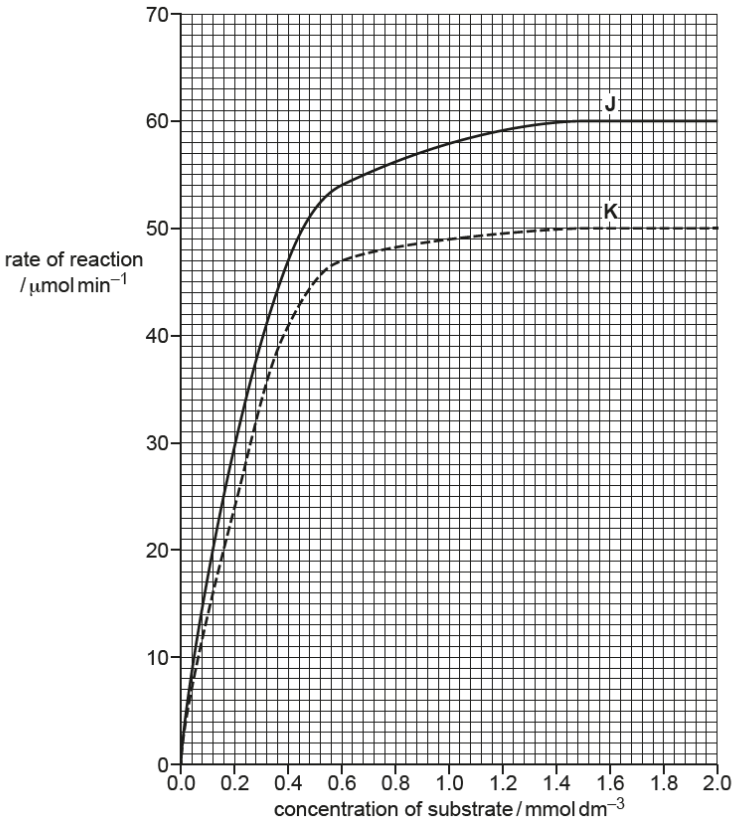

Fig. 4.1

(a) With reference to Fig. 4.1, account for the relationship when the concentration of substrate increases from 0.0 to 0.4 mmoldm^{-3} and rate of reaction for **J**. .

……

……

……

……

……

……

……

……

……[4]

(b) Describe and suggest an explanation for the effect of the mutation on the activity of G6PD.

……

……

……

……

……

……

……

……

……[4]

Fig. 4.2 shows the dimeric arrangement of human G6PD enzyme consisting of the two subunits symmetrically located across a complex interface of β-sheets and each subunit binds to a Nicotinamide Adenine Dinucleotide Phosphate ($NADP^+$) molecule that confers structural stability.

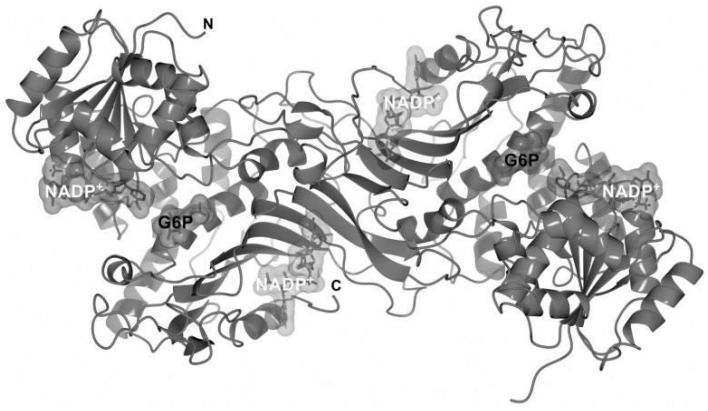

Fig. 4.2

(c) State the level of protein structure of G6PD and describe how the globular structure is held together.

……

……

……

……

……[2]

[Total: 10]

QUESTION 5

Fig. 5.1 shows the ends of a telomere elongated by a telomerase. Proteins associated with the telomerase and the RNA strand are shown.

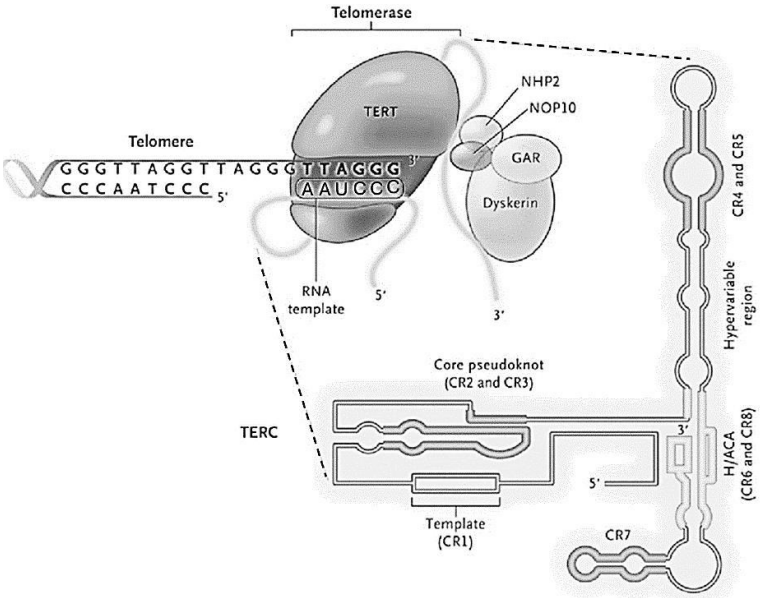

Fig. 5.1

(a) Explain why telomerase is known as a reverse transcriptase.

……

……[1]

(b) Using your knowledge and Fig. 5.1, suggest how the telomerase maintains telomere length.

……

……

……

……

……

……

……

……

……[4]

(c)(i) State two structural similarities between the RNA strand found in telomerase and tRNA.

……

……

……

……

……[2]

(ii) Describe how tRNA is adapted to its role in translation.

……

……

……

……

……[2]

[Total : 9]

QUESTION 6

In a sample of rat bladder tumours, more than a thousand different mutations in the *p53* tumour suppressor gene were found. A mutation frequency map of the mutated *p53* tumour suppressor gene is shown in Fig. 6.1. The mutation frequency map comprises the following:

- the incidence of tumour-derived mutation at each amino acid residue is indicated by the height of the bars,
- the amino acid sequence is indicated in a single-letter nomenclature,
- the underlined residues are those most highly conserved in the protein in normal rats, and
- the rectangles and arrows represent α-helices and β-pleated sheets respectively.

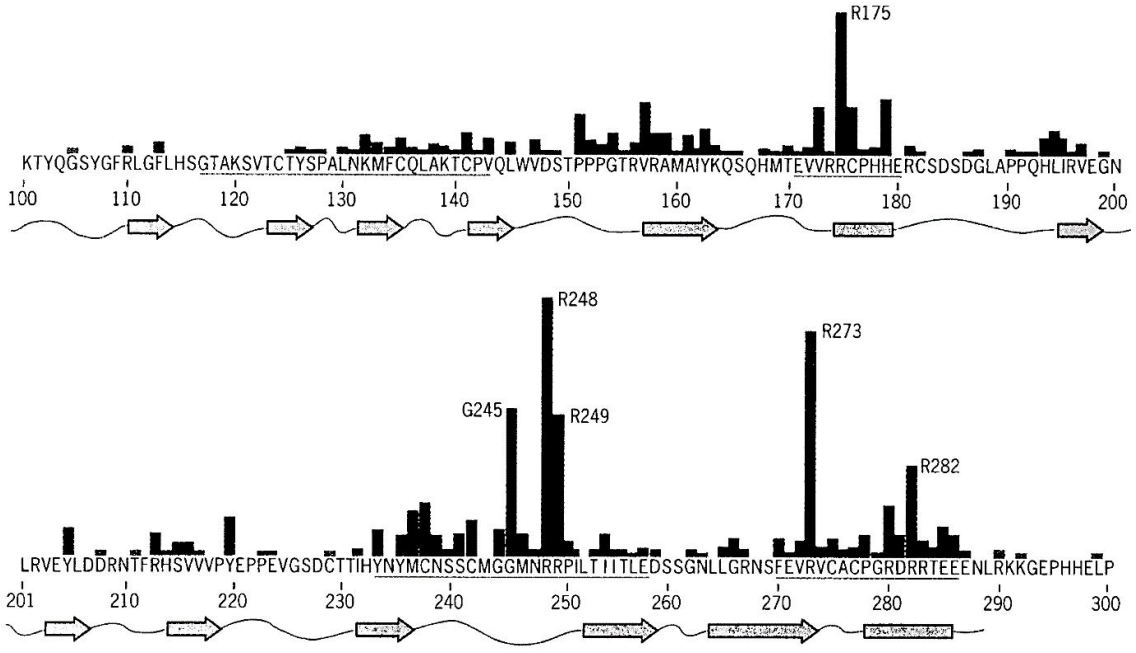

Fig. 6.1

(a) With reference to Fig. 6.1, deduce the relationship between the locations of the mutations and their frequency of occurrence in the *p53* tumour suppressor gene.

……

……

……

……

……[2]

(b) Explain how these mutations in the *p53* gene can contribute to the formation of rat bladder tumours.

……

……

……

……

……

……

……[3]

In the same sample of rat tumours, it was found that the concentration of epidermal growth factor was higher than other normal cells. Epidermal growth factor promotes cell growth and cell survival. Fig. 6.2 shows the cell signaling pathways of epidermal growth factor.

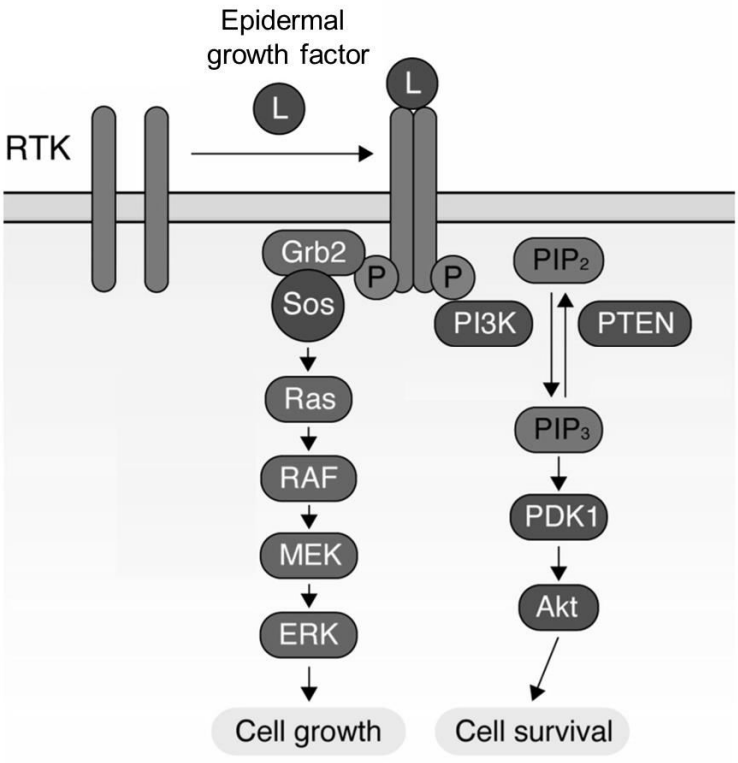

Fig. 6.2

(c) With reference to Fig. 6.2, describe how a higher concentration of epidermal growth factor contributes towards to formation of tumour.

……

……

……

……

……

……

……

……

……

……

……[5]

[Total: 10]

QUESTION 7

(a) Describe the stages in meiosis that allows variation to occur.

……

……

……

……

……

……

……

……

……[4]

Inheritance of wing shape and eye colour in the fruit fly, *Drosophila melanogaster*, is controlled by two genes.

Gene **N**/**n** controls wing shape. Allele **N** for wrinkled wings is dominant to allele **n** for normal wings.

Gene **E**/**e** controls eye colour. Allele **E** for rosy eyes is dominant to allele **e** for red eyes

A biologist predicted that, if the genes are on **different** chromosomes, the ratio of the phenotypes of the F2 generation would be 9:3:3:1.

The biologist carried out a breeding experiment.

- Homozygous dominant fruit flies with wrinkled wings and rosy eyes were crossed with homozygous recessive fruit flies with normal wings and red eyes.
- All the F1 fruit flies had wrinkled wings and rosy eyes.

The F1 fruit flies were crossed with each other.

Table 7.1 shows the results for the F2 generation and the biologist also calculated the predicted frequency using the 9:3:3:1 ratio.

Table 7.1

F2 phenotypes	Observed Frequency	Predicted frequency
wrinkled wings, rosy eyes	50	45
wrinkled wings, red eyes	6	15
normal wings, rosy eyes	4	15
normal wings, red eyes	10	5
Total	80	80

(b) Using the symbols provided, draw a genetic diagram to explain the cross between the F1 generation and the results of the F2 generation.

Genetic Cross:

[4]

(c) Explain for the difference in the observed and predicated frequency of the F2 generation.

……

……

……

……

……[2]

[Total: 10]

QUESTION 8

In 1946, Lederberg and Tatum performed an experiment to determine if genetic transfer occurs between bacteria cells. They used two strains of bacteria lacking in essential genes. Strain A does not encode for biotin (bio^-) and methionine (met^-) while strain B does not encode for phenylalanine (phe^-) and threonine (thr^-). Bacteria lacking in essential genes cannot grow on minimal media.

These two strains were also mixed in the same test tube and then plated on minimal media.

Fig. 8.1 shows the experiment and the results obtained.

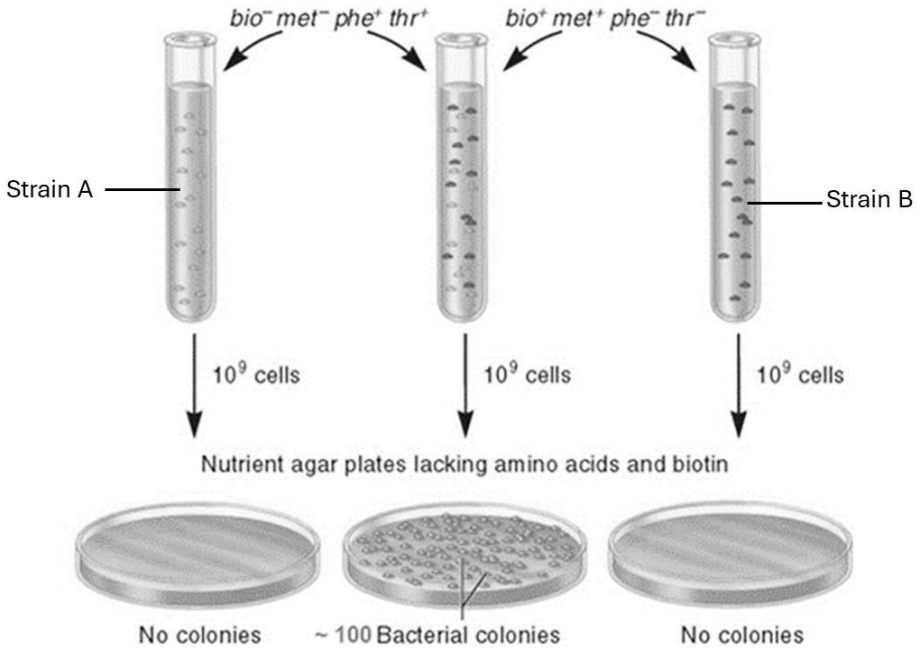

Fig. 8.1

(a) **(i)** With reference to the results and the information provided, infer the conclusion of this experiment.

……

……

……

……

……[2]

In 1950, Bernard Davis performed a similar experiment. He put two strains of bacteria, each lacking in essential genes, into a U-tube and separated them with a filter (Fig. 8.2). The filter has pores small enough to allow the passage of genetic material and viruses but too small to permit the passage of bacterial cells. The application of alternating pressure and suction promoted the movement of liquid through the filter.

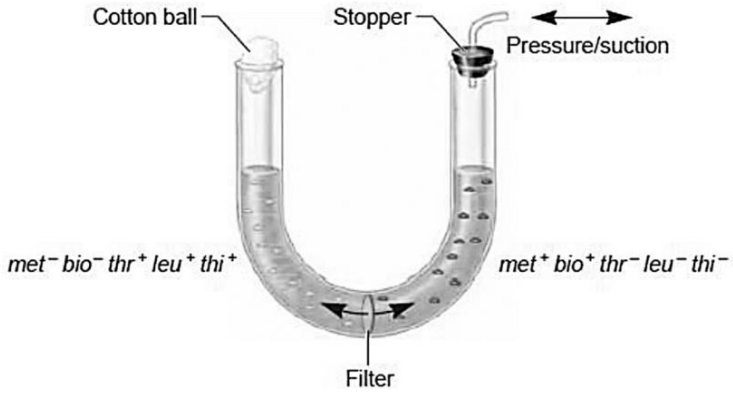

Fig. 8.2

Bacteria from either side of the tube were placed on minimal media. No bacteria colonies grew on the plates.

(ii) Based on both Lederberg and Tatum's and Davis's experiments, explain why no bacteria colonies grew from either side of the tube.

……

……

……

……

……[2]

In bacteria, the concentration of the amino acid methionine is regulated by the *met* operon. The *met* operon is a repressible operon that functions in the same way as the *trp* operon.

(b) (i) Using your understanding of the *trp* operon, discuss how synthesis of methionine can be repressed.

……

……

……

……

……

……

……[3]

(ii) In a population of bacteria infected by lambda phage, methionine was synthesised regardless of the concentration of methionine. Suggest how this may occur.

……

……

……

……

……[3]

[Total: 10]

Question 9

Twenty million years ago, an ocean covered the area where the country of Panama is now located. There was a gap between the continents of North America and South America through which the waters of the Atlantic and Pacific Oceans flowed freely.

The porkfish, *Anisotremus sp*, lived in this area between North America and South America.

Fig. 9.1 shows a porkfish.

Fig. 9.1

Inhabiting shallow inshore waters over reefs and rocky bottoms, the porkfish is found at depths of 6-65 feet (2-20 m).

About 3 million years ago, volcanic activity and sedimentation formed a narrow strip of land, Panama, joining North America and South America.

Twenty million years ago, porkfish in the Atlantic and Pacific Oceans were able to breed successfully and produce fertile offspring.

Fig. 9.2 shows the area 20 million years ago and now.

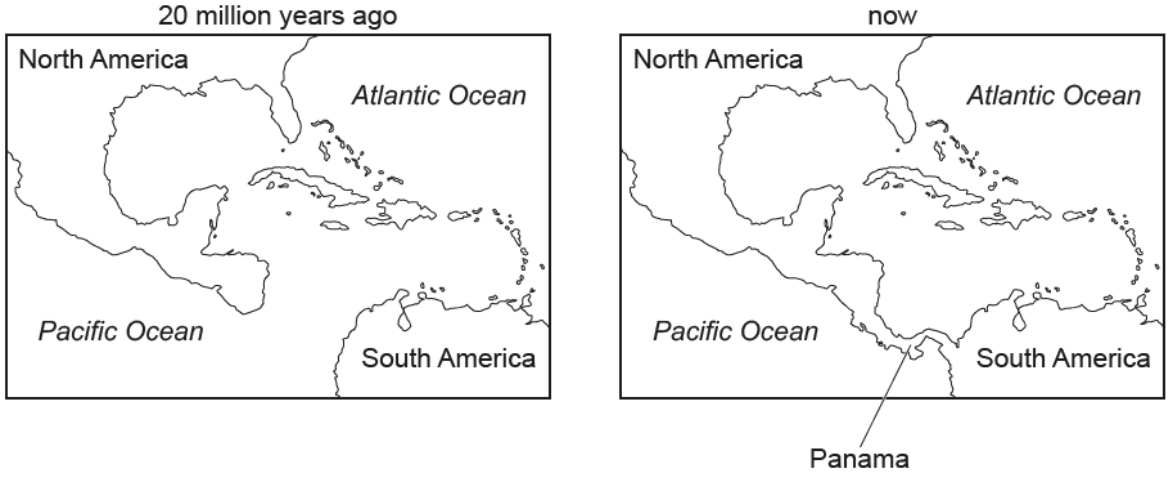

Fig. 9.2

(a) Using your knowledge on the species concept, explain why the Atlantic porkfish and Pacific porkfish were considered one species twenty million years ago.

……

……

……

……

……[2]

(b) Explain why Atlantic porkfish and Pacific porkfish are now not able to breed successfully to produce fertile offspring.

……

……

……

……

……

……

……[3]

Fig. 9.3 shows forelimb skeletal pattern of four vertebrates,

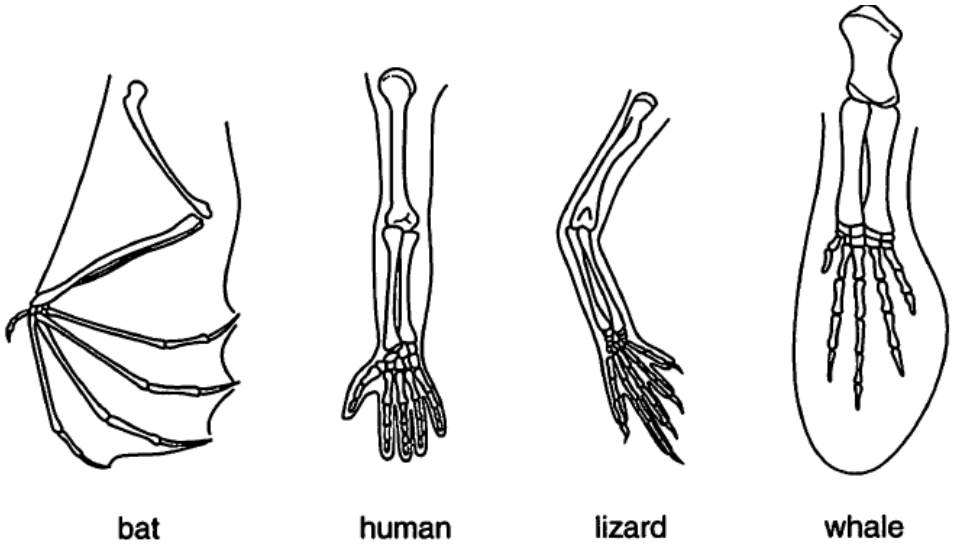

Fig. 9.3

(c) Explain how the relationship between the structures in Fig. 9.3 provide evidence to support the theory of evolution.

……

……

……

……

……

……

……[3]

HoxA/D cluster genes are active during limb development, and over the last two decades, have been the focus of many studies aimed at gaining insights into the evolutionary origin of limb-specific morphologies.

(d) State two advantages of using molecular methods in classifying organisms.

……

……

……

……

……[2]

[Total: 10]

Question 10

Fig. 10.1 is a simplified diagram representing a section through the human immunodeficiency virus (HIV) particle that causes HIV/AIDS. The diagram shows the virus particle about to attach to the cell surface membrane of a T-helper cell at a receptor protein called CD4. A second protein (coreceptor) called CCR5 is also necessary for the virus particle to enter and then infect the T-helper cell.

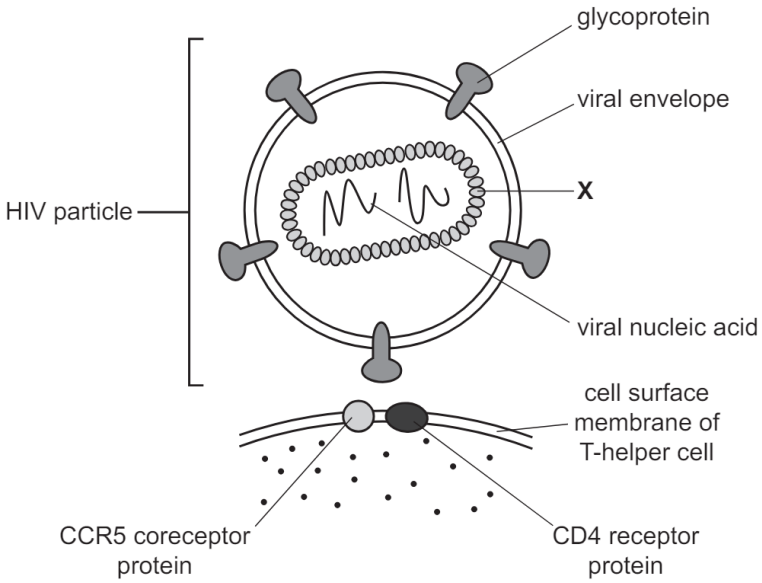

Fig. 10.1

(a) Identify structure X in Fig. 10.1.

……[1]

(b) Explain how the ability of the immune system to resist the damaging effects of a pathogen is affected by destruction of T-helper cells.

……

……

……

……

……

……

……

……[3]

(c) Studies have shown that some individuals did not become infected with HIV even though they were repeatedly exposed to the virus. Later discoveries indicated that these individuals had a mutation in the gene for the CCR5 coreceptor protein. Suggest how mutation of the gene for the CCR5 coreceptor protein provided protection against HIV infection.

……...……

……...……[1]

[Total: 5]

Question 11

Fig. 11.1 shows the number of bleaching events around the world.

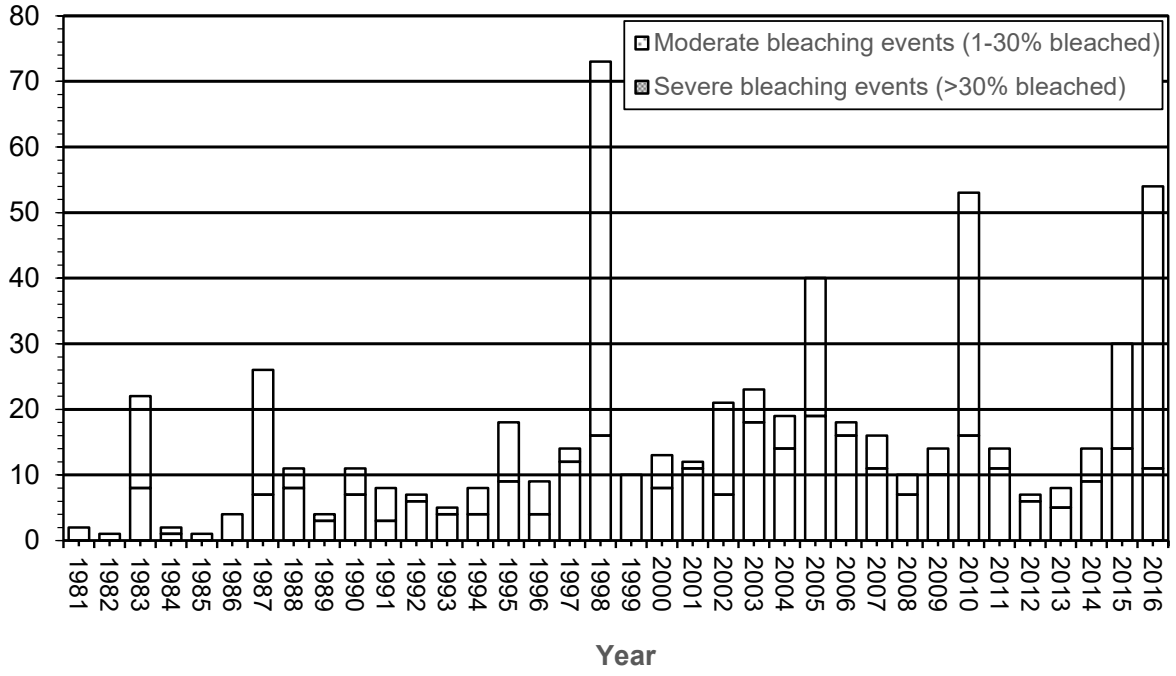

Fig. 11.1

(a) With reference to Fig. 11.1, state the differences in the number of bleaching events in 1981 and 2016.

……

……

……

……

……[2]

(b) Describe how climate change causes severe bleaching events.

……

……

……

……

……[2]

[Total: 4]