YISHUN INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAM
Higher 2

NAME

INDEX NO | CG

BIOLOGY

9744/02

Paper 2 Structured Questions

30 Aug 2023

Candidates answer on the Question Paper.

2 hours

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index no. and CG on this cover page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer all questions in the spaces provided on the Question paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

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

For Examiner's Use	
Section A	
1	/10
2	/10
3	/8
4	/10
5	/10
6	/12
7	/10
8	/10
9	/10
10	/5
11	/5
Total	/100

This document consists of **23** printed pages and **1** blank page.

Answer **all** questions.

1 Fig. 1.1 shows an electron micrograph of a chloroplast.

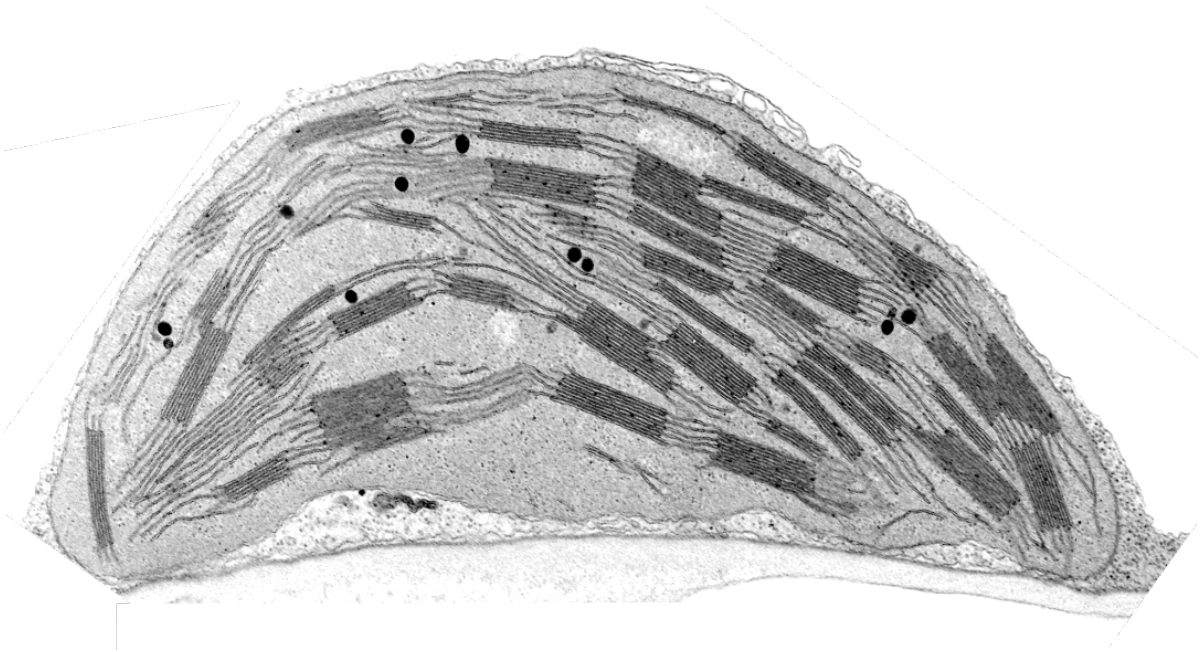

Fig. 1.1

(a) **(i)** On Fig. 1.1, use the letter **X** and a label line to identify where the light-independent stage of photosynthesis occurs. [1]

(ii) Describe **two** ways in which the structure of the chloroplast is adapted for its function.

---

[2]

(iii) Both the chloroplast and the mitochondrion have double membranes. State **two** other structural similarities between the chloroplast and the mitochondrion.

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[2]

(b) Fig. 1.2 shows the relationship between CO_2 assimilation rate and increasing light intensity on a plant, when carbon dioxide concentration is not a limiting factor.

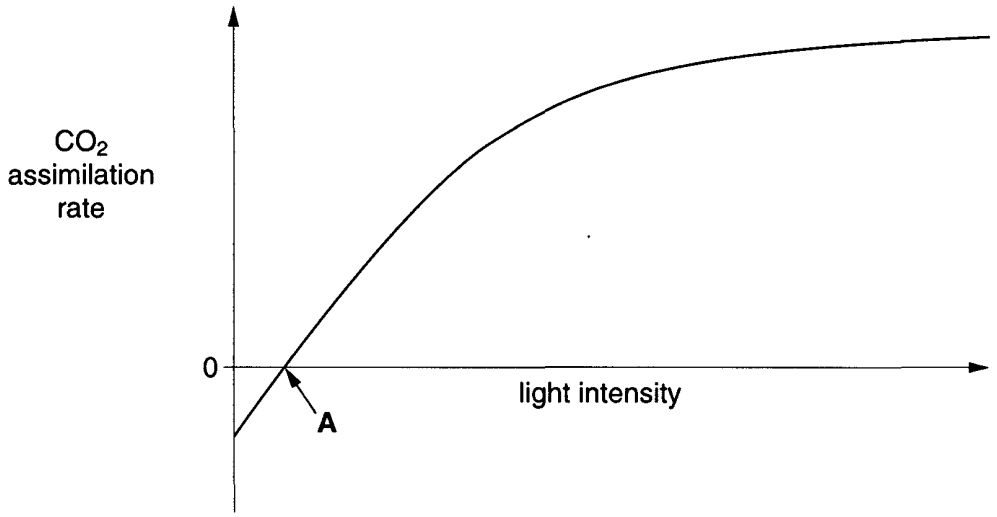


Fig. 1.2

(i) Explain why the CO_2 assimilation rate plateaus at high light intensity.

[3]

(ii) Describe what is occurring at point **A**.

[2]

[Total: 10]

2 An investigation was carried out to find the optimum pH and the optimum temperature of an amylase obtained from the bacterium *Anoxybacillus thermarum*.

Fig. 2.1 shows the results of the investigation.

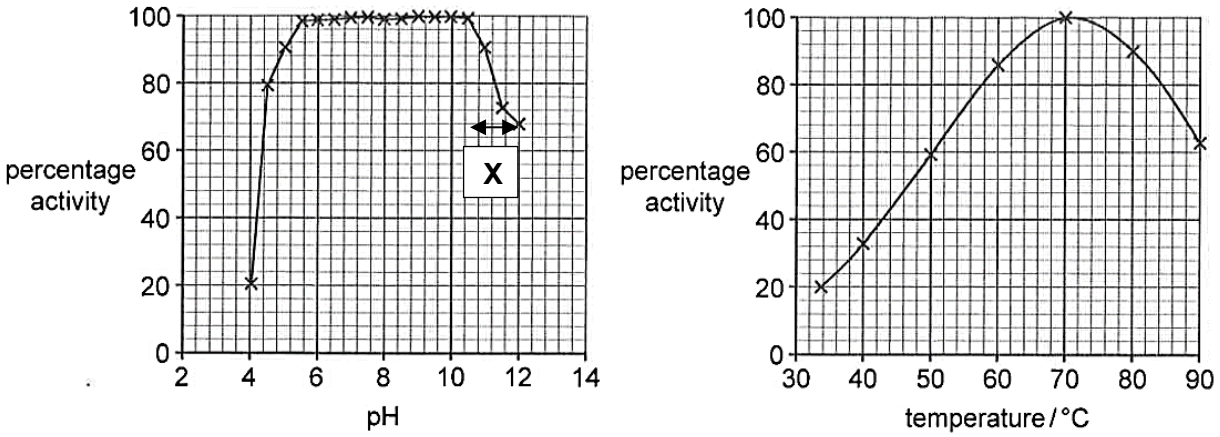


Fig. 2.1

(a) With reference to Fig. 2.1, compare the effect of temperature on the activity of the amylase and the effect of pH on the activity of the amylase.

[3]

(b) Explain the percentage activity of amylase at **X**.

[3]

Table 2.1 shows the optimum pH and optimum temperature for amylase from different species of bacteria.

Table 2.1

species of bacteria	optimum pH	optimum temperature /°C
Bacillus amyloliquefaciens	7.0	70
Bacillus circulans	4.9	48
Bacillus halodurans	10.5–11.0	60–65
Bacillus licheniformis	4.0–9.0	90
Bacillus subtilis	7.5	50
Geobacillus stearothermophilus	5.6	80

(c) **(i)** Using the data in Fig. 2.1 and Table 2.1, identify the bacterial species that has amylase most similar to amylase from *Anoxybacillus thermarum*.

.....

[1]

(ii) Suggest why the amylase molecules of some species of bacteria are able to work at higher temperatures than others.

.....

.....

.....

.....

.....

.....

.....

[3]

[Total: 10]

3 **(a)** Stem cells from the human bone marrow that are involved in blood cell formation are described as multipotent, rather than totipotent.

Compare multipotent and totipotent stem cells.

[2]

(b) Some fully differentiated cells can be stimulated to change back into stem cells in tissue culture. Such cells are called induced pluripotent stem cells (iPS cells).

In *in vitro* experiments with human cells, it was discovered that the introduction of five genes would cause fully differentiated skin fibroblast cells to change to iPS cells. There is evidence to suggest that the introduction of the five genes caused an increase in the production of telomerase reverse transcriptase (TERT) in the fully differentiated cells.

(i) Explain how TERT may help to change the fully differentiated cells back into stem cells.

[3]

(ii) Explain why it may be advantageous to use iPS cells for treating diseases in humans, instead of performing organ or tissue transplant.

[2]

(c) Suggest why the use of stem cells in treatment gives a greater risk of cancer in the future.

[1]

[Total: 8]

4 Fig. 4.1 shows the structure of TLA-1 virus, a newly discovered virus which causes coral disease.

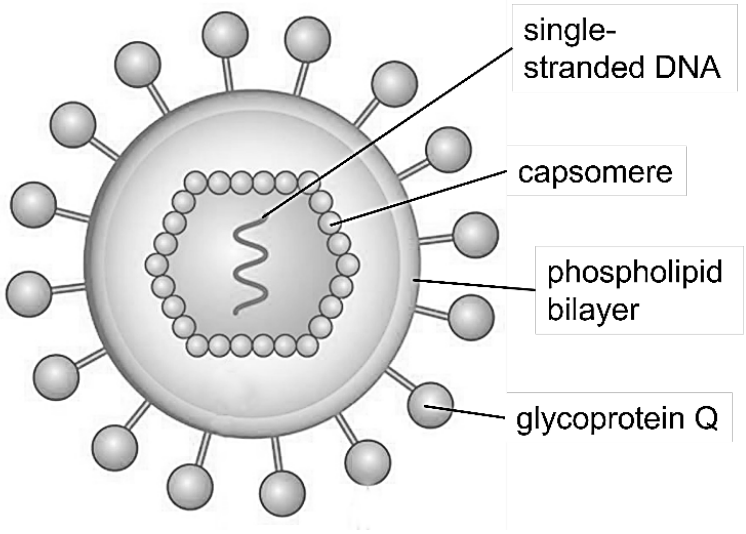


Fig. 4.1

(a) Describe two differences between the structures of TLA-1 virus and the Human Immunodeficiency Virus (HIV).

[2]

Fig. 4.2 shows the number of T helper cells in the blood and the number of HIV viruses in the body over the course of an untreated HIV infection.

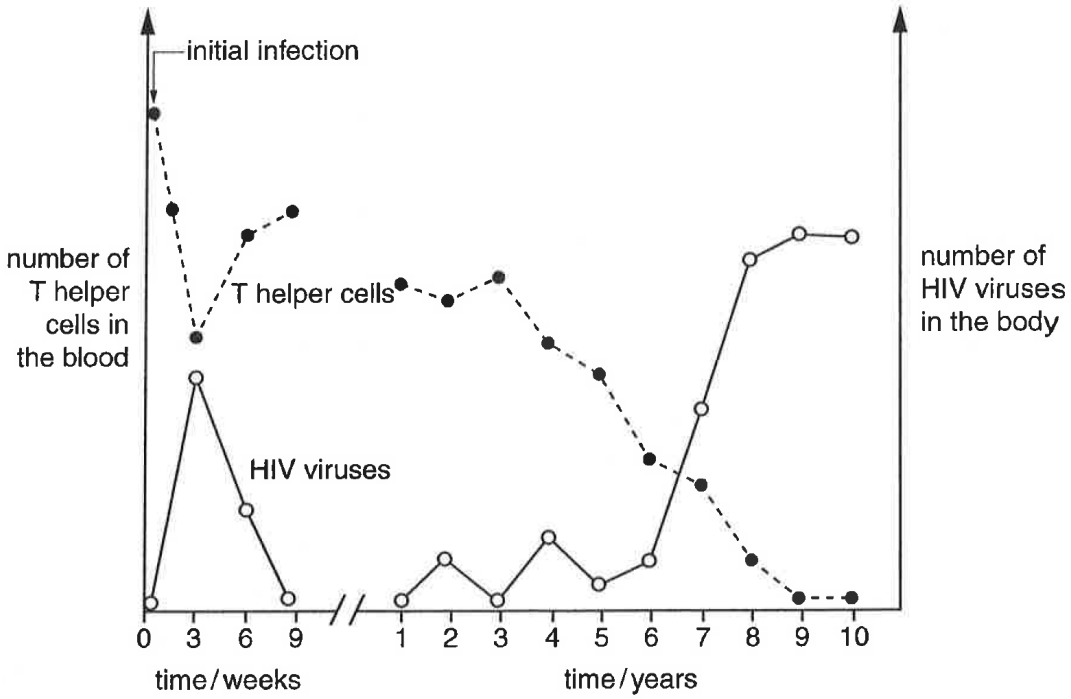


Fig. 4.2

(b) **(i)** Describe the changes shown in Fig. 4.2.

[2]

(ii) Suggest how the changes in the number of T helper cells from year 1 to year 10 would affect the health of the untreated HIV patient.

[2]

(iii) Explain why HIV is considered a retrovirus.

[2]

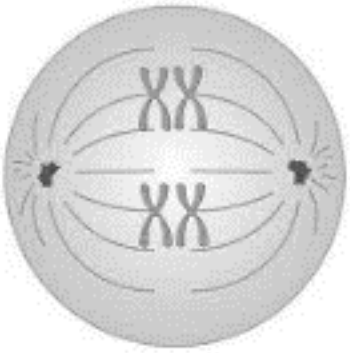
(iv) Explain why viruses are considered obligate parasites.

[2]

[Total: 10]

5 Fig 5.1 shows the electron micrographs of two stages of meiosis, **J** and **K**.

stage **J**



stage **K**

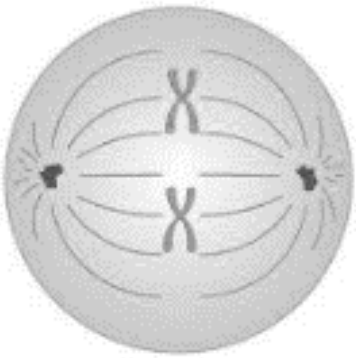


Fig. 5.1

(a) Name the stages of meiosis labelled **J** and **K** in Fig. 5.1 **and** describe the behaviour of chromosomes in each of these stages.

stage **J** ---

behaviour of chromosomes in **J** ---

---

stage **K** ---

behaviour of chromosomes in **K** ---

---

[4]

(b) Describe **four** main differences between mitosis and meiosis.

	Mitosis	**Meiosis**
1		
2		
3		
4		

[4]

(c) In the absence of chromosomal aberration, gene mutation or events during stage **J**, outline how events **before** stage **J** and **after** meiosis lead to genetic variation between offspring of the same parents.

[2]

[Total:10]

6 The genes for eye colour and coat colour in mouse-deer are found on separate chromosomes. One gene is found on chromosome 3, while the other gene is found on the X chromosome. Female mouse-deer are XX and male mouse-deer are XY.

To investigate the inheritance of eye colour and coat colour in mouse-deer, a scientist performed a reciprocal cross using purebred individuals. Table 6.1 shows the phenotypic ratio of the F_1 generations from the reciprocal cross.

Table 6.1

Cross	Parents (purebred)	F_1 phenotypic ratio	Number of F_1 progeny
1	Black eyed, coloured-coat female × Pink eyed, albino-coat male	1 black eyed, coloured-coat female : 1 black eyed, coloured-coat male	88
2	Black eyed, coloured-coat male × Pink eyed, albino-coat female	1 black eyed, coloured-coat female : 1 pink eyed, coloured-coat male	90

(a) Explain what is meant by *reciprocal cross.*

.....

.....

[1]

(b) State whether the gene coding for eye colour or coat colour is found on the X chromosome.

.....

[1]

(c) Explain your answer to **(b)**.

.....

.....

.....

.....

[1]

(d) Using appropriate symbols to represent alleles coding for eye colour and coat colour, draw a genetic diagram to illustrate **cross 2** in Table 6.1.

[4]

(e) The scientist proceeded with a more detailed count of the F_1 progeny from cross 2. He determined that there were 40 black eyed, coloured-coat females and 50 pink eyed, coloured-coat males.

To check if the deviation between the observed and expected numbers of the F_1 progeny from cross 2 was statistically significant, the scientist carried out the chi-squared (χ^2) test.

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

where Σ = sum of
O = observed value
E = expected value

Table 6.2

degrees of freedom	probability, p				
	0.10	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

Using the formula for χ^2 provided and Table 6.2,

(i) state the expected numbers in cross 2 for

black eye, coloured-coat females: .....

pink eye, coloured-coat males: ..... [1]

(ii) State the calculated chi-squared value, to 2 decimal places.

..... [1]

(iii) State the conclusions drawn from the chi-squared test.

.....

.....

.....

.....

..... [3]

[Total: 12]

7 Fig 7.1 shows the protein structure of G protein-linked receptor (GPLR).

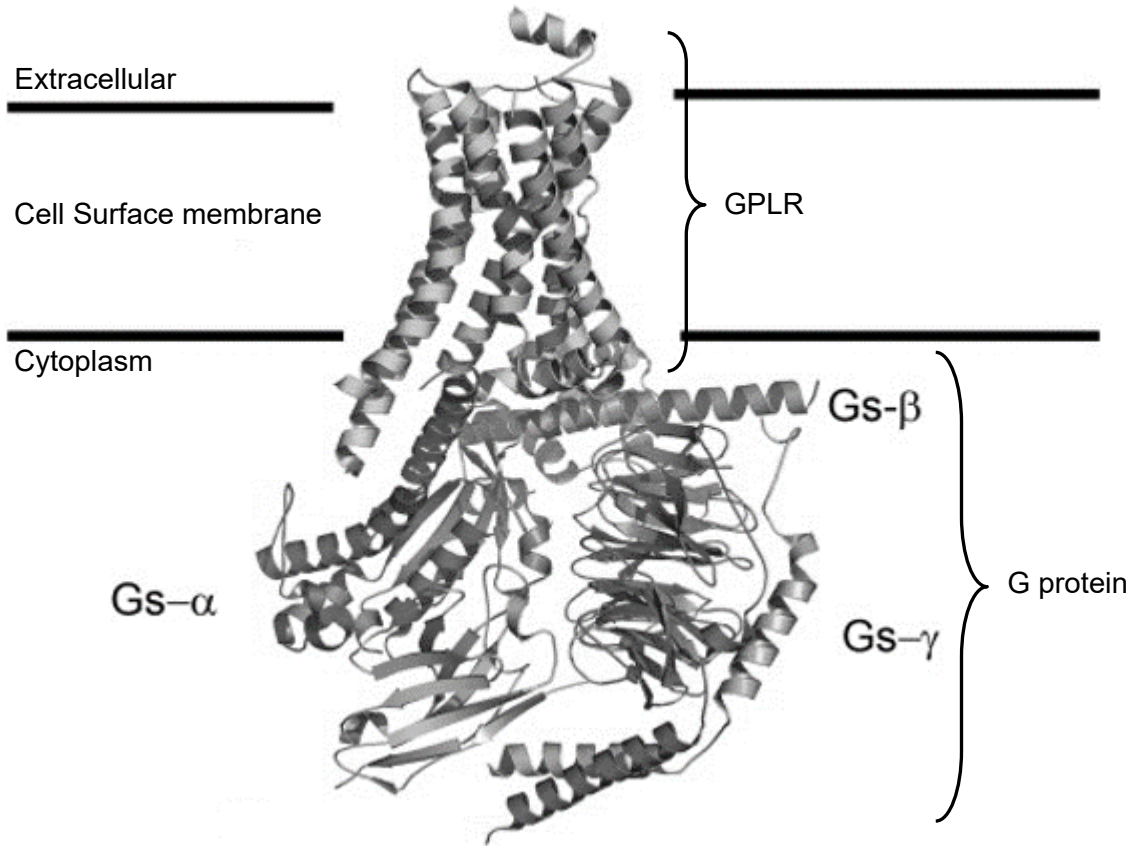


Fig. 7.1

(a) Describe how GPLR is anchored in the cell surface membrane.

.....

.....

.....

.....

[2]

(b) State the highest level of protein structure for GPLR.

.....

[1]

(c) GPLR signalling with glucagon prevents blood glucose concentration from dropping below the threshold level.

Explain **two** ways in which GPLR signalling with glucagon prevent the blood glucose concentration from dropping below threshold level.

[2]

(d) The G protein is made up of three subunits, Gs-α, Gs-β and Gs-γ. Inactive G protein is bound to GDP.

Explain how the activation of the G protein results in the production of cyclic AMP (cAMP).

[3]

(e) Receptor tyrosine kinases (RTKs) are another type of cell surface receptors for many polypeptide growth factors, cytokines, and hormones.

Describe **two** ways in which the signalling pathways of RTK and GPLR differ.

[2]

[Total: 10]

8 The liver tissue was homogenised and cell fractionation was performed. A sample of mitochondria was obtained by differential centrifugation and resuspended in a buffer.

The concentration of H^+ in two compartments within mitochondria was measured at regular intervals. Ten minutes after the start of the experiment, a 10nM pyruvate solution was added to the buffer containing mitochondria.

The results of the experiment are shown in Fig. 8.1.

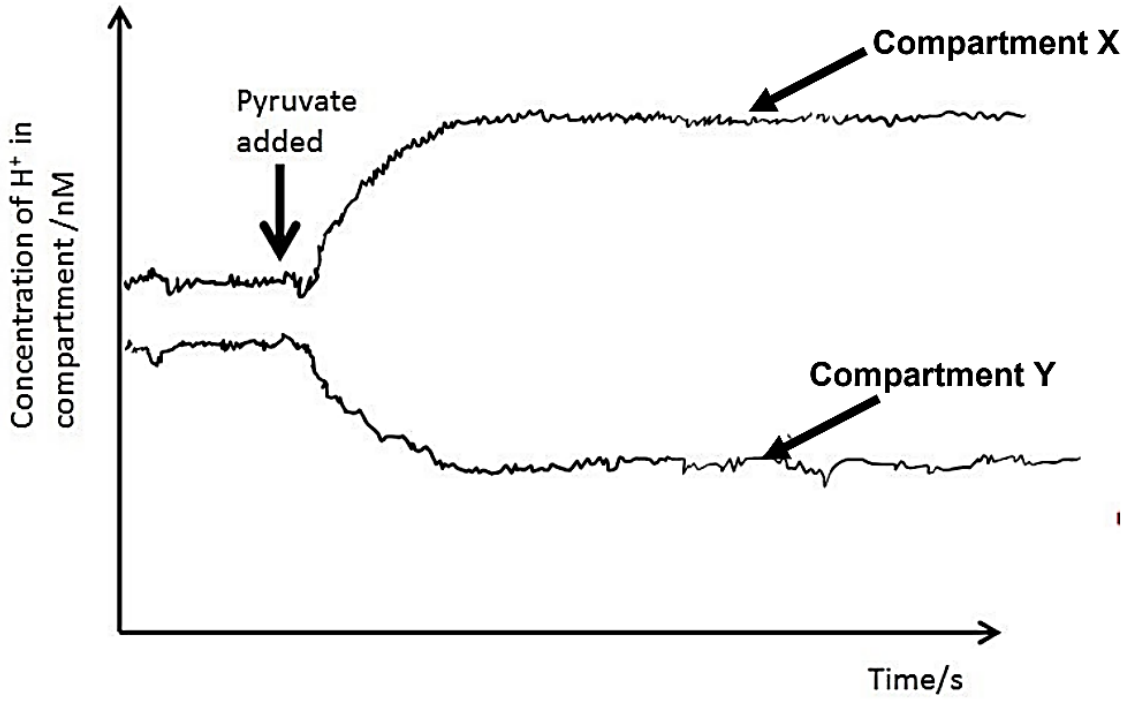


Fig. 8.1

(a) **(i)** Identify compartments **X** and **Y** in a mitochondrion.

X .....

Y ..... [1]

(ii) Explain the changes in the concentration of H^+ in compartment **X** following the addition of pyruvate into the buffer.

.....

.....

.....

.....

.....

..... [3]

(b) A metabolic poison, 2,4-dinitrochlorobenzene (2DNP), acts as a proton ionophore, an agent that can transport protons across biological membranes down a concentration gradient.

(i) The experiment was repeated in the presence of high concentration of 2DNP.

Sketch on Fig. 8.1, a graph that shows the concentration of H^+ in compartment **Y** in the presence of 2DNP. [1]

(ii) Explain the effect of 2DNP on ATP synthesis.

[2]

(c) Compare the production of ATP in photophosphorylation and oxidative phosphorylation.

[3]

[Total: 10]

9 The aye-aye, *Daubentonia madagascariensis*, is a primate native to Madagascar. Aye-ayes are nocturnal (active at night) and make their nests high up in trees. They feed on insect larvae in the trunks of trees.

Fig. 9.1 shows an aye-aye.

Fig. 9.1

The International Union for Conservation of Nature (IUCN) is the world's largest global environmental organisation. The IUCN Red List of Threatened Species™ evaluates the conservation status of plant and animal species.

The aye-aye is categorised as endangered on the IUCN Red List, which means that it faces a very high risk of becoming extinct in the wild.

(a) (i) Table 9.1 shows the taxonomic classification of the aye-aye.

Table 9.1

Domain	Eukarya
Kingdom	.....
.....	Chordata
.....	Mammalia
.....	Primates
Family	Daubentoniidae
Genus	.....
.....	*Daubentonia madagascariensis*

Complete Table 9.1. [3]

(ii) Suggest **one** reason why aye-ayes have become endangered.

.....

[1]

.....

There are two main aye-aye populations on the island of Madagascar, one in the west and one in the east.

Fig. 9.2 is a map of Madagascar showing the location of the two main populations.

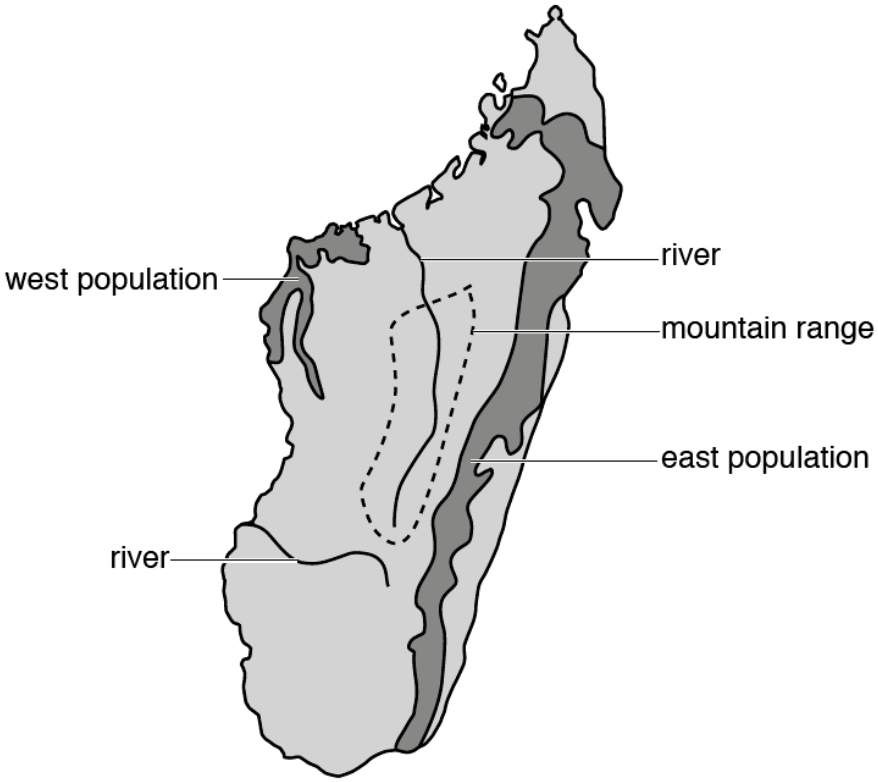


Fig. 9.2

A study into the variation in the DNA nucleotide sequence of aye-ayes showed that the genetic difference between the east and west populations has been gradually increasing over the past decades.

It is postulated that the two populations of aye-ayes may be experiencing divergent evolution.

(b) **(i)** State one advantage of using DNA nucleotide sequence in this study.

.....

[1]

.....

(ii) With reference to Fig. 9.2, suggest why the two populations of aye-ayes may be experiencing divergent evolution.

[4]

(iii) As the two populations of aye-ayes continue to experience divergent evolution, they could eventually become two different species.

Name the type of speciation that may occur.

[1]

[Total: 10]

10 In Singapore, the Bacillus Calmette-Guerin (BCG) vaccine is used to prevent tuberculosis (TB). The vaccine contains the live, attenuated strain of *Mycobacterium bovis*.

The genus *Mycobacterium* is characterised by slender, non-motile rods with complex, lipid-rich cell walls, as shown in Fig. 10.1. Many mycobacterial species share similar growth and biochemical characteristics.

Fig. 10.1

(a) Describe how tuberculosis is transmitted from one person to another.

[2]

(b) Explain how vaccinating a person using the BCG vaccine can provide him with long-term protection against tuberculosis.

[3]

[Total: 5]

11 The *Aedes aegypti* mosquito is the main vector that transmits the viruses that cause dengue. The viruses are passed on to humans through the bites of an infective female *A. aegypti* mosquito, which mainly acquires the virus while feeding on the blood of an infected person.

Fig. 11.1 shows the monthly number of dengue cases from 2018 to 2021 with highest number of cases coinciding with summer.

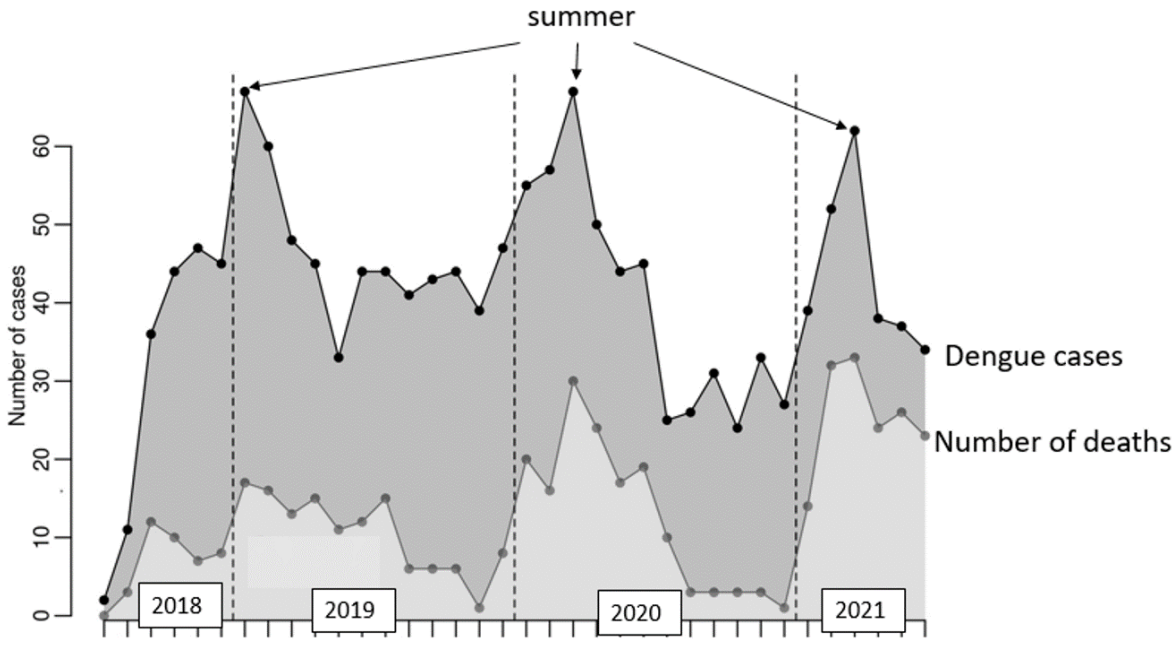


Fig. 11.1

(a) Describe the pattern of resurgence (sudden increase) of dengue cases from 2019 to 2021 shown in Fig.11.1.

[2]

(b) Suggest **three** possible ways in which climate change can result in the pattern described in **(a)**.

[3]

[Total: 5]

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