VICTORIA JUNIOR COLLEGE
PRELIMINARY EXAMINATION
HIGHER 2

CANDIDATE NAME: ……

CT GROUP: ……

BIOLOGY 9744/02

Paper 2 Structured Questions 14 September 2023

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and CT group in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, 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 bracket [ ] at the end of each question or part question.

Question	Marks
1	/9
2	/12
3	/9
4	/9
5	/10
6	/12
7	/9
8	/8
9	/12
10	/5
11	/5
Total	**100**

Answer **all** questions.

1 The cell surface membrane regulates the movement of different substances via different mechanisms.

Table 1.1 shows the results from an investigation to determine how two different drugs A and B enter animal cells.

Table 1.1

concentration of drug **A** in container / arbitrary units	concentration of drug **A** inside the cells after 5 minutes / arbitrary units	concentration of drug **B** in container / arbitrary units	concentration of drug **B** inside the cells after 5 minutes / arbitrary units
0	0	0	0
5	5	5	4
10	10	10	7
15	15	15	11
20	19	20	13
25	24	25	13

Cells which did not contain either drug were placed into separate containers. Different concentrations of each drug were added and after 5 minutes, the drug concentration in the cells was measured.

(a) Based on the data shown in Table 1.1,

(i) state the chemical nature of drugs A and B.

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(ii) explain the difference between the transport of drugs A and B.

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(b) Viruses make use of certain properties of the cell membrane to facilitate their release from the host cell. Fig. 1.1 shows such a process.

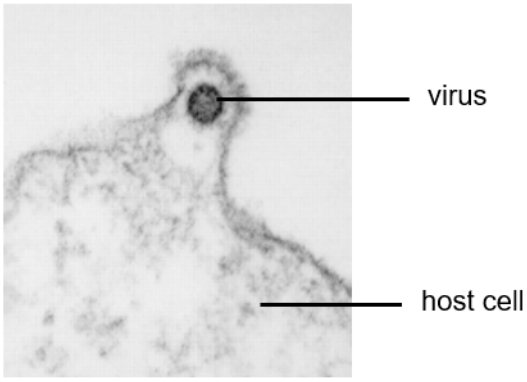

Fig. 1.1

(i) Explain clearly how the structure of the cell membrane facilitates this process.

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(ii) Contrast the process seen in Fig 1.1 with the process in which HIV virus enters the host cell.

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[Total: 9]

2 (a) Starch molecules are the main storage molecules in many types of cereal grain, such as the grain of the barley plant. When the seed inside a barley grain germinates, enzymes are synthesised to catalyse the hydrolysis of the starch molecules.

(i) Starch is a mixture of two different molecules.

Name these **two** molecules.

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(ii) Describe two features of starch that allows it to be a good storage molecule.

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Two of the enzymes synthesised by the barley seed are α-amylase and maltase. These are involved in the hydrolysis of the stored starch during seedling formation.

In the food industry, the starch extracted from barley seeds (barley starch) is used in the production of sugar syrups. Fig. 2.1 summarises the reactions catalysed by α-amylase in the production of maltose syrup and by maltase in the production of glucose syrup.

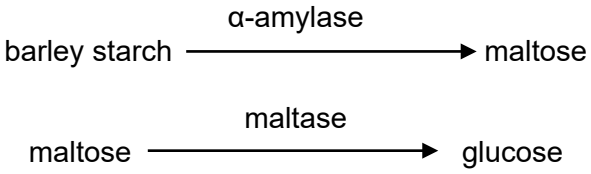

Fig. 2.1

(b) In the space below, draw the molecular structure of maltose and show how it can be catalysed by maltase to produce glucose molecules.

[3]

When producing sugar syrups, there are advantages in using enzymes extracted from microorganisms.

For example, some enzymes extracted from microorganisms are heat stable. Heat-stable enzymes are used to increase productivity because the reactions can be carried out at higher temperatures.

(c) Suggest one other advantage of using enzymes obtained from microorganisms, rather than enzymes extracted from barley seeds, in the production of sugar syrups.

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(d) Fig. 2.2 is a graph showing how the activity of α-amylase extracted from barley seeds changes as the temperature increases from 10 °C to 66 °C.

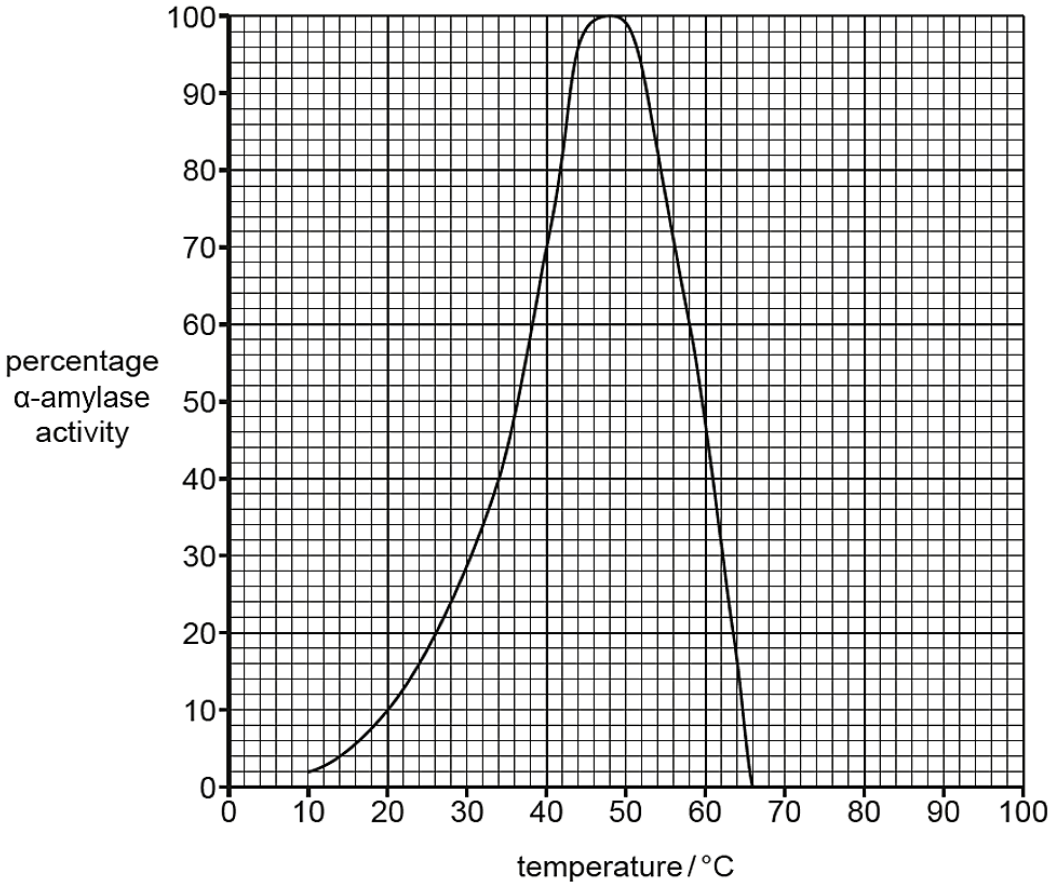

Fig. 2.2

(i) Explain the effect of temperature on the activity of α-amylase extracted from barley seeds, as shown in Fig. 2.2.

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(ii) Sketch on Fig. 2.2 the curve that would be obtained using the heat stable α-amylase enzyme extracted from microorganisms.

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[Total: 12]

3 Collagen is present in large quantities in connective tissue and provides tendons and ligaments with high tensile strength. Fig. 3.1 below shows how tropocollagen molecules is organised in collagen.

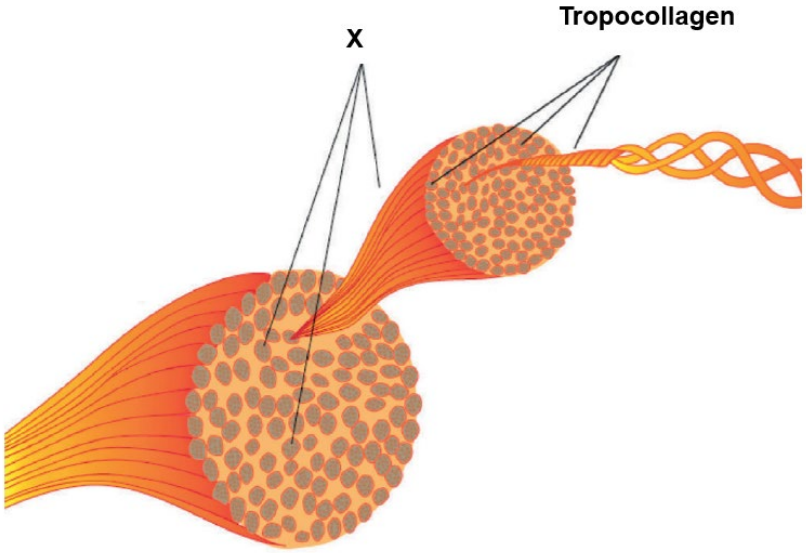

Fig. 3.1

(a) Identify structure **X** and explain how it allows collagen to serve a structural role.

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(b) Each of the three polypeptides in the tropocollagen is a kinked helix whereas in another macromolecule, cellulose, each chain is a straight chain.

(i) Explain how the kinked helix in tropocollagen and the straight chain in cellulose contribute to high tensile strength.

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(ii) Explain how the arrangement of monomers in tropocollagen and cellulose results in their respective shapes.

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[Total: 9]

4 (a) Fig. 4.1 shows the process of translation in a prokaryote.

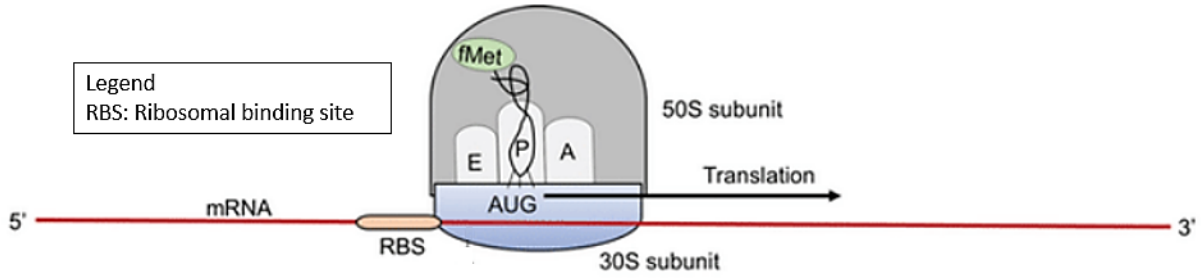

Fig. 4.1

With reference to Fig. 4.1,

(i) state all the differences you would expect if this process occurs in a eukaryote.

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(ii) briefly describe the process that results in the translation of the entire polypeptide.

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(b) Fig. 4.2 shows an electron micrograph of the translation process in a human epithelial cell.

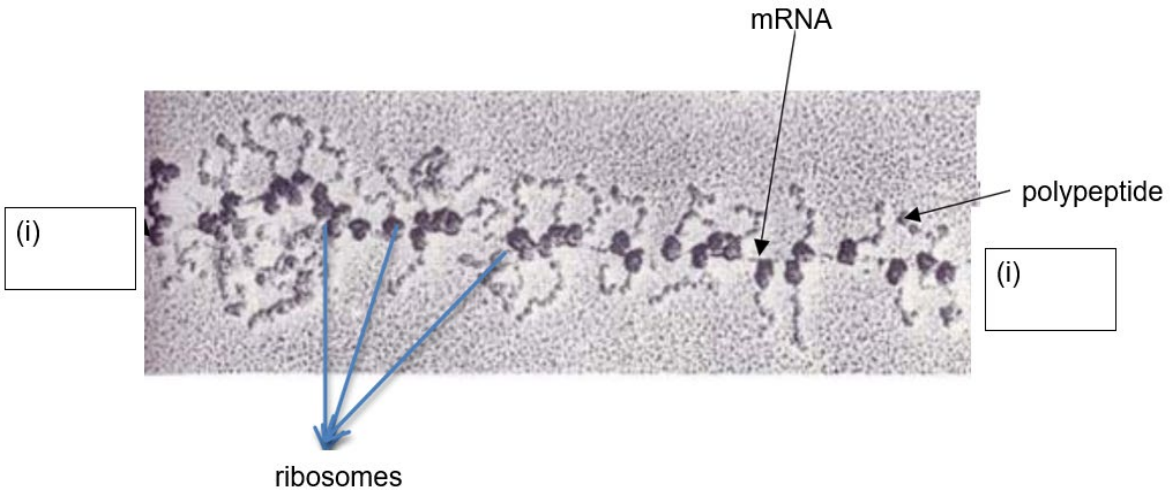

Fig. 4.2

With reference to Fig. 4.2,

(i) label the ends of the mRNA strand in the boxes provided. [1]

(ii) state the significance of the structure shown.

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..... [1]

[Total: 9]

5 **(a)** Fig. 5.1 shows a cell from the testis of a locust undergoing meiosis.

Fig. 5.1

(i) Identify the stage shown in Fig. 5.1.

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(ii) Explain the significance of this stage in the formation of the products.

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(b) Uncontrolled mitosis can cause cancer in humans.

Paclitaxel is a drug used in the treatment of some form of cancer.

Researchers investigated the effect of Paclitaxel on the mitotic cell cycle of cancer cells.

- The cancer cells were grown for two days and then divided into groups.
- Each group was treated with a different concentration of Paclitaxel.

After 28 hours (one cell cycle)

- The percentage of cells in stages of mitosis was calculated
- The ratio of the number of cells in anaphase to the number of cells in metaphase was determined.

The results of the investigation are shown in Fig 5.2.

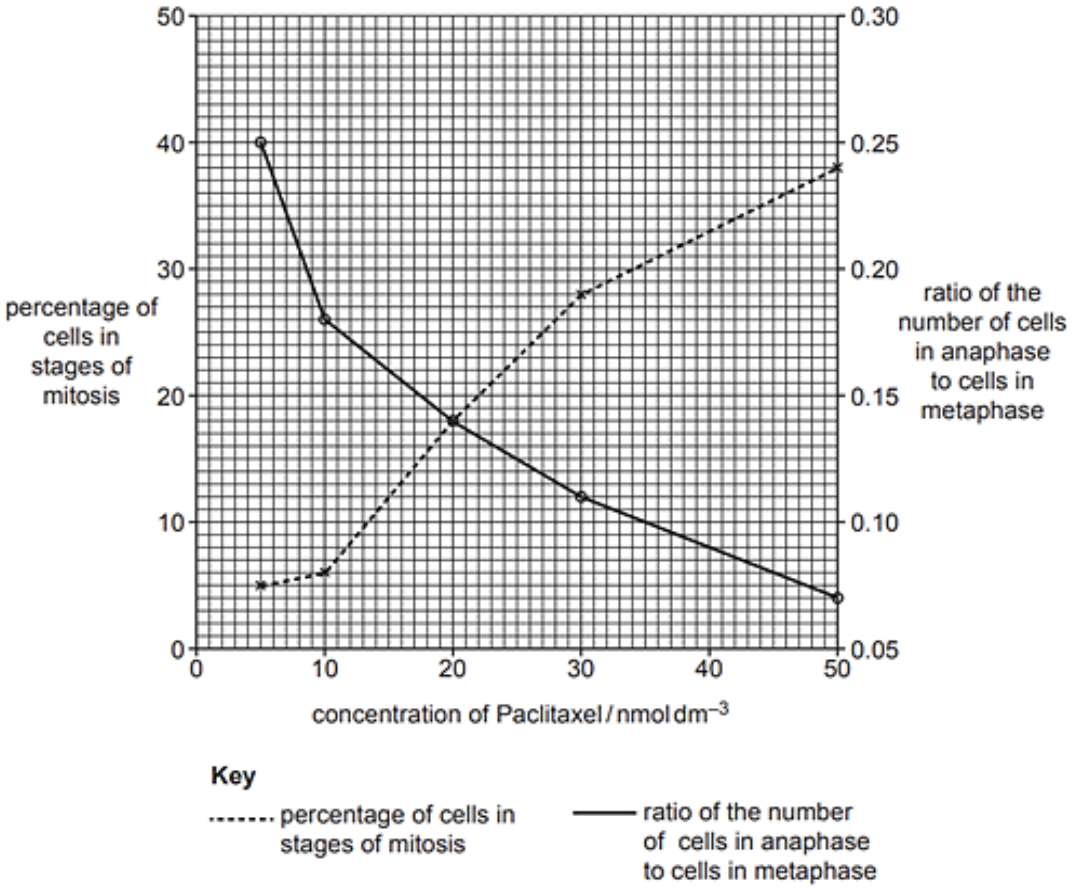

Fig. 5.2

With reference to Fig 5.2,

(i) describe the effects of Paclitaxel on the mitotic cell cycle.

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(ii) suggest an explanation for the effect of Paclitaxel.

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[Total: 10]

6 The bacterium, *Escherichia coli*, can use glucose or disaccharides, such as lactose, in its metabolism. Lactose needs to be hydrolysed by the enzyme β-galactosidase to form glucose and galactose, which can then be used by *E. coli*.

The production of β-galactosidase is controlled by a length of DNA called the *lac* operon.

(a) Explain the term operon.

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(b) In an investigation into the growth of *E. coli*, a sample of the bacterium was grown in a medium that contained limited concentrations of glucose and lactose. The population size of *E. coli* was measured at regular intervals.

Fig. 6.1 shows the population growth curve obtained for this investigation.

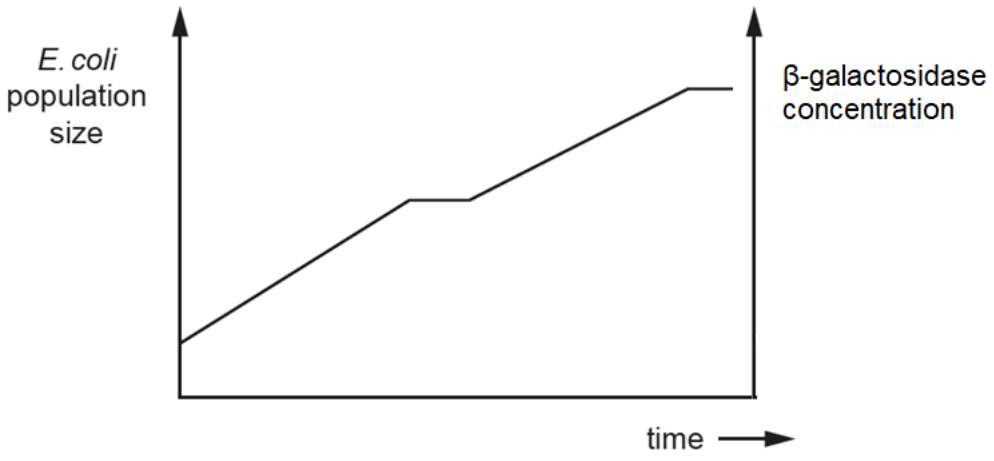

Fig. 6.1

(i) Describe **and** suggest reasons for the population growth curve shown in Fig. 6.1.

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(ii) Sketch in Fig. 6.1 the change in β-galactosidase enzyme concentration over the same time period.

[1]

(iii) Provide an explanation for your answer in **(ii)**.

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(c) β-galactosidase is also found in human cells.

Describe how the regulation of this gene differs from that in *E. coli*.

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[Total: 12]

7 The Labrador is a breed of domestic dog. Its fur coat can be chocolate, black and yellow.

In Labradors, TYRP1 is a gene that codes for the fur colour. In this gene locus, it has two alleles, B and b.

- The dominant allele, B, codes for an enzyme that will result in the production of melanin, leading to black fur.
- The recessive allele, b will code for another enzyme that results in the production of a brown form of melanin, leading to chocolate fur.

Another gene, MC1R, interacts with TYRP1. In this gene locus, it also has two alleles, E and e.

- The dominant allele E, allows for the alleles of TYRP1 to be expressed.
- The recessive allele e, prevents the alleles of TYRP1 from being expressed.
- When there is no melanin produced, the Labrador will have yellow fur.

(a) Explain the terms *locus* and *dominant* allele.

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(b) A test cross of a female with a black male Labrador resulted in offspring with all three different fur colours. Construct a genetic diagram to explain the results of the cross.

[5]

(c) While the fur colour of Labradors is due to epistasis, the fur colour of rabbits is due to multiple alleles.

Distinguish between the inheritance of fur colour in Labrador and rabbit.

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[Total: 9]

8 Respiration and photosynthesis are vastly different processes but they share similarities in terms of having triose phosphate(TP) as one of the intermediates as well as the use of coenzymes.

(a) (i) Describe two similarities in how triose phosphate is formed in respiration and photosynthesis.

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(ii) Describe the role played by the coenzyme involved in photosynthesis.

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(b) Fig. 8.1 shows some of the components involved in respiration in a Gram negative bacterium.

Gram negative bacteria have two cell membranes.

Some bacteria can undergo aerobic respiration in the same way as eukaryotic cells. However, Link reaction and Krebs cycle occur in the cytoplasm.

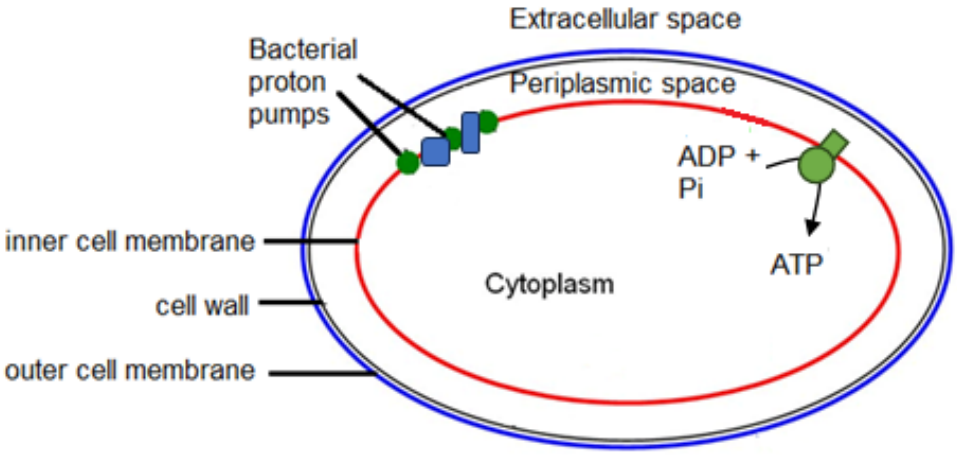

Fig. 8.1 (not drawn to scale)
(Source: modified from https://www.madsci.org/posts/archives/2007-11/1193962676.Mi.r.html)

With reference to Fig. 8.1, suggest how the proton pumps present on the inner membrane serve as a link between the respiratory processes in the cytoplasm and the synthesis of ATP.

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[Total: 8]

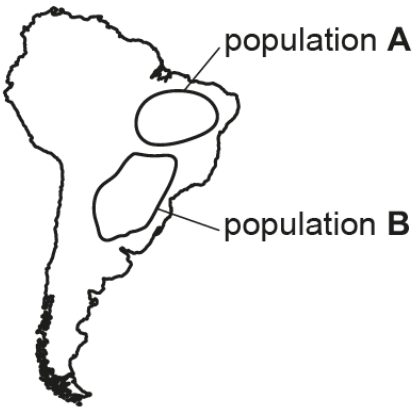
Question 9 starts on page 20

9 Cats are members of the Felidae family. Two genera of Felidae are *Leopardus* and *Panthera*.

The genus *Leopardus* consists of species of wild cats that are small and spotted. In 2013, researchers investigated the evolution of *Leopardus tigrinus* in South America.

Fig. 9.1 shows the locations in South America of two populations of. *L. tigrinus*, population **A** and population **B**. The cats in population **A** have a lighter coat colour and a different pattern of spots from the cats in population **B**.

With more compelling data uncovered by the researchers, Population **B** has now been reclassified as a new species, *L. guttulus*.



Population **A** lives in grassland and desert habitats.

Population **B** lives in forest habitats.

Fig. 9.1

(a) With reference to Fig. 9.1 and the information given above, explain why the two populations can be considered as separate species.

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Fig. 9.2 shows the tail lengths and weights of the two species of wild cats.

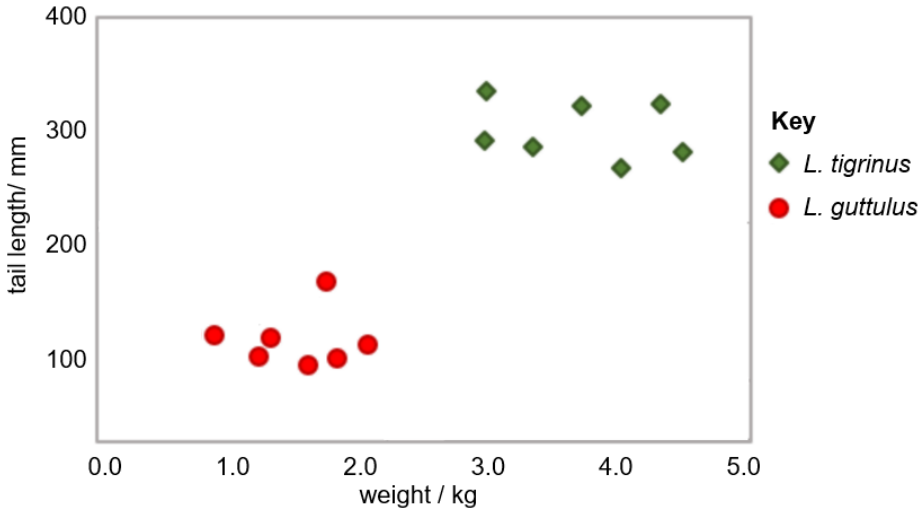

Fig. 9.2

(b) Discuss how the information in Fig. 9.1 and Fig. 9.2 shows how both micro-evolution and macro-evolution may have contributed to the evolution of the wild cats.

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(c) The researchers obtained extensive sequence data for three homologous genes from mtDNA, Y chromosome and X chromosome. From these data, the molecular phylogenetic relationships of cats of the genus Leopardus in South America are established.

Fig. 9.3 shows the family tree of South American cats, including *L. tigrinus* and *L. guttulus*.

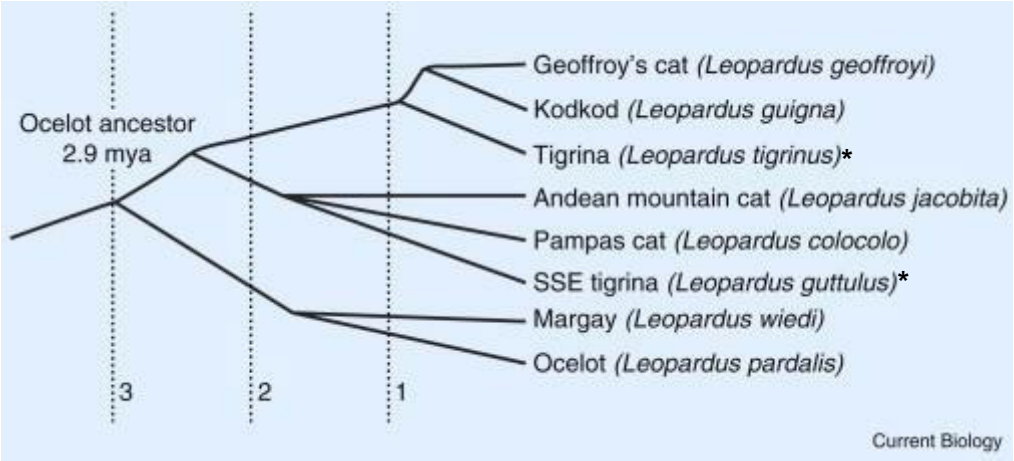

Fig. 9.3

Taken from https://www.sciencedirect.com/science/article/pii/S0960982213013821#bib20

(i) Describe how polymerase chain reaction (PCR) can be used to isolate homologous genes.

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(ii) Describe **and** explain **one** characteristic of mtDNA that makes it more useful than using X chromosome to provide evidence of evolution.

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[Total: 12]

10 COVID-19 is respiratory disease. The cells of the airway epithelium are the first line of defence against the pathogen.

(a) Describe how the cells of the airway epithelium provide the first line of defence against the pathogen.

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Early signs of COVID-19 infection include a fever, a sore throat and headache.

(b) Explain how the COVID-19 virus may cause these symptoms.

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[Total: 5]

11 India has been facing freshwater shortage issues for decades. Climate change has further exacerbated the situation, making water scarcity a persistent and pressing issue in India.

Fig. 11.1 below shows the water demand and supply in India over the years. Researchers have also predicted the trend of water demand/supply in 2030.

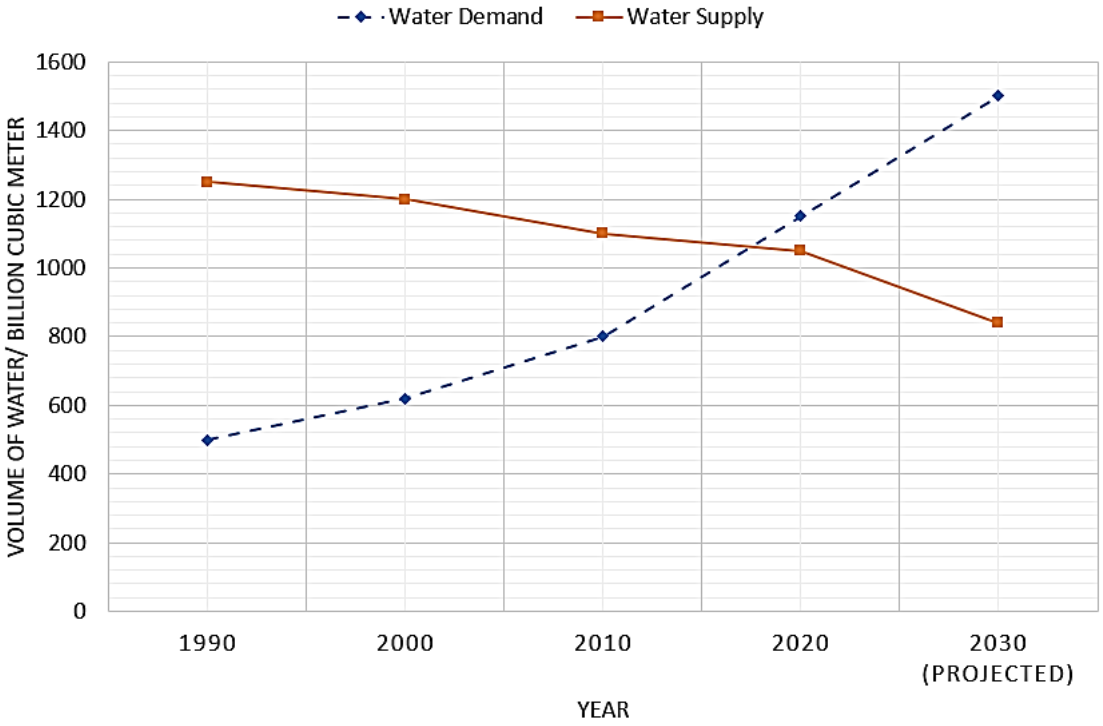

Fig. 11.1

(a) With reference to Figure 11.1, describe the water scarcity situation from Year 2000 to Year 2020.

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(b) Explain how climate change can result in the projected water supply in Year 2030.

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[Total: 5]