NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examination
Higher 2

CANDIDATE NAME			
BIOLOGY CLASS	2bi2_____	REGISTRATION NUMBER	

Biology

9744/02

Paper 2: Structured Questions

24 August 2023

Candidates answer on the Question Paper.

2 hours

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, Biology class and registration number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB 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 workings or if you do not use appropriate units.

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

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

This document consists of **24** printed pages.

Section A

Answer **all** the questions in this section.

1 Triglycerides are transported via lipoproteins such as low-density lipoproteins (LDL). LDL are taken up by target cells as shown in Fig. 1.1.

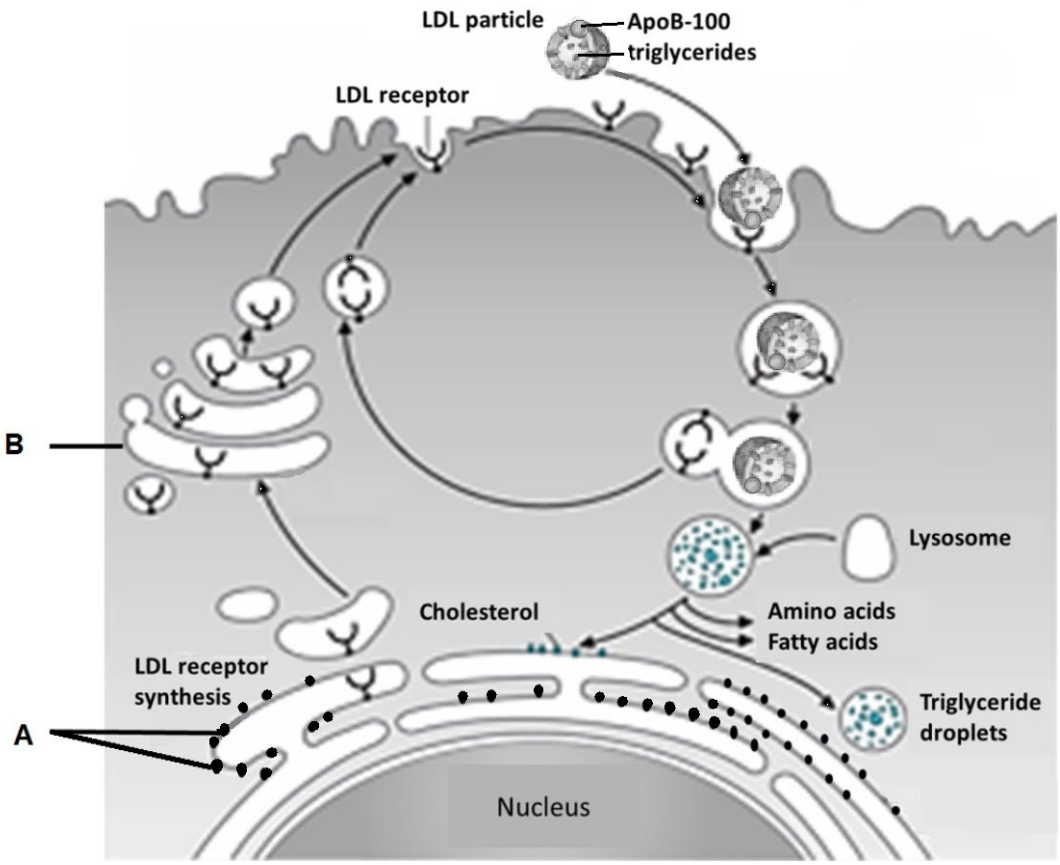

Fig. 1.1

(a) Name the structures labelled **A** in Fig. 1.1.

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[1]

(b) Explain the roles of **B** in the synthesis of LDL receptor.

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[2]

(c) With reference to Fig. 1.1, describe how an LDL particle is taken up by a target cell.

[3]

Lipoproteins are made up of proteins and lipids. Their function is to transport cholesterol, triglycerides, and other lipids in the bloodstream.

Fig. 1.2 represents the structure of a lipoprotein.

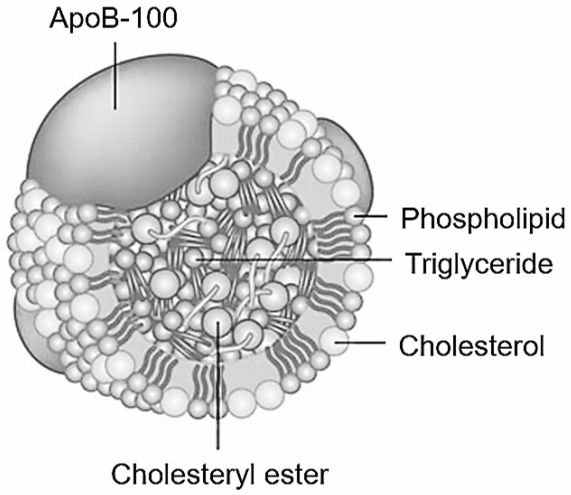

Fig. 1.2

(d) (i) With reference to Fig. 1.2, describe the arrangement of phospholipids in lipoproteins.

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..... [2]

(ii) Suggest why lipoproteins are needed to transport cholesterol, triglycerides and other lipids in the bloodstream.

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..... [2]

[Total: 10]

2 Collagen serves as the main structural protein in various connective tissues in animals. These tissues include bone cartilage, blood vessels, gum, and skin.

(a) Describe the primary structure of collagen.

[2]

(b) Explain how the structure of collagen differs from cellulose.

[3]

Fig 2.1 show the main steps involved in the synthesis and assembly of collagen.

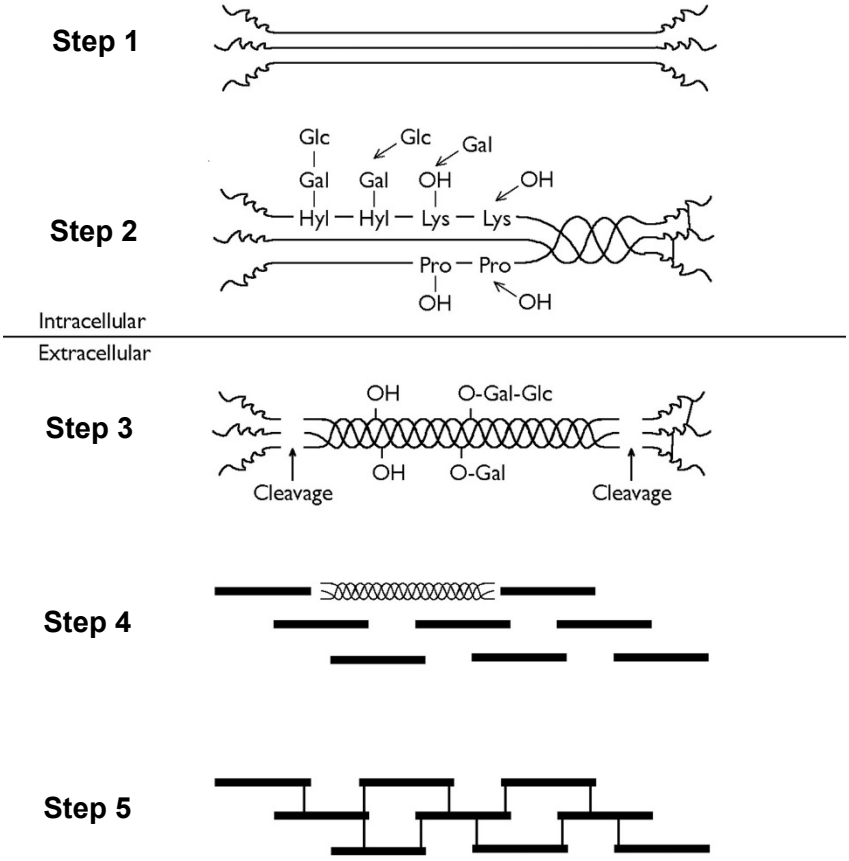

Fig 2.1

(c) Suggest why the assembly of collagen takes place outside the cell.

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..... [2]

(d) Vitamin C is necessary in aiding the hydroxylation of amino acids to form hydroxyproline and hydroxylysine in **Step 2**. A deficiency in Vitamin C can lead to scurvy, a disease associated with symptoms such as loss of teeth and easy bruising.

Suggest why vitamin C deficiency can lead to scurvy.

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[Total: 9]

3 In eukaryotes, transcription of a gene produces RNA transcripts that must be successfully processed before they can be exported out of the nucleus into the cytoplasm for translation. This process is illustrated in Fig. 3.1.

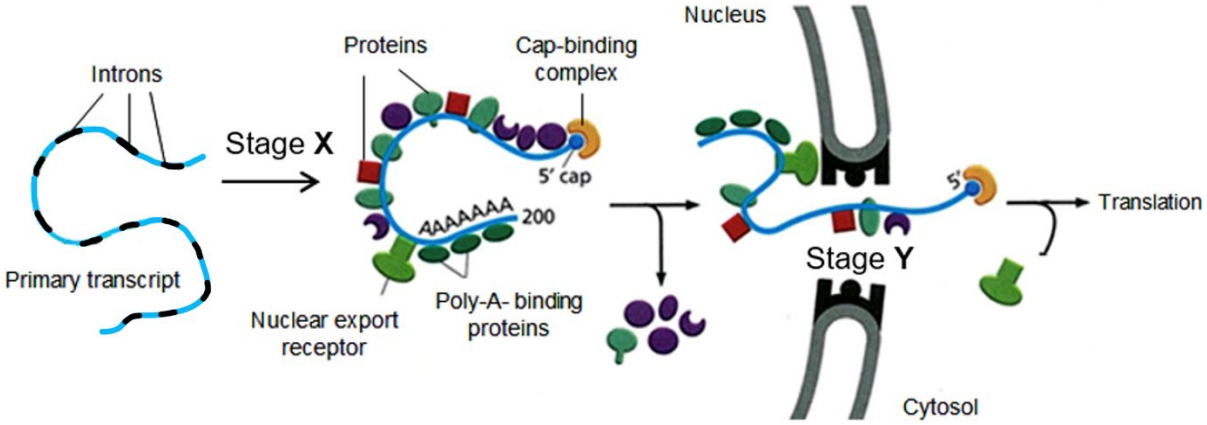

Fig. 3.1

(a) With reference to Fig. 3.1,

(i) describe the process occurring at stage **X** that results in the formation of a continuous coding sequence in mRNA.

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(ii) suggest why the cap-binding complex and poly-A-binding proteins are essential for stage **Y**.

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..... [1]

(b) Describe **three** differences between eukaryotic and prokaryotic translation.

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..... [3]

(c) The development of a mouse, from a fertilised egg into an adult, is regulated by variations in DNA methylation. Fig. 3.2 shows the developmental stages of a mouse with corresponding levels of DNA methylation. **R**, **S** and **T** represent the zygote, inner cell mass of blastocyst, and embryo respectively.

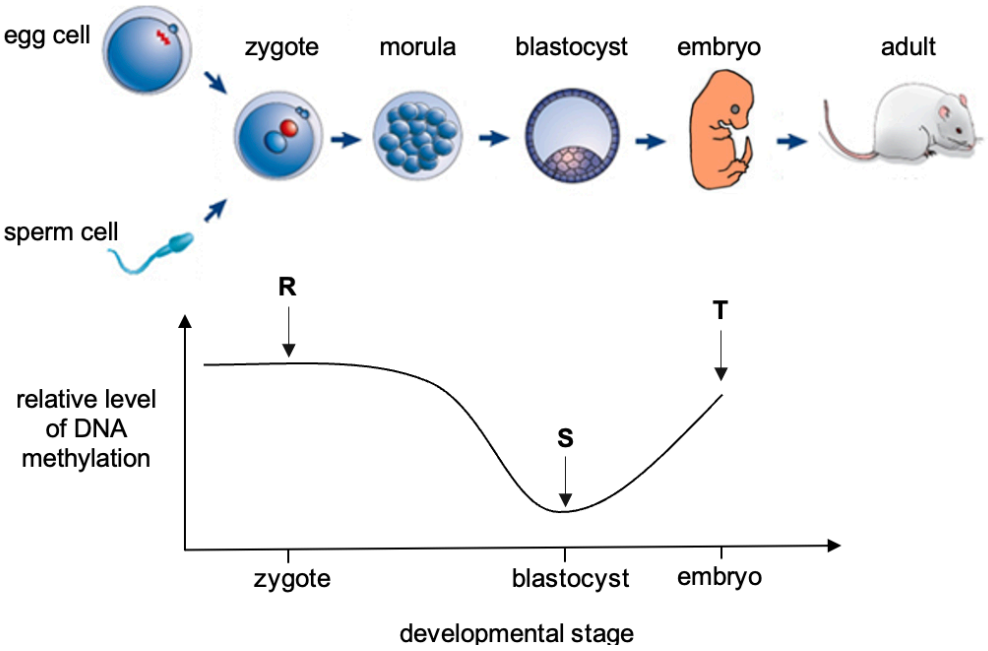

Fig. 3.2

(i) State the level of potency of the inner cell mass of blastocyst.

.....[1]

(ii) With reference to Fig. 3.2, suggest reasons for the different relative levels of DNA methylation at **R**, **S** and **T**.

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.....[3]

(iii) Although the inner cell mass of blastocyst has low levels of DNA methylation, many genes are not transcribed.

Suggest how the levels of transcription is kept low in blastocyst.

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.....[1]

[Total: 11]

4 Influenza and COVID-19 are both contagious respiratory diseases caused by different viruses. COVID-19 is caused by infection with a coronavirus, SARS-CoV-2, first identified in 2019. Flu is caused by infection with an influenza virus.

Fig. 4.1 shows the structure of the SARS-CoV-2.

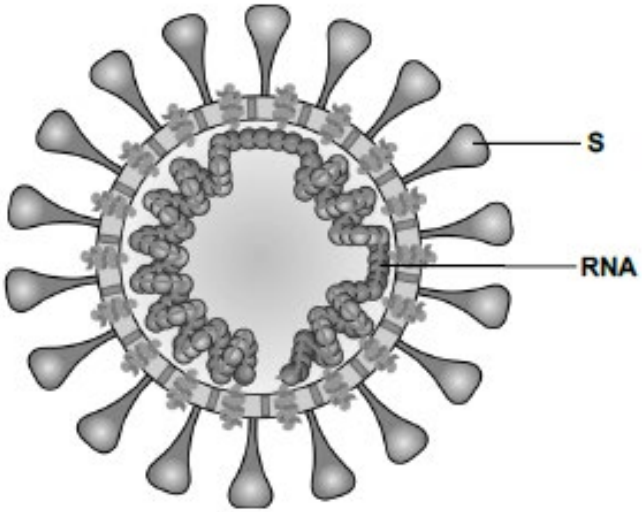

Fig. 4.1

(a) Compare the structures of SARS-CoV-2 and influenza virus.

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..... [2]

(b) Both influenza virus and SARS-CoV-2 have viral genes coding for viral RNA polymerases.

Explain why such genes coding for viral RNA polymerase are needed by these viruses despite the availability of host RNA polymerases.

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..... [2]

The subtypes of the influenza virus that infect birds, human and pigs in one area of the world in recent times are shown in the Table 4.1 below.

Table 4.1

time period	influenza virus subtypes present	
	humans	pigs
1918-1957	H1N1	H1N1
1958-1970	H2N2	
1971-present day	H3N2 H1N1	H3N2 H2N3

(c) Based on the above information, discuss the plausibility that an antigenic shift of the influenza virus can occur from H2N2 combining with H1N1 or H3N2 in present human populations.

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..... [3]

(d) Fig. 4.2 shows the structure of haemagglutinin (HA) of the influenza virus. The numbers in Fig. 4.2 indicate the positions of amino acids that are frequently changed.

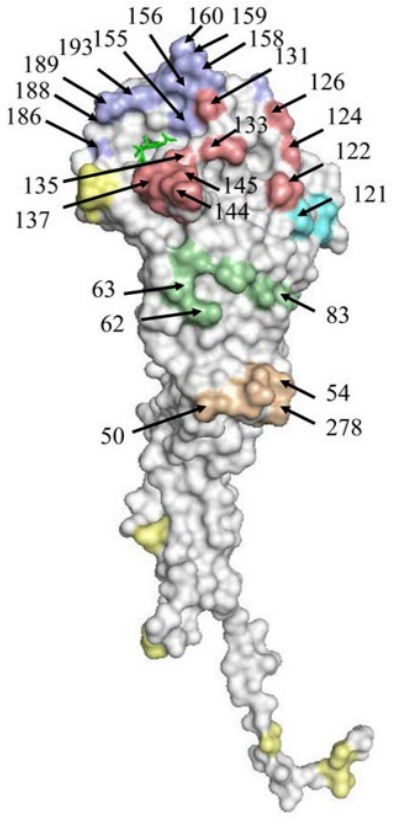

Fig. 4.2

(i) Based on your knowledge on the reproductive cycle of influenza, explain why amino acids in HA are frequently changed.

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..... [3]

(ii) Suggest why such frequent changes is a significant burden on the economy.

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..... [1]

[Total: 11]

5 In bacteria, the synthesis of amino acid tryptophan is regulated by a repressible operon, *trp* operon.

(a) Explain the term repressible operon.

[2]

Bacteria cells can take up tryptophan from their surroundings. When external supply of tryptophan is high, transcription of genes in the *trp* operon is repressed.

(b) Explain how the *trp* operon is repressed in the presence of high tryptophan supply.

[2]

In an experiment, bacteria strain **A** and bacteria strain **B** were mixed together. Strain **A** has the *trp* operon but lacks the *lac* operon. Strain **B** has the *lac* operon but lacks the *trp* operon. Mixing of the two strains of bacteria resulted in bacteria strain **C** containing a fusion of *trp* and *lac* operon. This experiment is illustrated in Fig 5.1.

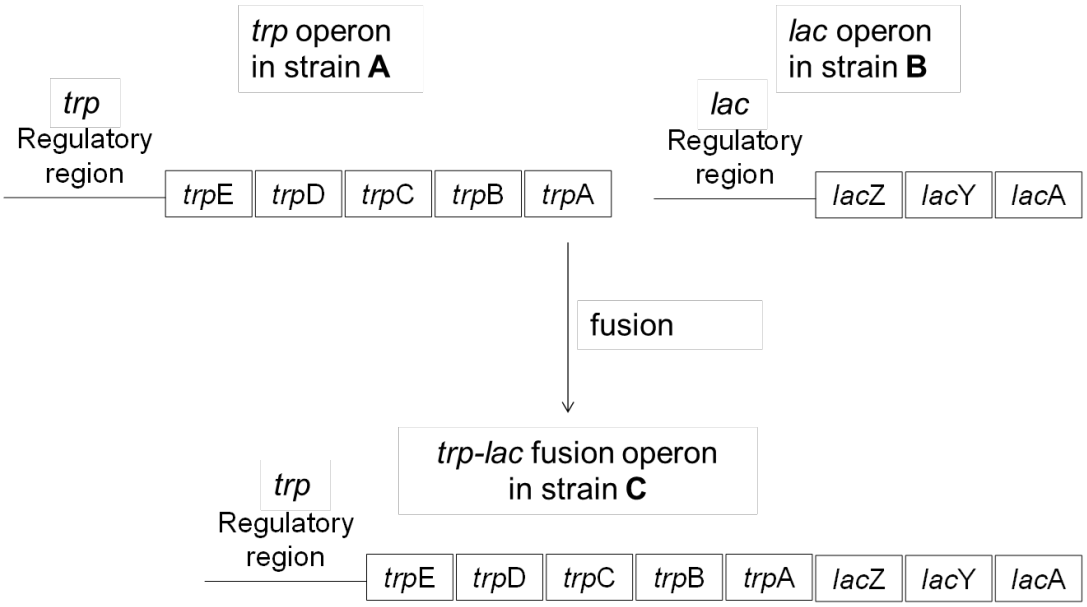

Fig 5.1

(c) Suggest, with reason, the condition(s) needed for β-galactosidase to be expressed in bacteria strain **C**.

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..... [3]

(d) Experiments were performed to determine how the two operons become fused. It was found that bacteria strain **C** contains a Fertility factor.

Explain why there is insufficient evidence to conclude that conjugation resulted in the fusion of the two operons.

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..... [2]

[Total: 9]

Question 6 starts on page 15

6 In domestic cats, fur colour is controlled by several genes.

The gene for melanin production is located on the X chromosome. This gene has two alleles, allele **B** codes for eumelanin resulting in black fur, and allele **O** codes for phaeomelanin resulting in orange fur. These two alleles are codominant so a heterozygous cat will have fur with patches of black and orange colours, known as a tortoiseshell. Male cats rarely have tortoiseshell colour.

Another gene known as the white masking gene is located on a different chromosome. The allele **W** prevents normal development of melanocytes (pigment-producing cells). This results in cats with entirely white fur regardless of the alleles for melanin. Note that these white cats are not albino.

(a) State the name for this type of interaction between gene loci.

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[1]

(b) A female cat with black fur mates with a male cat with white fur, and one of the kittens produced has tortoiseshell fur.

Using appropriate symbols, draw a genetic diagram to explain the result of the cross.

[4]

Another gene, piebald spotting, determines the occurrence of patches of white fur. Cats which are homozygous recessive (**ss**) for this gene do not have any patches of white, while cats with at least one dominant **S** allele will have patches of white.

A female cat with black fur and white spots mates with a black fur male and produced four kittens. Fig. 6.1 shows the pedigree of this family of cats and their phenotypes.

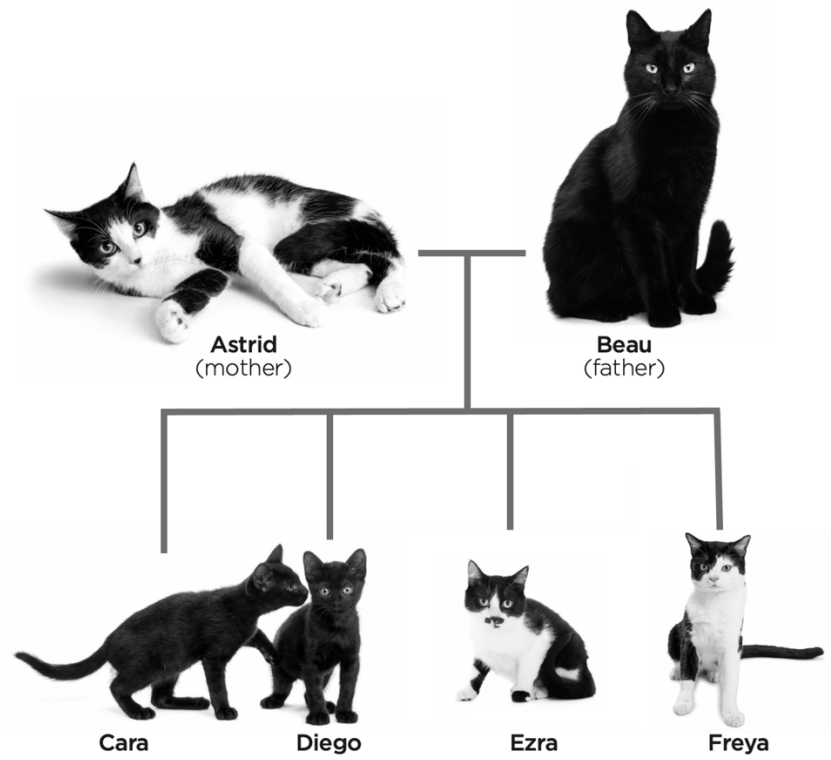

Fig. 6.1

The DNA from each of the cats were isolated and PCR was performed to amplify the piebald spotting gene. The PCR products were separated by gel electrophoresis and the results are shown in Fig. 6.2.

Fig. 6.2

(c) Explain the main principles that allow gel electrophoresis to separate DNA fragments.

[3]

(d) With reference to Fig. 6.1 and Fig. 6.2,

(i) state the genotype of Astrid (mother) for all three genes.

[1]

(ii) explain which band corresponds to the allele for white patches.

[3]

[Total: 12]

7 Krebs cycle is a stage in aerobic respiration where acetyl-CoA is oxidised through a series of reactions. Electron carriers, reduced NAD and reduced FAD, are produced from these reactions. These electron carriers are used to generate ATP through oxidative phosphorylation.

(a) State the precise location in a cell where Krebs Cycle occurs.

.....[1]

(b) Describe how reduced NAD and reduced FAD can be used to generate ATP through oxidative phosphorylation.

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.....[4]

There is another metabolic pathway that can bypass some reactions in Krebs cycle. This pathway is called glyoxylate cycle as shown in Fig. 7.1.

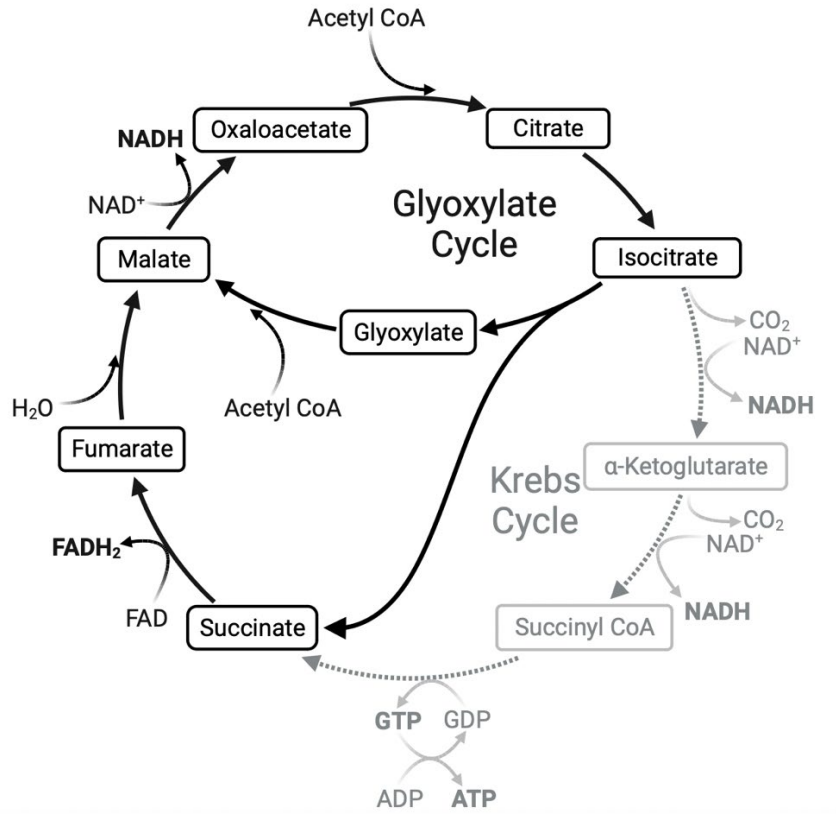

Fig 7.1

(c) Compare the efficiency of ATP production between Krebs and glyoxylate cycles when **2** molecules of acetyl-CoA enter each cycle. Show your workings.

Assume that 1 molecule of reduced NAD is converted into 3 ATP and 1 molecule of reduced FAD is converted into 2 ATP during oxidative phosphorylation.

For Krebs cycle:

Number of ATP molecules = ……

For glyoxylate cycle:

Number of ATP molecules = ……

Compare the efficiency of ATP production between both cycles.

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[3]

(d) Oxaloacetate is an intermediate of both Krebs and glyoxylate cycles and is needed for amino acids synthesis.

Although Krebs cycle generates more ATP, glyoxylate cycle is preferred over Krebs cycle during seed germination for plant growth.

Suggest why glyoxylate cycle is preferred over Krebs cycle during seed germination.

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..... [2]

[Total: 10]

8 Odorant receptors are found on sensory neurons. Binding of odorants to their respective receptors triggers signal transduction pathways, resulting in the perception of smells.

Fig. 8.1 shows the binding of an odorant to its receptor and its resulting signalling pathway.

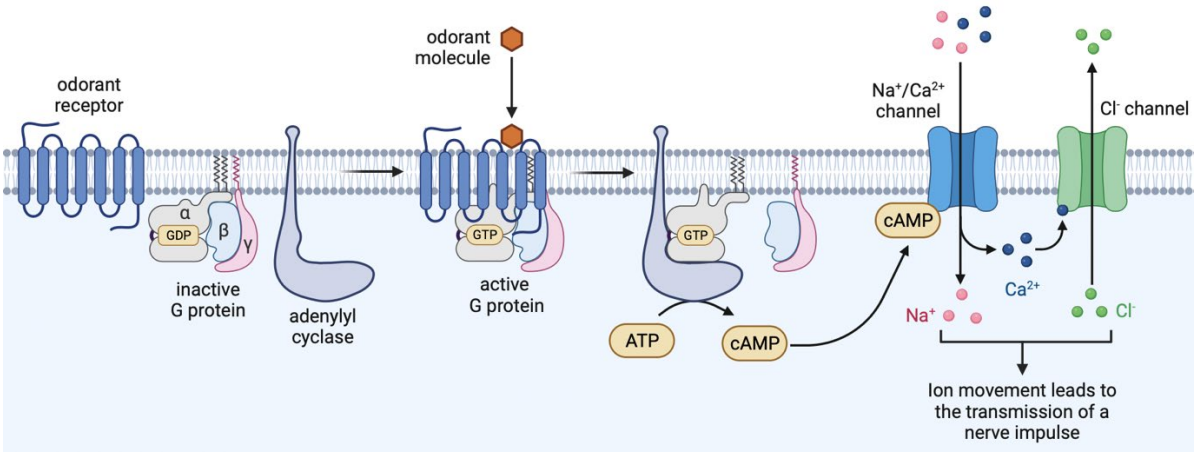

Fig. 8.1

(a) With reference to Fig. 8.1,

(i) describe how the binding of an odorant molecule to the odorant receptor results in the activation of G-proteins.

[3]

(ii) explain how the initial signal is amplified via signal transduction.

[2]

Olfactory fatigue is a temporary condition where the sense of smell becomes less sensitive after prolonged exposure to a specific scent. This phenomenon is due to the desensitisation of the odorant receptor.

Fig. 8.2 shows a desensitised odorant receptor.

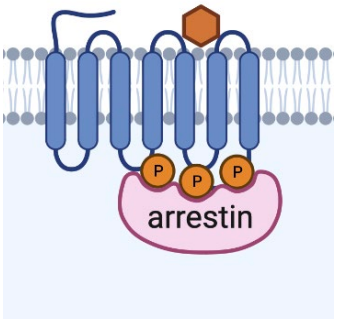

Fig. 8.2

(b) With reference to Fig. 8.2, suggest how an odorant receptor becomes desensitised.

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..... [2]

(c) In the perfume industry, buyers are instructed to inhale the smell of coffee beans in between the testing of perfume samples to recover from olfactory fatigue.

Suggest a mechanism by which the inhalation of coffee beans may achieve recovery from olfactory fatigue.

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..... [1]

[Total: 8]

9 Two subspecies of reindeer, *Rangifer tarandus*, live in North America. Members of the different subspecies belong to the same species, but they have some morphological differences and are found in different geographical locations.

Fig. 9.1 shows the two subspecies of reindeer in their respective habitats.

southern woodland subspecies,

R. tarandus caribou

northern barren ground subspecies,

R. tarandus groenlandicus

Fig. 9.1

(a) During the last ice age, an ice sheet separated southern and northern populations of *R. tarandus* in North America.

With reference to Fig. 9.1, explain how this ice sheet resulted in the formation of two different subspecies of *R. tarandus*.

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..... [4]

(b) A mixed population consisting of individuals from both subspecies now occupies the area previously covered by the ice sheet.

(i) Explain why *R. tarandus caribou* and *R. tarandus groenlandicus* are consider the same species.

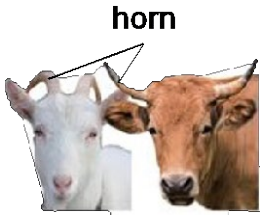
[2]

(ii) Evaluate the ability of this mixed population compared to the pure subspecies populations to adapt to increasing temperatures from climate change.

[2]

(c) Reindeer belong to a suborder Ruminantia, which are the only group of mammals with cranial appendages, also known as headgear. Table 9.1 shows the different headgear morphologies of different ruminant families.

Table. 9.1

family	 Antilocapridae	 Giraffidae	 Cervidae	 Bovidae
headgear structure	bone covered by skin, hair, and a keratinous sheath	bone covered by skin and hair	regenerable bone covered by skin, hair	bone covered by skin, hair, and a keratinous sheath

With reference to Table 9.1, explain how the structure of headgears provides evidence to support the theory of evolution.

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..... [2]

[Total: 10]

10 Fig. 10.1 shows the immune response upon an infection of the lungs with *Mycobacterium tuberculosis*.

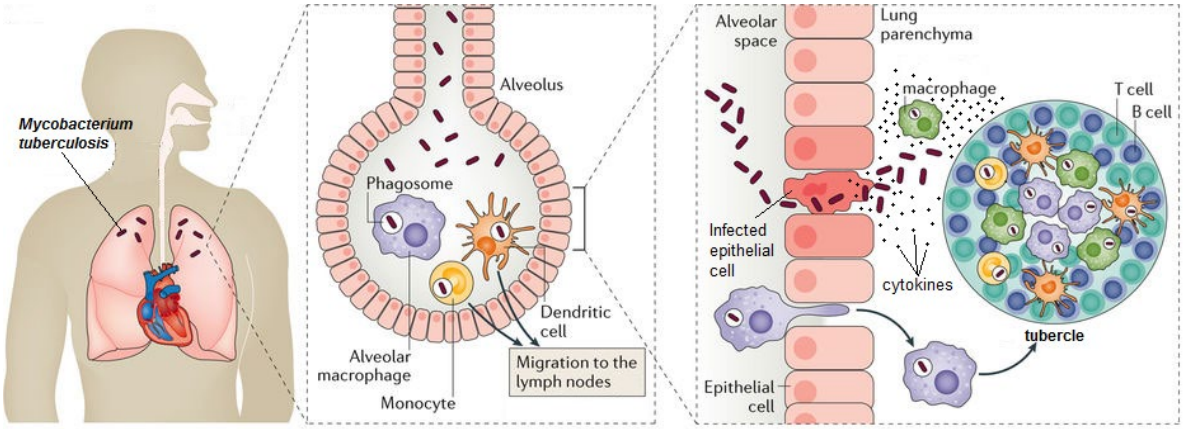

Fig. 10.1

(a) State the mode of transmission by *M. tuberculosis.*

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[1]

(b) With reference to Fig. 10.1, describe the immune response to *M. tuberculosis*.

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[3]

(c) Suggest why it is challenging to treat tuberculosis by antibiotics.

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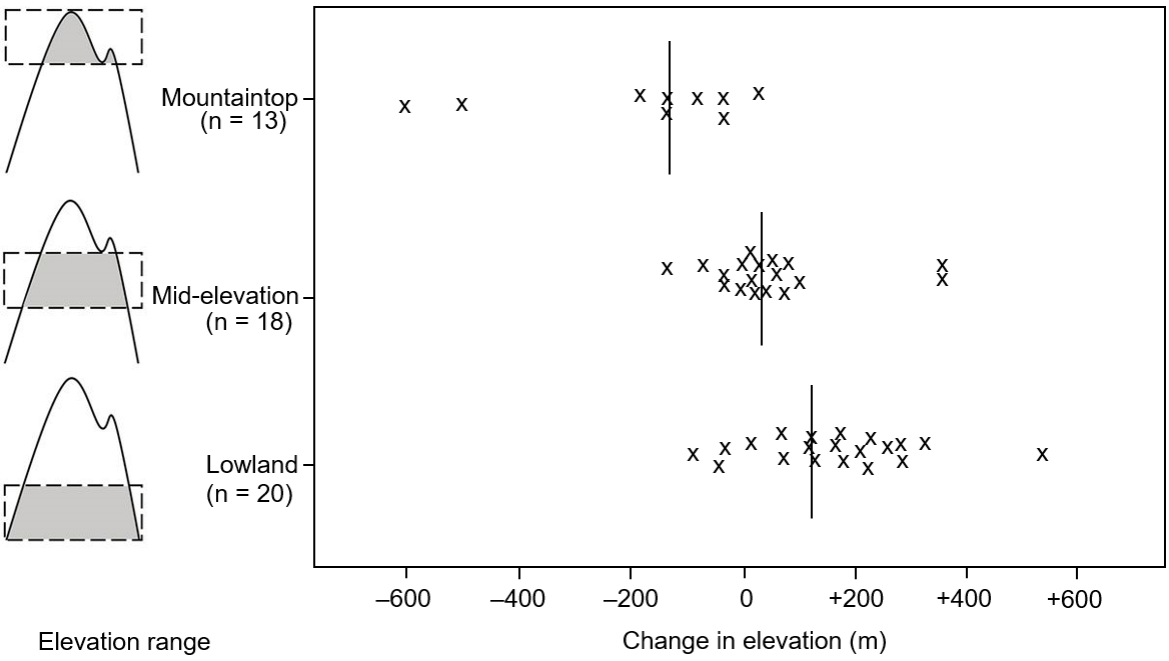
[1]

[Total: 5]

11 The response to increasing temperature from climate change may differ between species. One response is to migrate to a different elevation.

Researchers studied 51 species in Malaysia over a 10-year period to assess the impact of increasing temperature on their habitat range on a mountain.

Fig. 10.1 shows the change in elevation of each species' habitat after the 10-year study.



Key

n - number of species originally present at that elevation range

x - data point for change in elevation for one species after the 10-year study

vertical line (I) - the average change at that elevation range

Fig. 11.1

(a) Describe and explain the effects of increasing temperature on the change in elevation for species living at lowland and mid-elevation.

[3]

(b) Suggest two reasons why species living at mountaintop migrate to a lower elevation as a result of climate change.

[2]

[Total: 5]

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