

NAME: _____

CLASS: _____

INDEX: _____



CATHOLIC JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
Higher 2

BIOLOGY
STRUCTURED QUESTIONS

9744/02
01 Sept 2025
2 hours

READ THESE INSTRUCTIONS FIRST

Write your **name (as per NRIC)**, **class**, and **index number** on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

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

There are **11 questions with multiple subparts** in this paper.

Answer **all** questions in the spaces provided on the Question Paper.

For Examiner's Use	
Total	100
1	
2	
3	
4	
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6	
7	
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9	
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11	

Answer **all** questions

- 1 Fig. 1.1 shows ribosomes attached to the endoplasmic reticulum, carrying out protein synthesis.

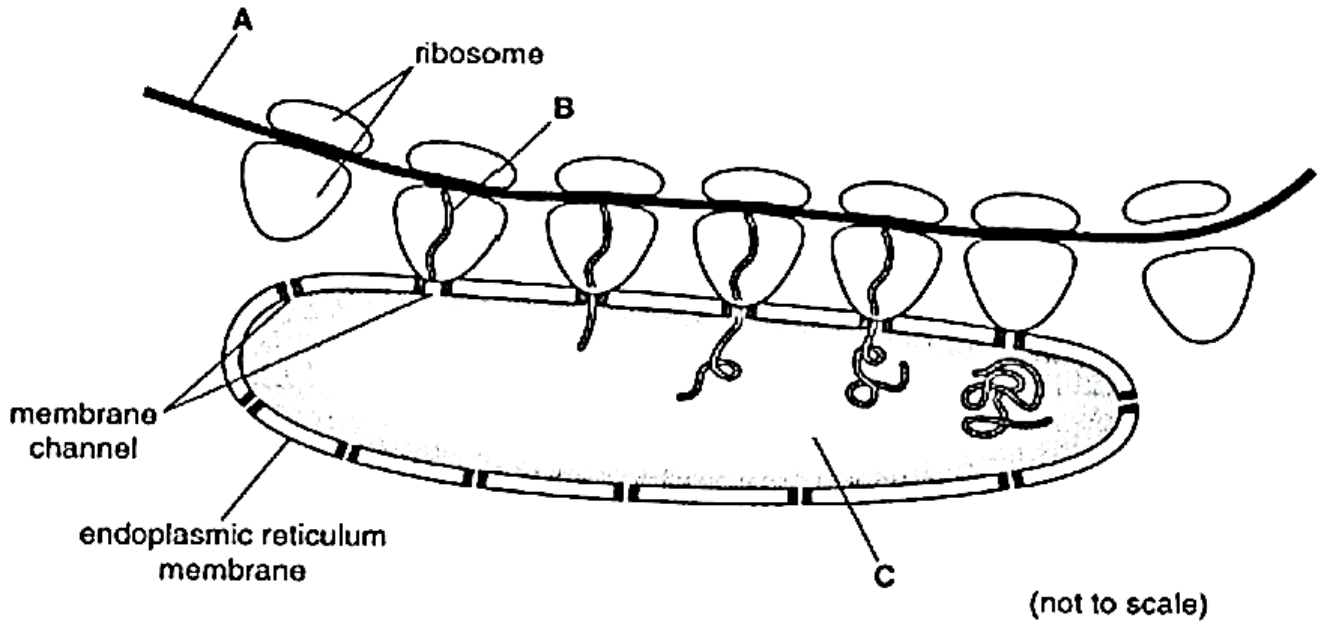


Fig. 1.1

- (a) Name the structures labelled **A** to **C**

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 [3]

- (b) With reference to Fig. 1.1, suggest the function of the protein that forms the membrane channel.

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 [3]

- (c) Proteins synthesised by ribosomes attached to the endoplasmic reticulum may be transported out of the cell. Explain the type of modification that occurs and the route taken.

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- (d) Suggest how prokaryotes, which have no endoplasmic reticulum or vesicles, are able to secrete proteins.

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..... [1]

[Total: 10]

- 2 Fig. 2.1 shows two possible ways in which enzymes interact with their substrates.

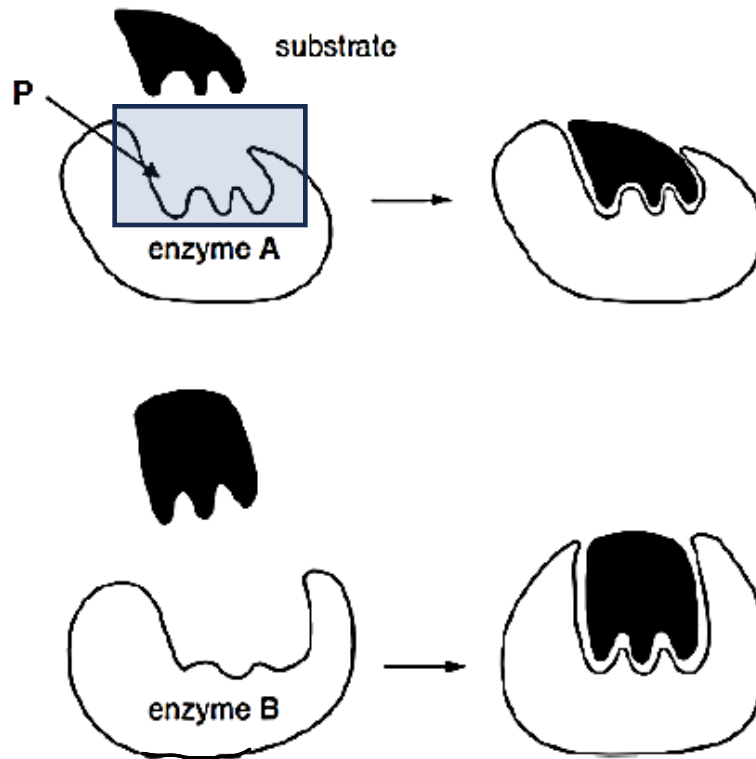


Fig. 2.1

- (a) Explain the two roles of amino acids directly involved with enzyme action found at site P.

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..... [2]

- (b) Enzymes act with specificity and catalyse reactions. With reference to Fig. 2.1, explain how the two types of enzymes are able to do so.

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Acetyl-CoA carboxylase (ACC) is a four-subunit enzyme that regulates the synthesis of fatty acid by catalysing the conversion of acetyl-CoA to malonyl-CoA. ACC can also be allosterically activated by the action of another molecule, citrate.

Fig. 2.2 shows the effect of the concentration of acetyl-CoA on ACC activity.

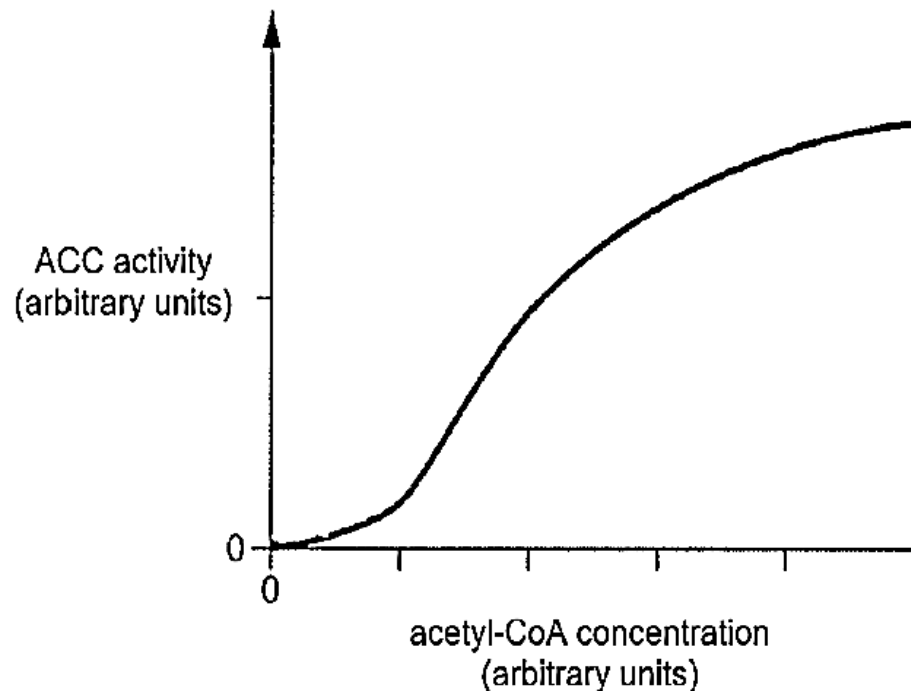


Fig. 2.2

(c) Explain how ACC can be activated by citrate.

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..... [2]

(d) On Fig. 2.2, draw and label the expected graph in the presence of citrate.

..... [1]

- (e) Biotin, also known as vitamin B, is attached to ACC for its proper functioning. Explain the role of biotin.

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..... [2]

[Total: 9]

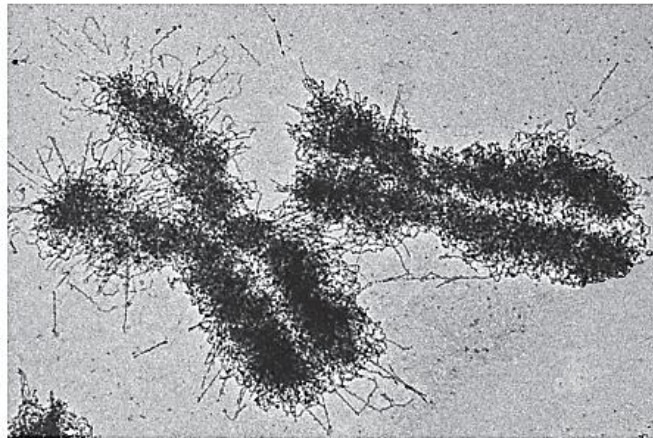
- 3** During interphase of the cell cycle, individual chromosomes cannot be seen within the nucleus. The genetic material is termed chromatin during this stage.

(a) Changes occur to chromatin during mitosis so that chromosomes become visible.

State what happens to chromatin so that individual chromosomes can be seen during mitosis.

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 [1]

(b) Fig. 3.1 is a transmission electron micrograph of two human chromosomes at metaphase of mitosis.



magnification = $\times 14\,000$

Fig. 3.1

Describe the structure of chromosomes at metaphase, such as the two chromosomes in Fig. 3.1.

.....

 [4]

- (c) Yeasts are unicellular organisms from the kingdom Fungi. *Saccharomyces cerevisiae* is one species of yeast that can carry out either asexual reproduction by mitosis or sexual reproduction by meiosis.

Budding in *S. cerevisiae* is a process where a small daughter cell forms as a bud on the parent cell. The bud contains a copy of the parent cell nucleus and it eventually separates from the parent cell to form a new cell.

S. cerevisiae can exist in two forms: haploid cells or diploid cells.

- Haploid cells can be one of two different mating types: **a** and **α**.
- Haploid cells can only mate with other haploid cells of the opposite mating type.

Fig. 3.2 shows the life cycle of *S. cerevisiae* with its asexual and sexual reproductive stages.

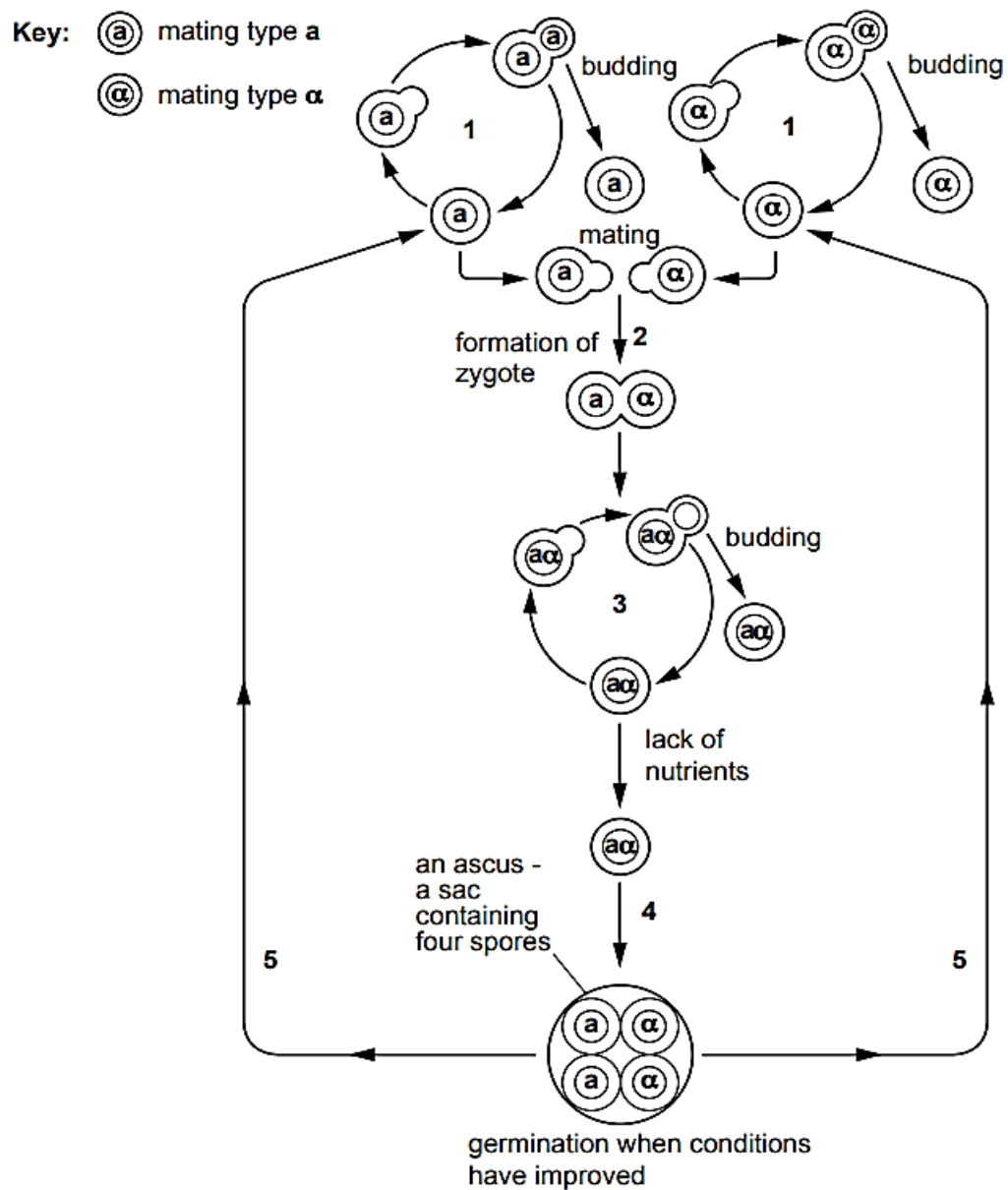


Fig. 3.2

- (i) With reference to Fig. 3.2, state the number(s) of the stages **1–5** that:

involve mitosis

involve meiosis

[2]

- (ii) When there is a lack of nutrients, cells made in stage **3** will carry out stage **4** to make spores, which germinate only when conditions improve.

Suggest **and** explain how the type of reproduction that makes spores during stage **4** is advantageous for *S. cerevisiae* in a changing environment.

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..... [3]

[Total: 10]

4 Transcription and translation are integral to gene expression.

(a) Contrast between transcription and translation in eukaryotes.

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The TATA binding protein (TBP) is a transcription factor that binds to a DNA sequence called the TATA box. When TBP binds to a TATA box within the DNA it distorts the DNA, causing the helix to partially unwind and placing strain on the two DNA strands.

Fig. 4.1 shows TBP attached to DNA.

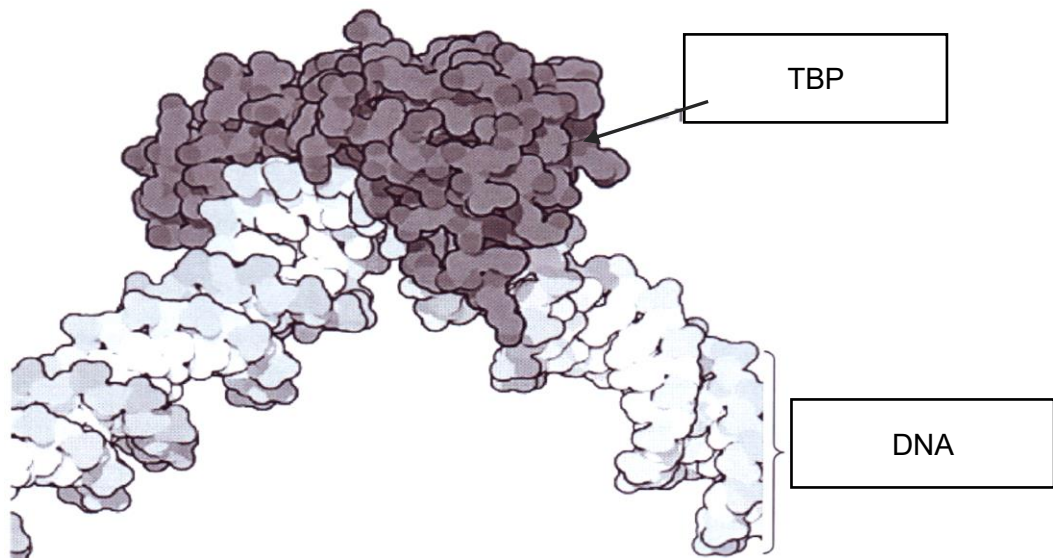


Fig. 4.1

(b) Suggest how transcription factors such as TBP bind to DNA.

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..... [2]

- (c) Explain why the unwinding of the double helix of DNA promotes transcription.

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..... [2]

Fig. 4.2 shows how a spliceosome removes an intron from pre-mRNA following transcription.

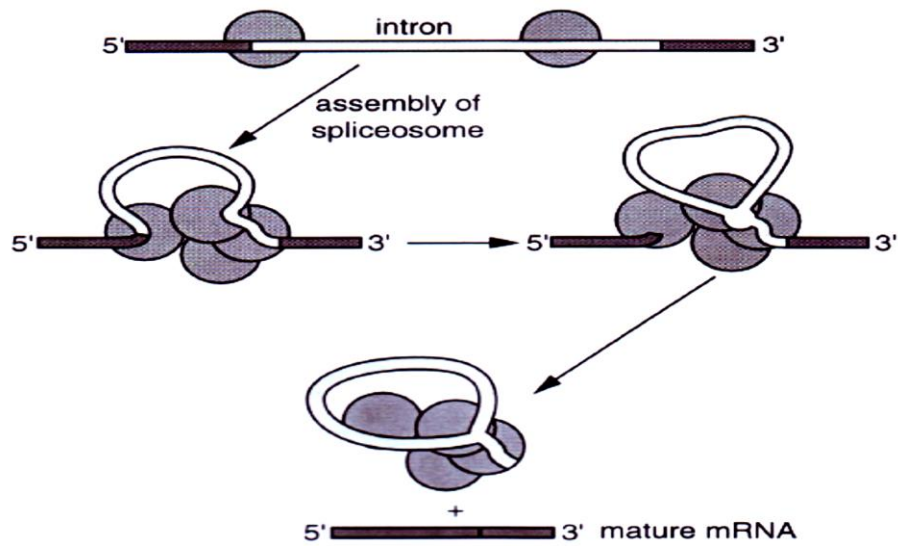


Fig. 4.2

- (d) With reference to Fig. 4.2, outline the process above and explain why such processing of pre-mRNA molecules is necessary.

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..... [4]

[Total: 11]

- 5 Animal viruses like the influenza virus and the human immunodeficiency virus (HIV) target and recognise specific host cells.

(a) Compare how influenza virus and human immunodeficiency virus enter the host cells.

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..... [3]

Fig. 5.1 shows the influenza viruses and its genome.

The **HA** and **NA** RNA segments encode the proteins haemagglutinin (HA) and neuraminidase (NA), which are the primary targets for antiviral drugs.

Haemagglutinin, a glycoprotein, mediates viral attachment to host cells.

Neuraminidase, an enzymatic protein, enables the release of newly formed virions from infected cells.



Fig. 5.1

- (b) State the location of viral genome replication in the cell.

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..... [1]

- (c) The Polymerase complexes like PA, PB1 and PB2 shown in Fig. 5.1. are essential for the viral replication. Explain why such complexes are needed by the virus.

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..... [2]

- (d) Zanamivir is an antiviral drug that is used in the treatment of influenza. It acts as an inhibitor of the neuraminidase on the influenza virus.

Explain how inhibiting neuraminidase can prevent influenza.

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..... [2]

Swine flu virus, H1N1, is a subtype of the influenza virus that causes a respiratory infection in pigs. In 2009, the H1N1 virus infected millions of people worldwide causing a pandemic.

- (e) Suggest why swine flu could be passed to human beings.

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..... [2]

[Total: 10]

- 6 The tortoise beetle, *Chelymophra alternans*, is an insect found in Panama that has several different colour patterns. Fig. 6.1 shows a tortoise beetle.

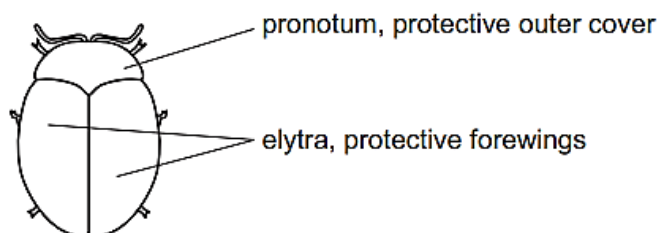



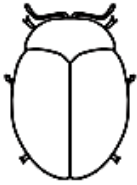



Fig. 6.1

Researchers have identified a gene, L , that controls colour pattern in the pronotum and elytra. Gene L has four different alleles: L^V , L^T , L^R and L^r .

Table 6.1 shows five different colour pattern phenotypes of tortoise beetles and their genotypes.

Table 6.1

phenotype	genotypes
rufipennis 	$L^R L^R$ $L^R L^V$ $L^R L^r$
darien f. militaris-a (dfm-a) 	$L^T L^T$ $L^T L^V$ $L^T L^r$
darien f. militaris-b (dfm-b) 	$L^T L^R$
veraguensis 	$L^V L^V$ $L^V L^r$
metallic 	$L^r L^r$

- (a) Explain why the inheritance of colour pattern in tortoise beetles can be described as involving multiple alleles.

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 [1]

- (b) A tortoise beetle with **dfm-b** phenotype was crossed with another tortoise beetle with **dfm-b** phenotype.

Construct a genetic diagram to show the results of this cross, including the ratio of offspring phenotypes.

parental phenotypes: **dfm-b** × **dfm-b**

- (c) Colour pattern phenotype involves alleles that show codominance. There is also an order of dominance of alleles (dominance hierarchy).

Use the information in Table 6.1 to:

- identify the codominant alleles
- list the dominance hierarchy with alleles from the most dominant to the least dominant.

codominant alleles

dominance hierarchy[2]

- (d) Researchers carried out two crosses.

Cross 1: female veraguensis tortoise beetles were crossed with male metallic tortoise beetles.

The results are shown in Table 6.2.

Table 6.2

number of observed offspring phenotypes				ratio of observed colour pattern phenotypes
male veraguensis	female veraguensis	male metallic	female metallic	
139	153	136	140	1.06:1

Cross 2: female veraguensis tortoise beetles were crossed with male veraguensis tortoise beetles.

The results are shown in Table 6.3.

Table 6.3

number of observed offspring phenotypes				ratio of observed colour pattern phenotypes
male veraguensis	female veraguensis	male metallic	female metallic	
693	592	237	213	2.9:1

- (i) Using Table 6.1, deduce the genotypes of **each** of the parental beetles used in cross 1 and cross 2.

cross 1

cross 2[2]

- (ii) An assumption was made that female tortoise beetles have XX chromosomes and males have XY chromosomes. Gene **L** is **not** located on the X chromosome. It was concluded that colour pattern phenotype followed autosomal inheritance.

Explain how the evidence in Table 6.3 supports this conclusion.

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..... [1]

[Total: 10]

7 Fig. 7.1 shows a transmission electron micrograph of part of a chloroplast.

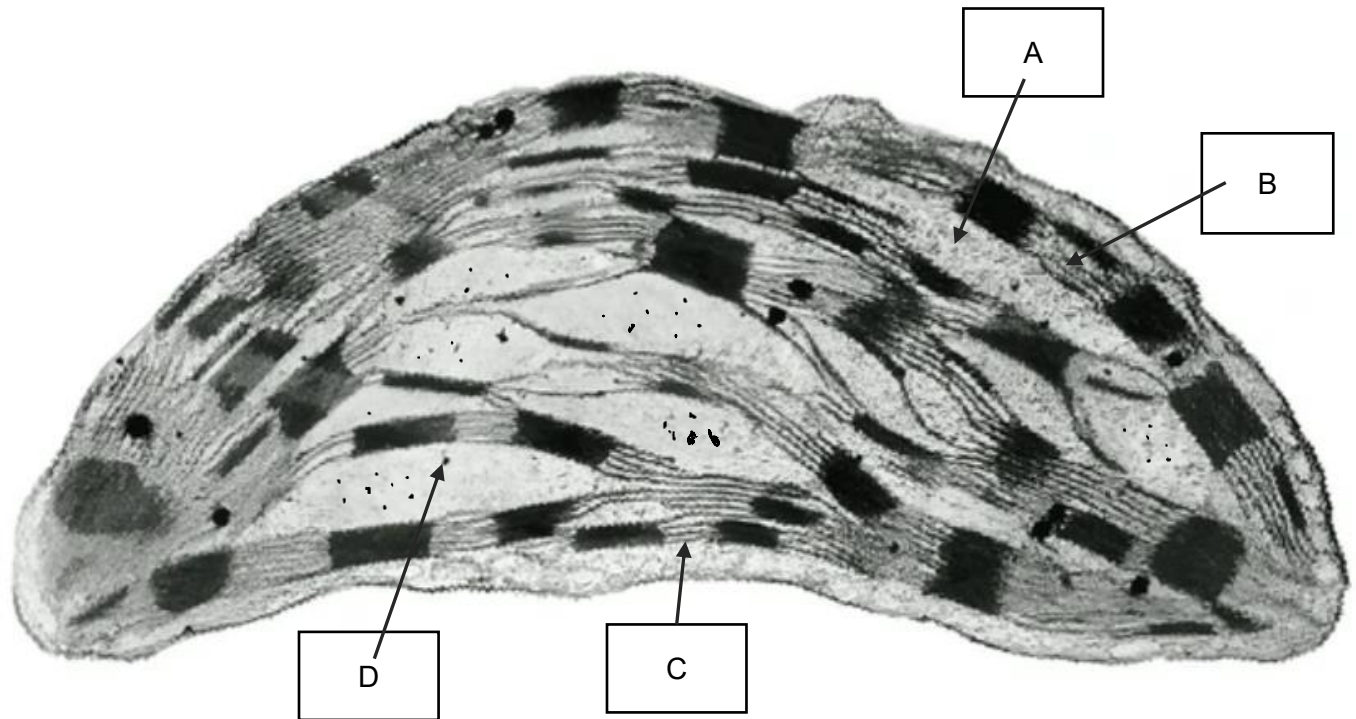


Fig. 7.1

(a) Table 7.1 describes some functions that occur in different parts of a chloroplast.

Complete Table 7.1 by identifying the letter on Fig. 7.1 that is a location matching the description. Each letter may be used once, more than once, or not at all.

Table 7.1

description	letter
accumulates (builds up) a high concentration of protons	
makes triose phosphate	
makes some chloroplast proteins	
pumps protons	

[4]

(b) An experiment was carried out to investigate the effect of changing light conditions on the pH of the chloroplast stroma. Scientists followed pH changes in chloroplast stroma using fluorescent chemicals that can be used as pH indicators.

- Chloroplasts were isolated from cells.
- A suspension of chloroplasts was prepared and kept in the dark for 180 seconds.
- The chloroplasts were exposed to a period of light of fixed intensity for 240 seconds, then returned to dark conditions.
- The pH of chloroplast stroma was continuously measured and recorded.

Fig. 7.2 shows the results of this experiment.

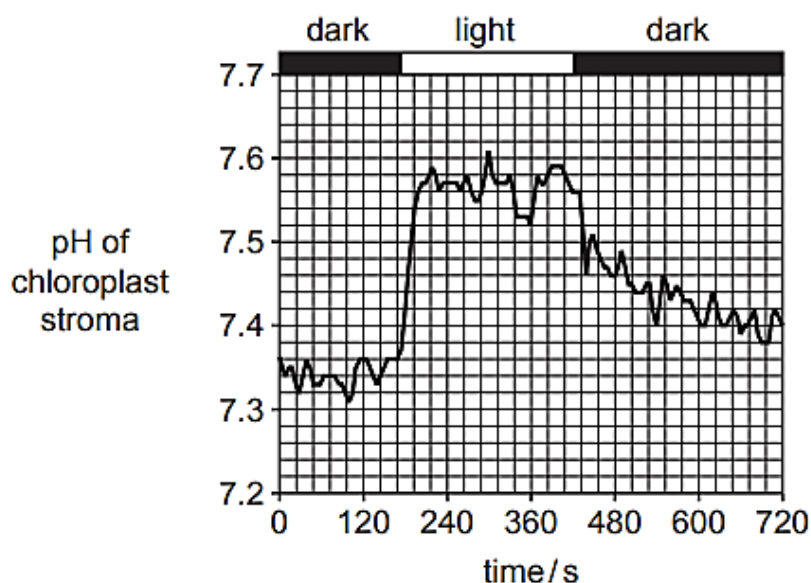


Fig. 7.2

(i) Describe the results shown in Fig. 7.2.

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..... [3]

- (ii) Explain how the results in Fig. 7.2 support that chemiosmosis occurs during photophosphorylation.

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[Total: 10]

- 8 (a) Insulin has an important role in the maintenance of blood glucose concentration.

An investigation measured how blood glucose concentration and blood insulin concentration changed after a glucose-rich meal had been eaten.

The results are shown in Fig. 8.1.

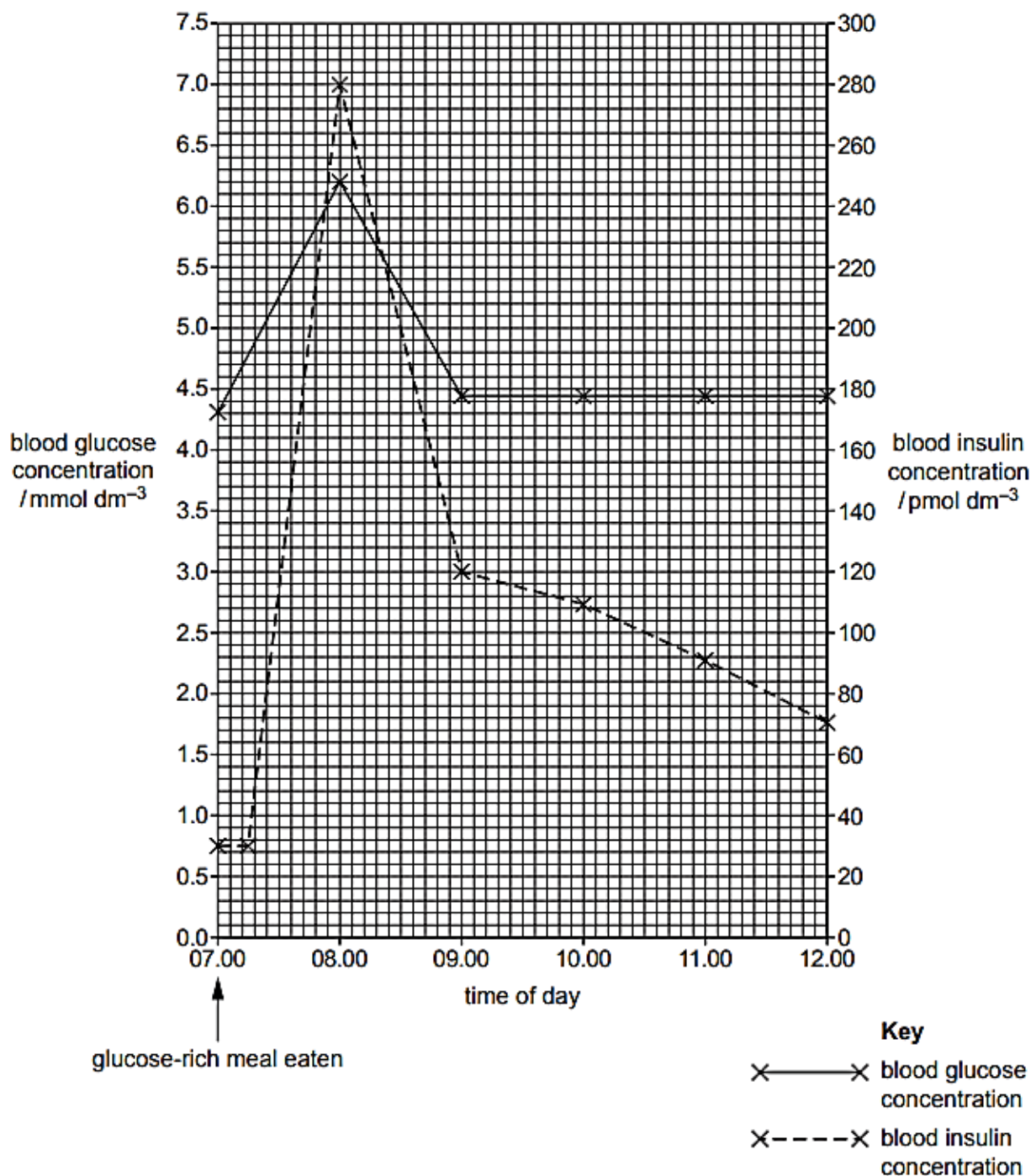


Fig. 8.1

- (i) Describe **and** explain how the results shown in Fig. 8.1 indicate a relationship between blood glucose concentration and blood insulin concentration after the consumption of a glucose-rich meal.

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- (ii) Suggest **and** explain how the results shown in Fig. 8.1 would change if the meal was mostly starch rather than glucose.

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- (b) Glucagon is synthesised by cells in the pancreas known as alpha (α) cells. Glucagon binds to G-protein-coupled receptors in the cell surface membrane of liver cells. This results in the activation of G-proteins.

Outline the sequence of events occurring within the cell after the activation of G-proteins that helps to restore the blood glucose concentration to its set point.

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..... [4]

[Total: 10]

- 9 The puma, *Puma concolor*, lives in North and South America.

Fig. 9.1 shows a puma.



Fig. 9.1

Fig 9.2 shows the distribution of the puma species.

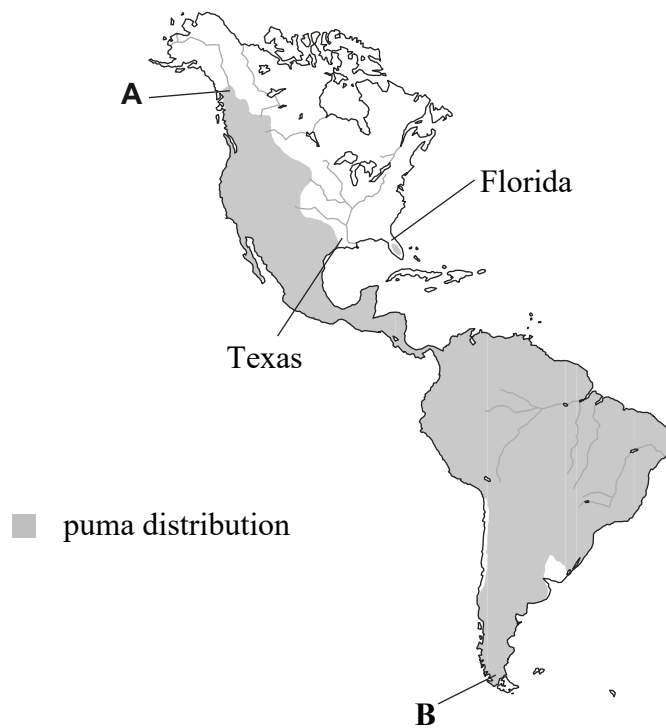


Fig. 9.2

- (a) Members of different subspecies belong to the same species but have some morphological differences and are found in different geographical locations. Members of different subspecies are still able to interbreed with one another.

In the past the puma has been divided into 32 subspecies. The subspecies of puma varied in body size, coat colour and behaviour to adapt each population to its environment.

Explain how the different subspecies of puma have evolved.

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..... [4]

In 2016, genetic analysis concluded that there are only two genetically distinct subspecies of puma, one North and Central America and one in South America.

- (b) Outline how practical techniques could be used to conduct a genetic analysis of the puma species.

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..... [2]

- (c) Fig. 9.2 shows the location of an isolated puma population in Florida. In 1990, the size of this population was very small, with fewer than 30 individuals.

Three phenotypic features that vary in pumas are the shape of the tail, the pattern of hair growth on the back and the position of the testes in male pumas.

Variant forms of these phenotypic features that are normally rare occur at a high frequency in the small Florida population. These variant forms are:

- bent tail
- abnormal pattern of hair growth on the back
- testes remain in abdomen (undescended) in some male pumas.

- (i) Explain how the small size of the Florida population resulted in a high frequency of these normally rare variant forms.

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- (ii) In 1995, eight puma females from Texas were introduced to Florida to increase the breeding success and future size of the puma population in Florida. In the next 20 years the population grew substantially.

Suggest why the introduced females were taken from Texas and not from points **A** or **B** on Fig. 9.2.

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..... [1]

[Total: 10]

10 B lymphocytes are crucial to the adaptive immune system.

(a) Outline the mechanism that generates B cells that can recognise a multitude of infectious agents.

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..... [4]

[Total: 4]

- 11 The mean sea surface temperature was measured each year and compared to the 100-year average. Fig. 11.1 shows the data from 1880 to 2020 between 60°N and 60°S.

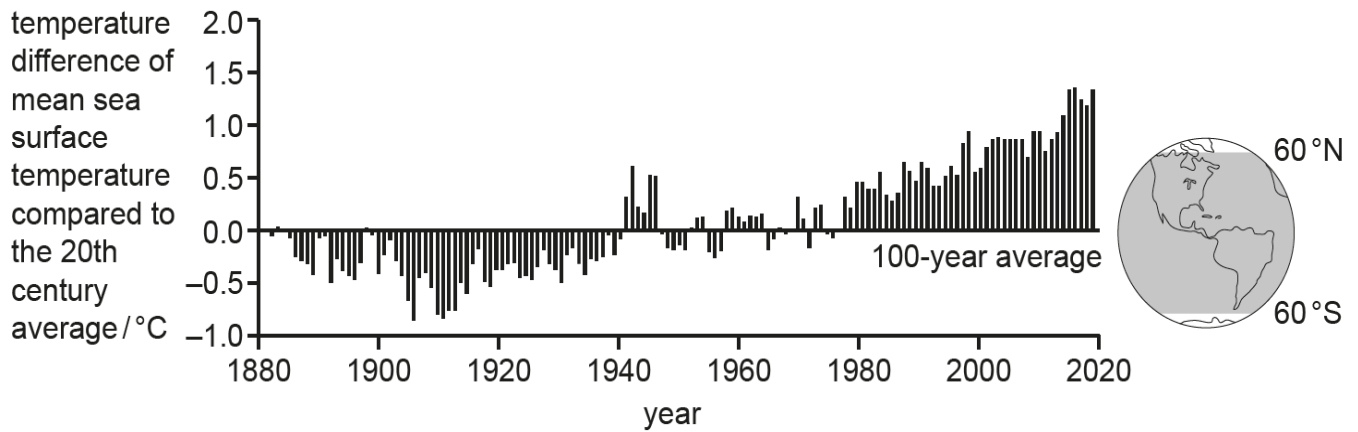


Fig. 11.1

- (a) Describe the trends in the mean sea surface temperatures shown in Fig. 11.1.

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..... [3]

- (b) One impact of changing sea temperatures is a change in the location of marine organisms.

Fig. 11.2 shows an American lobster.



Fig. 11.2

Fig. 11.3 shows the location of a population of American lobster in the North Atlantic, compared to their location in 1980.

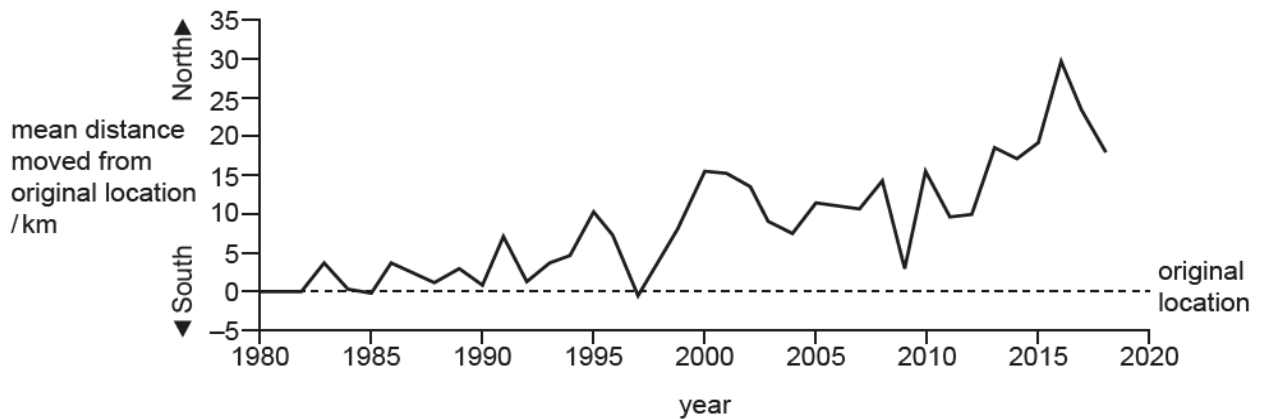


Fig. 11.3

Suggest reasons for the change in location of American lobster. Use data from Fig. 11.1 and Fig. 11.3 in your answer.

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[Total: 6]

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