

NAME: _____

CLASS: _____

INDEX: _____



CATHOLIC JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
Higher 2

Suggested Answers

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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7	
8	
9	
10	
11	

Answer **all** questions

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

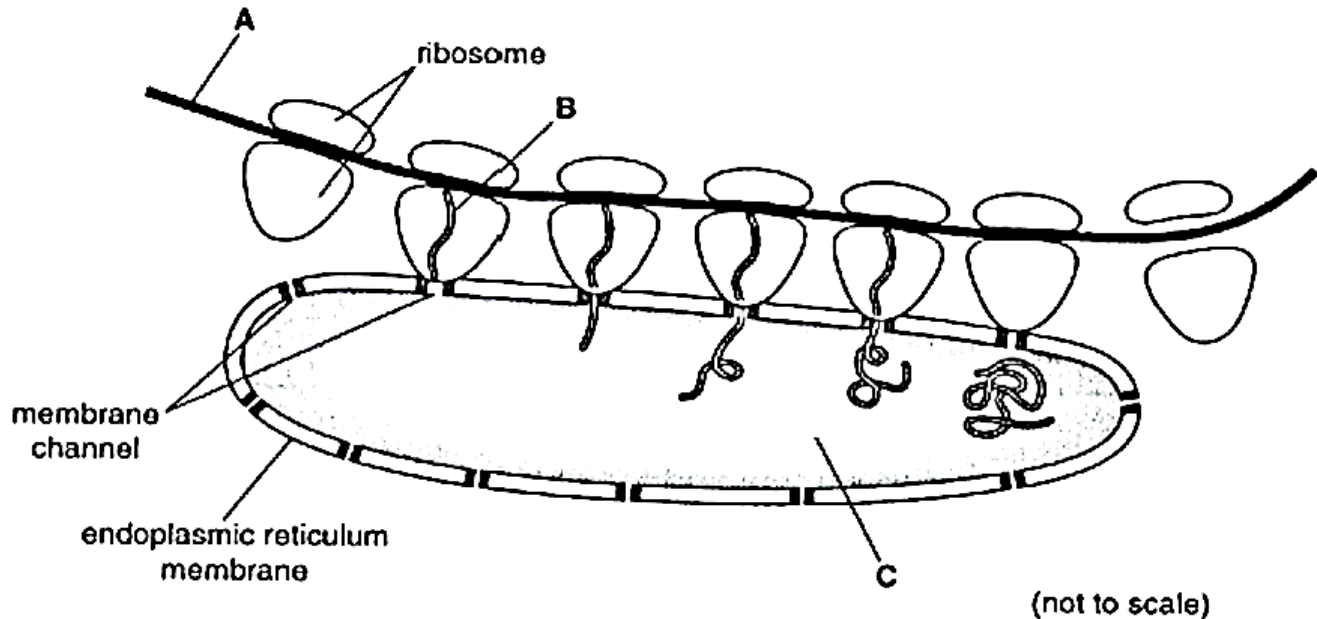


Fig. 1.1

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

.....
 [3]

A – mature mRNA
 B – **Growing** polypeptide
 C – **Lumen** of the RER/Cisterna

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

.....

 [3]

1. The function of the protein that forms the membrane channel is to allow **large and polar** molecules, such as polypeptide, to be transported across the membrane.
2. The protein also functions as a **receptor** to allow the binding of the signal peptide from the initial translation of the mRNA.
3. This allows the **ribosome** to bind to/dock and anchor onto the endoplasmic reticulum to complete the translation of protein directly into the cisternae of the ER.

(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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..... [3]

1. The polypeptide will **fold** into its **3D conformation** in the cisternae of the ER and packaged into an ER **transport vesicle**.
2. ER vesicle will transport the protein to the **Golgi body for further modification** such as glycosylation to form glycoprotein.
3. Modified proteins are packaged into Golgi **secretory vesicles** and bud off at the *trans* face of the Golgi body, the secretory vesicles moves to the cell surface membrane for **exocytosis** of the proteins out of the cells.
4. Microtubules form tracks to assist in the vesicle trafficking within the cell.

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

.....

..... [1]

1. Proteins bind to specific sites of **protein carriers / membrane protein** present on the **cell surface membrane** of prokaryotic cells, transporting the proteins out of the cell/OWTTE.

[Total: 10]

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

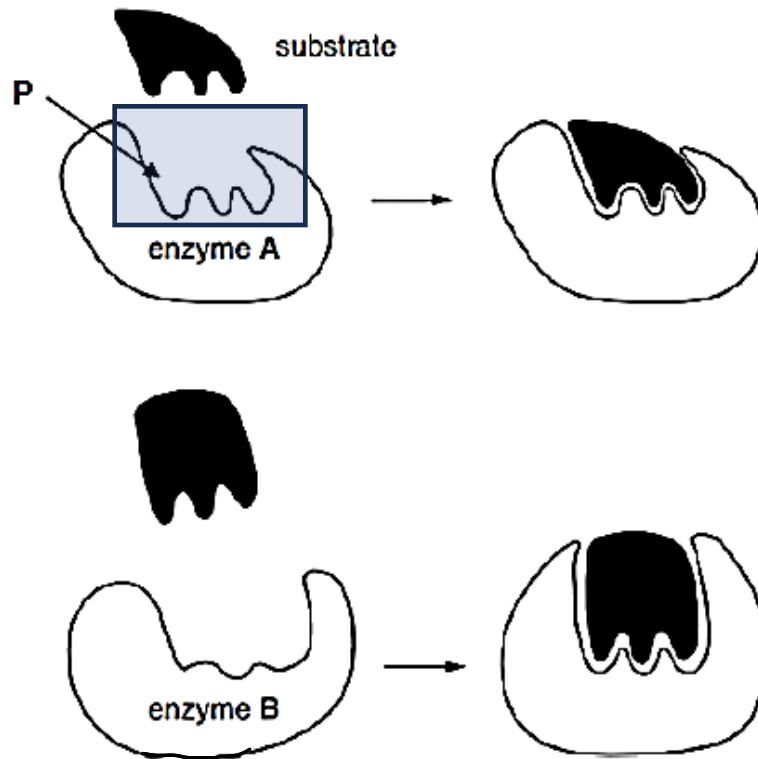


Fig. 2.1

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

.....

 [2]

1. **Catalytic (R group) residues;** are responsible for the ability of the enzyme to catalyse a particular chemical reaction; acts on the chemical bonds in the substrate.
2. **Contact (R group) residues;** are responsible for the **specificity of the enzyme** and form a shape that is **complementary to the shape of substrate.**

- (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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..... [2]

1. **lock and key hypothesis**, the **substrate molecule(s)** has a **shape complementary** to the **active site of its enzyme** fit into active site like a key to a lock, forming the **enzyme-substrate complex**.
2. **Induced-fit hypothesis**, the substrate does not have a shape exactly complementary to the active site of enzyme at first. As the substrate molecule(s) binds to the active site of enzyme, it induces a **conformational change in the structure of the active site of the enzyme** so that the molecule(s) become more precisely fit to the active site of enzyme.

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.

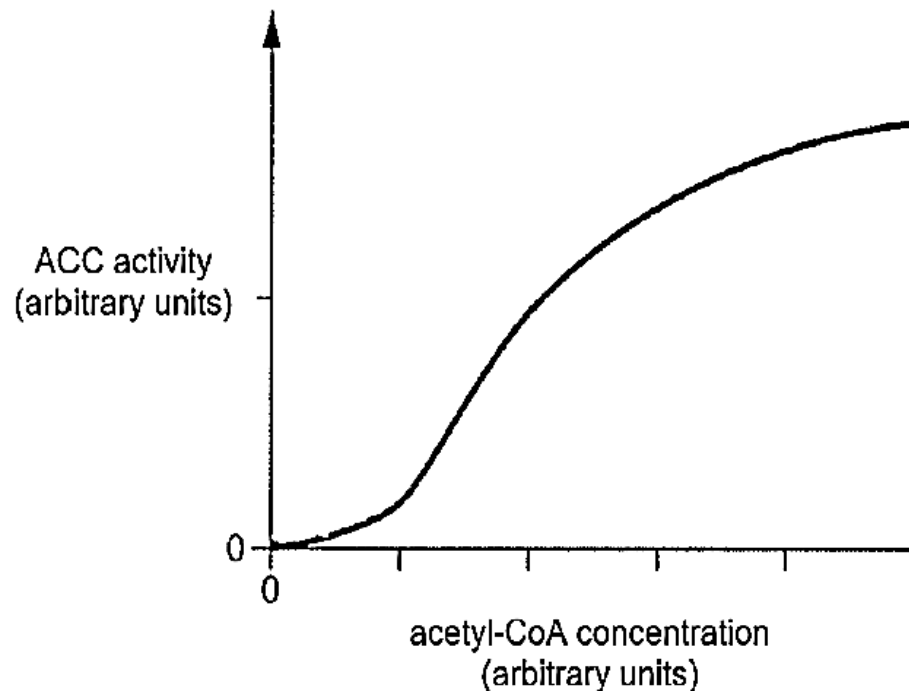


Fig. 2.2

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

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..... [2]

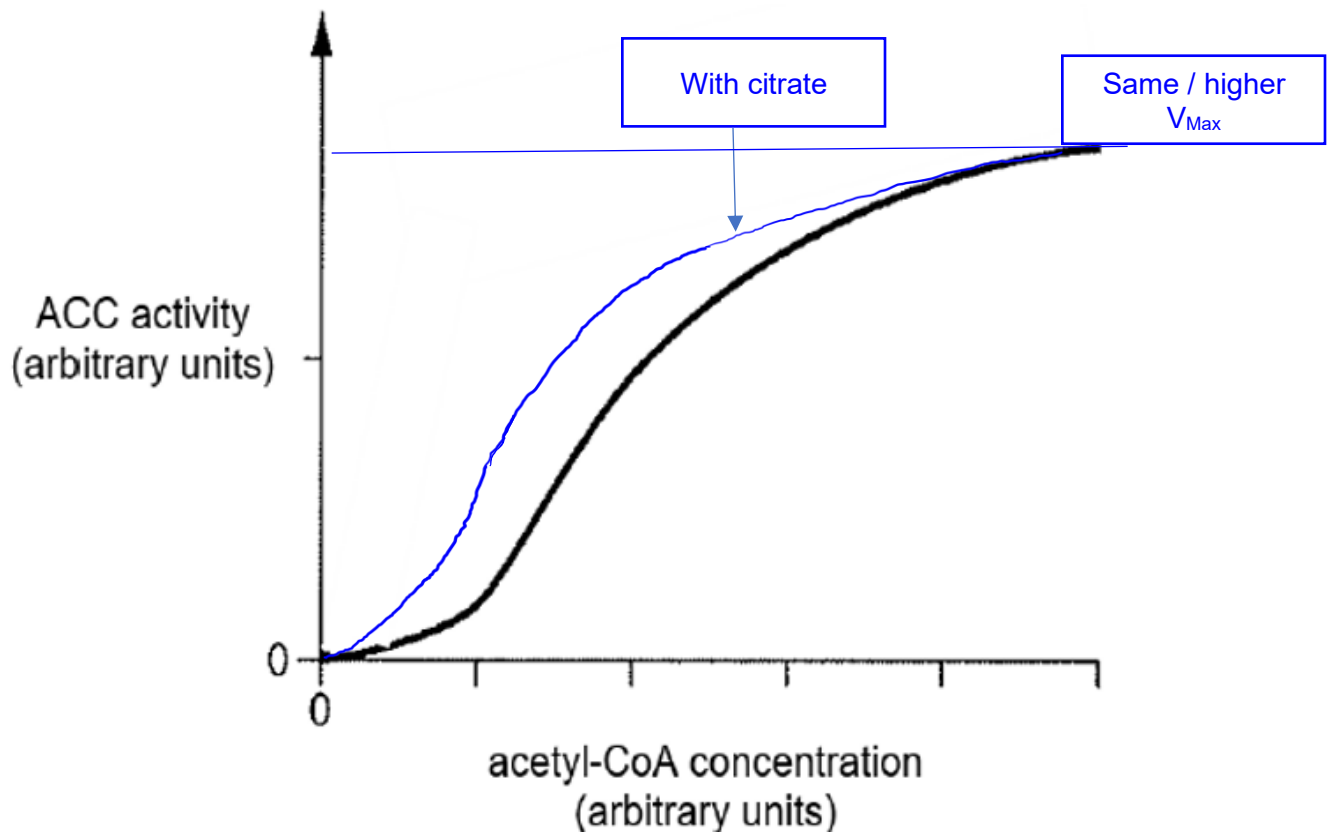
1. Citrate **Binds to Allosteric Site:** The activator (e.g., a metabolite or signaling molecule) binds non-covalently.
2. **Induced Conformational change:** The enzyme changes shape, the active site becomes more accessible or efficient in catalysing the reaction.

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

..... [1]

Ensure graph is always higher; V_{max} is same or higher.

Must label the graph



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

..... [2]

1. Biotin are **Cofactors**; non-protein chemical compounds
2. that assist enzymes in catalysing biochemical reactions, that would otherwise be too slow or impossible
3. explanation of how it affects enzyme action / OWTTE.

[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.

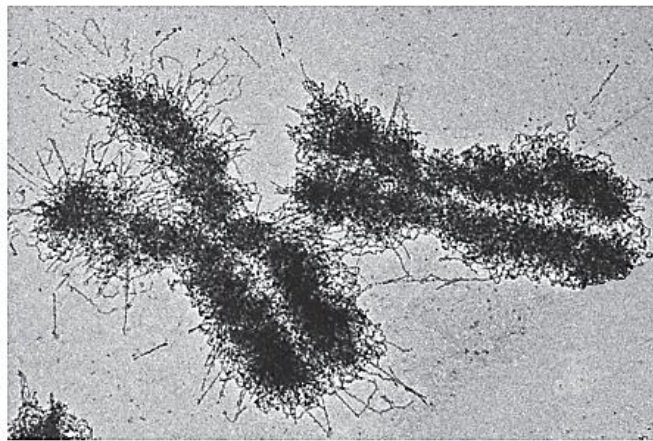
(a) Changes occur to chromatin during mitosis so that chromosomes become visible.

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

.....
 [1]

1. coiling / supercoiling / condensation / becomes more compact / AW ;

(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]

any **four** from:

1. each has two **genetically identical sister chromatids** ;
2. **sister chromatids joined** by a **centromere** ;
3. each chromatid has a **single DNA molecule** ;
Accept: 2 chromatids and 2 DNA molecules
4. metaphase chromosome is short and thick, **1400nm in diameter** ;
5. DNA associated with, **histone** proteins / histones;
6. **telomeres** / repeating non-coding sequences, at ends of, chromatids / chromosomes ;

- (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.

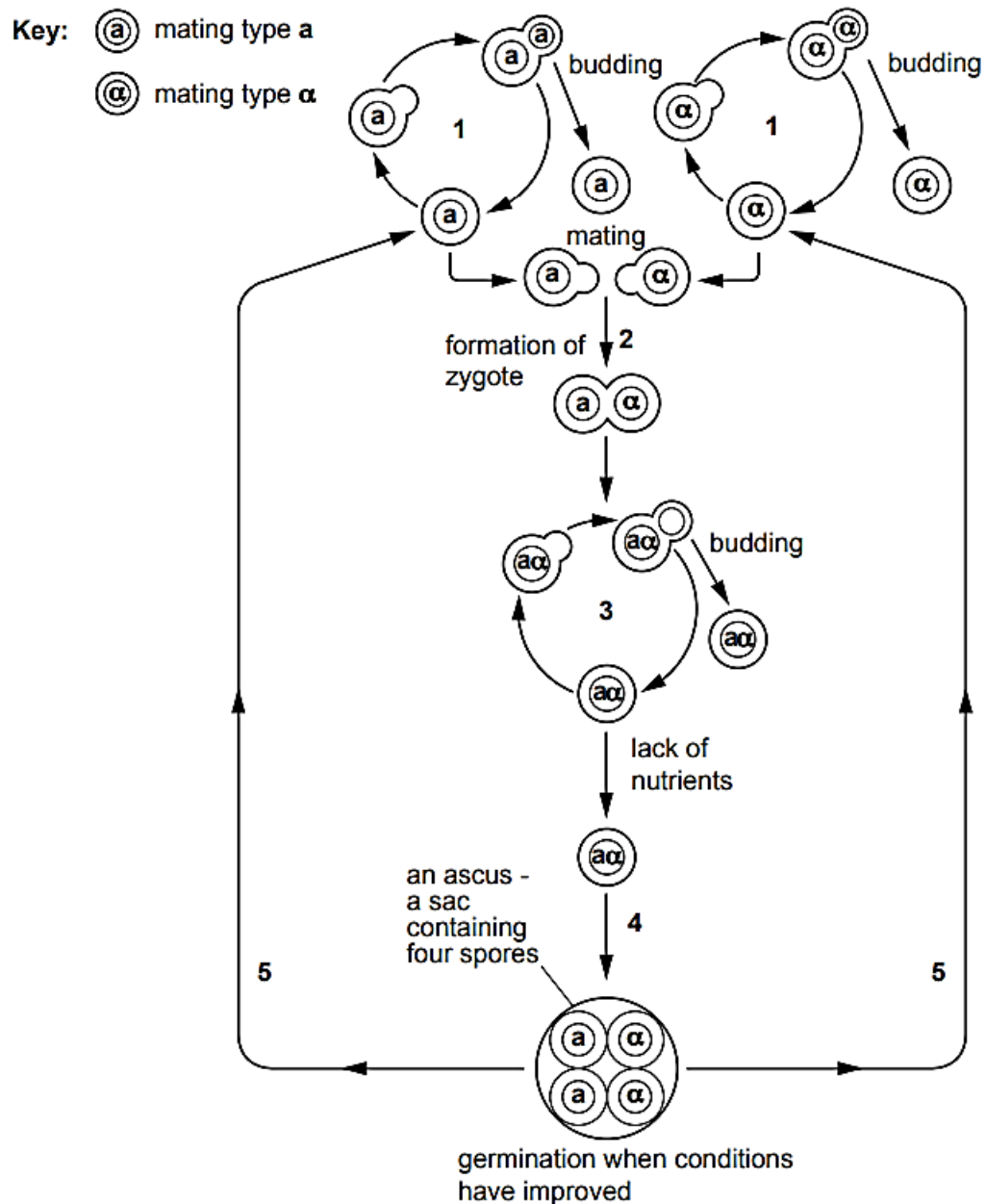


Fig. 3.2

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

involve mitosis

involve meiosis

[2]

1. involve mitosis: **1 and 3** ;
2. involve meiosis: **4** ;

(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]

any **three** from:

1. **genetic variation** ;
2. due to, **crossing over / independent assortment** ;
3. some will, be adapted (to changing environment) / survive or avoids whole population being wiped out / or reverse argument ;
4. (allows) stage 1 / stage 3 / asexual reproduction without the need to find a mating partner;
5. (allows) random, mating / fertilisation / fusion of gametes ;
6. some have advantageous combinations of alleles ;
7. AVP ; e.g. ref. to dormancy that allows for population to survive even when conditions are not favourable, preserving genetic variation

[Total: 10]

4 Transcription and translation are integral to gene expression.

(a) Contrast between transcription and translation in eukaryotes.

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..... [3]

any three from

Feature	Transcription	Translation
Location	Nucleus	Either: (i) Free ribosomes in cytosol OR (ii) Bound ribosomes on membrane of rough endoplasmic reticulum (RER)
Template	DNA template / noncoding strand	mRNA
Raw materials	Free ribonucleotides	Amino acids carried by tRNAs
Bond formed between basic unit	Phosphodiester bond formed between the C3 of ribose of one nucleotide and the phosphate group of the next nucleotide	Peptide bond formed between the carboxyl group of one amino acid and the amino group of the next amino acid
Enzyme involved in bond formation	RNA polymerase catalyses the formation of phosphodiester bonds between ribonucleotides	Peptidyl transferase catalyses the formation of peptide bond between two amino acids held by tRNAs located in the 'P' and 'A' sites of the large ribosomal subunit.
Direction in which genetic message is read	RNA polymerase moves along the DNA sense / noncoding / template strand and reads it in a 3' → 5' direction	Ribosome moves along the mRNA and reads it in a 5' → 3' direction
Products	mRNA, tRNA, rRNA	Polypeptide is synthesised from the N-terminus (amino) to C-terminus (carboxyl)

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.

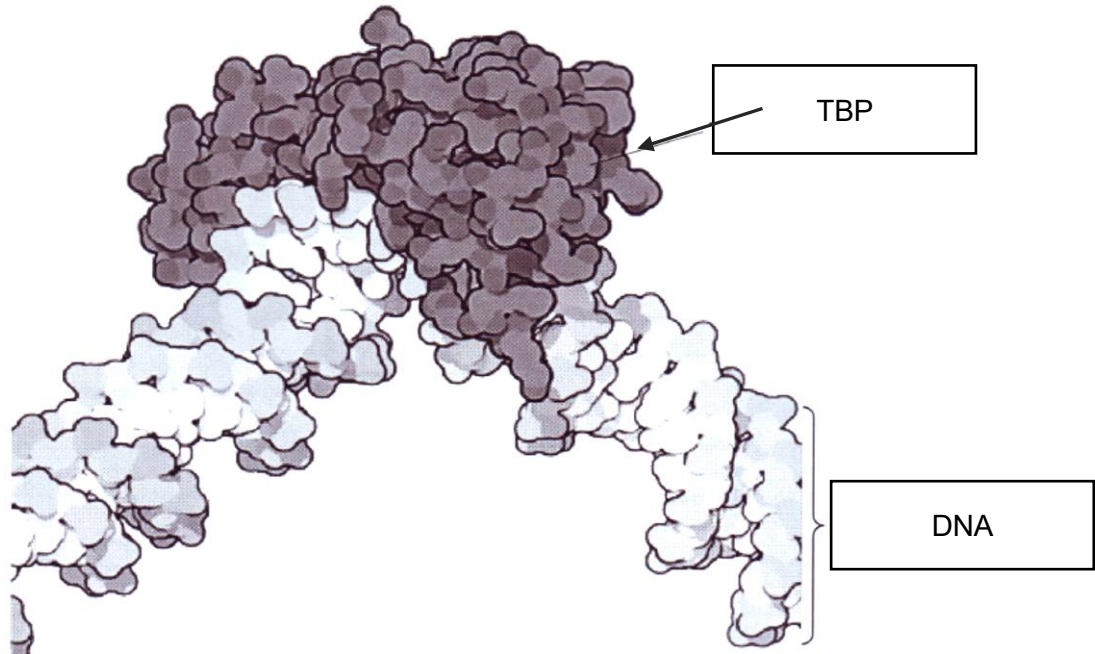


Fig. 4.1

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

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..... [2]

1. TBP has a **specific binding site** which is complementary to the **shape** of the TATA box.
2. This allows the TBP to bind to the DNA by **hydrogen bonding** and **hydrophobic interactions**

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

.....

 [2]

1. Unwinding the double helix allows the binding of other **general transcription factors and RNA polymerase** to promoter on the non-coding strand to initiate the formation of transcription initiation complex to promote transcription.
2. Double helix is unwound to **expose** both the coding strand and non-coding strand of DNA.
3. This allows **hydrogen bonds to be formed between complementary base-pairs** of free ribonucleotides and the non-coding DNA strand in the formation of the primary mRNA transcript.

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

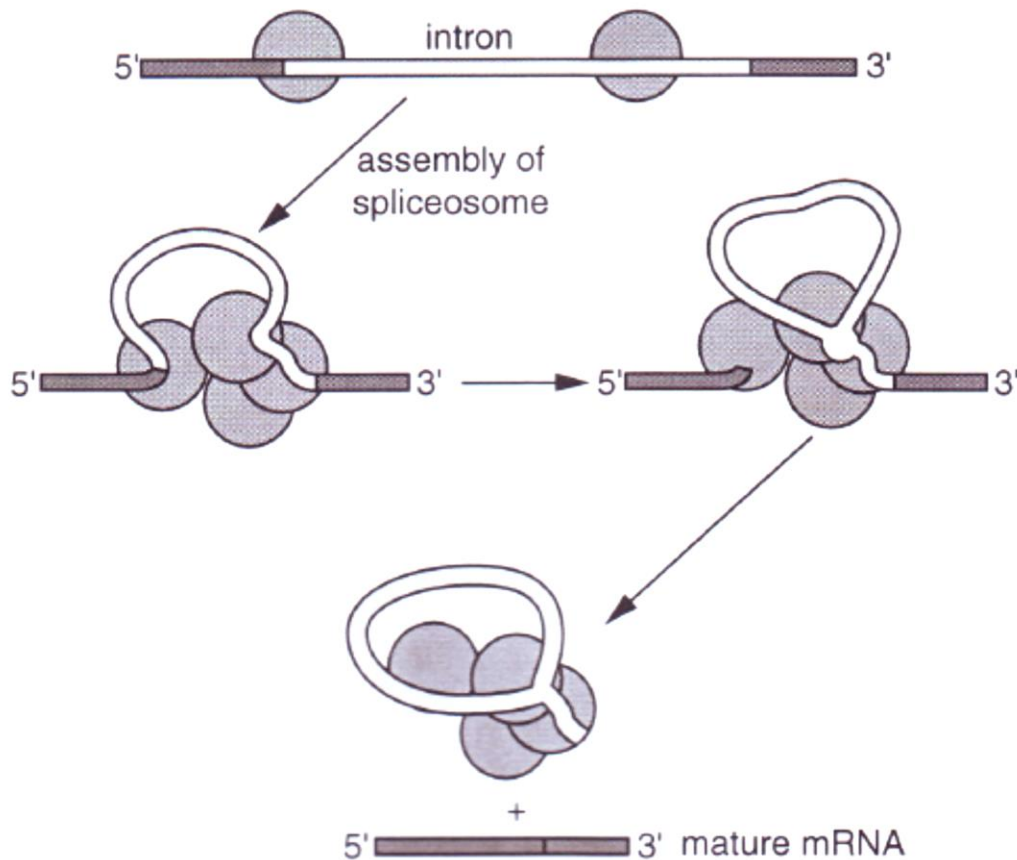


Fig. 4.2

- (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]

1. **Recognition and binding** of spliceosome **subunits** at specific **5'** and **3'** sites within the intron.
[Compulsory]
2. **Hydrolysis of phosphodiester bonds** at both ends of introns.
3. Pre-mRNA contains both **exons**, which are coding regions, and **introns**, which are non-coding regions.
4. If introns are not excised by the action of spliceosome, the unspliced pre-mRNA when translated, will form a **longer polypeptide with different amino acids**.
5. These additional amino acids will cause the polypeptide to fold into a **different three-dimensional conformation** that can, disrupt the function of the protein.
6. The exons must be **spliced together to form the mature mRNA** that codes for the correct amino acid sequence in the polypeptide.

[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]

Similarities: Use of glycoproteins to recognize receptors on the host cells. [Compulsory]

Feature	Influenza Virus	HIV
Target Cells	Respiratory epithelial cells	CD4+ T cells
Viral Glycoprotein	Haemagglutinin (HA)	gp120 and gp41
Receptor	Sialic acid	CD4 and CCR5/CXCR4
Entry Route	Receptor -mediated endocytosis	Direct membrane fusion

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.

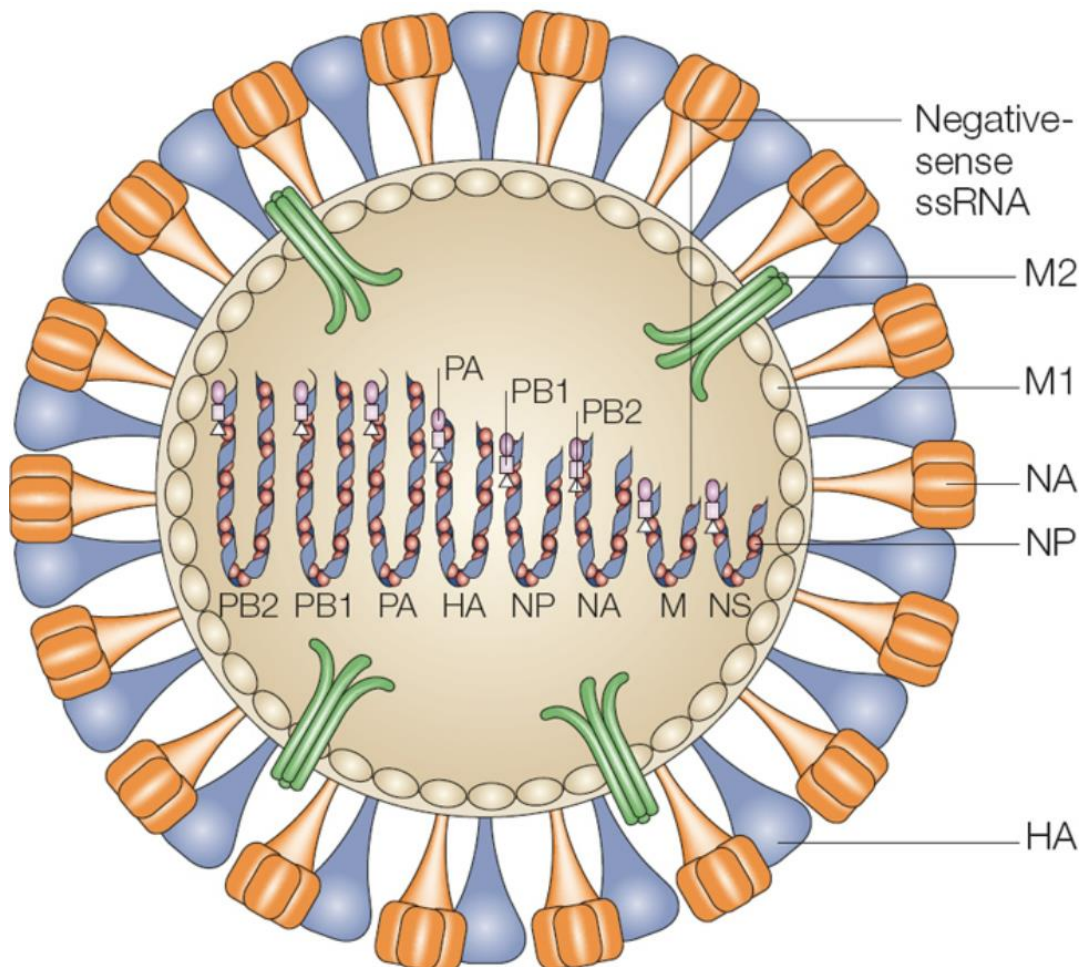


Fig. 5.1

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

.....
 [1]

1. nucleus.

- (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.

.....

 [2]

1. Such RNA segments are templates which code for viral RNA-dependent RNA polymerase **not present in host cell**;
2. Viral RNA-dependent RNA polymerase uses **negative sense RNA as a template** to synthesize positive sense RNA, which acts as an mRNA to be used in translation process for formation of **viral** proteins, and which also acts as a template for replication of new **viral** (negative sense) RNA genome

- (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.

.....

 [2]

1. Sialic acid on the viral envelope derived from host membrane during **budding** is **not** cleaved and removed by neuraminidase
2. result in agglutination of the enveloped virus thus **preventing new viruses from being released** to infect surrounding host cells.

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.

.....

 [2]

1. **Antigenic drift**, mutation on the glycoproteins of the virus
2. allowed for the **complementary binding to the sialic acid receptors on human cells** which are structurally similar from those on pig cell.

[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.

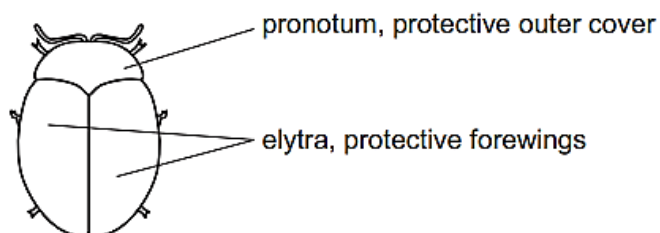



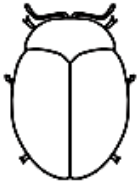



Fig. 6.1

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.

.....

 [1]

1. **gene L has four alleles** / L^V , L^T , L^R and L^r ;
 OR
gene coding for colour pattern has more than two alleles

- (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** [4]

Parental phenotypes:

dfm-b

dfm-b

Parental genotypes:

$L^T L^R$

X

$L^T L^R$

[1m]

gametes:

L^T L^R

L^T L^R

[1m]

1m awarded for correct gametes and circle of gametes.

offspring genotypes:

$L^T L^T$

$L^T L^R$

$(L^T L^R)$

$L^R L^R$

[1m]

offspring phenotypes:
linked to genotypes

dfm-a

dfm-b

(dfm-b)

rufipennis

ratio of offspring phenotypes: 1 dfm-a
[1m]

:

2 dfm-b

:

1 rufipennis

- (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]

L^T and L^R ;

L^T and $L^R > L^V > L^r$ or $L^T / L^R, L^V, L^r$;

- (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]

(female) $L^V L^r$ and (male) $L^r L^r$;

$L^V L^r$ (and $L^V L^r$) ;

- (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.

.....

 [1]

female metallic offspring are produced in cross 2 ;

or if linked to X chromosome no female metallic offspring are produced in cross 2 ;

or if linked to X chromosome, Table 6.3 would show equal proportion of males having veraguensis to metallic phenotype (1:1)

or if linked to X chromosome, there should be more female offsprings with veraguensis phenotype, but there are similar numbers of male and female offspring produced for each phenotype;

[Total: 10]

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

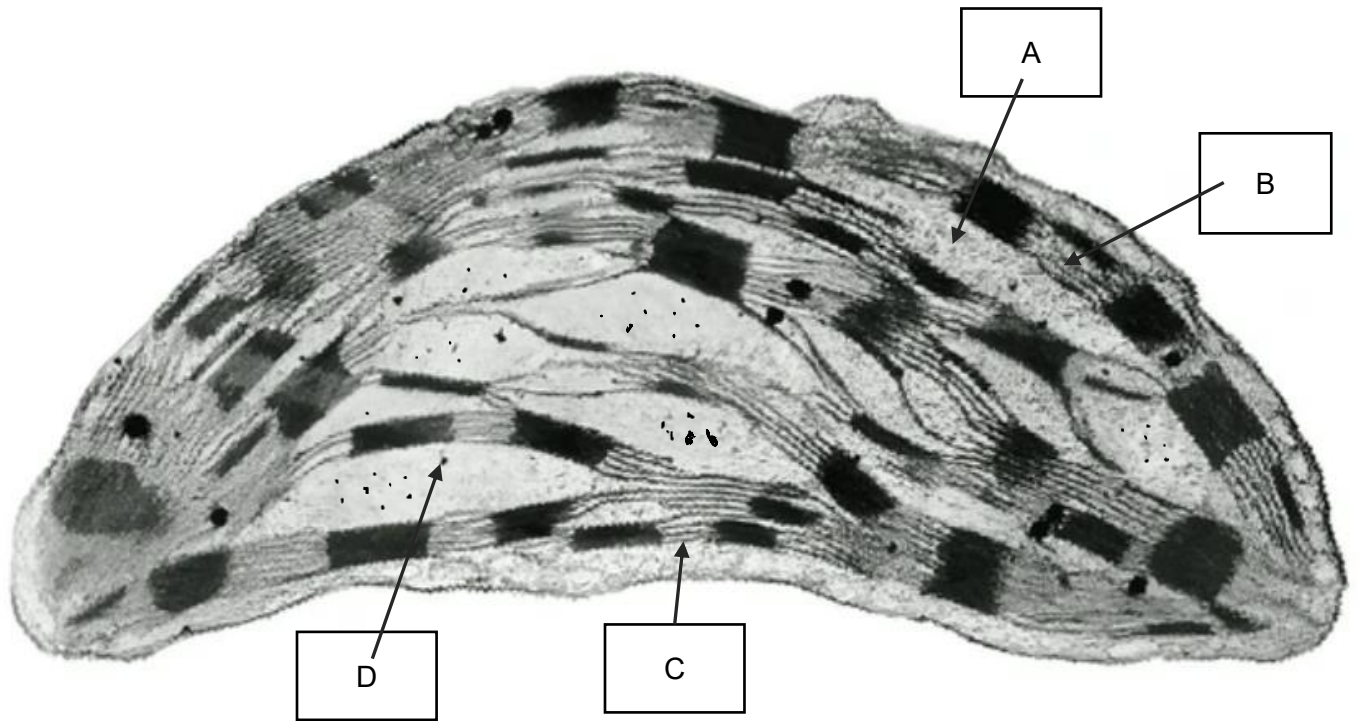


Fig. 7.1

- (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]

description	letter
accumulates (builds up) a high concentration of protons	B ;
makes triose phosphate	A ;
makes some chloroplast proteins	D ;
pumps protons	C ;

(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.

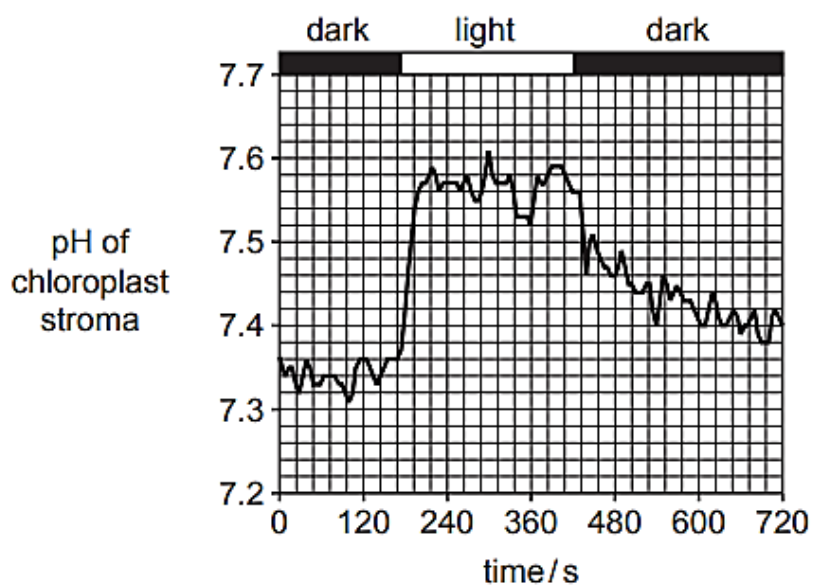


Fig. 7.2

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

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..... [3]

any **three** from:

1. the pH is **higher** in the light than in the dark/ or reverse argument
or the pH **increases** (from dark) to light
or the pH **decreases** (from light) to dark ;

and
 accompanying data to support ;
 (mp1) dark(1) ~ pH 7.31–7.36 vs light ~ 7.52–7.61 vs dark (2) ~ 7.51–7.38

2. the pH, increases **sharply** and levels off/ AW, when **changed to light** ;
and
 accompanying data to support ;
 (mp2) from pH 7.36 to 7.56-7.58 in **48 seconds**/from **168s to 216s** (1½ square and each square 24 s)

3. the pH decreases, **gradually** / less steeply, when **returned to the dark**
or
 decrease in pH **does not return to original** (dark) pH ;
and
 accompanying data to support ;
 (mp3) from pH 7.56 to 7.4 in **288 s** / from **420s to 720s** (12.5 squares)

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

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..... [3]

any **three** from:

1. in the presence of light, **light energy** is being used to **photoexcite electrons in the chlorophyll**, energy released as **electrons move down the electron transport chain down the energy gradient** ;
2. energy is used to **pump H⁺ ions out (of stroma) into thylakoid space / lumen**, (leads to) **decreased H⁺ concentration** in the stroma, evidenced by **the increase in pH in stroma** in the presence of light ;
3. Subsequently, in the dark, **H⁺ diffuse back** (into stroma) through **ATP synthase**, (leads to) **increased H⁺ concentration** in the stroma, causing stroma to **decrease pH**;

[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.

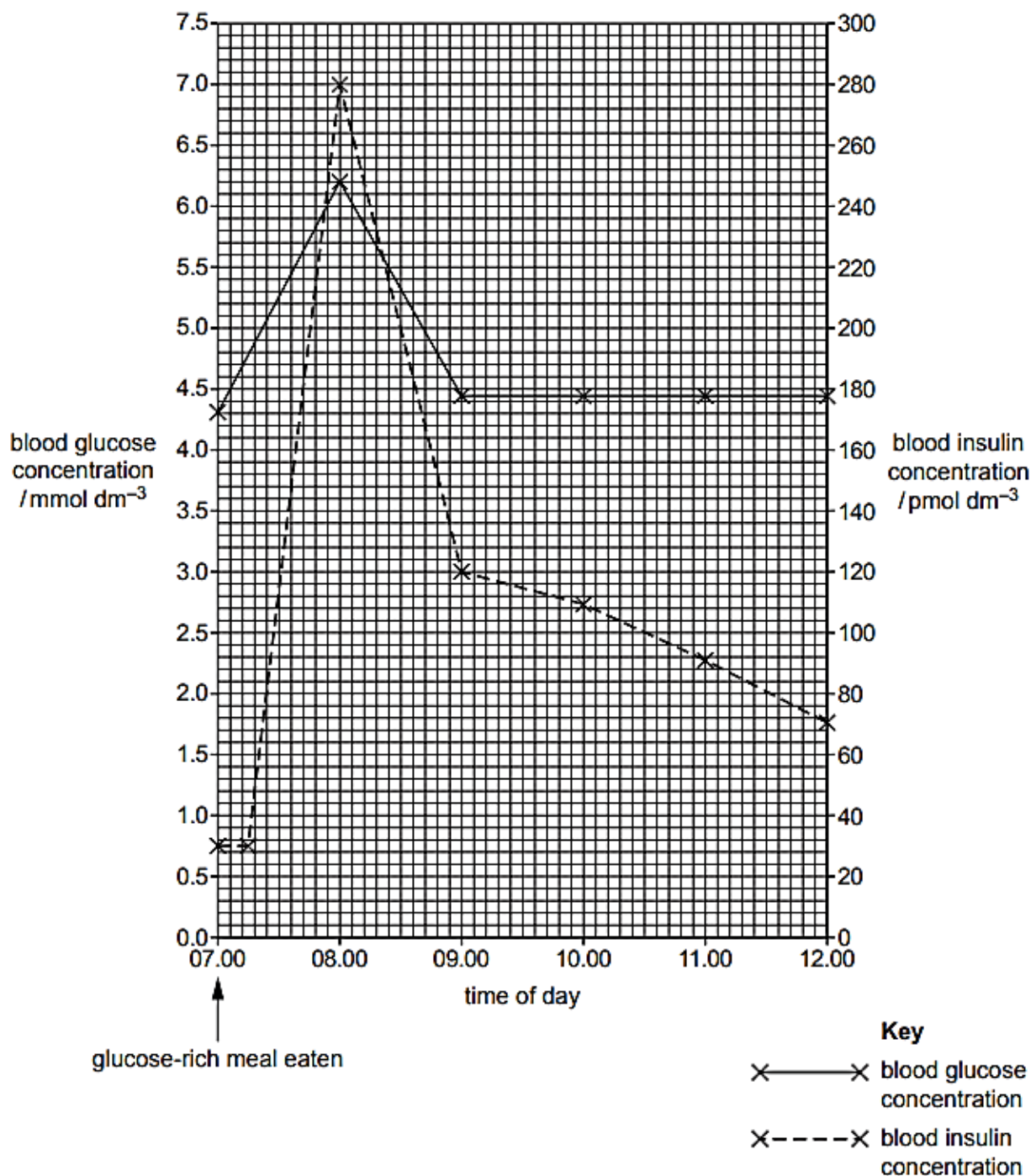


Fig. 8.1

- (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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..... [3]

any **three** from:

1. as the, **blood glucose** / glucose concentration, **increases** the, **blood insulin** / insulin concentration, **increases** ;
Accept: positive correlation

data quote for mp1

time of day ± 1.5 min	blood glucose conc / mmol dm^{-3} ± 0.025	time of day ± 1.5 min	blood insulin conc / pmol dm^{-3} ± 1
07.00	4.3	07.15	30
08.00	6.2	08.00	280

2. increase in, blood glucose / glucose concentration, causes **release of insulin from pancreas** ;
3. insulin stimulates the **conversion of glucose to glycogen** / glycogenesis or insulin **increases permeability** (of liver / muscle) **cells to glucose** / AW ;
4. insulin causes, **blood glucose / glucose concentration, to return back to set point** ;

data quote for mp4

time of day ± 1.5 min	blood glucose conc / mmol dm^{-3} ± 0.025	time of day ± 1.5 min	blood insulin conc / pmol dm^{-3} ± 1
08.00	6.2	08.00	280
09.00	4.45	09.00	120

- (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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..... [3]

suggest

max 2 from:

1. ref. to **delay before both graphs increase** / AW ;
2. **peaks for both would be lower** ;
3. both curves would take longer to decrease ;

explain

4. time is needed for starch to be, broken down / converted (to glucose) ;

- (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.

..... [4]

any **four** from:

1. ref. to binding and activation of adenylyl cyclase;
2. formation of, **cyclic AMP / cAMP** which acts as a second messenger that **activates protein kinase A**;
3. protein kinase A phosphorylates and activates other protein kinases which initiates a **phosphorylation cascade**;
4. **amplification of signal** where one protein kinase can activate many protein kinases;
5. **glycogenolysis / gluconeogenesis** / described, glucose released into blood, restoring set point of 90 mg of glucose / 100 ml of blood;

- 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.

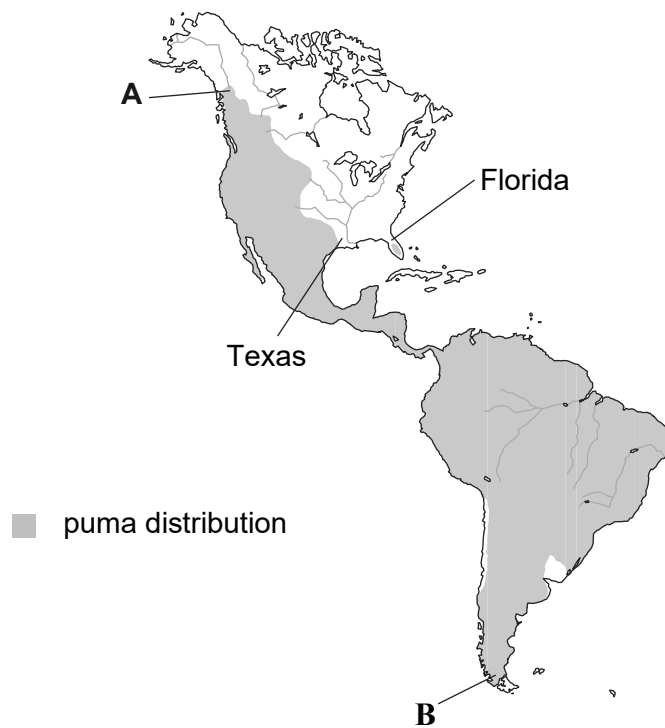


Fig. 9.2

- (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]

1. Populations of pumas became **geographically isolated** due to barriers such as mountains or rivers.
2. This isolation between the separated puma populations/subpopulations, resulting in little or no gene flow / disruption to **gene flow**.
3. Each isolated (sub) population experienced different **environmental conditions** and **selection pressures**, such as variations in climate / habitat / vegetation / available prey.
4. Over time, **random mutations** that result in different alleles that code for the phenotypic variations / morphological differences, independent **adaptation** / independent evolution and **natural selection**
5. led to **changes in allele frequencies**, resulting in the evolution of different **gene pools** and the formation of distinct subspecies.

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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1. **DNA can be extracted** from blood, tissue, or cells obtained from pumas at different locations or from different subspecies and then **amplified using Polymerase Chain Reaction (PCR)** to produce sufficient quantities for analysis.
2. Molecular techniques (at least 2) such as **gel electrophoresis** followed by **Southern blotting**, DNA sequencing / DNA profiling / genetic fingerprinting can be used to compare **nucleotide sequences of common gene / genetic similarities / molecular homologies** between individuals, with the help **of bioinformatics tools or genetic databases**.
3. AVP, e.g. idea of number of differences and the degree of evolutionary relatedness; more differences in nucleotide sequence, less closely-related / more distantly related / share a more distant common ancestor

(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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1. The Florida puma population has gone through a **genetic bottleneck**, which drastically reduced its size.
2. As a result, **genetic diversity was reduced** and some alleles were lost from the gene pool, leaving behind the over-production / over-representation of recessive alleles that code for the normally rare variant forms
3. The rare and recessive alleles coding for the rare variant forms that are usually masked in heterozygotes were more likely to be inherited in homozygous form, allowing their effects such as bent tails or undescended testes to be expressed.
4. Ref. to **inbreeding** - within the isolated puma population, inbreeding became more likely, leading to increased homozygosity and reduced heterozygosity.

- (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]

Any **one** of the following:

1. Texas is closer to Florida unlike points A or B which are more distant and far away
2. Given their close proximity, Texas and Florida pumas are more closely-related / more genetically similar / share a more recent common ancestor
3. Texas and Florida have similar climates / habitats / environment
4. Ref. to availability – Texas has many pumas

[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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1. **Somatic recombination** involving both the variable regions of both the light and heavy chain gene loci;
2. Only 1 segment from **V, D and J gene segments** is chosen and joined to the constant region sequence to make the **heavy chain**;
3. Only 1 segment from **V and J gene segments** is chosen and joined to the constant region sequence to make the **light chain**;
4. Many **possible combinations** of V(D)J gene segments, resulting in formation of a repertoire of B cells with different B cell receptors that are specific to different antigens present on infectious agents;

[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.

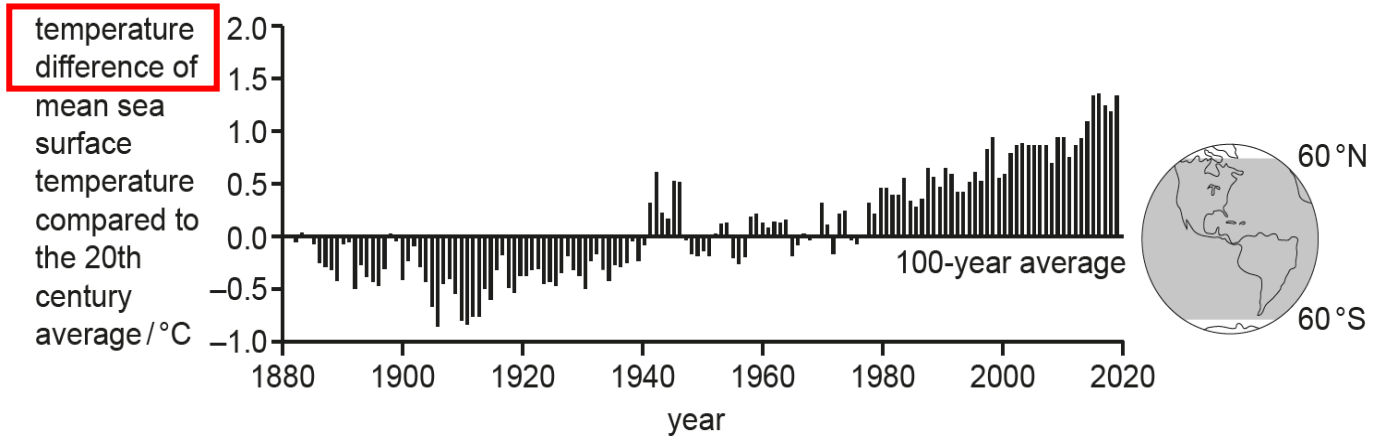


Fig. 11.1

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

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- Overall trend described (for 100-year period), e.g. mean sea surface temperatures **increased** from below 100-year average to above 100-year average / getting warmer / increasing; and correctly quoted data trend for stated year range; any two of the following:

[Accept: data cited from Fig. 11.1 in terms of temperature difference of mean sea surface temperature compared to 20th century average, but only if these are correctly referenced as such, i.e. temperature difference of..]

- From 1880 to 1940 / before 1940 / until 1940, mean temperatures were below the 100-year average;
- From 1940 to 1975 mean temperatures fluctuated above and below the 100-year average;
- From 1975 to 2020 mean temperatures fluctuated but were above (the 100-year average) / trend from 1975 to 2020 mean temperatures increased above (the 100-year average)

- (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.

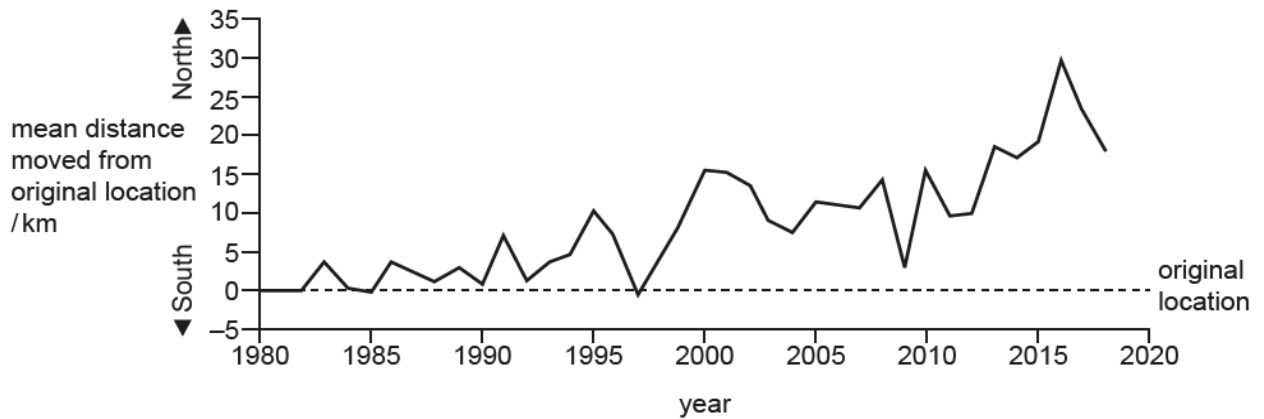


Fig. 11.3

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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1. As mean **surface sea temperature** (continues to) **increases**, the lobster **move further north / further away** from their original location;
2. From 1980 to 2020, with increasing temperature difference of mean sea surface temperature compared to 20th century average of 0.4 to 1.4°C , lobsters start to move north / northwards / migrate, from 0 km to about 20 km away from the original location.
3. As latitude increases / further north; sea water temperatures are cooler
4. so migrating north puts the lobsters in their preferred temperature / temperature that they are used to / habitable temperatures / where it is cooler;

[Total: 6]

END OF PAPER

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