2023 ‘A’ Level Examinations

H2/9744 Biology

Paper 2

General comments by Cambridge examiners

The candidates’ responses were generally of a high standard and displayed very good subject knowledge.

Most candidates were able to accurately interpret graphical information and apply their knowledge to novel situations.

Candidates did not always use correct scientific terminology and there was a tendency for responses to include irrelevant details that did not address the requirements of the question. Explanations were sometimes not fully developed.

QUESTION 1

Fig. 1.1 shows the effect of increasing the external concentration of glucose or fatty acids on the rate of uptake of these molecules into a cell.

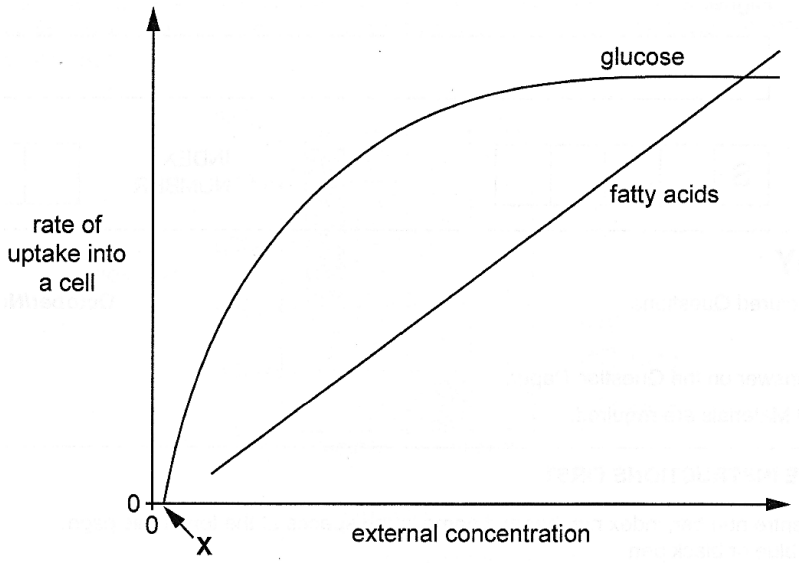


Fig. 1.1

(a) With reference to Fig. 1.1, explain the effect of increasing the external concentration of glucose on the rate of uptake of glucose into a cell. [3]

1. **[describe]** Rate of uptake into the cell via facilitated diffusion increases as external concentration increases.

2. **[explain]** Due to increase in glucose concentration gradient.

3. **[describe]** Rate no longer increases beyond a certain external concentration.

4. **[explain]** The glucose transporters are all saturated with glucose.

Examiners' Comments

Many responses clearly explained the relationship between glucose concentration and glucose uptake.

Weak responses often did not consider the specific mechanism by which glucose molecules cross cell surface membranes or recognise the role of specific membrane components in this process.

Some described the relationship shown in the graph rather than trying to explain it.

(b) Explain why there is no uptake of glucose into the cell at **X** even though glucose is present outside the cell. [1]

1. The concentration gradient is not steep enough for glucose to diffuse into the cell / the concentration of glucose outside and inside the cell are at equilibrium.

2. The affinity of glucose transporter is not high enough to bind to glucose at such low concentrations.

Examiners' Comments

Most candidates were able to give a correct explanation. Some responses incorrectly referred to a lag time or a lack of ATP.

(c) One suggested mechanism for the transport of fatty acids into cells is shown in Fig. 1.2. This mechanism is referred to as a flip-flop mechanism.

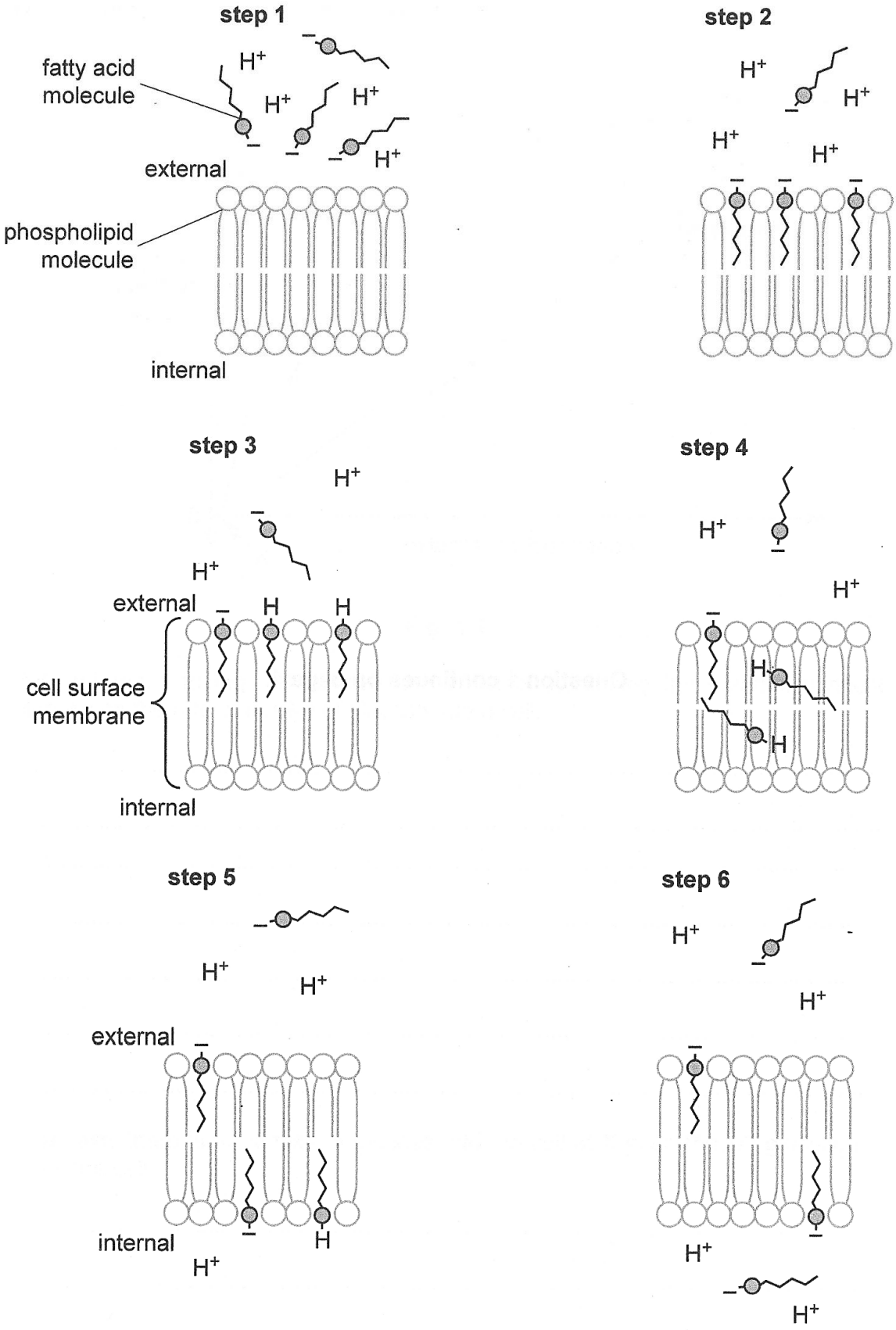


Fig. 1.2

With reference to Fig. 1.2, explain the flip-flop mechanism for the transport of fatty acid molecules across the cell surface membrane, including the role of hydrogen ions. [5]

1. Fatty acid contains a **long hydrophobic hydrocarbon** and a **carboxylate group** / **COO^-**

2. Due to the charged COO^- group, fatty acid **cannot interact with the hydrophobic fatty acid tail** of the membrane to be directly transported.

3. The hydrocarbon of the fatty acid first **inserts** into the **outer phospholipid layer of the membrane**, with the COO^- interacting with the phosphate group and aqueous environment.

4. **Protons** (H^+) then **reacts with COO^-** group to **neutralize the charge** (–COOH)

5. This allows the fatty acid to traverse through the **hydrophobic fatty acid core** of the membrane to be inserted into the **inner phospholipid layer of the membrane**.

6. The **proton** then **dissociates** from the fatty acid to **restore its COO^- group**.

7. The fatty acid is then **released into the cytosol**.

Examiners' Comments
Strong responses made effective use of scientific terminology to explain the alignment of fatty acid molecules in the phospholipid bilayer and the involvement of hydrogen ions in the flip-flop mechanism.
Some candidates were unclear about the distinction between phospholipids, triglycerides and fatty acids. Weaker responses often referred to a phosphate head or glycerol on the fatty acid molecule.

[Total: 9]

QUESTION 2

Hydrogen peroxide is a harmful by-product of many metabolic processes in cells and is quickly broken down into oxygen and water by the enzyme catalase.

Fig. 2.1 shows the energy changes during the breakdown of hydrogen peroxide into water and oxygen with, and without, catalase.

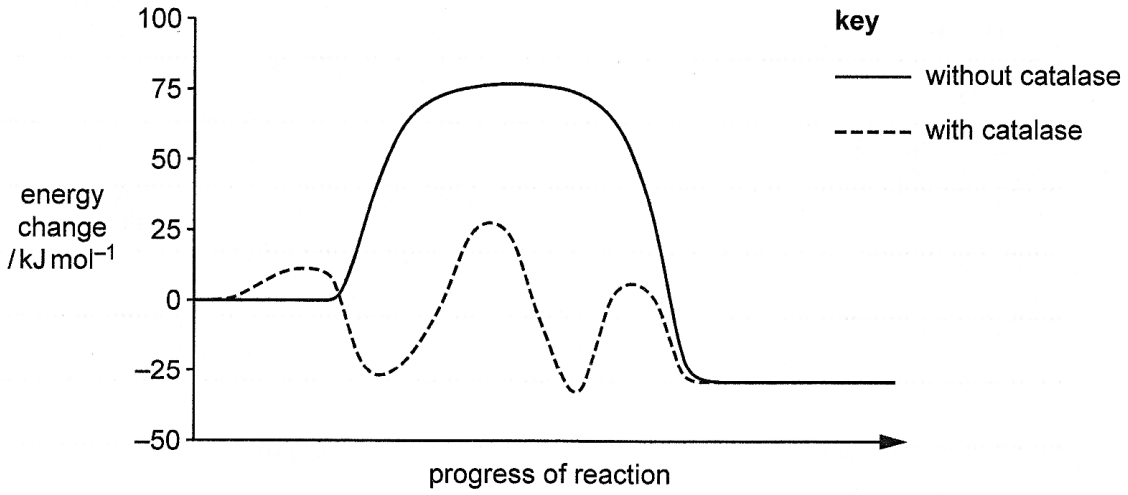


Fig. 2.1

(a) Explain how the change in activation energy shown in Fig. 2.1 affects the rate of a catalase-controlled reaction. [2]

1. Catalase **lowers the activation energy** to **speed up** the rate of reaction.

2. As **lesser energy** is needed for the substrate to **overcome** to reach **transition state**.

Note: the x-axis "progress of reaction" is NOT time. It refers to the state of the reaction: substrate to the unstable intermediates and eventually to products.

Examiners' Comments

Most candidates interpreted the graph correctly and recognised the effect of enzymes on activation energy. Strong responses provided an explanation for the effect of changes in activation energy on the rate of reaction.

Weak responses often simply quoted figures from the graph without addressing the question.

(b) The effect of storage temperature on the activity of catalase was investigated over a period of 1.6 hours.

The results are shown in Fig. 2.2.

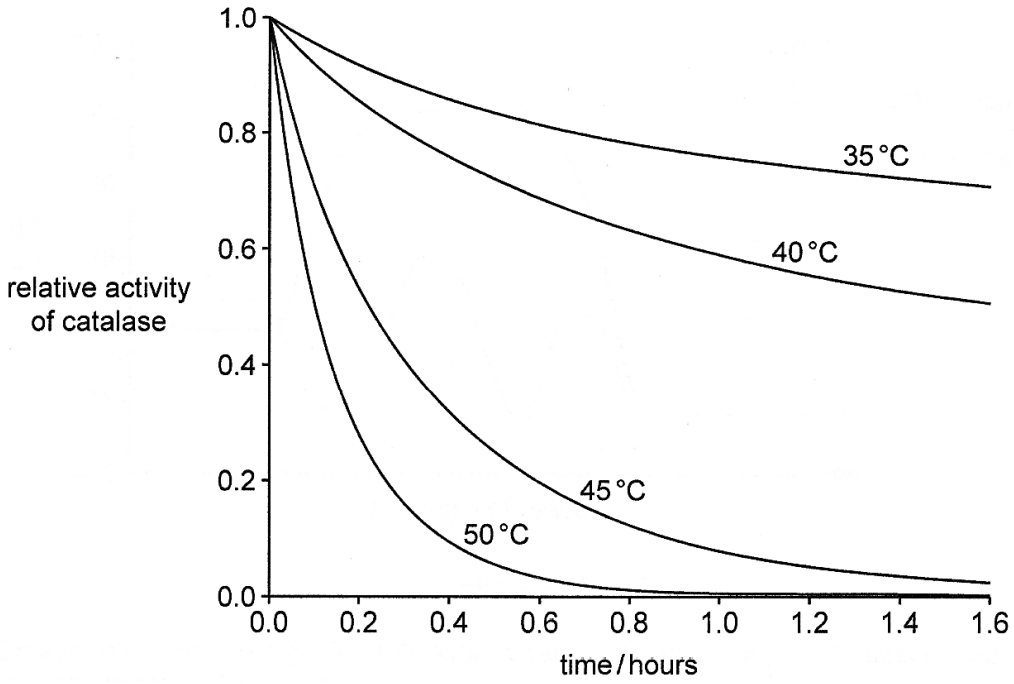


Fig. 2.2

(i) With reference to Fig. 2.2, state what can be concluded from the results of the investigation.

[3]

1. The higher the storage temperature, the faster the relative activity of catalase falls.

2. As the storage time increases, the relative activity of catalase continues to decrease.

3. However, the relative activity of catalase does not fall by the same magnitude with every 5°C increase / decrease in relative activity is the most drastic when the storage temperature is increased from 40°C to 45°C, e.g. @0.6h, from 0.7 to 0.2.

4. At 50°C, relative catalase activity reaches 0 by 1.2h, the fastest drop among the storage temperatures. **[Accept:** 1.1h to 1.4h**]**

Examiners' Comments
Many candidates found this a challenging question and simply listed data from the graph rather than drawing conclusions. Several did not appreciate that the question was about storage temperature of the enzyme and answered the question in terms of the effect of temperature on enzyme activity.

(ii) Explain the effect of storage temperature on the activity of catalase, as shown in Fig. 2.2. [5]

1. The higher the temperature, the **greater the kinetic energy** of catalase
2. Higher rate of breakage of **hydrogen bonds** and **ionic bonds** between **R-groups**
3. Disrupts the **3D conformation** / **tertiary structure** of catalase
4. Leads to **denaturation** of catalase
5. **Change** in **shape** of the **active site**
6. **Unable to bind to substrate** to form **enzyme-substrate complex**, (hence decrease in relative activity as temperature increases).

Examiners' Comments
This was generally well answered, with many candidates expressing themselves clearly and showing a good understanding of the reasons why different storage temperatures affect catalase activity.

Weaker responses often omitted to consider relevant details such as how storage temperature affected the tertiary structure of the enzyme. Some provided descriptions of the graph rather than developing an explanation.

[Total: 10]

QUESTION 3

Bacteria can take up DNA fragments from the environment and incorporate them into their genomes. This process is known as transformation. As a result of transformation, bacteria may acquire new genetic traits such as resistance to antibiotics.

The DNA fragments usually come from dead bacteria lysing (splitting open) and releasing their contents into the surrounding area.

Fig. 3.1 shows the main features of environmental DNA uptake by bacteria.

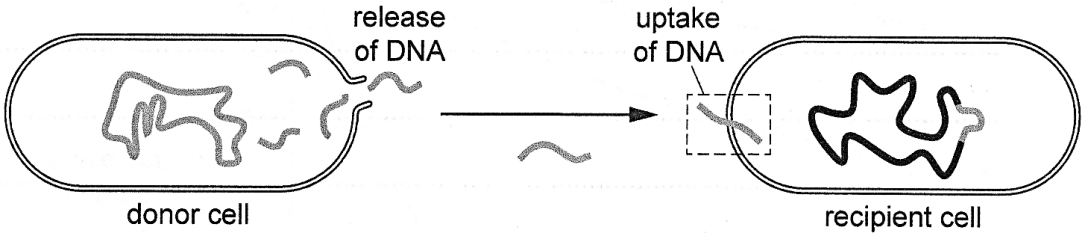


Fig. 3.1

Fig. 3.2 represents an enlargement of the region labelled 'uptake of DNA' in Fig. 3.1. It shows in detail how environmental DNA enters the recipient cell.

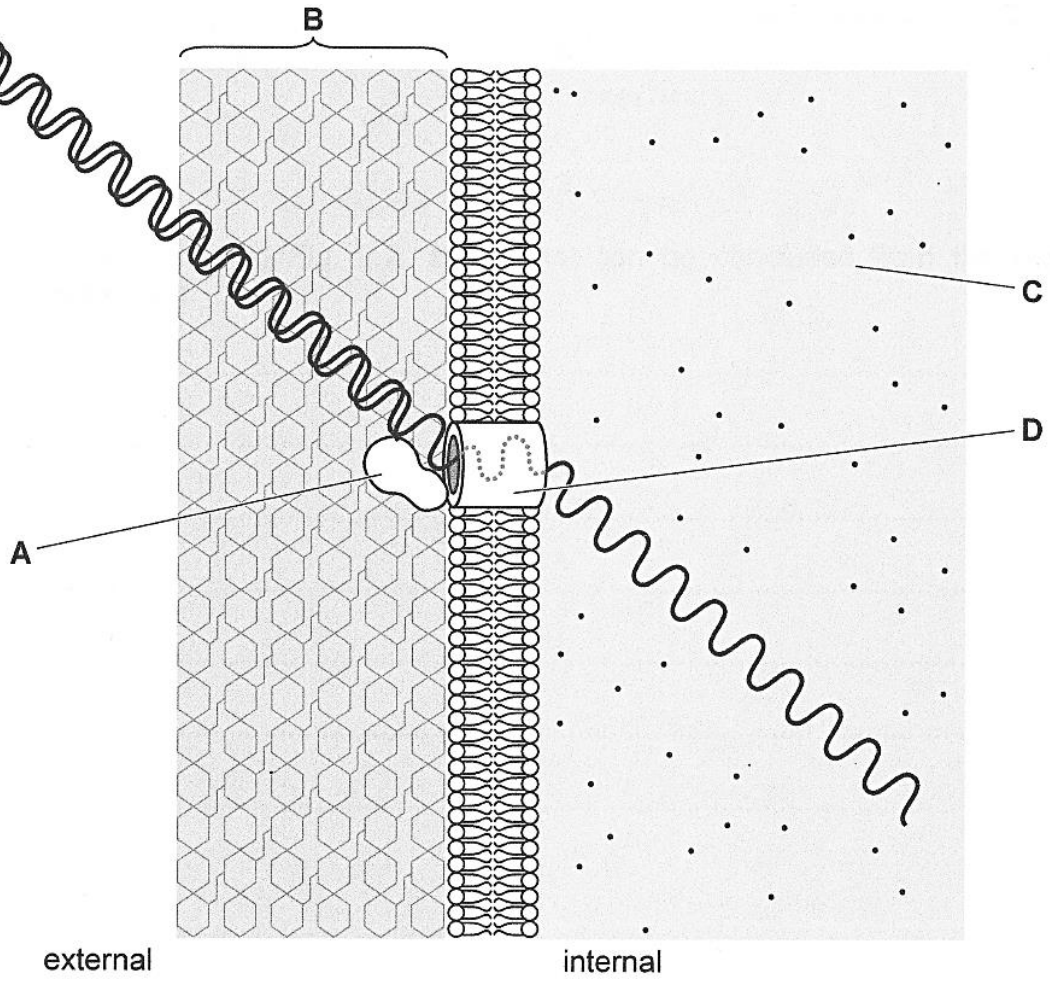


Fig. 3.2

(a) Name the parts of Fig. 3.2 labelled **B**, **C** and **D**. [3]

B peptidoglycan cell wall

C cytosol / cytoplasm

D transport protein / channel protein

Examiners' Comments
Few candidates were able to name all of the labelled parts. Most responses correctly identified part C, but parts B and D were recognised much less frequently.

(b) With reference to Fig. 3.2, suggest how environmental DNA fragments enter the bacterial cell. [3]

1. Double stranded DNA binds to protein A (a DNA-binding protein).
2. Protein A digests / hydrolyses one of the strands of the dsDNA
3. The remaining DNA strand enters the cytosol via protein D.

Examiners' Comments
Strong responses made effective use of the diagram to develop an explanation that referenced the structures labelled in the diagram. Weaker responses only referred vaguely to the structures shown in Fig. 3.2 and did not consider the interactions between these structures and the DNA molecule.

(c) Two other ways in which DNA can enter bacterial cells are transduction and conjugation.

Describe how DNA enters bacterial cells by transduction and conjugation. [4]

transduction

1. DNA is packaged into the icosahedral capsid head of a daughter **bacteriophage**.
2. This bacteriophage attaches to and injects the DNA into another bacterial cell.

conjugation

3. **F+ cell** forms a **sex pilus** (a cytoplasmic bridge) with a **F− cell**.
4. One of the DNA strands of the **F plasmid** in the F+ cell is **nicked** and transferred, **5' end first**, into the F− cell.
5. The strand then acts as a template for the synthesis of the complementary strand in the F− cell, forming dsDNA.

Examiners' Comments
This was generally well answered, although some responses included unnecessary details.

Many candidates correctly described the role of a bacteriophage in transduction, but further details were often omitted.

The majority of candidates correctly described conjugation. Weaker responses were vague and often omitted to use the expected scientific terminology. Some referred only to F plasmids with no mention of the bacterial cells.

[Total: 10]

QUESTION 4

(a) The annealing temperature for the polymerase chain reaction must be close to, but below, the temperature (melting temperature) at which the primer and template DNA separate.

One way to calculate the melting temperature of a DNA sequence is to use this equation:

$$T_m = 64.9 + [41 \times (nG + nC - 16.4) / (nA + nT + nG + nC)]$$

key

T_m = melting temperature in °C
nA = number of nucleotides containing the base adenine
nT = number of nucleotides containing the base thymine
nC = number of nucleotides containing the base cytosine
nG = number of nucleotides containing the base guanine

(i) Use the equation to calculate the melting temperature at which this primer DNA sequence separates from template DNA: [1]

TCGACTTCCTCGAACC

$T_m = 64.9 + [41 \times (2 + 7 - 16.4) / (3 + 4 + 2 + 7)]$
$T_m = 64.9 + [41 \times (-7.4) / (16)]$
$T_m = 64.9 + [-18.9625]$
$T_m =$ **45.9°C**

Melting temperature = ……°C

(ii) The equation predicts that the melting temperature of DNA sequences of the same length will increase as the proportion of nucleotides containing cytosine and guanine increases.

Use your knowledge of DNA structure to suggest why an increased proportion of bases containing cytosine and guanine will increase the melting temperature. [2]

1. **Three hydrogen bonds** between C and G as compared to two between A and T, hence **stronger**.

2. **More heat energy** (hence higher melting temperature) is required to break the hydrogen bonds between C and G.

Examiners' Comments
Many candidates correctly identified the difference in the number of hydrogen bonds between the different base pairs; fewer went on to suggest how this could affect the melting temperature.

Some responses incorrectly referred to differences in the strength of hydrogen bonds without any consideration of the number of bonds.

(iii) DNA sequences with very low melting temperatures are unsuitable for use as primers for the polymerase chain reaction. This is because they require the use of low annealing temperatures and, at low temperatures, base pairing can occur between non-complementary nucleotides.

Suggest the consequence for the results of a polymerase chain reaction of using low annealing temperatures. [1]

- The primers will bind non-specifically to multiple regions of the initial template DNA, resulting in the amplification of unintended regions of the DNA.

Examiners' Comments
Many responses provided rational suggestions. Weak responses often repeated the question stem without providing any further details.

(b) Describe the advantages of using the polymerase chain reaction. [3]

1. Sensitivity: PCR can detect minute amounts of DNA, even from a small sample, making it highly sensitive in identifying pathogens or genetic material.

2. Specificity: primers allow PCR to target and amplify specific DNA sequences, allowing for precise detection and analysis of particular gene or sequence.

3. Speed: PCR can amplify DNA exponentially within hours, enabling quick analysis compared to traditional methods that might take days or weeks.

4. Versatility: It has diverse applications such as diagnosing diseases, genetic testing, forensics, studying evolutionary relationships.

5. Quantification: PCR can also be used for quantitative analysis, determining the initial amount of DNA present in a sample through methods like real-time PCR.

6. Automation: Modern PCR machines are automated, reducing human error and increasing efficiency in handling multiple samples simultaneously.

(c) State the limitations of the polymerase chain reaction. [3]

1. PCR is sensitive, so contamination of sample with extraneous (foreign) DNA can result in unintended sequences being amplified.

2. Prior knowledge of the sequence flanking the target DNA needs to be known for suitable DNA primers to be synthesized.

3. *Taq* DNA polymerase has low replication fidelity since it lacks a 3' to 5' exonuclease proofreading activity, hence may cause mutations in the PCR products.

4. The length of DNA that can be reliably amplified is limited by the polymerase's processivity and the efficiency of the amplification process, hence long DNA fragments might not amplify efficiently.

Examiners' Comments
Candidate knowledge of the limitations of PCR was not as strong as their knowledge of its advantages, with many omitting any mention of well-known problems. Good responses were expressed clearly and included relevant details.

[Total: 10]

QUESTION 5

Fig. 5.1 shows the behaviour of one pair of homologous chromosomes during two stages of meiosis I and two stages of meiosis II.

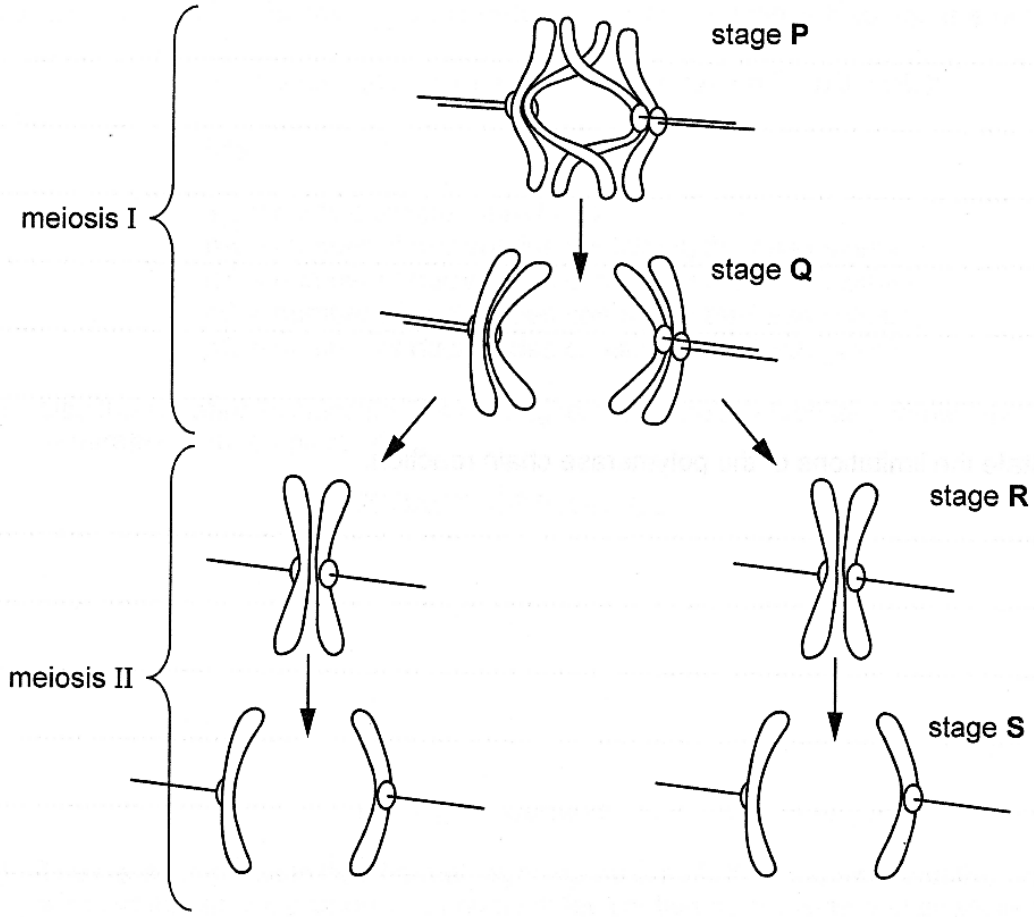


Fig. 5.1

(a) Name the stages of meiosis shown in Fig. 5.1. [2]

stage **P** metaphase I

stage **Q** anaphase I

stage **R** metaphase II

stage **S** anaphase II

Examiners' Comments

The majority of responses identified stages Q, R and S correctly. Several incorrectly identified stage P as prophase I.

(b) Describe similarities and differences between stage **Q** and stage **S**. [3]

similarities

1. Both involves the **shortening** of **pole-to-centromere spindle fibers**
2. Both involves the separation of chromosomes to opposite poles of the cell

differences

3. Stage Q separates **homologous chromosomes** but stage S separates **sister chromatids**.
4. The **centromere does not divide** in stage Q but **divides** in stage S.
5. Two spindle fibres attach to each (double-arm) chromosome in stage Q while one spindle fibre attaches to each (single-arm) chromosome in stage S.
6. In stage Q, cells are still **diploid** but in stage S, cells are **haploid**.

Examiners' Comments
The majority of candidates correctly described some similarities between stage Q and stage S and many also described at least one difference. One common error was for candidates to refer to separation of non-sister chromatids rather than separation of sister chromatids..

(c) Stage **P** and stage **R** are both important in the production of gametes that are genetically different.

In stage **R**, genetic variation could not be generated without an event that occurs during an earlier stage of meiosis.

(i) Name this event and the stage of meiosis in which it occurs. [2]

event crossing over

stage prophase I

Examiners' Comments
Most candidates were able to recall the name of the event but not all recognised the stage of meiosis in which it occurs. Some responses incorrectly identified the event as independent assortment.

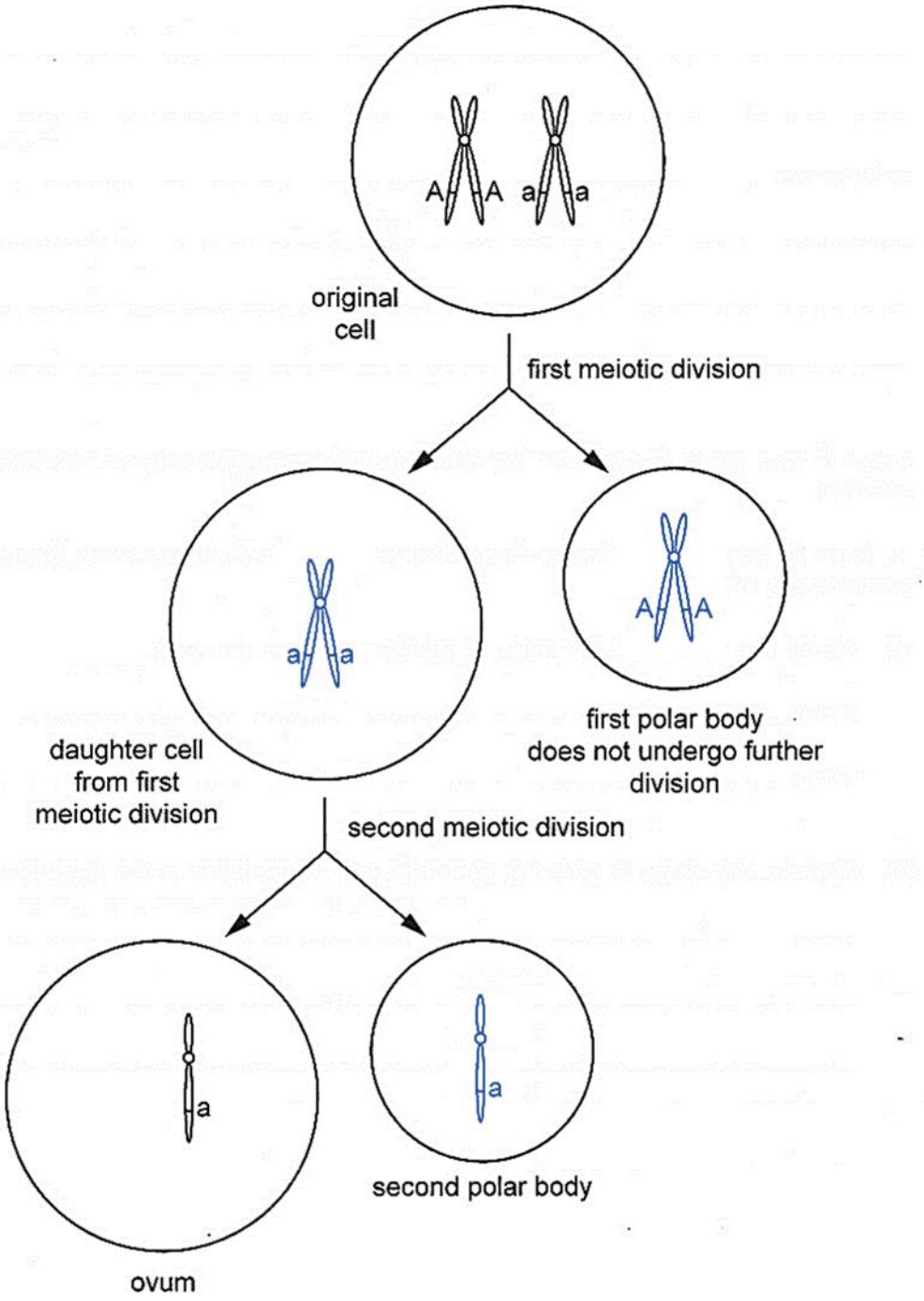
(ii) Explain why stage **R** does not generate genetic variation in the absence of this event. [1]

- In the absence of crossing over, the **sister chromatids of each chromosome will remain genetically identical** (since crossing over produces non-genetically identical sister chromatids).

Examiners' Comments
Many responses correctly explained why genetic variation did not occur. A minority explained how stage R generates genetic variation rather than explaining why this would not happen in the absence of the event named in (c)(i).

(d) Fig. 5.2 represents the production of an ovum by meiosis. A single pair of homologous chromosomes with one gene having two alleles, A and a, is shown in the original cell.

As a result of meiosis, one ovum and two polar bodies are produced..



Complete Fig. 5.2 to show the chromosomes and alleles that are present in the daughter cell from the first meiotic division, the first polar body and the second polar body.

You should assume that the event named in (c)(i) has not occurred. [2]

[Total: 10]

QUESTION 6

The inheritance of coat colour in labrador retriever dogs is controlled by two unlinked genes, each with a dominant allele and a recessive allele. The recessive allele of each gene produces no functional product.

Fig. 6.1 shows how the presence of the dominant alleles of these two genes, E and B, affects the coat colour of labrador retriever dogs.

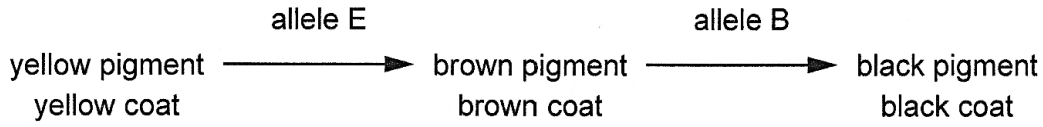


Fig. 6.1

(a) State the coat colour shown by labrador retrievers with the following genotypes. [1]

eeBb yellow

EeBb black

Examiners' Comments
The majority of candidates answered this correctly. Weaker responses incorrectly gave the genotype eeBb as black coat.

(b) Explain the coat colour of labrador retrievers with the genotype Eebb. [3]

1. Brown coat
2. One copy of allele E codes for a functional enzyme that converts yellow pigment to brown pigment.
3. Two copies allele b results in no functional enzyme to further convert the brown pigment to black pigment.
4. allele e of gene E/e is epistatic over allele B of gene B/b.

Examiners' Comments
Strong responses provided concise and reasoned explanations. Weak explanations were muddled or only discussed the coat colour rather than the production of a pigment.

(c) Two black labrador retrievers were mated and the resulting litter of puppies included yellow, brown and black coat colours.

Draw a genetic diagram to explain the results of this cross. Indicate the expected phenotypic ratio of the offspring.

Use the symbols B, b, E and e to represent the alleles. [5]

Parent phenotype: black x black

Parent genotype: EeBb x EeBb

Gametes: (EB) (Eb) (eB) (eb) x (EB) (Eb) (eB) (eb)

F_2 genotypes and phenotypes:

	(EB)	(Eb)	(eB)	(eb)
(EB)	EEBB black coat	EEBb black coat	EeBB black coat	EeBb black coat
(Eb)	EEBb black coat	EEbb brown coat	EeBb black coat	Eebb brown coat
(eB)	EeBB black coat	EeBb black coat	eeBB yellow coat	eeBb yellow coat
(eb)	EeBb black coat	Eebb brown coat	eeBb yellow coat	eebb yellow coat

F2 phenotypic ratio: 9 black coat : 3 brown coat : 4 yellow coat

Examiners' Comments
The majority of candidates answered this well. A few errors were seen in the completion of the Punnett square offspring genotypes and some correct genotypes were assigned incorrect phenotypes.

(d) Name the type of gene interaction shown in Fig. 6.1. [1]

- (Recessive) epistasis

[Total: 10]

QUESTION 7

Fig. 7.1 shows the arrangement of the large protein complexes involved in oxidative phosphorylation in mitochondria.

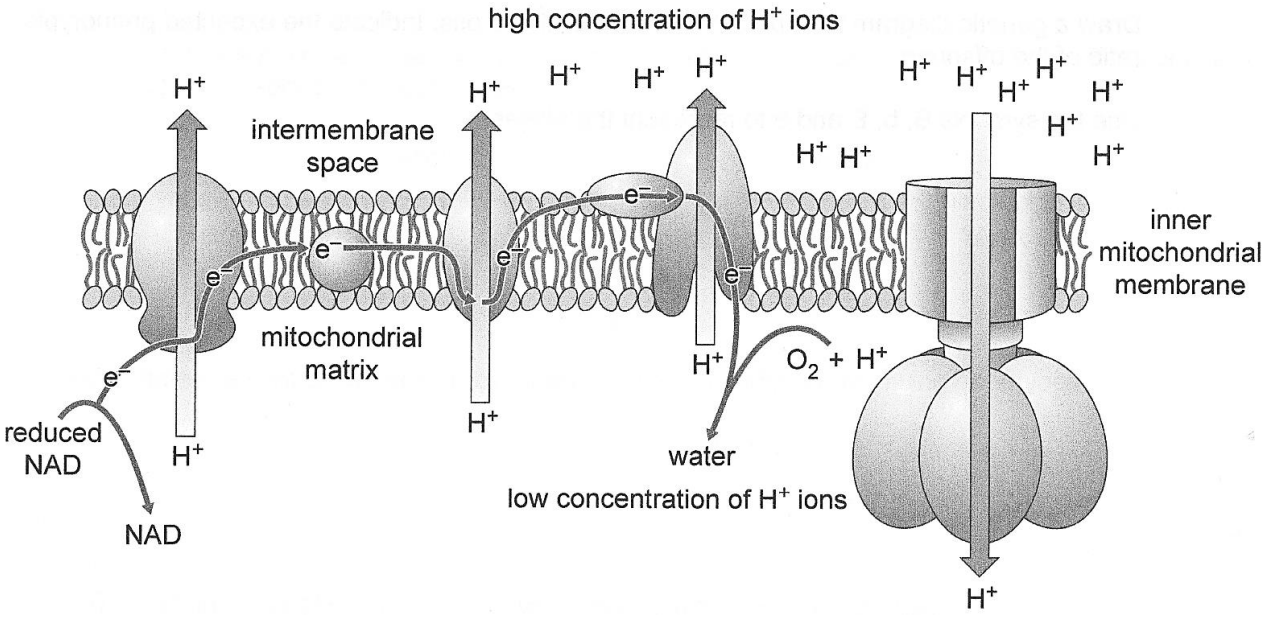


Fig. 7.1

(a) With reference to Fig. 7.1, explain the movement of protons **into** the intermembrane space using the large protein complexes. [4]

1. Reduced NAD is oxidised to release high-energy electrons (e−)
2. The e− is transported down a series of electron carriers of progressively lower energy level
3. This **releases** energy that is used by H^+ pump to transport H^+ from mitochondrial matrix to the intermembane space
4. Against the H^+ concentration gradient.

Examiners' Comments

Many candidates were able to correctly explain the movement of protons into the intermembrane space.

One common error was the improper use of terms as in 'generation' or 'production' of energy.

Other errors included the misconception that the movement of protons took place through channel proteins via facilitated diffusion, or that proton movement required ATP.

(b) Explain the role of oxygen in oxidative phosphorylation. [3]

1. As the **final electron acceptor**

2. Combines with electron and protons to form water

3. Enables electron transport chain to continue transporting electron to maintain high proton concentration in the intermembrane space.

4. Also ensures that NAD^+ and FAD are regenerated for glyvolysis, link reaction and Kreb cycle.

Examiners' Comments
Most responses correctly explained some aspects of the role of oxygen in oxidative phosphorylation. Few provided full explanations that considered what would happen in the absence of oxygen.

(c) NAD is an important molecule in aerobic respiration and NADP is an important molecule in photosynthesis.

Compare the role of reduced NAD in aerobic respiration with the role of reduced NADP in photosynthesis. [3]

1. Both are **coenzymes**.

2. Both are **electron donors**.

3. NADH **donates electron** to the **electron transport chain** during **oxidative phosphorylation** while NADPH **reduces 1,3-bisphosphoglycerate** to **glyceraldehyde-3-phosphate** in **Calvin cycle**.

4. Upon oxidation, the proton from NADH contributes to the proton concentration in the mitochondrial matrix, while the proton in NADPH is used to **reduce 1,3-bisphosphoglycerate** to **glyceraldehyde-3-phosphate** in **Calvin cycle**

Examiners' Comments
Candidates found this question challenging; many responses lacked a clear structure and omitted significant details. There were few clear statements about the roles of reduced NAD and reduced NADP. Reduced NAD and reduced NADP were often referred to incorrectly as electron acceptors.

Strong responses included details of the use of reduced NADP in the Calvin cycle with reference to the various compounds involved, and the use of reduced NAD in oxidative phosphorylation.

[Total: 10]

QUESTION 8

Glucagon receptors are examples of G-protein linked receptors and are found in the cell surface membrane of hepatocytes (liver cells).

Fig. 8.1 represents the molecular structure of a glucagon receptor attached to its ligand, glucagon, and shows how the receptor is inserted in the cell surface membrane of a hepatocyte.

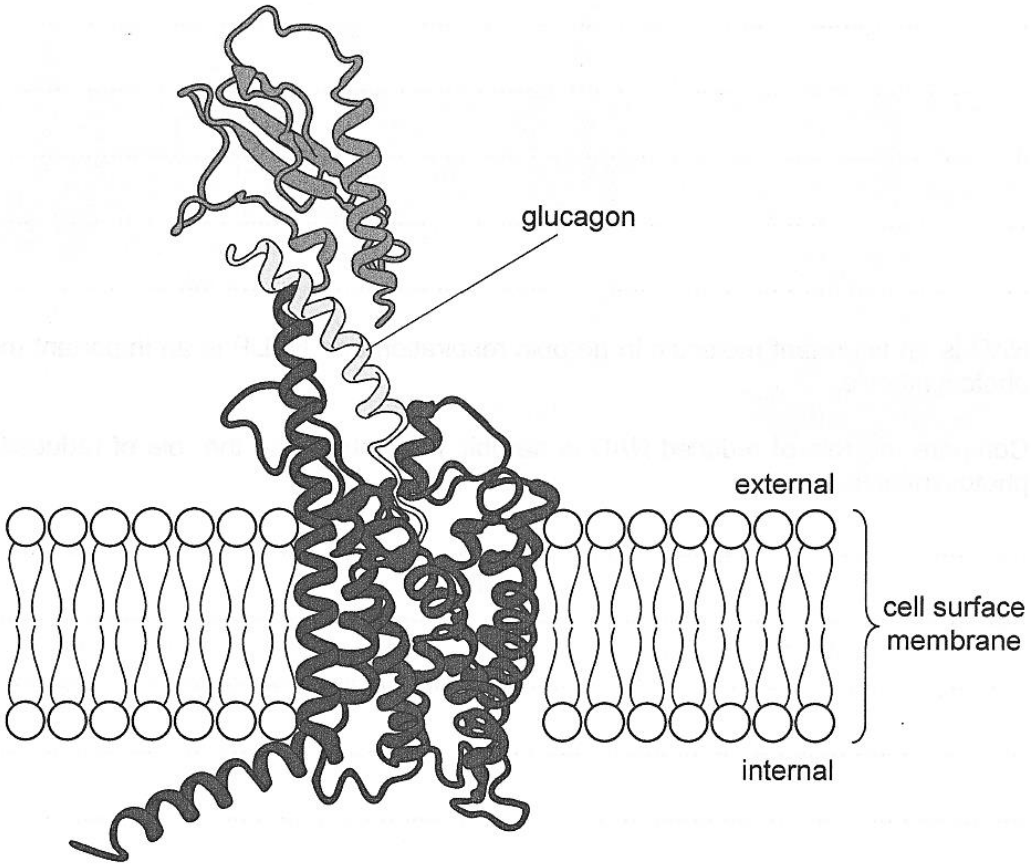


Fig. 8.1

(a) With reference to Fig. 8.1, explain how the molecular structure of the G-protein linked receptor relates to its function. [5]

1. The **transmembrane domain** interacts with the hydrophobic fatty acid tails of the membrane via hydrophobic interaction, and the **ligand-binding domain** and **cytoplasmic domain** interact with **water** via **hydrogen bonding** or ion-dipole interaction. This allow GPLR to span the membrane.

2. The **ligand-binding domain** faces the external and has a **complementary shape** to **bind to glucagon**

3. The **cytoplasmic domain** **binds to a G protein**.

4. Ligand binding induces a series of **conformational changes** in the GPLR structure.

5. These conformational changes allow the signal from glucagon to be **transduced** into the cell.

Examiners' Comments
The majority of responses addressed some aspects of the molecular structure of the G-protein linked receptor and how these related to its functions. Details were sometimes incomplete. For example, when considering how the protein spans the cell surface membrane, explanations were often limited only to hydrophobic interactions.

Strong responses considered several aspects of the G-protein linked receptor in relation to effects of ligand binding.

(b) Binding of glucagon to the glucagon receptor (G-protein linked receptor) leads to the release of cAMP as the second messenger.

Explain how the release of cAMP leads to a cellular response. [5]

1. cAMP binds to and activates **protein kinase A** (PKA)…

2. …by binding to its regulatory subunits, causing them to dissociate from the catalytic subunits.

3. The catalytic subunits of PKA **phosphorylates** and (de)activate various **target proteins**, leading to a cellular response.

4. The phosphorylated target protein either changes conformation or binds to other proteins to become (de)activated.

5. **e.g.** Phosphorylation can **activate enzymes** involved in **glycogen breakdown**.

6. **e.g.** Phosphorylation can **activate transcription factors** that **regulate expression of genes** involved in **gluconeogenesis** / **glycogenolysis**.

Examiners' Comments
Strong responses provided a concise, sequential account of the stages involved, using correct scientific terminology.

A common error was for responses to include a description of the events that occur before cAMP is made. This was not required by the question. Other commonly seen errors included confusion over which enzymes were activated or inactivated and between the terms glucagon and glycogen.

Key terms were not always spelt correctly, sometimes obscuring which term was intended.

[Total: 10]

QUESTION 9

Lord Howe Island is a small isolated oceanic volcanic island in the Tasman Sea, 600 km from the Australian mainland. Two species of palm tree, *Howea forsteriana* and *H. belmoreana*, have evolved by sympatric speciation on the island since it was formed 6.9 million years ago.

Fig. 9.1 shows the flowering times of the two species.

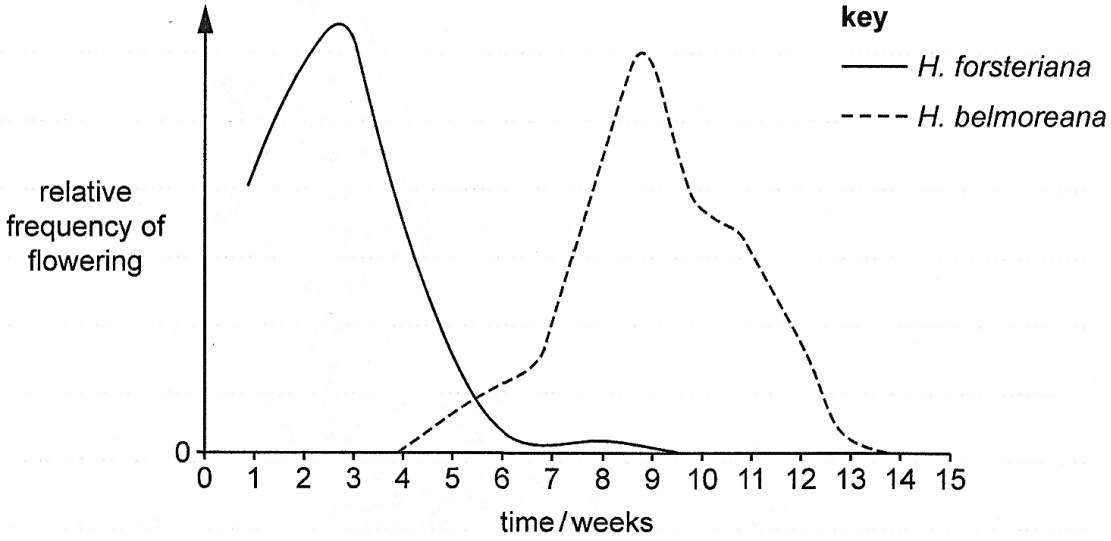


Fig. 9.1

(a) With reference to Fig. 9.1, suggest how these two species of palm tree may have evolved by sympatric speciation. [5]

1. Fig 9.1 shows that the two species today have **different peak flowering times** (**week 3 vs week 9**)

2. This suggests that their **common ancestor exhibited variation in flowering times**, hence started to be temporally isolated.

3. **Reduced gene flow** between the populations with different flowering times, as they were **not pollinated at the same time** / could not cross-pollinate each other.

4. **Mutations** occurred **independently** from each other, so allele frequencies changed differently.

5. Over time, both populations **accumulated sufficient genetic differences** (genetic divergence).

6. Eventually, the two populations no longer interbred, leading to the two different species that are **reproductively isolated** today.

7. Since these two species are on the **same isolated oceanic island**, they are **not geographically isolated**, hence evolved by sympatric speciation.

Examiners' Comments

Many responses demonstrated a sound understanding of sympatric speciation; fewer related this understanding to the context of these two palm tree species evolving on an isolated oceanic island.

Some responses referred to the two species as though they had always existed, rather than referring to how the two species had evolved from a common ancestor.

(b) Fig. 9.2 shows a phylogenetic tree for the two species of *Howea* from Lord Howe Island and their closest relatives from mainland Australia (*Linospadix* and *Laccospadix*).

Fig. 9.2

A student concluded that Fig. 9.2 shows that Lord Howe Island was originally colonised by a species of plant that was a common ancestor for *Howea*, *Laccospadix* and *Linospadix*.

Explain whether or not this conclusion is correct. [2]

1. **Incorrect**, since the **island was formed** only **6.9 million years ago**.

2. Fig. 9.2 shows that the **common ancestor** for *Howea*, *Laccospadix* and *Linospadix* diverged **11.5 million years ago**.

Examiners' Comments
Many responses incorrectly stated that the conclusion was correct. Few related the information in the phylogenetic tree to the age of the island.

(c) State the types of evidence that can be used to establish the phylogenetic relationships between species. [3]

1. **Nucleotide sequence** of **homologous DNA/gene** shared by all the species.

2. **Amino acid sequence** of **homologous protein** shared by all the species.

3. **Biogeography** – studying the **geographical distributions** of animals and plants, including fossils.

4. **Carbon dating** of **fossils records** to **estimate the time of existence** of the extinct common ancestor.

Examiners' Comments
Most responses included consideration of at least two types of evidence. Some mistakenly referred to fossil **fuels** as evidence.

[Total: 10]

QUESTION 10

Fig. 10.1 shows the specific T cell and antibody response in people with mild and severe symptoms caused by infection by the same virus.

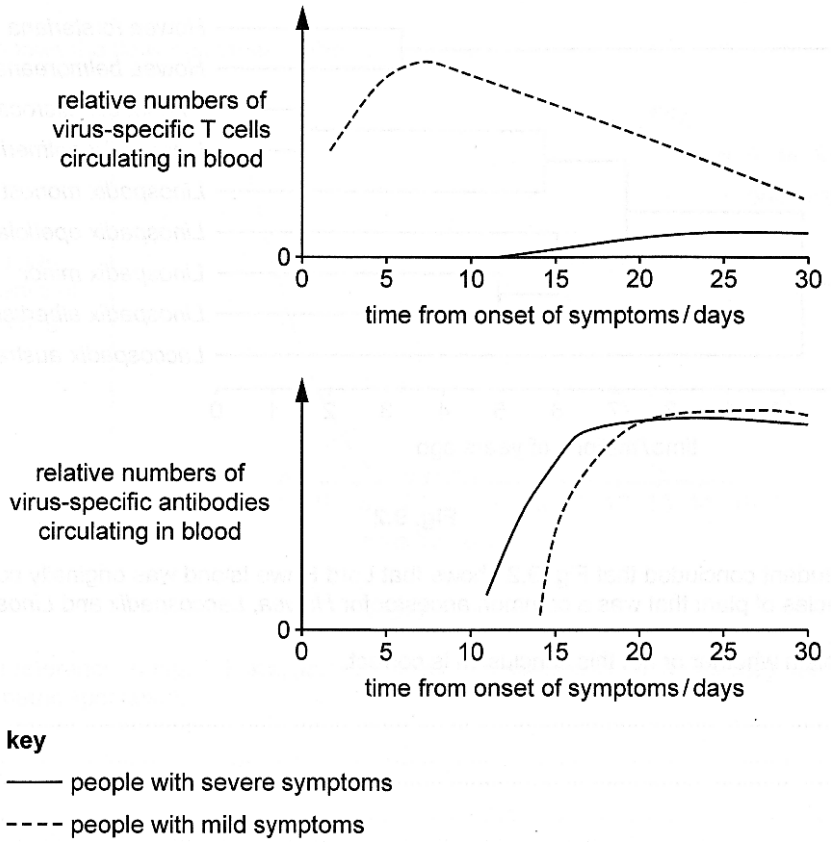


Fig. 10.1

(a) With reference to Fig. 10.1, describe the differences in the immune response of infected people with mild symptoms and infected people with severe symptoms. [3]

feature	people with mild symptoms	people with severe symptoms
relative numbers of virus-specific T cells	Appears **earlier** on **day 2** from onset of symptoms	Appears **later** on **day 12** from onset of symptoms
	Increases **quickly** and **peaks** at **day 7**, then **gradually decline** till **day 30**	**Increases** very **slowly** till **day 30**
	Higher at every time point compared to severe symptoms	Lower at every time point compared to mild symptoms
Relative numbers of virus-specific antibodies	Appears **earlier** on **day 11** from onset of symptoms	Appears **later** on **day 14** from onset of symptoms
	peaks at **day 16**	**peaks** later at **day 21**

Examiners' Comments

Many candidates interpreted the data correctly. Weaker candidates confused the key to the graphs and referred to mild symptoms instead of severe or referred to antibodies instead of T cells.

(b) Suggest **and** explain what vaccination for this virus needs to achieve in order to give long-term protection against severe symptoms. [2]

1. Active immunity - vaccination with **attenuated/weakened** form of the **whole virus** **OR** **surface glycoproteins** of the virus.

2. This allows **memory T cells** to form.

3. Allows **rapid clonal expansion of virus-specific T cells**, which is found to be delayed in people with severe symptoms (Fig. 10.1).

Examiners' Comments
Some responses described the type of vaccine that would be used, or the need for herd immunity, which did not address the requirements of the question.

Many referred to memory cells, but few made full use of the information in Fig. 10.1 to identify the most important factors needed to achieve long-term protection against severe symptoms.

[Total: 5]

QUESTION 11

Alexander von Humboldt visited Mount Chimborazo in Ecuador in 1802. Humboldt took measurements of the heights up the mountain at which glaciers and vegetation occurred.

Fig. 11.1 compares the heights at which glaciers and vegetation occurred on Mount Chimborazo in 1802 with the heights at which glaciers and vegetation occurred on Mount Chimborazo in 2012. Only heights above 4400 m are shown. Below this height, no glaciers occurred and vegetation cover was continuous.

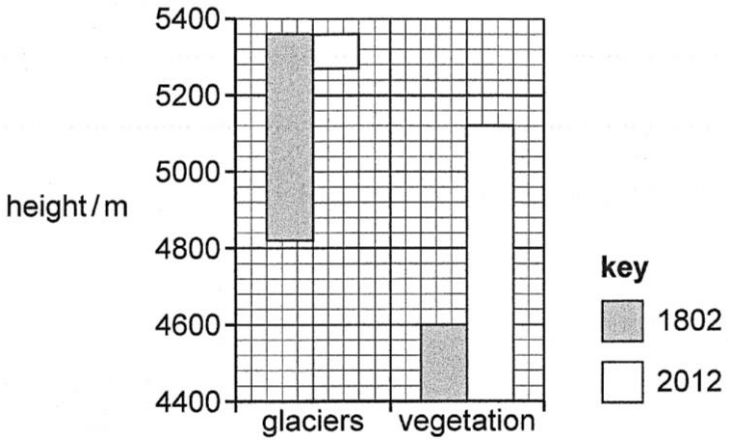


Fig. 11.1

(a) Describe the changes shown in Fig. 11.1 from 1802 to 2012. [2]

1. The **range** in which **glaciers** occurred **decreases** from **between 4820m and 5360m in 1802** to between **5270m and 5360m in 2012**.

2. The **range** in which **vegetation** occurred **increases** from **between 0m and 4600m in 1802** to between **0m and 5120m in 2012**.

Examiners' Comments

Many candidates correctly quoted comparative figures to describe the changes shown in Fig. 11.1. A number of responses referred incorrectly to a decrease in the height of glaciers rather than a decrease in the height range over which glaciers occur.

(b) Suggest how human activity may account for the changes shown in Fig. 11.1. [4]

1. ***Ref to*** any anthropogenic activities that increases greenhouse gases.
    a. Deforestation for the purpose of other land uses
    b. Burning of fossil fuels for electricity and heating
    c. Livestock farming due to increased meat consumption demand

2. **Enhanced greenhouse gases trap more heat** in Earth's atmosphere, leading to **global warming**.

3. **Higher altitudes** that were once colder **becomes warmer**.

4. Hence, **glaciers** at **lower altitude** have **melted**, and thus **limited** to only the **highest altitude**.

5. Hence, vegetations have extended to higher altitudes where temperatures are now suitable for vegetation growth.

Examiners' Comments
The majority of responses demonstrated a good understanding of the human activities that lead to increased global warming. Weak responses did not consider that it was the increase in various relevant human activities that was important.

[Total: 6]

😊 **END OF PAPER 2** 😊