H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME

CLASS

BIOLOGY

8876/02

Paper 2 Structured and Free-response Questions

13 September 2018

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do no use staples, paper clips, glue or correction fluid.

Section A

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

Section B

Answer any **one** question in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

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

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
Total	

This document consists of **15** printed pages and **1** blank page.

[Turn over

Section A

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

1 Cholesterol is synthesised in the smooth endoplasmic reticulum (SER) in liver cells by a series of enzyme-catalysed reactions.

Within the SER, molecules of cholesterol and triglycerides are surrounded by proteins and phospholipids to form lipoproteins. These lipoprotein particles enter the Golgi apparatus where they are packaged into vesicles and pass to the blood.

Fig. 1.1 is an electron micrograph of part of a liver cell showing lipoprotein particles within the Golgi apparatus.

Fig. 1.1

(a) Name structure T in Fig. 1.1 and state its role in liver cells.

....

....

....

.... [2]

(b) Suggest why cholesterol is packaged into lipoproteins before release from liver cells into the blood.

....

.... [1]

(c) Cholesterol is also packaged into vesicles by the SER and then secreted from the cell into small fluid-filled spaces between the liver cells. These spaces form ducts that drain into the gall bladder to form bile.

Explain how cholesterol is secreted into ducts, such as the duct in Fig. 1.1.

[3]

(d) Both the Golgi body and the rough endoplasmic reticulum are part of the internal network of membranes in cells.

Outline structural features shown in Fig. 1.1 that identify **G** as the Golgi body and not the rough endoplasmic reticulum.

[2]

Cholesterol is a major component of all membranes. The concentration of cholesterol largely varies between membranes of different cells and tissues. There are other differences in the chemical composition of cell membranes in different organisms, such as the type of fatty acid chains in phospholipids.

Fig. 1.2 shows the structure of the phospholipids in the membranes of Organism A, which is an extreme thermophile (live in extremely high temperature places like hot springs), and Organism B, which live in normal environment (non-thermophile).

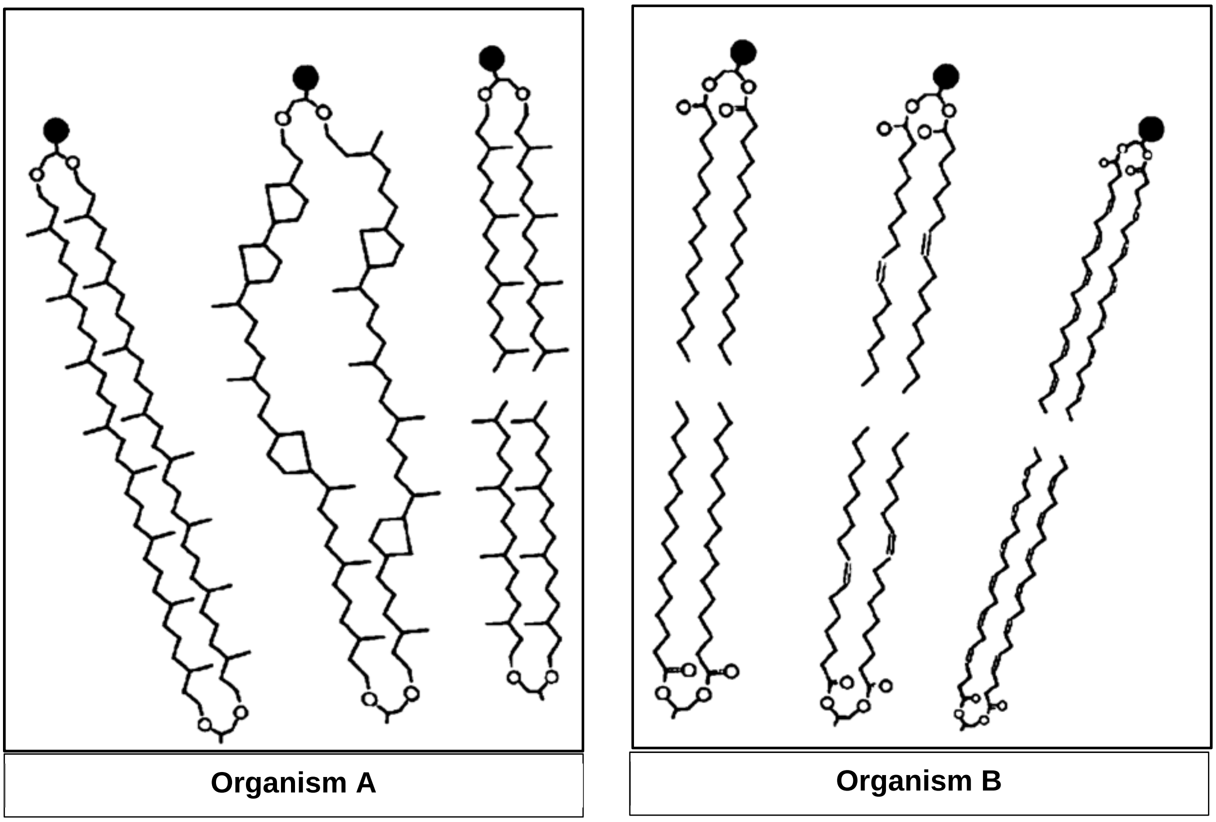

Fig. 1.2

(e) **(i)** With reference to Fig. 1.2, other than the presence of side branches and rings, state two structural differences between the phospholipids of Organism **A** and **B**.

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.... [2]

(ii) Suggest how the differences stated in **(e)(i)** enable Organism **A** to thrive in environments with extreme high temperature condition.

----

[2]

[Total: 12]

2 Chitinases are enzymes synthesized by bacteria, fungi, yeasts, plants, that can degrade chitin into low molecular weight, soluble and insoluble oligosaccharides. Chitin is a modified polysaccharide found in a number of different organisms, for example in fungal cell walls and the hard outer skeletons of insects.

Chitinase is made up of 825 amino acids. Fig 2.1 shows the arrangement of some of the conserved amino acids found close together in the active site of chitinase. Fig. 2.2 shows the structure of a single chitinase molecule.

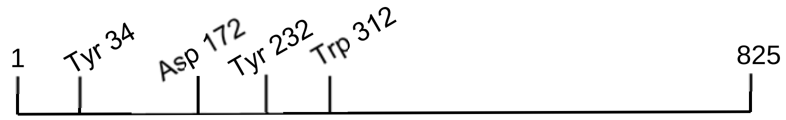

Fig. 2.1

Fig. 2.2

(a) With reference to Fig 2.2, describe how the amino acid residues at different positions may be brought together when chitinase is synthesized.

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....

.... [3]

Chitin and the products of chitin hydrolysis have many useful medical and environmental applications. Chitinase enzymes can be used commercially to hydrolyse chitin. Enzyme stability and activity are important considerations in technological applications of chitinase.

Fig. 2.3 is a graph showing the effects of temperature on chitinase extracted from a soil bacterium. The relative activity of the enzyme was measured at different temperatures, with 100% representing maximum enzyme activity.

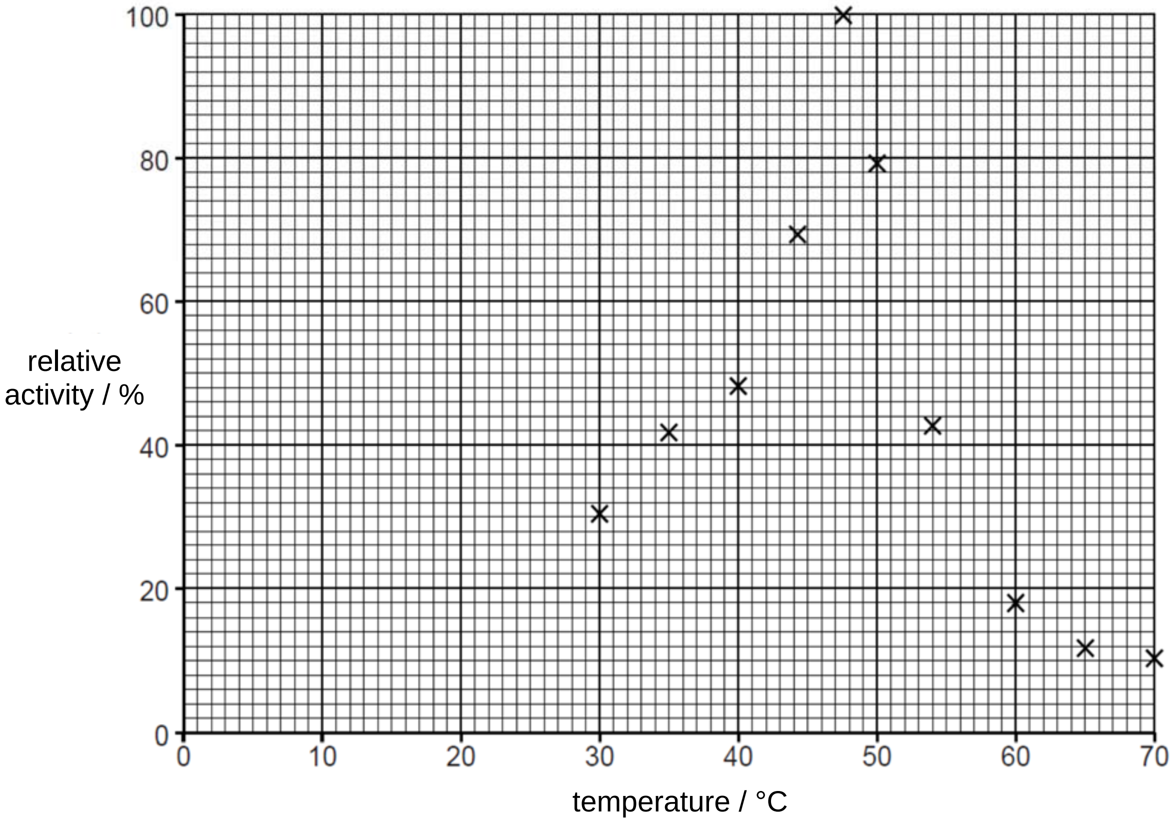

Fig. 2.3

(b) (i) With reference to Fig. 2.3, state the optimum temperature for the chitinase enzyme.

.... [1]

Fig. 2.4 is a graph showing how temperature affects the stability of chitinase. The activity of the enzyme was measured over a time period of 72 hours at each of five different temperatures.

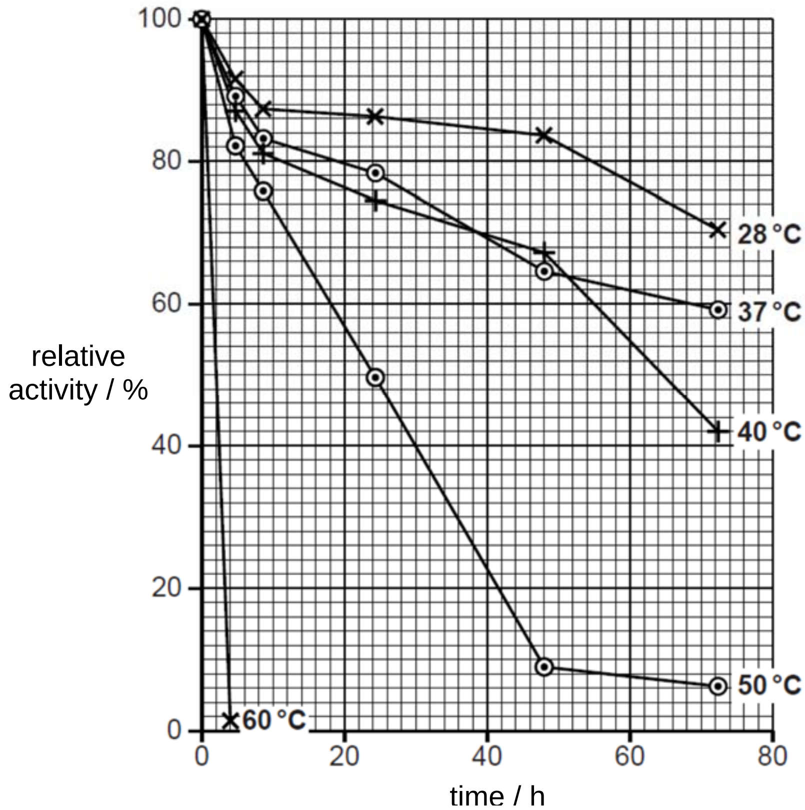

Fig. 2.4

(ii) With reference to Fig. 2.3 and Fig. 2.4, describe **and** discuss the effect of temperature on chitinase activity **and** stability.

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[5]

[Total: 9]

3 In mice, fur colour is controlled by a gene with multiple alleles. These alleles are listed below in no particular order.

black and tan = C^{bt} yellow = C^{y}

agouti = C^{a} black = C^{b}

(a) Explain how multiple alleles arise.

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....

....

.... [2]

(b) Suggest explanations for the results of the following crosses between mice.

(i) Mice with agouti fur crossed with mice with black fur may produce all agouti offspring **or** some agouti and some black offspring.

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....

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.... [2]

(ii) Crosses between heterozygous parents with the genotype $C^{y}C^{b}$ always produce a ratio of two yellow mice to one black mouse.

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....

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.... [2]

(iii) Mice with yellow fur crossed with mice with black fur will produce one of the following outcomes:

- some yellow offspring and some agouti offspring
- some yellow offspring and some black and tan offspring
- some yellow offspring and some black offspring.

[2]

(c) A test cross is used to determine the genotype of an organism.

Describe how you would carry out a test cross to determine the genotype of a black and tan mouse.

[2]

[Total: 10]

4 Global warming has changed both the thickness and surface area of sea ice of the Arctic Ocean as well as the Southern Ocean that surrounds Antarctica. Sea ice is highly sensitive to changes in temperature.

Scientists have calculated a long-term mean for the surface area of sea ice in the Arctic and in the Southern Ocean around Antarctica. This mean value is used as a reference to examine changes in ice extent. The graph Fig. 4.1 shows the variations from this mean (zero line) over a period of time.

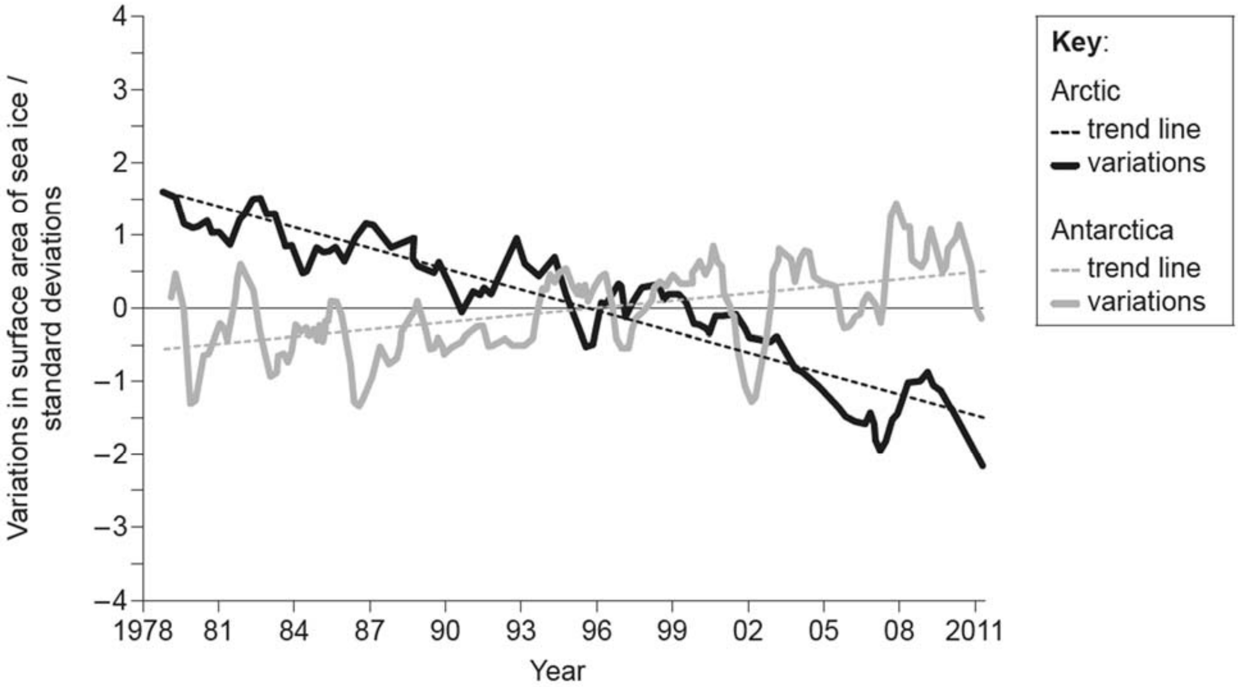

Fig. 4.1

(a) State the trend in the surface area of sea ice in the Southern Ocean around Antarctica.

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.... [1]

(b) Distinguish between changes in the surface area of sea ice in the Arctic and Antarctica.

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.... [2]

(c) Discuss the data as evidence of global warming.

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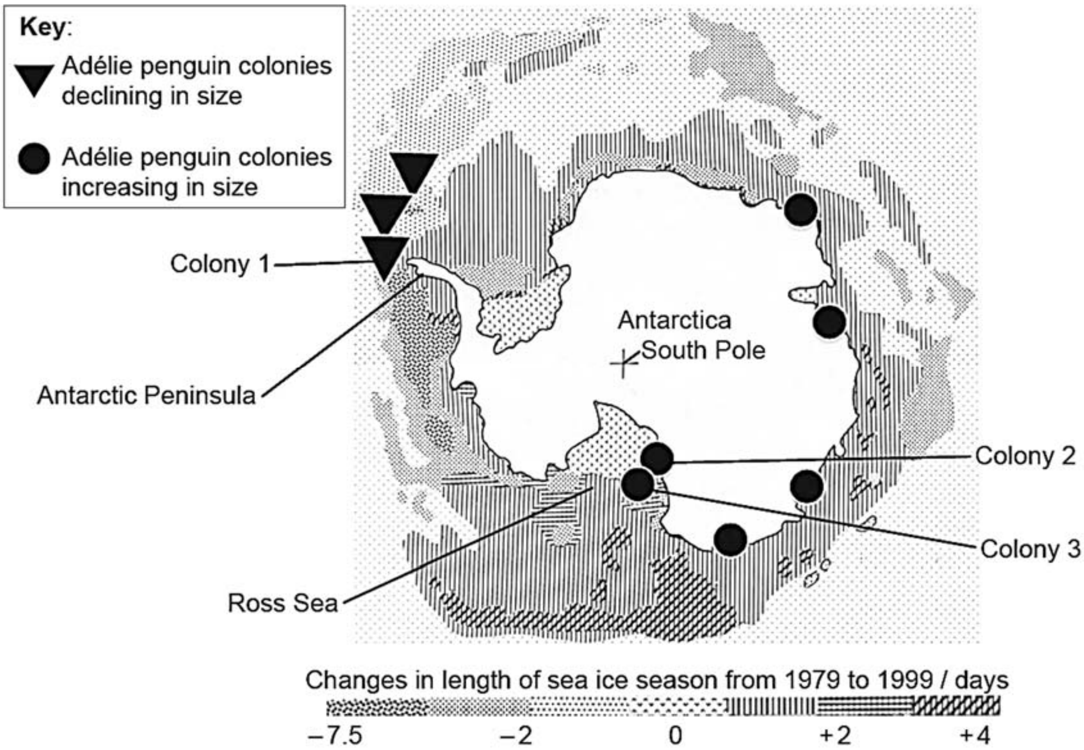
[3]

Adélie penguins (*Pygoscelis adeliae*) are only found in Antarctica and need sea ice for feeding and nesting. Biologists are able to deduce how these penguins have responded to changes in their environment for the last 35 000 years, as the Antarctic conditions have preserved their bones and their nests. The image is a map of Antarctica and the surrounding Southern Ocean. It shows the trends in the length of the sea ice season (days of the year when sea ice is increasing) and the sites of nine Adélie penguin colonies.



[Source: Data sourced from the penguinscience.com website]

Fig. 4.2

(d) Describe the trends in the length of the sea ice season around the Antarctic Peninsula and in the Ross Sea.

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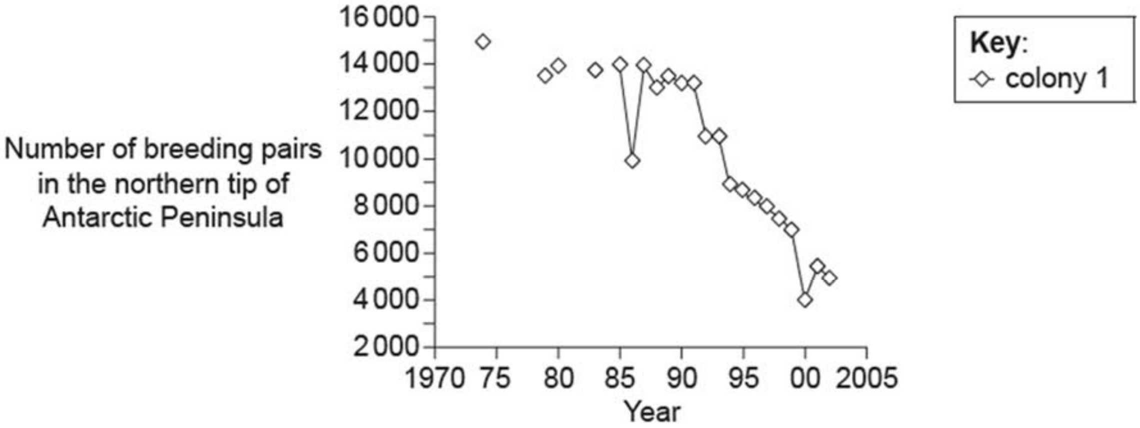
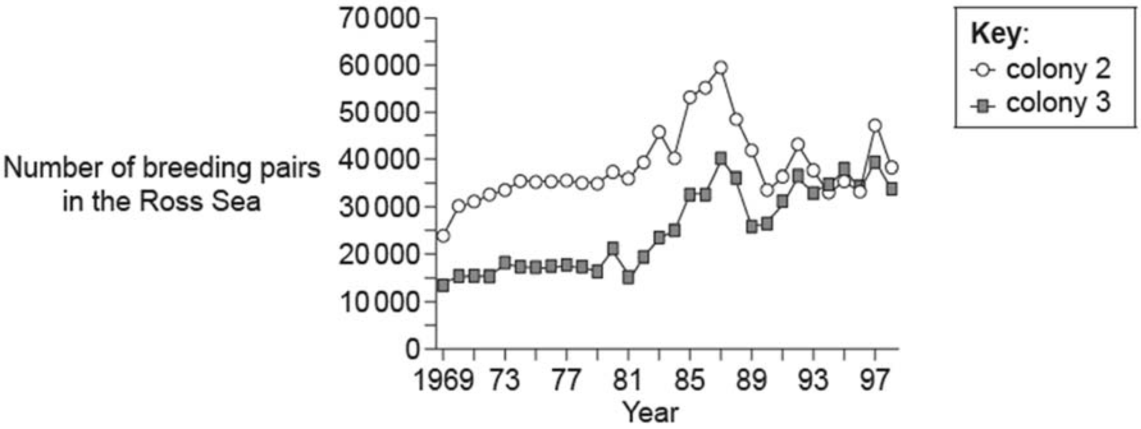
.... [2]

The graphs show the changes in penguin population in three of the colonies shown on the map.





[Source: Data sourced from: www.penguinscience.com/clim_change.php]

Fig. 4.3

(e) Analyse the trends in colony size of the Adélie penguins in relation to the changes in the sea ice.

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[3]

(f) Discuss the use of Adélie penguins in studying the effects of global warming.

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[3]
[Total: 14]

Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

5 **(a)** Outline the structural differences between typical prokaryotic and eukaryotic cells and explain how it relates to differences in gene expression. [6]

(b) Explain, with examples, how environmental factors act as forces of natural selection. [9]

[Total: 15]

6 **(a)** Explain how organisms grown from genetically identical zygotes can have different phenotypes. [6]

(b) Charles Darwin proposed that evolution occurs primarily by natural selection. However deleterious recessive alleles are not eliminated from population. Describe and explain how these alleles remain in the population. [9]

[Total: 15]

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Section A

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Within the SER, molecules of cholesterol and triglycerides are surrounded by proteins and phospholipids to form lipoproteins. These lipoprotein particles enter the Golgi apparatus where they are packaged into vesicles and pass to the blood.

Fig. 1.1 is an electron micrograph of part of a liver cell showing lipoprotein particles within the Golgi apparatus.

Fig. 1.1

(a) Name structure T in Fig. 1.1 and state its role in liver cells.

Mitochondrion;

produces / synthesises / AW, ATP ; @ release / supply, ATP / energy

® produces energy

® ATP energy

example of use of ATP in liver cells ;

e.g. for synthesis of, cholesterol / glycogen / protein / biological molecules / polymers / AW

intracellular movement of vesicles

exocytosis / endocytosis / bulk transport

active transport

[2]

(b) Suggest why cholesterol is packaged into lipoproteins before release from liver cells into the blood.

lipoproteins are <u>soluble</u> ;

cholesterol is <u>not water-soluble</u> ;

cholesterol surrounded by / lipoproteins have, phospholipid heads / proteins, that are hydrophilic ;

allows transport in blood ;

(max 1)

[1]

(c) Cholesterol is also packaged into vesicles by the SER and then secreted from the cell into small fluid-filled spaces between the liver cells. These spaces form ducts that drain into the gall bladder to form bile.

Explain how cholesterol is secreted into ducts, such as the duct in Fig. 1.1.

vesicles travel along microtubules / cytoskeleton towards the cell surface membrane;

exocytosis ;

vesicle membrane fuses with cell surface membrane;

vesicle contents containing cholesterol are released ;

[3]

(d) Both the Golgi body and the rough endoplasmic reticulum are part of the internal network of membranes in cells.

Outline structural features shown in Fig. 1.1 that identify **G** as the Golgi body and not the rough endoplasmic reticulum.

any two from:

<u>(flattened) sacs</u> have layered appearance / no **connection between membranes** / AW / ora;

not, connected to / contiguous with / continuous with, (outer membrane of) **nuclear envelope** / ora ;

swellings at end of sacs (for vesicle formation) / vesicles at ends of sacs ;

no **ribosomes** / ora ;

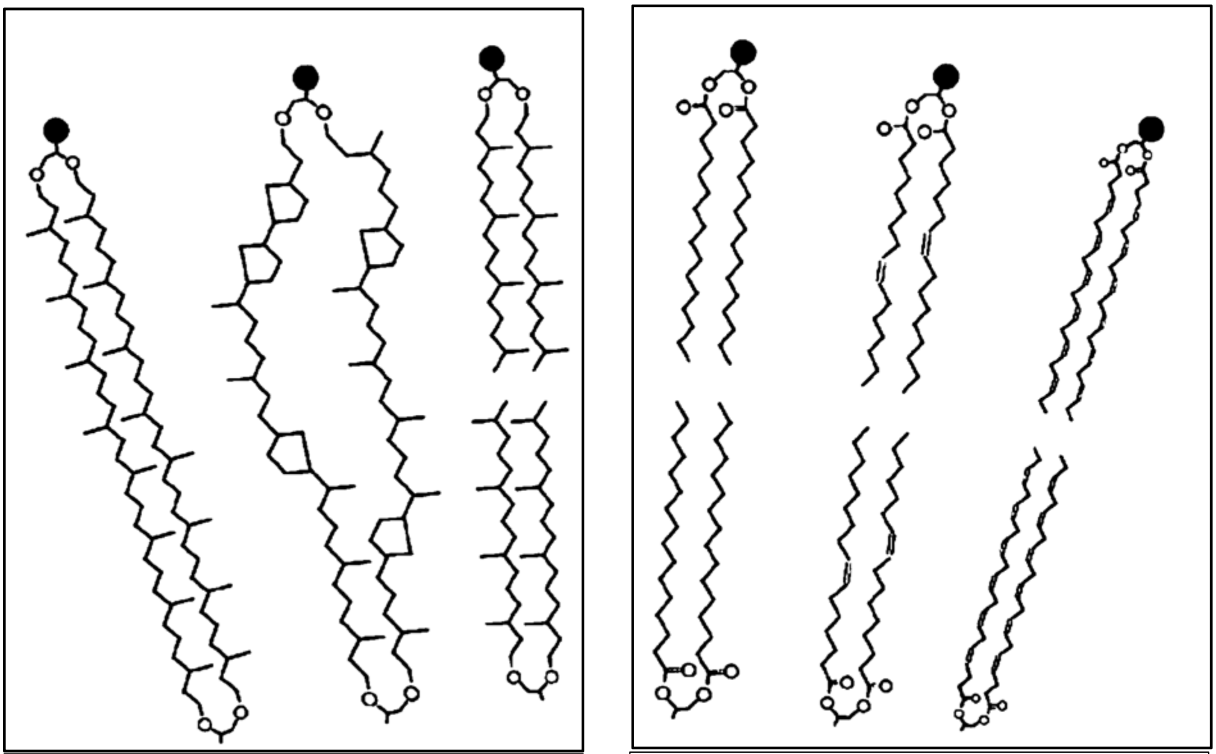
ora: or reverse argument

AW: alternative wording (where responses vary more than usual)

[2]

Cholesterol is a major component of all membranes. The concentration of cholesterol largely varies between membranes of different cells and tissues. There are other differences in the chemical composition of cell membranes in different organisms, such as the type of fatty acid chains in phospholipids.

Fig. 1.2 shows the structure of the phospholipids in the membranes of Organism A, which is an extreme thermophile (live in extremely high temperature places like hot springs), and Organism B, which live in normal environment (non-thermophile).



Organism A | **Organism B**

Fig. 1.2

(e) **(i)** With reference to Fig. 1.2, other than the presence of side branches and rings, state two structural differences between the phospholipids of Organism **A** and **B**.

Any two:

Archaea membranes	Bacterial membranes
▪ Phospholipid tails contain only saturated hydrocarbon chains.	▪ Phospholipid tails contain both unsaturated and saturated hydrocarbon chains.
▪ Hydrocarbon chains / phospholipid tails are longer / twice as long / pass completely through the membrane	▪ Hydrocarbon chains / phospholipid tails are shorter / do not pass completely through the membrane

▪ Absence of ester linkages / presence of ether linkages	▪ Presence of ester linkages
▪ Phospholipid molecules form a monolayer in the membrane	▪ Phospholipid molecules form a bilayer in the membrane

[2]

(ii) Suggest how the differences stated in **(e)(i)** enable Organism **A** to thrive in environments with extreme high temperature condition.

Any two (points must be related to differences stated in (b)(i)):

Longer phospholipid tails increase hydrophobic interactions, hence reduces membrane fluidity / increases stability of membrane at high temperatures.

Phospholipid monolayer reduces membrane fluidity / increases stability of membrane at high temperatures.

Presence of saturated hydrocarbon tails make organism A's membranes more resistant to oxidation / less fluid, thus increases stability at high temperatures

Absence of ester linkages / presence of ether linkages, therefore phospholipid molecules are more resistant to hydrolysis in an environment of high salinity.

[2]

[Total: 12]

2 Chitinases are enzymes synthesized by bacteria, fungi, yeasts, plants, that can degrade chitin into low molecular weight, soluble and insoluble oligosaccharides. Chitin is a modified polysaccharide found in a number of different organisms, for example in fungal cell walls and the hard outer skeletons of insects.

Chitinase is made up of 825 amino acids. Fig 2.1 shows the arrangement of some of the conserved amino acids found close together in the active site of chitinase. Fig. 2.2 shows the structure of a single chitinase molecule.

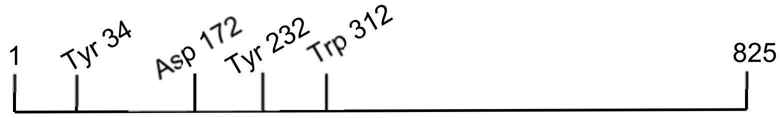


Fig. 2.1

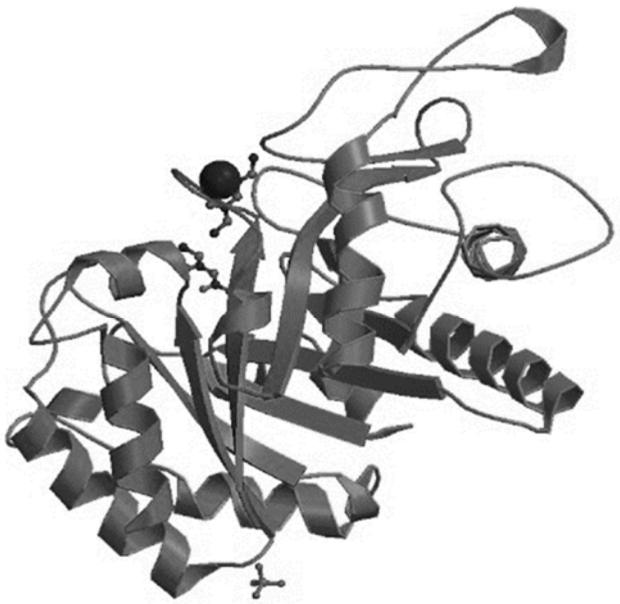


Fig. 2.2

(a) With reference to Fig 2.2, describe how the amino acid residues at different positions may be brought together when chitinase is synthesized.

1. Primary structure consisting of 825 amino acids joined together by peptide bonds; [1/2]

2. Is repeatedly coiled and folded;

3. to form secondary structures α- helices and β-pleated sheets respectively;

4. Held by hydrogen bonds formed between N-H group in a peptide bond of an amino acid and C=O group in a peptide bond of another amino acid.;

5. Secondary structures are then further coiled and folded to form tertiary structure;

6. Held by interactions + e.g. hydrogen bonds, disulphide bonds, ionic bonds and hydrophobic interactions between R-groups of amino acids;

7. give rise to specific three-dimensional structure of chitinase;

[3]

Chitin and the products of chitin hydrolysis have many useful medical and environmental applications. Chitinase enzymes can be used commercially to hydrolyse chitin. Enzyme stability and activity are important considerations in technological applications of chitinase.

Fig. 2.3 is a graph showing the effects of temperature on chitinase extracted from a soil bacterium. The relative activity of the enzyme was measured at different temperatures, with 100% representing maximum enzyme activity.

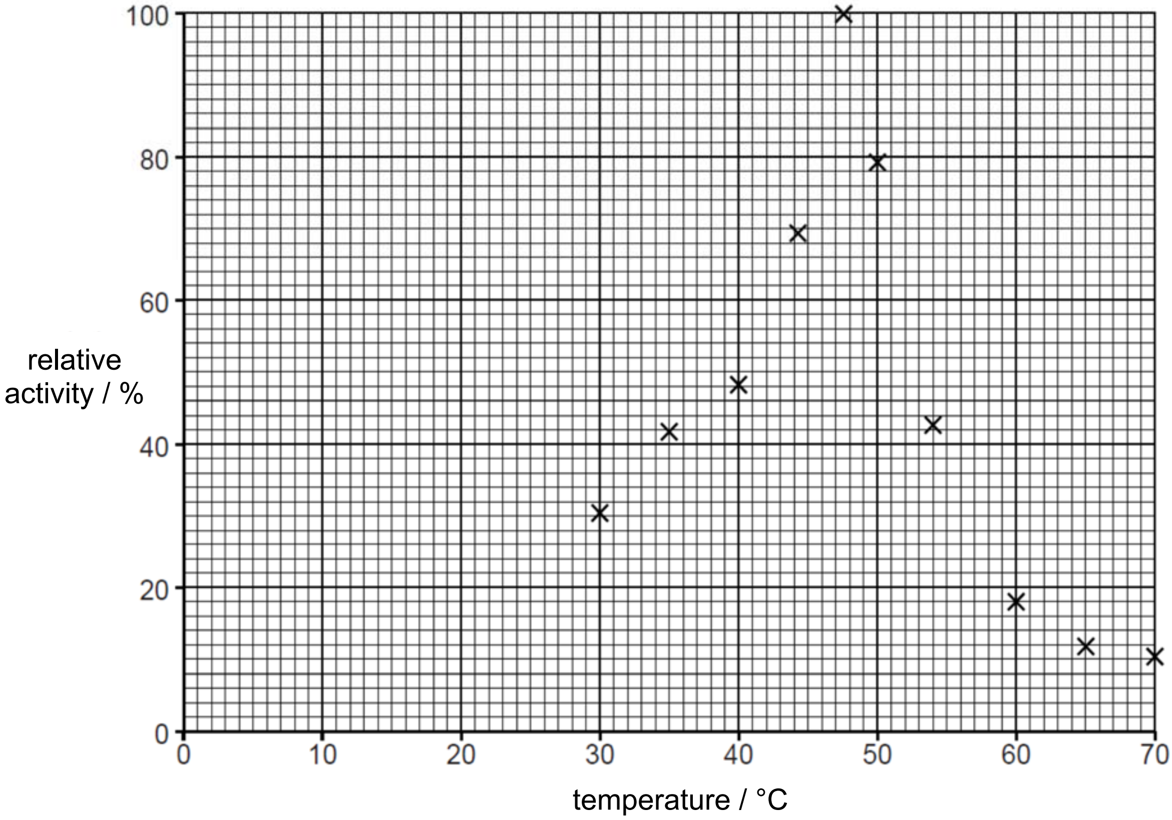


Fig. 2.3

(b) (i) With reference to Fig. 2.3, state the optimum temperature for the chitinase enzyme.

47.5 °C ;

[1]

Fig. 2.4 is a graph showing how temperature affects the stability of chitinase. The activity of the enzyme was measured over a time period of 72 hours at each of five different temperatures.

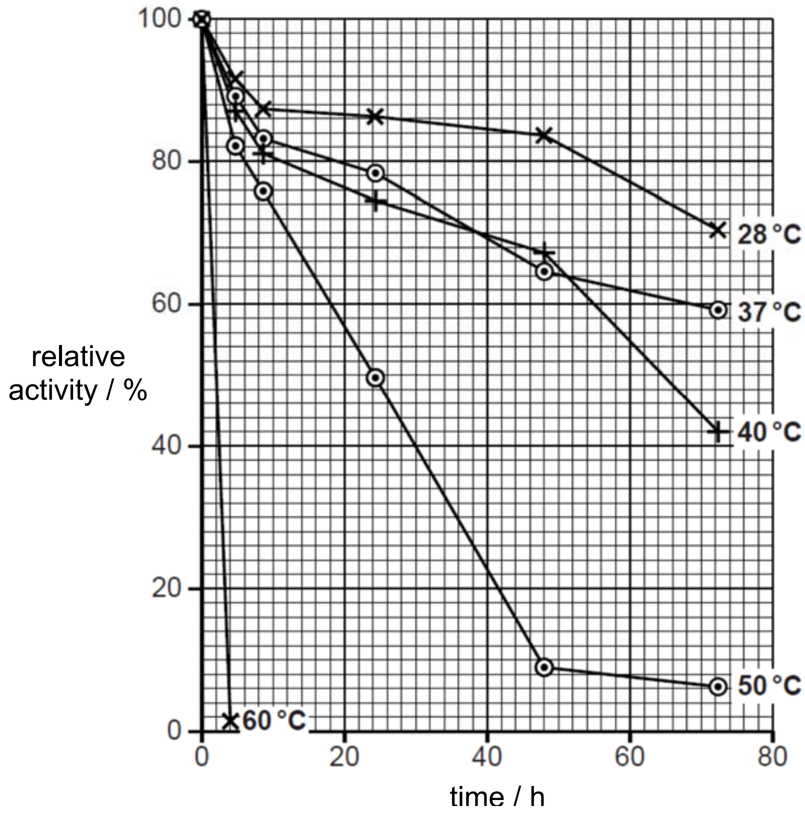


Fig. 2.4

(ii) With reference to Fig. 2.3 and Fig. 2.4, describe **and** discuss the effect of temperature on chitinase activity **and** stability.

accept activity for relative activity throughout

accept manipulated data quotes and penalise once for, incorrect / no, units

Describe [max 3]

Fig. 2.3 (relative activity of enzyme at different temperatures)

1 as temperature increases, activity increases up to, optimum / 47.5 °C (allow ecf from (i), then decreases ;

2 activity increases from 30 °C to 47.5 °C, then decreases to 70 °C ; also mp 1

or

increase <u>or</u> decrease, described with comparative data *(activity and temperature compared with another activity and temperature)*

3 at higher temperatures (compared to most others) enzyme still active ;

4 high optimum temperature (compared to most other enzymes) ;

Fig. 2.4 (stability over time for enzyme maintained at different temperatures)

5 enzyme becomes less stable over time ;

@ activity decreases over time

@ description if at least two temperatures described

6 data quote to support ; activity at two times for any one temperature

if time 0 or 'start', then assume 100% relative activity

if 100%, assume time 0

7 (over the time period) the lower the temperature, the more stable the enzyme ; ora

@ enzyme has higher activity at the lower temperatures

@ stated temperature**s** (at least two) to illustrate the point

e.g. 28 °C **higher** activity than 40 °C throughout

@ 28 °C, high**est** activity / enzyme most stable (throughout)

8 data quote to support ; *temperatures and (relative) activity (with one time)*

Discuss [2 marks]

9 e.g. Fig 2.3 reason for increasing activity up to optimum / decrease after optimum.

- freq of effective collisions, kinetic energy increase e.g. denaturation at 60–70 °C

® denaturation at 50 °C (but @ denaturation begins) [1/2]

- suggested reason for higher optimum temperature e.g. more bonds, more stronger covalent bonds [1/2]

Fig. 2.4

(suggests that) more molecules become, denatured / inactive, as time progresses

greater stability / higher activity, at 40 °C than 37 °C between 40–50 hours

Fig. 2.3 and 2.4

optimum temperature for activity not most stable temperature

steep decrease in stability at 60 °C in a short time as (nearly complete) denaturation occurs *(allow once only)*

commercial application e.g. if hydrolysis occurs over a longer time period, better to use a lower temperature than optimum [max 5]

---

[5]
[Total: 9]

3 In mice, fur colour is controlled by a gene with multiple alleles. These alleles are listed below in no particular order.

black and tan = C^{bt} yellow = C^{y}
agouti = C^{a} black = C^{b}

(a) Explain how multiple alleles arise.

gene mutation ;

a change in the, base(s) / nucleotide(s) ;

e.g. base, substitution / deletion / addition

[2]

(b) Suggest explanations for the results of the following crosses between mice.

(i) Mice with agouti fur crossed with mice with black fur may produce all agouti offspring **or** some agouti and some black offspring.

1 agouti allele / C^{a}, dominant to black allele / C^{b} ; ora

2 black parents homozygous recessive ;

3 agouti parents heterozygous **or** homozygous ;

[2]

(ii) Crosses between heterozygous parents with the genotype $C^{y}C^{b}$ always produce a ratio of two yellow mice to one black mouse.

1 yellow allele / C^{y}, dominant to, black allele / C^{b} ;

2 ref. to modified 3:1 ;

3 (homozygous) genotype C^{y} C^{y} , lethal / does not survive ;

[2]

(iii) Mice with yellow fur crossed with mice with black fur will produce one of the following outcomes:

- some yellow offspring and some agouti offspring
- some yellow offspring and some black and tan offspring
- some yellow offspring and some black offspring.

1 yellow allele / C^{y}, dominant to all others ;

2 agouti / C^{a} **or** black and tan / C^{bt}, allele, dominant to black allele ;

@ black allele recessive to all other alleles

3 yellow mice all heterozygous (must be stated) ;

[2]

(c) A test cross is used to determine the genotype of an organism.

Describe how you would carry out a test cross to determine the genotype of a black and tan mouse.

1 cross (black and tan mouse) with, black mouse / homozygous recessive mouse / $C^b C^b$;

2 if **all** offspring black and tan then parent, $C^{bt} C^{bt}$ / homozygous ;

3 if some offspring are black (and some are black and tan) then parent, $C^{bt}C^*$ / heterozygous ;

[2]

[Total: 10]

4 Global warming has changed both the thickness and surface area of sea ice of the Arctic Ocean as well as the Southern Ocean that surrounds Antarctica. Sea ice is highly sensitive to changes in temperature.

Scientists have calculated a long-term mean for the surface area of sea ice in the Arctic and in the Southern Ocean around Antarctica. This mean value is used as a reference to examine changes in ice extent. The graph Fig. 4.1 shows the variations from this mean (zero line) over a period of time.

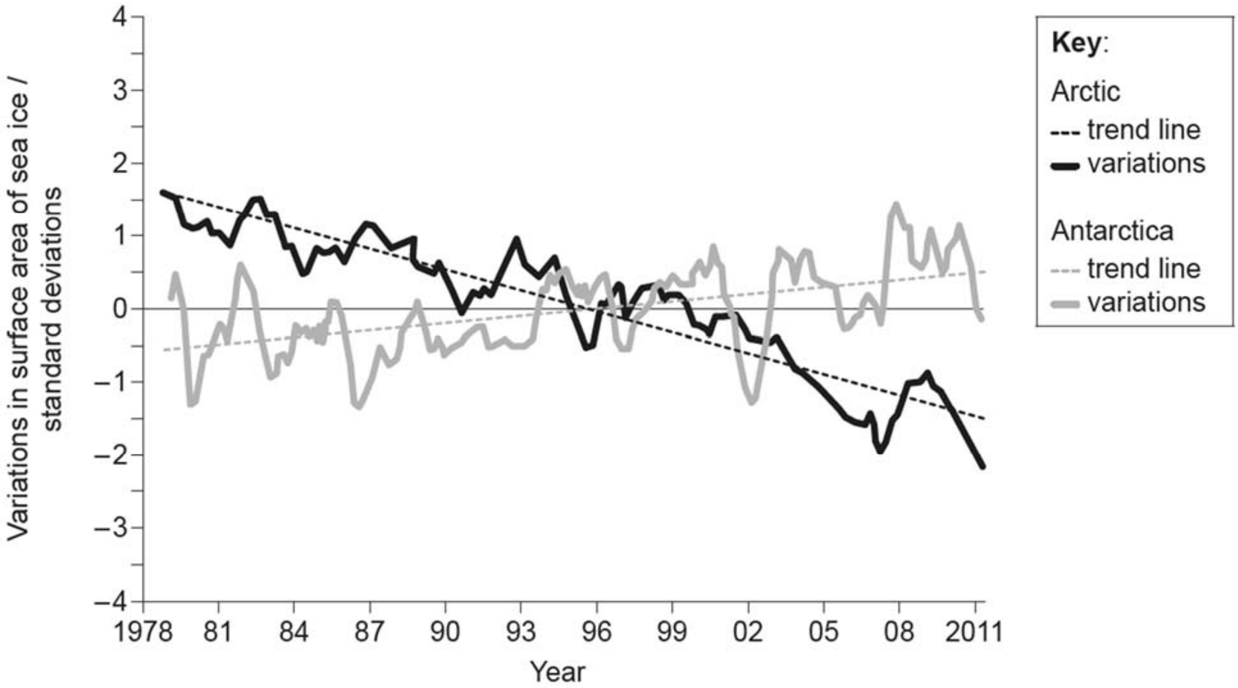


Fig. 4.1

(a) State the trend in the surface area of sea ice in the Southern Ocean around Antarctica.

increasing/positive trend/correlation;

[1]

(b) Distinguish between changes in the surface area of sea ice in the Arctic and Antarctica.

In the Arctic ocean the surface area of sea ice has declined whereas in Antarctica the surface area has increased;

it is acceptable if there is no comparative term such as "whereas" or "but";

the rate of change is greater for the Arctic than for Antarctica;

there are greater fluctuations in the surface area of sea ice in Antarctica than in the Arctic;

[2 max]

[2]

(c) Discuss the data as evidence of global warming.

a. change / decrease / melting of sea ice is expected with global warming;

b. decrease of sea ice in Arctic is supportive evidence of global warming;

c. increase in sea ice in Antarctic is not supportive evidence of global warming;

d. Antarctic increase / both changes may be associated with climate change (caused by global warming);

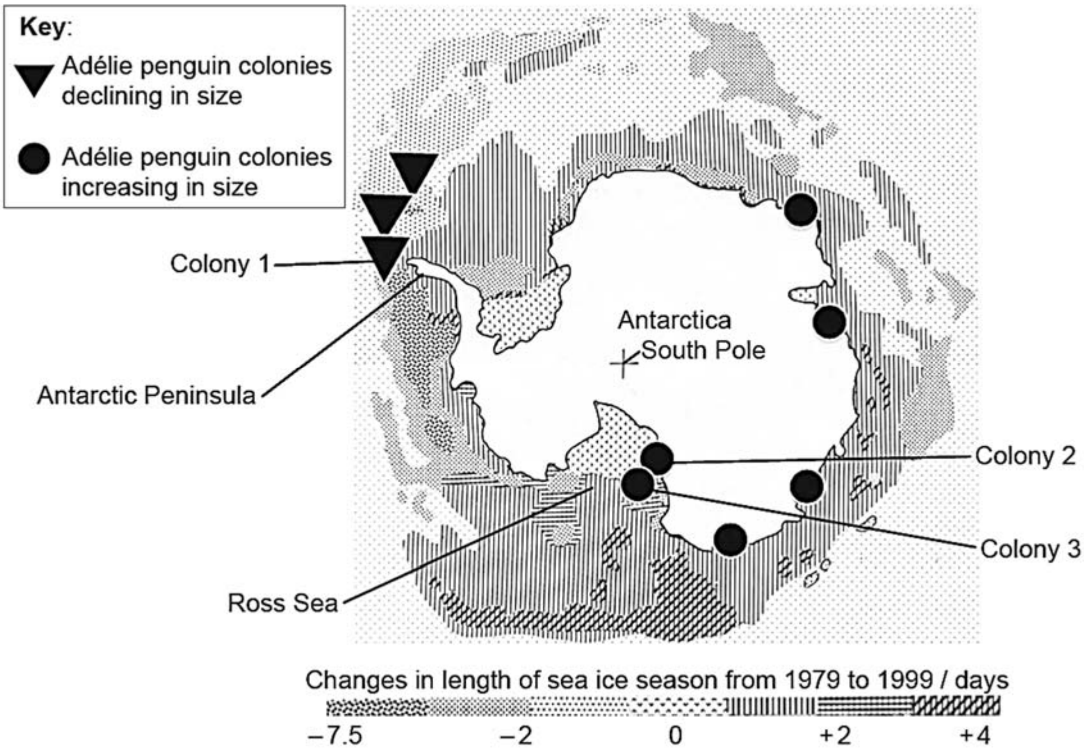
e. global warming does not affect all areas in the same way / global warming has complex effects;

f. data is inconsistent/inconclusive / data on its own does not establish cause and effect / not over a very long period of time;

[3 max]

[3]

Adélie penguins (*Pygoscelis adeliae*) are only found in Antarctica and need sea ice for feeding and nesting. Biologists are able to deduce how these penguins have responded to changes in their environment for the last 35 000 years, as the Antarctic conditions have preserved their bones and their nests. The image is a map of Antarctica and the surrounding Southern Ocean. It shows the trends in the length of the sea ice season (days of the year when sea ice is increasing) and the sites of nine Adélie penguin colonies.



[Source: Data sourced from the penguinscience.com website]

Fig. 4.2

(d) Describe the trends in the length of the sea ice season around the Antarctic Peninsula and in the Ross Sea.

One mark for correct description of the trend off the Antarctic Peninsula and

One mark for correct description for the Ross Sea;

accept correct statements other than those listed in the scheme but do not award a mark for contradictions; marks can be awarded for correct statements about the sea ice season for Antarctica overall;

Some students are referring to moving South in the Ross Sea when it is clear that they are moving North. If you can discern their intention, then give the BOD on this;

Antarctic Peninsula:

a. decrease/stable at the base of the peninsula / decrease in the area of the penguin colonies/West of the tip / increase/+1 above and below the peninsula / variable pattern;

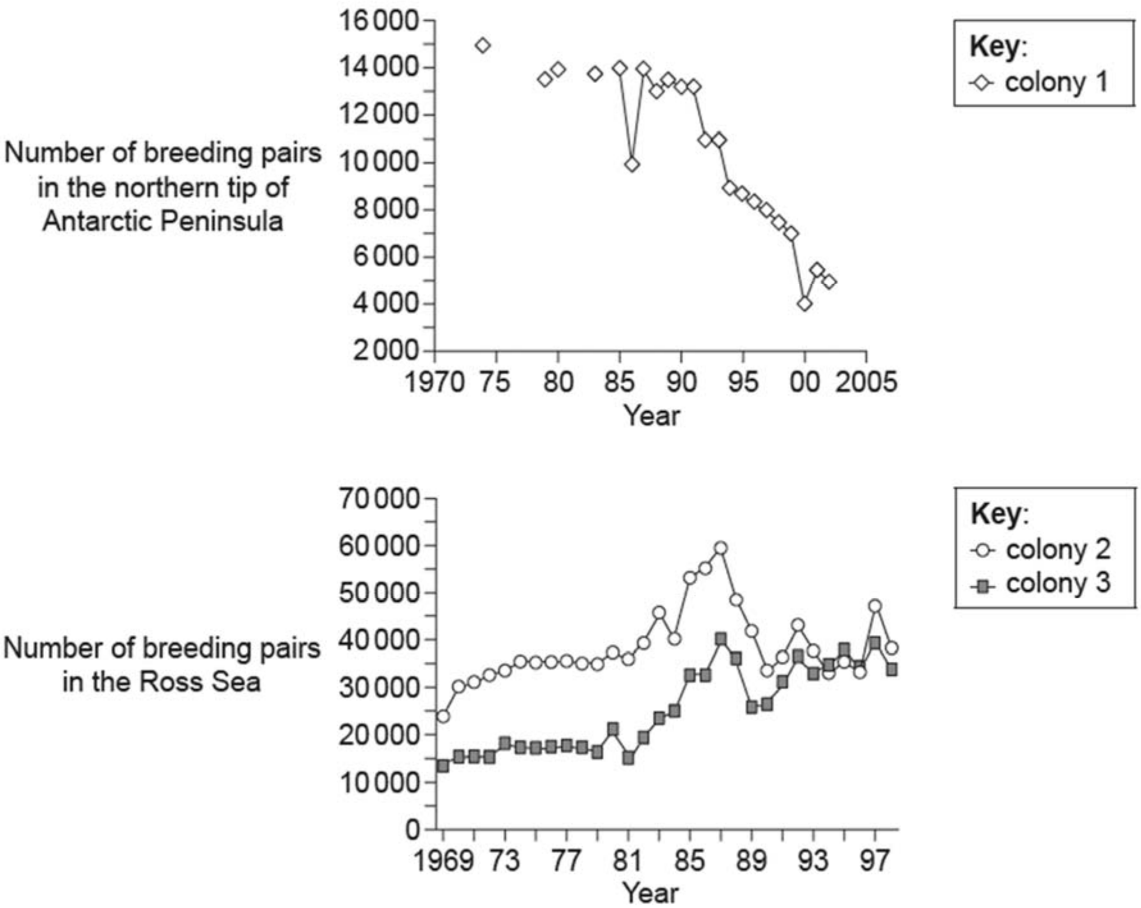
Ross Sea:

b. sea ice is increasing / +1 in the Ross Sea / area below / North of the Ross Sea

/ lower Ross Sea / Southern part of Ross Sea/closest to the South pole is stable/no change to the length of the sea ice season / variable pattern; [2 max]

[2]

The graphs show the changes in penguin population in three of the colonies shown on the map.



[Source: Data sourced from: www.penguinscience.com/clim_change.php]

Fig. 4.3

(e) Analyse the trends in colony size of the Adélie penguins in relation to the changes in the sea ice.

a. (off Antarctic Peninsula) sea ice season has declined as has penguin population;

b. colony 2 and 3 sea ice season has not declined and population increased;

c. colony 3 increase in population and growing length of **sea ice season**;

d. colony 2 has stable / increasing numbers and **sea ice season** is not changing;

e. colony size and sea ice season length/area are correlated;

f. Population numbers for colony 1 and 3 the same at start of study but both experience a big (opposite change);

[3 max]

[3]

(f) Discuss the use of Adélie penguins in studying the effects of global warming.

a. global warming leads to **climate / environmental change**; eg temperature change / ice melting

b. stable ice associated with stable population / no climate change;

c. ice changes associated with **population changes**;

d. changes in penguin population size can indicate climate change / global warming;

e. example of how climate change can alter population; eg prey availability / habitat loss;

f. not all species will be affected in the same way (so care needed in applying conclusions more widely)

g. there is information on changes of population over the past 35 000 years;

[3 max]

[3]

[Total: 14]

Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

5 **(a)** Outline the structural differences between typical prokaryotic and eukaryotic cells and explain how it relates to differences in gene expression. [6]

(b) Explain, with examples, how environmental factors act as forces of natural selection. [9]

[Total: 15]

6 **(a)** Explain how organisms grown from genetically identical zygotes can have different phenotypes. [6]

(b) Charles Darwin proposed that evolution occurs primarily by natural selection. However deleterious recessive alleles are not eliminated from population. Describe and explain how these alleles remain in the population. [9]

[Total: 15]

5 (a) Outline the structural differences between typical prokaryotic and eukaryotic cells and explain how it relates to differences in gene expression. [6]

Structural differences	**Prokaryotes**	**Eukaryotes**
Presence of nucleus / nuclear membrane / nuclear envelope	No nuclear membrane. Genome exist in the nucleoid region	Have nuclear membrane, genome is enclosed within it
Size of genome	Smaller genome and smaller number of bases / smaller number of genes / coding regions.	More than one chromosome and larger number of chromosomes and bases / genome / larger number of genes / coding regions.
Level of compaction	Not as highly condensed as euk - form loop domains and undergoes further DNA supercoiling	Many levels of condensation of DNA - elaborate, multilevel system of DNA packing **to fit all the DNA into the nucleus** in preparation for cell division / 10 nm fiber to 30 nm chromatin fiber or solenoid to looped domain forming 300 nm

		fiber to metaphase chromosome.
Association with histone proteins	Non-histone proteins	DNA associated with histone proteins to form nucleosomes
Presence of introns	Absent	Present; interspersed between exons

Differences in gene expression:

1. Simultaneous transcription and translation can occur VS Absence of simultaneous transcription and translation. Transcription occurs within the nucleus and translation outside the nucleus in the cytoplasm.

2. No post-transcriptional modification VS need for post-transcriptional modification needed to produce mature mRNA for translation.

3. No RNA splicing VS need for RNA splicing to produce continuous coding sequence.

4. No alternative splicing, only one possible mRNA and protein product per gene VS introns which allows for alternative splicing → Different mature mRNA molecules and hence multiple protein variants are produced from the same gene.

5. mRNA is less stable / more easily degraded VS mRNA is more stable / less easily degraded.

5. Changes in chromosome structure not used as method to regulate transcription VS Rate of transcription is controlled by allowing for increased DNA condensation / conversion between euchromatin and heterochromatin states.

6. Fewer levels of control of gene expression VS more levels of control of gene expression.

7. QWC:
1 mark for relating **relevant** structural differences to differences in gene expression.

(c) Explain, with examples, how environmental factors act as forces of natural selection. [9]

For each example:
1 a **named example** of a species that has evolved in this way;
2 description/clear statement of the **change** that occurred in the environment / **Selection pressure**;
3 description/clear statement of **different varieties** (that existed at the same time);
4 **explanation** of/reason for one variant having a **selective advantage**;
5 the **change in the population/species** due to **natural selection/evolution**;

Example 1: Galapagos Finches (Darwin's finches)

1 For natural selection to occur, there must be **<u>heritable variation</u>** for a particular trait. In this case, it is the alleles of the gene which determine the size and depth of the beaks in Galapagos finches.
2 Give **e.g. of variation -** Some had large and heavy beaks adapted for eating large seeds, others for small seeds; some had parrot-like beaks for feeding o buds and fruits, and some had slender beaks for feeding on small insects. One used a thorn to probe for insect larvae in wood, like some woodpeckers do. (Six were ground-dwellers, and eight were tree finches.)
3 **Selection pressure: Limited food source**
4 The type of beak phenotype that is being **selected for** depends on the availability of the food source due to different environmental conditions or different habitats.
5 E.g. If small tender seeds are available at that island, finches with small beaks are at a **selective advantage** as it allows it to feed. If large hard seeds are available at that island, finches with large, more powerful beaks were **selected for / selective advantage**.
6 Individuals which are more adapted to surviving in a particular habitat will **<u>survive to maturity, reproduce to produce viable offspring</u>** and **<u>pass on the</u>** **<u>beneficial alleles</u>** to the next generation.
7 Hence there was **<u>differential survival and reproductive success</u>** associated with the possession of the particular beak type, therefore this leads to a change in **<u>allele frequency</u>** in a population for beak type.

Example 2: Soapberry bugs (*Jadera haematoloma*)

1 **<u>Heritable variation</u> -** beak length. Soapberry bugs feed most effectively when their beak length closely matches the depth at which the seeds are found within the fruit.

2 **Selection pressure: Change in food supply**

3 Food supply **-** the soapberry bug feeds on the seeds of a native plant, the balloon vine (*Cardiospermum corindum*). However in Central Florida, balloon vines have become rare and thus the soapberry bugs in this region feeds on the goldenrain tree (*Koelreuteria elegans*), a species that was introduced from Asia.

4 Seeds of the goldenrain tree fruit are much closer to the surface than seeds of the balloon vine. Therefore bugs with shorter beak lengths would be selected for by natural selection, as they would be able to feed on the seeds of goldenrain tree fruit, which are more widely available.

5 In Southern Florida where the balloon vine is more common, the seeds are found deeper within the fruit. Therefore bugs with longer beak lengths would be selected for by natural selection, as they would be able to feed on the seeds of balloon vine fruit, which are more widely available.

6 Individuals which are more adapted to feeding on the seeds of the plant at the specific region will survive to maturity, reproduce to produce viable offspring and pass on the beneficial alleles to the next generation.

7 Hence there was differential survival and reproductive success associated with the possession of the particular beak length, therefore this leads to a change in allele frequency in a population for beak length at that region. For central Florida, allele frequency for shorter beak length increased due to natural selection, over successive generations. For southern Florida, allele frequency for longer beak length increased due to natural selection, over successive generations.

Example 3: Evolution of drug-resistant bacteria (*MRSA: methicillin-resistant Staphylococcus aureus*)

Staphylococcus aureus/MRSA/*Clostridium difficile*/other named species;
Selection pressure: Use of methicillin antibiotic ;
some bacteria were resistant and others were not;
resistant bacteria survived (and multiplied) while non-resistant were killed;
percentage of the population showing resistance increased;

QWC:
At least 2 examples of natural selection including the respective type of environment factor acting as the force of natural selection.

__[9]__ can be awarded if the candidate scores __[5]__ for one example and __[3]__ for the other.
Do not accept examples where the evidence of evolution comes from fossils, or where the variation is not heritable.
(Plus __[1]__ for quality)

6 **(c)** Explain how organisms grown from genetically identical zygotes can have different phenotypes. [6]

Suggested introduction:
The **phenotype** of an organism refers to the observable characteristics of an individual (also accept: physical or chemical expression of the organism's genes) [1/2] while **genotype** refers to the genetic makeup of the organism or the alleles that an organism has [1/2]

Genotype is the ultimate factor determining a phenotypic expression but in some cases [1/2], the environment affects the level of expression of the genes / affects the subsequent expression of the genetic potential [1/2].

This is shown when genetically identical individuals develop differently in different environments. Hence, the expression of a phenotype is affected by interaction of genotype and environmental factors. [1/2]

1. Genetically identical zygote can be different due to wide range of environment effects;
2. idea that phenotype results from interaction of genotype and environment / The expression of genotype may be influenced by environment factors like nutrients, light, or temperature;
3. environment may, limit / modify, expression of gene(s) / AW ;
4. continuous variation example ; e.g. size / mass / height
5. due to environment factors; e.g. because, food / nutrients / ions, missing or malnutrition occurs
1. environment effect usually greater on polygenes ;
1. E.g. Fur colour in Himalayan rabbits is affected by a temperature-sensitive enzyme involved in pigment synthesis;
2. Low temperature can results in active enzyme that result in black pigment formation. Thus, Himalayan rabbit are black extreme parts of the body;
3. E.g. Phenotypes of honey bee (drones, queen or workers) are determined by the diet of larvae during development;
4. Royal jelly diet will give rise a queen bee;
5. Environment may induce mutation (affecting phenotype) / Spontaneous somatic mutation may occur and cause different phenotypes;

® meiosis / crossing over as gamete formation occurs before a zygote is formed.

Other named e.g.

Named example 1: Effect of environmental conditions (e.g. light) on plant development / height

(Height in plants)
- The height of a plant is genetically-determined [1/2] (e.g. Mendel's tall variety of the garden peas plant) but growth depends on adequate light, water and soil conditions [1/2]
- A reduction in the supply of any one condition prevent the gene for height from exerting its full potential [1]

(Chlorophyll synthesis in plants)
- Although the ability to synthesize chlorophyll is genetically determined [1/2], light is a requirement [1/2]
- Evidence: seeds grown in the dark; such plants exhibit etiolation (e.g. stems are long and thin; seedlings are yellow) [1]

(Floral colours in Hydrangea)
- Hydrangea may have different floral colours despite carrying the same alleles; [1/2]
- The soil acidity, in which the plants grow affects the plants' ability to take up aluminium; [1/2]
- In acidic soils (pH 5.5 or lower), aluminum assumes a form that is easily absorbed by plant roots, and thus flowers are predominately blue; [1/2]
- In soils where the pH is 6.5 or higher / alkaline, aluminum is unavailable and flower color is pink purple; [1]
- Sometimes a single plant will have both blue and pink flowers because of varying soil conditions around the plant; [1]

(Height of yarrow plants)
- Height is genetically determined; [1/2]
- Cuttings from the same plant have the same genotype but grow differently at different altitudes / elevations; [1/2]
- Cuttings from one plant grew tall at lowest and highest elevation; [1/2]
- But remained short at mid-elevation; [1/2]

Named example 2: Effect of temperature on development of animal
(max 2 marks)

(Wing development in fruit-flies)
- The allele for vestigial wing in Drosophila / “fruit-flies” is recessive to that for long wing [1/2]
- However individuals which are homozygous for this allele [1/2] will only express the vestigial wings at low temperatures [1/2]
- Reference to vestigial wings at 21oC; [1/2] intermediate wings (26oC); long wings (31oC) [1/2]

Named example 3: Effect of diet on development of human / animal
(max 3 marks)
(Phenylketonuria in humans)
- Diet affects traits such as height, weight and intelligence in humans [1/2]
- Phenylalanine is metabolized by phenylalanine hydroxylase [1/2]
- Individuals with two copies of the mutant recessive alleles (homozygous recessive condition) do not have functional enzyme [1/2] □ unable to break down the amino acid consumed through their diet [1/2] □ phenylalanine accumulates in their bodies [1/2] □ disease: phenylketonuria (PKU); mental retardation [1/2]
- Hence, these individuals need diet free from the particular amino acid [1/2]

(Reproductive system in honey bees)
- In a bee colony, the male bees or drones develop from unfertilized haploid eggs while the female bees develop from fertilized diploid eggs. [1/2]
- The worker bees are sterile while the queen bee is fertile
- Worker bees are smaller and have larger mouthparts and modified legs as compared to the queen bee; (they are phenotypically different even though genetically similar) ;
- The development of the female larvae to a queen bee or worker bee depends on the diet. [1/2]
- Once a particular female larva is selected to become the sexually mature queen bee, it is fed exclusively with royal jelly. [1/2]
- It is the high protein level in the royal jelly that stimulated the development of the female reproductive system. [1/2]
- Otherwise, it would be like the rest of the honey bee larvae which are fed royal jelly for the first few weeks after hatching (briefly) and then fed with a diet of honey and pollen. [1/2]

Named example 4: Effect of environment on development of human (max 3 marks)

(Pattern baldness in humans)
- male gender; premature pattern baldness due to an allele which is differentially expressed in the sexes; [1/2]
- both male homozygotes and heterozygotes develop bald patches; [1/2]
- only female homozygotes show balding; [1/2]
- expression of allele is probably triggered by testosterone; [1/2]
- females produce less of testosterone and thus seldom develop bald patches; [1/2]

(Skin colour in humans)
- exposure to the sun will result in the darkening of the skin / tanned skin;
- due to melanin production in cells;
- despite having an allele coding for fair skin;

(f) Charles Darwin proposed that evolution occurs primarily by natural selection. However deleterious recessive alleles are not eliminated from population. Describe and explain how these alleles remain in the population. [9]

Heterozygote protection/Diploidy

1. ***Heterozygote protection*/diploidy**** occurs in diploid organism with 2 copies of each gene
2. 2 different alleles at 1 gene locus where dominant allele determines the organism's phenotype/recessive allele remains hidden/masked
3. Recessive homozygote with unfavourable phenotype selected against/dominant phenotype selected for + heterozygotes survive
4. thus heterozygotes pass on recessive allele to offspring when heterozygotes propagate/interbreed maintaining recessive allele in population
5. e.g. Heterozygous condition hides recessive Hb^S allele that is less favourable from natural selection which only acts on sickle cell anaemia phenotypes
   any relevant example with details
   [cap at 4m for heterozygote protection]

Balancing selection

6. ***balancing selection**** where natural selection maintains two or more alleles at a gene locus (such as in heterozygote advantage and frequency dependent selection)

Heterozygote advantage

7. ***heterozygote advantage**** when individuals who are heterozygous at a particular locus have greater fitness than / selective advantage over / can survive and reproduce better than both kinds of homozygotes
8. Heterozygote is selected for with named e.g. in malaria prone regions, Hb^AHb^S do not suffer from negative effects/do not die of sickle cell anemia or more resistant to malaria
9. thus heterozygotes pass on recessive allele (Hb^S) to offspring when heterozygotes propagate/interbreed maintaining recessive allele in population
10. Both homozygotes are selected against with named e.g. Hb^SHb^S individuals will be disadvantaged due to serious effect of sickle-cell anaemia and $Hb^A Hb^A$ will be susceptible to malaria.
    any relevant example with details

Frequency-dependent selection

11. ***frequency dependent selection**** is where the fitness/selective advantage of the phenotype depends on how common it is
12. the frequency of each phenotype oscillates over time but is kept close to 50%, thus maintaining both alleles
13. e.g. in Lake Tanganyika in Africa, there are two forms of the scale-eating fish i.e. left-mouthed and right-mouthed. The prey of the scale-eating fish guards itself against attack from whatever phenotype of scale-eating fish is most common in the lake. So from year to year, selection favours whichever mouth phenotype is least common.

Neutral mutations

14. ***Neutral mutations**** are those that do not undergo natural selection because when they are expressed, they do not confer a selective disadvantage or advantage to the individual/do not affect fitness/selectively neutral
15. They can occur as a result of: (any 1)
    - ***Silent mutations**** where despite a mutation, the same amino acid is coded for, so no change in protein structure and function
    - ***Conservative substitution**** where mutation codes for another chemically similar amino acid resulting in no change in protein structure and function
    - Mutations in non-regulatory sequences in non-coding regions/mutations that do not fall within regulatory sequences resulting in no change in protein function and quantity of protein produced