NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME

CLASS

BIOLOGY 8876/01

Paper 1 Multiple Choice **25 September 2018**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name and CT on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

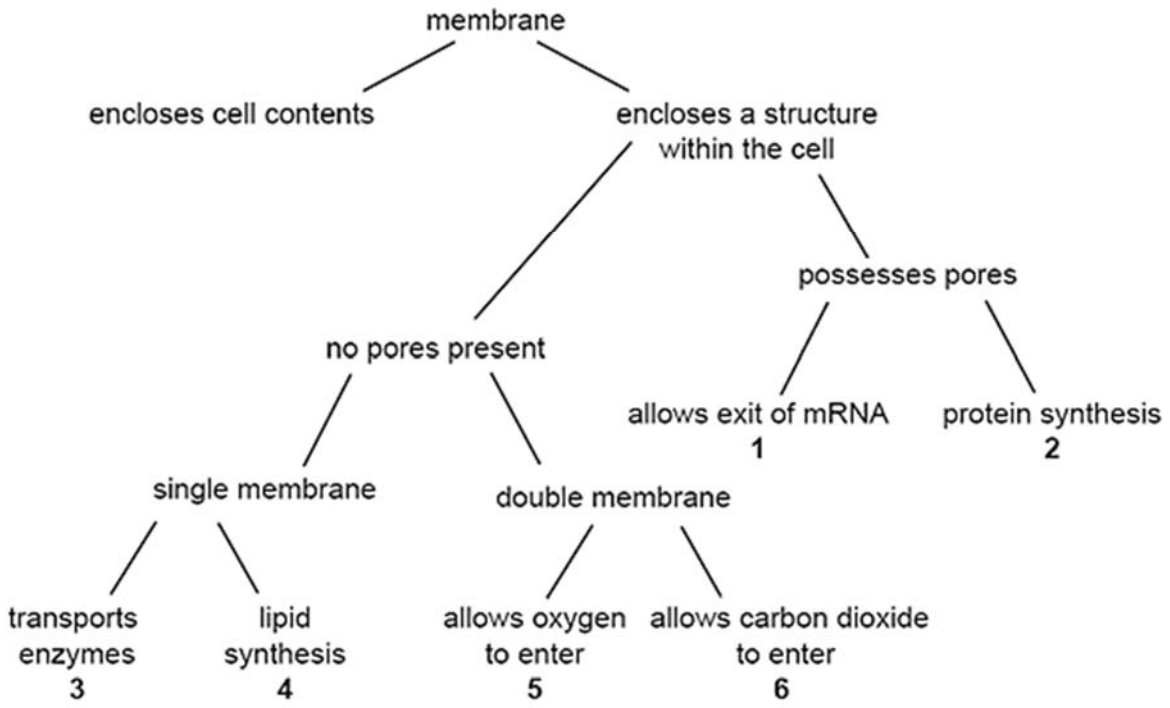
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Calculators may be used.

This document consists of **20** printed pages and **0** blank page.

[Turn over

1 Membranes within and at the surface of cells have different roles.

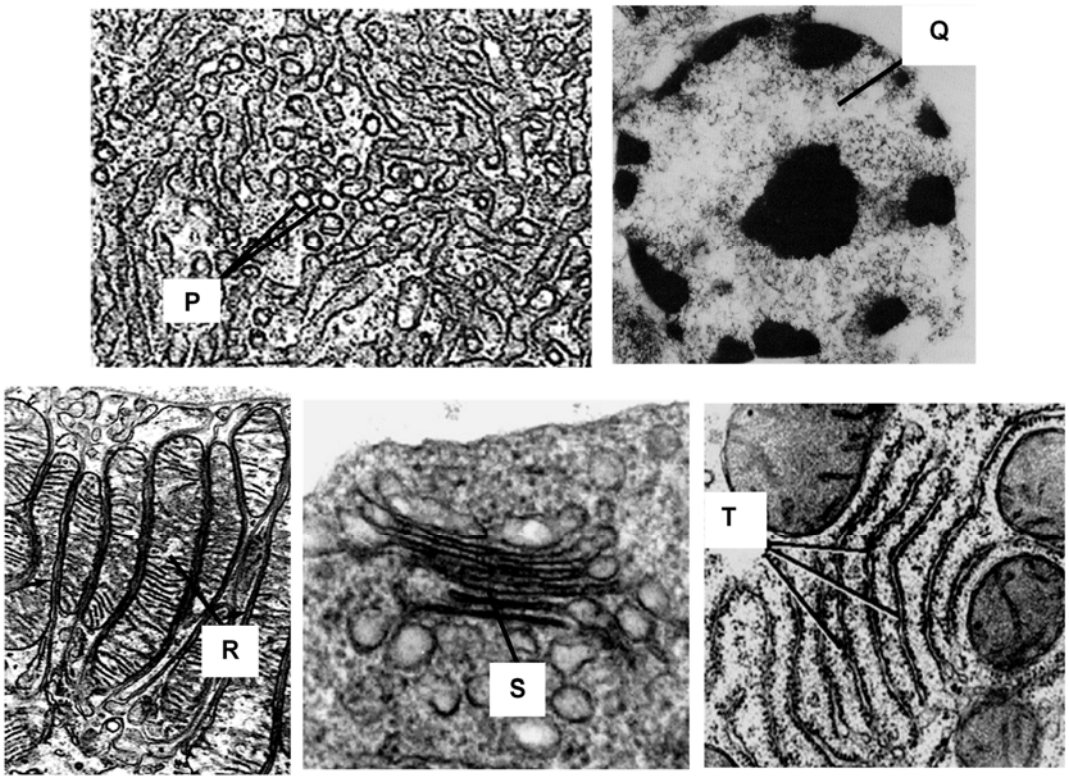
The diagram allows the identification of the various organelles within the cell, by describing the membrane structure and function.



Which of the outcomes shown below correctly identifies the organelles that possess the membrane and function concerned?

	1	2	3	4	5	6
A	nucleus	ribosome	vesicle	smooth ER	mitochondrion	chloroplast
B	nucleolus	rough ER	vesicle	smooth ER	nucleus	mitochondrion
C	nucleus	rough ER	vesicle	smooth ER	mitochondrion	chloroplast
D	nucleus	smooth ER	mitochondrion	rough ER	vesicle	chloroplast

2 The following electron micrographs show various organelles **P** to **T** present in a liver cell.



Radioactive amino acids are supplied to the liver cell to synthesise insulin receptors.

Which sequence shows the correct order in which these amino acids would be detected in the organelles during the synthesis of insulin receptors?

A Q → T → R → P → S

B Q → T → P → S

C T → P → S → R

D T → S → P

3 A symbiont may be defined as a species in which individuals live in a long-term, intimate and beneficial relationship with hosts of a different species. As the name suggests, endosymbionts live within their hosts.

Which statement provides evidence that mitochondria and chloroplasts are endosymbionts?

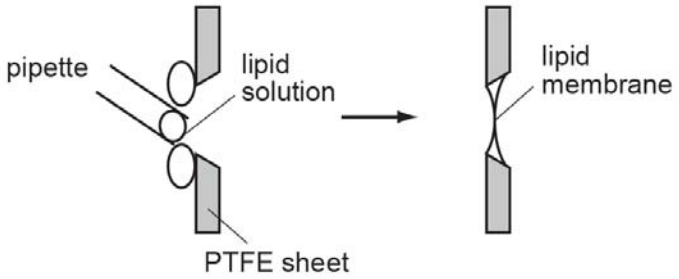
A Proteins encoded by the nucleus are exported to these organelles.

B Their inner membrane has different structure from other intracellular membranes.

C They are surrounded by double membrane.

D They contain their own ribosomes.

4 Lipid membranes can be formed in the laboratory by painting phospholipids over a PTFE sheet with a hole in it.



Such a lipid membrane is impermeable to water soluble materials including charged ions such as Na^+ or K^+.

In one experiment with Na^+ ions, no current flowed across the membrane until a substance called gramicidin was added to the membrane, at which time current flowed.

What kind of molecule is gramicidin?

A A carbohydrate molecule found only on the outside of the membrane.

B A non-polar lipid which passes all the way through the membrane.

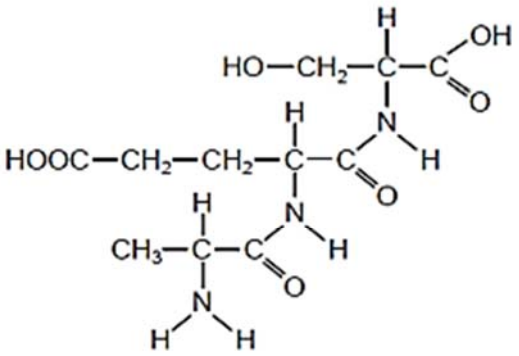
C A protein molecule with both hydrophilic and hydrophobic regions.

D A protein molecule which has only hydrophobic regions.

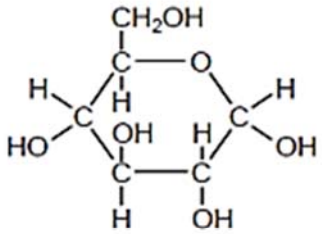
5 Samples of a mixture of biological molecules were tested using Benedict's reagent, biuret solution and ethanol. After testing, the solutions were blue with Benedict's reagent, purple with biuret solution and cloudy with ethanol emulsion test.

Which molecules could the mixture contain?

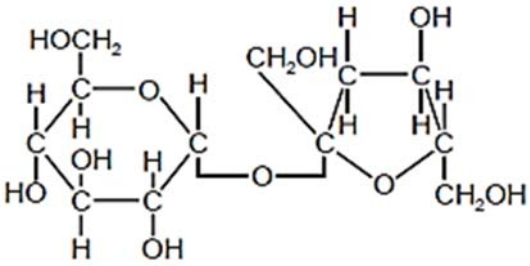
W



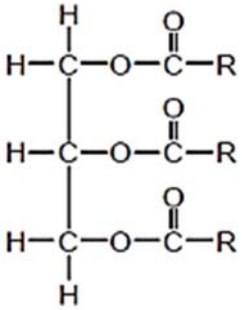
X



Y



Z



A W, X and Y

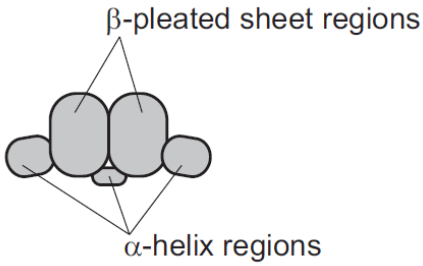
B W, X and Z

C W, Y and Z

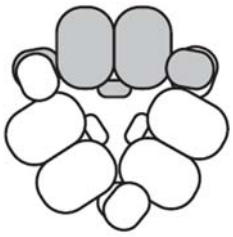
D X, Y and Z

6 Approximately half of the total protein in a pea seed consists of the storage protein vicilin.

- Each molecule of vicilin is made up of three identical polypeptides.
- Each polypeptide is made up of two β-pleated sheet regions with linking α-helix regions, folded into the shape shown to the right.



- This allows the three polypeptides to pack together into a compact, flat storage molecule, as shown below.

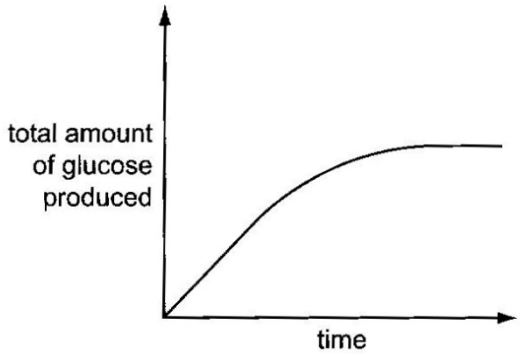


Which row correctly describes the structure of vicilin?

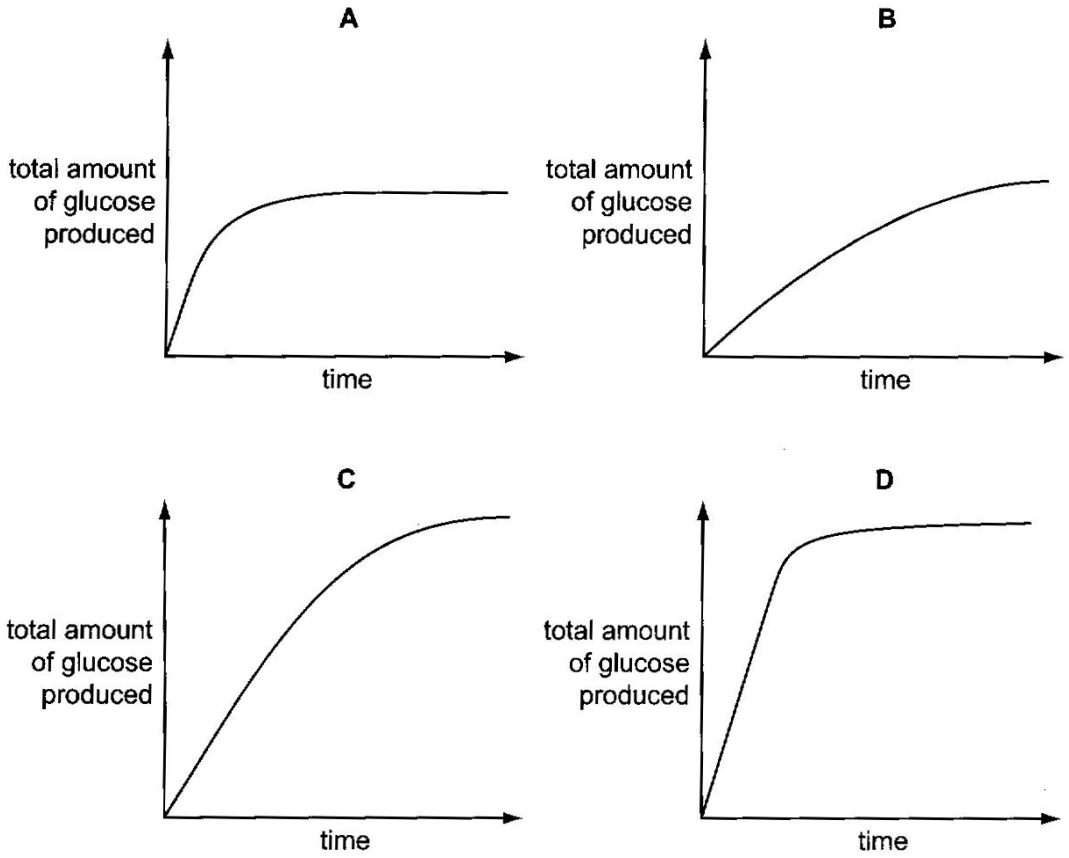
	primary structure	secondary structure	tertiary structure	quaternary structure
A	amino acid sequence of one polypeptide	α-helix and β-pleated sheet regions of each polypeptide	association of three polypeptides	folding of each polypeptide
B	amino acid sequence of one polypeptide	α-helix and β-pleated sheet regions of each polypeptide	folding of each polypeptide	association of three polypeptides
C	association of three polypeptides	amino acid sequence of one polypeptide	α-helix and β-pleated sheet regions of each polypeptide	folding of each polypeptide
D	association of three polypeptides	amino acid sequence of one polypeptide	folding of each polypeptide	α-helix and β-pleated sheet regions of each polypeptide

7 Lactose is a disaccharide present in milk. The enzyme β-galactosidase catalyses the conversion of lactose to glucose and galactose.

10 cm^3 of a 1% β-galactosidase solution was added to 10 cm^3 of milk. The graph shows the total amount of glucose produced over the next ten minutes.



Then, 10 cm^3 of a 2% β-galactosidase solution was added to 10cm^3 of milk. Which graph shows the results that would be obtained?



8 Serine proteases, such as chymotrypsin and trypsin, are enzymes that cleave peptide bonds in proteins. Three specific amino acids (aspartic acid, histidine, serine) arranged in a special alignment, are found conserved in all serine proteases. This conserved alignment is often referred to as "the catalytic triad". At the active site, scientists also found a variable region between different members in this class of enzymes.

Which feature allows different serine proteases to bind to different substrates?

A Different R-group properties of amino acids lining the variable region

B Specific spatial arrangement of aspartic acid, histidine, and serine at the active site

C Presence of a specific cofactor required for catalysis

D Different R-group properties of amino acids in the catalytic triad

9 Some RNA molecules, called ribozymes, can catalyse reactions in a similar way to protein enzymes. Most of these ribozymes have other RNA molecules as their substrates and catalyse reactions that break specific sugar phosphate bonds in the substrate molecules.

Which statements about these ribozymes are correct?

1 Hydrogen, ionic and disulfide bonds will be involved in the ribozyme structure.

2 The active site of a ribozyme is formed from a specific sequence of nucleotides

3 Ribozymes can form because RNA can have a specific secondary and tertiary structure.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

10 What is the role of stem cells with regards to the function of adult tissues and organs?

A Stem cells are fully differentiated cells that reside under the surface of epithelial tissue, in position to take over the function of the tissue when the overlying cells become damaged or worn out

B Stem cells are totipotent cells that divide asymmetrically, giving rise to one daughter cell that remains a stem cell and one daughter cell that will differentiate to replace damaged and worn out cells in the adult tissue or organ.

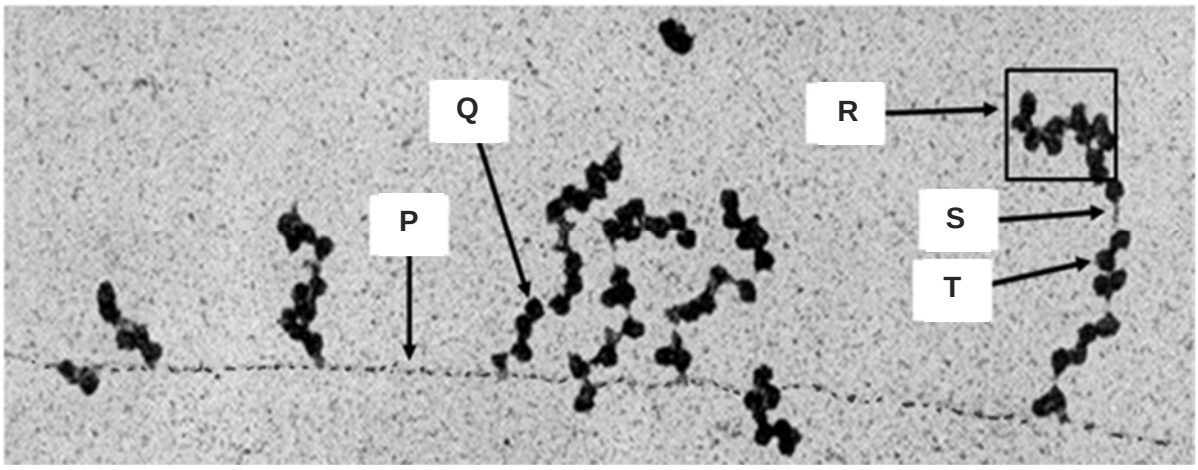
C Stem cells are embryonic cells that persist in the adult, and can give rise to all of the cell types in the body.

D Stem cells are cells that have yet to express the genes and produce proteins characteristic of their differentiated state, but do so when needed for repair of tissues and organs.

11 The table below shows the percentage of nitrogenous base in four samples of nucleic acids. Which base is adenine?

Sample	Bases				
	A	**B**	**C**	**D**	**Uracil**
1	19	31	30	19	Nil
2	27	23	24	26	Nil
3	25	25	Nil	25	25
4	17	32	33	18	Nil

12 The electron micrograph shows 5 structural components **P**, **Q**, **R, S and T** involved in the expression of a particular gene in a prokaryotic cell.



Which of the following statement(s) is / are true?

1 RNA polymerase adds incoming nucleotides to form **P**.

2 The products synthesized by **Q** and **T** are identical.

3 Structure **R** can also be found in eukaryotes.

4 **T** is involved in forming **S**.

A 3 only

B 2 and 3 only

C 1, 2 and 4 only

D All of the above

13 In a genetic engineering experiment, a piece of double-stranded DNA containing 6000 nucleotides is transcribed and translated into a polypeptide consisting of amino acids of fifteen different kinds.

What is the total number of amino acids used and the theoretical minimum number of different tRNA molecules required to translate the mRNA for this peptide?

A 500 amino acids and 20 different tRNA

B 1000 amino acids and 15 different tRNA

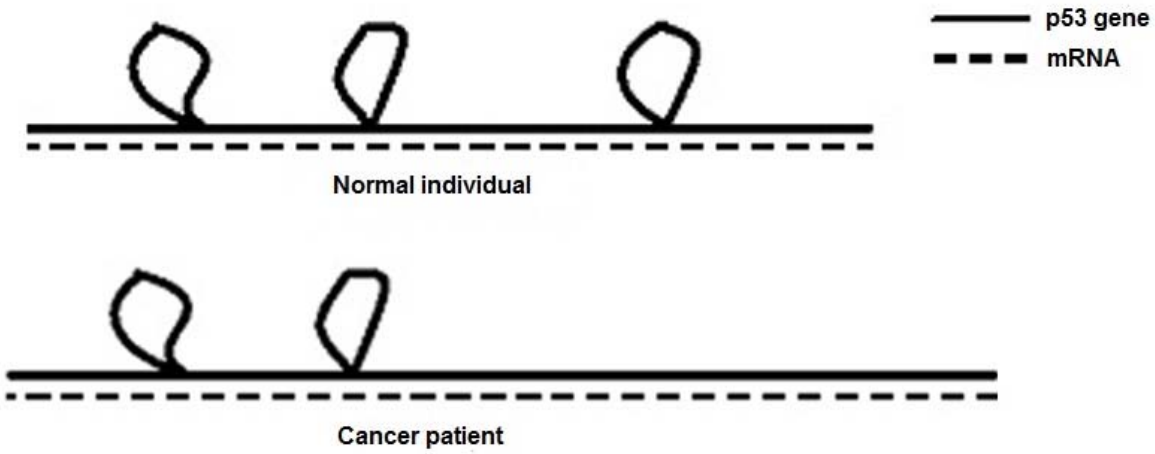
C 2000 amino acids and 20 different tRNA

D 3000 amino acids and 15 different tRNA

14 Which of the following shows the possible effects of a single nucleotide substitution in each of the following locations in a gene, on the production of the protein it codes for?

	Promoter	**Transcription terminator**	**Start codon**	**Stop codon**	**Middle of an intron**
A	No protein product is produced	Protein product is shorter than normal	Protein product is longer than normal	Protein product is normal	Too much protein product is produced
B	Too much protein product is produced	Protein product is normal	No protein product is produced	Protein product is longer than normal	Protein product is normal
C	Protein product is normal	Protein product is longer than normal	Protein product is shorter than normal	Too much protein product is produce	Protein product is longer than normal
D	Protein product is longer than normal	Too much protein product is produced	Protein product is normal	Protein product is shorter than normal	No protein product is produced

15 mRNA was isolated from a normal individual and a patient suffering from cancer. The mRNA was allowed to hybridise with the *p53* gene. The schematic diagram shows the results of the hybridisation process under the electron microscope.



Which of the following could be a possible explanation why the patient is suffering from cancer?

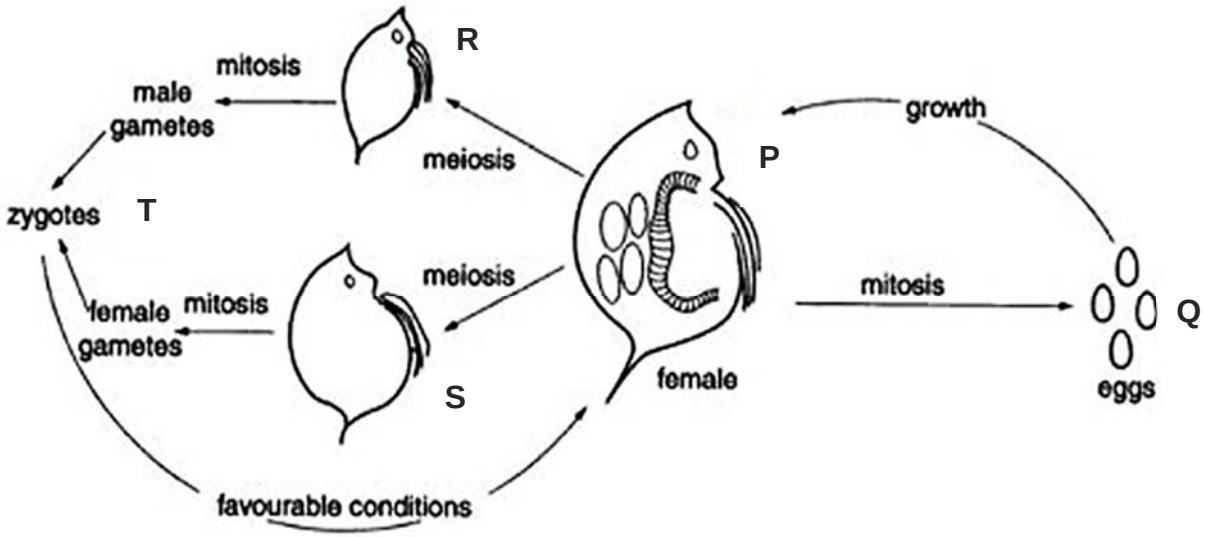
A A point mutation had occurred in the intron leading to the failure to excise one intron, hence leading to a longer dysfunctional protein being translated.

B A point mutation had occurred in the intron leading to an exon being excised, hence leading to a shorter dysfunctional protein being translated.

C A point mutation had occurred leading to the failure of spliceosome to recognise splice sites leading to the excision of the wrong intron, leading to a dysfunctional protein being translated.

D Gene amplification had occurred leading to the multiple copies of a trinucleotide repeat in an intron, hence causing splice site to be misread due to frameshift mutation, leading to a longer dysfunctional protein being translated.

16 The figure shows the life cycle of the water flea, *Daphnia*. The cells of individual **R** contain 10 chromosomes.



Which of the following are correct?

	Individual	Ploidy level	Number of chromosomes	Reason for choice
I	**P**	2n	20	The cells of **P** can undergo both mitosis and meiosis.
II	**Q**	2n	20	**P** produces eggs by mitosis which develop into females.
III	**S**	n	10	The gametic cells of **P** have undergone normal meiosis.
IV	**T**	2n	20	Random fertilisation of haploid gametes from **R** and **S** occurred to form zygote **T**.

A **I** and **II** only

B **I** and **III** only

C **II** and **IV** only

D All of the above

17 The cells of an organism contain six chromosomes, with an average of 18 units of DNA per chromosome.

The table below shows the results of measuring the amount of DNA in the cells of this organism at different stages of meiosis.

Which of the following shows the amount of DNA in the cell during anaphase I?

	Units of DNA per cell
A	36
B	54
C	108
D	216

18 Which pair of statements correctly describes how cellular DNA content and ploidy level change after meiosis I and meiosis II?

A Statement 1: Cellular DNA content is halved after both meiosis I and meiosis II.
Statement 2: Ploidy level changes from diploid to haploid only after meiosis II.

B Statement 1: Cellular DNA content is halved after both meiosis I and meiosis II.
Statement 2: Ploidy level changes from diploid to haploid after meiosis I, and remains haploid after meiosis II.

C Statement 1: Cellular DNA content is halved only after meiosis I.
Statement 2: Ploidy level changes from diploid to haploid only after meiosis II.

D Statement 1: Cellular DNA content is halved only after meiosis I.
Ploidy level changes from diploid to haploid after meiosis I, and remains haploid after meiosis II.

19 The sex chromosome combination XYY is found in a small proportion of men. Such a combination is possible if one contributory gamete to the zygote is

A a sperm produced by a father whose cells lack an X chromosome

B a sperm produced by non-disjunction at meiosis II

C an egg containing an X and a Y chromosome

D an egg produced by non-disjunction at meiosis I

20 A strain of toad has only one nucleolus in the nucleus of each cell instead of the usual two. When toads with one nucleolus per cell are mated, approximately a quarter of the offspring have two nucleoli per nucleus, half have one nucleolus per nucleus and a quarter have no nucleoli.

What is the most likely explanation of these results?

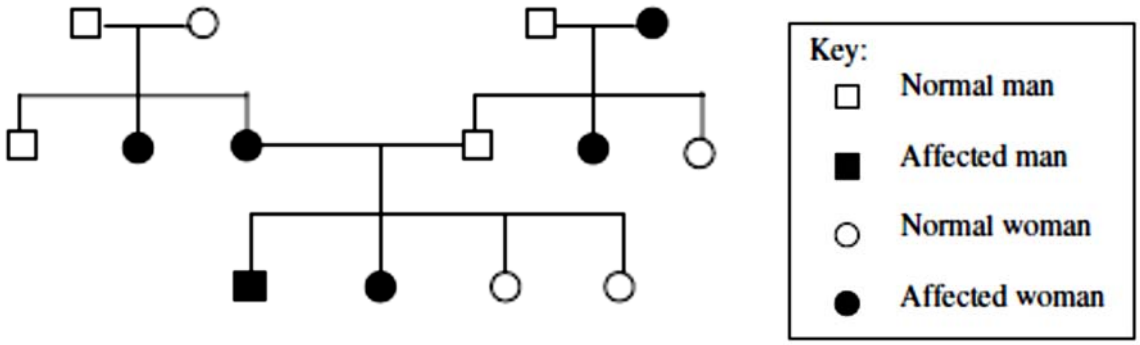
A The possession of one nucleolus is due to autosomal linkage.

B The possession of one nucleolus is due to the heterozygous condition.

C The allele for the presence of two nucleoli is recessive.

D The allele for the presence of two nucleoli is dominant.

21 The family tree shows the inheritance of a skin condition.



What is the genetic basis of the skin condition?

A autosomal dominant

B sex-linked dominant

C autosomal recessive

D sex-linked recessive

22 In birds, sex is determined by a ZW chromosome scheme. Males are ZZ and females are ZW. A recessive lethal allele that causes death of the embryo is sometimes present on the Z chromosome in pigeons. What would be the sex ratio in the offspring of a cross between a male that is heterozygous for the lethal allele and a normal female?

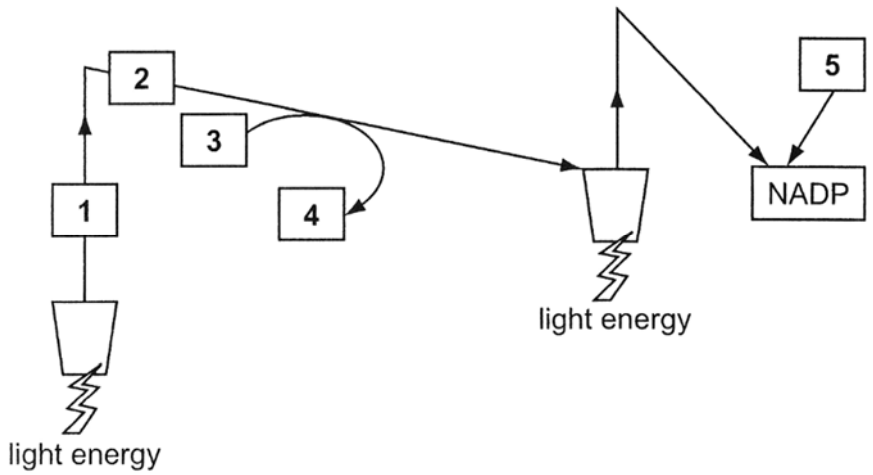
A 2:1 male to female

B 1:2 male to female

C 1:1 male to female

D 3:1 male to female

23 The diagram represents non-cyclic photophosphorylation.



Which reactants would be present at points **1**, **2**, **3**, **4**, and **5**?

	1	2	3	4	5
A	Electrons	Electron carrier	ATP	ADP	Hydrogen molecules
B	Electron carrier	Electrons	ADP	ATP	Electrons
C	Electrons	Electron carrier	ADP	ATP	Hydrogen ions
D	Electron carrier	Electrons	ADP	ATP	Electrons and hydrogen ions

24 Dinitrophenol is a compound that can lodge within the thylakoid membranes of chloroplasts. Its presence provides an alternative route for H^+ ions to diffuse across the thylakoid membranes.

In what way would the Calvin cycle be affected in chloroplasts poisoned with dinitrophenol?

A No effect since Calvin cycle is an enzyme-controlled process.

B The rate of Calvin cycle would increase as pH in the stroma decreases.

C The rate of Calvin cycle would decrease with the accumulation of glycerate-3-phosphate.

D The rate of Calvin cycle would decrease with the accumulation of glyceraldehyde–3-phosphate

25 Six tubes were set up as shown in the table.

tube	contents
1	Glucose + homogenized plant cells
2	Glucose + mitochondria
3	Glucose + cytoplasm lacking organelles
4	Pyruvate + homogenized animal cells
5	Pyruvate + mitochondria
6	Pyruvate + cytoplasm lacking organelles

After incubation, each sample was analysed to determine the presence of carbon dioxide and ethanol.

In which tube(s) is lactate most likely to be present?

A 1 and 3 only

B 2, 3, 5 and 6 only

C 4, 5, and 6 only

D 3 and 6 only

26 Which effect of natural selection is likely to lead to speciation?

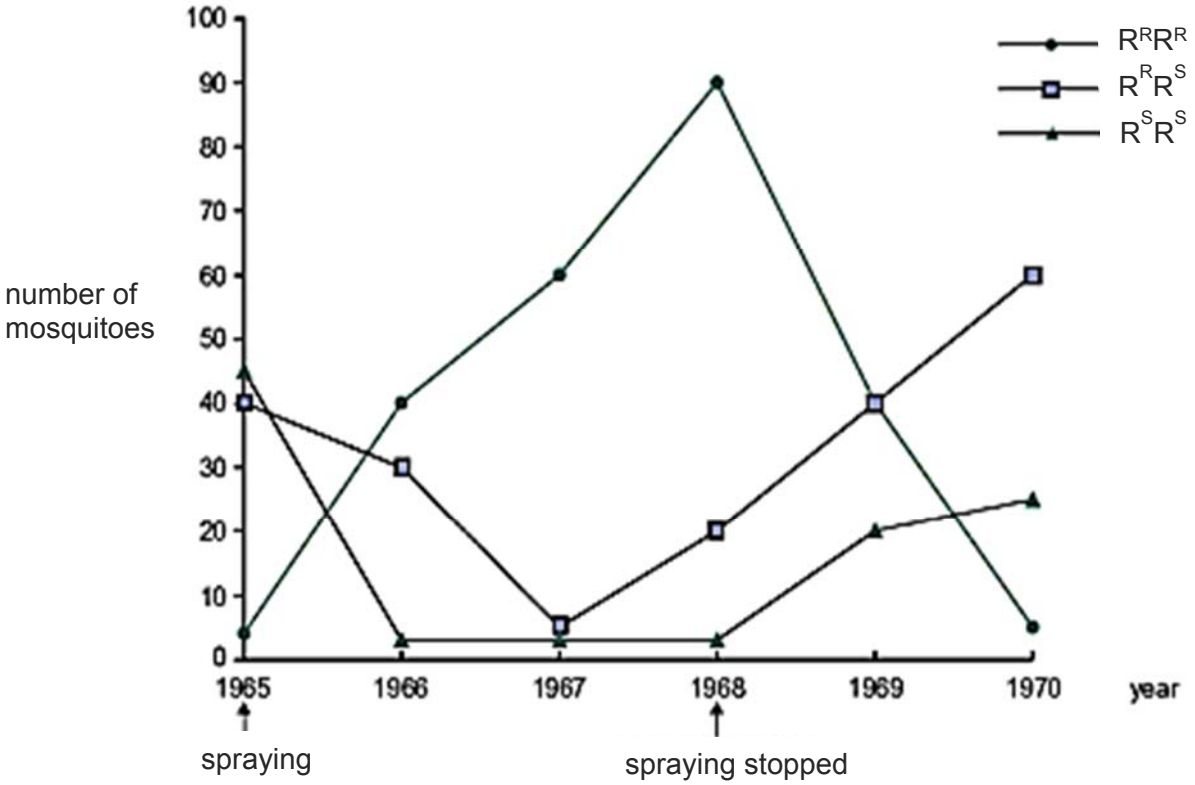
A Differences between populations are increased.

B Favourable genotypes are maintained in the population.

C Genetic diversity is reduced.

D Selection pressure on some alleles reduces reproductive success.

27 In the mosquito, there is a gene locus which has two alleles, R^R and R^s, involved in resistance to the insecticide DDT. R^R represents the allele for DDT resistance and R^s represents the allele for DDT sensitivity. The graph shows the number of mosquitoes of three genotypes collected from 1965, when DDT was first used, through to 1970, two years after the spraying of DDT stopped.



From the data, it is possible to conclude that

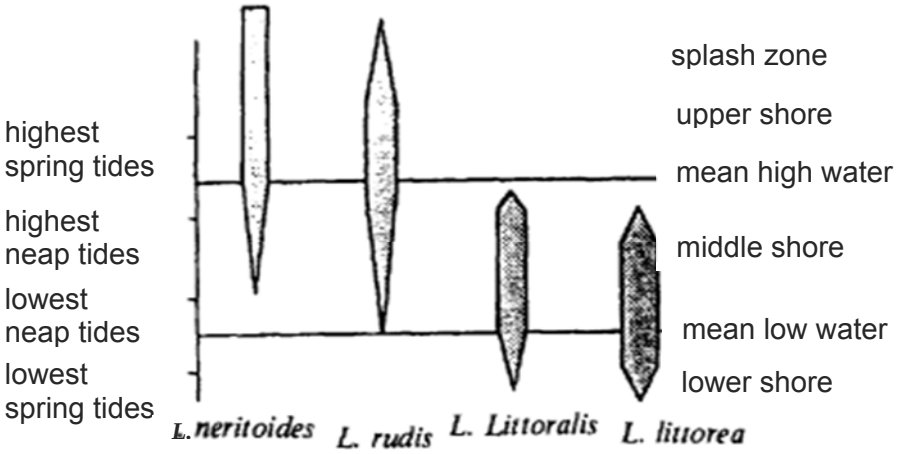
A the frequency of the R^S allele is greater than the frequency of the R^R allele in 1968.

B many generations after the removal of DDT, the R^R allele would disappear from the population.

C after removal of DDT from the environment in 1968, having the R^RR^R genotype reduces the chance of survival.

D in the presence of DDT in the environment between 1967 and 1968, mosquitoes with the R^RR^S genotype are most likely to survive.

28 The diagram below shows the frequency and distribution of four *Littorina* species on a rocky shore. All feed in a snail-like manner by grazing on algae.



spring tide: Refers to the 'springing forth' of the tide during new and full moon

neap tide: Happens seven days after a spring tide. Refers to a period of moderate tides when the sun and moon are at right angles to each other

Which one of the following factors could **not** directly contribute to this distribution pattern?

A Variation in the tolerance of each species to desiccation

B Competition between species for different feeding niches

C The photoperiod and seasonal change in day length

D The differential selection of Littorina by predators

29 Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperm, and they selectively kill developing male embryos.

In Samoa in the 1960s, the proportion of male blue moon butterflies fell to less than 1% of the population. However, by 2006, the proportion of males was almost 50% of the population.

Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

1 *Wolbachia* acts as a selective agent.

2 The selective killing of male embryos is an example of artificial selection.

3 When infected with *Wolbachia*, male embryos that are homozygous for the recessive allele of the suppressor gene die.

4 All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.

5 The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

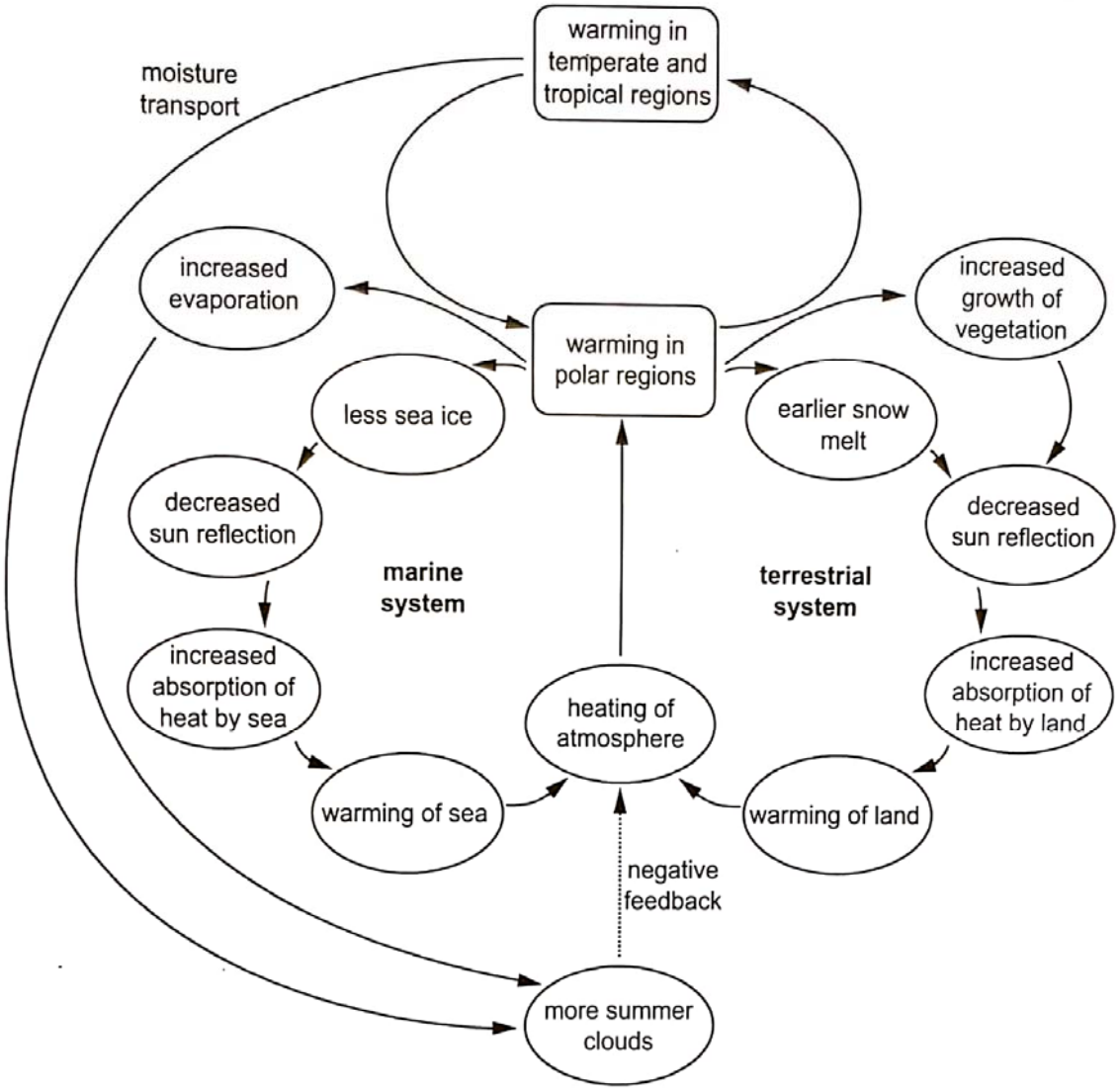
A 1 and 4 only

B 2 and 3 only

C 1, 3 and 5

D 2, 4 and 5

30 The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.



Which effect of higher temperatures in the polar regions could increase global warming?

A Melting of ice and snow results in less reflection of sunlight and more heat absorption by the Earth.

B Increased evaporation leads to more rainfall, which absorbs heat from the land and the sea.

C Melting sea ice causes more cloud formation, which increases absorption of heat in the atmosphere.

D Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.

H

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CANDIDATE NAME ANSWER

CLASS

BIOLOGY

8876/01

Paper 1 Multiple Choice

26 June 2018

1 hour

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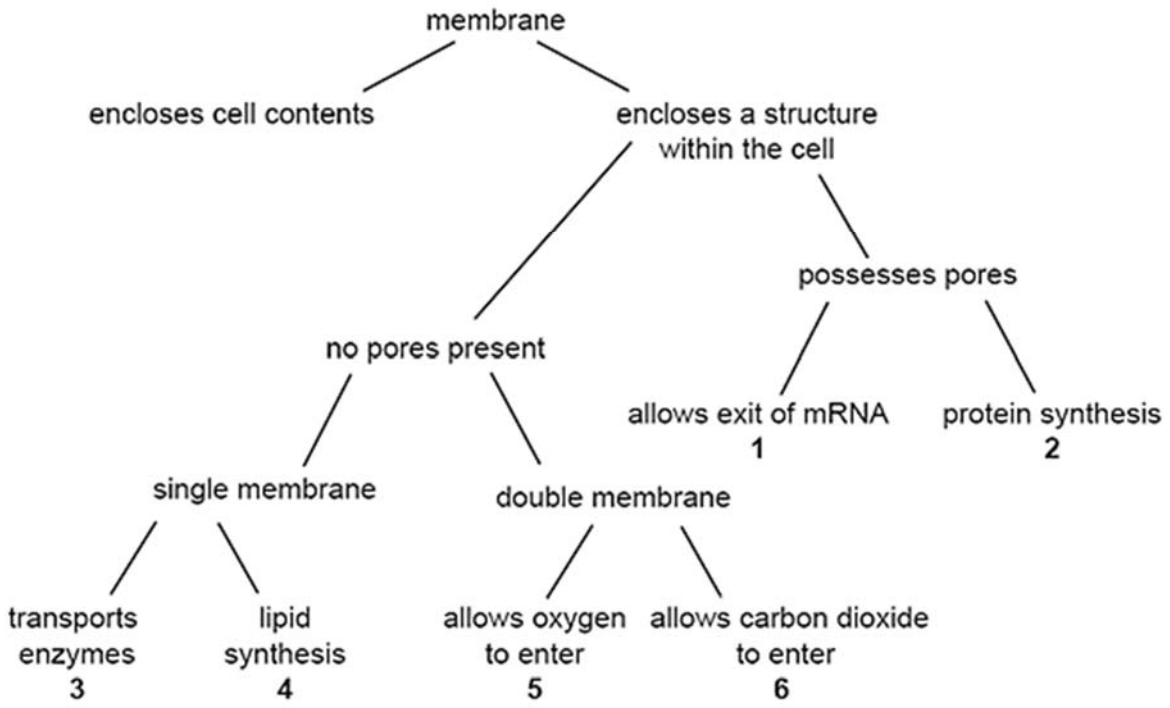

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D	nucleus	smooth ER	mitochondrion	rough ER	vesicle	chloroplast

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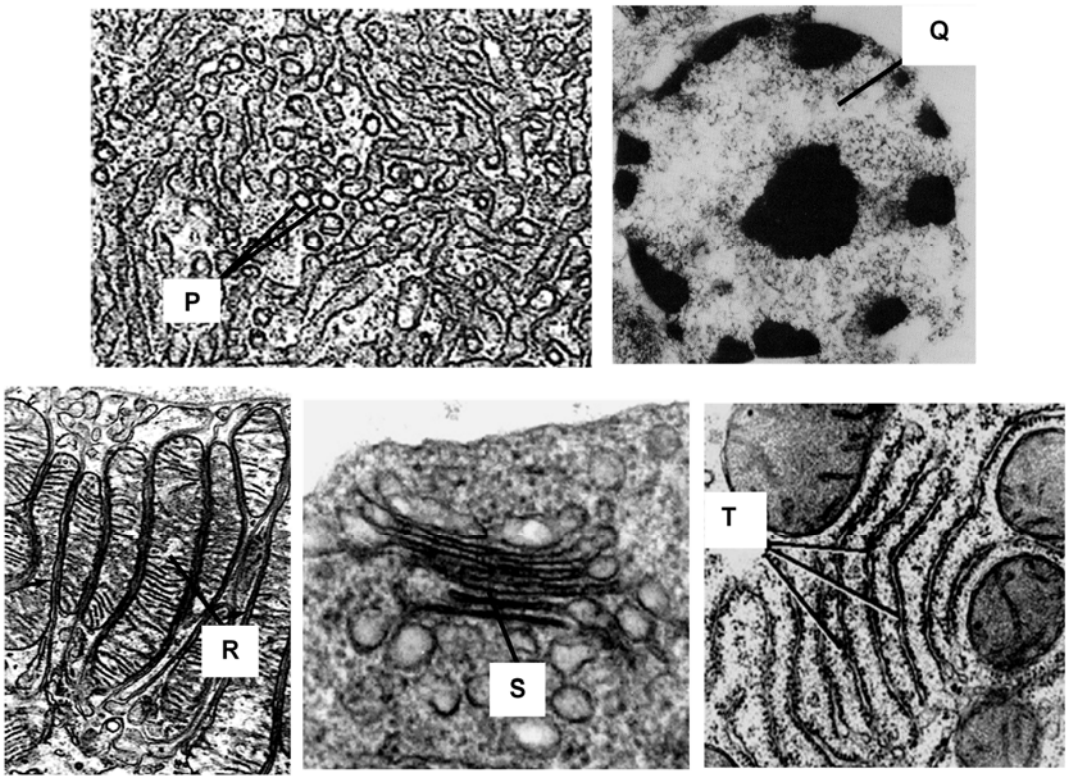

Radioactive amino acids are supplied to the liver cell to synthesise insulin receptors.

Which sequence shows the correct order in which these amino acids would be detected in the organelles during the synthesis of insulin receptors?

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Which statement provides evidence that mitochondria and chloroplasts are endosymbionts?

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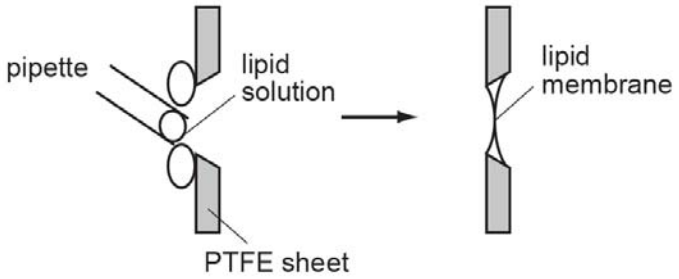
D They contain their own ribosomes.

4 Lipid membranes can be formed in the laboratory by painting phospholipids over a PTFE sheet with a hole in it.



Such a lipid membrane is impermeable to water soluble materials including charged ions such as Na^+ or K^+.

In one experiment with Na^+ ions, no current flowed across the membrane until a substance called gramicidin was added to the membrane, at which time current flowed.

What kind of molecule is gramicidin?

A A carbohydrate molecule found only on the outside of the membrane.

B A non-polar lipid which passes all the way through the membrane.

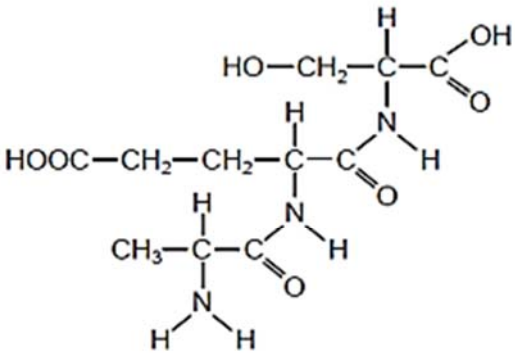
C A protein molecule with both hydrophilic and hydrophobic regions.

D A protein molecule which has only hydrophobic regions.

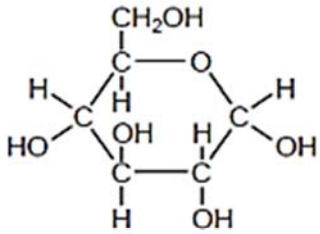
5 Samples of a mixture of biological molecules were tested using Benedict's reagent, biuret solution and ethanol. After testing, the solutions were blue with Benedict's reagent, purple with biuret solution and cloudy with ethanol emulsion test.

Which molecules could the mixture contain?

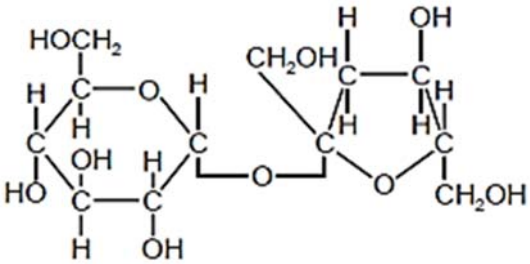
W



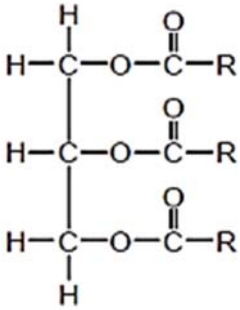
X



Y



Z



A W, X and Y

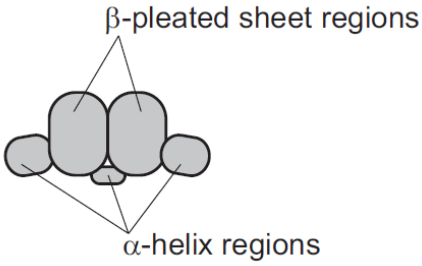
B W, X and Z

C W, Y and Z

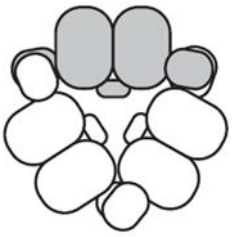
D X, Y and Z

6 Approximately half of the total protein in a pea seed consists of the storage protein vicilin.

- Each molecule of vicilin is made up of three identical polypeptides.
- Each polypeptide is made up of two β-pleated sheet regions with linking α-helix regions, folded into the shape shown to the right.



- This allows the three polypeptides to pack together into a compact, flat storage molecule, as shown below.

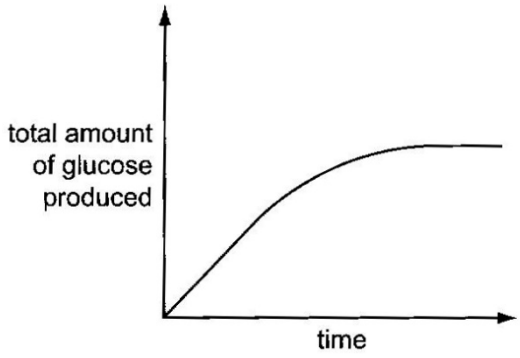


Which row correctly describes the structure of vicilin?

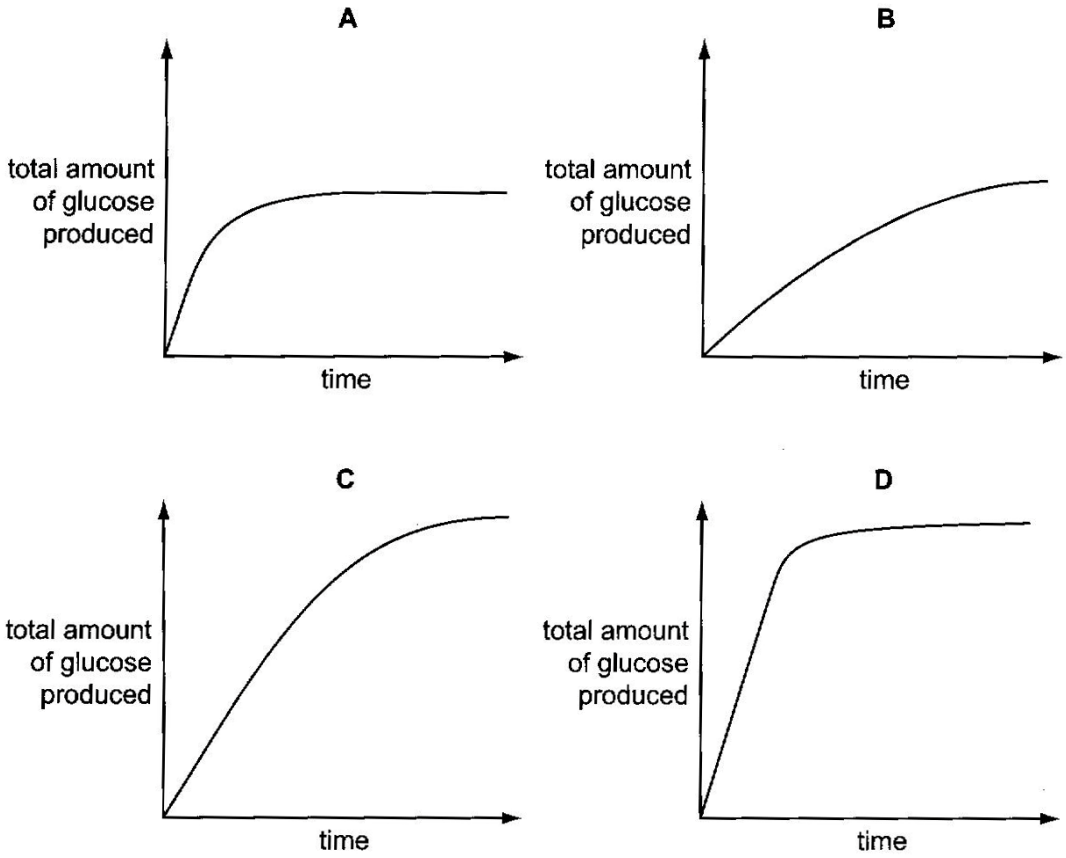
	primary structure	secondary structure	tertiary structure	quaternary structure
A	amino acid sequence of one polypeptide	α-helix and β-pleated sheet regions of each polypeptide	association of three polypeptides	folding of each polypeptide
B	amino acid sequence of one polypeptide	α-helix and β-pleated sheet regions of each polypeptide	folding of each polypeptide	association of three polypeptides
C	association of three polypeptides	amino acid sequence of one polypeptide	α-helix and β-pleated sheet regions of each polypeptide	folding of each polypeptide
D	association of three polypeptides	amino acid sequence of one polypeptide	folding of each polypeptide	α-helix and β-pleated sheet regions of each polypeptide

7 Lactose is a disaccharide present in milk. The enzyme β-galactosidase catalyses the conversion of lactose to glucose and galactose.

10 cm^3 of a 1% β-galactosidase solution was added to 10 cm^3 of milk. The graph shows the total amount of glucose produced over the next ten minutes.



Then, 10 cm^3 of a 2% β-galactosidase solution was added to 10cm^3 of milk. Which graph shows the results that would be obtained? AAAAAAAAAAAAAAAAAAAAAAA



8 Serine proteases, such as chymotrypsin and trypsin, are enzymes that cleave peptide bonds in proteins. Three specific amino acids (aspartic acid, histidine, serine) arranged in a special alignment, are found conserved in all serine proteases. This conserved alignment is often referred to as "the catalytic triad". At the active site, scientists also found a variable region between different members in this class of enzymes.

Which feature allows different serine proteases to bind to different substrates?

A Different R-group properties of amino acids lining the variable region

B Specific spatial arrangement of aspartic acid, histidine, and serine at the active site

C Presence of a specific cofactor required for catalysis

D Different R-group properties of amino acids in the catalytic triad

9 Some RNA molecules, called ribozymes, can catalyse reactions in a similar way to protein enzymes. Most of these ribozymes have other RNA molecules as their substrates and catalyse reactions that break specific sugar phosphate bonds in the substrate molecules.

Which statements about these ribozymes are correct?

- Hydrogen, ionic and disulfide bonds will be involved in the ribozyme structure.
- The active site of a ribozyme is formed from a specific sequence of nucleotides
- Ribozymes can form because RNA can have a specific secondary and tertiary structure.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

10 What is the role of stem cells with regards to the function of adult tissues and organs?

A Stem cells are fully differentiated cells that reside under the surface of epithelial tissue, in position to take over the function of the tissue when the overlying cells become damaged or worn out

B Stem cells are totipotent cells that divide asymmetrically, giving rise to one daughter cell that remains a stem cell and one daughter cell that will differentiate to replace damaged and worn out cells in the adult tissue or organ.

C Stem cells are embryonic cells that persist in the adult, and can give rise to all of the cell types in the body.

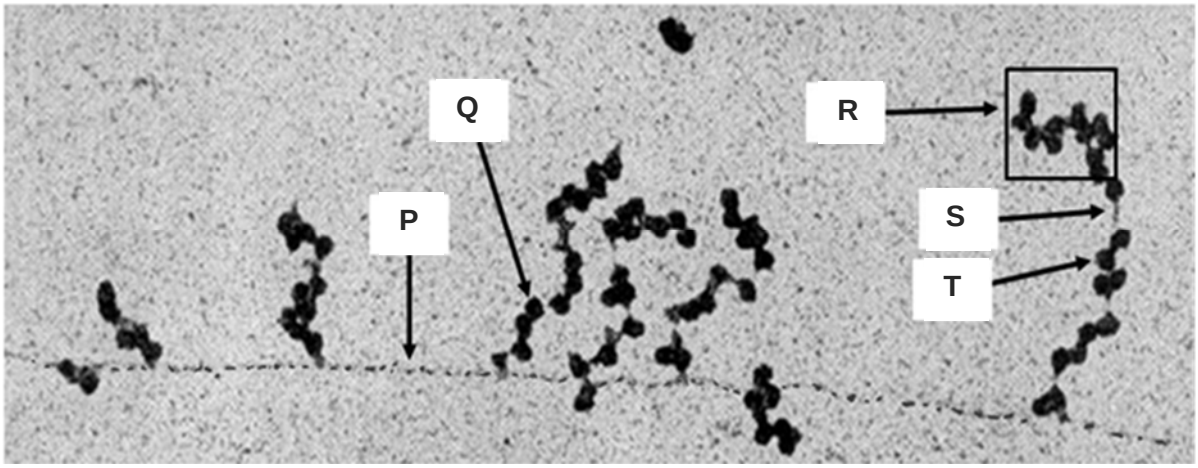
D Stem cells are cells that have yet to express the genes and produce proteins characteristic of their differentiated state, but do so when needed for repair of tissues and organs.

11 The table shows the percentage of nitrogenous base in four samples of nucleic acids.

Sample	Bases				
	A	**B**	**C**	**D**	**Uracil**
1	19	31	30	19	Nil
2	27	23	24	26	Nil
3	25	25	Nil	25	25
4	17	32	33	18	Nil

Which base is adenine? **BBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBB**

12 The electron micrograph shows 5 structural components **P**, **Q**, **R, S and T** involved in the expression of a particular gene in a prokaryotic cell.



Which of the following statement(s) is / are true?

- RNA polymerase adds incoming nucleotides to form **P**.
- The products synthesized by **Q** and **T** are identical.
- Structure **R** can also be found in eukaryotes.
- **T** is involved in forming **S**.

A 3 only

B 2 and 3 only

C 1, 2 and 4 only

D All of the above

13 In a genetic engineering experiment a piece of double-stranded DNA containing 6000 nucleotides is transcribed and translated into a polypeptide consisting of amino acids of fifteen different kinds.

What is the total number of amino acids used and the theoretical minimum number of different tRNA molecules required to translate the mRNA for this peptide?

A 500 amino acids and 20 different tRNA

B 1000 amino acids and 15 different tRNA

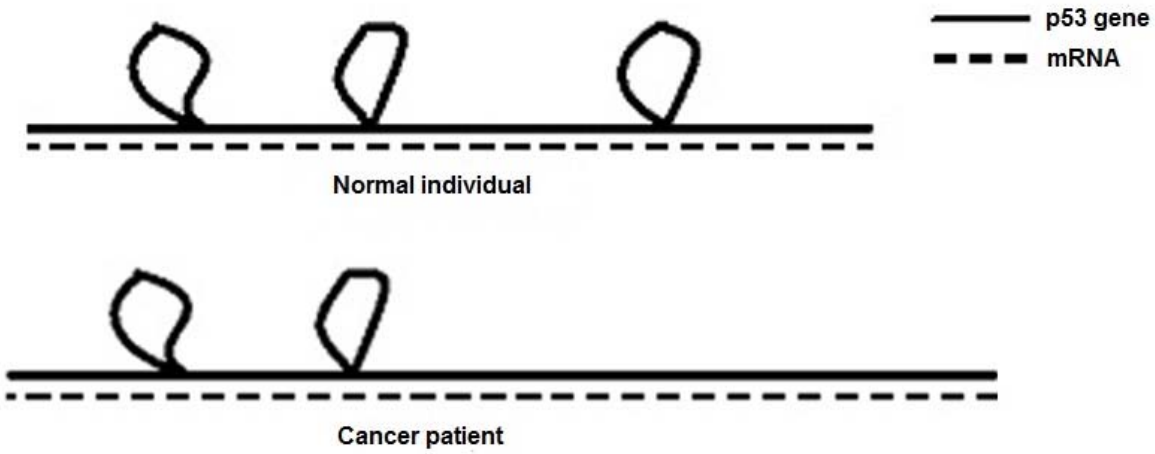
C 2000 amino acids and 20 different tRNA

D 3000 amino acids and 15 different tRNA

14 Which of the following shows the possible effects of a single nucleotide substitution in each of the following locations in a gene on the production of the protein it codes for?

	Promoter	**Transcription terminator**	**Start codon**	**Stop codon**	**Middle of an intron**
A	No protein product is produced	Protein product is shorter than normal	Protein product is longer than normal	Protein product is normal	Too much protein product is produced
B	Too much protein product is produced	Protein product is normal	No protein product is produced	Protein product is longer than normal	Protein product is normal
C	Protein product is normal	Protein product is longer than normal	Protein product is shorter than normal	Too much protein product is produce	Protein product is longer than normal
D	Protein product is longer than normal	Too much protein product is produced	Protein product is normal	Protein product is shorter than normal	No protein product is produced

15 mRNA was isolated from a normal individual and a patient suffering from cancer. The mRNA was allowed to hybridise with the *p53* gene. The schematic diagram shows the results of the hybridisation process under the electron microscope.



Which of the following could be a possible explanation why the patient is suffering from cancer?

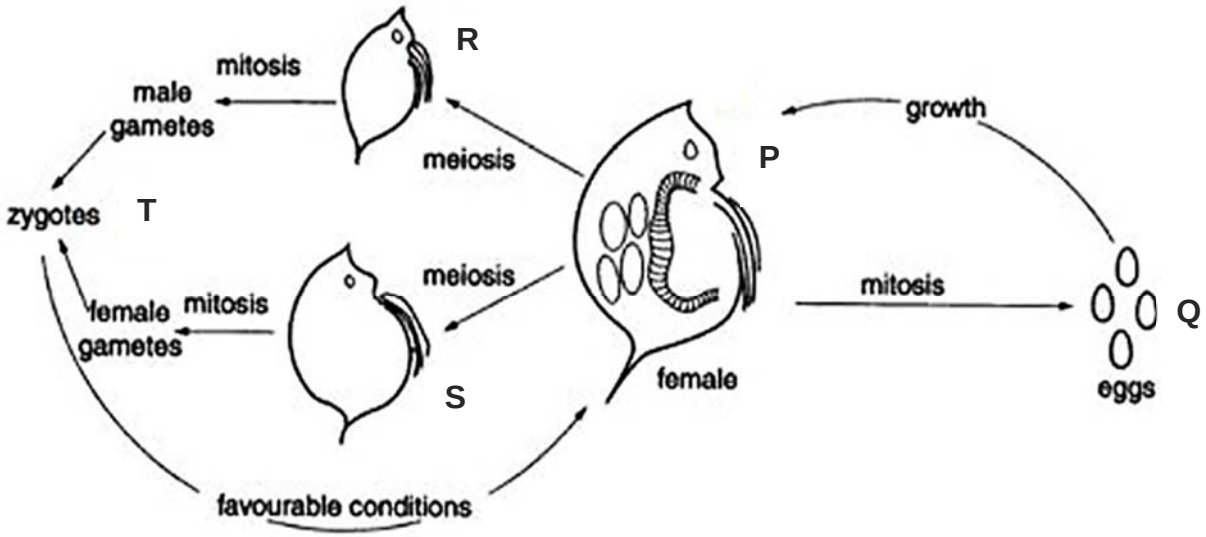
A A point mutation had occurred in the intron leading to the failure to excise one intron, hence leading to a longer dysfunctional protein being translated.

B A point mutation had occurred in the intron leading to an exon being excised, hence leading to a shorter dysfunctional protein being translated.

C A point mutation had occurred leading to the failure of spliceosome to recognise splice sites leading to the excision of the wrong intron, leading to a dysfunctional protein being translated.

D Gene amplification had occurred leading to the multiple copies of a trinucleotide repeat in an intron, hence causing splice site to be misread due to frameshift mutation, leading to a longer dysfunctional protein being translated.

16 The figure shows the life cycle of the water flea, *Daphnia*. The cells of individual **R** contain 10 chromosomes.



Which of the following are correct?

	Individual	Ploidy level	Number of chromosomes	Reason for choice
I	**P**	2n	20	The cells of **P** can undergo both mitosis and meiosis.
II	**Q**	2n	20	**P** produces eggs by mitosis which develop into females.
III	**S**	n	10	The gametic cells of **P** have undergone normal meiosis.
IV	**T**	2n	20	Random fertilisation of haploid gametes from **R** and **S** occurred to form zygote **T**.

A **I** and **II** only

B **I** and **III** only

C **II** and **IV** only

D All of the above

17 The cells of an organism contain six chromosomes, with an average of 18 units of DNA per chromosome.

The table below shows the results of measuring the amount of DNA in the cells of this organism at different stages of meiosis.

Which of the following shows the amount of DNA in the cell during anaphase I?

	Units of DNA per cell
A	36
B	54
C	108
D	216

18 Which pair of statements correctly describes how cellular DNA content and ploidy level change after meiosis I and meiosis II?

A Cellular DNA content is halved after both meiosis I and meiosis II.
Ploidy level changes from diploid to haploid only after meiosis II.

B Cellular DNA content is halved after both meiosis I and meiosis II.
Ploidy level changes from diploid to haploid after meiosis I, and remains haploid after meiosis II.

C Cellular DNA content is halved only after meiosis I.
Ploidy level changes from diploid to haploid only after meiosis II.

D Cellular DNA content is halved only after meiosis I.
Ploidy level changes from diploid to haploid after meiosis I, and remains haploid after meiosis II.

19 The sex chromosome combination XYY is found in a small proportion of men. Such a combination is possible if one contributory gamete to the zygote is

A a sperm produced by a father whose cells lack an X chromosome

B a sperm produced by non-disjunction at meiosis II

C an egg containing an X and a Y chromosome

D an egg produced by non-disjunction at meiosis I

20 A strain of toad has only one nucleolus in the nucleus of each cell instead of the usual two. When toads with one nucleolus per cell are mated, approximately a quarter of the offspring have two nucleoli per nucleus, half have one nucleolus per nucleus and a quarter have no nucleoli.

What is the most likely explanation of these results?

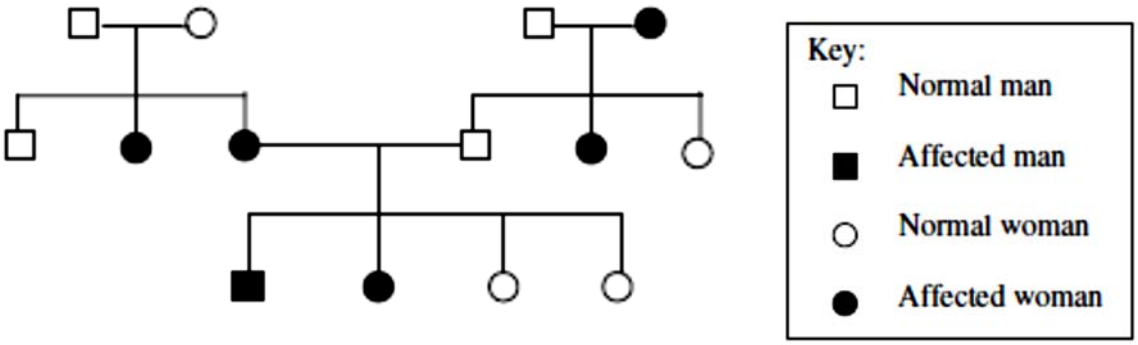
A The possession of one nucleolus is due to autosomal linkage.

B The possession of one nucleolus is due to the heterozygous condition.

C The allele for the presence of two nucleoli is recessive.

D The allele for the presence of two nucleoli is dominant.

21 The family tree shows the inheritance of a skin condition.



What is the genetic basis of the skin condition?

A autosomal dominant

B sex-linked dominant

C autosomal recessive

D sex-linked recessive

22 In birds, sex is determined by a ZW chromosome scheme. Males are ZZ and females are ZW. A recessive lethal allele that causes death of the embryo is sometimes present on the Z chromosome in pigeons. What would be the sex ratio in the offspring of a cross between a male that is heterozygous for the lethal allele and a normal female?

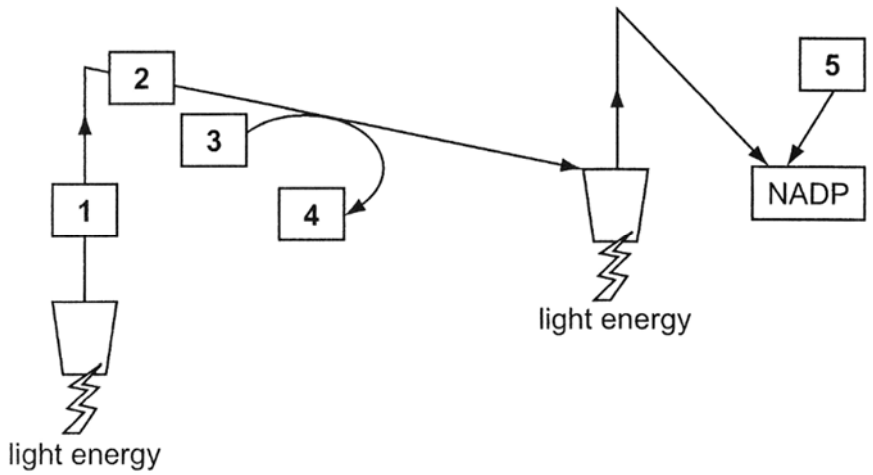
A 2:1 male to female

B 1:2 male to female

C 1:1 male to female

D 3:1 male to female

23 The diagram represents non-cyclic photophosphorylation.



Which reactants would be present at points **1**, **2**, **3**, **4**, and **5**?

	1	2	3	4	5
A	Electrons	Electron carrier	ATP	ADP	Hydrogen molecules
B	Electron carrier	Electrons	ADP	ATP	Electrons
C	Electrons	Electron carrier	ADP	ATP	Hydrogen ions
D	Electron carrier	Electrons	ADP	ATP	Electrons and hydrogen ions

24 Dinitrophenol is a compound that can lodge within the thylakoid membranes of chloroplasts. Its presence provides an alternative route for H^+ ions to diffuse across the thylakoid membranes.

In what way would the Calvin cycle be affected in chloroplasts poisoned with dinitrophenol?

A No effect since Calvin cycle is an enzyme-controlled process.

B The rate of Calvin cycle would increase as pH in the stroma decreases.

C The rate of Calvin cycle would decrease with the accumulation of glycerate-3-phosphate.

D The rate of Calvin cycle would decrease with the accumulation of glyceraldehyde–3-phosphate

25 Six tubes were set up as shown in the table.

tube	contents
1	Glucose + homogenized plant cells
2	Glucose + mitochondria
3	Glucose + cytoplasm lacking organelles
4	Pyruvate + homogenized animal cells
5	Pyruvate + mitochondria
6	Pyruvate + cytoplasm lacking organelles

After incubation, each sample was analysed to determine the presence of carbon dioxide and ethanol.

In which tube(s) is lactate most likely to be present?

A 1 and 3 only

B 2, 3, 5 and 6 only

C 4, 5, and 6 only

D 3 and 6 only

26 Which effect of natural selection is likely to lead to speciation?

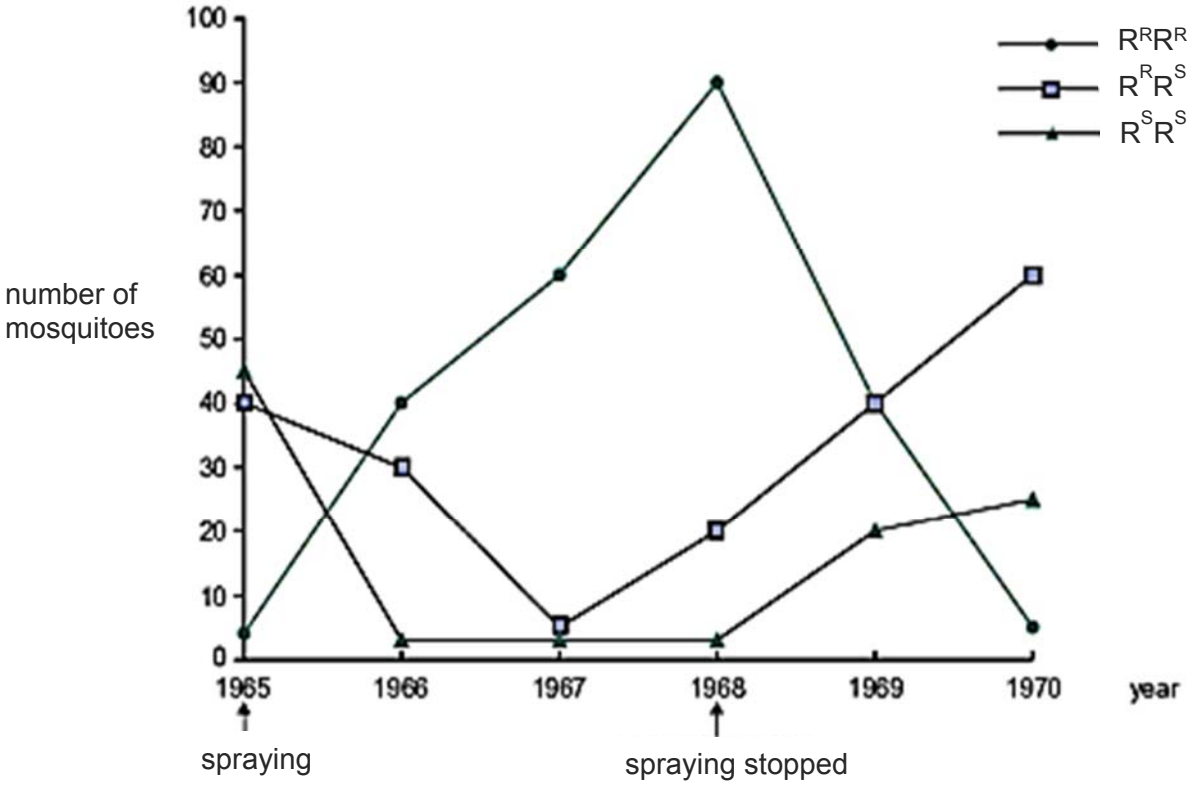
A Differences between populations are increased.

B Favourable genotypes are maintained in the population.

C Genetic diversity is reduced.

D Selection pressure on some alleles reduces reproductive success.

27 In the mosquito, there is a gene locus which has two alleles, R^R and R^s, involved in resistance to the insecticide DDT. R^R represents the allele for DDT resistance and R^s represents the allele for DDT sensitivity. The graph shows the number of mosquitoes of three genotypes collected from 1965, when DDT was first used, through to 1970, two years after the spraying of DDT stopped.



From the data, it is possible to conclude that

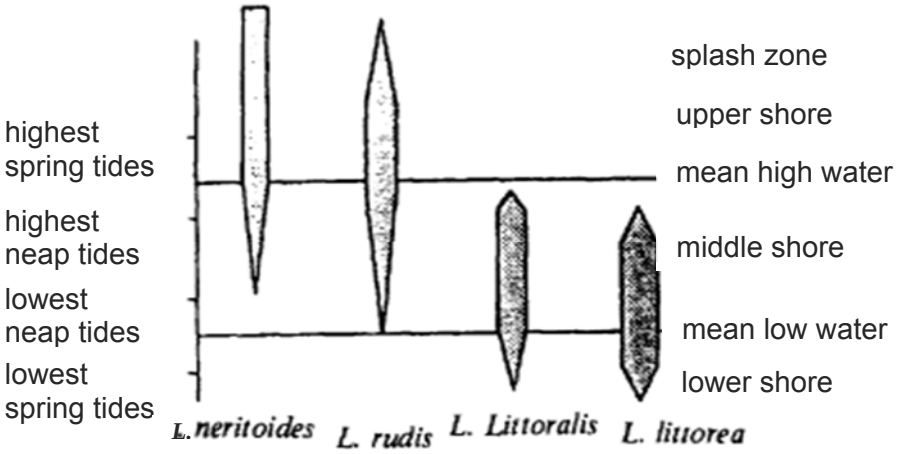
A the frequency of the R^S allele is greater than the frequency of the R^R allele in 1968.

B many generations after the removal of DDT, the R^R allele would disappear from the population.

C after removal of DDT from the environment in 1968, having the R^RR^R genotype reduces the chance of survival.

D in the presence of DDT in the environment between 1967 and 1968, mosquitoes with the R^RR^S genotype are most likely to survive.

28 The diagram below shows the frequency and distribution of four *Littorina* species on a rocky shore. All feed in a snail-like manner by grazing on algae.



spring tide: refers to the 'springing forth' of the tide during new and full moon

neap tide: Happens seven days after a spring tide. Refers to a period of moderate tides when the sun and moon are at right angles to each other

Which one of the following factors could **not** directly contribute to this distribution pattern?

A Variation in the tolerance of each species to desiccation

B Competition between species for different feeding niches

C The photoperiod and seasonal change in day length

D The differential selection of Littorina by predators

29 Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperm, and they selectively kill developing male embryos.

In Samoa in the 1960s, the proportion of male blue moon butterflies fell to less than 1% of the population. However, by 2006, the proportion of males was almost 50% of the population.

Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

1 *Wolbachia* acts as a selective agent.

2 The selective killing of male embryos is an example of artificial selection.

3 When infected with *Wolbachia*, male embryos that are homozygous for the recessive allele of the suppressor gene die.

4 All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.

5 The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

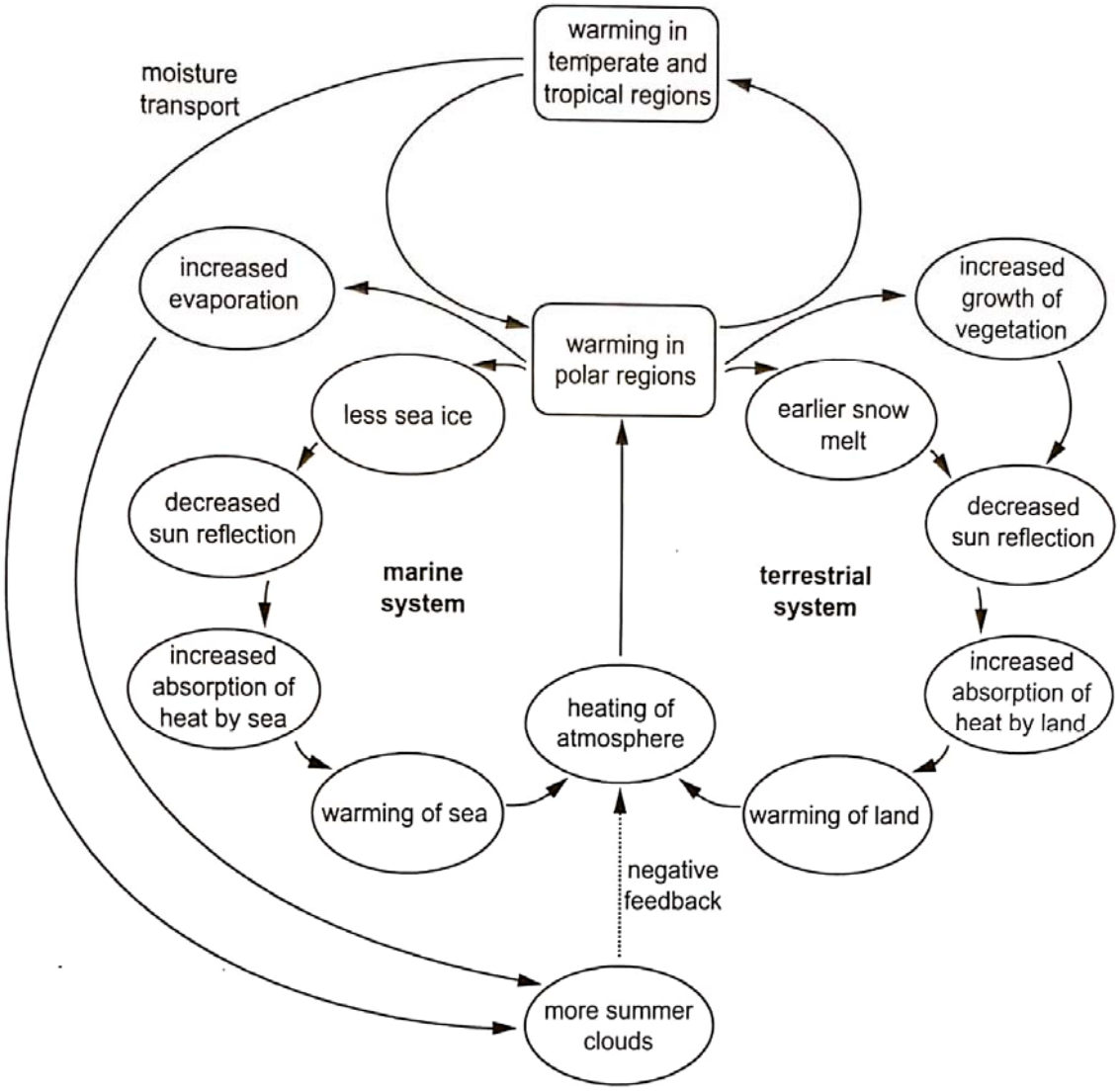
A 1 and 4 only

B 2 and 3 only

C 1, 3 and 5

D 2, 4 and 5

30 The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.



Which effect of higher temperatures in the polar regions could increase global warming?

A Melting of ice and snow results in less reflection of sunlight and more heat absorption by the Earth.

B Increased evaporation leads to more rainfall, which absorbs heat from the land and the sea.

C Melting sea ice causes more cloud formation, which increases absorption of heat in the atmosphere.

D Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.

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.

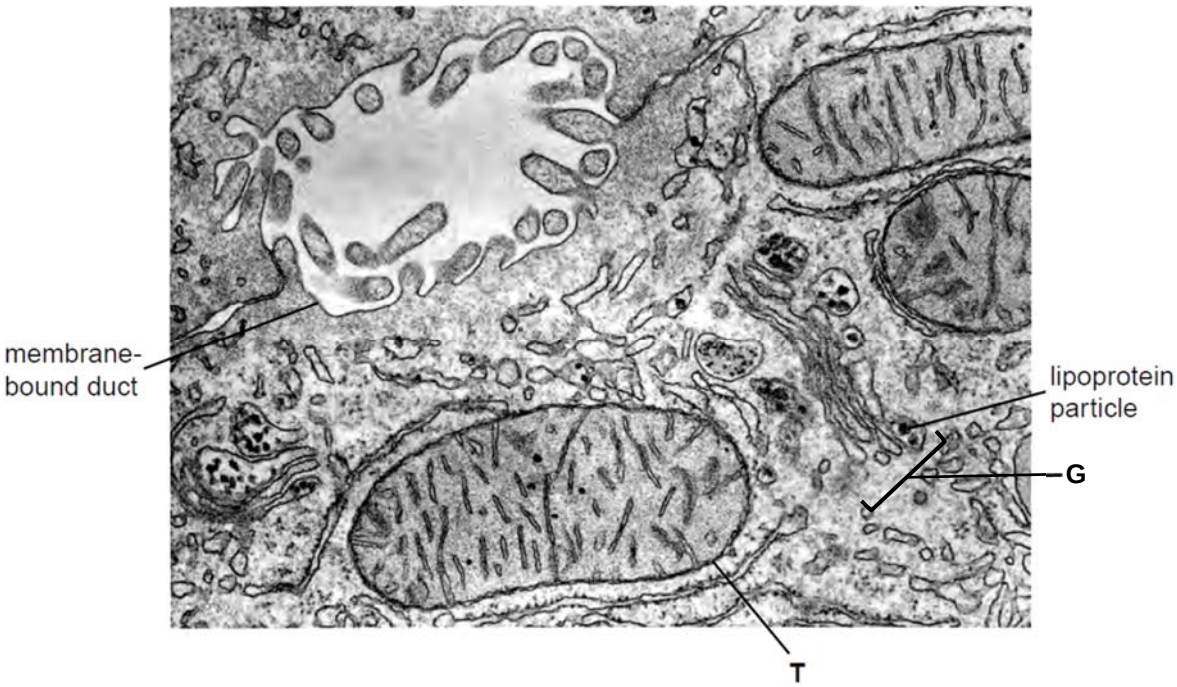


Fig. 1.1

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

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[2]

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

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[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.

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[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.

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[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).

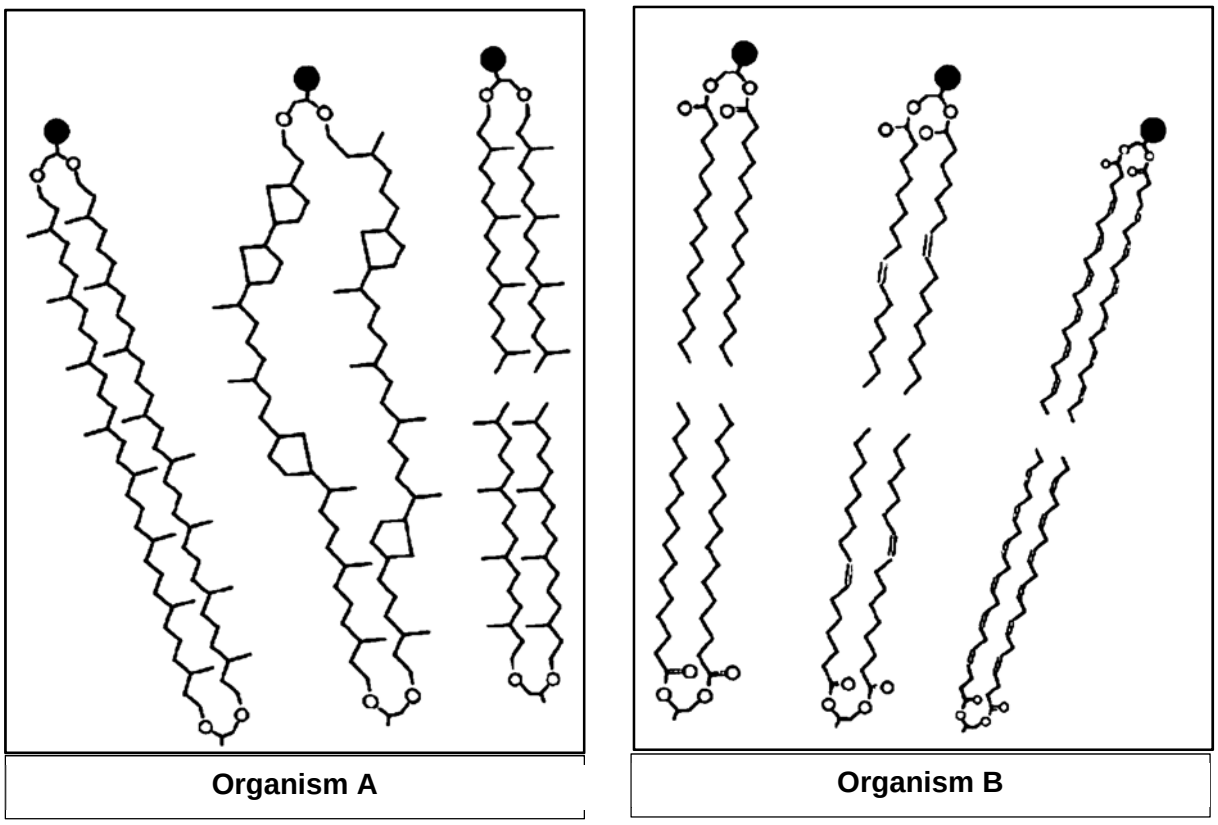

Fig. 1.2

(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.

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[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.

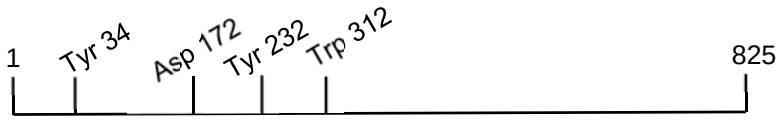

Fig. 2.1

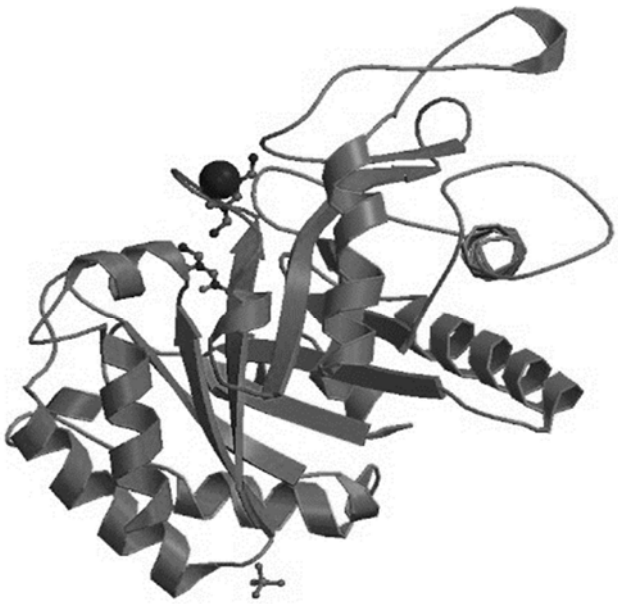

Fig. 2.2

(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.

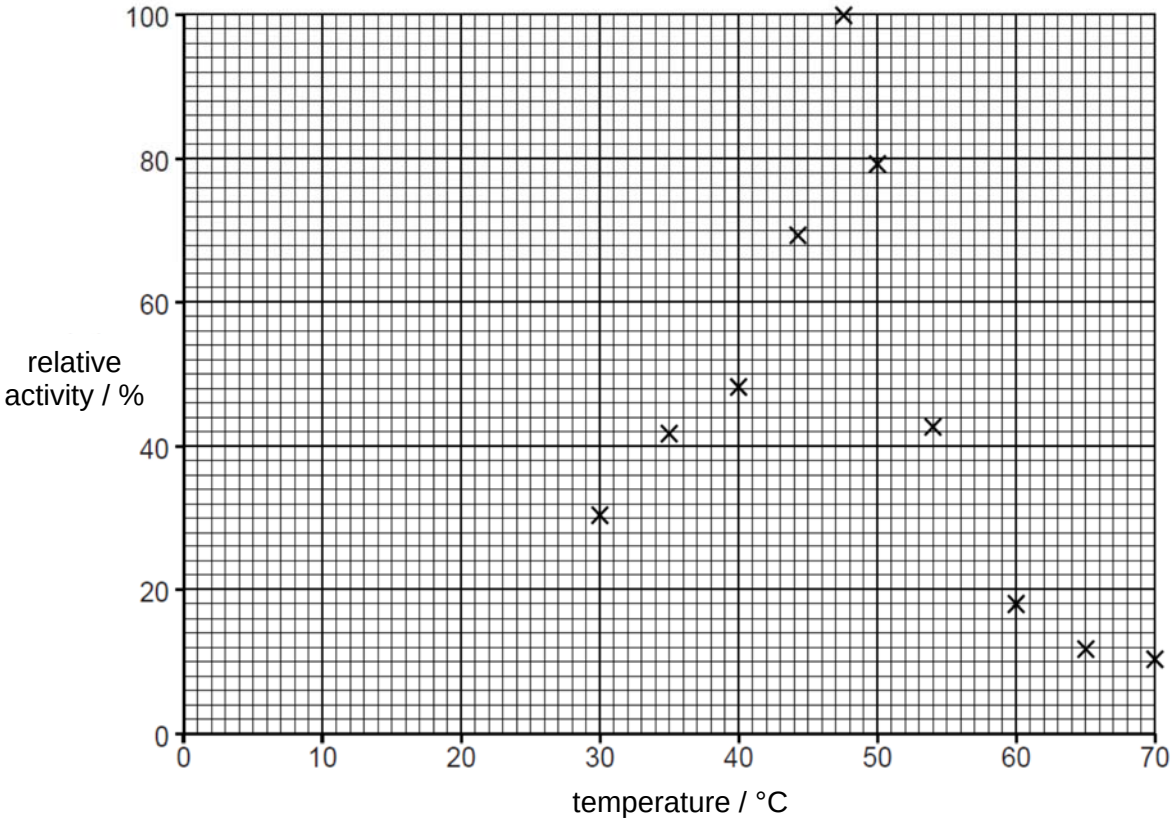

Fig. 2.3

(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.

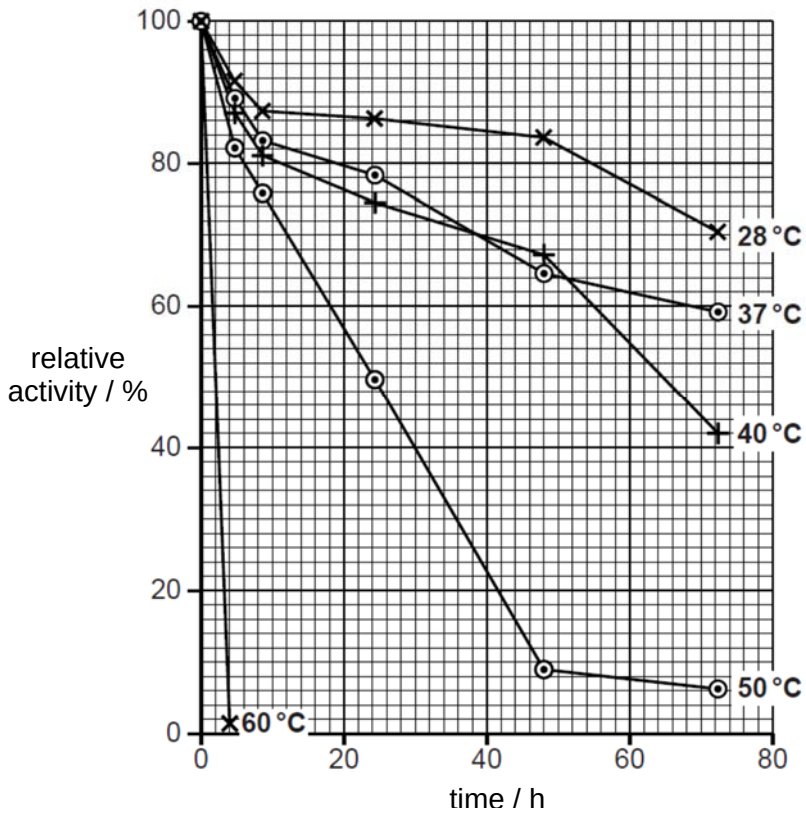

Fig. 2.4

(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.

.....

.....

.....

..... [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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..... [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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.....

.....

..... [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.

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.....
[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.

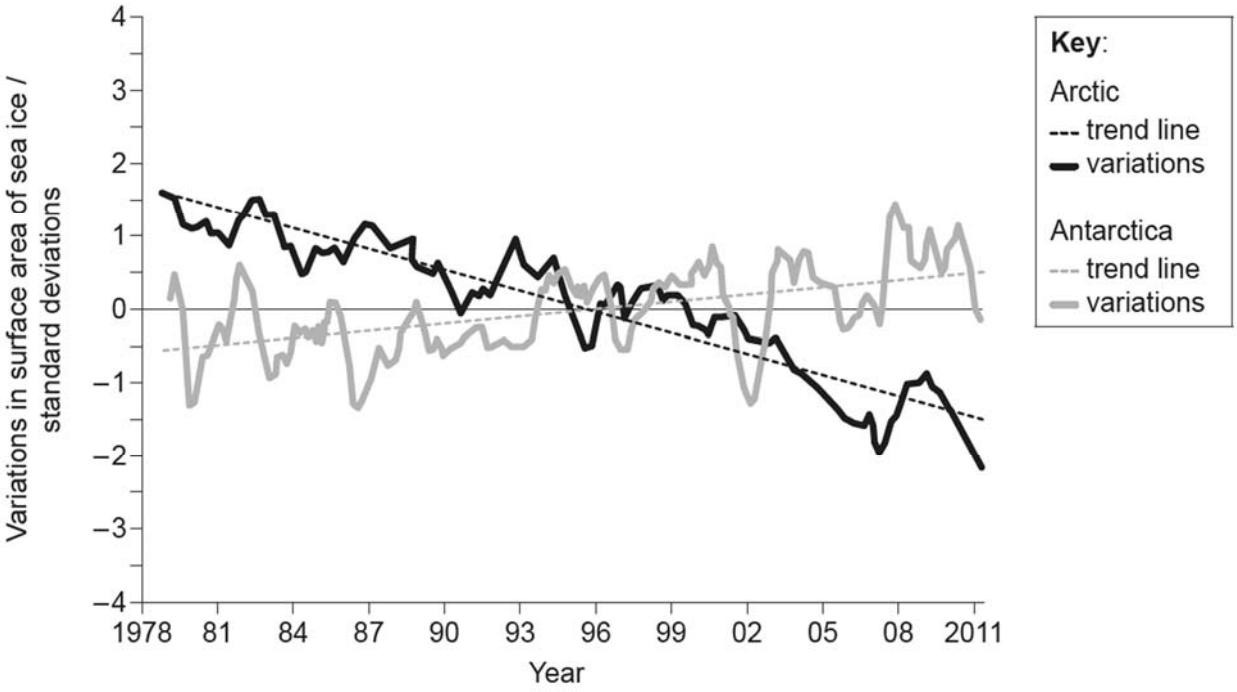

Fig. 4.1

(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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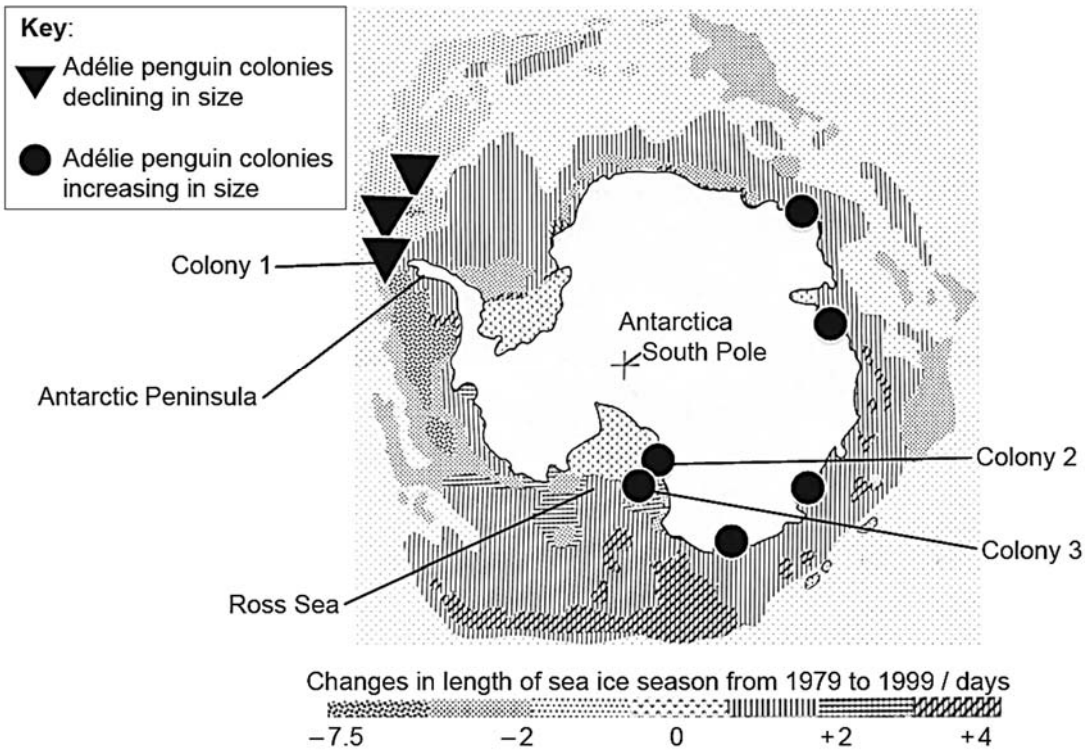
[3]

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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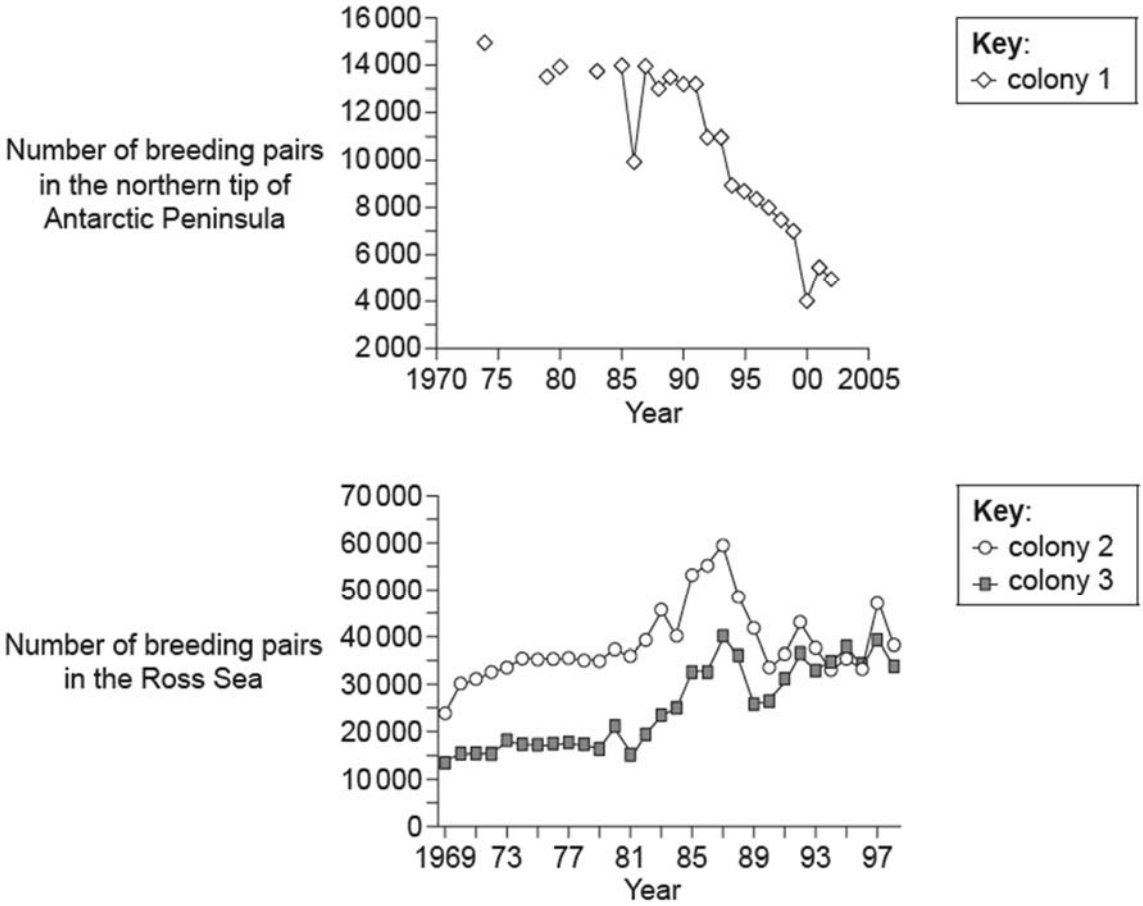
..... [2]

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.

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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]

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[Total: 15]

H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME

MARK SCHEME

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.

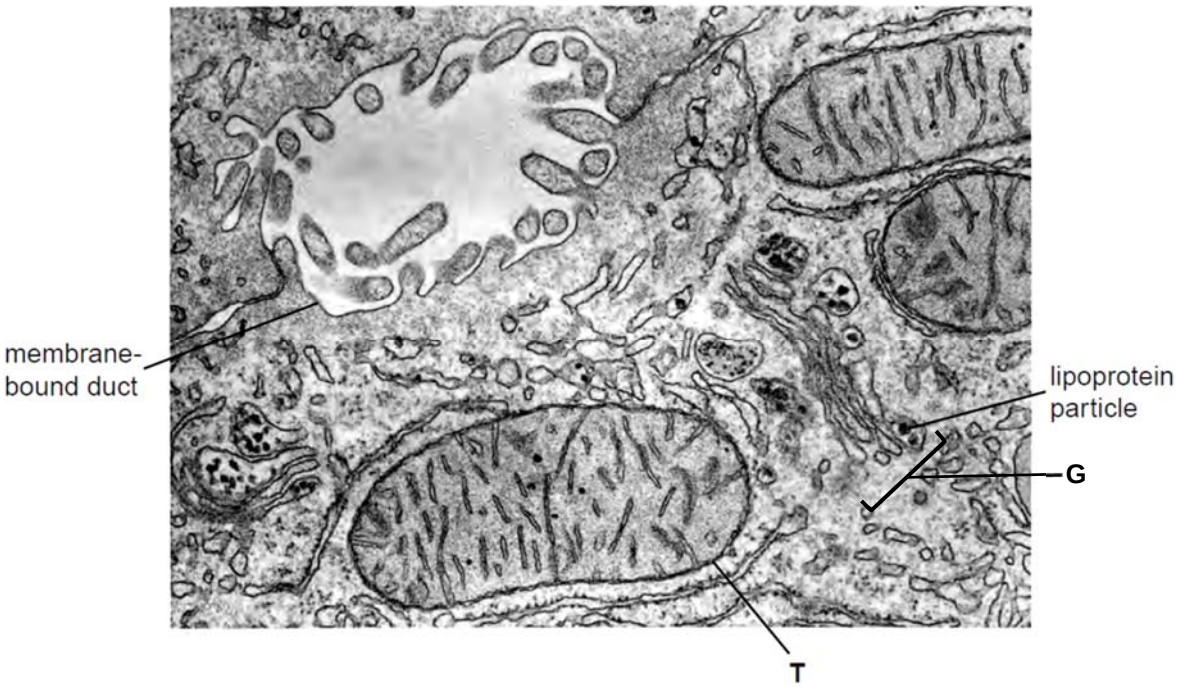


Fig. 1.1

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

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 soluble ;

cholesterol is not water-soluble ;

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:

(flattened) sacs 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).

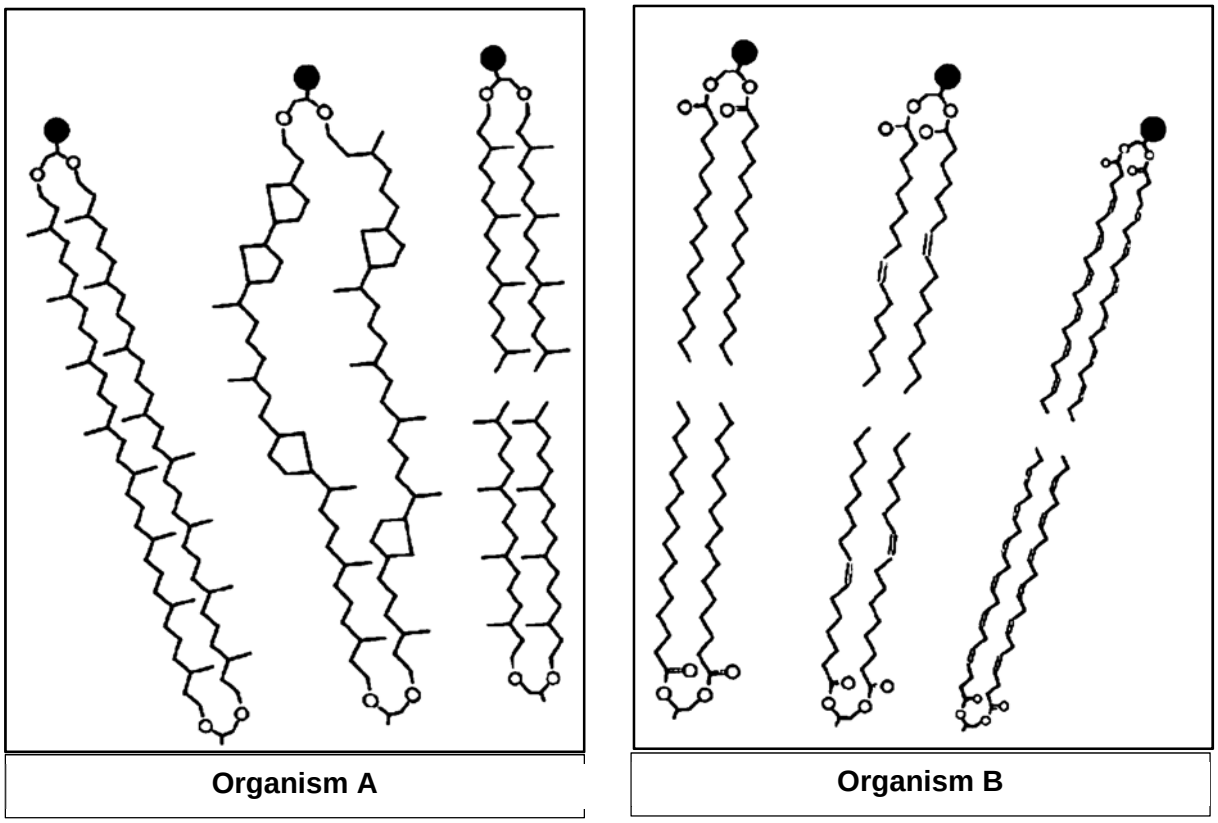


Fig. 1.2

(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.

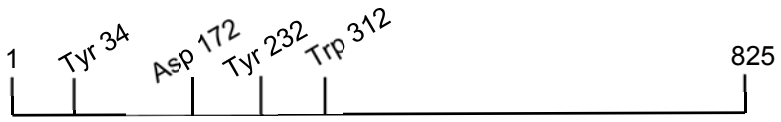


Fig. 2.1

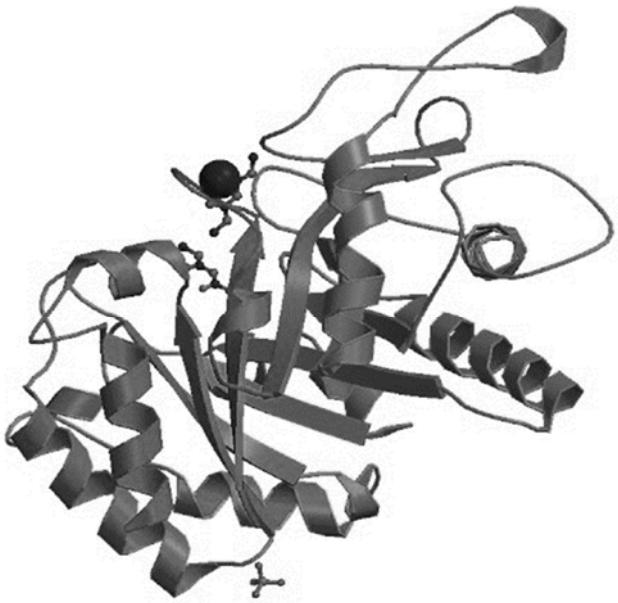


Fig. 2.2

(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.

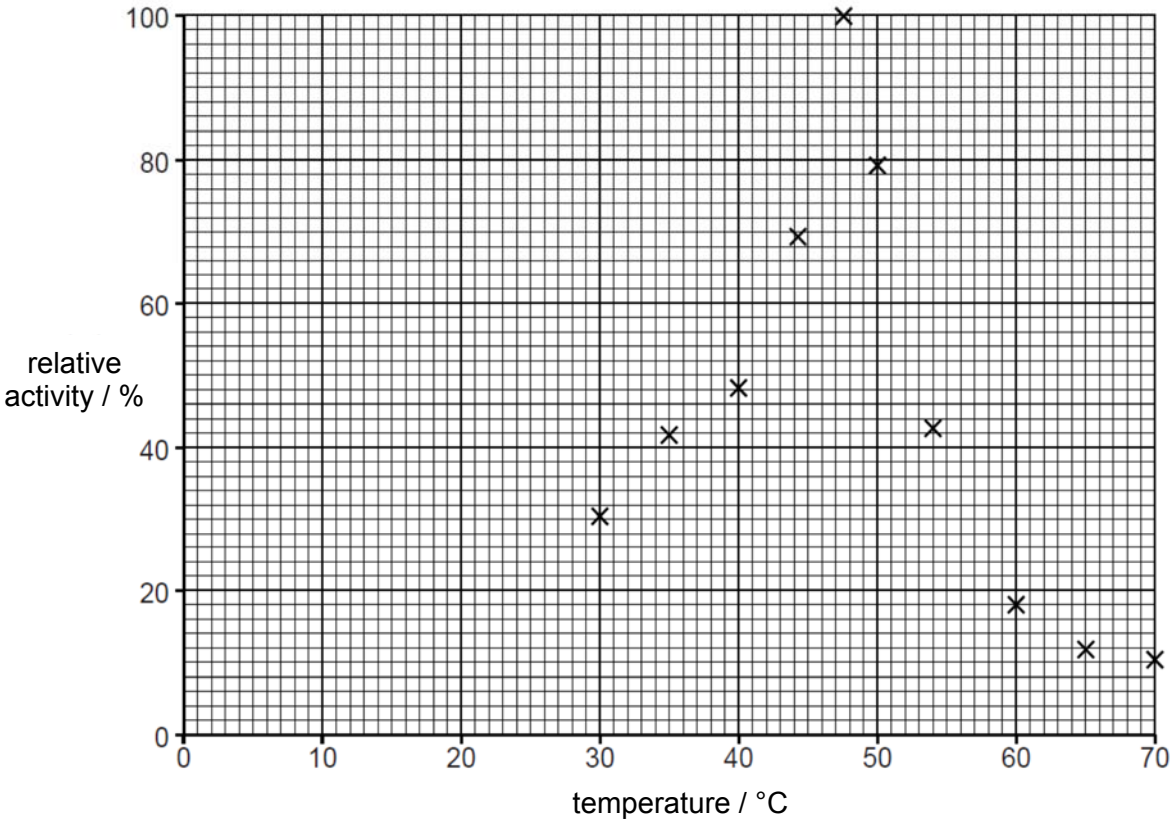


Fig. 2.3

(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.

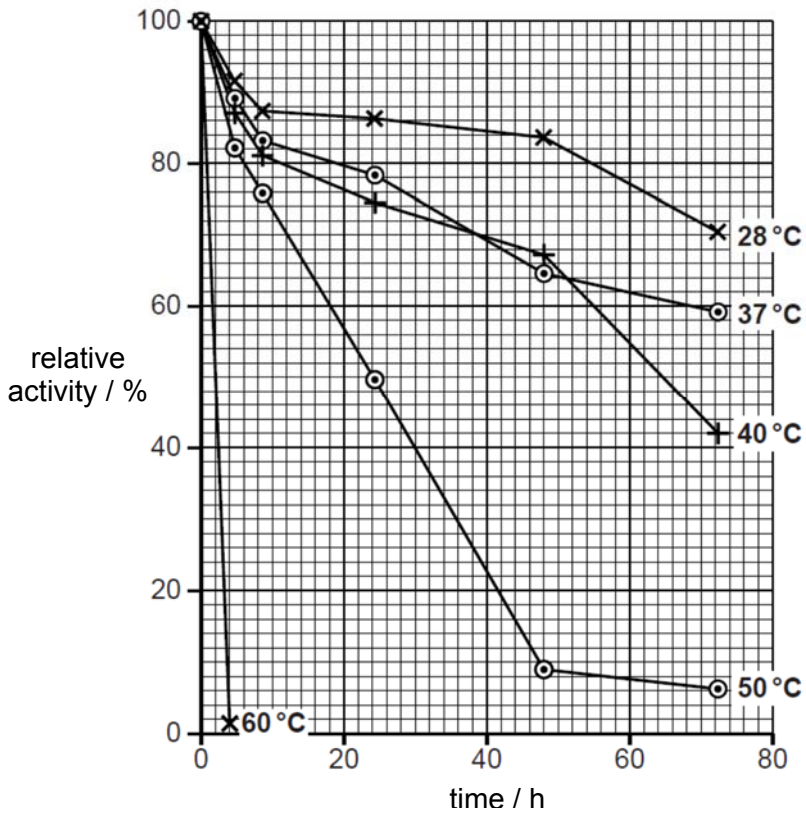


Fig. 2.4

(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 or 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.

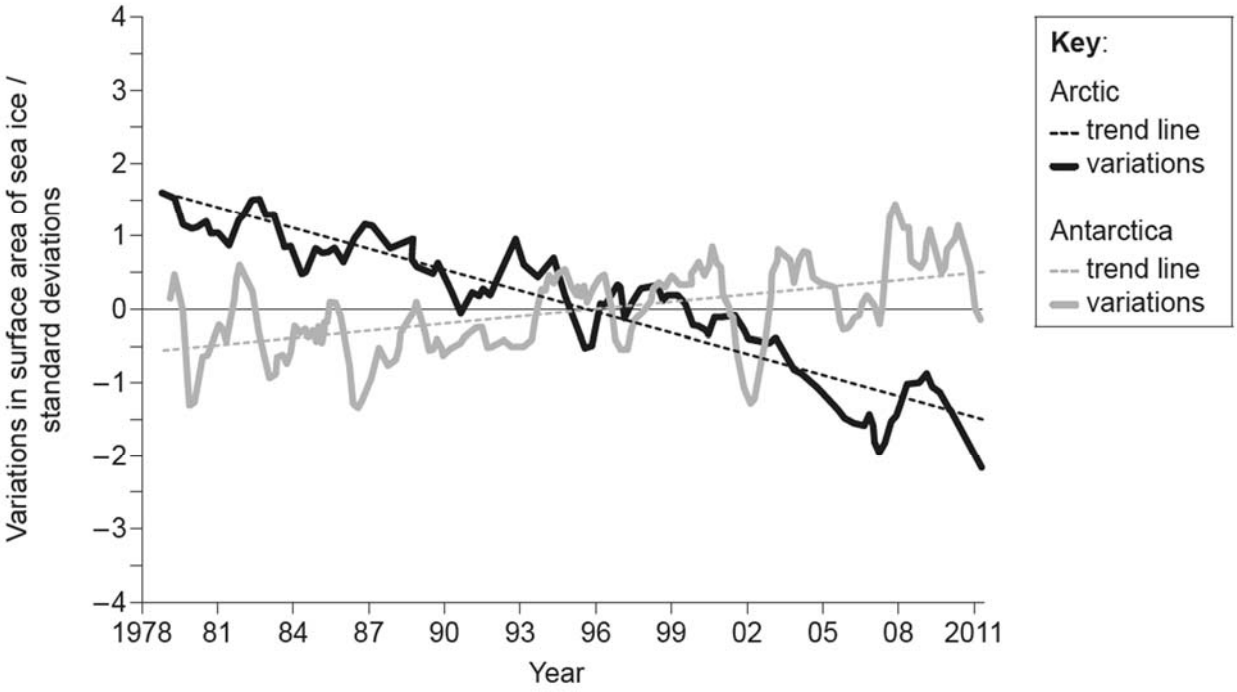


Fig. 4.1

(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);

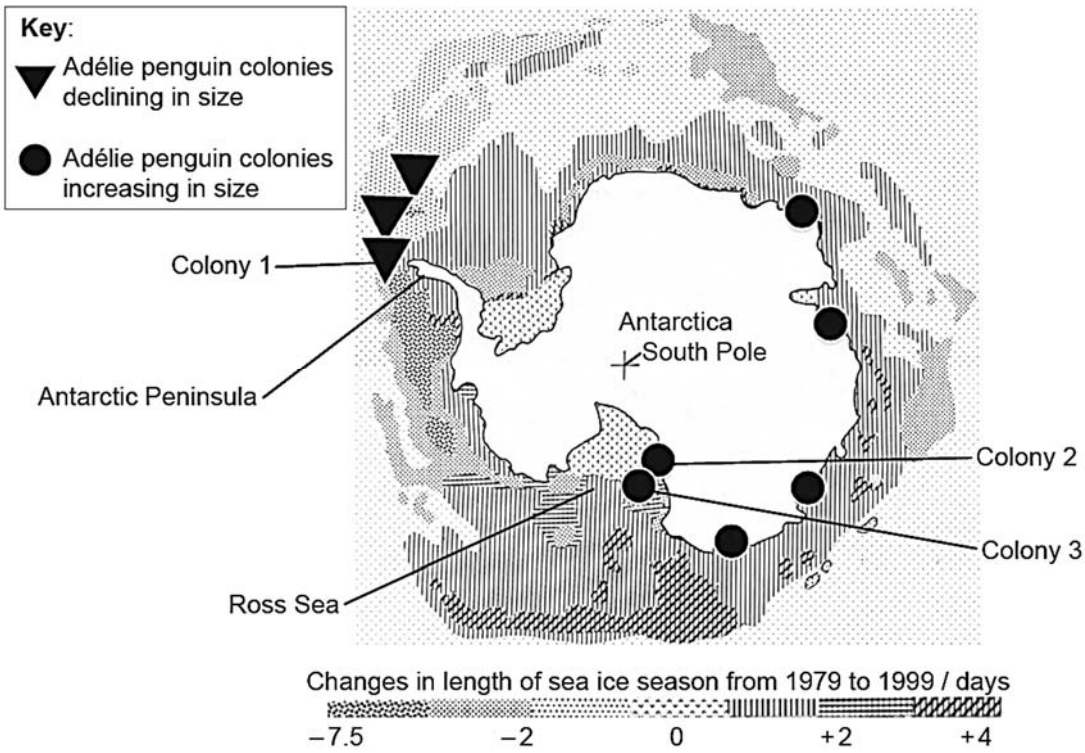
e. global warming does not affect all areas in the same way / global warming has complex effects;

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;

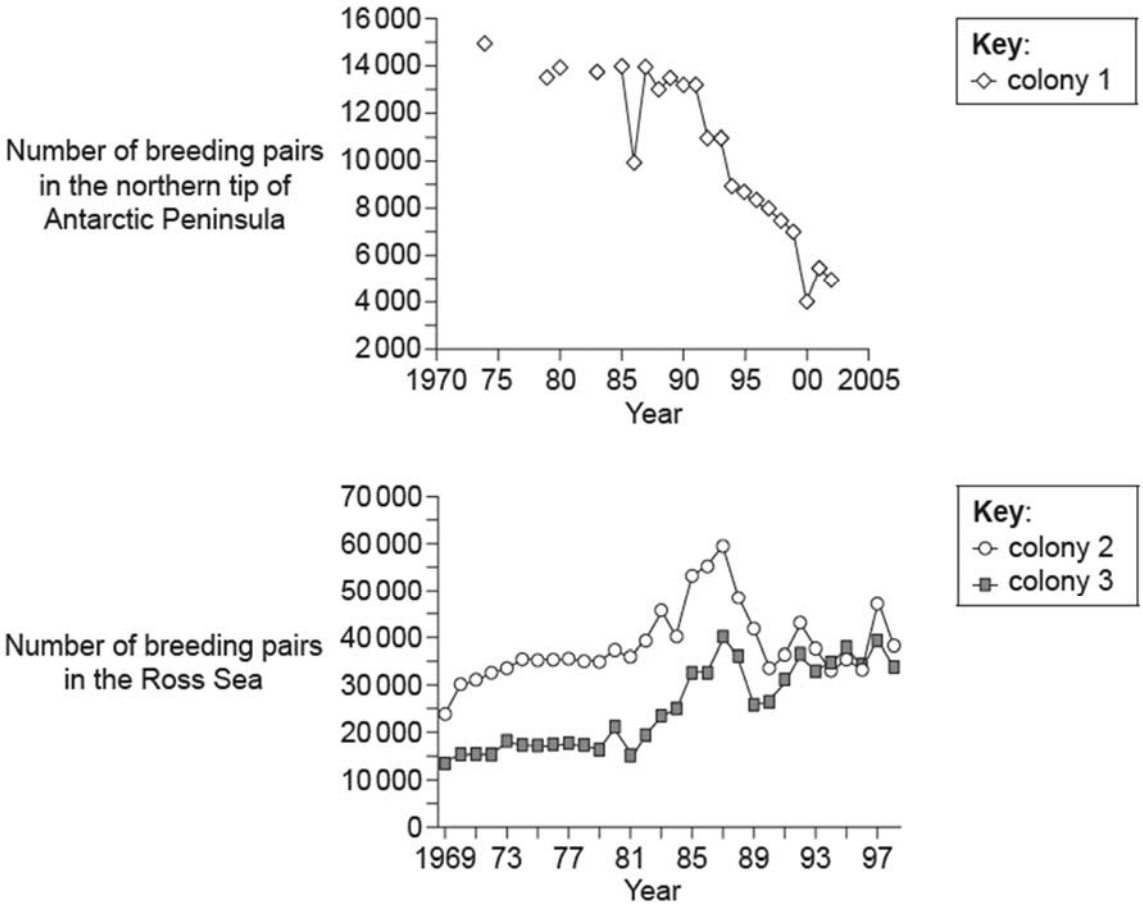
Ross Sea:

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]

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[Total: 15]

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[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 **heritable variation** 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 **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 type, therefore this leads to a change in **allele frequency** in a population for beak type.

Example 2: Soapberry bugs (*Jadera haematoloma*)

1 **Heritable variation** - 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