

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE
NAME

CLASS

BIOLOGY

Paper 1 Multiple Choice

8875/01

26 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

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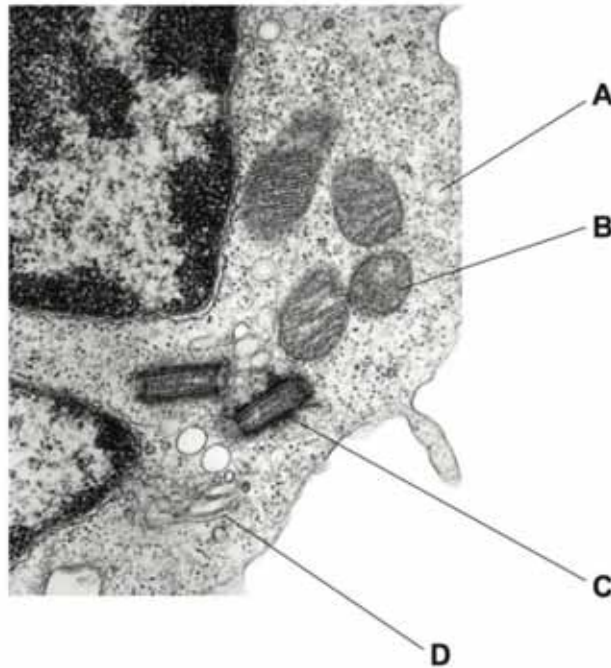
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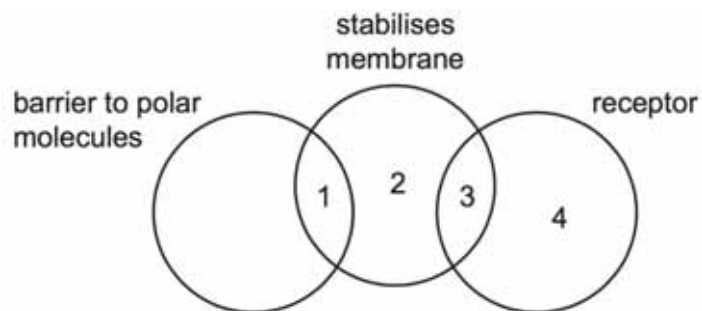
- 1 A student has drawn a cell structure as seen using a light microscope.
The magnification of the drawing is $\times 600$.
The length of the structure on the drawing is 6mm.

What is the actual length of the cell structure?

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- 2 The electron micrograph shows part of a eukaryotic cell.
Which of the labelled organelles is a site of protein synthesis?

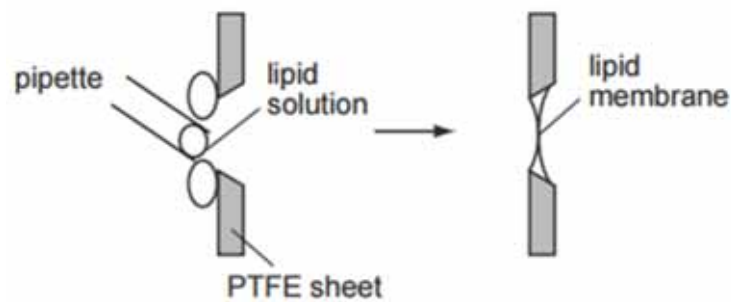


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Such a lipid membrane is impermeable to water-soluble materials including charged ions such as Na^+ or K^+ .

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Which two polymers form starch?

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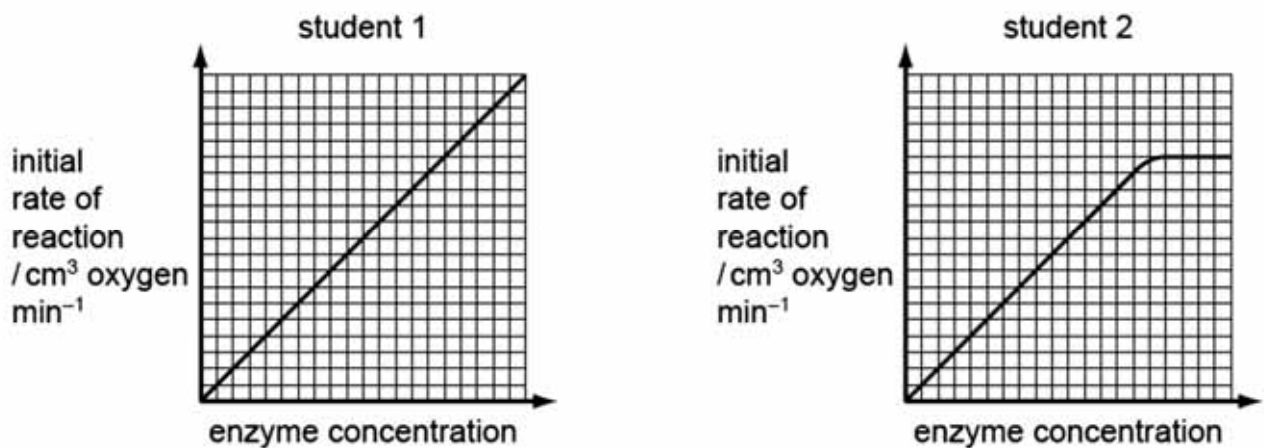
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Two students investigated the effect of enzyme concentration on the rate of reaction of the enzyme catalase. The students predicted their results would show the same trend. The graphs show the rates obtained by each student.



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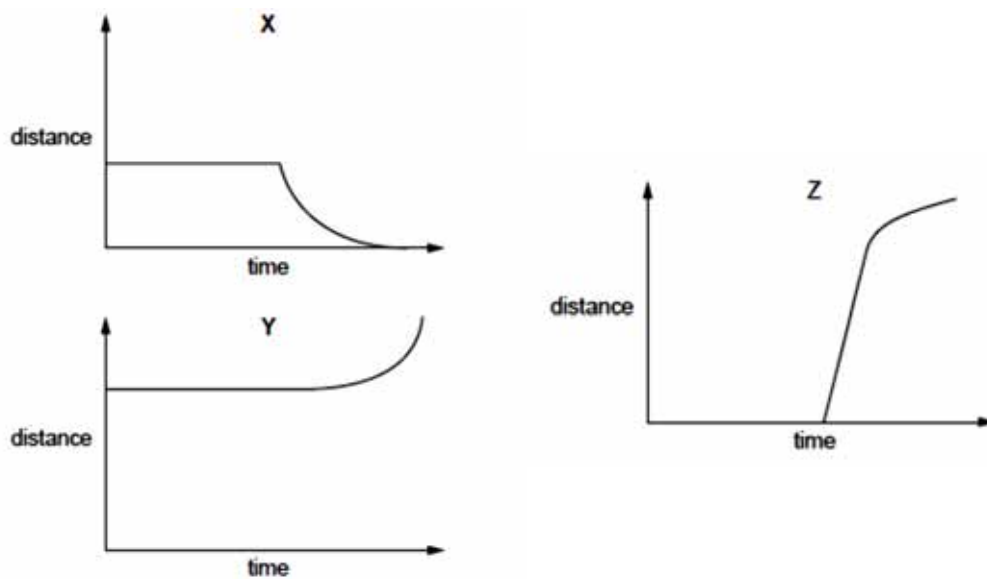
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- P** All bacteria contain ^{15}N DNA.
- Q** All bacteria contain hybrid DNA (^{15}N DNA and ^{14}N DNA).
- R** Bacteria contain either all ^{14}N DNA or hybrid DNA.
- S** Bacteria grown in a ^{15}N medium for many generations.
- T** Bacteria transferred to a ^{14}N medium and sampled every 20 minutes.

Which sequence of letters shows the correct order of the steps in the experiment?

- A** P→Q→R→S→T
- B** P S T R Q
- C** S P T Q R
- D** S P T R Q

12 Polypeptide synthesis is based on sequences of three nucleotides, each specific for an amino acid.

Which row shows the correct nucleotide sequences for an amino acid?

	nucleotide sequence of		
	non-transcribed DNA strand	mRNA codon	tRNA anticodon
A	GGT	CCA	GGU
B	GGG	CCC	CCC
C	CCG	CCG	GGC
D	CCT	CCU	CCU

13 Which statement(s) about tRNA structure is/are correct?

- 1 There is a binding site for the attachment of a specific amino acid, as well as a different binding site for the attachment to the ribosome, in order to allow translation to occur.
- 2 There is a ribose-phosphate backbone with strong covalent phosphodiester bonds and areas within the polynucleotide chain where base-pairing by hydrogen bonding occurs.
- 3 There is a section known as an anticodon that contains the same triplet of bases as the triplet of DNA bases that has been transcribed to produce the mRNA codon.

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

14 The following table shows the mRNA codons for six different amino acids.

mRNA codons	amino acid
AAA AAG	lysine
AGA AGG CGG	arginine
GGU GGA GGC GGG	glycine
CCU CCA CCC CCG	proline
UGG	tryptophan
UAU UAC	tyrosine

The base sequence of mRNA coding for part of a polypeptide is shown below.

U A U A A G A G G C C U U G G
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
 ↑
start reading

From the information provided, which of the predictions stated below is **not** true?

- A The insertion of a nucleotide between positions 3 and 4 is expected to result in a greater change in the amino acid sequence than an insertion between positions 12 and 13.
- B The deletion of a nucleotide at position 5 would result only in an alteration of the second amino acid in the chain.
- C The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain.
- D The substitution of a different nucleotide at position 13 would result in the alteration of one amino acid.

- 15 The following table shows the chromosome numbers in the hybrids formed between cabbage (*Brassica oleracea*) and radish (*Raphanus sativus*).

<i>type of cell</i>	<i>no. of chromosomes per cell</i>
parental cabbage	18
parental radish	18
parental gametes	9
F ₁ hybrids	18
F ₁ gametes	18
F ₂ hybrids	36
F ₂ gametes	18
F ₃ hybrids	36

During which of the following stages can the occurrence of non-disjunction explain the results?

- A formation of the F₁ gametes
 - B formation of the F₂ gametes
 - C fusion of the parental gametes
 - D fusion of the F₁ gametes
- 16 A In horses, there are 3 coat colour patterns, *cremello* (beige), *chestnut* (brown) and *palomino* (golden with pale coloured mane and tail). When 2 *palomino* horses were crossed, they produce 25% *cremello*, 25% *chestnut* and 50% *palomino* horses.

Which of the following statement is true about the cross?

- A The *cremello* offspring are all heterozygotes.
- B There are 3 alleles involved in the coat colour patterns of the horses.
- C All the *palomino* offspring are heterozygotes.
- D The allele that code for *chestnut* is recessive to the *cremello*.

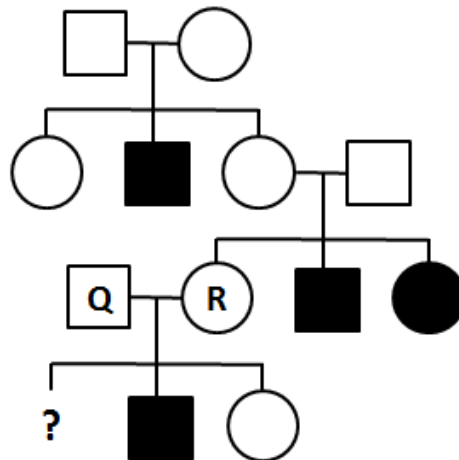
- 17 In mice, the alleles coding for coat pattern is located on the X chromosome. The 'dappled' coat allele is denoted D and its recessive allele for 'plain' coat, d. The alleles coding for 'straight' whiskers (W) and the recessive condition, 'bent' whiskers (w), are found on autosomes.

A male mouse with plain coat and bent whiskers was mated on several occasions to the same female and the large number of offspring consisted of males and females in equal numbers in all combinations of phenotypes, as shown in the table.

Offspring	
dappled, straight whiskers	plain, straight whiskers
dappled, bent whiskers	plain, bent whiskers

If X^D represents an X chromosome carrying the allele for 'dappled' coat and X^d represents an X chromosome carrying the allele for 'plain' coat, what is the genotype of the female parent?

- A $X^D X^D WW$
 B $X^D X^D Ww$
 C $X^D X^d WW$
 D $X^D X^d Ww$
- 18 Adducted thumb syndrome is a condition where affected individual will have malformation of the thumb and upper limbs. The figure below show a pedigree chart of a family with the history of adducted thumb syndrome.



If individual Q and R give birth to a son, what is the possibility that their son will be affected by the condition?

- A 0.125
 B 0.25
 C 0.50
 D 0.75

19 Which of the following would cause phenotypic variation among organisms of the same genotype?

- A** continuous variation within the species
- B** different varieties of the same species
- C** exposure to different environments
- D** mutation

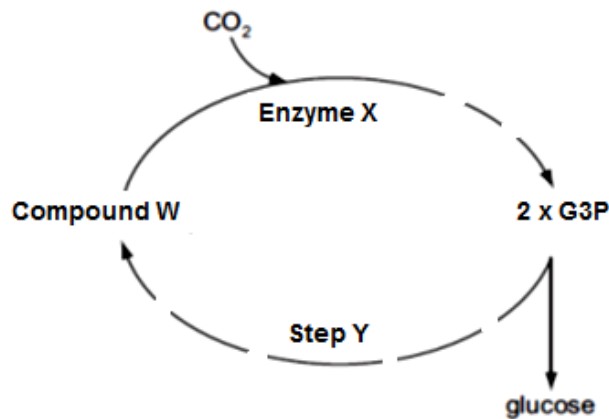
20 In a series of experiments, actively photosynthesizing plants were supplied with labelled reactants.

- 1** water containing ^{18}O isotope
- 2** carbon dioxide containing ^{17}O isotope
- 3** carbon dioxide containing ^{13}C isotope

Where in the chloroplast would the products of photosynthesis from these reactants be formed?

	^{18}O	^{17}O	^{13}C
A	stroma	stroma	thylakoids
B	stroma	thylakoids	stroma
C	thylakoids	stroma	stroma
D	thylakoids	stroma	thylakoids

- 21 The figure below summaries some key reactions which occur in the Calvin cycle. Note that the dashed lines would indicate that there is more than one reaction present.



Using the figure above and your knowledge of Calvin cycle, determine which one of the following statements below is **true**?

- A Compound W is expected to accumulate if carbon dioxide concentration increases under low light intensity.
- B Enzyme X is expected to accumulate when carbon dioxide concentration decreases.
- C Increase in temperature under high light intensity will increase the activity of enzyme X until the optimum temperature.
- D ATP from substrate level phosphorylation is required for Step Y to proceed and Compound W to be formed.
- 22 In an experiment, four tubes were set up as shown in the table below.

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

If all other conditions are kept constant, which of the following shows the amount of ATP produced in each tube in **increasing** order?

- A 1 – 3 – 4 – 2
- B 2 – 3 – 4 – 1
- C 4 – 2 – 3 – 1
- D 3 – 2 – 1 – 4

23 Darwin's view of the process of evolution to form new species (speciation) has been reinforced by more recent discoveries in genetics and cell biology.

In this view, which sequence of events is considered most likely to lead to speciation?

A	adaptation of population → competition and predation leading to natural selection → behavioural isolation → sympatric speciation
B	adaptation of population → competition and predation leading to natural selection → behavioural isolation → allopatric speciation
C	competition and predation leading to natural selection → geographical isolation → adaptation of isolated populations → sympatric speciation
D	competition and predation leading to natural selection → geographical isolation → adaptation of isolated populations → allopatric speciation

24 Natural selection acts

- A** directly on an individual's genetic make-up, thereby changing the survival probability of the individual.
- B** on individuals by changing their genes so they are better able to adapt to their environment.
- C** on the structures, physiologies and behaviours expressed by individuals in a population to change allele frequencies.
- D** on phenotypes of individuals so that they change to adapt to their environment and pass on these changes to their offspring.

- 25 The map shows the distribution (shaded area) of the lizards belonging to the family Iguanidae. Most species of iguana are found in America but a few species inhabit Madagascar and the islands of Fiji and Tonga (arrows at the bottom centre and bottom right of map).



Two observations were made about the different species of iguana:

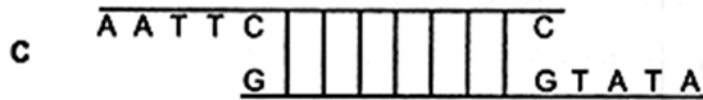
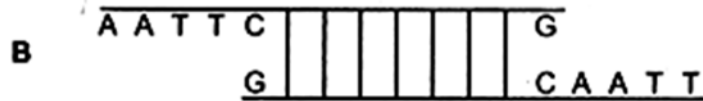
- 1 The various American iguana species shared more similar characteristics among themselves than with those iguana species on the island of Fiji.
- 2 The Madagascar iguana species was only distantly related to other lizard species on the African mainland.

Which observation and explanation best support the Darwinian concept of descent with modification?

	Observation	Explanation for the observation
A	1	The various American iguana species had a more recent common ancestor as compared to those iguana species on the island of Fiji that had diverged a longer time ago.
B	1	The various American iguana species shared more similarities among themselves as the degree of homology in their DNA was higher.
C	2	The Madagascan iguana species was reproductively isolated from the lizard species on the African mainland and thus diverged a long time ago.
D	2	The superficial similarities shared among the Madagascan iguana and the lizards on the African mainland were analogous, not homologous.

- 26 In genetic engineering, a restriction enzyme is used to cut plasmid DNA at a specific target site. The enzyme recognises a sequence of six bases and forms sticky ends.

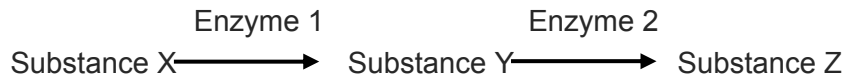
Which diagram of such a cut section of DNA is correct?



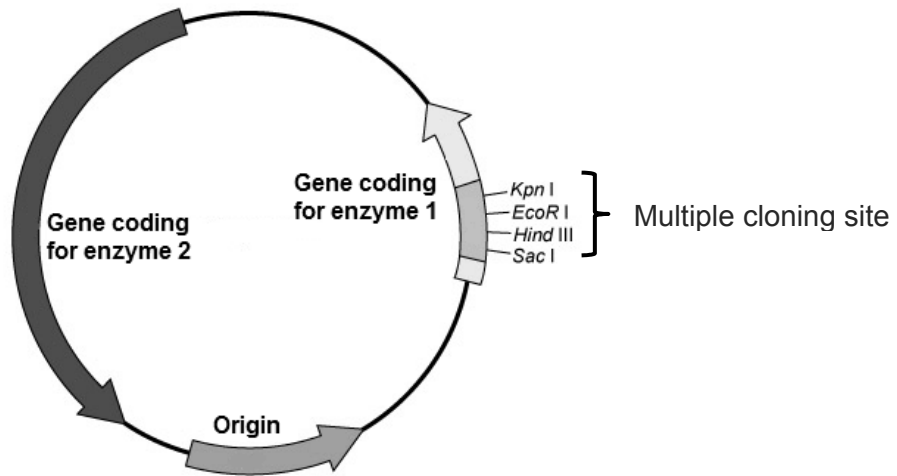
- 27 Which one of the following statements regarding polymerase chain reaction is **false**?

- A Taq polymerase is chosen for use because of its heat-stable property.
- B Amplification of the DNA products requires DNA primers to be added for initiation.
- C Initiation of the amplification need not start at the promoter region of the gene.
- D The amount of products formed by PCR is not limited by the nucleotides added into reaction mixture.

- 28 The metabolic pathway shown below is utilised by a species of bacteria to produce substance Z, which is essential for the replication of the bacterial chromosome. When provided with substance X or substance Y, wild-type bacteria are able to synthesise substance Z.



Mutant bacteria, lacking the genes coding for both enzyme 1 and 2, were genetically modified to contain the human insulin gene. The following plasmid was used as a vector for transformation.



The transformed cells were plated onto an agar plate containing only substance Y. Which of the following replica plates have to be prepared in order to identify the colony containing recombinant bacteria?

- A Replica plate containing substance X only
- B Replica plate containing substance X and Y
- C Replica plate containing substance Y and Z
- D Replica plate containing substance Z only

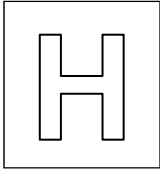
29 Which is a correct statement about obtaining human embryonic stem cells for research?

- A Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.
- B The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.
- C The cells must be removed within a day following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.
- D The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.

30 Efforts to develop salt-tolerant crop varieties using selective breeding techniques have been unsuccessful. Recently, plant biologists have developed a genetically engineered tomato plant that can thrive in salty water. This genetically modified plant produces significantly higher levels of a naturally occurring transport protein. This transport protein moves salt, in the form of sodium ions into the central vacuoles of leaf cells specifically.

Which statement correctly describes the benefit of genetic engineering of this tomato plant?

- A Improving crop yield through maximizing the use of land.
- B Improving crop quality since the fruit will be juicy due to influx of water via osmosis.
- C Improving crop yield by changing the way the plant uses its energy resources.
- D Improving crop quality since the tomato fruit can supplement salt loss to sweating.



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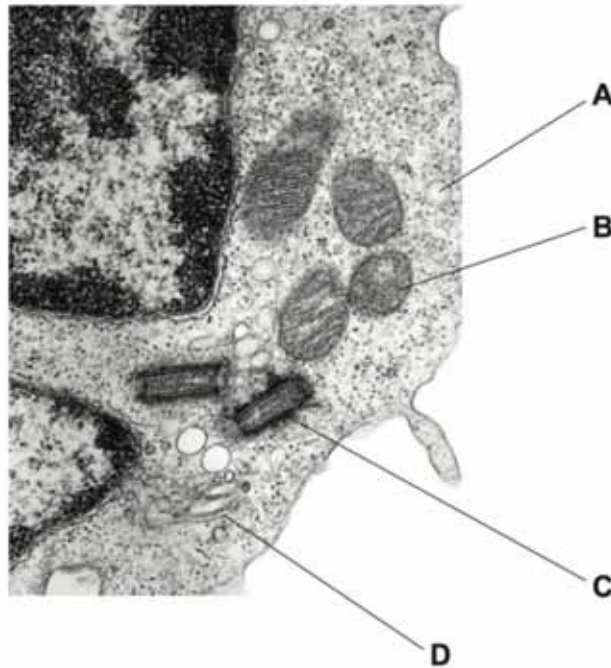
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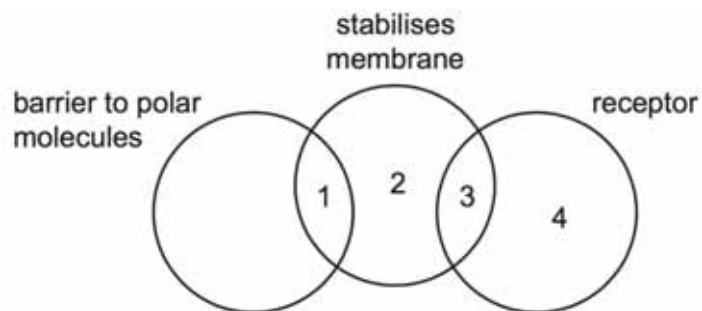
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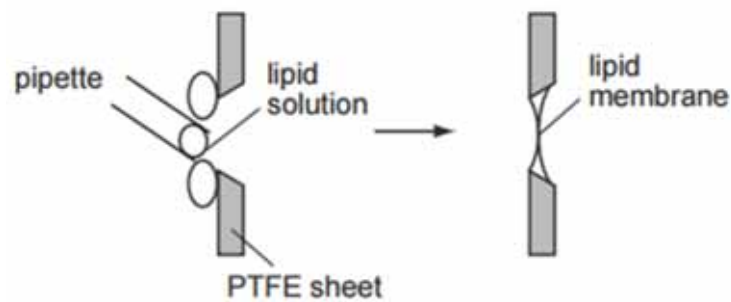


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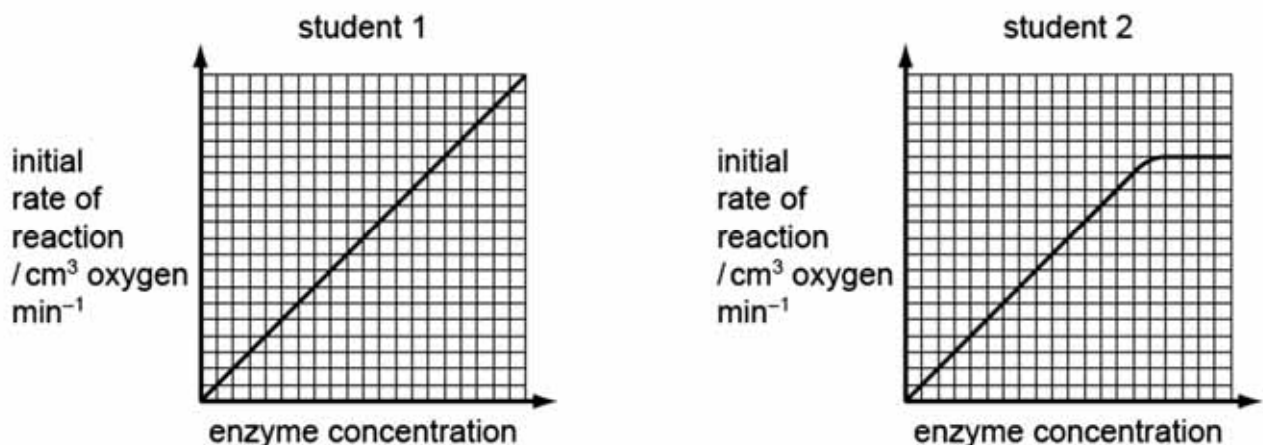
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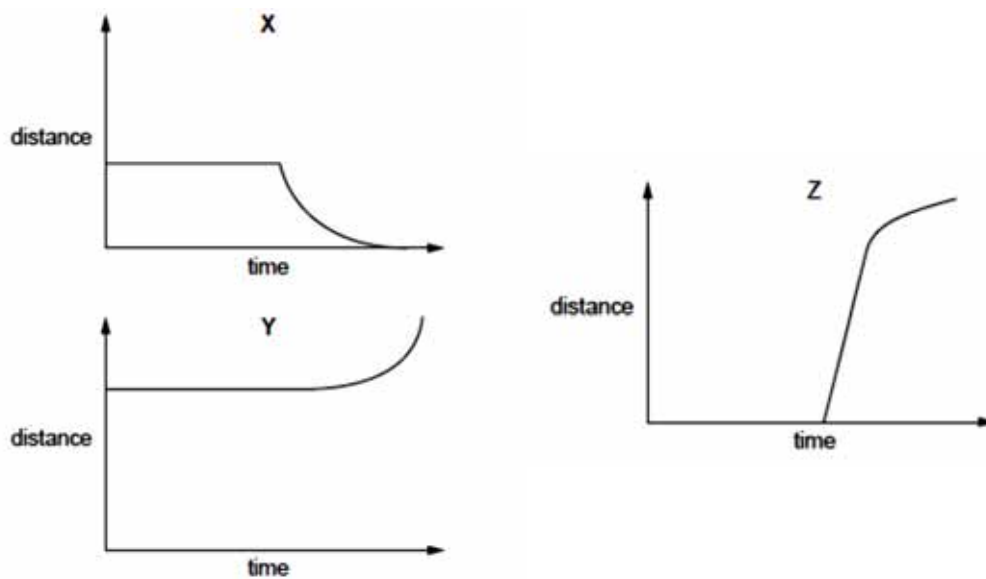
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- S Bacteria grown in a ^{15}N medium for many generations.
- T Bacteria transferred to a ^{14}N medium and sampled every 20 minutes.

Which sequence of letters shows the correct order of the steps in the experiment?

- A P → Q → R → S → T
- B P S T R Q
- C S P T Q R**
- D S P T R Q

12 Polypeptide synthesis is based on sequences of three nucleotides, each specific for an amino acid.

Which row shows the correct nucleotide sequences for an amino acid?

	nucleotide sequence of		
	non-transcribed DNA strand	mRNA codon	tRNA anticodon
A	GGT	CCA	GGU
B	GGG	CCC	CCC
C	CCG	CCG	GGC
D	CCT	CCU	CCU

13 Which statement(s) about tRNA structure is/are correct?

- 1 There is a binding site for the attachment of a specific amino acid, as well as a different binding site for the attachment to the ribosome, in order to allow translation to occur.
- 2 There is a ribose-phosphate backbone with strong covalent phosphodiester bonds and areas within the polynucleotide chain where base-pairing by hydrogen bonding occurs.
- 3 There is a section known as an anticodon that contains the same triplet of bases as the triplet of DNA bases that has been transcribed to produce the mRNA codon.

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

14 The following table shows the mRNA codons for six different amino acids.

mRNA codons	amino acid
AAA AAG	lysine
AGA AGG CGG	arginine
GGU GGA GGC GGG	glycine
CCU CCA CCC CCG	proline
UGG	tryptophan
UAU UAC	tyrosine

The base sequence of mRNA coding for part of a polypeptide is shown below.

U A U A A G A G G C C U U G G
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
 ↑
start reading

From the information provided, which of the predictions stated below is **not** true?

- A The insertion of a nucleotide between positions 3 and 4 is expected to result in a greater change in the amino acid sequence than an insertion between positions 12 and 13.
- B The deletion of a nucleotide at position 5 would result only in an alteration of the second amino acid in the chain.**
- C The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain.
- D The substitution of a different nucleotide at position 13 would result in the alteration of one amino acid.

- 15 The following table shows the chromosome numbers in the hybrids formed between cabbage (*Brassica oleracea*) and radish (*Raphanus sativus*).

<i>type of cell</i>	<i>no. of chromosomes per cell</i>
parental cabbage	18
parental radish	18
parental gametes	9
F ₁ hybrids	18
F ₁ gametes	18
F ₂ hybrids	36
F ₂ gametes	18
F ₃ hybrids	36

During which of the following stages can the occurrence of non-disjunction explain the results?

- A formation of the F₁ gametes
 - B formation of the F₂ gametes
 - C fusion of the parental gametes
 - D fusion of the F₁ gametes
- 16 A In horses, there are 3 coat colour patterns, *cremello* (beige), *chestnut* (brown) and *palomino* (golden with pale coloured mane and tail). When 2 *palomino* horses were crossed, they produce 25% *cremello*, 25% *chestnut* and 50% *palomino* horses.

Which of the following statement is true about the cross?

- A The *cremello* offspring are all heterozygotes.
- B There are 3 alleles involved in the coat colour patterns of the horses.
- C All the *palomino* offspring are heterozygotes.
- D The allele that code for *chestnut* is recessive to the *cremello*.

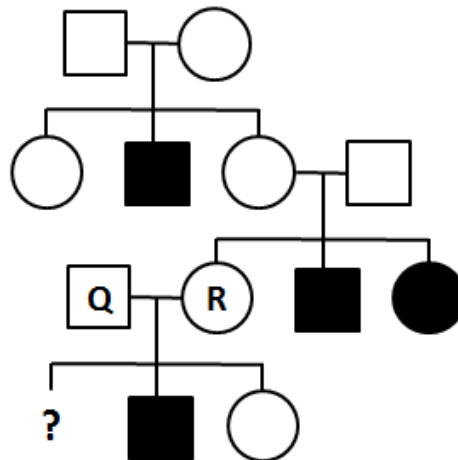
- 17 In mice, the alleles coding for coat pattern is located on the X chromosome. The 'dappled' coat allele is denoted D and its recessive allele for 'plain' coat, d. The alleles coding for 'straight' whiskers (W) and the recessive condition, 'bent' whiskers (w), are found on autosomes.

A male mouse with plain coat and bent whiskers was mated on several occasions to the same female and the large number of offspring consisted of males and females in equal numbers in all combinations of phenotypes, as shown in the table.

Offspring	
dappled, straight whiskers	plain, straight whiskers
dappled, bent whiskers	plain, bent whiskers

If X^D represents an X chromosome carrying the allele for 'dappled' coat and X^d represents an X chromosome carrying the allele for 'plain' coat, what is the genotype of the female parent?

- A $X^D X^D WW$
 B $X^D X^D Ww$
 C $X^D X^d WW$
 D $X^D X^d Ww$
- 18 Adducted thumb syndrome is a condition where affected individual will have malformation of the thumb and upper limbs. The figure below show a pedigree chart of a family with the history of adducted thumb syndrome.



If individual Q and R give birth to a son, what is the possibility that their son will be affected by the condition?

- A 0.125
 B 0.25
 C 0.50
 D 0.75

19 Which of the following would cause phenotypic variation among organisms of the same genotype?

- A continuous variation within the species
- B different varieties of the same species
- C exposure to different environments**
- D mutation

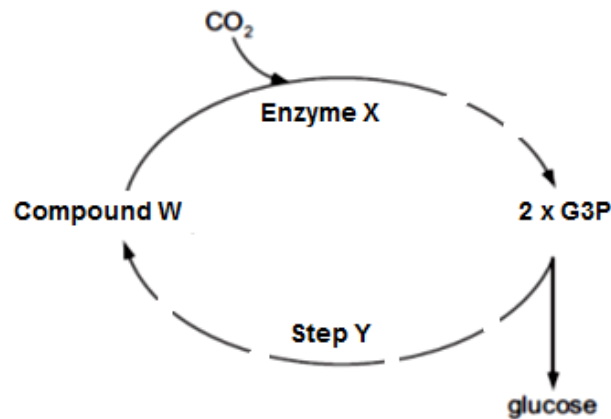
20 In a series of experiments, actively photosynthesizing plants were supplied with labelled reactants.

- 1 water containing ^{18}O isotope
- 2 carbon dioxide containing ^{17}O isotope
- 3 carbon dioxide containing ^{13}C isotope

Where in the chloroplast would the products of photosynthesis from these reactants be formed?

	^{18}O	^{17}O	^{13}C
A	stroma	stroma	thylakoids
B	stroma	thylakoids	stroma
C	thylakoids	stroma	stroma
D	thylakoids	stroma	thylakoids

- 21 The figure below summaries some key reactions which occur in the Calvin cycle. Note that the dashed lines would indicate that there is more than one reaction present.



Using the figure above and your knowledge of Calvin cycle, determine which one of the following statements below is **true**?

- A Compound W is expected to accumulate if carbon dioxide concentration increases under low light intensity.
- B Enzyme X is expected to accumulate when carbon dioxide concentration decreases.
- C Increase in temperature under high light intensity will increase the activity of enzyme X until the optimum temperature.**
- D ATP from substrate level phosphorylation is required for Step Y to proceed and Compound W to be formed.
- 22 In an experiment, four tubes were set up as shown in the table below.

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

If all other conditions are kept constant, which of the following shows the amount of ATP produced in each tube in **increasing** order?

- A 1 – 3 – 4 – 2
- B 2 – 3 – 4 – 1**
- C 4 – 2 – 3 – 1
- D 3 – 2 – 1 – 4

23 Darwin's view of the process of evolution to form new species (speciation) has been reinforced by more recent discoveries in genetics and cell biology.

In this view, which sequence of events is considered most likely to lead to speciation? **D**

A	adaptation of population → competition and predation leading to natural selection → behavioural isolation → sympatric speciation
B	adaptation of population → competition and predation leading to natural selection → behavioural isolation → allopatric speciation
C	competition and predation leading to natural selection → geographical isolation → adaptation of isolated populations → sympatric speciation
D	competition and predation leading to natural selection → geographical isolation → adaptation of isolated populations → allopatric speciation

24 Natural selection acts

- A** directly on an individual's genetic make-up, thereby changing the survival probability of the individual.
- B** on individuals by changing their genes so they are better able to adapt to their environment.
- C** on the structures, physiologies and behaviours expressed by individuals in a population to change allele frequencies.
- D** on phenotypes of individuals so that they change to adapt to their environment and pass on these changes to their offspring.

- 25 The map shows the distribution (shaded area) of the lizards belonging to the family Iguanidae. Most species of iguana are found in America but a few species inhabit Madagascar and the islands of Fiji and Tonga (arrows at the bottom centre and bottom right of map).



Two observations were made about the different species of iguana:

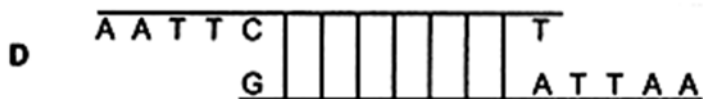
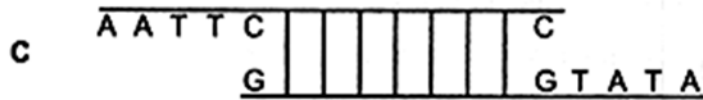
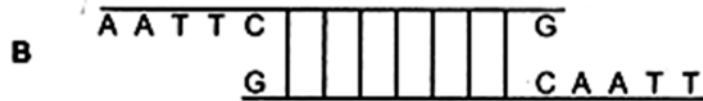
- 1 The various American iguana species shared more similar characteristics among themselves than with those iguana species on the island of Fiji.
- 2 The Madagascar iguana species was only distantly related to other lizard species on the African mainland.

Which observation and explanation best support the Darwinian concept of descent with modification?

	Observation	Explanation for the observation
A	1	The various American iguana species had a more recent common ancestor as compared to those iguana species on the island of Fiji that had diverged a longer time ago.
B	1	The various American iguana species shared more similarities among themselves as the degree of homology in their DNA was higher.
C	2	The Madagascan iguana species was reproductively isolated from the lizard species on the African mainland and thus diverged a long time ago.
D	2	The superficial similarities shared among the Madagascan iguana and the lizards on the African mainland were analogous, not homologous.

- 26 In genetic engineering, a restriction enzyme is used to cut plasmid DNA at a specific target site. The enzyme recognises a sequence of six bases and forms sticky ends.

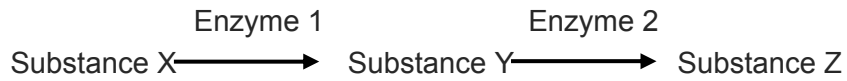
Which diagram of such a cut section of DNA is correct? **AAAAAAAAAAAAAAAAAAAA**



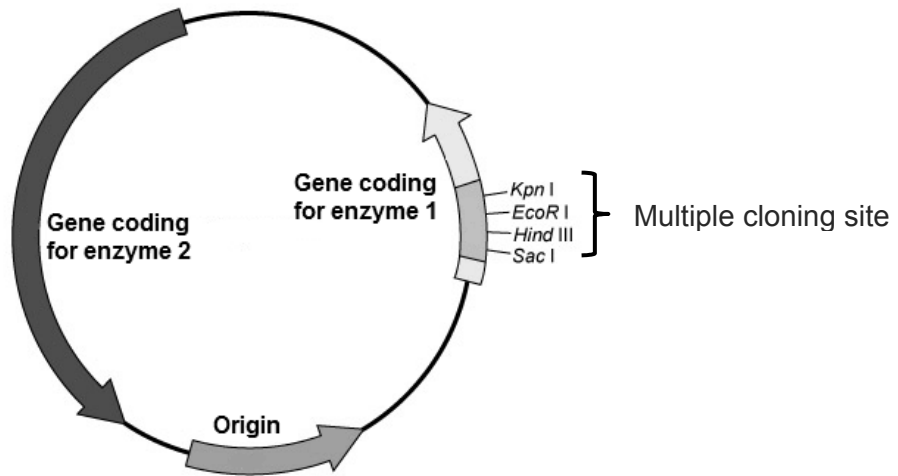
- 27 Which one of the following statements regarding polymerase chain reaction is **false**?

- A Taq polymerase is chosen for use because of its heat-stable property.
- B Amplification of the DNA products requires DNA primers to be added for initiation.
- C Initiation of the amplification need not start at the promoter region of the gene.
- D The amount of products formed by PCR is not limited by the nucleotides added into reaction mixture.**

- 28 The metabolic pathway shown below is utilised by a species of bacteria to produce substance Z, which is essential for the replication of the bacterial chromosome. When provided with substance X or substance Y, wild-type bacteria are able to synthesise substance Z.



Mutant bacteria, lacking the genes coding for both enzyme 1 and 2, were genetically modified to contain the human insulin gene. The following plasmid was used as a vector for transformation.



The transformed cells were plated onto an agar plate containing only substance Y. Which of the following replica plates have to be prepared in order to identify the colony containing recombinant bacteria?

- A Replica plate containing substance X only
- B Replica plate containing substance X and Y
- C Replica plate containing substance Y and Z
- D Replica plate containing substance Z only

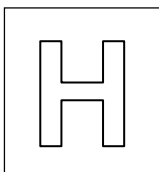
29 Which is a correct statement about obtaining human embryonic stem cells for research?

- A Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.
- B The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.**
- C The cells must be removed within a day following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.
- D The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.

30 Efforts to develop salt-tolerant crop varieties using selective breeding techniques have been unsuccessful. Recently, plant biologists have developed a genetically engineered tomato plant that can thrive in salty water. This genetically modified plant produces significantly higher levels of a naturally occurring transport protein. This transport protein moves salt, in the form of sodium ions into the central vacuoles of leaf cells specifically.

Which statement correctly describes the benefit of genetic engineering of this tomato plant?

- A Improving crop yield through maximizing the use of land.**
- B Improving crop quality since the fruit will be juicy due to influx of water via osmosis.
- C Improving crop yield by changing the way the plant uses its energy resources.
- D Improving crop quality since the tomato fruit can supplement salt loss to sweating.



NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE
NAME

CLASS

BIOLOGY

8875/02

Paper 2 Structured Questions

14 September 2017

Additional Materials: Answer Paper

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions 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.

At the end of the examination, fasten all your work securely together.

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 **10 printed pages.**

[Turn over

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

1 **Table 1.1** shows some features of four biological molecules that are all polymers.

(a) Complete Table 1.1 by using a tick (✓) to indicate the features that apply to each polymer.

Table 1.1

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				
contains glycosidic bonds				
polymer is branched				
contains nitrogen				
can be found in both animal and plant cells				

[4]

(b) **Fig. 1.1** is a simple diagram of a phospholipid molecule.

Explain how the structure of a phospholipid molecule makes it suitable for its function in cell membranes. You may label and annotate **Fig. 1.1** as part of your answer.



Fig. 1.1

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[3]

- (c) State two components of a cell surface membrane other than phospholipid molecules and describe their function.

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[4]

[Total: 11]

- 2 Fig. 2.1 below shows a diagram of a cell. The parts of a diagram are not drawn to scale.

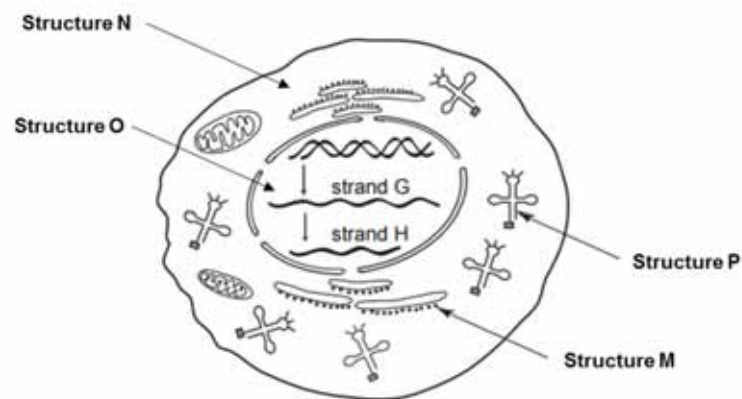


Fig. 2.1

- (a) (i) In which structure would RNA polymerase be found?

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[1]

(ii) Explain the mode of action of RNA polymerase.

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[4]

(b) Strand H is shorter than strand G. Describe the process that results in this shortening, using appropriate names for both strands.

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[2]

(c) Name strand H and structures P and M. Explain how each contributes to protein synthesis.

Strand H:

.....

.....

Structure P:

.....

.....

Structure M:

.....

.....

[3]

[Total: 10]

3 (a) Sometimes a gene has more than two alleles, termed *multiple alleles*.

The ABO blood group system in humans is controlled by a gene with three alleles, I^A, I^B and I^o. Alleles I^A and I^B are codominant and I^o is recessive to both.

The blood group **AB** is the result of codominance.

Explain what is meant by *codominance* in this context.

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[3]

(b) In humans, a gene that codes for the production of a protein, called factor VIII, is located on the X chromosome. The dominant allele for this gene produces factor VIII, but the recessive allele does not produce factor VIII.

A person who is unable to make factor VIII has haemophilia in which the blood fails to clot properly.

Explain why a man with haemophilia cannot pass haemophilia to his son but may pass haemophilia to his grandson.

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[3]

- (c) A gene for feather colour in chickens is carried on an autosome. This gene has two alleles, black (C^B) and splashed-white (C^W). When a male chicken with black feathers is mated with a female chicken with splashed-white feathers, all the offspring have blue feathers. This also occurs when a male chicken with splashed-white feathers is crossed with a female with black feathers.

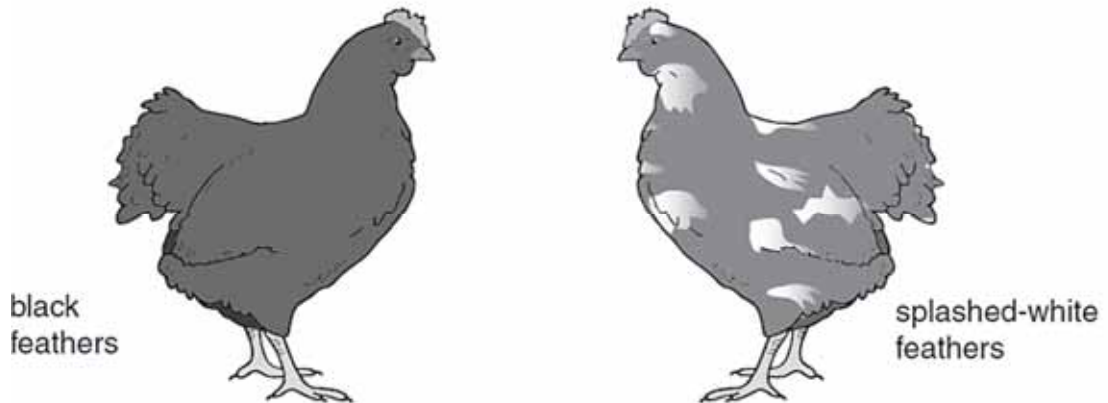


Fig. 3.1

Another gene may cause stripes on feathers (barred feathers). This gene is carried on the X chromosome. The allele for barred feathers (X^A) is dominant to the allele for nonbarred feathers (X^a).

In chickens, the male is homogametic and has two X chromosomes while the female is heterogametic and has one X chromosome and one Y chromosome.

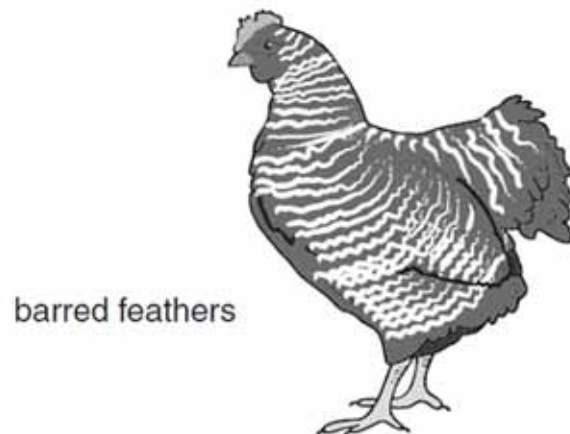


Fig. 3.2

- (i) A male chicken with black, non-barred feathers was crossed with a female chicken with splashed-white, barred feathers. All the offspring had blue feathers, but the males were barred and the females were non-barred.

Using the symbols given above draw a genetic diagram to show this cross.

[3]

- (ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

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[3]

[Total: 12]

- 4 Genetic information in humans can be obtained by DNA profiling. In DNA profiling, the polymerase chain reaction is used by a scientist to amplify a particular sequence of DNA.

(a) Briefly describe the steps of polymerase chain reaction.

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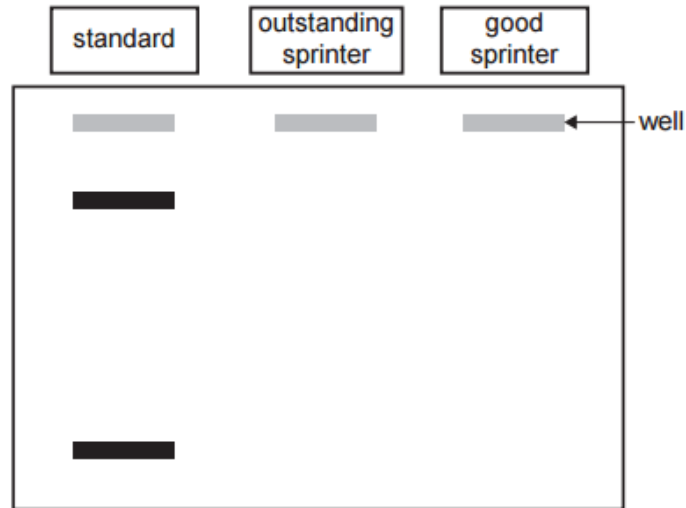
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[4]

Scientists investigating the performance of athletes found that one gene contributing to the performance of sprinters is the ACTN3 gene. There are two alleles of the gene, the 577R allele and the 577X allele. The 577X allele codes for a very short protein fragment in muscle fibres due to a stop codon mutation. The table below summarises the athletic potential for the three possible genotypes for the ACTN3 gene.

ACTN3 genotype	Athletic potential
577R / 577R	outstanding sprinter
577R / 577X	good sprinter or long-distance runner
577X / 577X	very good long-distance runner

- (b) A scientist tested sprinters to see if they possessed the 577R allele. Samples were obtained from athletes' muscle fibres. A standard containing proteins of the same lengths as the proteins coded for by both alleles 577X and 577R was used as a comparison. The standard and the samples were exposed to gel electrophoresis. In gel electrophoresis, protein molecules separate according to size and charge in the same way as DNA molecules. The result for the standard is shown below.



- (i) On the diagram of the gel above, draw the bands expected for an outstanding sprinter and for a good sprinter. [1]
- (ii) Explain why you have placed the bands in these positions. [2]

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[2]
[Total: 7]

Section B

Answer EITHER 4 or 5.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

Either

- 5 (a) Describe the structures of chloroplasts and mitochondria. [6]
- (b) State the similarities between ATP production in chloroplasts and mitochondria and suggest why these similarities exist. [6]
- (c) Distinguish between the processes of Krebs cycle and Calvin cycle. [8]

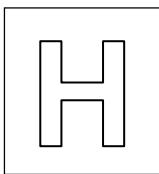
Or

- 6 (a) A guppy (*Poecilia reticulata*) is a species of small fish which originates in the freshwater mountain streams of the islands of Trinidad and Tobago.

It was observed in one stream, the guppies have bright and colorful rainbow markings, while in another nearby stream they would be less brightly colored.

Describe how natural selection may bring about the evolution of the less brightly colored guppies in the other stream. [5]

- (b) Explain how variation could arise in a sexually-reproducing population. [7]
- (c) Describe the unique features of stem cells and with reference to **named examples**, outline the normal functions of stem cells in a living organism. [8]



NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE
NAME

ANSWERS

CLASS

BIOLOGY

8875/02

Paper 2 Structured Questions

14 September 2017

Additional Materials: Answer Paper

2 hours

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For Examiner's Use	
Section A	40
1	11
2	10
3	12
4	7
Section B	20
Total	60

This document consists of **5 printed pages and 1 blank page.**

[Turn over

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

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(a) Complete Table 1.1 by using a tick (✓) to indicate the features that apply to each polymer.

Table 1.1

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				
contains glycosidic bonds				
polymer is branched				
contains nitrogen				
can be found in both animal and plant cells				

[4]

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				✓
contains glycosidic bonds	✓	✓		
polymer is branched	✓			
contains nitrogen			✓	✓
can be found in both animal and plant cells	;	;	✓;	✓;

(b) Fig. 1.1 is a simple diagram of a phospholipid molecule.

Explain how the structure of a phospholipid molecule makes it suitable for its function in cell membranes. You may label and annotate Fig. 1.1 as part of your answer.



Fig. 1.1

Structure: Hydrophilic / polar, phosphate, head / group and hydrophobic / non polar, hydrocarbon / fatty acid, tails / chains; **R** *if labelled correctly but incorrectly described in the text*

Structure: Phosphate heads faces aqueous medium and fatty acid tails faces each other / inwards / interior of the cell membrane, forming the phospholipid bilayer ;

Function: resulting in partially / selectively permeability **R** *semi-permeable* / ability to act as a barrier to, hydrophilic substances / water soluble substances / polar substances / ions / AW ;

Structure + function: Presence of unsaturated hydrocarbon tails in phospholipid results in kinks, preventing the close packing of phospholipids, thus regulating fluidity of membrane;

Max 3m

[3]

(c) State two components of a cell surface membrane other than phospholipid molecules and describe their function.

*max two components, one mark each
one mark for function to match the stated component*

Glycolipid / glycoprotein; **R** *oligosaccharide*
Receptors for cell signalling / cell-cell recognition / cell-cell adhesion;

Cholesterol;
Regulate membrane fluidity / in low temperatures increases fluidity / in high temperatures decreases fluidity / provides mechanical stability to membranes ;

Protein; **ignore any qualification of component e.g. channel / carrier / transport Receptor** for cell signalling / enzyme / channel protein / provides hydrophilic pore / channel / carrier protein / provides specific binding site for facilitated diffusion / active transport / transport of hydrophilic / polar / charged molecules ;

*max two components, one mark each
one mark for function to match the stated component*

[4]

[Total: 11]

2 Fig. 2.1 below shows a diagram of a cell. The parts of a diagram are not drawn to scale.

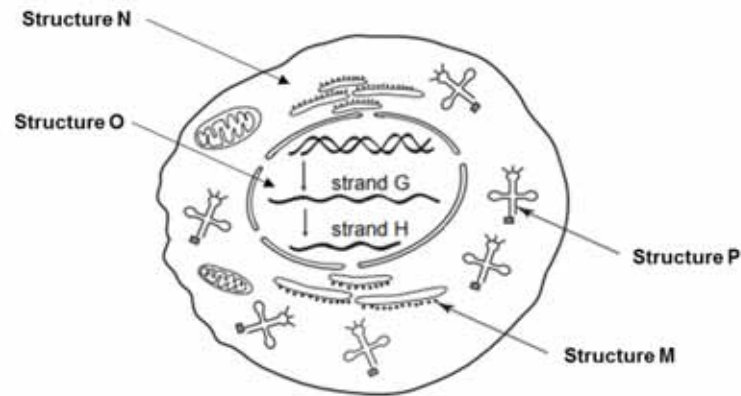


Fig. 2.1

(a) (i) In which structure would RNA polymerase be found?

Structure O which is the nucleus ;

[1]

(ii) Explain the mode of action of RNA polymerase.

Catalyses the formation of phosphodiester bond between incoming ribonucleotide and 3'OH end of the growing RNA strand ;

RNA polymerase has an active site that is complementary to the ribonucleotides in terms of shape, size, charge and orientation ;

Binding of incoming ribonucleotides to active site leads to formation of enzyme-substrate complex, which is a transition state;

Lowers the activation energy as it provides an alternative pathway for the reaction ;

[4]

(b) Strand H is shorter than strand G. Describe the process that results in this shortening, using appropriate names for both strands.

Strand G is pre-messenger ribonucleic acid while strand H is mature ribonucleic acid, after post-transcriptional modification;

Strand H is shortened due to RNA splicing as introns are removed;

[2]

(c) Name strand H and structures P and M. Explain how each contributes to **protein synthesis**.

Strand H: mature ribonucleic acid. It contains genetic information from the DNA in nucleus to the ribosomes in cytoplasm and acts as a template for protein synthesis ;

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Structure P: transfer ribonucleic acid (tRNA). It carries the correct amino acid to the ribosomes during translation ;

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Structure M: Ribosome. Contains peptidyl transferase that catalyses the formation of peptide bonds between adjacent amino acids ;

.....

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[3]
[Total: 10]

3 (a) Sometimes a gene has more than two alleles, termed *multiple alleles*.

The ABO blood group system in humans is controlled by a gene with three alleles, I^A , I^B and I^o . Alleles I^A and I^B are codominant and I^o is recessive to both.

The blood group **AB** is the result of codominance.

Explain what is meant by *codominance* in this context.

I^A allele codes for A antigen and I^B allele codes for B antigen;

Individual with genotype $I^A I^B$ will have both A and B antigens and therefore, AB blood group;

Phenotype of heterozygote different from either homozygote whereby $I^A I^A$ gives A blood group and $I^B I^B$ gives B blood group;

Ref. more than 2 phenotypes possible;

.....

[3]

- (b) In humans, a gene that codes for the production of a protein, called factor VIII, is located on the X chromosome. The dominant allele for this gene produces factor VIII, but the recessive allele does not produce factor VIII.

A person who is unable to make factor VIII has haemophilia in which the blood fails to clot properly.

Explain why a man with haemophilia cannot pass haemophilia to his son but may pass haemophilia to his grandson.

son receives Y chromosome from father / did not inherit X chromosome containing haemophilia allele from father ;

father will pass haemophilia allele to daughter(s) ;

daughter may pass allele to, her son / his grandson ;

[3]

- (c) A gene for feather colour in chickens is carried on an autosome. This gene has two alleles, black (C^B) and splashed-white (C^W). When a male chicken with black feathers is mated with a female chicken with splashed-white feathers, all the offspring have blue feathers. This also occurs when a male chicken with splashed-white feathers is crossed with a female with black feathers.

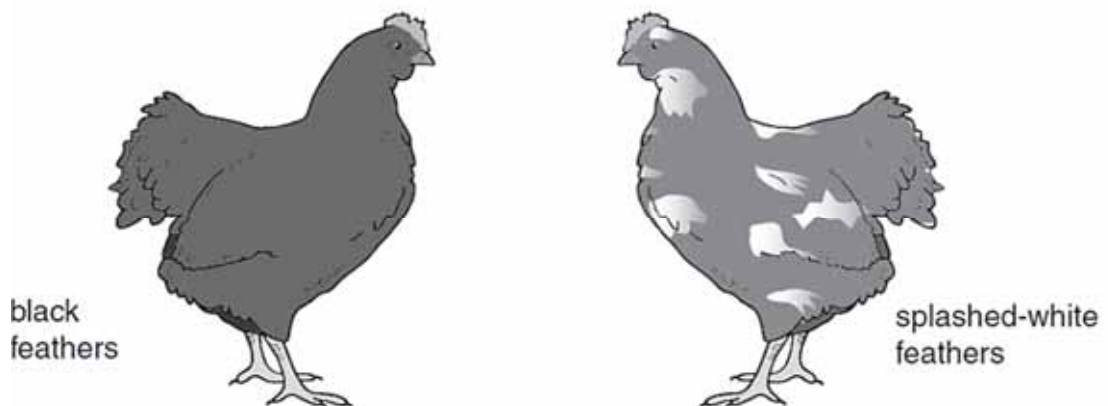


Fig. 3.1

Another gene may cause stripes on feathers (barred feathers). This gene is carried on the X chromosome. The allele for barred feathers (X^A) is dominant to the allele for nonbarred feathers (X^a).

In chickens, the male is homogametic and has two X chromosomes while the female is heterogametic and has one X chromosome and one Y chromosome.

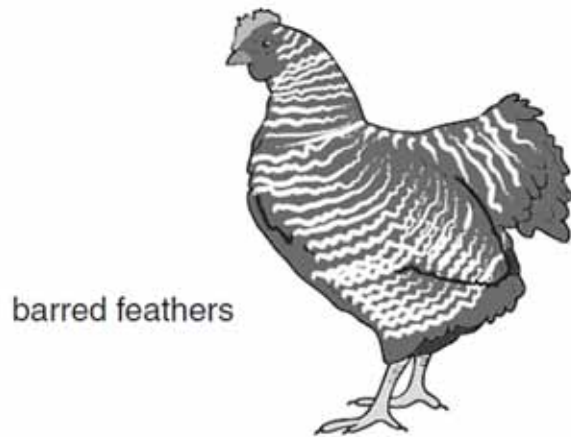


Fig. 3.2

- (i) A male chicken with black, non-barred feathers was crossed with a female chicken with splashed-white, barred feathers. All the offspring had blue feathers, but the males were barred and the females were non-barred.

Using the symbols given above draw a genetic diagram to show this cross.

(c) (i)	(male)	$C^B C^B X^a X^a$;	x	(female)	$C^W C^W X^A Y$;
	(gametes)	$C^B X^a$		$C^W X^A$	or $C^W Y$;
		$C^B C^W X^A X^a$;		$C^B C^W X^a Y$;	
		(male, blue, barred)		(female, blue, non-barred)	

accept other symbols but only with key

if male XY and female XX then mark gametes and offspring genotypes to max 2

if other symbols used but no key then mark to max 2

- 1 mark for parental genotype;
 1 mark for gametes;
 1 mark for offspring genotype and matching;

[3]

- (ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

with non-barred female (X^aY);
if all offspring barred, must be X^AX^A / homozygous ;
if some offspring non-barred, must be X^AX^A / heterozygous ;

[3]

[Total: 12]

- 4 Genetic information in humans can be obtained by DNA profiling.
In DNA profiling, the polymerase chain reaction is used by a scientist to amplify a particular sequence of DNA.

- (a) Briefly describe the steps of polymerase chain reaction.

Denaturation of double-stranded DNA to single-stranded DNA at 95°C by breaking hydrogen bonds;

Annealing of primers via complementary base pairing between primers and flanking sequence of the target DNA when temp is lowered to 50-60°C;

During elongation stage, temp increased to about 72°C where Taq polymerase catalyse the addition of deoxyribonucleotides to the 3'OH end of primers ;

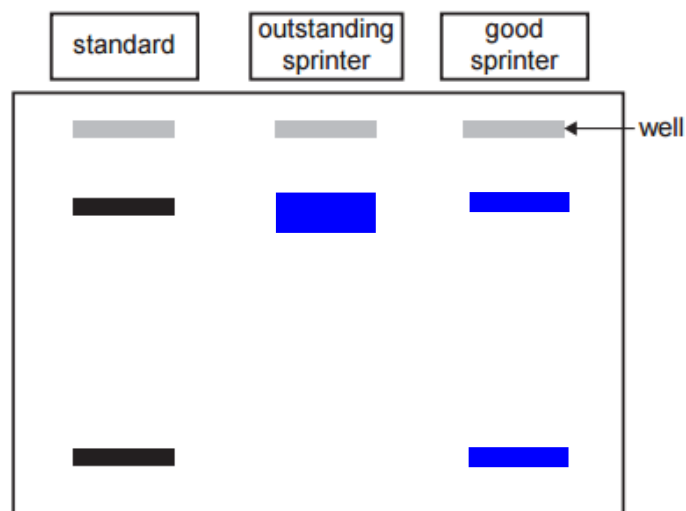
The sequential process of denaturation-annealing-elongation is repeated many times. This is called a chain reaction as the products of the previous reaction are used as reactants in the next cycle.

[4]

Scientists investigating the performance of athletes found that one gene contributing to the performance of sprinters is the ACTN3 gene. There are two alleles of the gene, the 577R allele and the 577X allele. The 577X allele codes for a very short protein fragment in muscle fibres due to a stop codon mutation. The table below summarises the athletic potential for the three possible genotypes for the ACTN3 gene.

ACTN3 genotype	Athletic potential
577R / 577R	outstanding sprinter
577R / 577X	good sprinter or long-distance runner
577X / 577X	very good long-distance runner

- (b) A scientist tested sprinters to see if they possessed the 577R allele. Samples were obtained from athletes' muscle fibres. A standard containing proteins of the same lengths as the proteins coded for by both alleles 577X and 577R was used as a comparison. The standard and the samples were exposed to gel electrophoresis. In gel electrophoresis, protein molecules separate according to size and charge in the same way as DNA molecules. The result for the standard is shown below.



- (i) On the diagram of the gel above, draw the bands expected for an outstanding sprinter and for a good sprinter. [1]
- (ii) Explain why you have placed the bands in these positions.

Outstanding sprinter only has one band as only one allele is present, thicker band due to the presence of two copies of the same allele / homozygous;

Good sprinter has two bands due to two different alleles / heterozygous;

[2]
[Total: 7]

Section B

Answer EITHER 4 or 5.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

Either

5 (a) Explain how ATP is produced in living organisms. [8]

1. Source of energy for synthesis of ATP: Photophosphorylation in chloroplast comes from light while oxidative phosphorylation in mitochondria comes from oxidation of glucose;
2. Electron transport chain are found in thylakoid membrane in chloroplasts and inner membrane in mitochondria;
3. Electrons are passed along the electron transport chain from one electron carrier to the next, each with an energy level lower than the one preceding it;
4. Energy is used to pump protons from matrix of the mitochondrion into the intermembrane space + from stroma of chloroplast into thylakoid space;
5. This produces a high concentration of H⁺ due to impermeable nature of membranes to protons, generating a steep electrochemical proton gradient;
6. Stalked particles containing ATP synthases ® **ATPase** are embedded on inner mitochondria membrane / thylakoid membrane;
7. Protons diffuse through them, synthesizing ATP by the phosphorylation of ADP with inorganic phosphate (P_i);
8. Substrate-level phosphorylation in glycolysis: synthesis of ATP using phosphate groups from glycolytic intermediates;
9. Substrate-level phosphorylation in Krebs cycle: synthesis of ATP using phosphate group from GTP;

(b) Describe the structure of chloroplast and distinguish it from the mitochondria. [7]

Structure of chloroplast:

1. Organelle bounded by a double membrane;
2. Contains 70S ribosomes and circular DNA;
3. Contains series of electron carriers forming the electron transport chain and stalked particles containing ATP synthase embedded on the thylakoid membrane;
4. Thylakoid membrane extensively folded;
5. Cylindrical in shape / rod-shaped;

Structural differences:

6. Chloroplast contains photosynthetic pigments such as chlorophyll/carotenoids but mitochondria do not;
7. Chloroplast contains starch grains while mitochondria contain glycogen granules;
8. Orientation of the stalked particles in chloroplast is such that the ATP synthase faces the stroma while that in mitochondria faces the mitochondrial matrix;

9. Inner membrane of chloroplast is thylakoid while that of mitochondria is cristae / inner mitochondrial membrane;
10. Mitochondrial matrix in mitochondria vs stroma in chloroplast;

(c) Describe, with examples, how the environment may affect the phenotype [5]

- 1 Genetically identical zygote can be different due to wide range of environment effects;
- 2 The expression of genotype may be influenced by environment factors like nutrients, light, or temperature;
- 3 E.g. Fur colour in Himalayan rabbits is affected by a temperature-sensitive enzyme involved in pigment synthesis;
- 4 Low temperature can result in active enzyme that result in black pigment formation. Thus, Himalayan rabbit are black extreme parts of the body;
- 5 E.g. Phenotypes of honey bee (drones, queen or workers) are determined by the diet of larvae during development;
- 6 Royal jelly diet will give rise a queen bee;
- 7 Spontaneous somatic mutation may occur due to exposure to harmful radiation or carcinogens and cause different phenotypes;

[Total:20]

Or

6 (a) Explain how variation could arise in a sexually-reproducing population. [8]

1. Meiosis is an important step for sexual reproduction as haploid gametes are produced;
2. Meiosis results in genetic variation as the reduction division allows the combining of genetic materials from two parents / individuals;
3. Due to crossing over of non-sister chromatids of homologous chromosomes, at the chiasmata, during prophase I;
4. Thus allowing corresponding sections to be exchanged, separating linked genes / creating new combination of alleles in each chromatid;
5. Due to independent assortment of chromosomes during metaphase I, whereby the orientation of homologous pair of chromosomes along the metaphase plate is independent of other bivalents;
6. This is followed by independent segregation during anaphase I, resulting in numerous possible chromosomal combinations in a gamete, i.e. $2n$, where n = number of homologous pairs of chromosomes;
7. In addition, during fertilization, random fusion of gametes occurs, resulting in numerous combinations of a zygote;

Maximum 2 marks on mutation;;

8. (Spontaneous) gene mutation: change in DNA sequence of a gene / change in one or a few nucleotides, giving rise to new alleles;
9. Chromosomal aberrations: change in structure of chromosomes due to translocation / deletion / duplication of chromosomal fragment + elaboration;
10. Chromosomal aberration: change in number of chromosome i.e aneuploidy / polyploidy – extra / lack of one chromosome or sets of chromosomes + elaboration;

(b) Describe how natural selection may bring about the evolution of the Galapagos finches.

1. Selection pressure: limited / different food source which led to the variety of beaks in different species of Galapagos finches
2. Idea of adaptive radiation: development of a variety of species from a single ancestral form (idea of descent with modification)
3. Variation in terms of beak size and shape exist between individuals within the Galapagos finches population
4. Individual finches who are better adapted to obtaining the food source will survive till maturity and produce fertile, viable offspring compared to the others
5. Ref to passing down of beneficial alleles to the offspring, accumulate genetic differences over long periods of time, leading to evolution of the finches

[5]

(c) Describe the unique features of stem cells and with reference to named examples, distinguish between pluripotent and multipotent stem cells.

Unique features of stem cells:

1. Stem cells are unspecialised cells ;
2. During a single division, they can divide into one genetically identical daughter cell and another more specialised daughter cell which can undergo further differentiation ;
3. They are capable of dividing and renewing themselves for long periods ;
4. They can give rise to specialised cell types according to internal / external signals ;

Differences:

- 5 Pluripotent stem cells such as embryonic stem cells can differentiate into almost any cell type to form any organ or any cell type ;
- 6 While multipotent stem cells such as blood / haematopoietic stem cells can differentiate into a limited range of cell type, usually of a closely-related family of cells;
- 7 Embryonic stem cells can give rise to the three primary germ layers: ectoderm, endoderm and mesoderm (which subsequently give rise to the multiple specialised cell types that form the heart, lungs, skin and other tissue) while blood / haematopoietic stem cells can differentiate into red blood cells, white blood cells, platelets etc. (for cell replacement / tissue repair) ;
- 8 Pluripotent stem cells like ESCs are not totipotent but are multipotent ;
- 9 Pluripotent stem cells like ESCs are obtained from the blastocyst in an embryo while multipotent stem cells like blood / haematopoietic stem cells are adult stem cells that can be found in organs / tissues such as the brain, bone marrow, skeletal muscle, skin or liver;

[7]

[Total:20]