MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examination 2018
Higher 1

CANDIDATE NAME								
CIVICS GROUP	1	7					INDEX NUMBER	

H1 BIOLOGY 8876/01

Paper 1 Multiple Choice **20 September 2018**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid/tape.
Write your name, civics group and index number on the Multiple Choice Answer Sheet provided.

There are **thirty** questions in 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 Multiple Choice Answer Sheet.

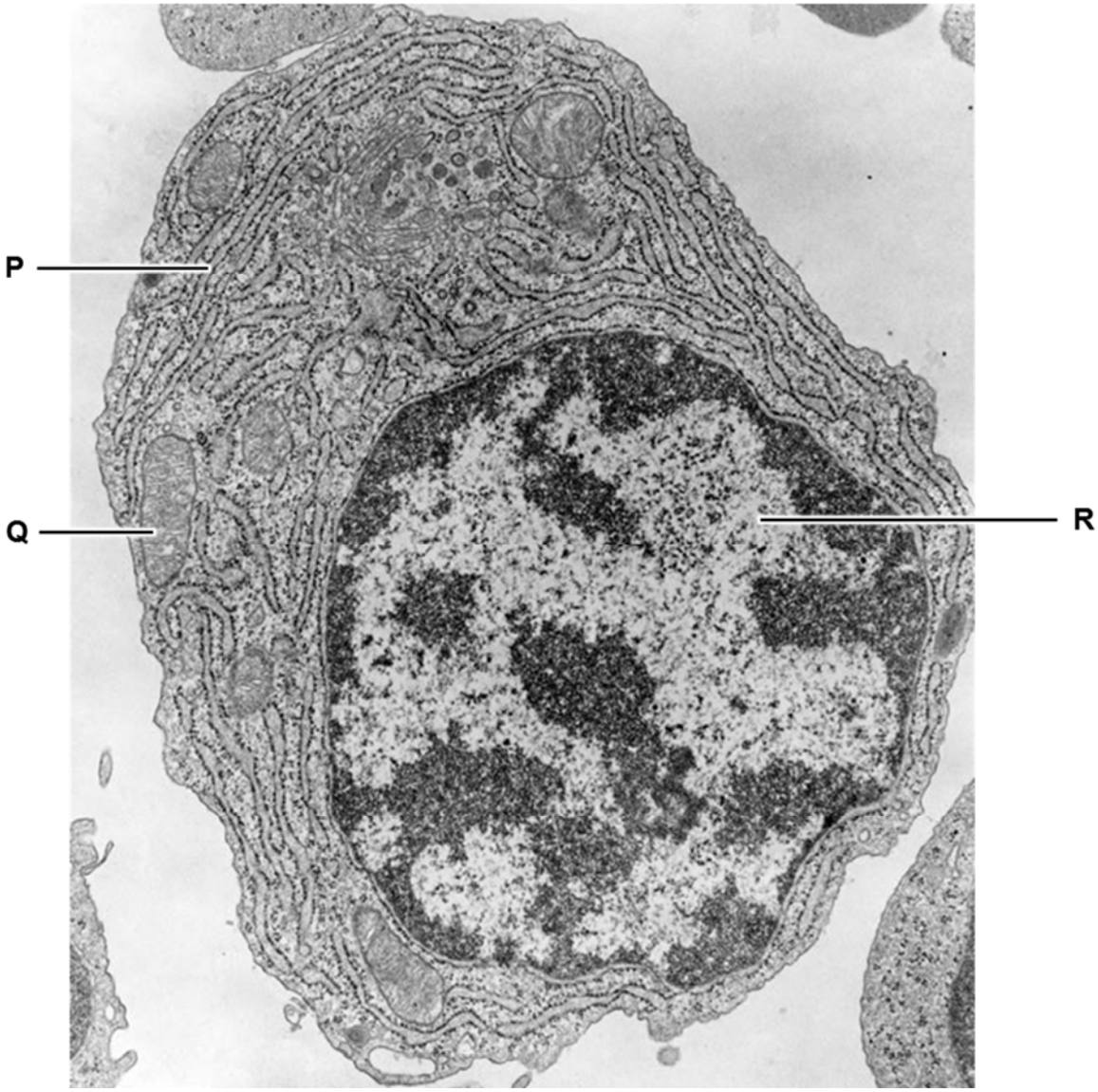
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

At the end of the examination, you may bring home Paper 1 question paper.

This document consists of **15** printed pages.

[Turn over]

QUESTION 1
The diagram shows an electron micrograph of a cell.



Which row correctly describes structures **P** – **R**?

	P	**Q**	**R**
A	synthesis of ribosomes	substrate level phosphorylation	active replication of genes
B	provision of large surface area for attachment of ribosomes	formation of ATP from light energy	active transcription of genes
C	synthesis of membrane proteins	oxidative decarboxylation	active transcription of genes
D	transport of proteins to Golgi apparatus	modification of mRNA transcripts	active replication of genes

QUESTION 2
A ribosome consists of a large and a small subunit, each subunit containing ribosomal RNA (rRNA) complexed with proteins.

Which sequence of events concerning ribosomes is correct?

A Within the nucleolus, rRNA and proteins are synthesised and subunits are formed. They become membrane bound as they are exported through the nuclear envelope to the cytoplasm and rough endoplasmic reticulum (rER).

B rRNA and proteins are synthesised in the Golgi body and are transported to the nucleolus for subunit formation.

C rRNA is synthesised in the nucleolus and proteins are synthesised by the rough endoplasmic reticulum (rER). Subunit formation occurs within the cytoplasm for free ribosomes and on the surface of the rER for attached ribosomes.

D rRNA synthesised within the nucleolus is complexed with proteins that have been imported from the cytoplasm. The subunits formed are exported to the cytoplasm via the nuclear pores.

QUESTION 3
Which two features contribute to the great tensile strength of cellulose?

1 glycosidic bonds linking the long chains of 1,4 α-glucose molecules

2 the –OH groups of the glucose molecules project outwards and form hydrogen bonds with neighbouring chains

3 the strength of the glycosidic bonds between the neighbouring chains of molecules

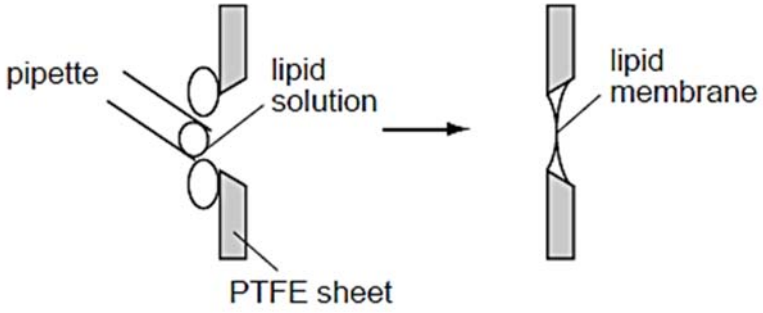
4 the successive glucose molecules are orientated at 180° to each other

A 1 and 3 only **B** 1 and 4 only **C** 2 and 3 only **D** 2 and 4 only

QUESTION 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, Na^+ ions did not flow across the membrane until a substance called gramicidin was added.



Which statement is consistent with this information and your knowledge of membrane structure?

Gramicidin becomes incorporated into the membrane and is

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 hydrophilic regions.

QUESTION 5
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 the strongest evidence that mitochondria and chloroplasts in eukaryotes originated as prokaryotic endosymbionts?

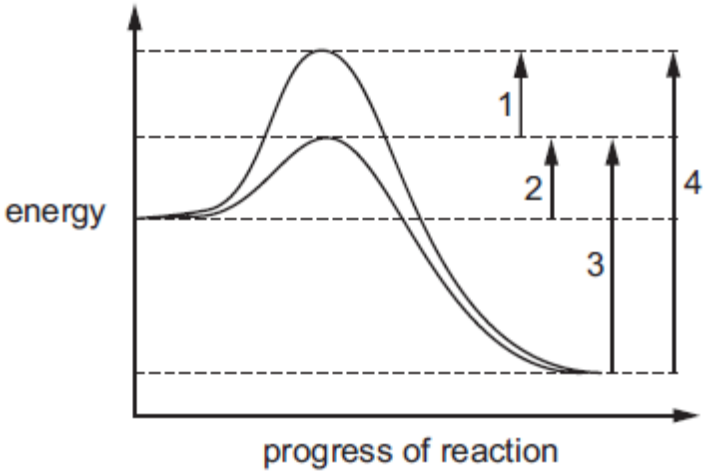
A Proteins encoded by the nucleus are exported to these organelles.

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

C They are surrounded by a double membrane.

D They contain their own DNA and have 70S, rather than 80S, ribosomes.

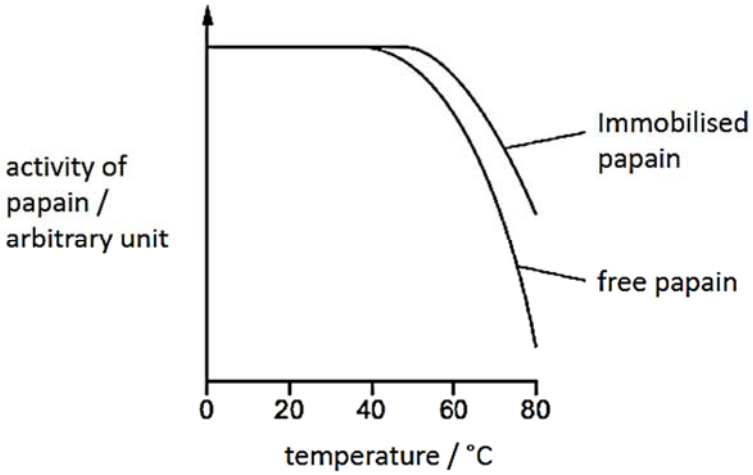
QUESTION 6
The graph shows energy changes in a chemical reaction.



What is the activation energy when an enzyme is added?

A 1 + 2 **B** 2 only **C** 3 – 2 **D** 4

QUESTION 7
The graph compares the effect of temperature on the activity of the protease enzyme, papain, when in solution (free) and when immobilised in alginate beads.



Which statement about the effect of immobilisation of papain is correct?

A It increases the stability of papain at higher temperatures.

B It alters the shape of papain's active site at higher temperatures.

C It decreases the activity of papain at higher temperatures.

D It reduces the number of collisions of papain with the substrate.

QUESTION 8
The table contains results recorded by a student from an investigation into the effect of temperature on an enzyme-catalysed reaction. All other variables were standardised.

temperature / ˚C	rate of reaction / arbitrary units
10	3
20	7
30	16
40	33
50	32
60	14

What can be best concluded from the results?

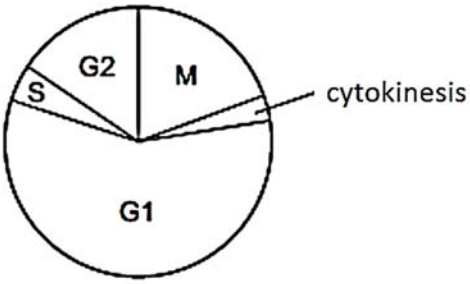
A The enzyme had the highest kinetic energy at 40˚C.

B The data for 50˚C was anomalous.

C The optimum temperature was between 30˚C and 50˚C.

D The enzyme was held by only disulfide bonds at 60˚C.

QUESTION 9
The diagram shows the cell cycle of a mammalian cell.



Checkpoints in the cell cycle of mammals prevent the cycle from continuing when mistakes are made or DNA is damaged.

Four of the checkpoints are described.

1 Mitosis is blocked if DNA replication is incomplete.

2 Anaphase is blocked if the assembly of chromatids on the spindle is unsuccessful.

3 DNA replication is blocked if DNA is damaged.

4 DNA replication stops if damage to DNA has not been repaired.

In which phases of the cell do these checkpoints occur?

	checkpoint			
	1	2	3	4
A	M	G1	S	G2
B	G2	M	G1	S
C	G2	S	G1	M
D	S	G2	M	G1

QUESTION 10
Which statement helps to explain how genetically identical cells are produced during the mitotic cell cycle?

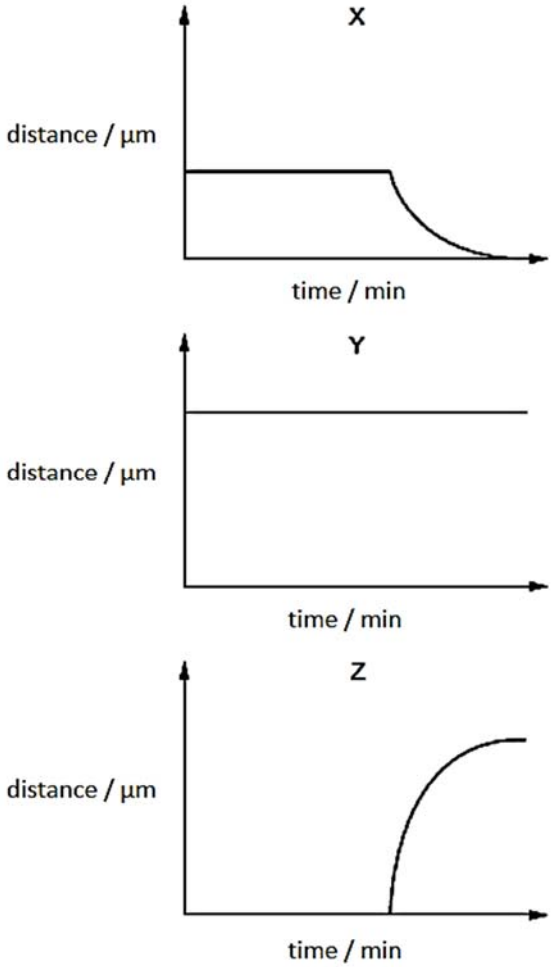
A There is only one origin of replication, which ensures that DNA replication begins at a controlled site.

B Checkpoints of cell division are carefully regulated.

C Complementary base pairing occurs during DNA replication.

D RNA polymerase can correct some mistakes during transcription.

QUESTION 11
The graphs show various distance measurements taken from metaphase of mitosis onwards. The graphs are to scale when compared to one another.



Which row correctly identifies the distance measurement for each graph?

	X	Y	Z
A	distance between poles of spindle	distance between sister chromatids	distance of centromeres from poles of spindle
B	distance between poles of spindle	distance of centromeres from poles of spindle	distance between sister chromatids
C	distance of centromeres from poles of spindle	distance between poles of spindle	distance between sister chromatids
D	distance of centromeres from poles of spindle	distance between sister chromatids	distance between poles of spindle

QUESTION 12
Which molecules are found in both cytoplasm and the nucleus of a typical eukaryotic cell?

1 DNA nucleotides

2 DNA polymerase

3 RNA nucleotides

4 RNA polymerase

A 1, 2, 3 and 4 **B** 1, 2 and 4 only **C** 2, 3 and 4 only **D** 3 and 4 only

QUESTION 13
Two polynucleotide strands make up a DNA molecule.

What is a correct description?

A The percentage of cytosine is 50% of that of guanine in the whole molecule.

B The percentage of cytosine is the same as that of guanine in each strand.

C The percentage of cytosine is the same as that of guanine in the whole molecule.

D The percentage of cytosine is the same in each strand of the molecule.

QUESTION 14
Which of the following statements explain the difference in the direction in which the two strands of a DNA molecule are synthesised?

1 The replication of DNA is semi-conservative.

2 DNA polymerase can only add deoxyribonucleotides to the 3'OH group.

3 Each DNA molecule consists of two anti-parallel polynucleotides.

4 The synthesis of the lagging strand requires many more RNA primers.

A 1 and 2 only **B** 2 and 3 only **C** 1, 2 and 4 only **D** 2, 3 and 4 only

QUESTION 15
Scientists have made a nucleic acid (HNA) that has a sugar with the same number of carbon atoms as glucose instead of deoxyribose. Although genetic information can be stored by HNA, naturally occurring DNA polymerase cannot replicate HNA.

Which statements could explain why naturally occurring DNA polymerase cannot replicate HNA?

1 DNA polymerase cannot form bonds between the sugars of two HNA nucleotides.

2 DNA polymerase cannot form hydrogen bonds between two HNA nucleotides.

3 HNA nucleotides do not fit into the active site of naturally occurring DNA polymerase.

4 The shape of an HNA nucleotide is slightly larger than that of a DNA nucleotide.

A 3 and 4 only **B** 1 and 4 only **C** 2 and 3 only **D** 1, 2, 3 and 4

QUESTION 16
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 be formed because RNA can have a specific three-dimensional conformation.

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

QUESTION 17
The codons UGU and UGC code for the amino acid cysteine, which can form disulfide bonds in a polypeptide.

The codon UGG codes for the amino acid tryptophan, which does not contain a sulfur atom.

The codon UGA is a stop signal.

The DNA triplet code for the 10th amino acid in a particular polypeptide is ACA.

Which single base substitutions in this triplet code will result in **no** disulfide bond being formed with the 10th amino acid in the polypeptide?

A ACC and ACG

B ACG and ACT

C ACT and ACC

D ACT only

QUESTION 18
Exceptions to the universal genetic code are found in mammalian mitochondria, as shown in the table.

mRNA codon	in mammalian cytoplasm, codes for	in mammalian mitochondria, codes for
AGA	arginine	stop
AGG	arginine	stop
AUA	isoleucine	methionine
UGA	stop	tryptophan

A short length of DNA triplet code with the following base sequence was transcribed.

TATTCTTCCACT

How many peptide bonds would be formed by ribosomes during translation in mammalian cell cytoplasm and in mammalian mitochondria?

	mammalian cell cytoplasm	mammalian mitochondria
A	2	1
B	2	0
C	3	0
D	3	1

QUESTION 19
Which statement(s) describe(s) how a gene mutation can lead to the production of a non-functional protein?

1 During transcription an incorrect nucleotide is added to a DNA molecule.

2 A codon in the mRNA transcribed from the mutated gene is changed.

3 The order of the bases in an anticodon on tRNA is altered during translation.

4 The sequence of nucleotides in the promoter of the gene is altered.

A 2 only **B** 1 and 2 only **C** 2 and 4 only **D** 2, 3 and 4 only

QUESTION 20
The following discoveries were made about myostatin, a protein that is produced in mammalian skeletal muscle cells.

- Myostatin circulates in the blood and acts on muscle tissue to slow down further differentiation and growth of muscle cell precursors called myoblasts.
- In racehorses that were bred true, a mutation involving the substitution of a single nucleotide has been identified in the *MSTN* gene which codes for myostatin.
- At the site of this mutation, the DNA nucleotide has either a cytosine (C) base or a thymine (T) base, giving race horses three possible genotypes for this mutation: CC, CT or TT.
- At two years of age, racehorses with the *MSTN* CC genotype have greater muscle mass than those with the TT genotype.

Which of the following statements may be best concluded from the above?

A Racehorses with the CC genotype contain hyperactive myostatin protein in their muscle tissue.

B In racehorses with the CC genotype, there is a change in the reading frame of the mRNA codon from the site of the mutation.

C All racehorses with the CC genotype are able to run faster than those with the CT and TT genotype.

D Racehorses with the TT genotype develop more muscles later in life.

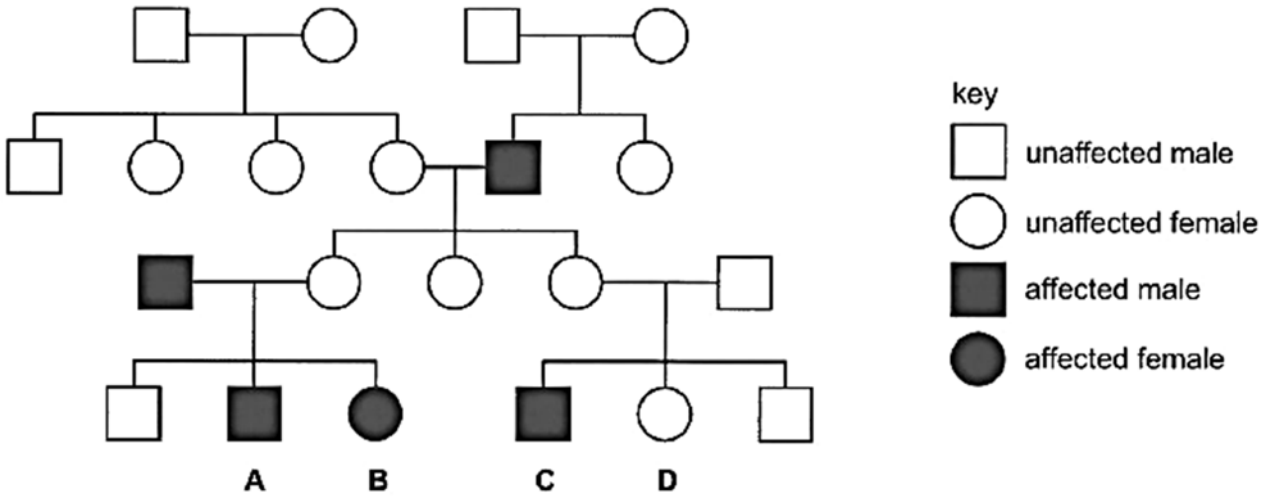
QUESTION 21
The Himalayan variety of rabbits has white hair on the body and black hair on the feet, tail, ears and face. The allele for the Himalayan rabbit pigment pattern, c^h, is recessive to the alleles for normal colour (all hair agouti), C, as well as dark chinchilla (all dark grey hair), c^{chd}, and is dominant to the allele for albino (all white hair, no pigment production), c. All of the alleles of this gene produce different versions of the same enzyme involved in pigment production.

A patch of white fur was removed from a Himalayan rabbit and an ice pack secured to the skin. The fur that grew back on the patch was black.

Which of the following statements is correct?

	Genotypes of Himalayan rabbits	**Explanation for pigment pattern in Himalayan rabbits**
A	c^hc^h only	The enzyme is denatured at the high skin temperatures found on the rabbits' bodies
B	cc only	The enzyme becomes inactive at the low skin temperatures found on the rabbits' feet, tail, ears and face
C	c^hc^h and c^hc only	The enzyme is denatured at the high skin temperatures found on the rabbits' bodies
D	c^hc^h and c^hc only	The enzyme becomes inactive at the low skin temperatures found on the rabbits' feet, tail, ears and face

QUESTION 22
The pedigree diagram shows the inheritance of an X-linked recessive trait in humans.
If the recessive allele is r, which individual possesses the genotype rr?



QUESTION 23
Uncontrolled cell division can form tumours.

Which statement is correct for tumour cells **only**?

A Metaphase does not take place.

B Cytokinesis does not occur.

C Interphase takes less time.

D They have mutated DNA.

QUESTION 24
What are the products of glycolysis?

1 pyruvate

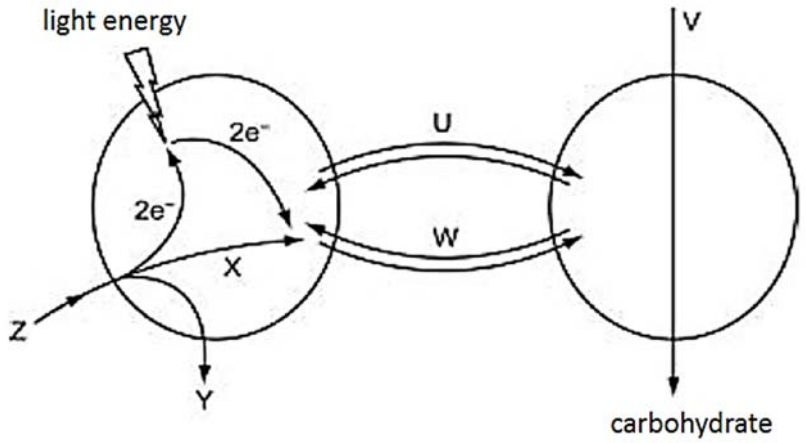
2 reduced FAD

3 reduced NAD

4 reduced NADP

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 2 and 4

QUESTION 25
The diagram summarises the reactions of photosynthesis in a plant.



Which of the following correctly identifies the substances involved?

	CO_2	reduced NADP	H_2O	ADP	2H	O_2
A	U	W	Y	V	Z	X
B	U	X	Z	W	Y	Z
C	V	U	Z	W	X	Y
D	V	W	Y	U	X	Z

QUESTION 26
Some apples can be stored in controlled atmospheric conditions for up to a year. Taste and texture are maintained by using conditions that reduce the production of a fruit-ripening plant hormone while limiting the build-up of ethanol. Ethanol damages the fruit.

The storage conditions needed include low temperature (1˚C), high carbon dioxide concentration (1.2%) and low oxygen concentration (0.9%).

Why are these conditions needed?

1 Low oxygen concentration favours anaerobic respiration.

2 Enzyme activity is reduced.

3 Conversion of sugar to ethanol is minimised.

4 High carbon dioxide concentration promotes photosynthesis.

A 1, 2 and 3 **B** 1, 2 and 4 **C** 2 and 3 only **D** 3 and 4 only

QUESTION 27
Which of the following describe processes that lead to an increase in variation?

1 breaking and re-joining in homologous chromosomes during prophase I of meiosis

2 random distribution of homologous chromosomes to the cell poles during anaphase I of meiosis

3 random variation in allele frequency with time that may result in alleles becoming more common

4 the production of new alleles by substitution of one base for another in DNA

A 1 and 4 only **B** 2 and 3 only **C** 1, 2 and 4 only **D** 1, 3 and 4 only

QUESTION 28
The skin of a small amphibian contains a substance, tetrodotoxin (TTX), that is deadly to all predators except the common garter snake. TTX acts by blocking membrane ion channels involved in muscular movement. Some of the garter snakes slow down for a few hours after eating the amphibian, but are not otherwise harmed.

Some variants of the amphibian have higher toxicity because of higher TTX production, while some variants of the garter snake have higher resistance. Where snakes have not been exposed to TTX, the snake variants with higher resistance have been observed to move more slowly than those with normal resistance.

From the information provided above, what is **not** a valid suggestion concerning natural selection and evolution in the amphibian and the garter snake?

A A selection pressure acting against the garter snake with higher resistance is the amphibian variant with normal toxicity.

B Locations with the most toxic amphibian variants are likely to have the most resistant garter snake variants.

C Predation by garter snakes is the selection pressure for increasing toxicity of the prey; the selection pressure acting against the most resistant garter snakes is predation.

D TTX resistance is likely to involve a mutation in the gene coding for the membrane ion channels.

QUESTION 29
By which mechanism do greenhouse gases contribute to global warming?

A Their higher concentration absorbs more long wave radiation coming from the sun.

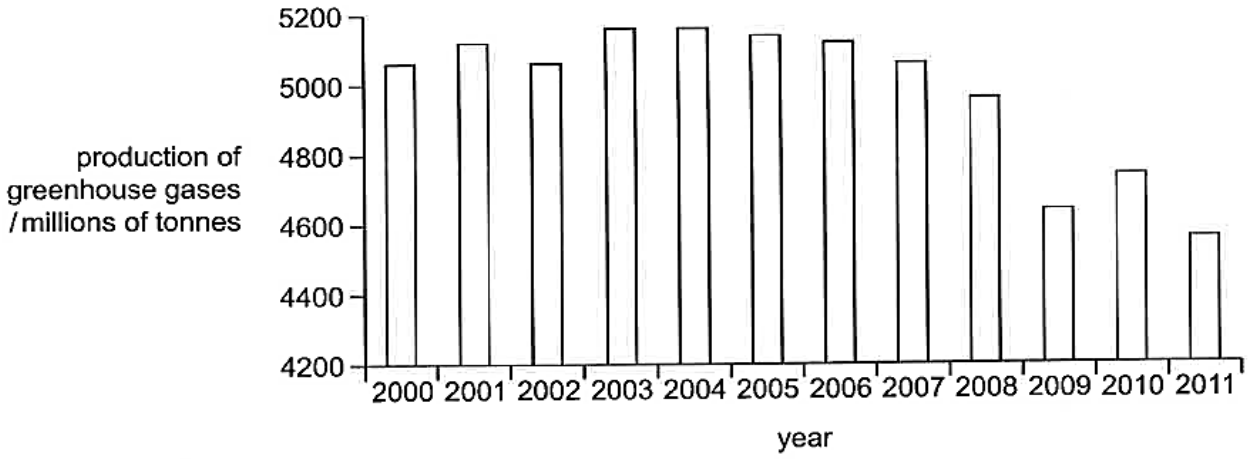
B Short wave radiation emitted from the Earth's surface increases with their concentration.

C They absorb higher amounts of long wave radiation emitted from the Earth's surface as their concentration increases.

D They absorb higher amounts of short wave radiation caused by increased combustion of fossilized organic matter.

QUESTION 30

The bar chart shows the production of greenhouse gases (carbon dioxide and methane) from agriculture in the European Union (EU) from 2000 to 2011, measured in millions of tonnes.



Which of the following could contribute to the trend seen between 2003 and 2009?

A conversion of intensive farmland into woodland reserves

B greater use of agricultural machinery for harvesting

C increased consumption of meat-based products

D increased import and export of crops between EU countries

End of Paper

H1 Biology Prelim Paper 1 Answers

1. C	**6. B**	**11. C**	**16. D**	**21. C**	**26. C**
2. D	**7. A**	**12. A**	**17. C**	**22. B**	**27. C**
3. D	**8. C**	**13. C**	**18. B**	**23. C**	**28. A**
4. C	**9. B**	**14. B**	**19. A**	**24. B**	**29. C**
5. D	**10. C**	**15. A**	**20. D**	**25. C**	**30. A**

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examination 2018
Higher 1

CANDIDATE NAME	

CIVICS GROUP	1	7				

INDEX NUMBER		

H1 BIOLOGY

8876/02

Paper 2

12 September 2018
2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not 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.

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	/ 9
2	/ 10
3	/ 11
4	/ 15
Section B	
5 or 6	/ 15
Total	/ 60

This document consists of **14** printed pages

[Turn over]

Section A

Answer **all** questions in this section

QUESTION 1

(a) Distinguish the processes of facilitated diffusion and active transport. [3]

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(b) A group of students investigated the uptake of chloride ions in barley plants. They divided the plants into two groups and placed their roots in solutions containing radioactive chloride ions.

- Group **A** plants had a substance that inhibited respiration added to the solution.
- Group **B** did not have the substance added to the solution.

The students calculated the total amount of chloride ions absorbed by the plants every 15 minutes. Their results are shown in Fig. 1.1.

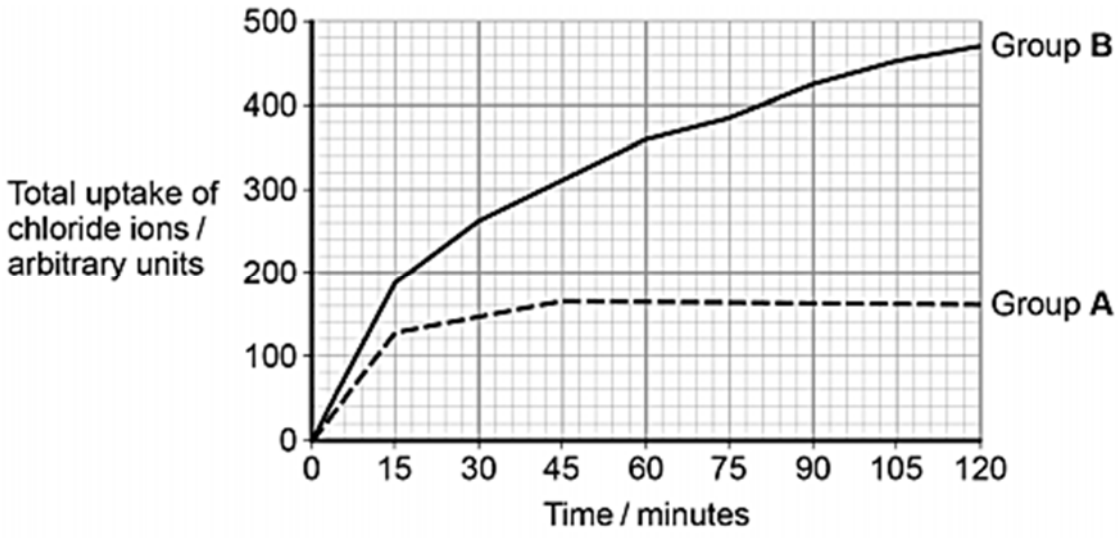

Fig. 1.1

(i) Calculate the ratio of the **rate** of uptake of chloride ions in the first hour to the **rate** of uptake of chloride ions in the second hour for group **B** plants. [2]

(ii) Explain the results shown in Fig 1.1. [4]

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[Total: 9]

QUESTION 2

Bone marrow contains many stem cells. Some of these stem cells are responsible for the replacement of white blood cells.

Fig. 2.1 shows the production of a white blood cell from one of these stem cells.

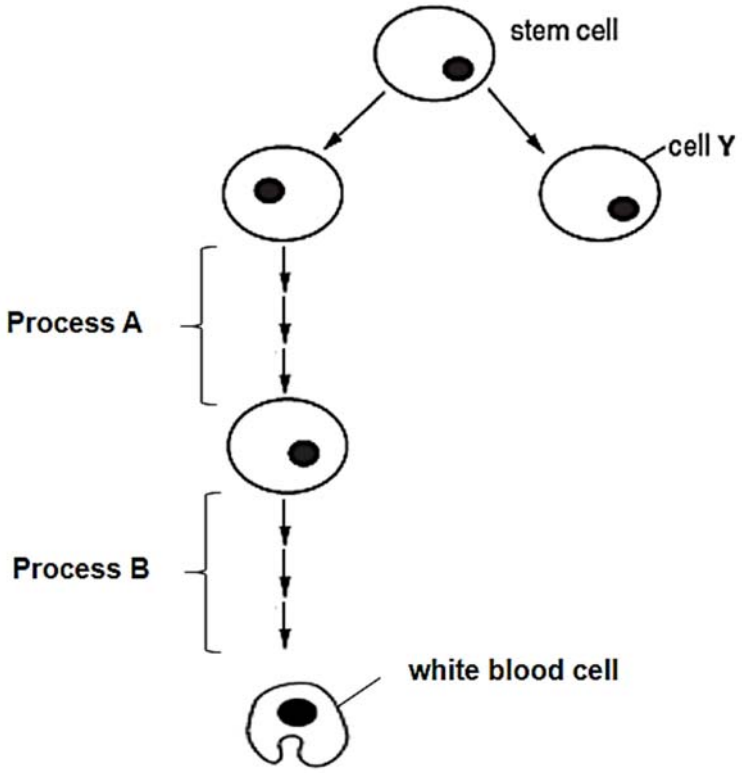

Fig. 2.1

(a) (i) State the potency of the stem cells found in the bone marrow. [1]

……..

(ii) Name the processes **A** and **B**. [2]

A ……

B ……

(iii) Suggest what may happen to cell **Y**. [1]

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The human induced pluripotent stem cells (HiPS cells) can be derived from fully differentiated adult somatic cells such as white blood cells. This has been hailed as an effective replacement for human embryonic stem cells for its usefulness in regenerative medicine.

Recent research shows that abnormal reprogramming can occur during the induction of HiPS cells and tumours could be generated.

(b) (i) Compare the embryonic stem cell and HiPS cell. [3]

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(ii) Comment on the ethical issues involved in the use of HiPS cells. [3]

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[Total: 10]

QUESTION 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 the term *multiple alleles*. [2]

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(b) Crosses between heterozygous parents with the genotype $C^{y}C^{b}$ always produce a ratio of two yellow mice to one black mouse. Explain the observation using a genetic diagram. [3]

(c) 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. [2]

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

- some yellow offspring and some agouti offspring
- some yellow offspring and some black and tan offspring
- some yellow offspring and some black offspring. [2]

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(d) 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]

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[Total: 11]

QUESTION 4

Malaria is a mosquito-borne infectious disease caused by the malarial parasites, *Plasmodium falciparum*, which is transmitted among humans by the female mosquito vectors *Anopheles*.

(a) Outline the general life cycle of a mosquito. [3]

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Malaria was common in Italy, a European country situated in the Northern Hemisphere. Widespread land drainage together with the use of the insecticide DDT and the drug chloroquine eradicated both the mosquito vectors and the malarial parasites in the 1950s. Due to the success of these measures, they were later discontinued as they were no longer necessary.

Articles in the scientific literature more recently show that malarial mosquitoes are returning to Italy and increasing their numbers and their northerly range, with some cases of malaria being reported. In general, winters are milder and summers are hotter in the south of the country, with temperatures decreasing to the north, especially in the winters.

(b) Discuss whether the return of malaria to Italy can be attributed to climate change. [4]

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(c) Chloroquine-resistant (CQR) malarial parasites, *P. falciparum,* were first reported in 1950s and are now widespread. The resistance is caused by mutations of a gene known as *pfcrt*.

(i) Explain why CQR *P. falciparum* are now widespread. [3]

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Analysis of *pfcrt* in CQR *P. falciparum* from different parts of the world shows differences in one section of the gene only. The amino acid sequences coded for by this section are shown in Table 4.1, together with the amino acid sequence coded for by the allele found in parasites that are still susceptible to chloroquine (non-CQR). The amino acid sequence coded for by the rest of the gene is the same in all cases.

Table 4.1

allele of *pfcrt* gene	amino acid sequence coded for by allele of *pfcrt* gene
non-CQR	—Cys—Met—Asn—Lys—His—Ala—Glu—Asn—Ile —Met—
CQR from Africa	—Cys—Ile —Glu—Thr—His—Ser—Glu—Ser—Ile —Ile —
CQR from Asia	—Cys—Ile —Glu—Thr—His—Ser—Glu—Ser—Thr—Ile —
CQR from Peru and Brazil	—Ser—Met—Asn—Thr—His—Ser—Gln—Asp—Leu—Arg—
CQR from Colombia	—Cys—Met—Glu—Thr—Gln—Ser—Gln—Asn—Ile —Thr—

(ii) With reference to Table 4.1, calculate the mean number of different amino acids coded for by CQR alleles in comparison with the non-CQR allele. Show your working. [2]

mean number of different amino acids ……..

In the non-CQR *P. falciparum*, chloroquine accumulates in the digestive vacuole of *P. falciparum* and interferes with the detoxification of haem in the host red blood cell. This results in parasite death.

Research shows that there is a point mutation in the *pfcrt* gene of CQR *P. falciparum* which leads to the formation of a chloroquine-resistance transporter located in the digestive vacuole membrane of CQR *P. falciparum*.

This mutation changes the amino acid from lysine to threonine at the binding site of the chloroquine-resistance transporter.

(iii) Using the information provided, suggest how this mutation of *pfcrt* gene increases the chloroquine resistance in *P. falciparum*. [3]

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[Total: 15]

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, were appropriate.
Your answers must be in continuous prose, where appropriate.
You answers must be set out in parts **(a)**, **(b)**, etc., as indicated in the question.

QUESTION 5

(a) Following cytokinesis, one of the daughter cells may not have a nucleolus. This cell is able to divide once more and then the new daughter cells die.

Explain how the cell is able to survive for one more cell division and suggest why the new daughter cells then die. [7]

(b) The same parents may produce offspring that are different in appearance. Discuss how this is brought about. [8]

[Total: 15]

QUESTION 6

(a) All cells, from bacteria to humans, express their genetic information via the central dogma of molecular biology which depicts the flow of genetic information from DNA to protein.

Outline the processes involved in the central dogma of molecular biology, and explain, using an example, why the central dogma may not always hold true. [7]

(b) The expression of genes gives rise to proteins that affect the biochemical reactions and other processes in organisms.

Discuss, with examples, the importance of specific shapes of proteins in organisms. [8]

[Total: 15]

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End of Paper

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examination 2018
Higher 1

CANDIDATE NAME	

CIVICS GROUP	1	7					INDEX NUMBER		

H1 BIOLOGY

Paper 2

ANSWER SCHEME

8876

12 September 2018
2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not 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.

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	/ 9
2	/ 10
3	/ 11
4	/ 15
Section B	
5 or 6	/ 15
Total	/ 60

Section A

Answer **all** questions in this section

QUESTION 1

(a) Distinguish the processes of facilitated diffusion and active transport. [3]

- Facilitated diffusion involves transport of substances **down a concentration gradient** whereas active transport occurs **against a concentration gradient**.
- Facilitated diffusion **does not require ATP** whereas active transport **requires ATP**.
- Facilitated diffusion involves **channel or carrier proteins** whereas active transport only involves **protein pump**.
- .

(b) A group of students investigated the uptake of chloride ions in barley plants. They divided the plants into two groups and placed their roots in solutions containing radioactive chloride ions.

- Group **A** plants had a substance that inhibited respiration added to the solution.
- Group **B** did not have the substance added to the solution.

The students calculated the total amount of chloride ions absorbed by the plants every 15 minutes. Their results are shown in Fig. 1.1

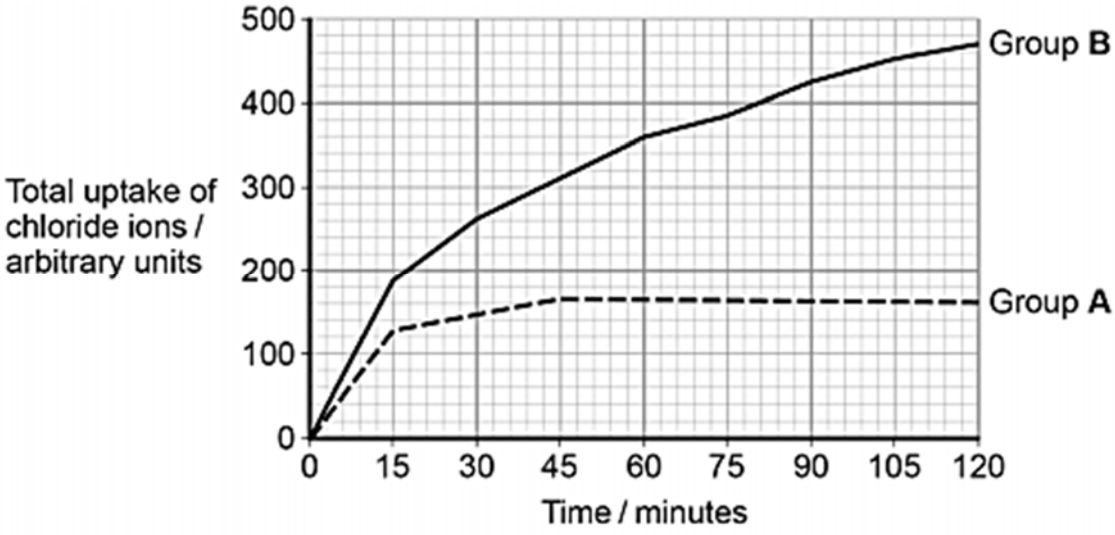

Fig. 1.1

(i) Calculate the ratio of the **rate** of uptake of chloride ions in the first hour to the **rate** of uptake of chloride ions in the second hour for group **B** plants. [2]

rate of uptake in the first hour = $\frac{360 - 0}{60}$

= 6 au min^{-1}

rate of uptake in the second hour = $\frac{470-360}{60}$

= 1.83 au min^{-1}

Ratio = 6/ 1.83 = **3.3 : 1**

(ii) Explain the results shown in Fig 1.1 [4]

- In Group A, **from 0-15 mins**, the initial rate of uptake of chloride ions is slower as only **facilitated diffusion** occurred.
- In Group A, **from 45-120 mins**, the total uptake of chloride ions **levels off/plateaus** because the concentrations of chloride ions inside cells and outside cells is the **same/reached equilibrium**.
- In Group B, **from 0-15 mins**, the initial rate of uptake of chloride ions is faster as both **facilitated diffusion** and **active transport** occurred.
- In Group B, **from 15-120 mins,** the total uptake of chloride ions continued to increase because the uptake of chloride ions is **against concentration/did not reach an equilibrium**.
- In Group B, **from 15-120 mins**, the rate of uptake **slows down** as **fewer chloride ions in external solution/ respiratory substrate is used up**.

[Total: 9]

QUESTION 2

Bone marrow contains many stem cells. Some of these stem cells are responsible for the replacement of white blood cells.

Fig. 2.1 shows the production of a white blood cell from one of these stem cells.

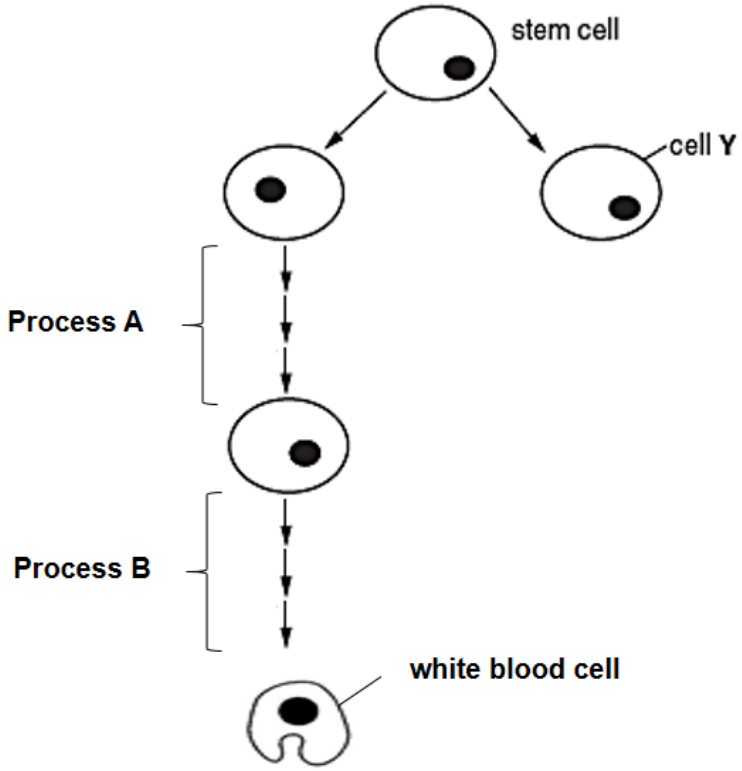

Fig. 2.1

(a) **(i)** State the potency of the stem cells found in the bone marrow. [1]

- Multipotent

(ii) Name the processes **A** and **B**. [2]

- **Process A – Mitosis**
- **Process B – Differentiation**

(iii) Suggest what may happen to cell **Y**. [1]

- Remains as a stem cell
- Undergoes cell division/mitosis
- Undergoes differentiation to become specialised cells

The human induced pluripotent stem cells (HiPS cells) can be derived from fully differentiated adult somatic cells such as white blood cells. This has been hailed as an effective replacement for human embryonic stem cells for its usefulness in regenerative medicine.

Recent research shows that abnormal reprogramming can occur during the induction of HiPS cells and tumours could be generated.

(b) (i) Compare the embryonic stem cell and HiPS cell. [3]

Difference

- Embryonic stem cell is obtained from **Inner cell mass of blastocyst** / **embryos** whereas HiPS cells are obtained from **differentiated somatic cell**

Similarities [any 2]

- Both are pluripotent /have the potential to become any cell type in the adult body but not those of the extra-embryonic membranes
- Both have **self-renewing capabilities** / can **divide continually**
- Both are **unspecialised/undifferentiated**

(ii) Comment on the ethical issues involved in the use of HiPS cells. [3]

- Overcome ethical issue of using embryonic stem cells for treatment as it does not involve killing of embryo.
- No tissue rejection involved as the HiPS cells are derived from the patient
- [idea of] Treatment to benefit patients/ alleviate the suffering of many people
- [idea of] Safety concerns on the use of HiPS cells.
- Potential to develop into a human embryo/ to clone human being/produce germ cells

[Total: 10]

QUESTION 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 the term *multiple alleles*. [2]

- Gene that exists in **more than two allelic forms** in a given population
- **only two** of which can be present in a **diploid** organism

(b) Crosses between heterozygous parents with the genotype $C^{y}C^{b}$ always produce a ratio of two yellow mice to one black mouse. Explain the observation using a genetic diagram. [3]

Parental phenotype:	Yellow mouse	x	Yellow mouse		**[1]**
Parental genotype (2n):	C^{y} C^{b}	x	C^{y} C^{b}		
Gametes (n):	C^{y} C^{b}	x	C^{y} C^{b}		**[1]**
F_1 genotype (2n):	C^{y} C^{y}	C^{y} C^{b}	C^{y} C^{b}	C^{b} C^{b}	
F_1 phenotype:	mouse dies	yellow fur	yellow fur	black fur	**[1]**
F_1 phenotypic ratio:	yellow fur : black fur 2 : 1				

(c) 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. [2]

- Agouti allele (C^{a}) is **dominant** to black allele (C^{b})
- Parents with agouti fur has genotype of $\mathbf{C^{a}\ C^{a}}$ or $\mathbf{C^{a}\ C^{b}}$
- Parents with black fur has genotype of $\mathbf{C^{b}\ C^{b}}$

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

- some yellow offspring and some agouti offspring
- some yellow offspring and some black and tan offspring
- some yellow offspring and some black offspring. [2]

- yellow allele (C^{y}) is dominant to all alleles (C^{a}, C^{bt}, C^{b})
- Agouti allele (C^{a}) and black and tan allele are dominant to black allele (C^{b}) OR black allele is recessive to all other alleles
- Yellow mice is heterozygous at the gene locus

(d) 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]

- Cross black and tan mouse with black mouse (C^b C^b)
- If **all** offspring is black and tan, then parent is homozygous (C^{bt} C^{bt})
- If some offspring are black and some are black and tan, then parent is heterozygous (C^{bt} _)

[Total: 11]

QUESTION 4

Malaria is a mosquito-borne infectious disease caused by the malarial parasites, *Plasmodium falciparum*, which is transmitted among humans by the female mosquito vectors *Anopheles*.

(a) Outline the general life cycle of a mosquito. [3]

- The female mosquitoes lay **eggs** in stagnant **water**
- develop as **larvae and pupae in water** [sequence must be correct]
- mature/develop into an **adult mosquito**.

Malaria was common in Italy, a European country situated in the Northern Hemisphere. Widespread land drainage together with the use of the insecticide DDT and the drug chloroquine eradicated both the mosquito vectors and the malarial parasites in the 1950s. Due to the success of these measures, they were later discontinued as they were no longer necessary.

Articles in the scientific literature more recently show that malarial mosquitoes are returning to Italy and increasing their numbers and their northerly range, with some cases of malaria being reported. In general, winters are milder and summers are hotter in the south of the country, with temperatures decreasing to the north, especially in the winters.

(b) Discuss whether the return of malaria to Italy can be attributed to climate change. [4]

[Yes]

- Range extending further north may relate to **warmer temperatures**
- [idea of] higher temperature lead to increase in number of mosquitoes due to e.g. hasten the life cycle of mosquitoes due to increased metabolism
- Climate change leads to **increase in rainfall** may result in **more flooded areas for mosquitoes to breed**

[No]

- Return of malaria was due to the **discontinued use of DDT**
- [idea of] Mosquitos could be introduced into Italy from the surrounding countries
- [idea of] The parasite thrive and spend most of their life cycle in host body temperature (37°C) hence ambient temperature has hardly any effect on their survival

(c) Chloroquine-resistant (CQR) malarial parasites, *P. falciparum,* were first reported in 1950s and are now widespread. The resistance is caused by mutations of a gene known as *pfcrt*.

(i) Explain why CQR *P. falciparum* are now widespread. [3]

- **Variation** in the population of *P. falciparum* due to random **mutations**
- Use of chloroquine acts as **selection pressure** on the *P. falciparum* population
- Chloroquine-resistant *P. falciparum* are at **selective advantage** and are likely to survive to reproduce
- ..and pass their **CQR allele/ mutated *pfcrt* allele** to their **fertile and viable offspring**
- **Allele frequency** for **CQR allele/ mutated *pfcrt* increases** over **many generations** within the *P. falciparum* population.

Analysis of *pfcrt* in CQR *P. falciparum* from different parts of the world shows differences in one section of the gene only. The amino acid sequences coded for by this section are shown in Table 4.1, together with the amino acid sequence coded for by the allele found in parasites that are still susceptible to chloroquine (non-CQR). The amino acid sequence coded for by the rest of the gene is the same in all cases.

Table 4.1

allele of *pfcrt* gene	amino acid sequence coded for by allele of *pfcrt* gene
non-CQR	—Cys—Met—Asn—Lys—His—Ala—Glu—Asn—Ile —Met—
CQR from Africa	—Cys—Ile —Glu—Thr—His—Ser—Glu—Ser—Ile —Ile —
CQR from Asia	—Cys—Ile —Glu—Thr—His—Ser—Glu—Ser—Thr—Ile —
CQR from Peru and Brazil	—Ser—Met—Asn—Thr—His—Ser—Gln—Asp—Leu—Arg—
CQR from Colombia	—Cys—Met—Glu—Thr—Gln—Ser—Gln—Asn—Ile —Thr—

(ii) With reference to Table 4.1, calculate the mean number of different amino acids coded for by CQR alleles in comparison with the non-CQR allele. Show your working. [2]

$\frac{6 + 7 + 7 + 6}{4}$ [1]

= **6.5** [1]

mean number of different amino acids ……..

In the non-CQR *P. falciparum*, chloroquine accumulates in the digestive vacuole of *P. falciparum* and interferes with the detoxification of haem in the host red blood cell. This results in parasite death.

Research shows that there is a point mutation in the *pfcrt* gene of CQR *P. falciparum* which leads to the formation of a chloroquine-resistance transporter located in the digestive vacuole membrane of CQR *P. falciparum*.

This mutation changes the amino acid from lysine to threonine at the binding site of the chloroquine-resistance transporter.

(iii) Using the information provided, suggest how this mutation of *pfcrt* gene increases the chloroquine resistance *in P. falciparum*. [3]

- **Base-pair substitution of a nucleotide at the 1st or 2nd nucleotide of the triplet** in the *pfcrt* gene of CQR *P. falciparum*
- ..**change in mRNA codon** that **codes for threonine** instead of **lysine**
- ..alters the **shape of the** **binding site** of pfcrt protein to become **complementary to chloroquine /** change the **charge of the binding site** in pfcrt protein to allow **binding to chloroquine**
- ..chloroquine are **transported out** of the digestive vacuole.

[Total: 15]

Section B

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QUESTION 5

(a) Following cytokinesis, one of the daughter cells may not have a nucleolus. This cell is able to divide once more and then the new daughter cells die.

Explain how the cell is able to survive for one more cell division and suggest why the new daughter cells then die. [7]

[Function of nucleolus]

1. The nucleolus is a site where **rRNA genes** are located and **transcribed** to produce **rRNA**.

2. The nucleolus is also the **site of assembly** of rRNA and ribosomal proteins to form the large and small **subunits of the ribosomes**.

3. Cells **without nucleolus** are **unable to synthesize ribosomes** that are required for translation to take place.

[How the cell without a nucleolus is able to survive for one more cell division]

4. Though this daughter cell has no nucleolus, it **contains sufficient ribosomes** derived **from the parental cell** during cell division, but is unable to produce new ribosomes.

5. Hence this cell is still able to use the ribosomes to **make proteins** to carry out **cellular activities**, allowing it to undergo cell division once more.

[Why the new daughter cells then die]

6. The new daughter cells produced have **no nucleoli**.

7. [idea of] The amount of ribosomes derived from the parental cell is insufficient to meet the demand of the cell (new daughter cells have half the original number of ribosomes present in the abnormal daughter cell).

8. As **insufficient ribosomes** cannot synthesize sufficient proteins to drive cellular processes/meet cellular demands (e.g. respiration), the new daughter cells die.

QWC [1]
Processes communicated accurately with no ambiguity.

(b) The same parents may produce offspring that are different in appearance. Discuss how this is brought about. [8]

1. [Definition of a gene] A **gene** is a **discrete unit of hereditary information** consisting of **specific nucleotide sequence in DNA**

2. Genetic information is encoded in gene which **determines the phenotype**

Different gametes produced by same parents due to:

Germline mutation

3. Mutations occur in **germ cells** of the parents which produce gametes that can be **inherited by the offspring** during fertilization to produce different phenotype.

Meiosis

4. During **prophase I**, **crossing-over between non-sister chromatids of homologous chromosomes** occur. This results in exchange of alleles between corresponding gene loci.

5. During **metaphase I** and **anaphase I**, there is **independent assortment and segregation of homologous chromosomes** respectively. The resulting daughter cells are different as each has only one of the two homologous chromosomes.

6. During **metaphase II** and **anaphase II,** there is **independent assortment and segregation of non-identical sister chromatids respectively**.

7. These processes give rise to a large number of **different chromosome combinations** in the **gametes.**

Random fertilisation of gametes

8. **The random fusion of gametes** from two different parents during **fertilization** adds variation to the offspring/ results in different appearance in the offspring

Phenotypic variation due to environment

9. **Genes can interact with the environment** to give rise to phenotypic variation /different appearance of the offspring

QUESTION 6

(a) All cells, from bacteria to humans, express their genetic information via the central dogma of molecular biology which depicts the flow of genetic information from DNA to protein.

Outline the processes involved in the central dogma of molecular biology, and explain, using an example, why the central dogma may not always hold true. [7]

[Transcription] max 3

1. **General transcription factors** and **RNA polymerase** bind to the **promoter**

2. **One** of the DNA strands is used as the **template** to synthesize **mRNA**

3. Template read from **3' to 5'**, mRNA synthesized from **5' to 3'**

4. RNA polymerase add ribonucleotides by **complementary base pairing** via **hydrogen bonds**

5. Catalyzes formation of **phosphodiester bonds** between adjacent ribonucleotides.

[Translation] max 3

6. **Mature mRNA** used as a **template** to synthesize **polypeptide**

7. mRNA read from **5' to 3'**, three bases (**codon**) at a time

8. Ribosome peptidyl transferase catalyses **peptide bond** between adjacent amino acids

9. **Each codon** codes for **one amino acid**

10. Punctuated: **AUG start**, **UAA/UGA/UAG stop**

[Why central dogma is not always true] – any 1

11. Flow may be reverse, from **RNA to DNA**
    Ref. to HIV: (+)ssRNA reverse transcribed to ssDNA

12. Flow may **end at RNA**
    Ref. to tRNA / rRNA

QWC [1]

Central Dogma processes communicated accurately and to include one specific example

(b) The expression of genes gives rise to proteins that affect the biochemical reactions and other processes in organisms.

Discuss, with examples, the importance of specific shapes of proteins in organisms.

[8]

1. Active site of enzyme has specific shape that substrate can fit into
2. Via lock and key mechanism
3. *[Importance]* To form enzyme-substrate complex/ products important for metabolic pathways / increase the rate of reaction
4. *[Example]* any *enzyme and substrate*

5. DNA to fit into binding site of proteins (point 6-9, 16-19)
6. *[Importance]* Ref. to **DNA replication**
7. *[Example]* DNA polymerase binds to 3'OH group of existing nucleotide/ helicase binds to origin of replication/ topoisomerase binds to DNA to unzip the double-stranded
8. *[Importance]* Ref. to **transcription**
9. *[Example]* **transcription factor** binding to DNA / **RNA polymerase** binds to promoter

10. Binding of substances to transport proteins
11. *[Importance]* Allows for movement of substances across cell membrane
12. *[Example]* transmembrane protein e.g. Na+ channel, Na+K+ pump, glucose transporter etc

13. *[Example]* Haemoglobin is made up of **4 polypeptides** and their **haem groups** to form a specific conformation
14. *[Importance]* allows it to **bind to oxygen molecules** to form oxyhaemoglobin/ transport oxygen to all parts of the body
15. Reference to **cooperative binding**

16. *[Importance]* Ref. to **separation of sister chromatids during anaphase**
17. E.g. kinetochore to bind to centromere via complementary shape

18. *[Importance]* Ref. to **amino acid activation**
19. E.g. tRNA anticodon bind to the anticodon attachment site of amino-acyl tRNA synthetase

QWC [1]
Importance of specific shapes communicated accurately and to include at least two examples

End of Paper