Civics Group	Index Number	Name (use BLOCK LETTERS)

H1

ST ANDREW'S JUNIOR COLLEGE
2018 JC2 Prelims

H1 BIOLOGY **8876/01**

Paper 1: Multiple Choice

Tuesday 18th Sept 2018 1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser (not supplied)
Soft pencil (type B or HB is recommended, not supplied)

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 the multiple choice answer sheet in the spaces provided.

There are **30** 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 separate multiple choice answer sheet.

INFORMATION TO CANDIDATES

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

At the end of the examination, submit the multiple choice answer sheet and question paper separately.

This document consists of **18** printed pages.

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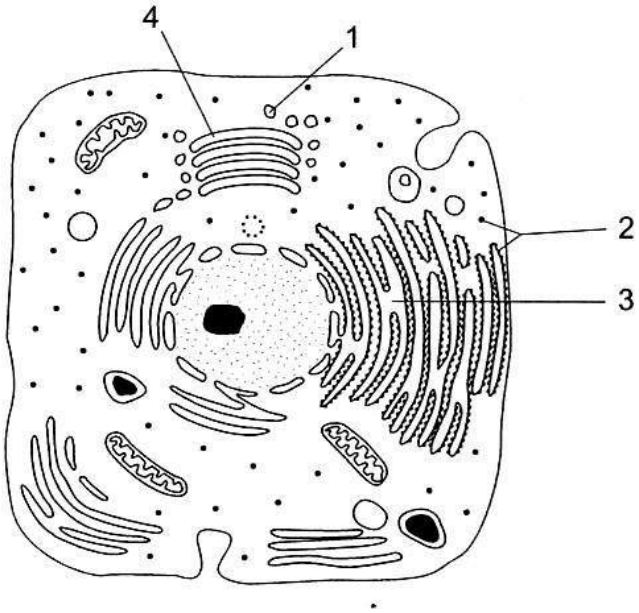
1 The figure below shows the structure of an animal cell.



Which of the following correctly identifies the functions of the labelled structures?

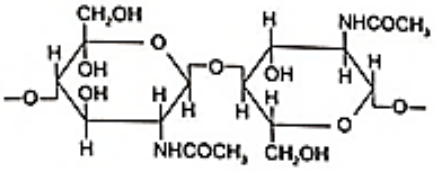
	Synthesising polypeptides from amino acids	Transporting proteins	Carrying out glycosylation	Secreting digestive enzymes
A	2	1	4	3
B	1	4	2	3
C	2	3	4	1
D	1	3	2	4

2 Nucleases are enzymes that hydrolyze phosphodiester bonds. In which of the following cell organelle(s) would one expect to see activity of this enzyme?

1 rough endoplasmic reticulum
2 mitochondrion
3 chloroplast
4 Golgi apparatus

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

3 The diagrams show short sections of some common polysaccharides and modified polysaccharides.



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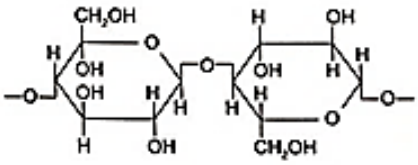

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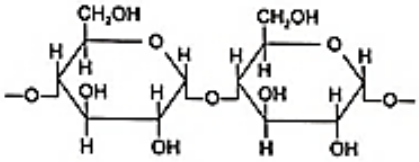

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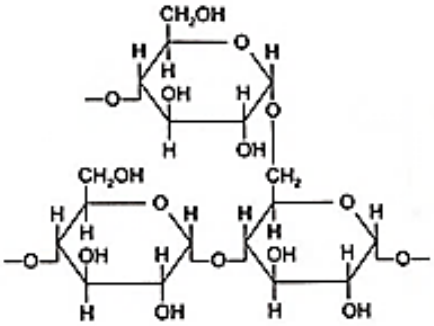

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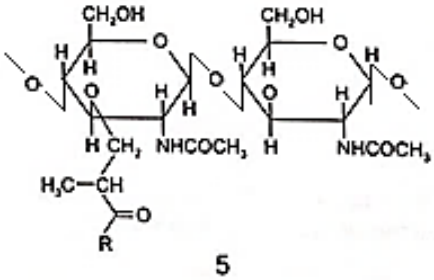


5

The polysaccharides can be described as below.

- Polysaccharide **F** is composed of β-glucose monomers with 1,4 glycosidic bonds.
- Polysaccharide **G** is composed of α-glucose monomers with 1,4 and 1,6 glycosidic bonds.
- Polysaccharide **H** is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with β-1,4 glycosidic bonds.
- Polysaccharide **J** is composed of α-glucose monomers with 1,4 glycosidic bonds.
- Polysaccharide **K** is composed of N-acetylglucosamine monomers with β-1,4 glycosidic bonds.

Which shows the correct pairings of polysaccharide descriptions and diagrams?

	Polysaccharide				
	F	**G**	**H**	**J**	**K**
A	2	4	5	3	1
B	2	5	4	1	3
C	3	4	1	2	5
D	3	5	4	1	2

4 Which statement is true for phospholipid, but **not** for protein?

A Its molecules have hydrophilic and hydrophobic components.
B Its molecules are synthesized from non-identical sub-units.
C It is a barrier to polar molecules.
D It is found in cell membranes.

5 With reference to carrier proteins, which of the following statements is/are true for all carrier proteins?

1 They contain binding sites for specific molecules or ions.
2 They directly require ATP to transport substances across the membrane.
3 They are soluble globular proteins.
4 They are embedded in membranes.

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

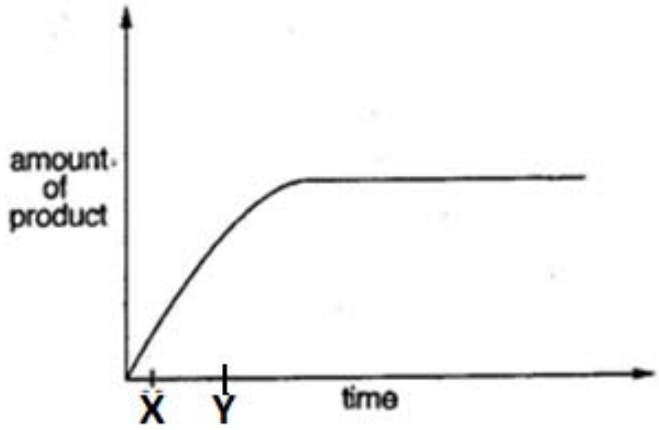
6 The list shows three characteristics of enzyme activity.

1 Reaction rate decreases if the concentration of non-competitive inhibitor increases.
2 Reaction rate is reduced at extremes of pH.
3 Reaction rate is reduced at low temperature.

What explains each of these characteristics?

	Availability of active sites is reduced	**Reduced kinetic energy reduces the rate of molecular collisions**	**Hydrogen bonding is disrupted**
A	1	2	3
B	2	1	3
C	1	3	2
D	2	3	1

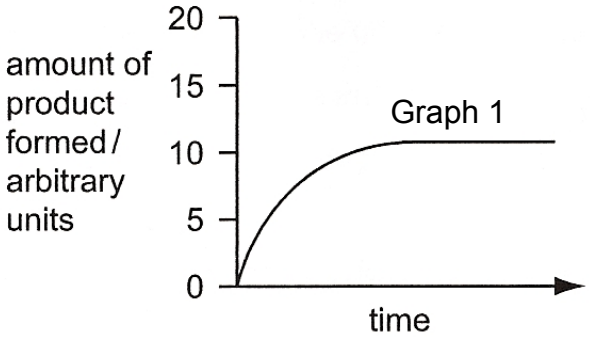
7 The graph below shows the amount of product formed in an enzyme-catalysed reaction over a certain period of time at 37°C.



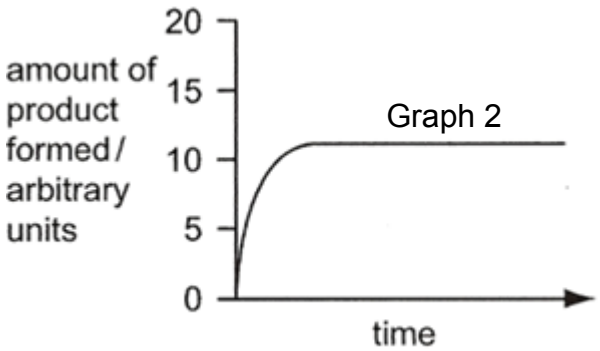
What is true at time **X**?

A Most enzyme molecules will have free active sites.
B The number of unreacted substrate molecules is high.
C The number of enzyme-substrate complexes is low.
D The rate of enzymatic reaction is lower than at time **Y**.

8 Graph 1 below shows the amount of product formed by a standard concentration of salivary enzymes and a standard concentration of substrate at a temperature of 15°C and pH of 7.



A change in condition(s) results in Graph 2.

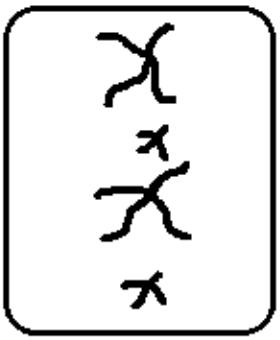


Which of the following conditions can best explain Graph 2?

1 Doubling of substrate concentration
2 Doubling of enzyme concentration
3 Increasing temperature to 20°C
4 Decreasing pH to 2

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

9 The diagram below shows metaphase of mitosis in a cell of an organism.



Each homologous pair of chromosomes in this organism contains 4 gene loci. This organism was genotyped and found to be heterozygous at all gene loci. The organism reproduces sexually via the production of millions of gametes by meiosis.

What is the maximum possible number of genetically different gametes that can be produced by this organism, assuming crossing over does not occur during meiosis in all cells?

A 2
B 4
C 16
D 256

10 Hybrid species can be produced from cabbage and radish.
The table below shows the chromosome numbers in the parental species and the hybrids.

type of cell	number of chromosomes per cell
parental cabbage	18
parental radish	18
parental gametes	9
F1 hybrids	18
F1 gametes	9
F2 hybrids	18
F2 gametes	18
F3 hybrids	36

Chromosomal mutation occurred at one stage. At which stage did it occur?

A during the formation of the F1 gametes.
B during the formation of the F2 gametes.
C during the fusion of the parental gametes.
D during the fusion of the F1 gametes.

11 3 different polynucleotide molecules (X, Y and Z) were isolated from a eukaryotic cell. One of them is a double-stranded DNA gene, while the other two are the pre-mRNA and mature mRNA that the DNA gene codes for.

The adenine nucleotide content of all 3 molecules was examined and shown in the table below:

Molecule	**Percentage of adenine nucleotides in the molecule / %**
X	49
Y	52
Z	53

Based on the information given, which of the following conclusions is/are valid and true?

1 X is definitely the DNA gene.
2 Z is definitely the mature mRNA.
3 The pre-mRNA molecule has more uracil than guanine in it.
4 Y has more purine nucleotides than pyrimidine nucleotides in it.

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

12 Which of the following order of steps is true for transcription?

1 RNA polymerase II binds to promoter
2 Primase adds a RNA primer to the 3' end of template strand
3 General transcription factors recognize and bind to TATA box of promoter
4 DNA polymerase III adds complementary deoxyribonucleotides to the 3' end of the growing DNA chain
5 RNA polymerase II transcribes a DNA sequence which codes for a polyadenylation signal (AAUAAA) in the RNA transcript
6 RNA polymerase II transcribes a stop codon
7 RNA polymerase II adds complementary ribonucleotides to the 3' end of the growing RNA chain
8 DNA polymerase III binds to promoter
9 Primer is hydrolyzed and replaced by deoxyribonucleotides

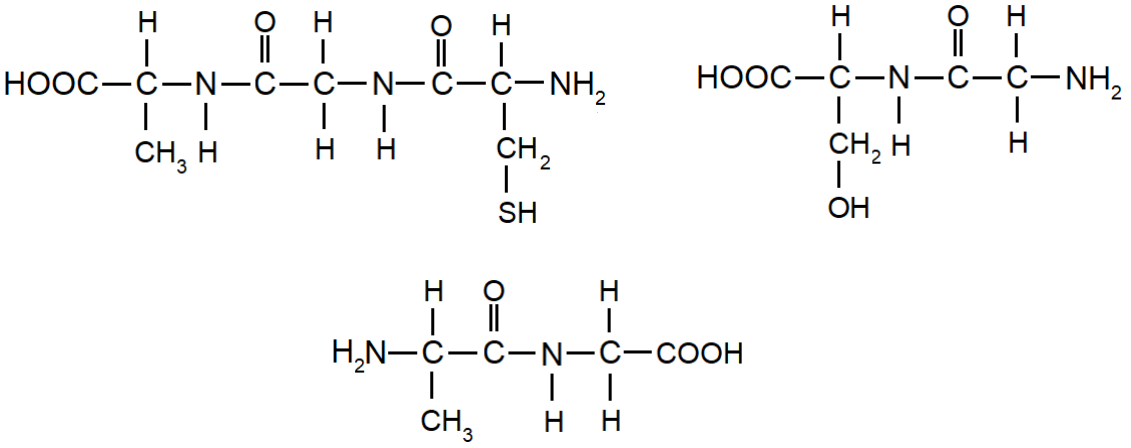
A 2, 1, 7, 5
B 2, 8, 4, 9
C 3, 1, 7, 5
D 3, 1, 7, 6

13 In an experiment, polypeptide A, which is coded for by a non-mutated version of a prokaryotic gene, was cleaved by a particular protease.

The cleavage produced 2 fragments, one of which contains the C-terminus of polypeptide A and is 5 amino acids long. This 5-amino-acid-long fragment, now called Peptide B, was then isolated for further investigation.

A solution containing many molecules of Peptide B was treated with another protease, called Protease X. The solution was analysed after the treatment and was found to contain various different fragments of different lengths and sequences.

The structures of 3 of these fragments are shown below:



It is known that Protease X is able to cleave any peptide bonds within the molecule of Peptide B. However, the cleavage of all peptide bonds within a single molecule is rare.

The mRNA codons involved in the synthesis of the Peptide B portion of Polypeptide A are shown below:

Amino acid	R group	mRNA codon
Glycine	H	5’ – GGC – 3’
Alanine	CH_3	5’ – GCC – 3’
Serine	CH_2OH	5’ – UCC – 3’
Cysteine	CH_2SH	5’ – UGU – 3’

Which of the following correctly shows a single point mutation in the portion of the template DNA sequence that codes for Peptide B, leading to a single amino acid substitution?

A 5’ – GGA GCC GCC GCC ACA – 3’
B 5’ – GCC GGA ACA GCC GCC – 3’
C 5’ – GCC GCC ACA GGA GCC – 3’
D 5’ – ACA GCC GCC GCC GGA – 3’

14 Translation did not occur successfully in a eukaryotic organism. Analysis of the structures in the cell revealed the following:

Structure	Presence (√) / Absence (X)
Free floating aminoacyl-tRNAs	√
Initiator tRNA- small ribosomal subunit complex	√
Initiator tRNA (base-pairing with AUG codon) in the P-site of large ribosomal subunit	√
Second aminoacyl-tRNA in the A-site of large ribosomal subunit	√
Polypeptide chain	X

Which is the most probable explanation for these observations?

A peptidyl-transferase is not functioning properly
B aminoacyl tRNA synthetases fail to attach amino acids to tRNA
C there is an error in the scanning for the start codon by tRNA-small ribosomal subunit complex
D release factor fails to hydrolyze polypeptide chain from the tRNA

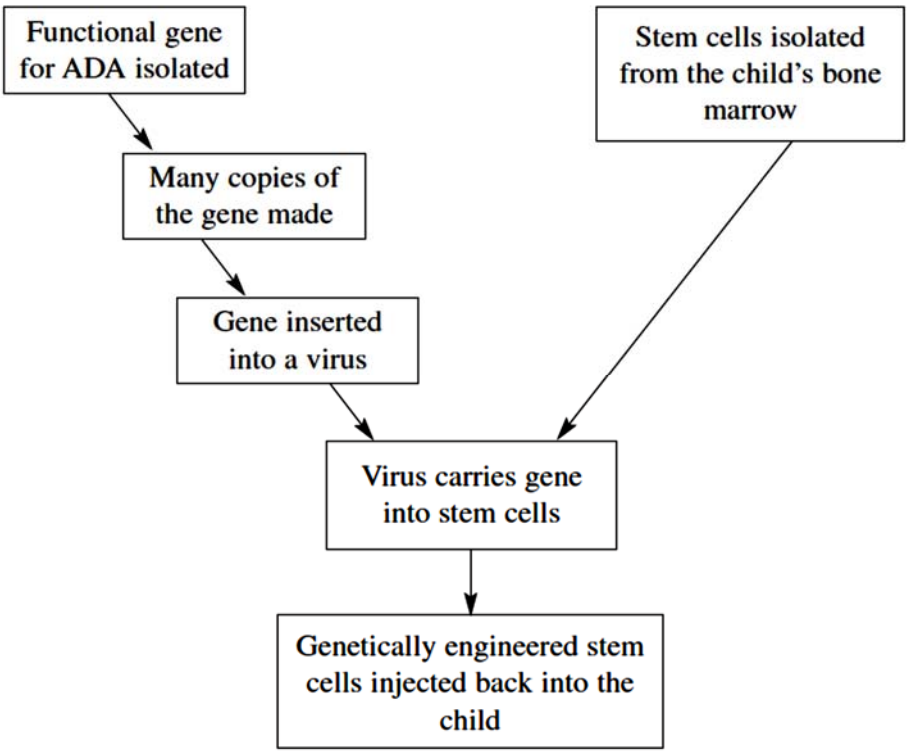
15 Which is a correct statement about obtaining human embryonic stem cells for research?

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

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

16 Children with severe combined immunodeficiency disorder (SCID) cannot produce the many types of white blood cells that fight infections. This is because they do not have the functional gene to make the enzyme ADA. Some children with SCID have been treated with stem cells.

The treatment used with the children is described in the flowchart.



Which of the following explains why stem cells can be used in the treatment of SCID?

1 They can divide mitotically to replace existing cells.
2 Due to their pluripotent nature, they have the ability to form only certain types of white blood cells that restores the ability to fight infection.
3 As the stem cells are from the child's own cells, there is no/little risk of rejection.
4 They possess a unique set of genome to allow for multipotency.

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

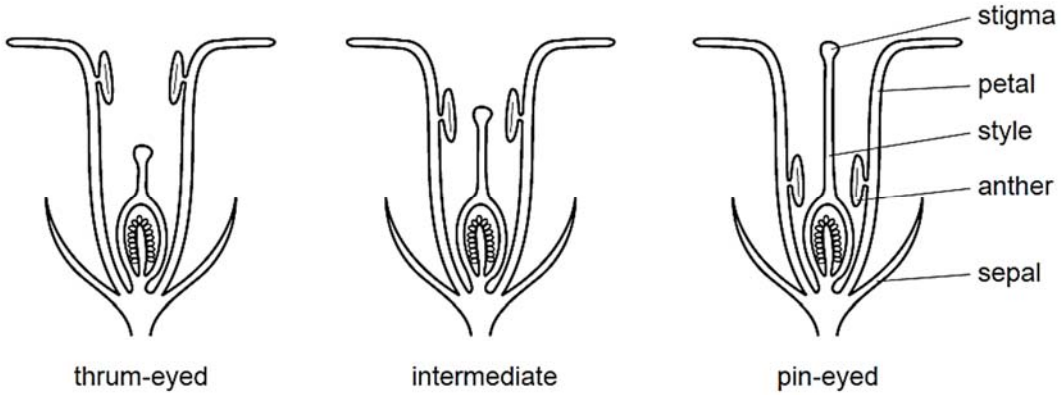
17 The primrose, *Primula vulgaris*, is a small herbaceous, yellow-flowered plant which is common in cooler areas of the Northern hemisphere including alpine and Arctic areas.

The flowers of the primrose have different flower shapes (polymorphic), which are adaptations for pollination. 'Thrum-eyed' primroses have a short style. 'Pin-eyed' primroses have much longer styles. The anther position also varies among the primrose.

Some populations of primrose consist almost entirely of plants with intermediate flowers. These populations are common where there are fewer winged insects.

Anthers produce pollen (male gametes) which land on the stigma, leading to fertilization.

The diagrams show polymorphic flowers of primroses.



Which statements are correct?

1 Cross-pollination will be favoured between pin-eyed and thrum-eyed primroses.
2 Primroses with pin-eyed flowers are likely to show more genetic diversity than primroses with intermediate flowers.
3 Primroses with thrum-eyed flowers are likely to be more able to adapt to changing environmental conditions than pin-eyed primroses.
4 Self-pollination is more likely to occur in primroses with intermediate flowers.

A 1 and 2
B 3 and 4
C 1, 2 and 4
D All of the above

18 On the tiny Lord Howe Island, 600 miles east of Australia, there are two species of palm which seem, from DNA analysis, to be descended from one original species. Factors involved in this speciation on this tiny island include:

1 linkage of genes for soil tolerance and flowering time
2 variation in flowering time
3 variation of soil tolerance
4 variation of soil types on the island

What is the correct sequence to explain this speciation?

A $1 \rightarrow 2 \rightarrow 3 \rightarrow 4$
B $2 \rightarrow 1 \rightarrow 4 \rightarrow 3$
C $3 \rightarrow 4 \rightarrow 1 \rightarrow 2$
D $4 \rightarrow 3 \rightarrow 2 \rightarrow 1$

19 A large population of equal numbers of dark and light mice was released into an area where owls are predators of mice. Because of predation, only 25 % of these mice survived and selective killing by owls changed the proportions of dark to light mice from 1:1 to 4:1.

If mice produce an average of eight offspring per litter and the pattern of predation remains the same, what would happen to the population of light mice?

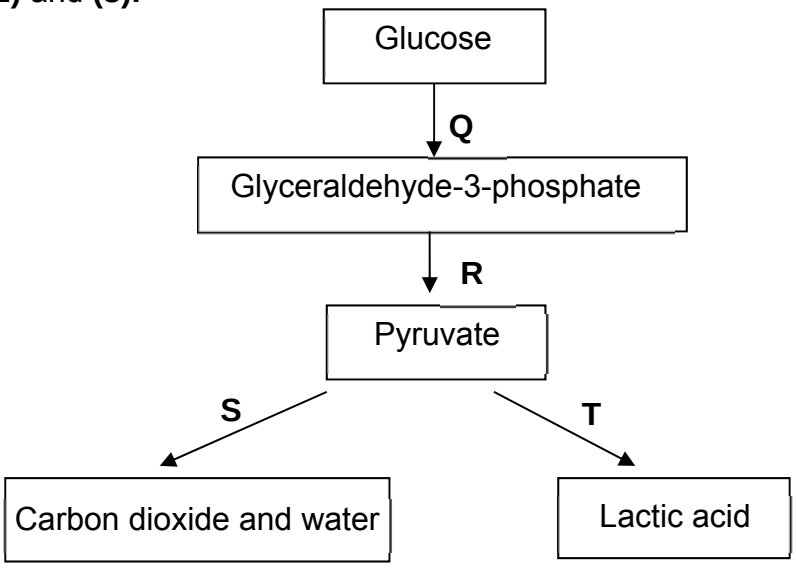
A They disappear after one further generation.
B They disappear after two further generations.
C They remain at the level of one fifth of the population.
D They will be reduced to a constant but very low frequency.

20 The frequency of recessive alleles in population is influenced by selection pressure.

Which row shows the conditions in which recessive alleles are retained in a population?

	Environmental variation of habitats	Heterozygote advantage	No selective advantage	Polymorphism (many phenotypes)
A	✓	✓	✓	✓
B	✓	×	×	✓
C	×	✓	×	×
D	×	×	✓	×

21 With reference to the diagram below, relate processes **Q, R, S, T** to statements **(1), (2)** and **(3).**



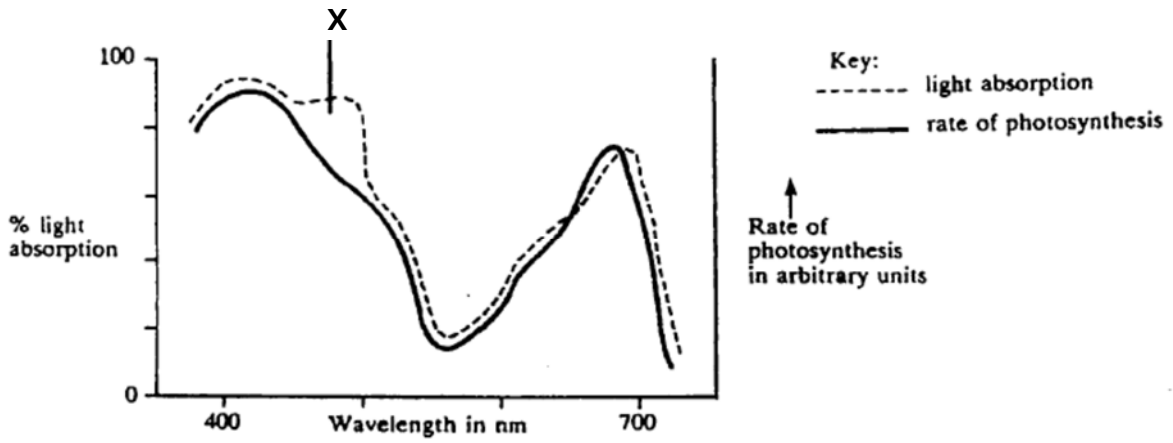
(1) NAD is regenerated without the use of the electron transport system
(2) ATP is synthesised via substrate level phosphorylation
(3) It can take place under anaerobic conditions.

	(1)	**(2)**	**(3)**
A	T only	R only	Q,R,T only
B	T only	R,S only	Q,R,T only
C	S,T only	R only	Q,R,S,T
D	S,T only	R,S only	Q,R,S,T

22 A major function of the mitochondrial inner membrane is the conversion of energy from electrons to the stored energy of the phosphate bond in ATP. To accomplish this function, this membrane must have all of the following features except

A high permeability to protons.
B integral, transverse ATP synthase.
C proteins to accept electrons from NADH.
D proton pumps embedded in the membrane.

23 The graph below shows the effect of different wavelengths of light on the rate of photosynthesis and on the amount of light absorbed by the pigments in a green seaweed.



The difference between the two curves at X is due to

A inefficient trapping of light energy by the chlorophyll
B no ATP production at that wavelength
C oxygen given off during photosynthesis interferes with the absorption of light.
D carotenes absorbing light that is not used in photosynthesis.

24 The incidence of primaquine sensitivity in a population is 14% in men and 2% in women. A proportion of the remaining women, but not the men, exhibit mild sensitivity.

What does this suggest about the inheritance of this defect?

A autosomal, codominant
B autosomal, recessive
C sex-linked, codominant
D sex-linked, recessive

25 In a series of plant breeding experiments, a pure-breeding plant with big and hairy leaves was crossed with a pure-breeding plant with small and hair-less leaves. The leaves in the F_1 generation were all big and hairy. Self-fertilisation of the F_1 generation produced the following results:

905	big and hairy leaves
301	big and hair-less leaves
305	small and hairy leaves
98	small and hair-less leaves

An F_2 plant with big and hairy leaves was crossed with an F_2 plant with small and hairy leaves. What is the maximum proportion of plants with small and hair-less leaves that could have appeared in the resulting progeny?

A 0%
B 12.5%
C 25%
D 50%

26 Fruit flies *Drosophila* homozygous for long wings, were crossed with flies homozygous for vestigial wings. The F_1 and F_2 generations were raised at three different temperatures.

At each temperature, the F_1 generation all had long wings.

The table below shows the results in the F_2 generation.

Temperature	***Result***
21°C	¾ long wings, ¼ vestigial wings
26°C	¾ long wings, ¼ intermediate wing length
31°C	all long wings

Which statement explains these results?

A Wing length is under polygenic control.
B Long wing and vestigial wing illustrate codominance at 26°C.
C Heterozygous flies have vestigial wings only at 21°C or below but have long wings at 31°C or above.
D Vestigial wing is recessive but causes a vestigial wing phenotype only at lower temperatures.

27 The table shows the results of a study made on a large number of twins.

Twin group	Mean difference in eye colour intensity/a.u.	Mean difference in weight/kg
Identical, raised together	1.7	2.0
Identical, raised apart.	1.8	4.8
Non-identical, same-sex, raised together	4.4	4.9

What do these results suggest about the influence of genes and environment on eye colour intensity and weight in humans?

A Genes have a greater influence than the environment on the eye colour intensity and the weight of identical twins.
B Eye colour intensity and weight are influenced by the environment.
C Weight is influenced by environment and genes; eye colour intensity is mainly influenced by genes.
D The environment has more effect than genes on the eye colour intensity and weight of non-identical twins.

28 The length of the petiole (leaf stalk) in a type of flowering plant is controlled by two genes, A and B. These genes are found on different loci on non-homologous chromosomes.

Homozygous dominant plants have long petioles (30 cm), homozygous recessive plants have short petioles (10 cm). Each dominant allele contributes 5cm to the petiole length.

F_1 plants with medium length petioles (20 cm) were obtained when a plant with short petiole is crossed with a plant with long petiole. If the F1 generation plants were allowed to cross, what proportion of their offspring would be expected to have medium length (20 cm) petioles?

A 0.0625
B 0.25
C 0.375
D 0.5

29 The Himalayan rabbits have white hair on the body and black hair on the extremities such as feet, tail, ears and face.

The allele for the Himalayan rabbit pigment pattern, $\mathbf{c^h}$, is recessive to the alleles for normal colour (all hair agouti), **C**, as well as dark chinchilla (all hair dark grey), $\mathbf{c^{chd}}$, and is dominant to the allele for albino (all hair white, 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 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 rabbit's bodies
B	c^hc^h only	The enzyme becomes inactive at the low skin temperatures found on the rabbit's 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 rabbit's bodies
D	c^hc^h and c^hc only	The enzyme becomes inactive at the low skin temperatures found on the rabbit's feet, tail, ears and face.

30 The Southern pine beetle is a pest native to pine forests in Central America and the southeastern U.S..

However recent observations show the latitude of this pest infestation creeping northward by about 40 miles a decade since 1980, and could damage 273,000 square miles of pine forests by 2080.

Which of the following explanations for the above observation are attributed to climate change?

1 Longer and more intense droughts weakening the defenses of trees, making them vulnerable to attack by the beetles.
2 Long-term suppression of forest fires leaving pine forests unnaturally dense and uniform, facilitating the beetles' spread from tree to tree.
3 Pines trees colonising new territories with cooler climates.
4 Increased temperatures in the winter allowing the beetles' lavae to survive.

A 1 and 4 only
B 2 and 3 only
C 1, 3 and 4 only
D All of the above

- **END OF PAPER** -

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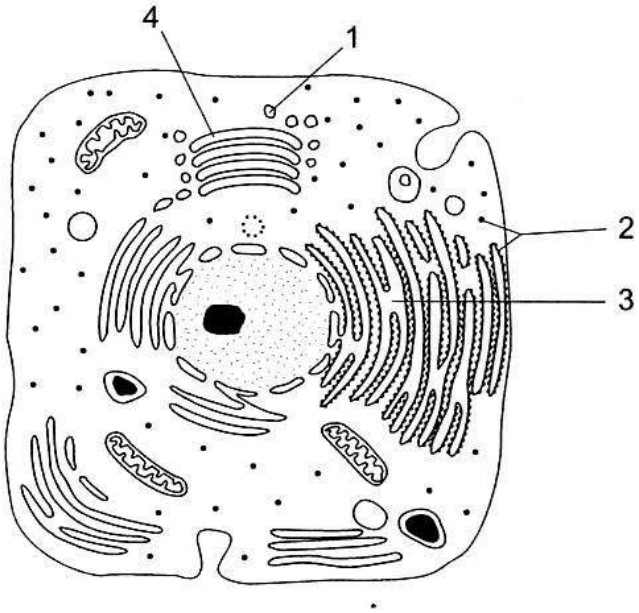

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2 Nucleases are enzymes that hydrolyze phosphodiester bonds. In which of the following cell organelle(s) would one expect to see activity of this enzyme?

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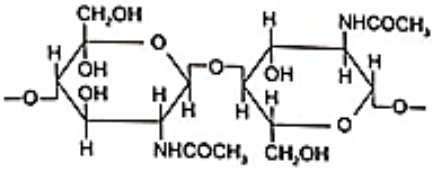

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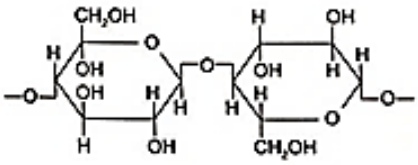

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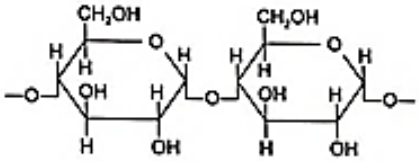

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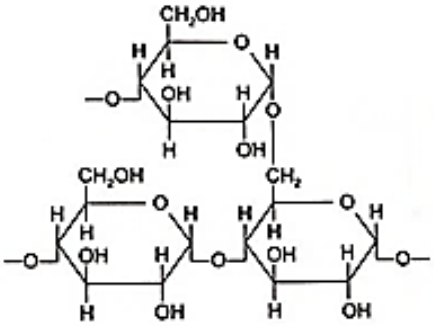

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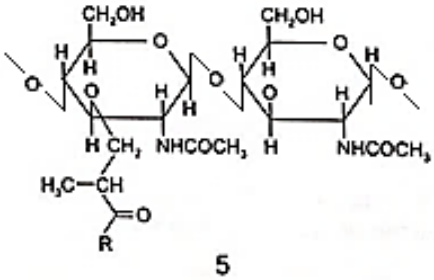


5

The polysaccharides can be described as below.

- Polysaccharide **F** is composed of β-glucose monomers with 1,4 glycosidic bonds.
- Polysaccharide **G** is composed of α-glucose monomers with 1,4 and 1,6 glycosidic bonds.
- Polysaccharide **H** is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with β-1,4 glycosidic bonds.
- Polysaccharide **J** is composed of α-glucose monomers with 1,4 glycosidic bonds.
- Polysaccharide **K** is composed of N-acetylglucosamine monomers with β-1,4 glycosidic bonds.

Which shows the correct pairings of polysaccharide descriptions and diagrams?

	Polysaccharide				
	F	**G**	**H**	**J**	**K**
A	2	4	5	3	1
B	2	5	4	1	3
C	3	4	1	2	5
D	3	5	4	1	2

4 Which statement is true for phospholipid, but **not** for protein?

A Its molecules have hydrophilic and hydrophobic components.
B Its molecules are synthesized from non-identical sub-units.
C It is a barrier to polar molecules.
D It is found in cell membranes.

5 With reference to carrier proteins, which of the following statements is/are true for all carrier proteins?

1 They contain binding sites for specific molecules or ions.
2 They directly require ATP to transport substances across the membrane.
3 They are soluble globular proteins.
4 They are embedded in membranes.

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

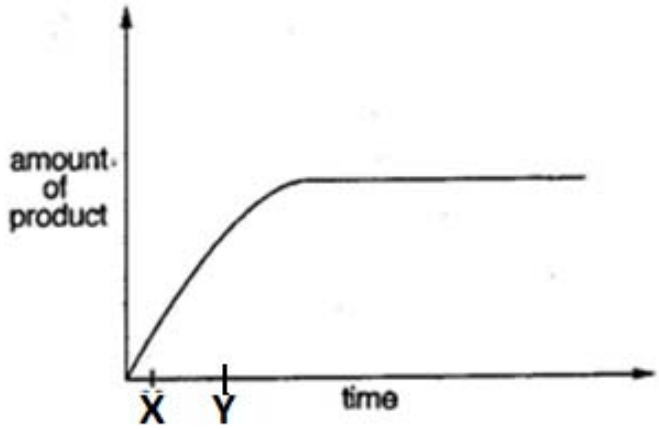
6 The list shows three characteristics of enzyme activity.

1 Reaction rate decreases if the concentration of non-competitive inhibitor increases.
2 Reaction rate is reduced at extremes of pH.
3 Reaction rate is reduced at low temperature.

What explains each of these characteristics?

	Availability of active sites is reduced	**Reduced kinetic energy reduces the rate of molecular collisions**	**Hydrogen bonding is disrupted**
A	1	2	3
B	2	1	3
C	1	3	2
D	2	3	1

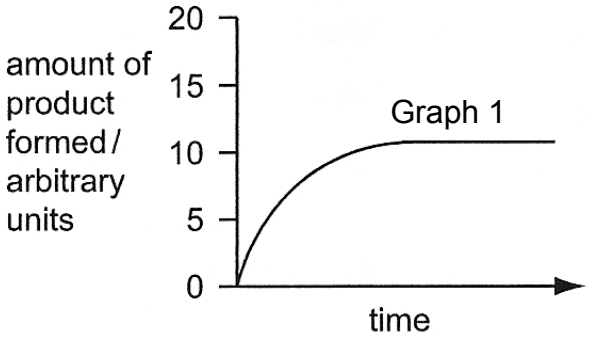
7 The graph below shows the amount of product formed in an enzyme-catalysed reaction over a certain period of time at 37°C.



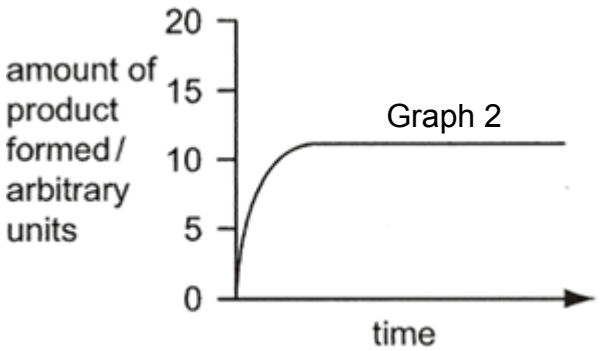
What is true at time **X**?

A Most enzyme molecules will have free active sites.
B The number of unreacted substrate molecules is high.
C The number of enzyme-substrate complexes is low.
D The rate of enzymatic reaction is lower than at time **Y**.

8 Graph 1 below shows the amount of product formed by a standard concentration of salivary enzymes and a standard concentration of substrate at a temperature of 15°C and pH of 7.



A change in condition(s) results in Graph 2.

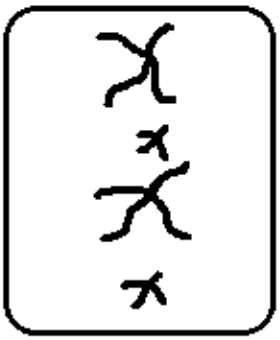


Which of the following conditions can best explain Graph 2?

1 Doubling of substrate concentration
2 Doubling of enzyme concentration
3 Increasing temperature to 20°C
4 Decreasing pH to 2

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

9 The diagram below shows metaphase of mitosis in a cell of an organism.



Each homologous pair of chromosomes in this organism contains 4 gene loci. This organism was genotyped and found to be heterozygous at all gene loci. The organism reproduces sexually via the production of millions of gametes by meiosis.

What is the maximum possible number of genetically different gametes that can be produced by this organism, assuming crossing over does not occur during meiosis in all cells?

A 2
B 4
C 16
D 256

10 Hybrid species can be produced from cabbage and radish.
The table below shows the chromosome numbers in the parental species and the hybrids.

type of cell	number of chromosomes per cell
parental cabbage	18
parental radish	18
parental gametes	9
F1 hybrids	18
F1 gametes	9
F2 hybrids	18
F2 gametes	18
F3 hybrids	36

Chromosomal mutation occurred at one stage. At which stage did it occur?

A during the formation of the F1 gametes.
B during the formation of the F2 gametes.
C during the fusion of the parental gametes.
D during the fusion of the F1 gametes.

11 3 different polynucleotide molecules (X, Y and Z) were isolated from a eukaryotic cell. One of them is a double-stranded DNA gene, while the other two are the pre-mRNA and mature mRNA that the DNA gene codes for.

The adenine nucleotide content of all 3 molecules was examined and shown in the table below:

Molecule	Percentage of adenine nucleotides in the molecule / %
X	49
Y	52
Z	53

Based on the information given, which of the following conclusions is/are valid and true?

1 X is definitely the DNA gene.
2 Z is definitely the mature mRNA.
3 The pre-mRNA molecule has more uracil than guanine in it.
4 Y has more purine nucleotides than pyrimidine nucleotides in it.

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

12 Which of the following order of steps is true for transcription?

1 RNA polymerase II binds to promoter
2 Primase adds a RNA primer to the 3' end of template strand
3 General transcription factors recognize and bind to TATA box of promoter
4 DNA polymerase III adds complementary deoxyribonucleotides to the 3' end of the growing DNA chain
5 RNA polymerase II transcribes a DNA sequence which codes for a polyadenylation signal (AAUAAA) in the RNA transcript
6 RNA polymerase II transcribes a stop codon
7 RNA polymerase II adds complementary ribonucleotides to the 3' end of the growing RNA chain
8 DNA polymerase III binds to promoter
9 Primer is hydrolyzed and replaced by deoxyribonucleotides

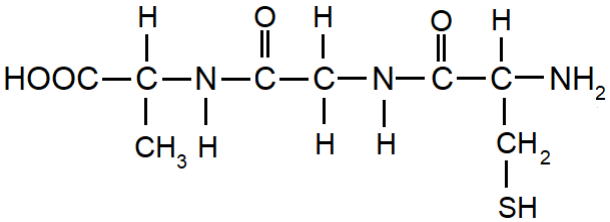
A 2, 1, 7, 5
B 2, 8, 4, 9
C 3, 1, 7, 5
D 3, 1, 7, 6

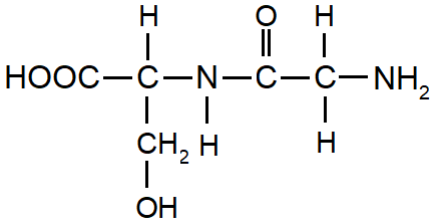
13 In an experiment, polypeptide A, which is coded for by a non-mutated version of a prokaryotic gene, was cleaved by a particular protease.

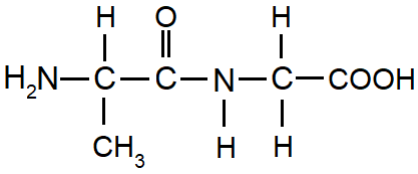
The cleavage produced 2 fragments, one of which contains the C-terminus of polypeptide A and is 5 amino acids long. This 5-amino-acid-long fragment, now called Peptide B, was then isolated for further investigation.

A solution containing many molecules of Peptide B was treated with another protease, called Protease X. The solution was analysed after the treatment and was found to contain various different fragments of different lengths and sequences.

The structures of 3 of these fragments are shown below:







It is known that Protease X is able to cleave any peptide bonds within the molecule of Peptide B. However, the cleavage of all peptide bonds within a single molecule is rare.

The mRNA codons involved in the synthesis of the Peptide B portion of Polypeptide A are shown below:

Amino acid	R group	mRNA codon
Glycine	H	5’ – GGC – 3’
Alanine	CH_3	5’ – GCC – 3’
Serine	CH_2OH	5’ – UCC – 3’
Cysteine	CH_2SH	5’ – UGU – 3’

Which of the following correctly shows a single point mutation in the portion of the template DNA sequence that codes for Peptide B, leading to a single amino acid substitution?

A 5’ – GGA GCC GCC GCC ACA – 3’
B 5’ – GCC GGA ACA GCC GCC – 3’
C 5’ – GCC GCC ACA GGA GCC – 3’
D 5’ – ACA GCC GCC GCC GGA – 3’

14 Translation did not occur successfully in a eukaryotic organism. Analysis of the structures in the cell revealed the following:

Structure	Presence (√) / Absence (X)
Free floating aminoacyl-tRNAs	√
Initiator tRNA- small ribosomal subunit complex	√
Initiator tRNA (base-pairing with AUG codon) in the P-site of large ribosomal subunit	√
Second aminoacyl-tRNA in the A-site of large ribosomal subunit	√
Polypeptide chain	X

Which is the most probable explanation for these observations?

A peptidyl-transferase is not functioning properly
B aminoacyl tRNA synthetases fail to attach amino acids to tRNA
C there is an error in the scanning for the start codon by tRNA-small ribosomal subunit complex
D release factor fails to hydrolyze polypeptide chain from the tRNA

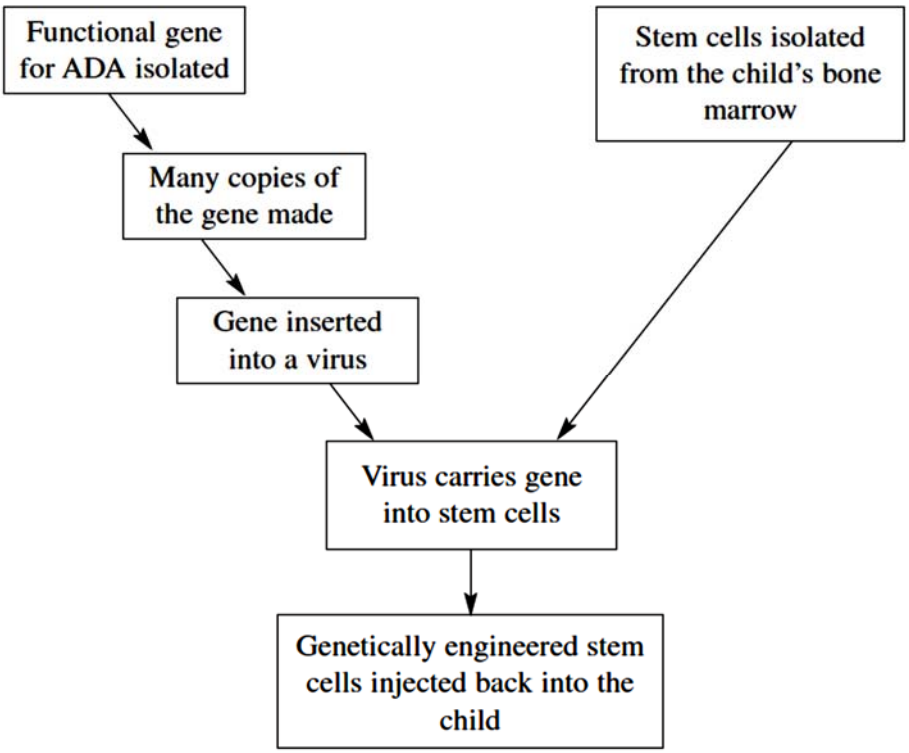
15 Which is a correct statement about obtaining human embryonic stem cells for research?

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

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

16 Children with severe combined immunodeficiency disorder (SCID) cannot produce the many types of white blood cells that fight infections. This is because they do not have the functional gene to make the enzyme ADA. Some children with SCID have been treated with stem cells.

The treatment used with the children is described in the flowchart.



Which of the following explains why stem cells can be used in the treatment of SCID?

1 They can divide mitotically to replace existing cells.
2 Due to their pluripotent nature, they have the ability to form only certain types of white blood cells that restores the ability to fight infection.
3 As the stem cells are from the child's own cells, there is no/little risk of rejection.
4 They possess a unique set of genome to allow for multipotency.

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

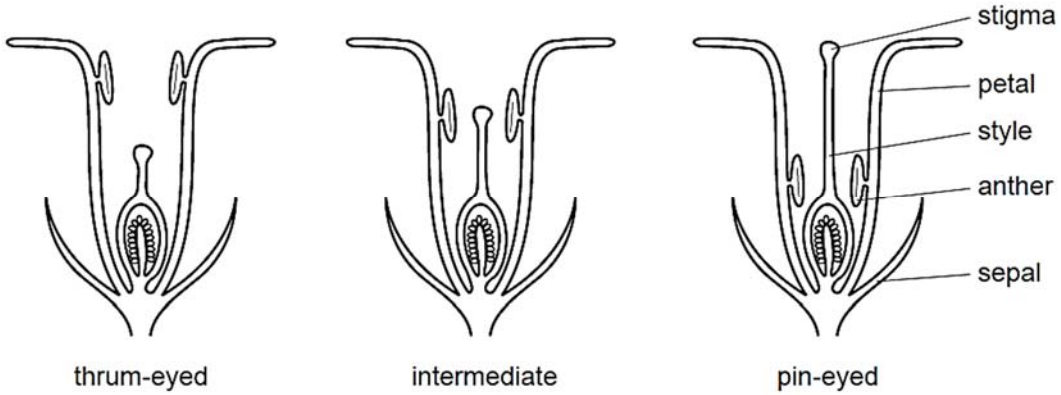
17 The primrose, *Primula vulgaris*, is a small herbaceous, yellow-flowered plant which is common in cooler areas of the Northern hemisphere including alpine and Arctic areas.

The flowers of the primrose have different flower shapes (polymorphic), which are adaptations for pollination. 'Thrum-eyed' primroses have a short style. 'Pin-eyed' primroses have much longer styles. The anther position also varies among the primrose.

Some populations of primrose consist almost entirely of plants with intermediate flowers. These populations are common where there are fewer winged insects.

Anthers produce pollen (male gametes) which land on the stigma, leading to fertilization.

The diagrams show polymorphic flowers of primroses.



Which statements are correct?

1 Cross-pollination will be favoured between pin-eyed and thrum-eyed primroses.
2 Primroses with pin-eyed flowers are likely to show more genetic diversity than primroses with intermediate flowers.
3 Primroses with thrum-eyed flowers are likely to be more able to adapt to changing environmental conditions than pin-eyed primroses.
4 Self-pollination is more likely to occur in primroses with intermediate flowers.

A 1 and 2
B 3 and 4
C 1, 2 and 4
D All of the above

18 On the tiny Lord Howe Island, 600 miles east of Australia, there are two species of palm which seem, from DNA analysis, to be descended from one original species. Factors involved in this speciation on this tiny island include:

1 linkage of genes for soil tolerance and flowering time
2 variation in flowering time
3 variation of soil tolerance
4 variation of soil types on the island

What is the correct sequence to explain this speciation?

A 1 → 2 → 3 → 4
B 2 → 1 → 4 → 3
C 3 → 4 → 1 → 2
D 4 → 3 → 2 → 1

19 A large population of equal numbers of dark and light mice was released into an area where owls are predators of mice. Because of predation, only 25 % of these mice survived and selective killing by owls changed the proportions of dark to light mice from 1:1 to 4:1.

If mice produce an average of eight offspring per litter and the pattern of predation remains the same, what would happen to the population of light mice?

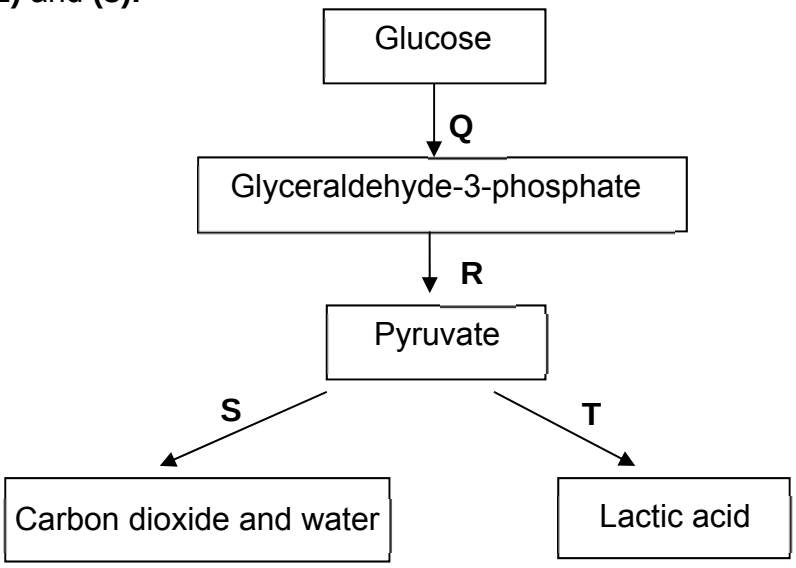
A They disappear after one further generation.
B They disappear after two further generations.
C They remain at the level of one fifth of the population.
D They will be reduced to a constant but very low frequency.

20 The frequency of recessive alleles in population is influenced by selection pressure.

Which row shows the conditions in which recessive alleles are retained in a population?

	Environmental variation of habitats	Heterozygote advantage	No selective advantage	Polymorphism (many phenotypes)
A	✓	✓	✓	✓
B	✓	×	×	✓
C	×	✓	×	×
D	×	×	✓	×

21 With reference to the diagram below, relate processes **Q, R, S, T** to statements **(1), (2)** and **(3).**



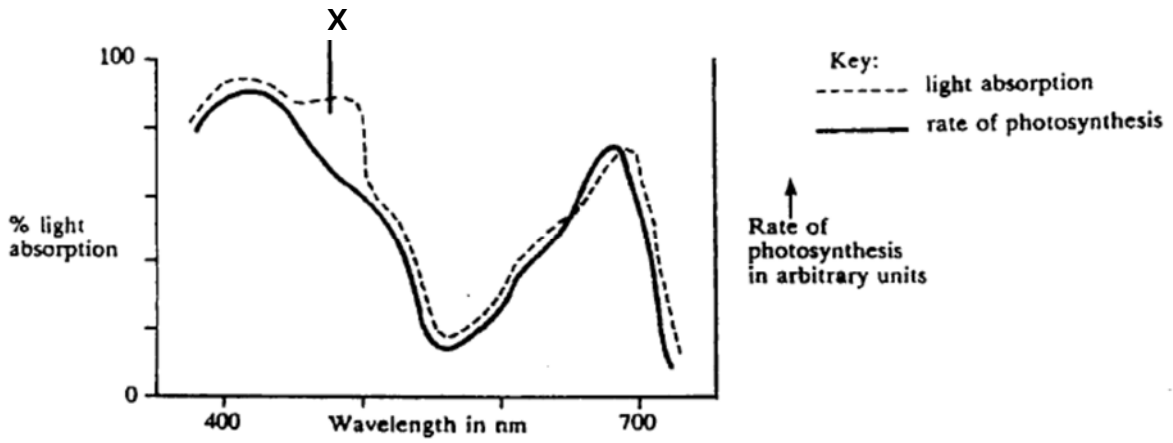
(1) NAD is regenerated without the use of the electron transport system
(2) ATP is synthesised via substrate level phosphorylation
(3) It can take place under anaerobic conditions.

	(1)	**(2)**	**(3)**
A	T only	R only	Q,R,T only
B	T only	R,S only	Q,R,T only
C	S,T only	R only	Q,R,S,T
D	S,T only	R,S only	Q,R,S,T

22 A major function of the mitochondrial inner membrane is the conversion of energy from electrons to the stored energy of the phosphate bond in ATP. To accomplish this function, this membrane must have all of the following features except

A high permeability to protons.
B integral, transverse ATP synthase.
C proteins to accept electrons from NADH.
D proton pumps embedded in the membrane.

23 The graph below shows the effect of different wavelengths of light on the rate of photosynthesis and on the amount of light absorbed by the pigments in a green seaweed.



The difference between the two curves at X is due to

A inefficient trapping of light energy by the chlorophyll
B no ATP production at that wavelength
C oxygen given off during photosynthesis interferes with the absorption of light.
D carotenes absorbing light that is not used in photosynthesis.

24 The incidence of primaquine sensitivity in a population is 14% in men and 2% in women. A proportion of the remaining women, but not the men, exhibit mild sensitivity.

What does this suggest about the inheritance of this defect?

A autosomal, codominant
B autosomal, recessive
C sex-linked, codominant
D sex-linked, recessive

25 In a series of plant breeding experiments, a pure-breeding plant with big and hairy leaves was crossed with a pure-breeding plant with small and hair-less leaves. The leaves in the F_1 generation were all big and hairy. Self-fertilisation of the F_1 generation produced the following results:

905	big and hairy leaves
301	big and hair-less leaves
305	small and hairy leaves
98	small and hair-less leaves

An F_2 plant with big and hairy leaves was crossed with an F_2 plant with small and hairy leaves. What is the maximum proportion of plants with small and hair-less leaves that could have appeared in the resulting progeny?

A 0%
B 12.5%
C 25%
D 50%

26 Fruit flies *Drosophila* homozygous for long wings, were crossed with flies homozygous for vestigial wings. The F_1 and F_2 generations were raised at three different temperatures.

At each temperature, the F_1 generation all had long wings.

The table below shows the results in the F_2 generation.

Temperature	***Result***
21°C	¾ long wings, ¼ vestigial wings
26°C	¾ long wings, ¼ intermediate wing length
31°C	all long wings

Which statement explains these results?

A Wing length is under polygenic control.
B Long wing and vestigial wing illustrate codominance at 26°C.
C Heterozygous flies have vestigial wings only at 21°C or below but have long wings at 31°C or above.
D Vestigial wing is recessive but causes a vestigial wing phenotype only at lower temperatures.

27 The table shows the results of a study made on a large number of twins.

Twin group	Mean difference in eye colour intensity/a.u.	Mean difference in weight/kg
Identical, raised together	1.7	2.0
Identical, raised apart.	1.8	4.8
Non-identical, same-sex, raised together	4.4	4.9

What do these results suggest about the influence of genes and environment on eye colour intensity and weight in humans?

A Genes have a greater influence than the environment on the eye colour intensity and the weight of identical twins.
B Eye colour intensity and weight are influenced by the environment.
C Weight is influenced by environment and genes; eye colour intensity is mainly influenced by genes.
D The environment has more effect than genes on the eye colour intensity and weight of non-identical twins.

28 The length of the petiole (leaf stalk) in a type of flowering plant is controlled by two genes, A and B. These genes are found on different loci on non-homologous chromosomes.

Homozygous dominant plants have long petioles (30 cm), homozygous recessive plants have short petioles (10 cm). Each dominant allele contributes 5cm to the petiole length.

F_1 plants with medium length petioles (20 cm) were obtained when a plant with short petiole is crossed with a plant with long petiole. If the F1 generation plants were allowed to cross, what proportion of their offspring would be expected to have medium length (20 cm) petioles?

A 0.0625
B 0.25
C 0.375
D 0.5

29 The Himalayan rabbits have white hair on the body and black hair on the extremities such as feet, tail, ears and face.

The allele for the Himalayan rabbit pigment pattern, $\mathbf{c^h}$, is recessive to the alleles for normal colour (all hair agouti), **C**, as well as dark chinchilla (all hair dark grey), $\mathbf{c^{chd}}$, and is dominant to the allele for albino (all hair white, 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 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 rabbit's bodies
B	c^hc^h only	The enzyme becomes inactive at the low skin temperatures found on the rabbit's 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 rabbit's bodies
D	c^hc^h and c^hc only	The enzyme becomes inactive at the low skin temperatures found on the rabbit's feet, tail, ears and face.

30 The Southern pine beetle is a pest native to pine forests in Central America and the southeastern U.S..

However recent observations show the latitude of this pest infestation creeping northward by about 40 miles a decade since 1980, and could damage 273,000 square miles of pine forests by 2080.

Which of the following explanations for the above observation are attributed to climate change?

1 Longer and more intense droughts weakening the defenses of trees, making them vulnerable to attack by the beetles.
2 Long-term suppression of forest fires leaving pine forests unnaturally dense and uniform, facilitating the beetles' spread from tree to tree.
3 Pines trees colonising new territories with cooler climates.
4 Increased temperatures in the winter allowing the beetles' lavae to survive.

A 1 and 4 only
B 2 and 3 only
C 1, 3 and 4 only
D All of the above

- **END OF PAPER** -

Civics Group	Index Number	Name (use BLOCK LETTERS)

H1

ST ANDREW'S JUNIOR COLLEGE
2018 JC2 PRELIMS

H1 BIOLOGY **8876/2**

Paper 2: Structured & Essay Questions

Monday 10 Sept 2018 2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A (Structured Questions)
Answer **all** questions.
Write your answers in the spaces provided in the question booklet.

Section B (Essay Question)
Answer **one** essay question.
Write your answers in the spaces provided in the question booklet.
All working for numerical answers must be shown.

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

Conceptual error (C)	Expression problem (E)	Misreading the question (Q)	Data quoting problem (D)

For Examiner's Use	
Section A	
1	/13
2	/12
3	/9
4	/11
Sub-total	/45
5/6	/15
Total	/60

This document consists of **17** printed pages.

[Turn over

Section A

Answer **all** *questions*.

QUESTION 1

Fig. 1.1 shows Process X in an eukaryotic cell which produces ribosomal RNA (rRNA).

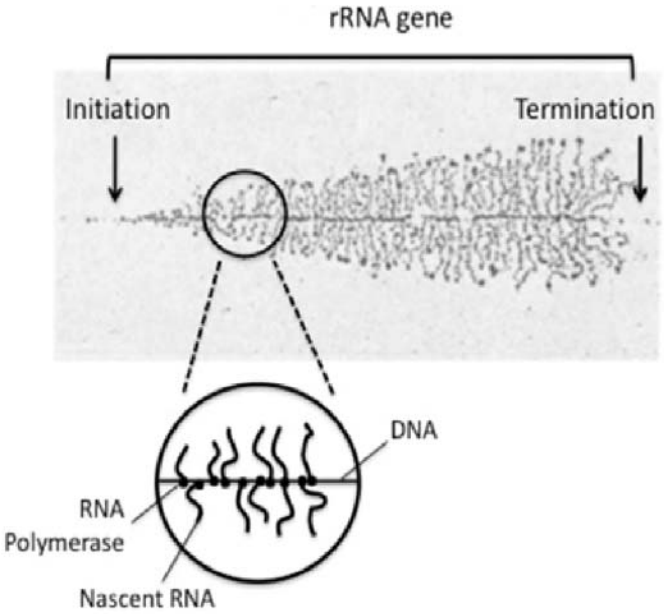


Fig. 1.1

(a)(i) Name the Process X occurring in **Fig. 1.1**.

……[1]

(ii) List one molecule **not mentioned in Fig. 1.1** that is required for Process X.

……[1]

(iii) Suggest how RNA polymerase is able to recognise and bind to the promoter on DNA and not to other DNA regions.

……

……

……

……

……[2]

(iv) Explain for the observed pattern of Process X in **Fig. 1.1**.

……

……

……

……

……[2]

(v) State the roles of rRNA in protein synthesis.

……

……

……

……

……[2]

(b) During protein synthesis in cells of an embryo, all tRNA molecules with UAC anticodon sequence, are observed to be bound to the arginine amino acid instead of methionine.

(i) Suggest how these tRNA molecules attached with the wrong amino acid might arise.

……

……

……

……

……[2]

(ii) Suggest and explain the effect of this wrong pairing of amino acid to tRNA on the embryo.

……

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……[3]

[Total: 13]

QUESTION 2

(a) About one third of the injuries to racehorses involve tendon damage.

In 2006, bone marrow stem cells were taken from injured racehorses and cultured so that they divided many times by mitosis. Each horse's cells (usually around 10 million cells for one tendon) were then injected into its damaged tendons.

80% of the treated horses returned to racing, compared with 30% of those treated conventionally.

(i) Explain how it is possible that bone marrow stem cells could differentiate into the range of cell types needed for repairing the tendon injuries.

……

……

……

……

……[2]

(ii) Suggest an advantage of the above stem cell therapy.

……

……[1]

(iii) Similar to stem cells, cancer cells are also capable to dividing many times via mitosis. List 2 differences between stem cells and cancer cells.

……

……

……

……

……[2]

(b) In a dihybrid inheritance, gene B/b codes for flower colour while gene H/h codes for leaf shape of a plant.

The F1 progeny of a pure-bred plant with red flowers and oval leaves, and another pure-bred plant with yellow flowers and fan-shaped leaves, have red flowers and fan-shaped leaves.

F1 plants then undergo a test cross.

(i) Predict the expected phenotypic ratio in the F2 progeny.

……

……..…….....…[1]

(ii) Identify and explain which are the dominant traits in this dihybrid cross.

……

……

……

……

……..…….....…[2]

(iii) Using the symbols for the alleles stated above, draw a genetic diagram to show the expected phenotypic ratios for the offspring of the test cross if inheritance is Mendelian. [3]

(iv) Plants are a good choice of experimental organisms for carrying out such crosses and for performing statistical tests.

Compared to plants, humans are less ideal and it is usually more difficult to arrive at reliable conclusions for observations involving humans. Suggest why.

……

……..…….....…[1]

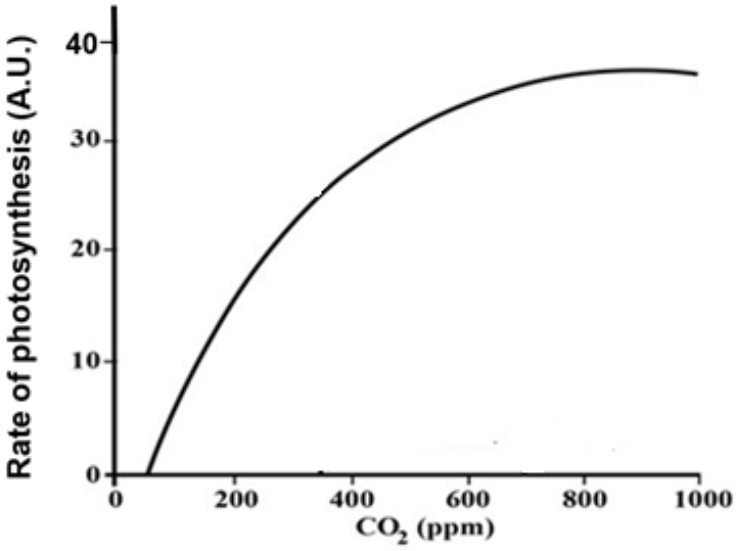
[Total: 12]

QUESTION 3

(a) In response to climate change, the rising carbon dioxide level has affected almost all crucial biological processes, including photosynthesis, respiration, and antioxidant systems, as well as other key secondary metabolisms in plants.

An experiment was designed to measure the rate of photosynthesis at a range of carbon dioxide concentrations provided to the plant.

The following results were obtained:



(i) Explain the experimental results obtained in relation to CO_2 being a limiting factor of photosynthesis.

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…..…..…….. [2]

(ii) Suggest why the rate of photosynthesis reaches a plateau after a while, given that sufficient light was provided.

……

…..…..…….. [1]

(iii) $NADP^+$ is an important electron carrier found in plants, but its level decreases sharply in the day. Suggest the significance of the decrease of $NADP^+$ during the day.

……

……

……

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……

…..…..…….. [2]

(b) Central to the energy metabolism of aerobically respiring cells is the enzyme ATP synthase. It consists of multiple subunits, coded for by several genes.

The enzyme is located on the inner mitochondrial membrane and catalyses the reversible reaction of ATP synthesis from ADP in intact mitochondria. Here, the **proton motive force** is required to drive the ATP synthesis.

Explain how the structure, including protein components, of the inner mitochondrial membrane is significant in driving the reaction of ATP synthase towards ATP synthesis during aerobic respiration.

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…..…..…….. [4]

[Total: 9]

QUESTION 4

(a) Climate change, in the form of global warming, is expected to have an impact on various organisms. This impact however, varies geographically, particularly for insects.

Fig. 4.1 and **Fig. 4.2** below show the fitness curves of representative insects from temperate and tropical locations respectively.

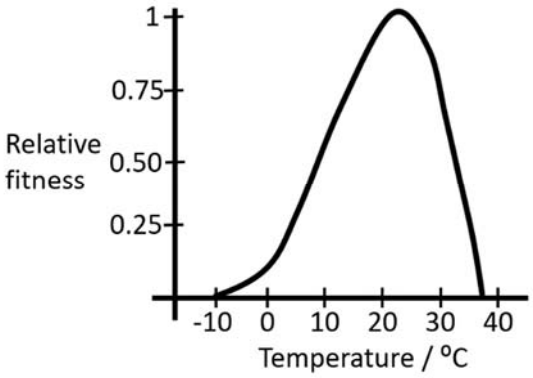

Fig. 4.1: Fitness curve of representative insect from temperate location

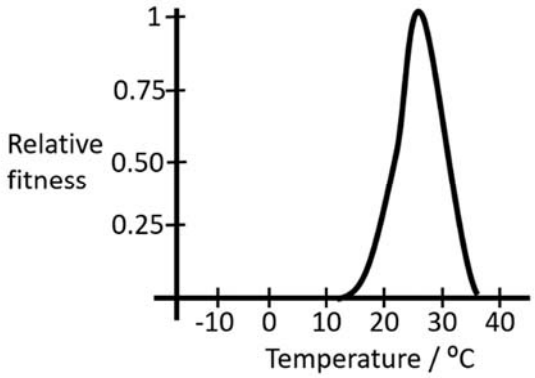

Fig. 4.2: Fitness curve of representative insect from tropical location

The mean annual temperature of the temperate location is 11□C, with a typical temperature range from 1□C to 20□C.

On the other hand, the mean annual temperature of the tropical location is 27□C, with a typical temperature range from 21□C to 31□C.

(i) Suggest what is meant by the term relative fitness in **Fig. 4.1** and **Fig. 4.2**.

……

……

……

……

……[2]

(ii) With reference to **Fig. 4.1** and **Fig. 4.2** and the information given, predict and explain which insects, from the temperate or tropical location, would face a greater extinction risk as a result of global warming, assuming the warming elevates temperatures equally at both locations.

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……[4]

(iii) Suggest one strategy that the insects in **(ii)** can employ to reduce the impact of global warming on themselves.

……

……[1]

(b) Carbon dioxide is one of the greenhouse gases that contribute to global warming and subsequently climate change.

A group of high school students decided to test whether varying temperatures would correspondingly affect the mean carbon dioxide gas emission.

Table 4.1 shows the mean carbon dioxide gas emission after exposing a fixed number of mealworms to different temperatures. Carbon dioxide gas emission was measured before and after exposure to experimental temperature.

Table 4.1 showing effects of varying temperatures on mean carbon dioxide gas emission, measured in parts per million (ppm).

Temperature /°C	**Mean Carbon dioxide gas emission /ppm**	
	Before exposure to experimental temperature	**After** exposure to experimental temperature
30.0	445 ± 25	450 ± 17
40.0	450 ± 20	500 ± 30
50.0	460 ± 17	540 ± 18

Values represent mean ± standard deviation.

(i) Describe the patterns shown by the data in **Table 4.1**.

……

……

……

……

……[2]

(c) Corals are affected by rising temperatures in ocean waters. Explain how.

……

……

……

……

……[2]

[Total: 11]

Section B

Answer **one** *question only*.

Write your answers on the spaces provided in this question booklet.

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

Your answers must be in continuous prose, where appropriate.

QUESTION 5
Cellulose is the most abundant biopolymer on earth. It forms a significant proportion of the dry mass of plants.

Outline the role of atmospheric CO_2 in contributing to the structure of cellulose in plants. [15]

QUESTION 6
Without genetic variation, some of the basic mechanisms bringing about evolutionary change cannot operate.

Explain how mutation events may contribute to variation, and how this variation can influence natural selection. [15]

- **END OF PAPER** -

(a) Stem cells undergo cell division to produce genetically identical daughter cells. Radioactive thymine was supplied to some stem cells. Fig. 1.1 shows how the amount of DNA per cell varies during periods A to E in the cell cycle.

Which monomers and types of bond are found in both glycogen and amylopectin?
A α-glucose, glycosidic, 1,6
B α-glucose, hydrogen, 1,4
C β-glucose, glycosidic, 1,4
D β-glucose, hydrogen, 1,6

The huia, Heteralocha acutirostris, was found in New Zealand until 1907, when it became extinct. This bird had a ground-feeding habit and was particularly noted for large, attractive tail feathers. Males and females had very different beak forms, with the males having a short strong beak, whilst the females had a long curved beak to reach into otherwise inaccessible places. What is the most likely reason for the extinction of the huia?
A Huia fed on species introduced by humans. When these declined, the huia population fell.
B In the face of a declining population the huia evolved into a tree-living species.
C Male and female huia were unable to breed successfully owing to strong sexual dimorphism.
D New competitors in New Zealand occupied part of the huia's niche.

[Total: 10]

Time

QUESTION 2 DNA

Fig 3.1 shows part of a DNA molecule.

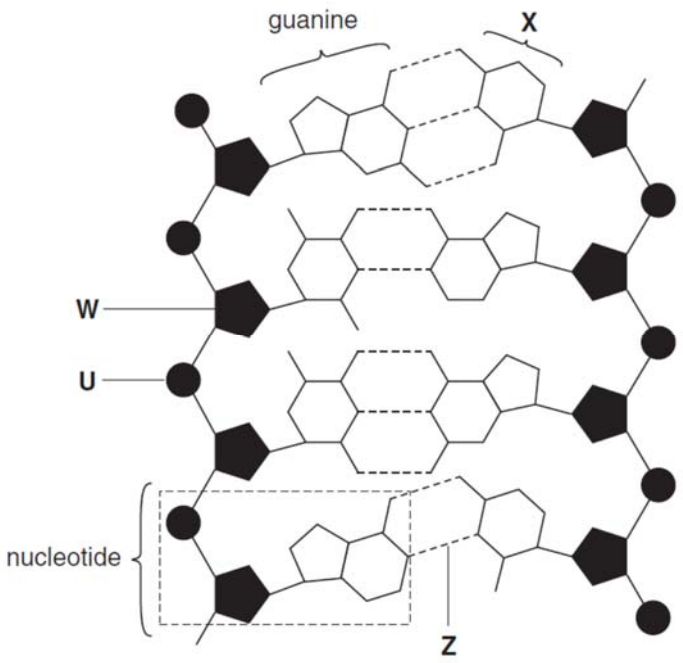


Fig 3.1

(a) (i) Name **U** to **X**.

U ……

W .....

X …….. [1]

1 **U** - phosphate / PO_4;
REJECT phosphoric acid / phosphorus / P
2 **W** - deoxyribose;
REJECT pentose
3 **X** - cytosine;
REJECT nitrogenous base / pyrimidine / C

(ii) Explain the significance of the bonds indicated by **Z** during the DNA replication process.

……..[2]

1 Hydrogen bonds
2 Allows for **complementary base pairing** (A = T, G =C) and DNA repair / **proof-reading**/replacement of incorrectly-inserted nucleotide;

3 Ref. genetic stability (DNA sequence remains intact) / maintains integrity of DNA base sequence;

(iii) Describe three features of a polypeptide molecule that are different from those found in a DNA molecule.

……..[3]

	polypeptide	**DNA**
1	amino acids as subunits/monomers;	Nucleotides as monomers;
2	one / single strand/chain	Exists as double helix; / two/double strandd/chains
3	peptide bonds between amino acids	Phosphodiester bonds between nucleotides;
4	Has no phosphate / PO_4	Has phosphate / PO_4
5	Consists of secondary and tertiary structure	Helical in structure

(b) Explain

☆☆……..[3]

[Total: 12]

Civics Group	Index Number	Name (use BLOCK LETTERS)

H1

ST ANDREW'S JUNIOR COLLEGE
2018 JC2 PRELIMS

H1 BIOLOGY **8876/2**

Paper 2: Structured & Essay Questions

[MARK SCHEME]

Monday 10 Sept 2018 2 hours

Additional Materials: Answer Paper
Cover Sheet for Section B

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A (Structured Questions)
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

Section B (Essay Question)
Answer **one** essay question.
Write your answers on the separate answer paper provided.
All working for numerical answers must be shown.

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

Conceptual error (C)	Expression problem (E)	Misreading the question (Q)	Data quoting problem (D)

For Examiner's Use	
Section A	
1	/13
2	/12
3	/9
4	/11
Sub-total	**/45**
5/6	/15
Total	**/60**

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

[Turn over

Section A

Answer **all** *questions*.

QUESTION 1
Fig. 1.1 shows Process X in an eukaryotic cell which produces ribosomal RNA (rRNA).

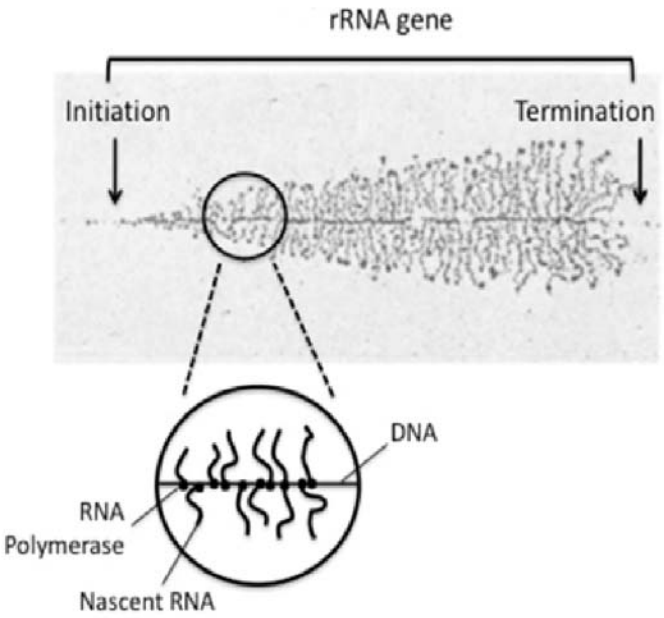


Fig. 1.1

(a)(i) Name the Process X occurring in **Fig. 1.1**.
……[1]
1. Transcription

(ii) List one molecule **not mentioned in Fig. 1.1** that is required for Process X.
……[1]
1. General <u>transcription factor</u> (**Reject**: Specific transcription factor due to it not being a real/essential requirement for transcription)
   / ribonucleotides
   / transcription initiation factors;

(iii) Suggest how RNA polymerase is able to recognise and bind to the promoter on DNA and not to other DNA regions.

……[2]

1. RNA polymerase contains a **DNA-binding site/domain** [Reject: active site] which recognize and bind to specific DNA sequence in the **promoter**;
2. ref. **Nucleotide sequence** / length / major and minor grooves of promoter offers a **complementary shape** to DNA-binding site/domain of RNA polymerase;

[Reject: complementary base pairing]

(iv) Explain for the observed pattern of Process X in **Fig. 1.1**.

……[2]

1. [Describe] **Shorter** RNA transcripts seen at the **beginning** of the DNA template strand, which get **longer** till the **end** of the transcription unit, (where the transcripts detach from the DNA template after transcription termination)
2. [Explain] Due to simultaneous transcription of rRNA gene **by multiple RNA polymerases**, causing RNA transcripts to extend perpendicularly from DNA template strand ;

(v) State the roles of rRNA in protein synthesis.

……[2]

1. The rRNA in ribosomes holds the tRNA and mRNA together in **close proximity**, (via complementary base pairing / hydrogen bonds)
2. positions the new amino acid for addition to the <u>carboxyl end</u> of the growing polypeptide
3. rRNA <u>peptidyl transferase</u> activity catalyzes formation of a <u>peptide bond</u> between the new amino acid and the polypeptide chain
4. Ref. rRNA associate with proteins to form ribosomal subunits / ribosomes (which synthesizes proteins)

(b) During protein synthesis in cells of an embryo, all tRNA molecules with UAC anticodon sequence, are observed to be bound to the arginine amino acid instead of methionine.

(i) Suggest how these tRNA molecules attached with the wrong amino acid might arise.

……[2]

1. Ref. possible mutation in the **gene** sequence for the aminoacyl tRNA synthetases,
2. resulting in **altered 3D conformation** of active site which is **complementary** (in shape) to the amino acid arginine and the corresponding tRNA with anticodon UAC

(ii) Suggest and explain the effect of this wrong pairing of amino acid to tRNA on the embryo.

……[3]

1. ref. altered **primary sequence** of polypeptides (all methionine replaced by arginine) and folding of polypeptides to **tertiary structure** / 3D conformation is affected;
2. ref. **non-functional proteins** made in cells
3. ref. possible disruption of metabolic processes in the **cell** / cells might die easily, **embryo cannot further develop** into a fetus

[Total: 13]

QUESTION 2

(a) About one third of the injuries to racehorses involve tendon damage.

In 2006, bone marrow stem cells were taken from injured racehorses and cultured so that they divided many times by mitosis. Each horse's cells (usually around 10 million cells for one tendon) were then injected into its damaged tendons.

80% of the treated horses returned to racing, compared with 30% of those treated conventionally.

(i) Explain how it is possible that bone marrow stem cells could differentiate into the range of cell types needed for repairing the tendon injuries.

……[2]

1 ref. bone marrow stem cells as **multipotent**;
/ able to differentiate into cells of **same/specific lineage;**
2 ref. bone marrow stem cells able to **respond to specific molecular signals** to differentiate;
3 AVP: stem cells containing a complete set of genome;

(ii) Suggest an advantage of the above stem cell therapy.

……[1]

1 Eliminates the risk of tissue/donor rejection if the cells were taken from another donor.
2 ref. stem cells **capable of continual self-renewal** and can be used **to expand cell numbers** in vitro **/** in the lab**;**

(iii) Similar to stem cells, cancer cells are also capable to dividing many times via mitosis. List 2 differences between stem cells and cancer cells.

……[2]

	Stem cells	**Cancer cells**
1	Differentiate into specialised cell types;	Do not differentiate into specialised cell types / remain undifferentiated and unspecialised;
2	Experience contact inhibition;	Does not experience contact inhibition;
3	Experience anchorage dependence / does not metastasize;	Does not experience anchorage dependence / metastasize to set up secondary tumors;
4	Divides or stops dividing upon response to molecular signals	Divides indefinitely / does not respond to molecular signals;
5	AVP: i.e. normal proto-oncogene / tumor suppressor gene	AVP: i.e. mutated proto-oncogene / tumor suppressor gene

(b) In a dihybrid inheritance, gene B/b codes for flower colour while gene H/h codes for leaf shape of a plant.

The F1 progeny of a pure-bred plant with red flowers and oval leaves, and another pure-bred plant with yellow flowers and fan-shaped leaves, have red flowers and fan-shaped leaves.

F1 plants then undergo a test cross.

(i) Predict the expected phenotypic ratio in the F2 progeny.

……[1]

1 1 Red flower, fan-shaped leaf : 1 Red flower, oval leaf : 1 Yellow flower, fan-shaped leaf: 1 Yellow flower, oval leaf

[**Reject**: 1:1:1:1 with no phenotypes]

(ii) Identify and explain the dominant traits in this dihybrid cross.

……[2]

1 red flowers and fan-shaped leaves;

2 ref. **dominant traits/alleles** being expressed in the **phenotype** in the **<u>heterozygous</u>** condition (i.e. F1 progeny)

/ **recessive <u>alleles</u>** (coding for yellow flowers and fan-shaped leaves), **being masked by dominant alleles** in the **<u>heterozygous</u>** condition;

(iii) Using the symbols for the alleles stated above, draw a genetic diagram to show the expected phenotypic ratios for the offspring of the test cross if inheritance is Mendelian.

……[3]

F_1 phenotypes:	Red flower, Fan-shaped leaf	x	Yellow flower, Oval leaf
F_1 genotype:	BbHh		bbhh
F_1 gametes	BH Bh bH bh		bh

F_2 genotypes:
<u>Punnett square:</u>

	BH	Bh	bH	bh
bh	BbHh (Red flower, Fan-shaped leaf)	Bbhh (Red flower, Oval leaf)	bbHh (Yellow flower, Fan-shaped leaf)	bbhh (Yellow flower, oval leaf)

F_2 / Progeny phenotypes:	Red flower, Fan-shaped leaf	Red flower, Oval leaf	Yellow flower, Fan-shaped leaf	Yellow flower, oval leaf
F_2 / Progeny phenotypic ratio:	1	1	1	1

Mark scheme:

1. F_1 phenotype and genotypes
2. Parental gametes – (Gametes **must** be circled)
3. F_2 genotypes correspond to phenotypes

(iv) Plants are a good choice of experimental organisms for carrying out such crosses and for performing statistical tests.

Compared to plants, humans are less ideal and it is usually more difficult to arrive at reliable conclusions for observations involving humans. Suggest why.
……[1]

1. Humans produce **limited offspring**. (This makes statistical tests difficult)
2. Humans have a long life span and **some traits only appear at a later stage in life**

[**Reject**: some human traits are under continuous variation. Plants also have continuous variation]

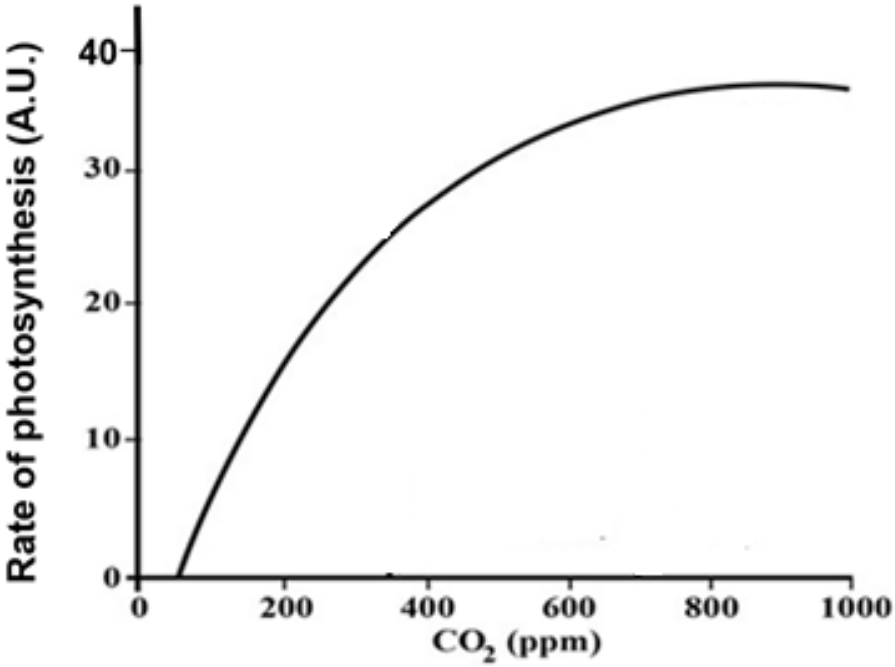
[Total: 12]

QUESTION 3

(a) In response to climate change, the rising carbon dioxide level has affected almost all crucial biological processes, including photosynthesis, respiration, and antioxidant systems, as well as other key secondary metabolisms in plants.

An experiment was designed to measure the rate of photosynthesis at a range of carbon dioxide concentrations provided to the plant.

The following results were obtained:



(i) Explain the experimental results obtained in relation to CO_2 being a limiting factor of photosynthesis.

…..…….. [2]

1 ref. carbon dioxide being a limiting factor of photosynthesis at values **lower than 700ppm** (Accept range: 700-800ppm)
/At higher concentrations of carbon dioxide tested (i.e. 700-800ppm and above), the rate of photosynthesis is affected by other limiting factors / carbon dioxide is no longer a limiting factor;

2 [Evidence] rate of photosynthesis reaches a **plateau** /**remains constant <u>around 35-37AU</u>**

(ii) Suggest why the rate of photosynthesis reaches a plateau after a while, given that sufficient light was provided.

…..…….. [1]

1 Rate of PS limited by **amount of Rubisco** in the plant;

(iii) $NADP^+$ is an important electron carrier found in plants, but its level decreases sharply in the day. Suggest the significance of the decrease of $NADP^+$ during the day.

…..…….. [2]

(ref. light-dependent reactions during day
/ photoexcited electrons (from PS I and II)being passed down ETC)

2 $NADP^+$ acts as the **final electron acceptor**, forming NADPH;
/ $NADP^+$ **accepts electrons and H^+ ions** to form NADPH;
3 NADPH (and ATP) used in **Calvin cycle** / light independent reactions to reduce PGA to PGAL **to synthesis of glucose;**

(b) Central to the energy metabolism of aerobically respiring cells is the enzyme ATP synthase. It consists of multiple subunits, coded for by several genes.

The enzyme is located on the inner mitochondrial membrane and catalyses the reversible reaction of ATP synthesis from ADP in intact mitochondria. Here, the **proton motive force** is required to drive the ATP synthesis.

Explain how the structure, including protein components, of the inner mitochondrial membrane is significant in driving the reaction of ATP synthase towards ATP synthesis during aerobic respiration.

……[4]

[Important structure – hydrophobic fatty acid tails]

1 **Hydrophobic** fatty acid tails / hydrocarbon chains / hydrophobic core of inner mitochondrial membrane **repels / does not allow hydrophilic / charged** H^+ ions to pass through membrane;

2 Allows **proton gradient / proton motive force** to be established;

[Important composition – series of electron carriers]

3 Electrons passed down a series of **electron carriers / ETC** present on membrane with increasing electronegativity and in order of **decreasing energy levels**; (until they reach final electron acceptor – oxygen)

4 Energy released during transfer of electrons along series of electron carriers used to **pump H^+ ions from mitochondrial matrix into intermembrane space**;

[Important composition – ATP synthase]

5 **ATP synthase** embedded in an orientation that allows facilitated **diffusion of H^+ ions from intermembrane space to mitochondrial matrix** to be coupled with ATP synthesis;

[Total: 9]

QUESTION 4

(a) Climate change, in the form of global warming, is expected to have an impact on various organisms. This impact however, varies geographically, particularly for insects.

Fig. 4.1 and **Fig. 4.2** below show the fitness curves of representative insects from temperate and tropical locations respectively.

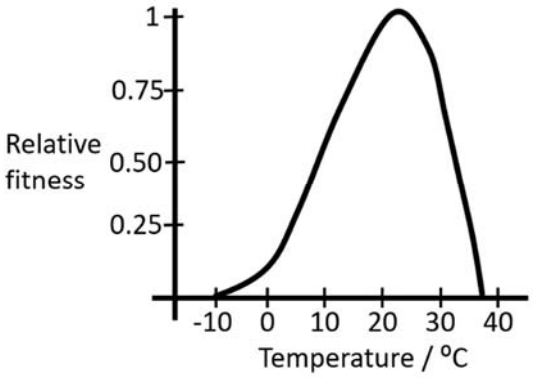


Fig. 4.1: Fitness curve of representative insect from temperate location

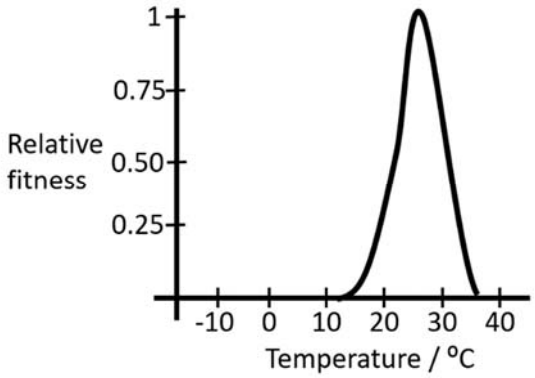


Fig. 4.2: Fitness curve of representative insect from tropical location

The mean annual temperature of the temperate location is 11□C, with a typical temperature range from 1□C to 20□C.
On the other hand, the mean annual temperature of the tropical location is 27□C, with a typical temperature range from 21□C to 31□C.

(i) Suggest what is meant by the term relative fitness in **Fig. 4.1** and **Fig. 4.2**.

……..[2]

1 **[Fitness]** a measure of evolutionary success as indicated by the number of surviving offspring left to produce the next generation;
2 **[Relative]** with reference to / as compared to **fitness at optimum temperature** (relative fitness of 1);

(ii) With reference to **Fig. 4.1** and **Fig. 4.2** and the information given, predict and explain which insects, from the temperate or tropical location, would face a greater extinction risk as a result of global warming, assuming the warming elevates temperatures equally at both locations.

……..[4]

[Predict]

1 Insects from the **<u>tropical location</u>**;

[Explain]

2 As these insects are already living **close to / just under / around /** (sometimes) **beyond** their **optimum temperature** for maximum relative fitness of 1 / these insects have a **narrower temperature tolerance**;

3 [Quote] Optimum temperature = 26 - 28□C (Accept: any figure within range) + mean annual temperature of the tropical location is 27□C OR typical temperature range from 21 to 31□C;

4 Ref. temperature predicted to increase by 2 – 3 □C as a result of global warming;

5 Ref. lower relative fitness beyond optimum temperature / Ref. temperature increase likely to lower relative fitness, thus, increasing extinction risk;

6 Ref. temperature increase likely to increase relative fitness of insects from temperate location instead, reducing extinction risk;

(iii) Suggest one strategy that the insects in **(ii)** can employ to reduce the impact of global warming on themselves.

……..[1]

1 Migration to cooler climate / regions / habitats / higher altitude / latitude;

(b) Carbon dioxide is one of the greenhouse gases that contribute to global warming and subsequently climate change.

A group of high school students decided to test whether varying temperatures would correspondingly affect the mean carbon dioxide gas emission.

Table 4.1 shows the mean carbon dioxide gas emission after exposing a fixed number of mealworms to different temperatures. Carbon dioxide gas emission was measured before and after exposure to experimental temperature.

Table 4.1 showing effects of varying temperatures on mean carbon dioxide gas emission, measured in parts per million (ppm).

Temperature /°C	**Mean Carbon dioxide gas emission /ppm**	
	Before exposure to experimental temperature	**After** exposure to experimental temperature
30.0	445 ± 25	450 ± 17
40.0	450 ± 20	500 ± 30
50.0	460 ± 17	540 ± 18

Values represent mean ± standard deviation.

(i) Describe the patterns shown by the data in **Table 4.1**.

……..[2]

1. [Trend] The mean carbon dioxide gas emission increases as temperature increases;
2. [Quote data] As temperature increases from 30.0°C to 50.0°C, emission increases from 450ppm to 540ppm.

OR

1. [Trend] **Increase** in carbon dioxide gas emission **after exposure** to experimental temperatures **compared to before** exposure, gets bigger as temperature increases
2. [Quote data] As temperature increases from 30.0°C to 50.0°C, increase in emission increases from 5ppm to 80ppm

(c) Corals are affected by rising temperatures in ocean waters. Explain how.

……..[2]

1. Ref. Absorption of **more carbon dioxide which dissolves** when ocean waters get warmer; **ocean pH decreases** / ocean acidification occurs
2. Hard **corals cannot absorb calcium carbonate** they need to maintain their **skeletons**, stony skeletons that support corals will dissolve and corals destroyed / Coral polyp metabolism is affected and **corals expels the zooxanthellae**, (leaving the coral skeleton bleached), and eventual **death of corals due to lack of nutrients (provided by zooxanthellae)**

OR

1. **Photosynthesis in zooxanthellae is disrupted** at higher than usual temperatures, thus producing an excess of **products that are toxic**

2. Coral polyp metabolism is affected and **corals expels the zooxanthellae**, (leaving the coral skeleton bleached), and eventual **death of corals due to lack of nutrients (provided by zooxanthellae)**

[Total: 11]

Section B

Answer **one** *question only*.

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

Your answer 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 parts **(a)** and **(b)**, as indicated in the question.

QUESTION 5
Cellulose is the most abundant biopolymer on earth. It forms a significant proportion of the dry mass of plants.

Outline the role of atmospheric CO_2 in contributing to the structure of cellulose in plants. [15]

Process of Calvin cycle
1. ref. **Calvin cycle** / light-independent reactions in **stroma** of **chloroplast**;
2. **CO_2** (1-carbon molecule) is **fixed** by combining with (a 5C compound called) **ribulose 1,5-bisphosphate (RuBP)**;
3. catalysed by the enzyme **rubisco (RuBP carboxylase)**,
4. to form an **unstable intermediate 6C compound**, which immediately splits into half to form **2 molecules** of (a 3C compound called) **glycerate-3-phosphaste (PGA/GP)**;
5. **PGA/GP** is **reduced** to **triose phosphate (PGAL/TP)**;
6. The **electrons (hydrogen)** for this **reduction** come from **NADPH** produced from the **light-dependent reactions**
7. and the **energy** for this step comes from **ATP** produced from the **light-dependent reactions**;
8. For every ***3*** molecules of **CO_2**, there are ***6*** molecules of **triose phosphate / glyceraldehyde-3-phosphate / TP / PGAL / G3P**;
9. but only **1** molecule of **PGAL/TP** (**3C**) exits the cycle, and will be used by the plant cell to synthesise **carbohydrate** like glucose (sugar).
10. The other **5** molecules of **PGAL/TP** must be **recycled** to **regenerate** 3 molecules of **RuBP**;
11. RuBP is now prepared to receive **CO_2** again, and the cycle **continues**;

Max 8 pts

Structure of cellulose
12. ref. cellulose as a polymer of **β-glucose**;
13. Each β-glucose comes from **2 molecules of PGAL/TP** that exited Calvin cycle;
14. **6** carbon dioxide molecules required for synthesis of **1** molecule of β-glucose;

15. ref. **β(1→4) glycosidic bonds** between β-glucose molecules
16. catalyzed by the enzyme cellulose synthase.
17. adjacent units are oriented 180^0 to each other;
18. ref. cellulose exist as linear chains/form;
19. **Hydrogen bonds form between parallel chains** (as –OH points outwards) to establish cross-linkages between chains ;
20. ref. Microfibrils (and macrofibril) formation through association of many cellulose molecules (i.e. Many microfibrils combine to form macrofibrils)

Max 6 pts

QwC: [1mark] Clear, organised flow without ambiguity for Calvin cycle description and to include the link between cellulose (formed from **β**–glucose) and Calvin cycle.

QUESTION 6
Without genetic variation, some of the basic mechanisms bringing about evolutionary change cannot operate.

Explain how mutation events may contribute to variation, and how this variation can influence natural selection. [15]

1. ref. **germ-line mutations** / mutations that occur in the **gametes**, being **inherited** by the offspring;
2. ref. phenotype (characteristics) of the organism;

Gene mutation [max 4]

3. Spontaneous errors made during **DNA replication / DNA recombination / DNA repair**
4. ref. a change in the nucleotide / base sequence (may involve one or more bases) of the DNA molecule in a particular/single **gene locus / region** on a chromosome
5. ref. insertion/deletion/substitution/inversion of incorrect nucleotides
6. ref. an alteration in the DNA sequence may change the amino acid sequence
7. ref. introduction of **new alleles** into gene pool;

Chromosomal aberration [max 6]

8. Several gene loci are involved
9. Involves reshuffling of existing alleles in the gene pool (no creation of new alleles)

Change in the number of chromosomes

10. ref. **non-disjunction in mitosis or meiosis**
11. ref. failure of sister chromatids to separate during anaphase in mitosis / homologous chromosomes to separate during anaphase I in meiosis / chromatids to separate during anaphase II in meiosis
12. Can affect one, several or all the chromosomes within a nucleus
13. leads to a **change in the number of chromosomes**

Change in structure of chromosomes

14. ref. **chromosomal breaks that occur during mitosis or meiosis**
15. resulting in deletion, duplication, inversion or translocation of chromosomal segments
16. leads to a **change in the structure of chromosomes**
17. ref. reshuffling of alleles on the affected chromosomes

Natural Selection [max 3]

18. ref. different selection pressures which select for / favour individuals with selective advantage / beneficial phenotype/alleles;
19. More survive till reproductive age/maturity and reproduce to pass on advantageous alleles to their offspring;

20. After <u>many</u> generations / over time, natural selection will lead to change in frequency of alleles.

QwC: [1mark] Clear, organised flow without ambiguity for explanation of evolution with natural selection, and to include at least 1 description for gene mutation and chromosomal aberration;

- **END OF PAPER** -