Civics Group	Index Number	Name (use BLOCK LETTERS)

H2

ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS

H2 BIOLOGY **9744/01**

Paper 1: Multiple Choice

Friday 20th September 2019 1 hour

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

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 Optical answer sheet.

INFORMATION TO CANDIDATES

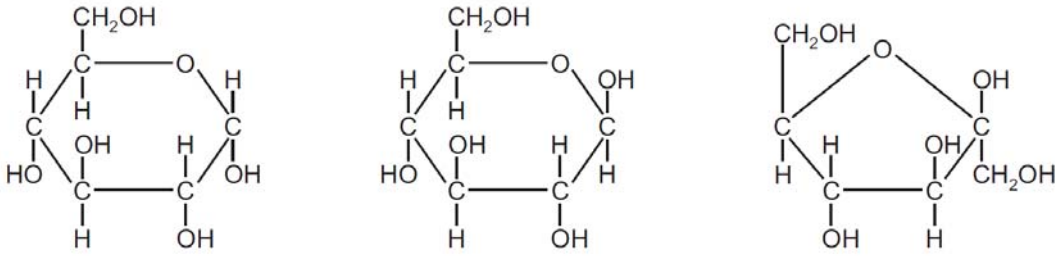
Each correct answer will score one mark. A mark will not be deducted for wrong answer. Any rough working should be done in this booklet.

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

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

[Turn over

1 The diagram shows a molecule of three hexose sugars.



1 2 3

Which row correctly shows examples of carbohydrates in which these hexose sugars are found?

	glycogen	amylopectin	cellulose
A	1	3	1
B	1	1	2
C	3	1	1
D	2	2	1

2 The table compares three molecules, X, Y and Z, which contain the elements carbon, hydrogen and oxygen only.

The percentage of carbon, hydrogen and oxygen atoms in each molecule is shown.

molecule	% carbon	% hydrogen	% oxygen
X	25.0	50.0	25.0
Y	28.5	47.7	23.8
Z	34.6	61.6	3.8

Which row correctly identifies molecules X, Y and Z?

	molecule		
	X	**Y**	**Z**
A	monosaccharide	disaccharide	polysaccharide
B	monosaccharide	polysaccharide	triglyceride
C	polysaccharide	triglyceride	monosaccharide
D	triglyceride	monosaccharide	polysaccharide

3 An investigation was carried out into the effect of different treatments on the permeability of the cell surface membranes and tonoplasts (central vacuole membrane) of beetroot cells. Beetroot cell vacuoles contain a red pigment. This pigment is unable to pass out of the cells because it cannot diffuse through the tonoplasts or cell surface membranes.

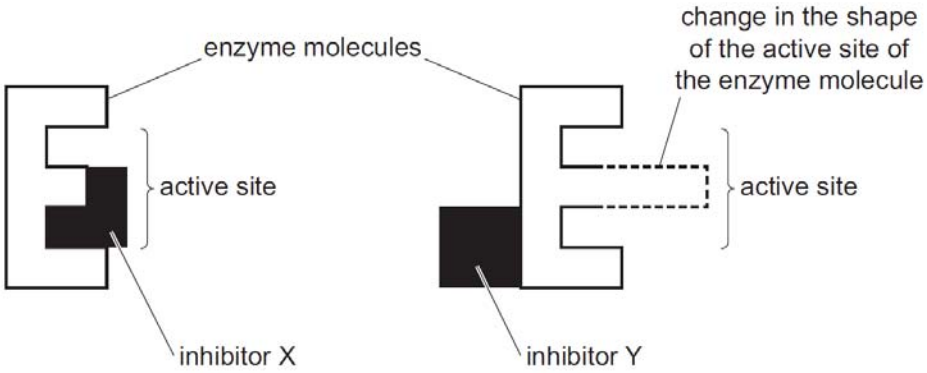
1 cm^3 cubes were cut from beetroot tissue and washed in running water for 20 minutes to remove any pigment released from damaged cells.

The cubes were then placed in test-tubes subjected to different treatments and the contents were observed for five minutes.

Which row shows a correct explanation for the observation recorded for one of the treatments?

	treatment	**observation**	**explanation**
A	dilute hydrochloric acid	contents of test-tube stay clear	membrane proteins have been denatured
B	ethanol	contents of test-tube turn red	lipids, including phospholipids, have dissolved
C	water at 20°C	contents of test-tube stay clear	membrane proteins have been denatured
D	water at 80°C	contents of test-tube turn red	lipids, including phospholipids, have dissolved

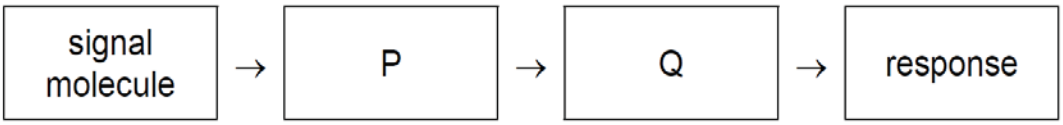
4 The diagram represents the interaction between the active site of an enzyme and different inhibitors, X and Y.



Which row correctly identifies the type of inhibition shown by inhibitor X and inhibitor Y respectively?

	X	**Y**
A	competitive	competitive
B	competitive	non-competitive
C	non-competitive	competitive
D	non-competitive	non-competitive

5 The diagram shows a simple cell signalling pathway in which a signal molecule leads to a response, such as a secretion.



Which row identifies P and Q?

	P	Q
A	activated enzyme in cytoplasm	target in cell surface membrane
B	lipid in cell surface membrane	extracellular enzyme
C	protein in cell surface membrane	activated enzyme in cytoplasm
D	target in cytoplasm	lipid in cell surface membrane

6 Drug Z is an inhibitor of aerobic respiration. A scientist proposed several likely targets that Z could act on.

1 Pyruvate decarboxylase in the Link reaction
2 α-ketoglutarate dehygrogenase in the Krebs cycle
3 Proton pumps in the Electron transport chain
4 ATP synthase

The scientist wanted to identify the actual target for Z. In his experiment, Z was added to a suspension of isolated mitochondria and pyruvate. The following observations were made 3 minutes after Z was added.

Variable Tested	Observation
• Uptake of oxygen	Negligible
• pH difference across the inner mitochondrial membrane	None
• ATP production	Negligible

Based on all of the observations, which of the following proposed target(s) of drug Z is/are **unlikely** to be correct?

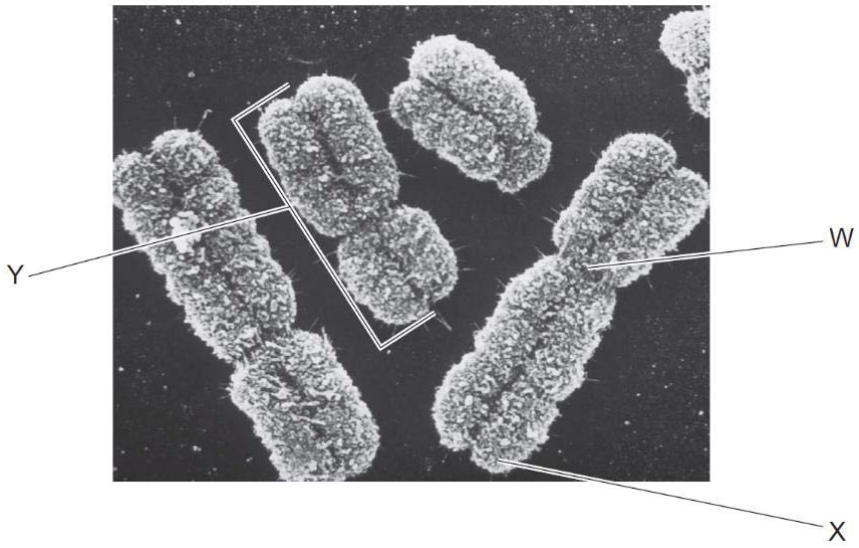
A 4 only
B 1 and 2
C 3 and 4
D 2, 3 and 4

7 The weedkiller DCMU blocks the flow of electrons down the electron transport chains in photophosphorylation.

Which of the following reason best explains why DCMU causes the death of plants?

A ATP and reduced NADP are not synthesised.
B Chemiosmosis cannot occur.
C Photoactivation of the chlorophyll cannot occur.
D Photolysis of water cannot occur.

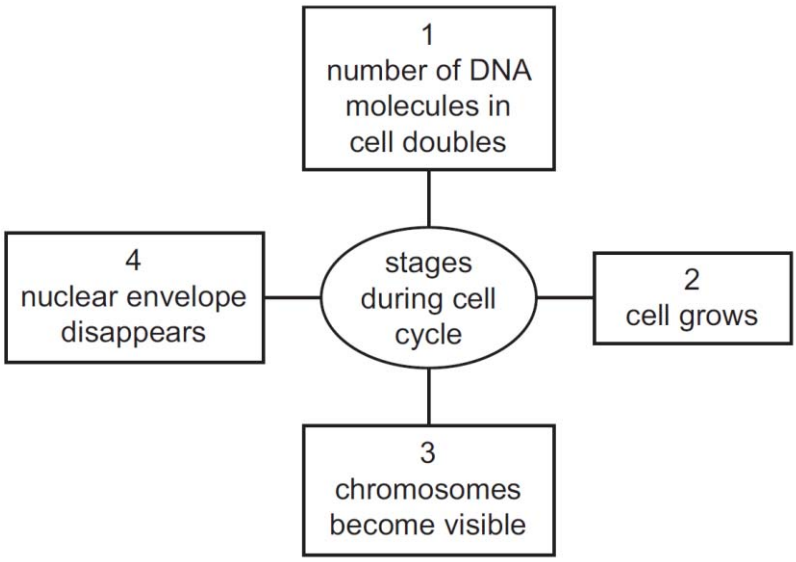
8 The electron micrograph shows a group of human chromosomes.



Which label is correct for each of the structures labelled W, X and Y?

	W	X	Y
A	centriole	centromere	chromatid
B	centriole	centromere	microtubule
C	centromere	telomere	chromatid
D	centromere	telomere	microtubule

9 The diagram shows some of the stages which take place during the cell cycle.



Which two stages take place during interphase?

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

10 A Robertsonian translocation is a type of chromosomal translocation in which the long arms of two chromosomes fuse together.

Fig. 10.1 shows this event occurring between chromosomes 14 and 21.

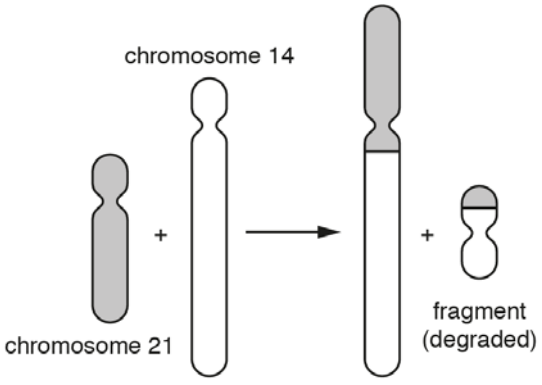


Fig. 10.1

An individual who inherits the translocated chromosome in **Fig. 10.1** will either have Down's syndrome or be a carrier of the disorder.

A couple has a child. The mother is a carrier and the father is genetically normal. The genetic material with respect to chromosomes 14 and 21 in the somatic cells of the parents are shown in **Fig. 10.2**.

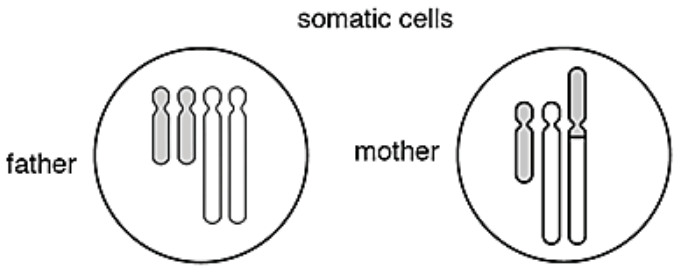
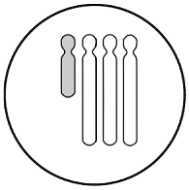


Fig. 10.2

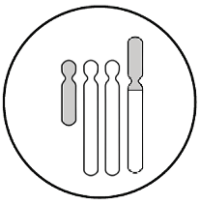
The child is born with Down's syndrome.

Which of the following shows the correct genetic material with respect to chromosomes 14 and 21 in the zygote of the child?

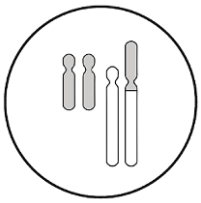
A



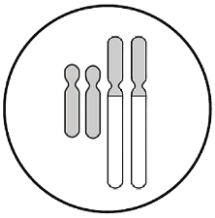
B



C



D



11 The diagram shows part of the DNA sequence of a gene and a mutated sequence of the same gene.

normal DNA sequence	...CCG GAT TAT TGC GAG AAA TGG CAT TCT AGG...
mutated DNA sequence	...CCG GAT GTA TTG CGA GAA ATG CAT TCT AGG...

What are possible effects of the mutated sequence?

1 the presence of additional mRNA stop codons, UAG, UAA or UGA
2 a change in the sequence of amino acids
3 formation of a non-functional protein
4 ribosomes cannot translate the mRNA

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

12 Which of the following comparison between the structure of prokaryotic genome and eukaryotic genome is **incorrect**?

	Prokaryotic Genome	**Eukaryotic Genome**
A	Circular chromosome	Linear chromosomes
B	Chromosome do not have telomeres	Chromosomes have telomeres
C	Contains mostly coding DNA	Contains mostly non-coding DNA
D	Does not contain regulatory sequences	Contains regulatory sequences

13 Use the information below to answer Questions 13 and 14.

Fig. 13 below shows the genomic structure of the wild-type human β-globin gene. The numbers within the boxes indicate the length of nucleotides of each region, inclusive of bases stated in the diagram. The DNA sequences corresponding to the start codon and the stop codon are indicated.

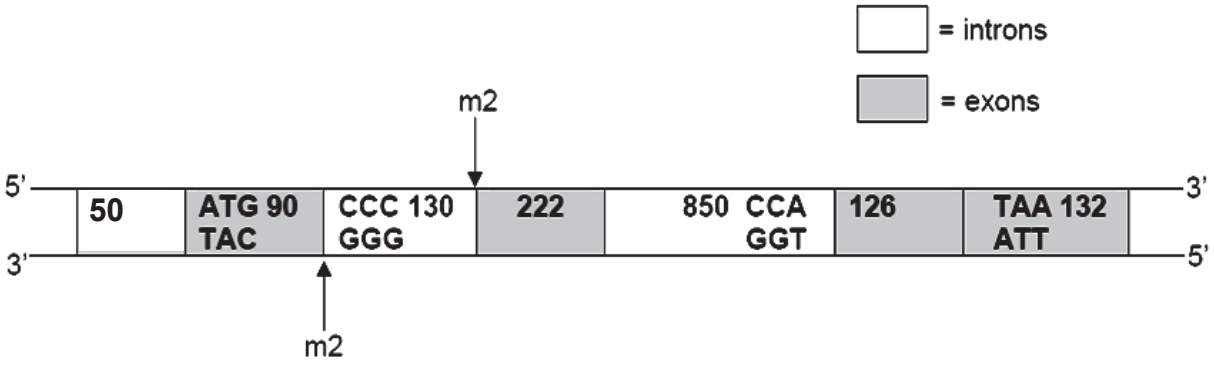


Fig. 13

Based on **Fig. 13,** what is the length (in nucleotides) of the wild-type β-globin primary mRNA transcript (pre-mRNA) and how many amino acids are present in the wild type β-globin polypeptide?

	Length of β-globin primary mRNA transcript	**No. of amino acids in wild type β-globin polypeptide**
A	570	146
B	570	190
C	1600	146
D	1600	190

14 Two base-pair substitution mutations (m2) occurred in the β-globin to form a mutant allele, as indicated in **Fig. 13**. This disrupts both the splice sites flanking the first intron of the β-globin gene. Splice site refers to the site where the DNA will be cut by spliceosomes.

Which of the following correctly describes the effect of the m2 mutations on the length (in nucleotides) of the primary mRNA transcript and mature mRNA transcript made from the mutant β-globin allele?

	Length of primary mRNA transcript	**Length of mature mRNA transcript**
A	No change	Increased by 43 bases
B	No change	Increased by 130 bases
C	Decreased by 222 bases	Decreased by 222 bases
D	Increased by 130 bases	Increased by 130 bases

15 A scientist investigated the mode of action of a drug, hydroxyurea (HU), that was known to prevent cell cycle progression in the parasite, *Leishmania*.

In the experiment, two groups of *Leishmania* parasites are used. **Group 1** is the untreated control. **Group 2** is incubated in a culture medium with HU for 1 hour before being transferred to a fresh medium without HU.

The effect of HU on histone synthesis was investigated by incubating parasite cells in a mixture of amino acids containing methionine that has been labelled with radioactive isotope sulfur. Histone synthesis was measured by the intensity of the dark bands shown in the autoradiograph. **Fig. 15** is an autoradiograph showing the levels of H2 histone proteins produced by Group 1 and Group 2 in the experiment.

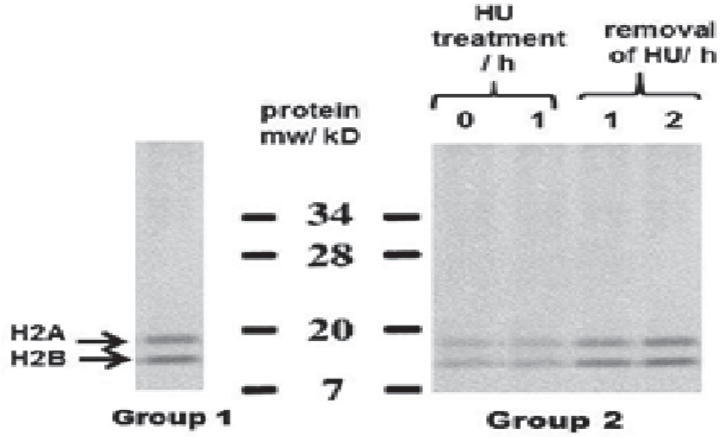


Fig. 15

With reference to the results in **Fig. 15**, which of the following **cannot** be a possible mode of action of HU?

A HU prevents the formation of the Transcription Initiation Complex.
B HU stops the binding of Translation Initiation factors to the small ribosomal subunit.
C HU inhibits poly(A) polymerase.
D HU prevents the addition of ubiquitin to histone proteins.

16 The following are some statements concerning cancer cells.

1 Cancer cells are likely to exhibit anchorage dependence.
2 Cancer cells do not undergo end replication problem as they have activated telomerases.
3 When a copy of the *p53* tumour suppressor allele is inactivated in a normal cell, that cell becomes cancerous.
4 When a copy of the *ras* proto-oncogene is converted into an oncogene in a normal cell, that cell becomes cancerous.

Which of the following statements are **false**?

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

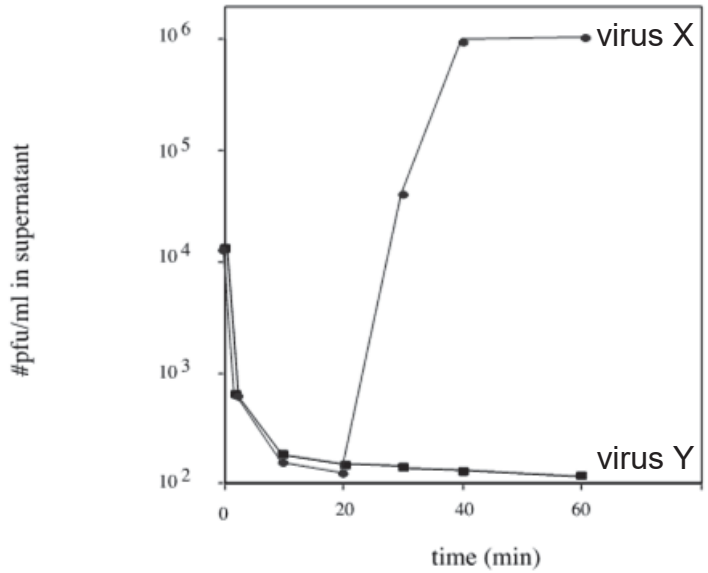
17 Two populations of genetically different bacteria cultured in a U-shaped tube are separated by a membrane filter (which does not allow phage particles and bacterial cells to pass). However, recombination takes place anyway. The mechanism of genetic exchange is _____.

A specialized transduction.
B generalized transduction.
C transformation.
D conjugation.

18 In generalised transduction, defective viruses are formed as a result of _____.

A viral enzymes cutting the host DNA such that the host DNA is assembled into the new virus.
B use of host enzymes by virus which cuts its own viral DNA such that it can be assembled into the new virus.
C hijacking of host transcription and translation machinery to make viral proteins and genome
D integration of viral DNA into host DNA and during excision of the prophage, the viral genome with the adjacent host DNA are assembled into the new virus.

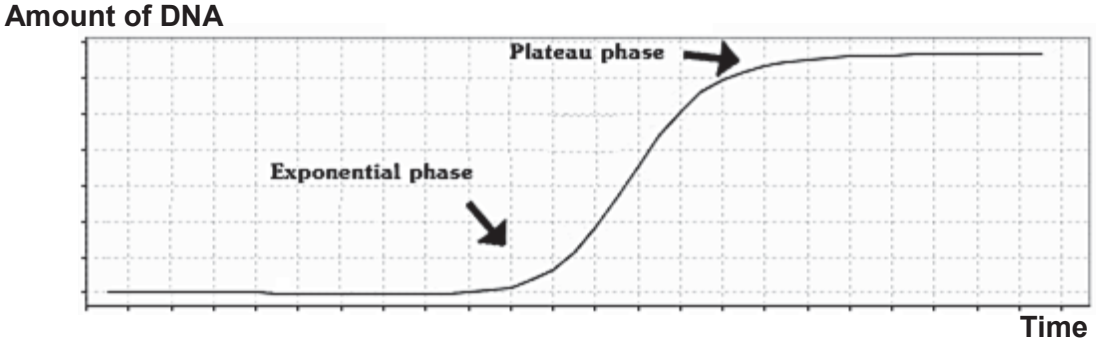
19 Two types of viruses, X and Y, were added to a culture of bacteria. For each type of virus, the change in the number of infectious virus particles present in the supernatant (pfu/ml in supernatant) was monitored for 60 minutes and shown in the graph.



What could explain the sharp increase in the number of infectious virus X particles present in the supernatant from 20 to 40 minutes?

A injection of viral DNA into host cell
B integration of viral DNA into host cell DNA
C release of viral particles by cell lysis
D release of viral particles by budding

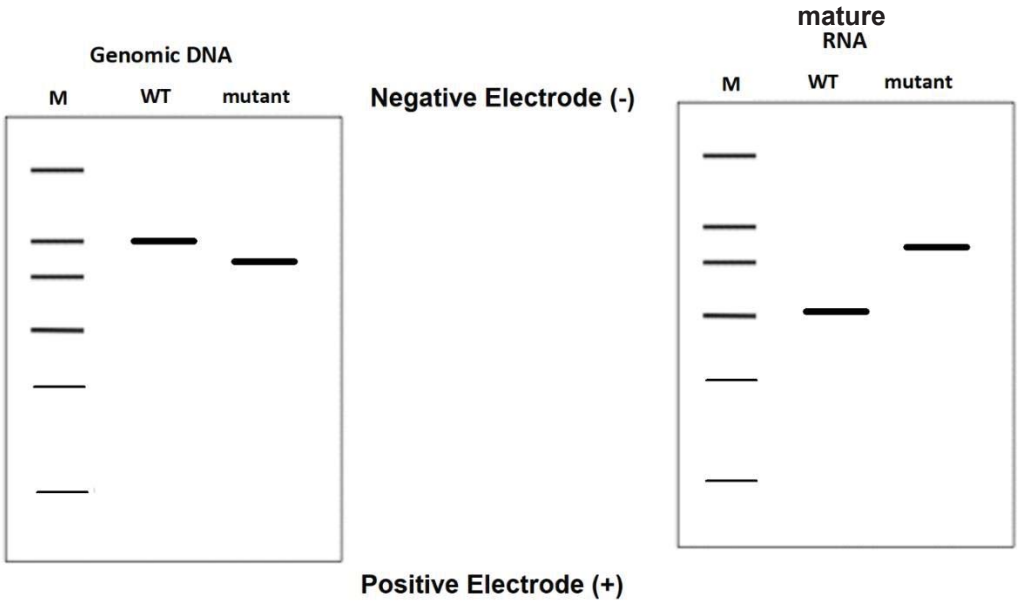
20 During PCR, the amount of DNA synthesised can be traced using fluorescent primers and the measurements are shown in the following plot. The process initially goes through an exponential phase, followed by a plateau phase eventually.



Which of the following statement is **true**?

A During the exponential phase, the number of DNA molecules synthesized after 15 cycles is 15^2.
B During the exponential phase, the temperature is always maintained at the optimum temperature of 72^{o}C hence there is rapid amplification.
C During the plateau phase, the reaction mixture might be depleted of ribonucleotides.
D During the plateau phase, *Taq* polymerase might be denatured.

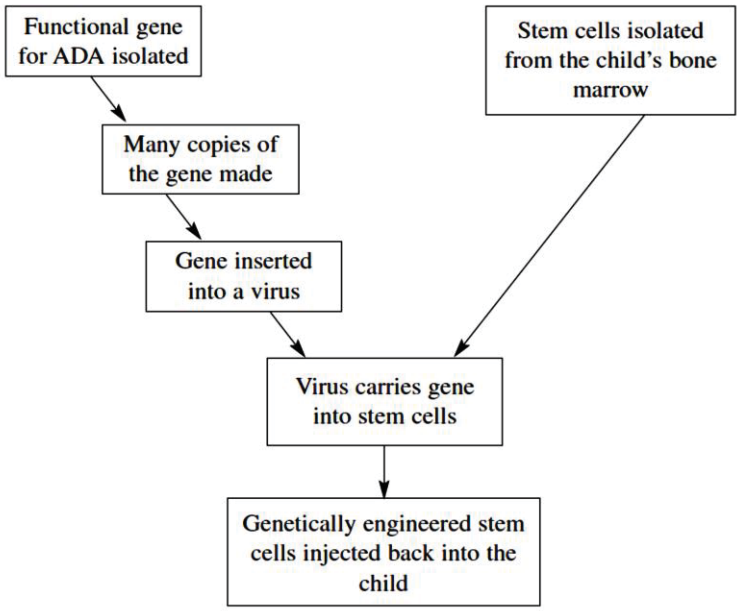
21 In an investigation of a gene suspected to be involved in a genetic disease, separate PCR procedures were done using genomic DNA and mature RNA isolated from healthy (wild-type WT) and diseased cells (mutant). The PCR products were analysed on polyacrylamide gels. The positions of the negative and positive electrodes are also indicated. M is a molecular weight marker that shows the positions of several nucleic acid fragments of specific lengths.



Which of the following best explains the results obtained?

A Deletion of an exon in the mutant.
B Deletion of a splice site in the mutant.
C Deletion of a stop codon in the mutant.
D Deletion of several introns in the mutant.

22 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 statement 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

23 Which statement about natural selection is **true**?

A Natural selection will have a greater effect in causing change if the variation that is shown for a trait is largely caused by environmental, rather than genetic, variation.
B One consideration in natural selection is the ability for a population, relative to other populations, to survive to reproductive age and produce offspring.
C Individuals better suited to the environment will be able to survive, reproduce and pass on favourable traits to their offspring.
D Environment will exert a selection pressure and only individuals best suited to the environment will be able to survive and reproduce.

24 The Galapagos Islands are a group of volcanic islands in the eastern Pacific Ocean, about 600 miles from mainland South America. Thirteen species of finch are found on the islands; they resemble each other closely but differ in their feeding habits and in the shape of their beaks.

Assuming that an ancestral stock of finches came from the mainland, what is the most likely explanation for the existence of similar but distinct species of Galapagos finches?

A Finches developed different kinds of beak in order to feed on different kinds of food.
B Finches evolved separately according to the habitat in which they settled in.
C Mainland finches bred with a resident population of a related species and produced new genotypes.
D Finches underwent convergent evolution to produce very similar species.

25 Some of the evidence for evolution are listed.

1 The fossil Archaeopteryx has many features in common with dinosaurs and some features in common with birds.

2 The bones found in the ears of reptiles and mammals have the same origin as the jaw bones of fish.

3 Many species that are present in older layers of sedimentary rock disappear from more recent layers.

4 The forelimb structure is found in all extant and extinct vertebrates.

Which evidences are based on homologies?

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

26 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

A 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%

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 greater influence than genes on the eye colour intensity and weight of non-identical twins.

28 T cells and B cells are isolated from a mouse for transplantation to immune-compromised mice that lack their own T and B cells.

- Mouse X received T cells only
- Mouse Y received T and B cells
- Mouse Z received B cells only

Mice X, Y and Z were then infected with the influenza virus and then were measured for their anti-influenza antibody response.

Which animal(s) would have produced anti-influenza antibodies?

A Mouse X
B Mouse Y
C Mouse Z
D Mouse Y and Mouse Z

29 Which features do the causative agents of dengue, malaria and tuberculosis (TB) have in common?

	presence of cytoplasm	the ability to produce ATP	presence of surface antigens
A	✓	✓	×
B	✓	×	✓
C	×	✓	×
D	×	×	✓

key
✓ = have in common
× = do not have in common

30 The habitat of sea turtles is shallow coastal water in warm and temperate seas. Sea turtles migrate to breeding areas to lay their eggs on sandy beaches. The nest temperature has a strong influence on the sex of the offspring. Colder temperatures result in a higher proportion of males and warmer temperatures result in a higher proportion of females.

Which effects of climate change could contribute to declines in populations of sea turtles?

1. increased melting of glaciers causing a rise in sea level
2. increased air temperature causing more heating of the Earth's surface
3. changes in ocean currents modifying migration pathways
4. heavy rainfall causing flooding of land and coastal erosion

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

- End of Paper -

Civics Group	Index Number	Name (use BLOCK LETTERS)

H2

ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS

H2 BIOLOGY **9744/2**

Paper 2

Thursday 29 August 2019 2 hours

Materials: Question Paper

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.

Answer **all** questions.
Write your answers in the spaces provided on the question paper.

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

For Examiners' Use	
1	/10
2	/7
3	/12
4	/12
5	/17
6	/10
7	/10
8	/12
9	/5
10	/5
Total	**/100**

This document consists of **27** printed pages.

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QUESTION 1

Fig. 1.1 shows an electron micrograph of a eukaryotic cell.

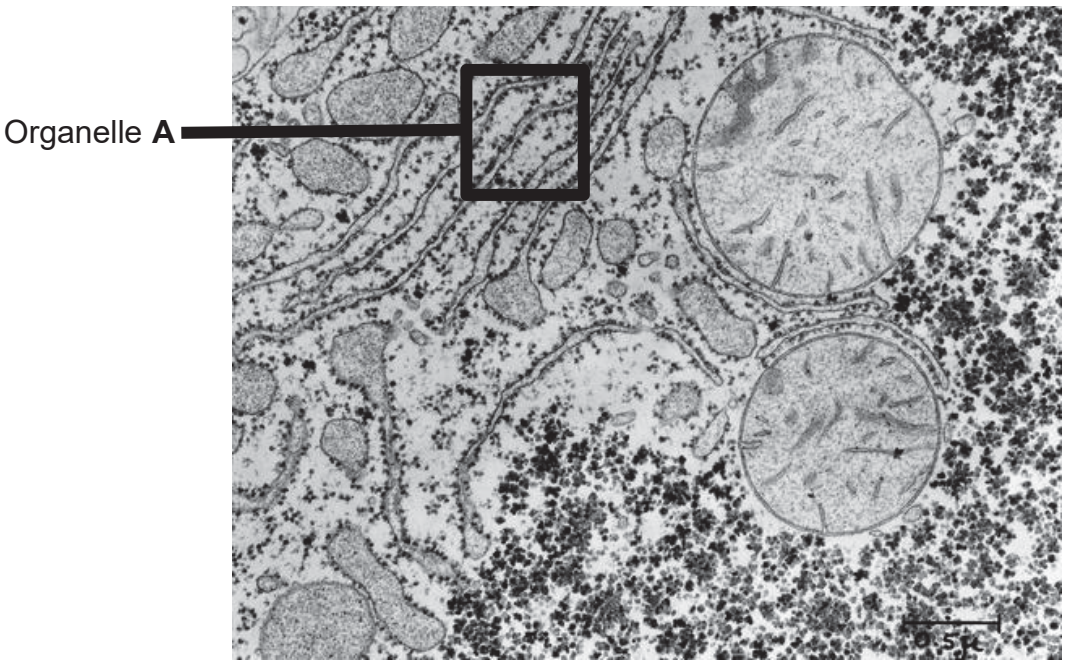

Fig. 1.1

(a) (i) With reference to **Fig 1.1**, state the identity of Organelle **A**.

Organelle **A** : ……..……..……[1]

(ii) Describe how the structure of organelle A relates to its function.

…….....

.....

.....

.....

.....[2]

Cellulose and collagen are molecules that are important in providing structural support. The basic structural unit of collagen is tropocollagen.

(b) Compare the structure of cellulose and tropocollagen.

……

.....

.....

.....

.....

.....

.....[3]

Fig. 1.2 shows the DNA content of a cell as time progresses.

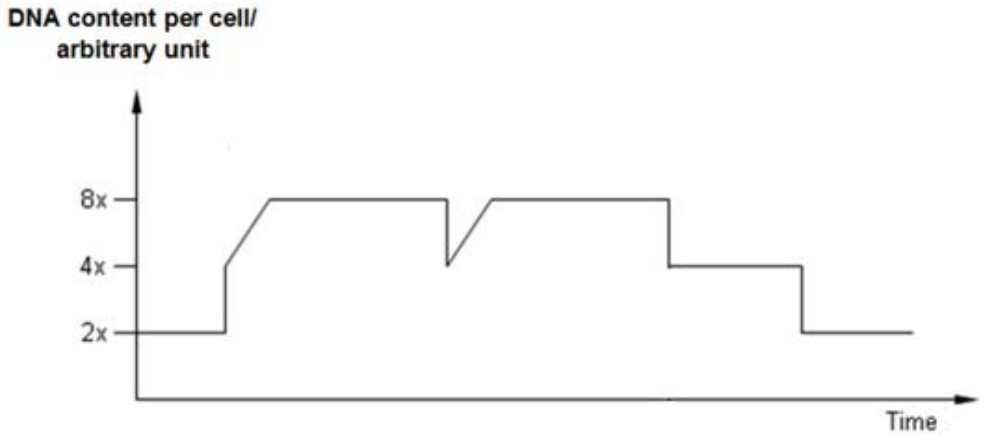

Fig. 1.2

(c) (i) Indicate, with a box, on **Fig. 1.2**, the time period at which meiosis is occurring.

……[1]

(ii) Explain your answer in **(c)(i)**.

……

.....

.....[1]

(iii) Explain the significance of meiosis.

……
.....
.....
.....[2]

[Total: 10]

QUESTION 2

The cell is surrounded by a plasma (cell surface) membrane. Substances entering or leaving the cell must pass through this membrane.

Fig. 2.1 is a diagram of part of the plasma membrane of a Chromista cell (Chromista are photosynthetic organisms that live in water).

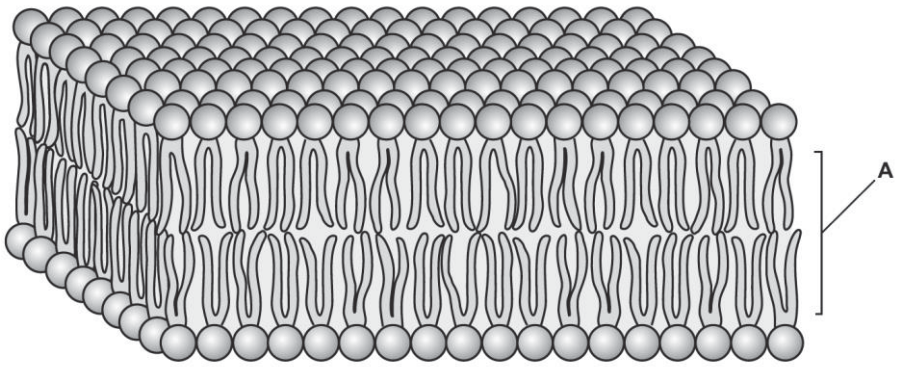

Fig. 2.1

(a) Identify region A and explain **one** property which contributes to how the membrane function as a barrier to the movement of galactose.

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……..[2]

Fig. 2.2 represents part of the plasma (cell surface) membrane of a cell that response to cytokines and illustrates the event that follows upon cytokines' binding.

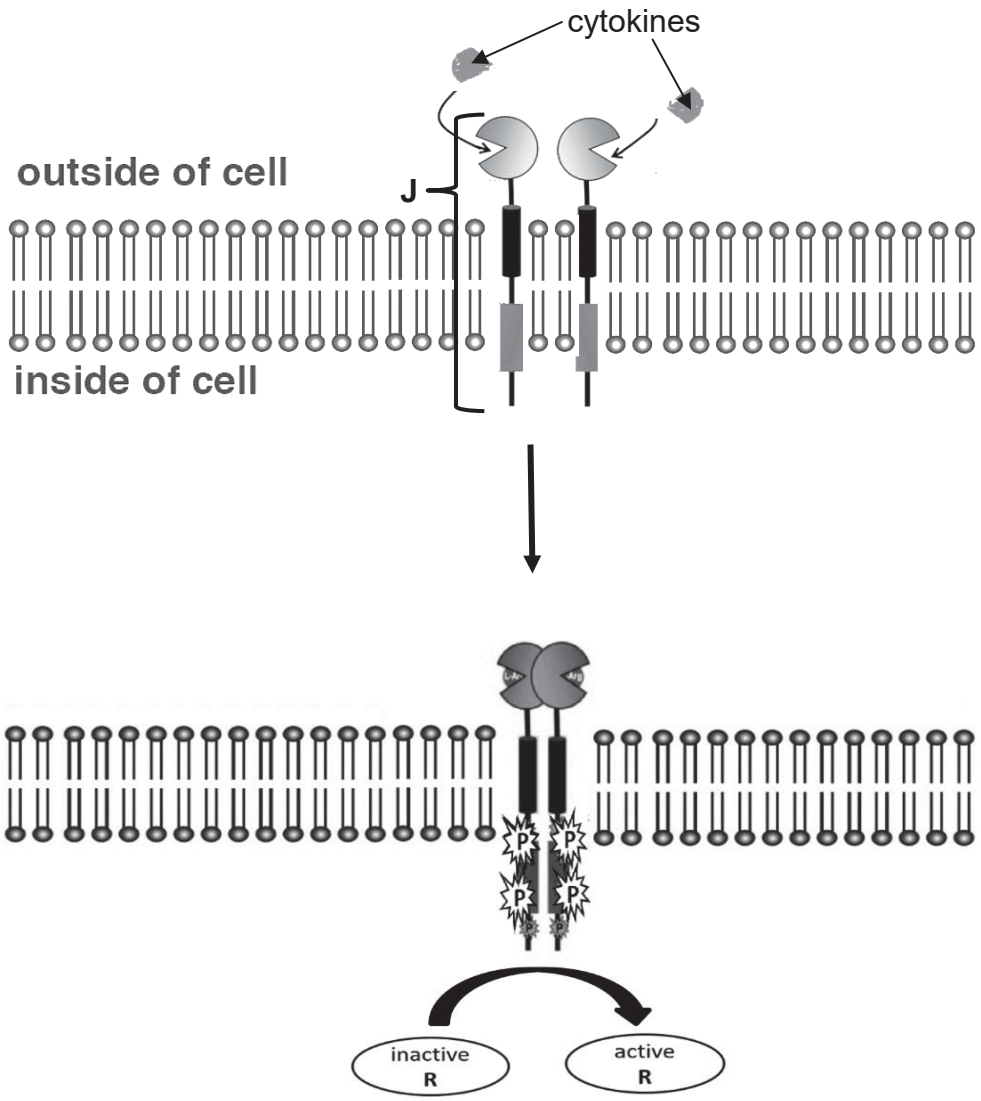

Fig. 2.2

(b) With reference to **Fig 2.2**, describe the sequence of events that follow cytokines' binding.

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……[5]

[Total: 7]

QUESTION 3

Fig. 3.1 shows the gene expression of a cytoplasmic protein in a eukaryotic cell.

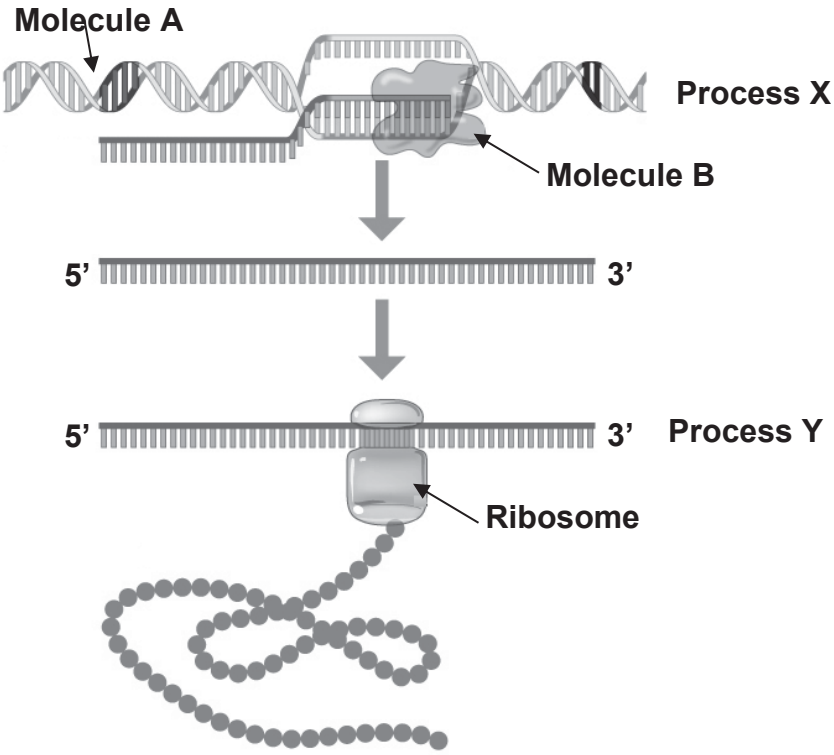

Fig. 3.1

(a) Name molecule A and describe one structure that enabled the identification.

……

.....[2]

(b) Describe how the structure of molecule B allows it to perform its function.

……

.....

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.....[2]

(c) Draw an arrow in **Fig. 3.1** to indicate the direction of movement of ribosome in Process Y.

……[1]

(d) Describe **three** ways in which process X differs from process Y.

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……[3]

Table 3 shows the mRNA codons for 11 different amino acids.

Amino acid	mRNA codon	Amino acid	mRNA codon	Amino acid	mRNA codon
Ala	GCG	Lys	AAG	Arg	CGC
Glu	GAG	Pro	CCU	Phe	UUC
His	CAC	Thr	ACU	Gly	GGA
Leu	CUG CUC	Val	GUG		

The first seven DNA triplets coding for the cytoplasmic protein are shown below.

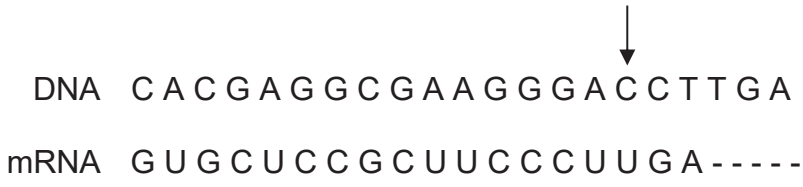

Fig 3.2

A mutation occurs at the **sixteenth** nucleotide in the DNA sequence. This is indicated by an arrow in **Fig. 3.2**. The corresponding complementary mRNA sequence to the mutated DNA sequence is shown in **Fig. 3.2**.

(e) (i) State the amino acid sequence encoded for by the mutated DNA sequence.

……[1]

(ii) Identify the mutation that has occurred and explain the effect of this mutation on the protein function.

……

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.....[3]

[Total: 12]

QUESTION 4

In a species of flea beetles, *Phyllotreta nemorum*, some individuals are parasitized by the *Hexamermis* species (a parasitic flatworm) while others have alleles that confer resistance to the parasite. Some flea beetles have also inherited the allele which codes for cellobiosidase, an enzyme that allows the individuals to feed on the toxic Winter Cress plants.

In a genetic experiment, pure-breeding flea beetles which are resistant to *Hexamermis* and are able to produce cellobiosidase were crossed with pure breeding flea beetles that are sensitive to *Hexamermis* and unable to produce cellobiosidase to produce only offspring with the ability to resist *Hexamermis* and produce cellobiosidase. When these resultant flea beetles of heterozygous genotype at both gene locus were sibling-mated, they produced the following F_2 generation:

Resistant to *Hexamermis*, able to produce cellobiosidase	178
Resistant to *Hexamermis*, unable to produce cellobiosidase	45
Sensitive to *Hexamermis*, able to produce cellobiosidase	53
Sensitive to *Hexamermis*, unable to produce cellobiosidase	156

(a) Define the term heterozygous.

……

…….[1]

(b) Calculate the recombination frequency obtained from the genetic experiment.

……

.....[1]

(c) Based on your answer in **(b)**, comment on the locations of these two genes' loci.

……

…….

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.....[2]

(d) Using the letters **A/a** (for resistance to *Hexamermis*) and **B/b** (for ability to produce cellobiosidase), draw a genetic diagram to show how the F2 generation is produced from sibling-mating of the F1 generation.

……[5]

(e) A chi-squared analysis was performed for this cross to determine if it follows Mendelian laws of inheritance.

Table 4.1 shows a chi-square table.

degrees of freedom	probability, p				
	0.10	*0.05*	*0.02*	*0.01*	*0.001*
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

The calculated χ^2 value is found to be 659.40.

Using the calculated χ^2 value and **Table 4.1**, state what conclusions may be drawn from the result.

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.....[3]

[Total: 12]

QUESTION 5

Fig. 5.1 is a diagram showing the structure of a section of a DNA molecule.

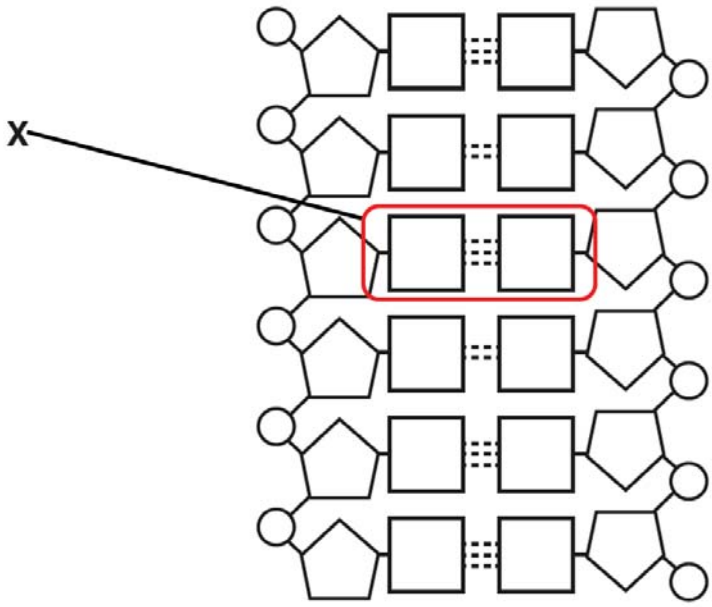

Fig. 5.1

(a) Name the two bases forming the base pair at **X** in Fig. 5.1 **and** give a reason for your answer.

……..……

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.....[2]

(b) The genomes of prokaryotic and eukaryotic cells contain chromosomes which are made of mainly of DNA molecules which may be associated with proteins.

With reference to organization of genes, describe **one** difference between prokaryotes and eukaryotes.

……

……..[1]

(c) Telomeres are found at the ends of chromsomes in eukaryotes. Outline the functions of telomeres.

……

……

……

……..[2]

(d) The differentiation of a eukaryotic stem cell into a specialized cell is controlled by many genes.

Fig. 5.2 summarises the interactions of some of these genes. The arrows represent the genes being switched on.

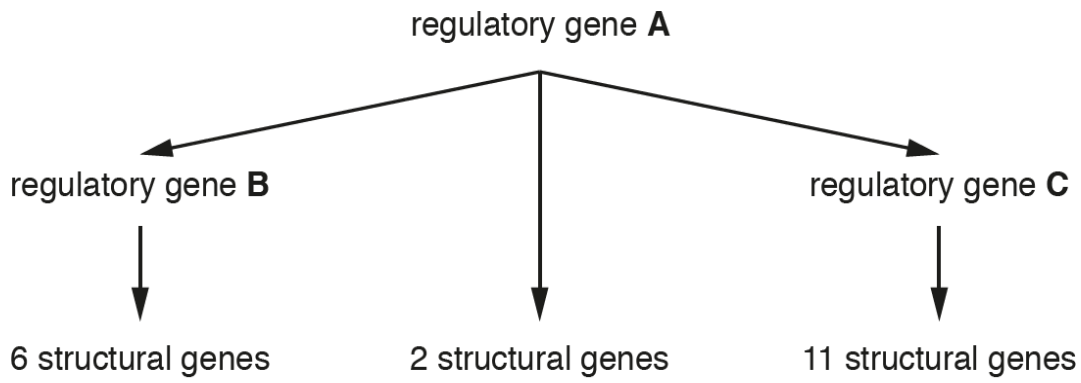

Fig. 5.2

With reference to **Fig. 5.2**, explain how genes such as **A**, **B** and **C** are able to switch on other genes.

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……[4]

(e) In prokaryotes, a cluster of functionally-related genes under the control of one promoter is organised into an operon. An example is the *lac* operon.

The *lac* operon is a section of DNA present in the genome of *Escherichia coli*. The structural genes of the *lac* operon are only fully expressed when the bacteria are exposed to high lactose concentrations.

Fig. 5.3 is a diagram showing the *lac* operon and a nearby region of the *E. coli* genome.

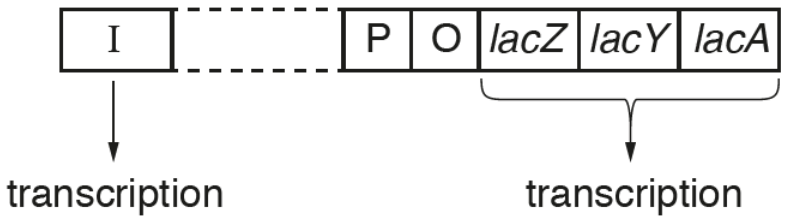

Fig. 5.3

(i) **Fig. 5.3** shows how the *lac* operon consists of structural genes and regulatory sequences.

Use **Fig. 5.3** to identify two structural genes.

Complete **Table 5.1** to name each structural gene and its product.

Table 5.1

structural gene	Name of gene product

[2]

(ii) Gene I is an example of a gene that undergoes constitutive expression.

Explain why it is necessary for some genes to be constitutively expressed.

……

……[1]

(iii) Describe the effect of the product of gene I on the functioning of the *lac* operon.

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……[3]

(f) If *E. coli* is put into a nutrient medium containing lactose, some enzymes are synthesised. These are described as inducible enzymes.

(i) Explain what is meant by an *inducible enzyme*.

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……...[1]

(ii) The structural genes of the *lac* operon are **not** expressed when lactose is absent.

Suggest **one** reason why this is beneficial to *E. coli*.

……
……..[1]

[Total: 17]

QUESTION 6

Viruses share common structural features. Some viruses, such as Human Immunodeficiency Virus (HIV), also have an outer envelope as part of their structure.

(a) List two other key structural features of viruses.

……

……

……

……..[2]

(b) HIV only infects certain types of cell, for example, the helper T-lymphocytes. These cells have CD4 receptor proteins in their cell surface membrane. HIV has glycoproteins embedded in its outer envelope.

HIV can remain in a dormant state within infected immune system cells for many years. A person diagnosed as HIV-positive (HIV+) has the virus but does not have symptoms of HIV/AIDS.

(i) The glycoproteins are important in allowing HIV to only infect certain types of cell. Explain the roles of these glycoproteins.

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……..[2]

(ii) Explain why there can be many years (up to ten years) between infection and the onset of symptoms.

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……..[2]

(c) Research showed that people with HIV are at higher risk of certain cancers compared with individuals without HIV. These cancers include Kaposi's sarcoma, lung cancer and cervical cancer etc.

Kaposi's sarcoma is a rare form of cancer that develops in the cells that line the mouth, nose, throat and blood vessels. It causes red or brown tumours, or lesions, on the skin or mucous membranes. These tumours can appear in other areas of the body such as the legs, lymph nodes and digestive tract.

(i) Suggest the one change to specific genes for HIV infections to increase the risk of developing cancer.

……

……..[1]

(ii) Outline how tumours can appear in other areas of the body in Kaposi's sarcoma.

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……..[3]

[Total: 10]

QUESTION 7

Fig. 7.1 shows the electron micrograph of an organelle found in a plant cell.

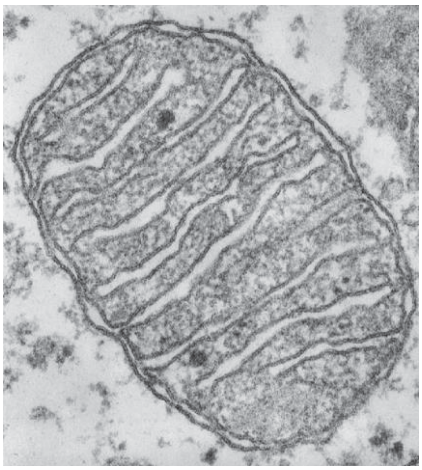

Fig. 7.1

(a) Certain reactions bring about the release of carbon dioxide in the organelle in **Fig. 7.1**.

State the type of reactions. Identify the stage(s) of aerobic respiration and location(s) where the reactions occur.

Type of reactions …….

Stage(s) of aerobic respiration ……..

Location(s) ……. [2]

(b) In plants, another organelle is involved in the uptake of carbon dioxide.

An enzyme RuBP carboxylase is involved in the process. Interestingly, it was found that the active site of this enzyme can be bound by either carbon dioxide or oxygen gas, with higher affinity for oxygen gas.

The entry of oxygen gas into the active site of RuBP carboxylase is detrimental for the plant.

Explain why.

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.....[2]

(c) In humans, certain tissues e.g. muscles can undergo anaerobic respiration if conditions make it necessary.

(i) Explain why there will be no production of ATP in the mitochondria during such conditions.

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.....[4]

(ii) During anaerobic respiration, pyruvate is converted to lactate. Explain the significance of this conversion.

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.....[2]

[Total: 10]

QUESTION 8

The greater racket-tailed drongo, *Dicrurus paradiseus,* is an insect-eating bird found in tropical broadleaved forests in southern Asia from Kashmir, India and Sri Lanka east to Indonesia.

Fig. 8.1 shows the geographic variation in the form of the crest among populations of the greater racket-tailed drongo.

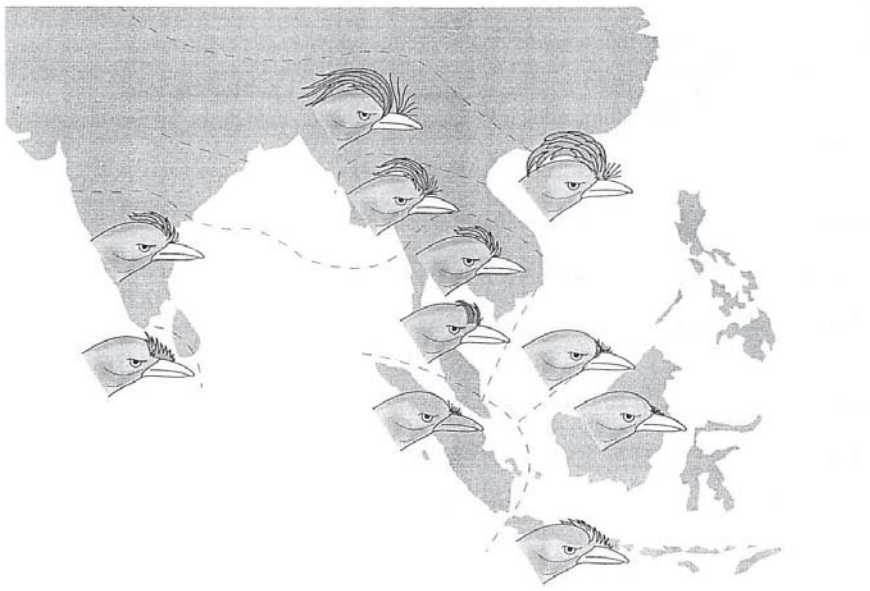

Fig. 8.1

(a) Explain how the distinct phenotypic differences between the populations may have arisen.

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.....[6]

(b) Suggest why these populations of greater racket-tailed drongos are classified as a single species

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.....[2]

Phylogenetic trees are constructed using molecular data instead of morphological data.

(c) Explain the advantages of using molecular evidences in determining phylogeny

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.....[4]

[Total: 12]

QUESTION 9

The immune system is the body's defense against infectious organisms.

Macrophages of the immune system are heavily involved in the persistence of *Mycobacterium tuberculosis* bacteria in the alveoli tissues during progression of tuberculosis (TB) disease.

Fig. 9.1 shows a macrophage engulfing a pathogen.

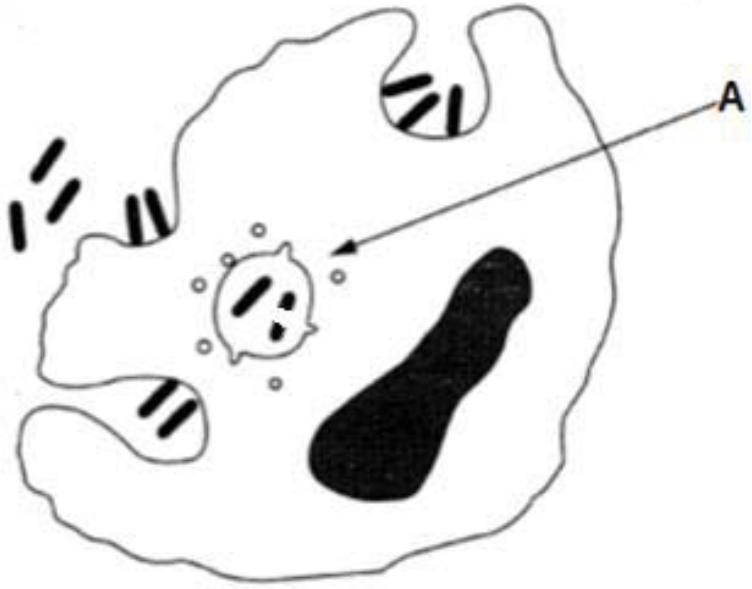

Fig. 9.1

(a) With reference to a named cellular organelle, describe step A.

……..……..……...

.....

.....

.....[2]

(b) Explain how the structure of antibodies, raised by prior vaccinations, may help macrophages engulf *Mycobacterium tuberculosis* bacteria.

.....

……..……..…….....[1]

(c) Explain why Acquired Immuno Deficiency Syndrome (AIDS) patients who are tested positive for *Mycobacterium tuberculosis* bacteria are more likely to experience TB related symptoms in the lungs e.g. chest pains and wheezing / difficulty in breathing.

……..……..……...

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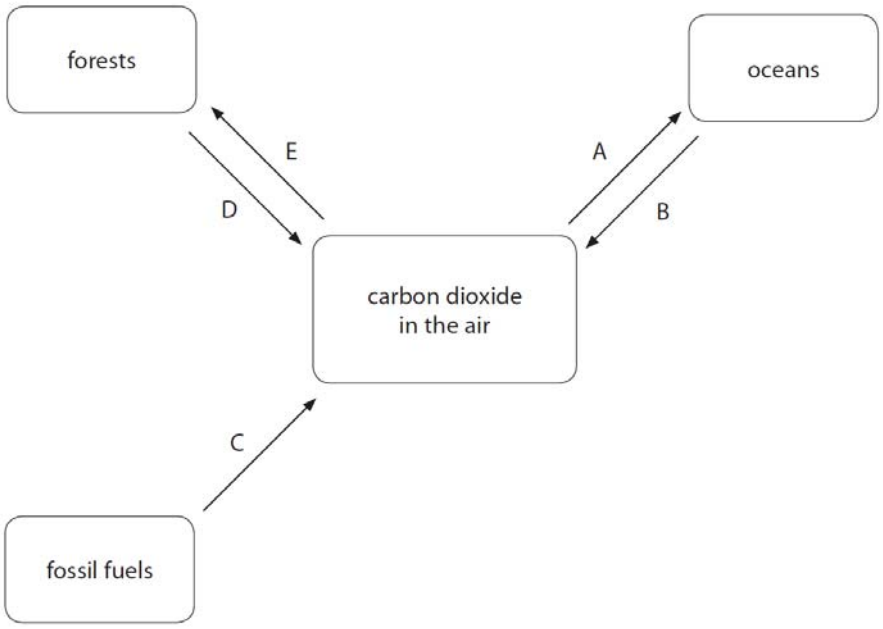
.....[2]

[Total: 5]

QUESTION 10

The diagram below shows part of the carbon cycle. The processes A, B, C, D and E, transfer carbon.



(a) Explain how carbon dioxide is removed from the air into the oceans by process A.

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.....[2]

(b) The table below shows how much carbon is being transferred by each of the processes in the diagram.

Process	A	B	C	D	E
Mass of carbon transferred / au	338	332	23	444	450

(i) Calculate how much more carbon is entering the air than is leaving it.

Show your working. [1]

(ii) Describe two human activities that contribute to increased emission of carbon dioxide.

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.....[2]

[Total: 5]

Civics Group	A Level Index Number	Name (use BLOCK LETTERS)	**H2**

ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS

H2 BIOLOGY **9744/03**

Paper 3

Thursday 19th September 2019 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 on the question paper.

Section B (Essay Question)
Answer **one** essay question (**parts a and b**).
Write your answers in the spaces provided on the question paper.

All working for numerical answers must be shown.

For Examiners' Use	
Section A	
1	/34
2	/10
3	/6
Section B	
4 or 5	/25
Total	**/75**

This document consists of **20** printed pages.

[Turn over

Section A

Answer **all** *questions*.

QUESTION 1

Blood is a bodily fluid in humans and other animals that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those same cells. The main components of blood include red blood cells, white blood cells and platelets.

Blood group is a classification of blood, based on the presence of antigenic substances on the surface of red blood cells. A total of 36 human blood group systems and 346 antigens are now recognized by the International Society of Blood Transfusion.

The most commonly known blood group system is the ABO system, an autosomal system which determines someone's blood type for suitability in blood transfusion.

(a) (i) Explain the type of variation which the blood group characteristic exhibits.

.....

.....

.....

.....[2]

(ii) John has blood group O while his wife Susan has blood group A. Susan's father has blood group O. State the probability of this couple having a son with blood group O.

Probability = …….. [1]

(iii) John and Susan are individuals belonging to the same species, *Homo sapiens*.

Describe a molecular technique, in general, to confirm that two organisms are the same species.

.....

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.....[2]

(iv) A specific gene was isolated from John and the DNA molecule was then made single-stranded.

This same process was repeated for Susan. Subsequently, one single strand from John's DNA and one single strand from Susan's DNA were hydribised together to form a hybrid DNA molecule.

It was observed that the temperature needed to separate this hybrid DNA is very high. Explain why.

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.....[2]

(b) Fig. 1.1 shows how blood cells are differentiated from blood stem cells from the bone marrow.

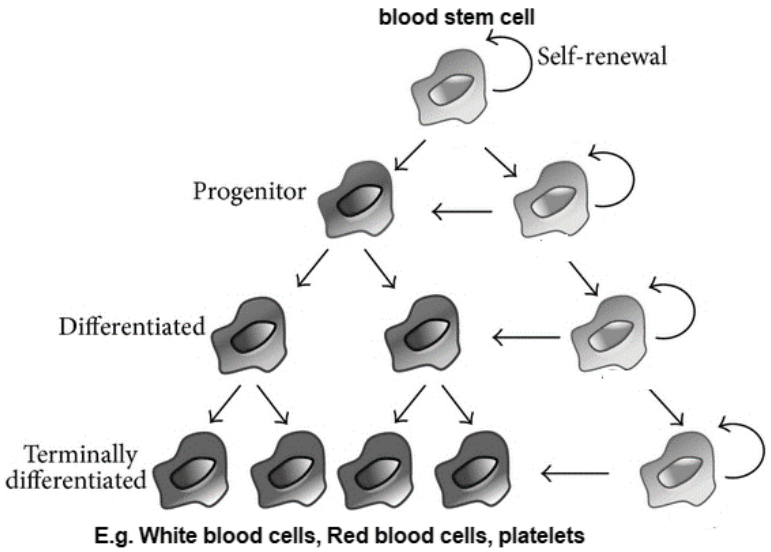

Fig. 1.1

(i) Explain why white blood cells are no longer able to differentiate further into other cell types while blood stem cells are still able to.

.....

.....

.....

.....[2]

(ii) **Fig. 1.1** also shows blood stem cells undergoing self-renewal which involves DNA replication before cellular division to form new stem cells.

During DNA replication, deoxyribonucleotides are polymerised to form daughter DNA molecules. Each base of a deoxyribonucleotide has a different **molecular structure** and therefore a different mass.

Name the two DNA bases that have the lowest masses and explain your answer.

.....

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.....

.....[2]

(iii) Outline the process of DNA replication.

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..... [5]

(iv) Bacteria is a good candidate for scientists to investigate about DNA replication. In 1958, an experiment was published by Meselson and Stahl investigating the way in which DNA replicates.

Suggest why bacteria were used in this experiment.

.....

.....[1]

(v) *Escherichia coli* bacteria were grown in a medium containing $^{15}NH_4Cl$. After very many generations, virtually all of the bacteria DNA contained ^{15}N and the DNA was described as 'heavy'.

The bacteria were then transferred to a medium containing $^{14}NH_4Cl$. A sample of bacteria was removed after the bacteria had divided once (first generation).

Further samples of bacteria were removed after they had divided again (second generation) and after they had divided once more (third generation).

The bacterial DNA from each generation was extracted and the **percentage of DNA strands containing ^{15}N (heavy) DNA in each sample was determined.**

From your knowledge of DNA replication, complete **Table 1.1 t**o show the percentage of %**^{15}N** in each sample for second and third generation.

Table 1.1

	E. coli generation		
	first	second	third
% of DNA strands containing ^{15}N in each sample	50		

[2]

(c) Haemoglobin is a protein found in red blood cells that transport oxygen around the body.

(i) Draw an **annotated** diagram to show how a peptide bond is formed when two amino acids are joined together during translation.

…… [2]

(ii) Every amino acid has an R group or variable region that gives it its properties.

Glutamic acid is a polar amino acid and is therefore hydrophilic.

Fig. 1.2 shows part of a cell membrane.

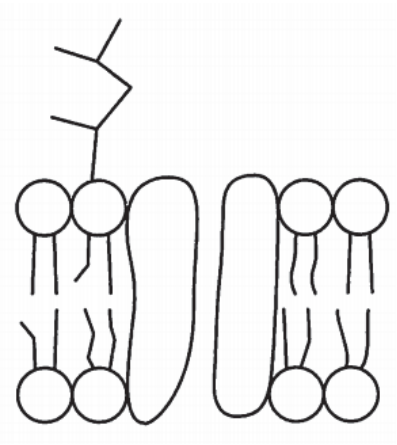

Fig. 1.2

On **Fig. 1.2**, use labeling lines and the letter X to label **two** different locations where you could expect to find glutamic acid.

……[2]

(iii) Describe the quaternary structure of haemoglobin.

.....

.....

.....

.....[2]

(d) Sickle cell anaemia is a genetic disease caused by a base substitution in the gene coding for haemoglobin. This base substitution removes a restriction site for the restriction enzyme *MstII*.

The disease can be detected in an unborn child by obtaining a few fetal cells. A small section of DNA that could contain the base substitution is isolated and amplified using Polymerase Chain Reaction (PCR).

Fig. 1.3 shows how the restriction enzyme, *MstII*, cuts the DNA of the normal allele (Hb^A) and mutant allele (Hb^S) into fragments.

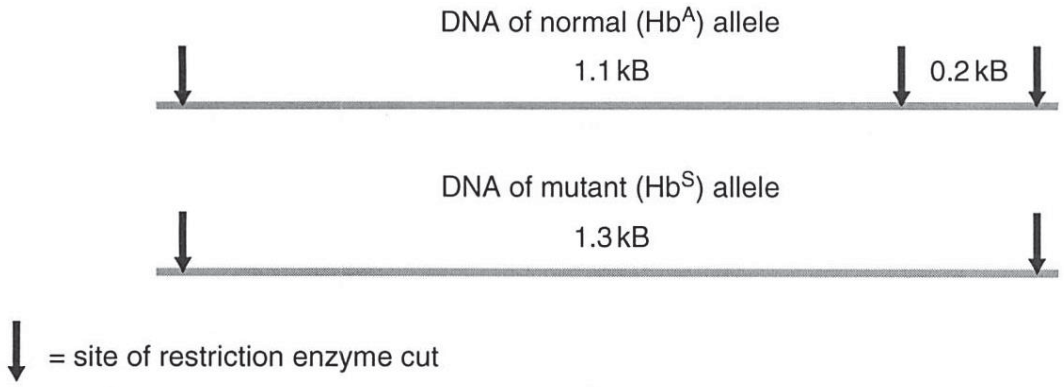

Fig. 1.3

(i) Explain why a single base substitution will result in the removal of one restriction site.

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.....[2]

Fig. 1.4 shows the patterns that are made visible after gel electrophoresis has been carried out using samples of DNA cut as shown in **Fig. 1.3**. The DNA samples are from three foetuses, one who is homozygous (Hb^A Hb^A), one who is heterozygous (Hb^A Hb^S) and one who is homozygous (Hb^S Hb^S).

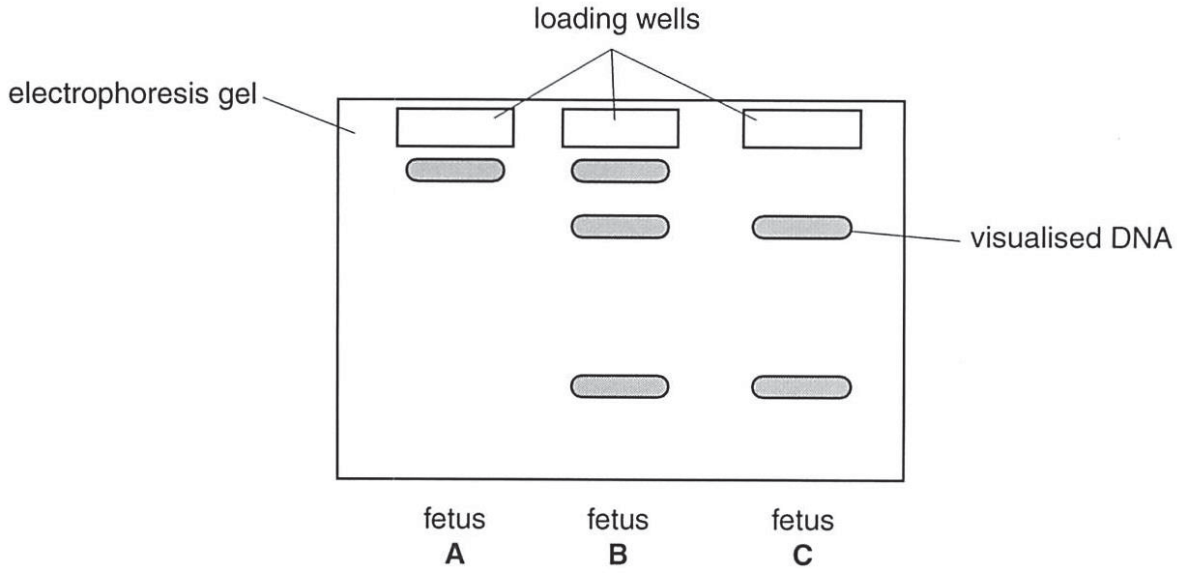

Fig. 1.4

(ii) Identify the genotypes of the foetuses labelled **A** and **B**.

A …… B…….. [2]

(iii) Explain why individual B has high evolutionary fitness in malaria-stricken areas.

.....

.....

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.....

.....

.....[3]

(e) A new anti-malaria drug was discovered. A statistical t-test was performed on a total of **10 Singaporean subjects** to investigate if this drug can result in significant improvements in the relief of certain symptoms compared to the control group (receiving no dosage of the drug). There are 5 subjects in the control group and 5 subjects in the experimental group receiving the drug.

The description of the human subjects are included in **Table 1.2.**

Table 1.2

Control group			
	Gender	**Age / years old**	**Race**
Subject number 1	Female	41	Chinese
Subject number 2	Male	55	Chinese
Subject number 3	Male	50	Chinese
Subject number 4	Female	62	Malay
Subject number 5	Male	39	Chinese
Experimental group			
	Gender	**Age / years old**	**Race**
Subject number 6	Male	21	Chinese
Subject number 7	Male	24	Chinese
Subject number 8	Male	30	Chinese
Subject number 9	Male	27	Chinese
Subject number 10	Female	25	Chinese

Table of t critical values

df	.10	.05
1	3.078	6.314
2	1.886	2.920
3	1.638	2.353
4	1.533	2.132
5	1.476	2.015
6	1.440	1.943
7	1.415	1.895
8	1.397	1.860
9	1.383	1.833
10	1.372	1.812

The t-score was calculated to be 5.514.

Using the calculated t-score, the table of t critical values, and **Table 1.2**, discuss if the conclusion that this anti-malaria drug is effective is valid.

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.....[2]

[Total: 34]

QUESTION 2

Antibodies are produced naturally by B lymphocytes in the human body, after exposure to foreign antigens.

(a) B lymphocytes are known to have slightly different genome as compared to other nucleated cells in the body. Suggest **one** reason why.

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.....

.....[2]

Fig. 2.1 shows the process of obtaining antibodies using mice as a "production vessel".

Fig. 2.1

In this process, the same antigen A is injected multiple times at regular intervals into the mice before collection of their blood to isolate the antibodies. Such isolated antibodies may then be injected into a person to achieve immunity.

(b)(i) State the type of immunity conferred by the injected antibodies.

.....[1]

(ii) Explain why such type of immunity is not long-lasting.

.....

.....[1]

(iii) Suggest why antibodies were collected from the blood after "the same antigen A is injected multiple times at regular intervals into the mice".

.....

.....[1]

(iv) Comment on one ethical implication of using mice for large-scale antibody production.

.....

.....[1]

(c) A team of students proposed a method to use prokaryotes instead of mice to make antibodies. In this proposed method, genes for specific antibodies are introduced into prokaryote cells (e.g. bacteria), which will then express the genes to make the antibodies.

However, the production of fully functional antibodies in prokaryotic cells is expected to be unsuccessful.

Explain why.

.....

.....

.....

.....[2]

(d) During an immune response, cells divide by mitosis. Describe the significance of mitosis in an immune response.

.....

.....

.....

.....[2]

[Total: 10]

QUESTION 3

Reef-building corals are marine invertebrates found in shallow, clear, tropical oceans. The corals secrete an exoskeleton of calcium carbonate that becomes the underlying structure of the coral reef ecosystem.

(a) Explain why the areas of sea containing coral reefs are susceptible to increased temperature resulting from global climate change.

.....

.....[1]

Zooxanthellae are a group of unicellular algae from the genus *Symbiodinium* that live within the cells of reef-building corals. The relationship has been described as mutualistic since it is beneficial to both coral and zooxanthellae.

(b) Evidence shows that the mutualistic relationship between zooxanthellae and reef building corals has evolved by free-living algae invading corals that did not contain algae.

(i) Suggest the benefits **to the zooxanthellae** of their association with the corals.

.....

.....

.....

.....[2]

(ii) Corals that do not need zooxanthellae can live at a greater depth than reef-building corals.

Explain why this is so.

.....

.....

.....

.....[2]

Under conditions of stress, the relationship between the reef-building corals and the zooxanthellae can break down. Loss of zooxanthellae and the subsequent whitening that occurs, shown in **Fig. 3.1**, is known as coral bleaching. Coral bleaching can lead to death of the coral.

Fig. 3.1

Increased sea temperature associated with global climate change is known to be an environmental stress that can cause coral bleaching. The temperature range for healthy survival of reef-building coral is 25 °C–29 °C.

(c) Suggest **one** reason why permanent loss of zooxanthellae can lead to death of the coral.

.....

.....[1]

[Total: 6]

Section B

Answer **one** question only in this section.

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

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

Your answers must be in continuous prose, where appropriate.

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

4 **(a)** Explain how various factors can affect the rate of respiration. [10]

(b) Discuss the various roles of hydrogen bonding in ensuring the continuity of life, using named examples where relevant. [15]

[Total: 25]

5 **(a)** Describe how the *Trp* operon operates in the absence of tryptophan as well as in the presence of tryptophan. [10]

(b) Explain how Penicillin works in treating bacterial infections. Discuss how Penicillin-resistance may arise in a bacteria population, with reference to the key processes involved. [15]

[Total: 25]

Civics Group		Full Name (use BLOCK LETTERS)
Centre number / Index Number		

H2

ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATION

H2 BIOLOGY **9744/04**

Paper 4: Practical Exam

Tuesday 17th September 2019 2 hours 30 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use a HB pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in 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.

IMPORTANT INFORMATION TO CANDIDATES:

Candidates with access to **microscope** at the start of the paper are given the **first 1h 15 min** to use them. Please answer **QUESTION 3** within this time frame.

Candidates with no access to microscope at the start of the paper will be given access **1h 15min after the start of the paper**. You may proceed with **QUESTION 1** first.

Candidates can attempt **QUESTION 2** at any juncture of the paper.

Shift
Laboratory

For Examiner's Use	
1	/ 23
2	/ 12
3	/ 20
Total	**/ 55**

This document consists of **21** printed pages and **3** blank pages

Answer **all** questions

QUESTION 1

You are advised to:

- *Read through the entire question first*
- *Prepare a table to record your results in **(b)(ii)***

  ***before** starting the investigation.*

In this question, you will investigate the effect of substrate concentration on the rate of hydrolysis of a disaccharide, sucrose.

The enzyme **E** catalyses the hydrolysis (breakdown) of sucrose to fructose and glucose.

The products of the hydrolysis of sucrose will change the colour of potassium manganate(VII) solution, **P**, from purple to colourless.

You are required to:

- prepare a simple dilution of sucrose solution
- investigate the action of **E** on the different concentrations of sucrose solution
- record the time taken to reach the end-point for each concentration of sucrose solution

You are provided with:

- 30.0 cm^3 of 10.0 % sucrose solution, labelled **S**,
- 50.0 cm^3 of distilled water, labelled **W**,
- 10.0 cm^3 of 1 mol dm^{-3} sulfuric acid, labelled **A,** which is an irritant
- 10.0 cm^3 of 1.0 % enzyme solution, labelled **E**, which is an irritant
- 20.0 cm^3 of 0.01 % potassium manganate(VII) solution, labelled **P**, which is a low risk irritant

Safety:

- It is recommended that you wear suitable eye protection.
- If **A**, **E** or **P** come into contact with your skin, wash off immediately under running water.

(a) Sketch a fully-labelled graph to show the expected relationship between the rate of hydrolysis of sucrose by enzyme **E** and sucrose concentration, as sucrose concentration increases. Assume that all other conditions are kept constant.

No units for axes are required.

[2]

Proceed as follows:

You are required to prepare different concentrations of the sucrose solution.

(b) Carry out **simple** dilutions of the sucrose solution, **S**, to obtain **five** different concentrations in which the concentration of sucrose is **reduced by 2.0 %** between each successive dilution.

Prepare 5.0 cm^3 for each concentration of sucrose solution, **using the small plastic containers provided.**

(i) Complete Table 1.1 to show how you will prepare the different concentrations of sucrose solution.

Table 1.1

Concentration of sucrose solution / %	Volume of **S** / cm^3	Volume of **W** / cm^3
10.0	5.0	0.0

[2]

Before proceeding further:

- Use the beaker labelled **Hot water** to collect approximately 200cm^3 of hot water from where it is provided in the laboratory.
- Use the beaker labelled **Cold water** to collect approximately 200cm^3 of tap water from the tap.

Read step 1 to step 13 before proceeding.

1. Prepare the concentrations of sucrose solution, as shown in Table. 1.1.

2. Label as many test-tubes as you require for all the sucrose solutions prepared in step 1.

3. Put 1.0 cm^3 of 10.0 % sucrose solution into the labelled test-tube.

4. Repeat step 3 with each of the other concentrations.

5. Using the water from the beakers labelled **hot water** and **cold water**, set up a water-bath at a temperature between 35 °C and 40 °C. Use hot water to adjust the temperature of the water-bath if it cools down too much.

*The reaction will start when **E** is added in step 6.*

6. Put 1.0 cm^3 of **E** into each test-tube. Shake gently to mix.

7. Put all of the test-tubes into the water-bath and start timing.

8. Leave the test-tubes in the water-bath for **8 minutes**.
   During this period, it is not necessary to maintain the temperature of the water-bath.

*During this incubation period, continue with **(b)(iv)** and the rest of Question 1.*

9. At 8 minutes, remove all test-tubes from the water-bath and **immediately** put 1.0 cm^3 of **A** into each of the test-tubes. Shake gently to mix. Leave the test-tubes on the test-tube rack.

10. Label a clean test-tube as **Z**.
    Put 1.0 cm^3 of **E** and 4.0 cm^3 of **W** into the test-tube. Shake gently to mix.
    Test-tube **Z** will serve as the reference for the colourless end-point.

11. Put 1.0 cm^3 of **P** into the test-tube containing 10.0 % sucrose solution. Start timing. Shake gently to mix.

12. Check on the colour of the test-tube up till a maximum 5 minutes.

    Record in **(b)(ii)** the time taken for the test-tube to reach the end-point, as shown by the contents of test-tube **Z**.

13. Repeat steps 11 to 12 for each of the other concentrations of sucrose.

    Also, calculate the (relative) rate of hydrolysis of sucrose and record in **(b)(ii)**.

    If the end-point has not been reached after 5 minutes, **stop timing** and record the time taken as 'more than 300' and the rate as 'zero'.

(ii) Record your results in a suitable format in the space given.

[4]

(iii) Discuss what your results suggest about the relationship predicted in **(a)**.

……...

……...

……..[2]

(iv) Explain the purpose of step 9, where solution **A** was added to the mixture.

……...

……..[1]

(v) Suggest why solution **P** is expected to (eventually) decolourise, when it was added to the mixture in step 11.

……..

……..[1]

(vi) Confidence in the results of this experiment may be limited by lack of replication and repeats.

Apart from conducting replicates and repeats, identify **one** other significant source of error in this experiment. Also, describe **one** method to overcome / reduce this source of error.

……..

……..

……..

……..[2]

(c) A student carried out a similar experiment to investigate the effect of pH on the activity of an enzyme.

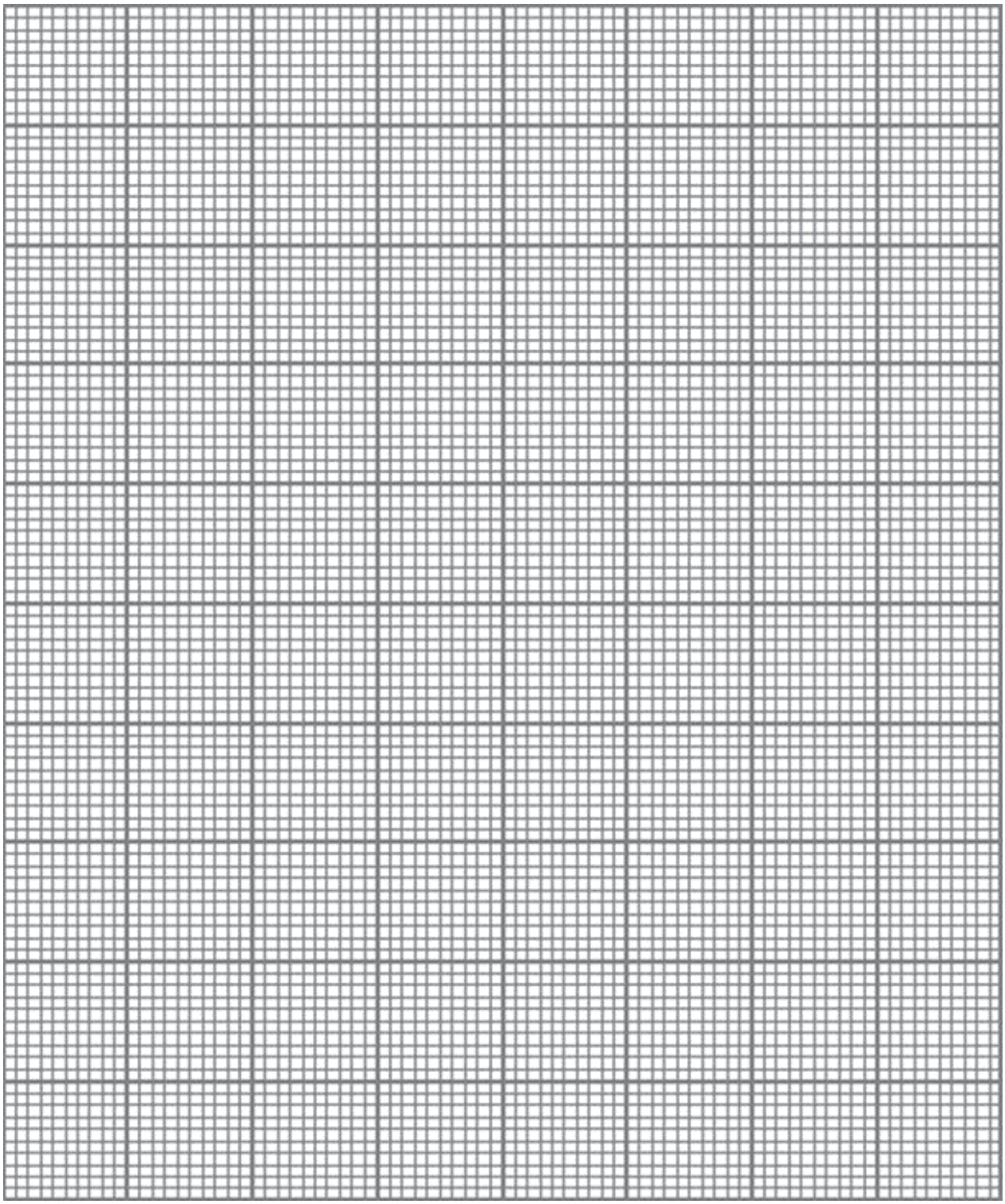
The rate of enzyme activity was measured when the solution was at different pH values.

All other variables were kept constant. The results are shown in Table 1.2.

Table 1.2

pH	**rate of enzyme activity / arbitrary units (A.U.)**
4.0	4.6
6.0	8.3
8.0	9.2
10.0	6.1
12.0	2.5

(i) Use the grid to plot a graph of the results shown in Table 1.2.



[4]

(ii) Using your graph, find the rate of enzyme activity which would be achieved if the pH of the solution was **11.0**.

Clearly indicate your working.

Rate of enzyme activity = ...A.U. [1]

(iii) Describe and explain the effect of increasing the pH from **8.0** to **12.0** on the rate of enzyme activity.

……...

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……...

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……...

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……...

……..[4]

[Total: 23]

QUESTION 2

A student wants to investigate the effect of temperature on the rate of digestion of sucrose, catalysed by enzyme sucrase.

Based on your knowledge of food tests, choose a relevant food test for this investigation.

Design an experiment to determine the effect of temperature on the **absolute rate** of sucrose digestion.

Your planning must be based on the assumption that you have been provided with the following equipment and apparatus which you **must** use.

You are provided with:

- 1% sucrase solution
- 1% sucrose suspension
- Benedict's solution
- Spectrophotometer
- Cuvettes
- Glass rod
- Stop watch
- Bunsen burner, tripod, gauze
- Access to hot water (80^{o}C – 90^{o}C)
- Supply of cool tap water
- Thermometer
- Distilled water
- Normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagrams, if necessary,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimize any risks associated with the proposed experiment.

[Total: 12]

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Write your answer for Question 2 on the lined paper provided on page 11 to 16.

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[12]

QUESTION 3

For this question, you will require access to a light microscope (with an eyepiece graticule) and the plastic container labelled M, which contains both a stage micrometer and specimen slide S1.

You are provided with a plastic container containing a stalk from an aquatic plant, submerged in distilled water.

1. Use the scissors and forceps to carefully remove a leaf from the stalk.
2. Use the mounting needle and forceps to carefully mount the specimen on a microscope slide.
3. Add 1 drop of **distilled water**.
4. Gently cover the specimen with a cover slip and use a paper towel to absorb any excess fluid.

(a) Observe your slide under the low-power (10X) and followed by high-power objective lens (40X) of your microscope.

Use the space below to make a **high-power detailed drawing** of **3** adjoining cells.

Label **3** different structures observed in your drawing.

[4]

(b) Slide **S1** is a microscope slide of a stained transverse section through a plant stem. This stem also grows submerged in water and contains air spaces.

You are not expected to be familiar with this specimen.

Observe **S1** under the low-power of your microscope.

Draw a **plan diagram** of a region of the stem on slide **S1**, as shown by the shaded area of Fig. 3.1. Within this part of the stem there will be a number of air spaces.

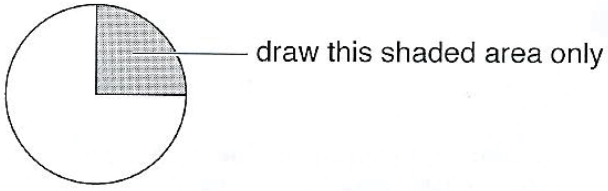

Fig. 3.1

A plan diagram shows the arrangement of the different tissues. Your drawing should show the correct shape and proportion of the tissues and air spaces.

No cells should be drawn. No labels are required.

[4]

(c) You are required to measure the length of **one** air space in the stem on slide **S1**, under **10x** objective lens.

When viewing slide **S1** under the microscope, select **one** air space in the stem located in the same region as your drawing in **(b)**, as shown by the shaded area of Fig. 3.2.

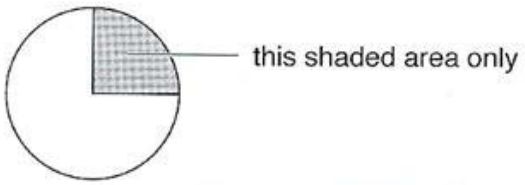

Fig. 3.2

(i) Before measuring the length of the selected air space, calibration of the eyepiece graticule needs to be conducted, under **10x** objective lens.

It is given that the length of each stage micrometer division is **0.01 mm**.

Describe the method to calibrate the eyepiece graticule.

……

……

……

……

……

……

……[3]

(ii) Based on your steps indicated in **(c)(i),** conduct the actual calibration for your eyepiece graticule under **10x** objective lens.

Find the actual length of **one** eyepiece graticule division.
Show all your workings clearly.

Actual length of 1 eyepiece graticule division = ..…….…… μm [1]

(iii) Using the information found in **(c)(ii)**, calculate the actual length of the selected airspace in the stem in slide **S1,** under **10x** objective lens

Show all your workings clearly.

Actual length of air space = …… μm [2]

(iv) Using the information found in **(c)(iii)**, calculate the magnification of your drawing of the air space in **(b)**.

Show all the steps in your working clearly.

Magnification = ...X [2]

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Turn over for remainder of Question 3.

(d) Fig. 3.3 is a photomicrograph of a stained transverse section through a stem of a different aquatic plant species. It also contains air spaces.

You are not expected to be familiar with this specimen.

(i) Observe the stem in Fig. 3.3 in comparison to that of slide **S1**.

You will use Fig. 3.3 to describe **two** observable differences between the stem in Fig. 3.3 and the stem in **S1**:

- Draw label lines to two different features in Fig. 3.3 and use only the labels **X** and **Y**.
- Complete Table 3.1 to describe how each feature on the stem in Fig. 3.3 differs from the stem in **S1**.

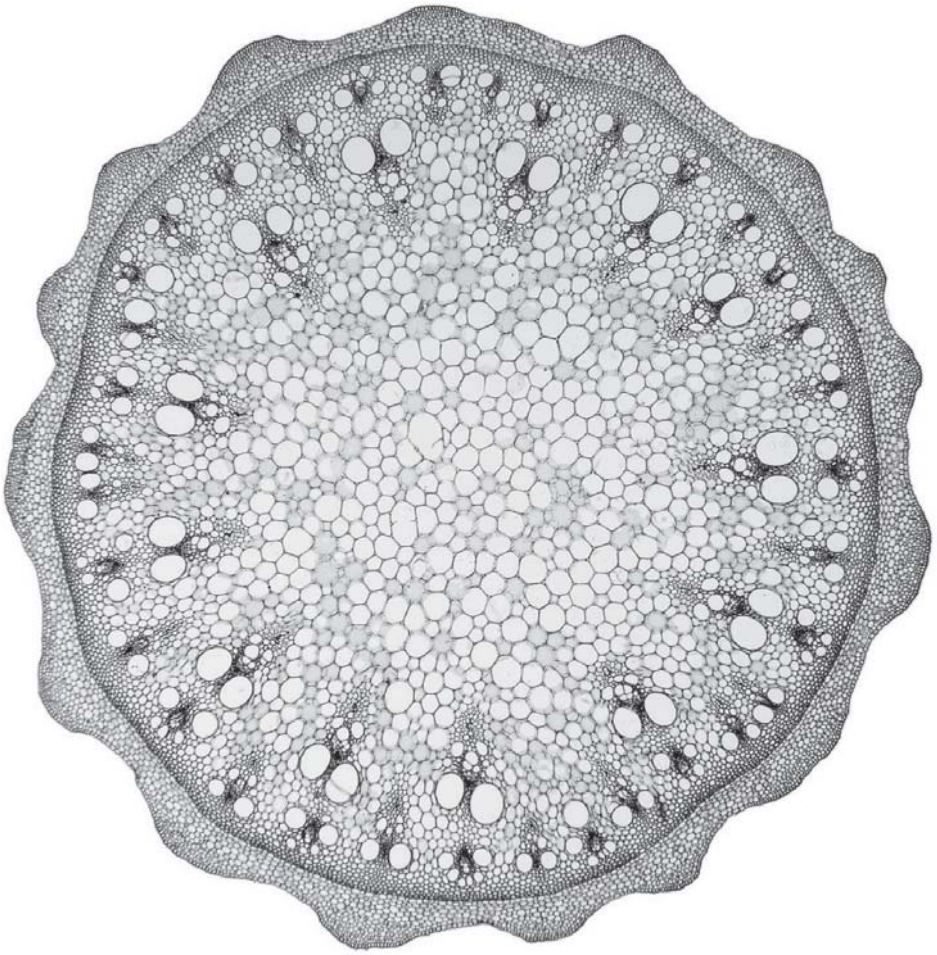

Fig. 3.3

Table 3.1

Feature	Slide S1	Fig. 3.3
X		
Y		

[3]

(ii) Suggest **one** advantage of having air spaces in stems of aquatic plants, as shown in slide **S1** and Fig 3.3.

……

……[1]

[Total: 20]

~ END OF PAPER 4 ~

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Civics Group	Index Number	Name (use BLOCK LETTERS)	H2

ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS

H2 BIOLOGY **9744/01**

Paper 1: Multiple Choice (MARK SCHEME)

Friday 20th September 2019 1 hour

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

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 Optical 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 both question paper and multiple choice answer sheet.

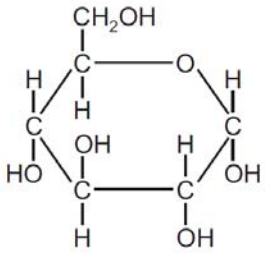
This document consists of **17** printed pages.

[Turn over

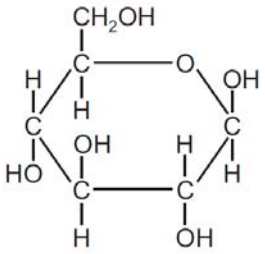
MCQ ANSWERS

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

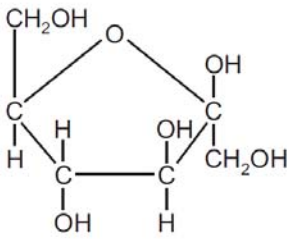
1 The diagram shows a molecule of three hexose sugars.



1



2



3

Which row correctly shows examples of carbohydrates in which these hexose sugars are found?

	glycogen	amylopectin	cellulose
A	1	3	1
B	1	1	2
C	3	1	1
D	2	2	1

2 The table compares three molecules, X, Y and Z, which contain the elements carbon, hydrogen and oxygen only.

The percentage of carbon, hydrogen and oxygen atoms in each molecule is shown.

molecule	% carbon	% hydrogen	% oxygen
X	25.0	50.0	25.0
Y	28.5	47.7	23.8
Z	34.6	61.6	3.8

Which row correctly identifies molecules X, Y and Z?

	molecule		
	X	**Y**	**Z**
A	monosaccharide	disaccharide	polysaccharide
B	monosaccharide	polysaccharide	triglyceride
C	polysaccharide	triglyceride	monosaccharide
D	triglyceride	monosaccharide	polysaccharide

3 An investigation was carried out into the effect of different treatments on the permeability of the cell surface membranes and tonoplasts (central vacuole membrane) of beetroot cells. Beetroot cell vacuoles contain a red pigment. This pigment is unable to pass out of the cells because it cannot diffuse through the tonoplasts or cell surface membranes.

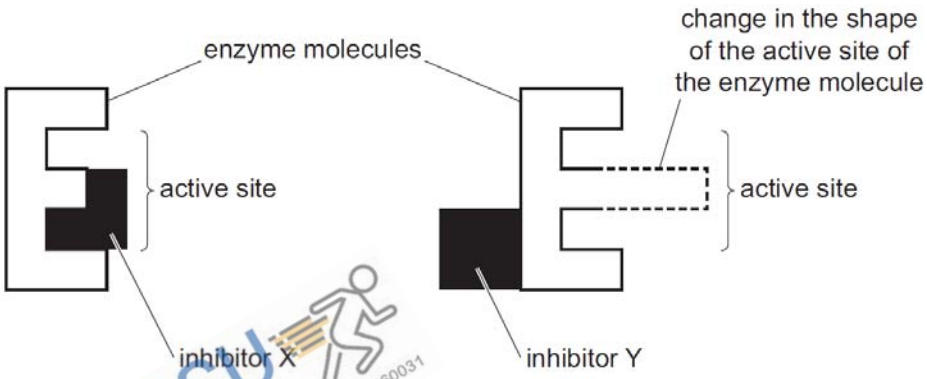
1 cm^3 cubes were cut from beetroot tissue and washed in running water for 20 minutes to remove any pigment released from damaged cells.

The cubes were then placed in test-tubes subjected to different treatments and the contents were observed for five minutes.

Which row shows a correct explanation for the observation recorded for one of the treatments?

	treatment	**observation**	**explanation**
A	dilute hydrochloric acid	contents of test-tube stay clear	membrane proteins have been denatured
B	ethanol	contents of test-tube turn red	lipids, including phospholipids, have dissolved
C	water at 20°C	contents of test-tube stay clear	membrane proteins have been denatured
D	water at 80°C	contents of test-tube turn red	lipids, including phospholipids, have dissolved

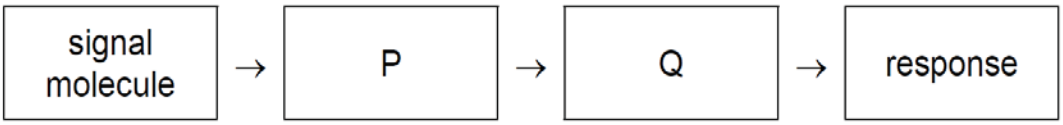
4 The diagram represents the interaction between the active site of an enzyme and different inhibitors, X and Y.



Which row correctly identifies the type of inhibition shown by inhibitor X and inhibitor Y respectively?

	X	**Y**
A	competitive	competitive
B	competitive	non-competitive
C	non-competitive	competitive
D	non-competitive	non-competitive

5 The diagram shows a simple cell signalling pathway in which a signal molecule leads to a response, such as a secretion.



Which row identifies P and Q?

	P	Q
A	activated enzyme in cytoplasm	target in cell surface membrane
B	lipid in cell surface membrane	extracellular enzyme
C	protein in cell surface membrane	activated enzyme in cytoplasm
D	target in cytoplasm	lipid in cell surface membrane

6 Drug Z is an inhibitor of aerobic respiration. A scientist proposed several likely targets that Z could act on.

1 Pyruvate decarboxylase in the Link reaction
2 α-ketoglutarate dehygrogenase in the Krebs cycle
3 Proton pumps in the Electron transport chain
4 ATP synthase

The scientist wanted to identify the actual target for Z. In his experiment, Z was added to a suspension of isolated mitochondria and pyruvate. The following observations were made 3 minutes after Z was added.

Variable Tested	Observation
• Uptake of oxygen	Negligible
• pH difference across the inner mitochondrial membrane	None
• ATP production	Negligible

Based on all of the observations, which of the following proposed target(s) of drug Z is/are **unlikely** to be correct?

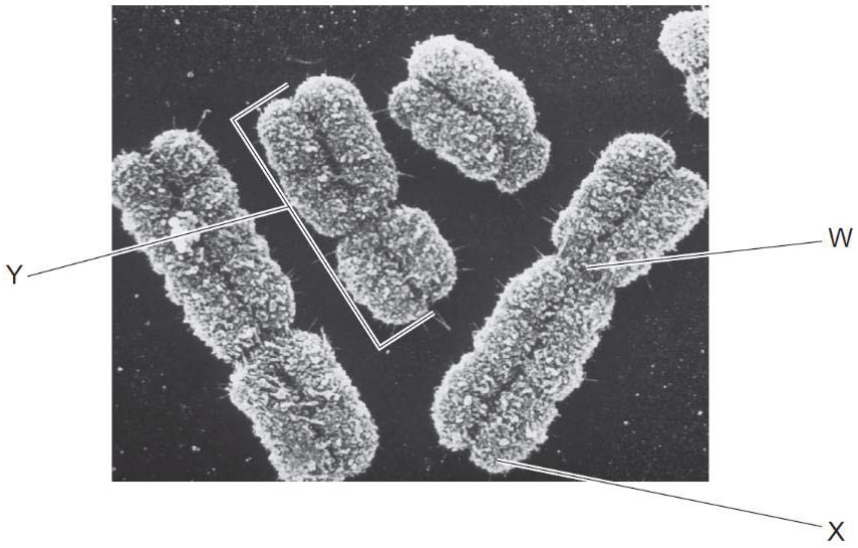
A 4 only
B 1 and 2
C 3 and 4
D 2, 3 and 4

7 The weedkiller DCMU blocks the flow of electrons down the electron transport chains in photophosphorylation.

Which of the following reason best explains why DCMU causes the death of plants?

A ATP and reduced NADP are not synthesised.
B Chemiosmosis cannot occur.
C Photoactivation of the chlorophyll cannot occur.
D Photolysis of water cannot occur.

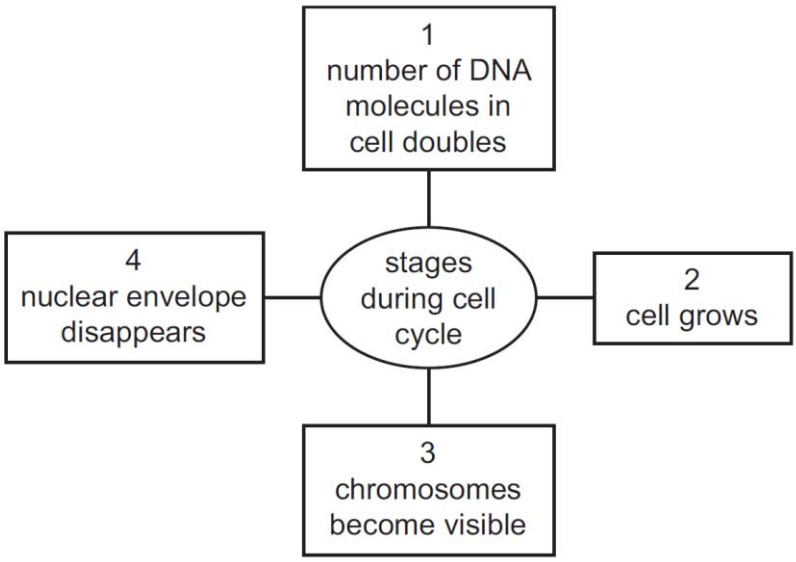
8 The electron micrograph shows a group of human chromosomes.



Which label is correct for each of the structures labelled W, X and Y?

	W	X	Y
A	centriole	centromere	chromatid
B	centriole	centromere	microtubule
C	centromere	telomere	chromatid
D	centromere	telomere	microtubule

9 The diagram shows some of the stages which take place during the cell cycle.



Which two stages take place during interphase?

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

10 A Robertsonian translocation is a type of chromosomal translocation in which the long arms of two chromosomes fuse together.

Fig. 10.1 shows this event occurring between chromosomes 14 and 21.

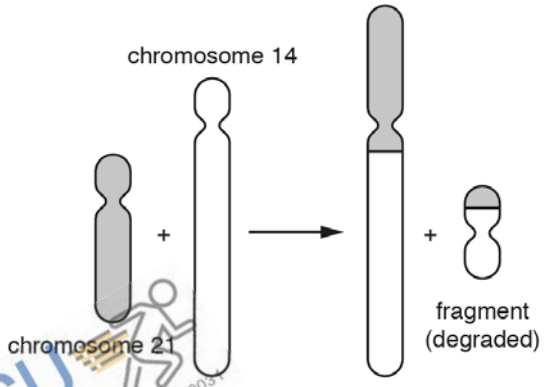


Fig. 10.1

An individual who inherits the translocated chromosome in **Fig. 10.1** will either have Down's syndrome or be a carrier of the disorder.

A couple has a child. The mother is a carrier and the father is genetically normal. The genetic material with respect to chromosomes 14 and 21 in the somatic cells of the parents are shown in **Fig. 10.2**.

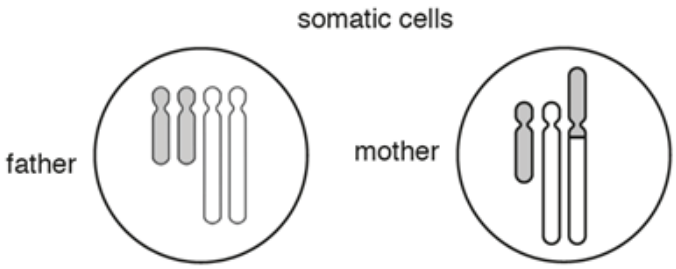
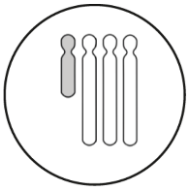


Fig. 10.2

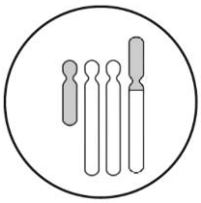
The child is born with Down's syndrome.

Which of the following shows the correct genetic material with respect to chromosomes 14 and 21 in the zygote of the child? ANS: C

A

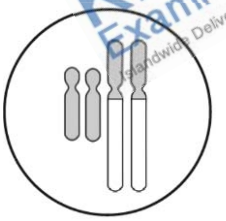


B



C

D



11 The diagram shows part of the DNA sequence of a gene and a mutated sequence of the same gene.

normal DNA sequence	...CCG GAT TAT TGC GAG AAA TGG CAT TCT AGG...
mutated DNA sequence	...CCG GAT GTA TTG CGA GAA ATG CAT TCT AGG...

What are possible effects of the mutated sequence?

1 the presence of additional mRNA stop codons, UAG, UAA or UGA
2 a change in the sequence of amino acids
3 formation of a non-functional protein
4 ribosomes cannot translate the mRNA

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

12 Which of the following comparison between the structure of prokaryotic genome and eukaryotic genome is **incorrect**?

	Prokaryotic Genome	**Eukaryotic Genome**
A	Circular chromosome	Linear chromosomes
B	Chromosome do not have telomeres	Chromosomes have telomeres
C	Contains mostly coding DNA	Contains mostly non-coding DNA
D	Does not contain regulatory sequences	Contains regulatory sequences

13 Use the information below to answer Questions 13 and 14.

The figure below shows the genomic structure of the wild-type human β-globin gene. The numbers within the boxes indicate the length of nucleotides of each region, inclusive of bases stated in the diagram. The DNA sequences corresponding to the start codon and the stop codon are indicated.

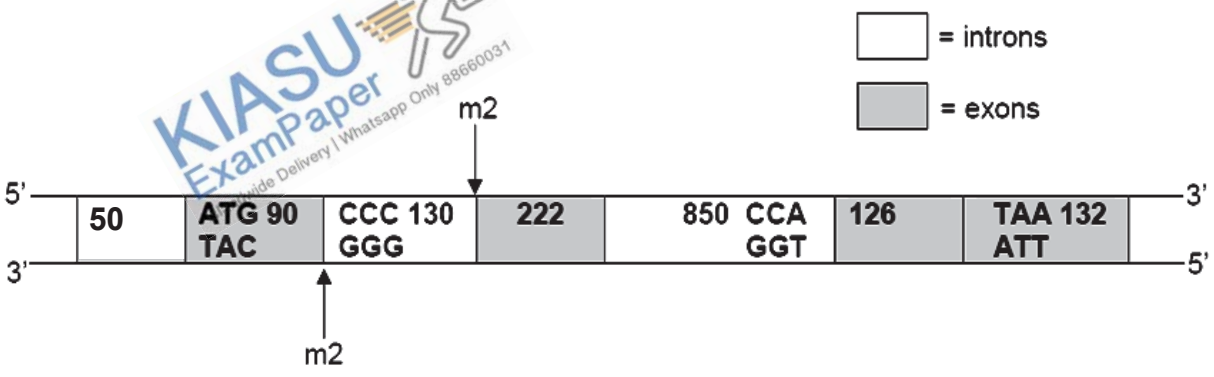


Fig. 13

Based on **Fig. 13,** what is the length (in nucleotides) of the wild-type β-globin primary mRNA transcript (pre-mRNA) and how many amino acids are present in the wild type β-globin polypeptide?

	Length of β-globin primary mRNA transcript	No. of amino acids in wild type β-globin polypeptide
A	570	146
B	570	190
C	1600	146
D	1600	190

Working for reference:

Primary RNA includes all exons and introns of sequence.

No of amino acids = addition of the length of all exons starting from ATG/ 3 = (90 + 222 + 126) = 438 / 3 = 146 aa

14 Two base-pair substitution mutations (m2) occurred in the β-globin to form a mutant allele, as indicated in **Fig. 13**. This disrupts both the splice sites flanking the first intron of the β-globin gene. Splice site refers to the site where the DNA will be cut by spliceosomes.

Which of the following correctly describes the effect of the m2 mutations on the length (in nucleotides) of the primary mRNA transcript and mature mRNA transcript made from the mutant β-globin allele?

	Length of primary mRNA transcript	Length of mature mRNA transcript
A	No change	Increased by 43 bases
B	No change	Increased by 130 bases
C	Decreased by 222 bases	Decreased by 222 bases
D	Increased by 130 bases	Increased by 130 bases

15 A scientist investigated the mode of action of a drug, hydroxyurea (HU), that was known to prevent cell cycle progression in the parasite, *Leishmania*.

In the experiment, two groups of *Leishmania* parasites are used. **Group 1** is the untreated control. **Group 2** is incubated in a culture medium with HU for 1 hour before being transferred to a fresh medium without HU.

The effect of HU on histone synthesis was investigated by incubating parasite cells in a mixture of amino acids containing methionine that has been labelled with radioactive isotope sulfur. Histone synthesis was measured by the intensity of the dark bands shown in the autoradiograph. **Fig. 15** is an autoradiograph showing

the levels of H2 histone proteins produced by Group 1 and Group 2 in the experiment.

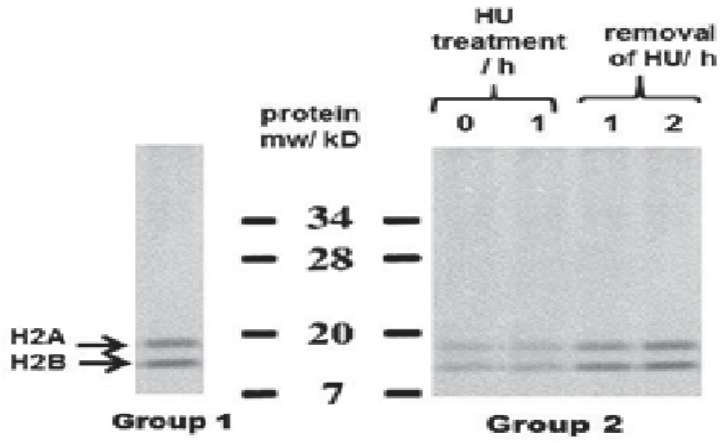


Fig. 15

With reference to the results in **Fig. 15**, which of the following **cannot** be a possible mode of action of HU?

A HU prevents the formation of the Transcription Initiation Complex.
B HU stops the binding of Translation Initiation factors to the small ribosomal subunit.
C HU inhibits poly(A) polymerase.
D HU prevents the addition of ubiquitin to histone proteins.

16 The following are some statements concerning cancer cells.

1 Cancer cells are likely to exhibit anchorage dependence.
2 Cancer cells do not undergo end replication problem as they have activated telomerases.
3 When a copy of the *p53* tumour suppressor allele is inactivated in a normal cell, that cell becomes cancerous.
4 When a copy of the *ras* proto-oncogene is converted into an oncogene in a normal cell, that cell becomes cancerous.

Which of the following statements are **false**?

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

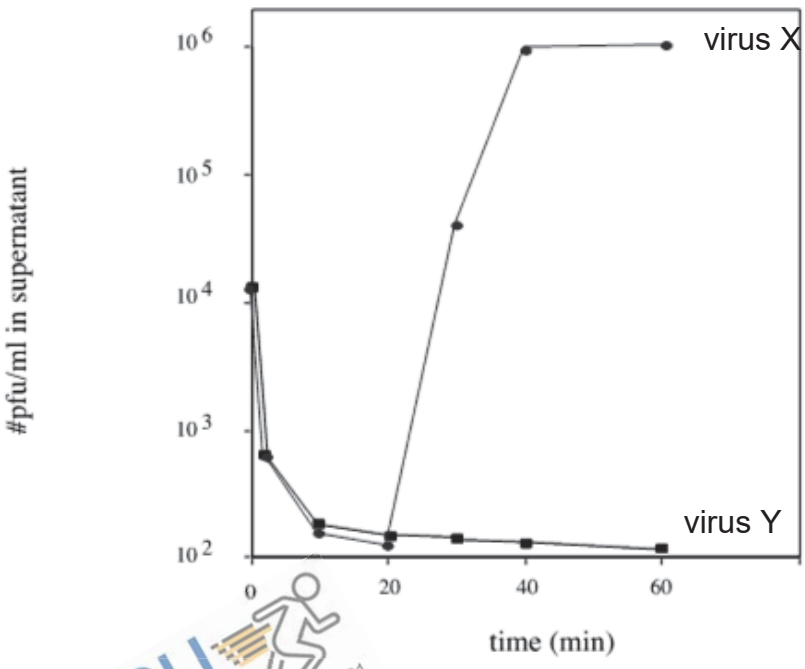
17 Two populations of genetically different bacteria cultured in a U-shaped tube are separated by a membrane filter (which does not allow phage particles and bacterial cells to pass). However, recombination takes place anyway. The mechanism of genetic exchange is _____.

A specialized transduction.
B generalized transduction.
C transformation.
D conjugation.

18 In generalised transduction, defective viruses are formed as a result of _____.

A viral enzymes cutting the host DNA such that the host DNA is assembled into the new virus.
B use of host enzymes by virus which cuts its own viral DNA such that it can be assembled into the new virus.
C hijacking of host transcription and translation machinery to make viral proteins and genome
D integration of viral DNA into host DNA and during excision of the prophage, the viral genome with the adjacent host DNA are assembled into the new virus.

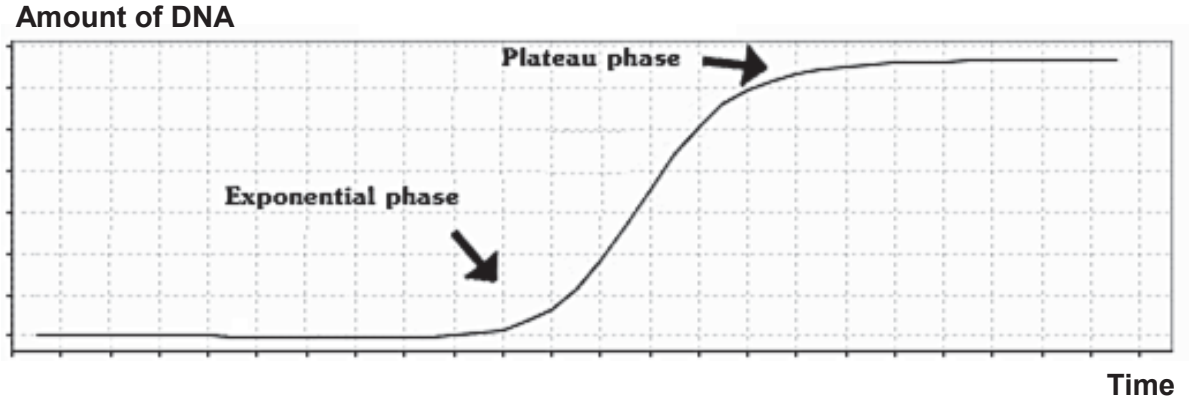
19 Two types of viruses, X and Y, were added to a culture of bacteria. For each type of virus, the change in the number of infectious virus particles present in the supernatant (pfu/ml in supernatant) was monitored for 60 minutes and shown in the graph.



What could explain the sharp increase in the number of infectious virus X particles present in the supernatant from 20 to 40 minutes?

A injection of viral DNA into host cell
B integration of viral DNA into host cell DNA
C release of viral particles by cell lysis
D release of viral particles by budding

20 During PCR, the amount of DNA synthesised can be traced using fluorescent primers and the measurements are shown in the following plot. The process initially goes through an exponential phase, followed by a plateau phase eventually.



Which of the following statement is **true**?

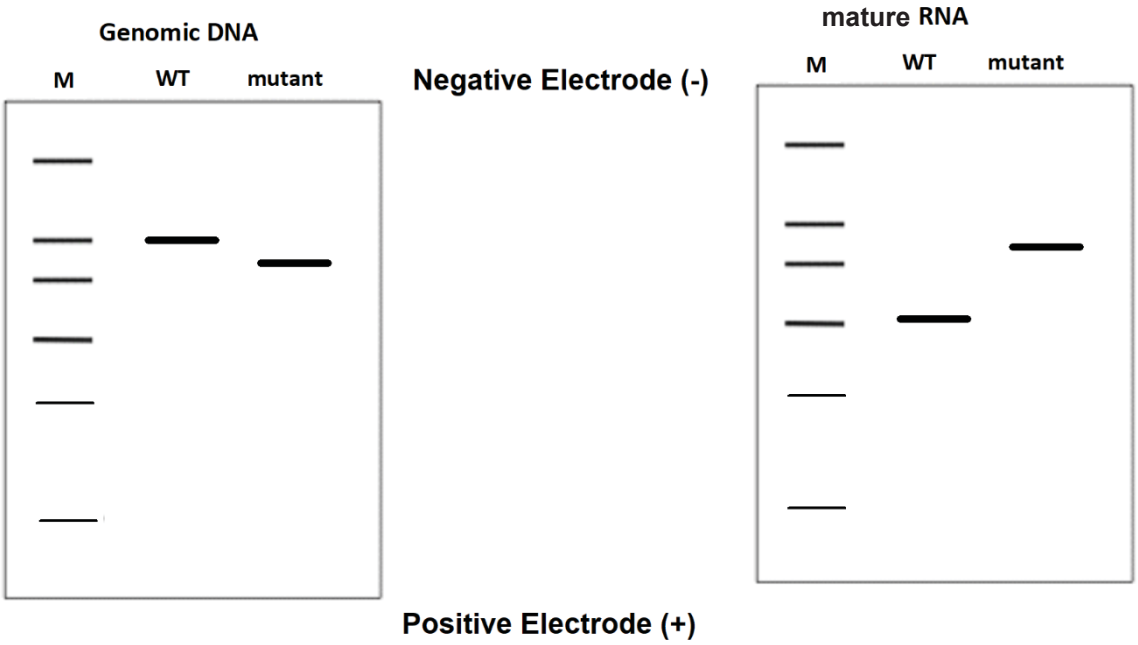
A During the exponential phase, the number of DNA molecules synthesized after 15 cycles is 15^2.

B During the exponential phase, the temperature is always maintained at the optimum temperature of 72°C hence there is rapid amplification.

C During the plateau phase, the reaction mixture might be depleted of ribonucleotides.

D During the plateau phase, *Taq* polymerase might be denatured.

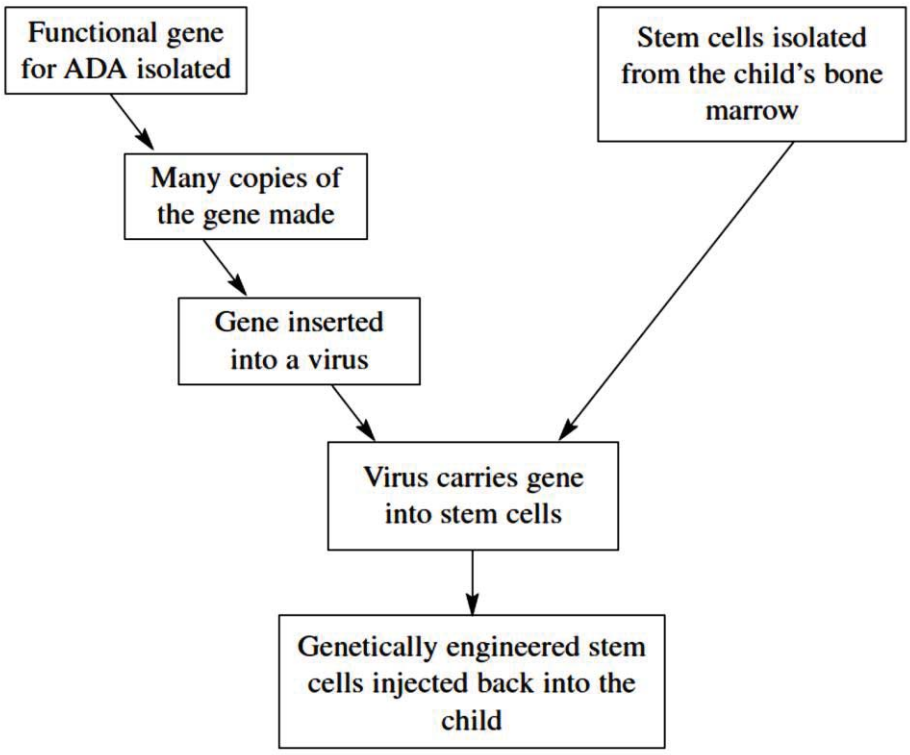
21 In an investigation of a gene suspected to be involved in a genetic disease, separate PCR procedures were done using genomic DNA and mature RNA isolated from healthy (wild-type WT) and diseased cells (mutant). The PCR products were analysed on polyacrylamide gels. The positions of the negative and positive electrodes are also indicated. M is a molecular weight marker that shows the positions of several nucleic acid fragments of specific lengths.



Which of the following best explains the results obtained?

A Deletion of an exon in the mutant.
B Deletion of a splice site in the mutant.
C Deletion of a stop codon in the mutant.
D Deletion of several introns in the mutant.

22 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 statement 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

23 Which statement about natural selection is **true**?

A Natural selection will have a greater effect in causing change if the variation that is shown for a trait is largely caused by environmental, rather than genetic, variation.
B One consideration in natural selection is the ability for a population, relative to other populations, to survive to reproductive age and produce offspring.
C Individuals better suited to the environment will be able to survive, reproduce and pass on favourable traits to their offspring.
D Environment will exert a selection pressure and only individuals best suited to the environment will be able to survive and reproduce.

24 The Galapagos Islands are a group of volcanic islands in the eastern Pacific Ocean, about 600 miles from mainland South America. Thirteen species of finch are found on the islands; they resemble each other closely but differ in their feeding habits and in the shape of their beaks.

Assuming that an ancestral stock of finches came from the mainland, what is the most likely explanation for the existence of similar but distinct species of Galapagos finches?

A Finches developed different kinds of beak in order to feed on different kinds of food.
B Finches evolved separately according to the habitat in which they settled in.
C Mainland finches bred with a resident population of a related species and produced new genotypes.
D Finches underwent convergent evolution to produce very similar species.

25 Some of the evidence for evolution are listed.

1 The fossil Archaeopteryx has many features in common with dinosaurs and some features in common with birds.

2 The bones found in the ears of reptiles and mammals have the same origin as the jaw bones of fish.

3 Many species that are present in older layers of sedimentary rock disappear from more recent layers.

4 The forelimb structure is found in all extant and extinct vertebrates.

Which evidences are based on homologies?

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

26 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

A 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%

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 greater influence than genes on the eye colour intensity and weight of non-identical twins.

28 T cells and B cells are isolated from a mouse for transplantation to immune-compromised mice that lack their own T and B cells.

- Mouse X received T cells only
- Mouse Y received T and B cells
- Mouse Z received B cells only

Mice X, Y and Z were then infected with the influenza virus and then were measured for their anti-influenza antibody response.

Which animal(s) would have produced anti-influenza antibodies?

A Mouse X
B Mouse Y
C Mouse Z
D Mouse Y and Mouse Z

29 Which features do the causative agents of dengue, malaria and tuberculosis (TB) have in common?

	presence of cytoplasm	the ability to produce ATP	presence of surface antigens
A	✓	✓	×
B	✓	×	✓
C	×	✓	×
D	×	×	✓

key
✓ = have in common
× = do not have in common

30 The habitat of sea turtles is shallow coastal water in warm and temperate seas. Sea turtles migrate to breeding areas to lay their eggs on sandy beaches. The nest temperature has a strong influence on the sex of the offspring. Colder temperatures result in a higher proportion of males and warmer temperatures result in a higher proportion of females.

Which effects of climate change could contribute to declines in populations of sea turtles?

1. increased melting of glaciers causing a rise in sea level
2. increased air temperature causing more heating of the Earth's surface
3. changes in ocean currents modifying migration pathways
4. heavy rainfall causing flooding of land and coastal erosion

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

~ End of paper ~

Civics Group	Index Number	Name (use BLOCK LETTERS)	H2

ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS

H2 BIOLOGY **9744/2**

Paper 2 (MARK SCHEME)

Thursday 29 August 2019 2 hours

Materials: Question Paper

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.

Answer **all** questions.
Write your answers in the spaces provided on the question paper.

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

For Examiners' Use	
1	/10
2	/7
3	/12
4	/12
5	/17
6	/10
7	/10
8	/12
9	/5
10	/5
Total	**/100**

This document consists of **27** printed pages.

[Turn over

QUESTION 1

Fig. 1.1 shows an electron micrograph of an eukaryotic cell.

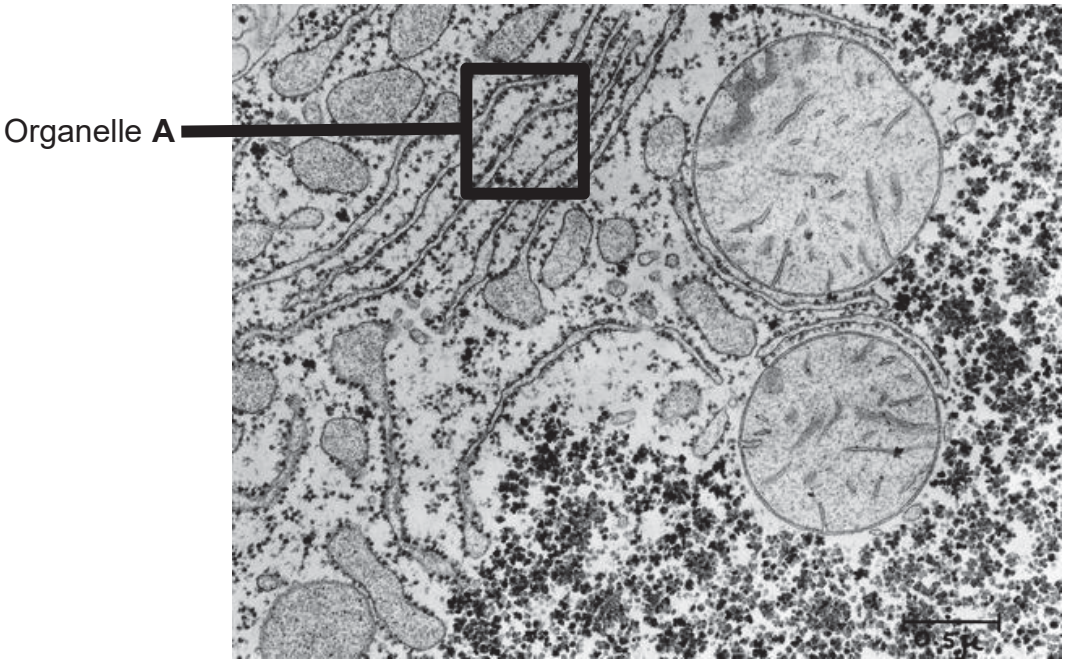


Fig. 1.1

(a) **(i)** With reference to **Fig 1.1**, state the identity of Organelle **A**.

Organelle **A** : ……..……..……[1]

1 Rough endoplasmic reticulum (Reject: rER)

(ii) Describe how the structure of organelle A relates to its function.

…….....[2]

1 Consist of flattened membrane-bound sacs;
for temporary storage of secretory proteins / contains enzymes to carry out {**post-translational modifications**/biochemical modification} of proteins e.g. proteolysis / glycosylation / phosphorylation
OR
serves as an intracellular transport network of proteins within cells / rER
transports protein via transport vesicles to Golgi body

2 **Presence of ribosomes** on its surface;
which are sites of **protein synthesis**

Cellulose and collagen are molecules that are important in providing structural support. The basic structural unit of collagen is tropocollagen.

(b) Compare the structure of cellulose and tropocollagen.

…….....[3]

Similarities [Max 1]

Cellulose	**Tropocollagen**
1. Both have <u>hydrogen bonds</u> (to stabilize their structures) 2. Both are made up of repeating units (to form polymer)	

Differences [Max 2]

Cellulose	**Tropocollagen**
3. Monomer is <u>β-glucose</u>	Monomer is <u>amino acid</u>
4. Monomers linked by <u>β(1,4) glycosidic bonds</u>	Monomers linked by <u>peptide bonds</u> [Reject: 'Amide bond / linkage']
5. Linear molecule	Each polypeptide is a **helical** structure (reject α-helix)
6. Hydrogen bonds formed involving <u>hydroxyl / OH groups</u> of **parallel chains** to establish cross-linkages between chains	Hydrogen bonds form between **-NH group of glycine** residues on each strand and **-CO groups of amino acid residues on the other 2 strands**/ Hydrogen bonds form between <u>hydroxyproline</u> residues.

Fig. 1.2 shows the DNA content of a cell as time progresses.

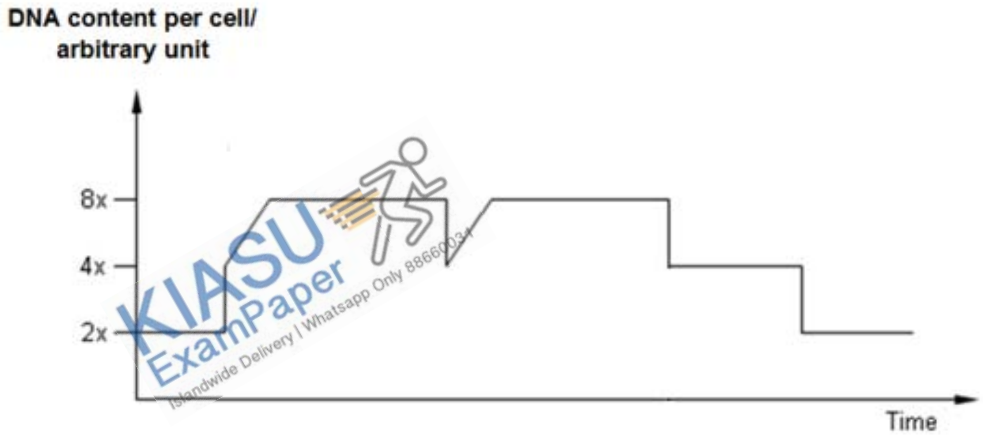
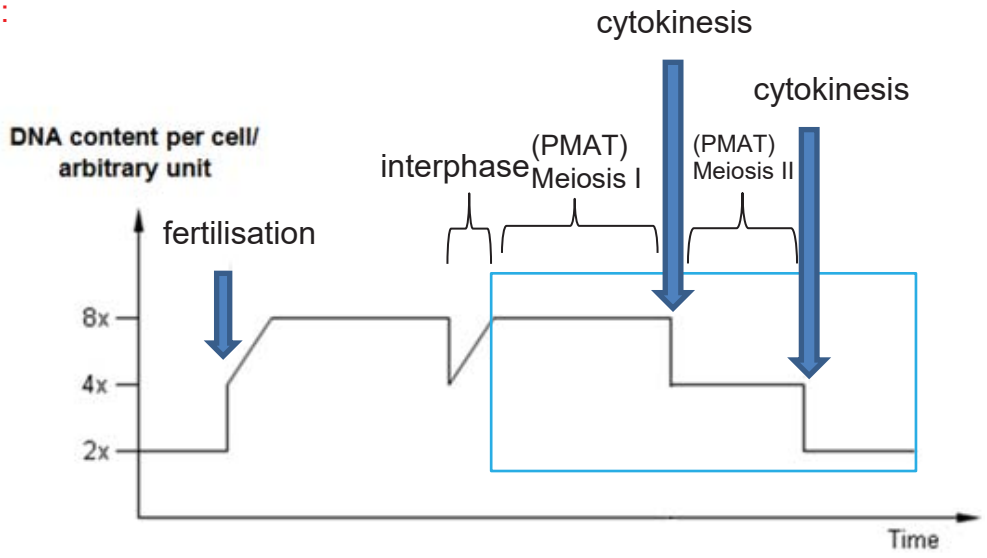


Fig. 1.2

(c) (i) Indicate, with a box, on **Fig. 1.2**, the time period at which meiosis is occurring.

…….....[1]

Ans:



(ii) Explain your answer in **(c)(i)**.

……[1]

1 (Meiosis consists of **two cycles of nuclear / cell divisions / two rounds of reduction**);
[Quote data] DNA content per cell **decrease** by half, from 8x to 4x after the first round of division. DNA content per cell **decrease** by another half, from 4x to 2x after the second round of division;

(iii) Explain the significance of meiosis.

……[2]

1 Meiosis gives rise to **haploid gametes**;
2 Fusion of the gametes during fertilization **restores the diploid nature** of the cells in a normal organism / maintains the number of chromosomes in each successive generation / prevent the doubling of chromosomes / restore chromosomes number to its original state ;
OR

1 Meiosis gives rise to **genetically variable gametes**;
2 Fusion of these gametes giving rise to genetically variable individuals which can **better adapt to the changing environment** / adapt to changes in the environment ; [
[**REJECT**: survival of species as it is too vague].

[Total: 10]

QUESTION 2

The cell is surrounded by a plasma (cell surface) membrane. Substances entering or leaving the cell must pass through this membrane.

Fig. 2.1 is a diagram of part of the plasma membrane of a Chromista cell (Chromista are photosynthetic organisms that live in water).

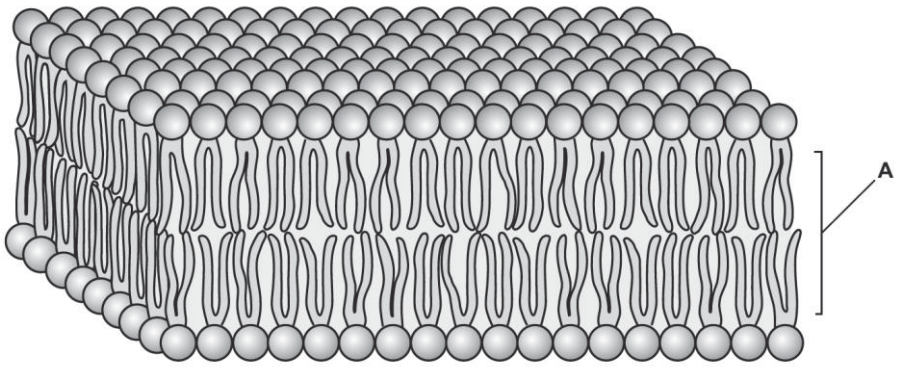


Fig. 2.1

(a) Identify region A and explain **one** property which contributes to how the membrane function as a barrier to the movement of galactose.

……..[2]

1 **fatty acid tails/hydrocarbon chains** of fatty acids in <u>phospholipid</u> / <u>hydrophobic core</u> of the <u>phospholipid</u> bilayer;

2 hydrophobic/non-polar; (prevent movement of galactose across the membrane)
Galactose is polar (must pass through, transport proteins/carrier proteins/channel proteins / require **specific** transport proteins to provide a water-filled channel *(facilitated diffusion)*

Fig. 2.2 represents part of the plasma (cell surface) membrane of a cell that response to cytokines and illustrates the event that follows upon cytokines' binding.

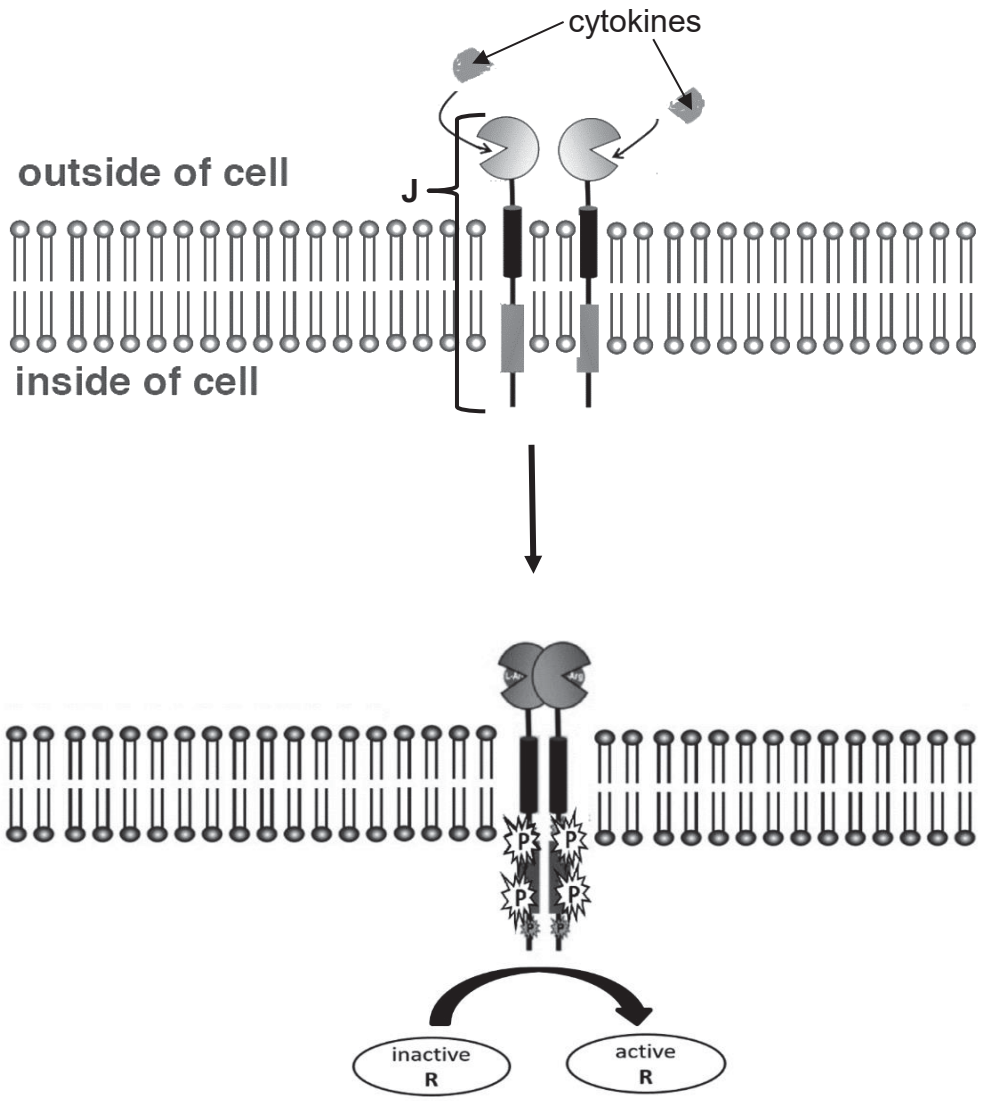


Fig. 2.2

(b) With reference to Fig 2.2, describe the sequence of events that follow cytokines' binding.

……[5]

1 (Molecule J is a receptor tyrosine kinase); J / receptor tyrosine kinase **dimerise** upon binding to the cytokines ;
2 results in the activation of the tyrosine kinase domains in the cytoplasmic tail ;
3 Each **receptor phosphorylates** the tyrosine residues at the cytoplasmic tails of the **other receptor** ;
4 via the addition of a phosphate from an ATP molecule in a process known as auto-crossphosphorylation ;
5 **Activation** of Molecule R (relay protein); ref. 3D **conformational change**

[Total: 7]

QUESTION 3

Fig. 3.1 shows the gene expression of a cytoplasmic protein in a eukaryotic cell.

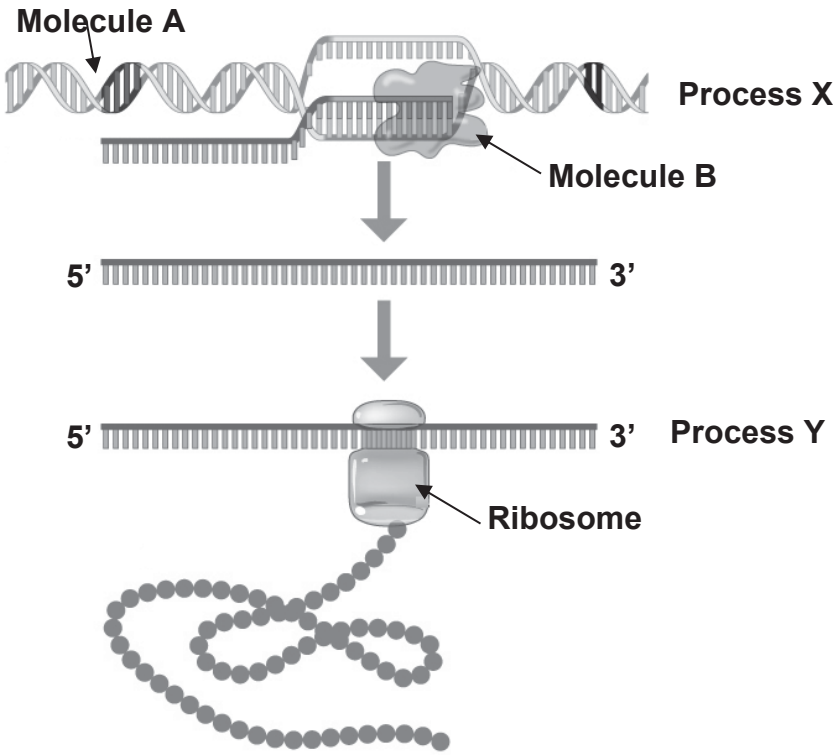


Fig. 3.1

(a) Name molecule A and describe one structure that enabled the identification.

…….....[2]

1 [Name of molecule A] Deoxyribonucleic acid / [Reject: DNA as naming requires full spelling];
2 [structure] **double-**helix molecule [Accept: presence of major and minor grooves]

(b) Describe how the structure of molecule B allows it to perform its function.

……..[2]

1 Active site of RNA polymerase (molecule B) has a specific **3D conformation** that is **complementary** to **DNA template strand and the incoming ribonucleotide;**
2 (This allows RNA polymerase to bind to template strand and) **catalyse the formation of phosphodiester bonds** / **synthesize a complementary mRNA strand during transcription;**
OR
1 **DNA binding domain** of RNA polymerase has a specific **3D conformation complementary** to the promoter;
2 This allows RNA polymerase to bind to promoter and **initiate** transcription;
OR
1 **DNA binding domain** of RNA polymerase has a specific **3D conformation complementary** to the DNA region;
2 Ref. allows for RNA polymerase to **elongate** the RNA chain;

(c) Draw an arrow in **Fig. 3.1** to indicate the direction of movement of ribosome in Process Y.

……..[1]

1. Arrow from 5’ to 3’ direction

(d) Describe **three** ways in which process X differs from process Y.

……..[3]

	Process X (transcription)	**Process Y (translation)**
1	Template is DNA strand	Template is mRNA
2	RNA polymerase; OR catalyses formation of phosphodiester bonds (between ribonucleotides)	Peptidyltransferase; OR catalyses formation of peptide bonds (between amino acids)
3	Monomer is ribonucleotide	Monomer is amino acid
4	Occurs at nucleus	Occurs at bound (at rER) and free ribosomes (in cytoplasm)
5	Template is **read** in 3’ to 5’ direction OR Product is **synthesized** in a 5’ to 3’ direction	Template is **read** in 5’ to 3’ direction OR Product is **synthesized** from N-terminal to C-terminal
6	Product is a single-stranded **RNA** (mRNA, tRNA, rRNA)	Product is a **polypeptide** chain

Table 3 shows the mRNA codons for 11 different amino acids.

Amino acid	mRNA codon	Amino acid	mRNA codon	Amino acid	mRNA codon
Ala	GCG	Lys	AAG	Arg	CGC
Glu	GAG	Pro	CCU	Phe	UUC
His	CAC	Thr	ACU	Gly	GGA
Leu	CUG CUC	Val	GUG		

The first seven DNA triplets coding for the cytoplasmic protein are shown below.

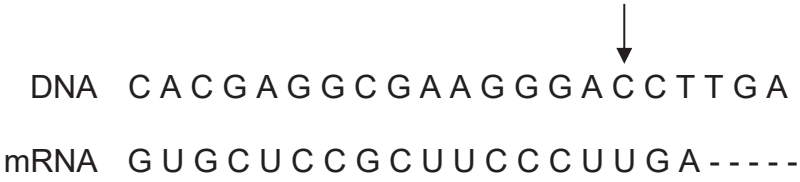


Fig 3.2

A mutation occurs at the **sixteenth** nucleotide in the DNA sequence. This is indicated by an arrow in **Fig. 3.2**. The corresponding complementary mRNA sequence to the mutated DNA sequence is shown in **Fig. 3.2**.

(e) (i) State the amino acid sequence encoded for by the mutated DNA sequence.

…….....[1]

1 Val Leu Arg Phe Pro

(ii) Identify the mutation that has occurred and explain the effect of this mutation on the protein function.

…….....[3]

1 Single base substitution [DNA level mutation term] from C to A (resulting in nonsense mutation [amino acid level mutation tern])
2 that leads to formation of a stop codon being read by ribosome
3 results in the synthesis of a **truncated** polypeptide chain / protein that is shorter than normal / **3D conformation** of protein **changes**;
AND
protein is **non-functional;**

[Total: 12]

QUESTION 4

In a species of flea beetles, Phyllotreta nemorum, some individuals are parasitized by the *Hexamermis* species (a parasitic flatworm) while others have alleles that confer resistance to the parasite. Some flea beetles have also inherited the allele which codes for cellobiosidase, an enzyme that allows the individuals to feed on the toxic Winter Cress plants.

In a genetic experiment, pure-breeding flea beetles which are resistant to *Hexamermis* and are able to produce cellobiosidase were crossed with pure breeding flea beetles that are sensitive to *Hexamermis* and unable to produce cellobiosidase to produce only offspring with the ability to resist *Hexamermis* and produce cellobiosidase. When these resultant flea beetles of heterozygous genotype at both gene locus were sibling-mated, they produced the following F_2 generation:

Resistant to *Hexamermis*, able to produce cellobiosidase	178
Resistant to *Hexamermis*, unable to produce cellobiosidase	45
Sensitive to *Hexamermis*, able to produce cellobiosidase	53
Sensitive to *Hexamermis*, unable to produce cellobiosidase	156

(a) Define the term heterozygous.

……[1]

1 Genotype of **two different alleles** (of a gene) ;

at a particular gene locus of homologous chromosomes ;

[**Reject**: genotype of a dominant and a recessive allele of a gene. In co-dominance, the allele is not dominant/recessive to the other]

(b) Calculate the recombination frequency obtained from the genetic experiment.

……[1]

1 Recombination frequency = total number of recombinants / total x 100%

= (45 + 53) / 432 x 100%
= 22.7% (3 s.f.)

(c) Based on your answer in **(b)**, comment on the locations of these two genes' loci.

……[2]

1 The 2 genes are on the **same chromosome** / genes are linked;

[From (b)] Recombination frequency = 22.7%

2 Distance between the two gene loci = 22.7 centimorgan (cM) / map units;

(d) Using the letters **A/a** (for resistance to *Hexamermis*) and **B/b** (for ability to produce cellobiosidase), draw a genetic diagram to show how the F2 generation is produced from sibling-mating of the F1 generation.

……[5]

Let:
A - allele that confers resistance to *Hexamermis*
a - allele that does not confer resistance to *Hexamermis*
Allele A is dominant to allele a

B - allele that codes for cellobiosidase
b - allele that does not code for cellobiosidase
Allele B is dominant to allele b

F1 phenotypes	Resistant to *Hexamermis*, able to produce cellobiosidase	x	Resistant to *Hexamermis*, able to produce cellobiosidase
F1 genotypes	$\frac{AB}{ab}$	x	$\frac{AB}{ab}$
F1 gametes	(AB) (ab) (Ab) (aB)	x	(AB) (ab) (Ab) (aB)
	Non-recombinant gametes; Recombinant gametes		Non-recombinant gametes; Recombinant gametes

F2 genotypes (shown in Punnett square)

	(AB)	(aB)	(Ab)	(ab)
(AB)	$\frac{AB}{AB}$ Resistant to *Hexamermis*, produce cellobiosidase	$\frac{AB}{aB}$ Resistant to *Hexamermis*, produce cellobiosidase	$\frac{AB}{Ab}$ Resistant to *Hexamermis*, produce cellobiosidase	$\frac{AB}{ab}$ Resistant to *Hexamermis*, produce cellobiosidase
(aB)	$\frac{aB}{AB}$ Resistant to *Hexamermis*,	$\frac{aB}{aB}$ Sensitive to *Hexamermis*,	$\frac{aB}{Ab}$ Resistant to *Hexamermis*,	$\frac{aB}{ab}$ Sensitive to *Hexamermis*,

	produce cellobiosidase	produce cellobiosidase	produce cellobiosidase	produce cellobiosidase
(Ab)	$\frac{Ab}{AB}$ Resistant to *Hexamermis*, produce cellobiosidase	$\frac{Ab}{aB}$ Resistant to *Hexamermis*, produce cellobiosidase	$\frac{Ab}{Ab}$ Resistant to *Hexamermis*, cannot produce cellobiosidase	$\frac{Ab}{ab}$ Resistant to *Hexamermis*, cannot produce cellobiosidase
(ab)	$\frac{ab}{AB}$ Resistant to *Hexamermis*, produce cellobiosidase	$\frac{ab}{aB}$ Sensitive to *Hexamermis*, produce cellobiosidase	$\frac{ab}{Ab}$ Resistant to *Hexamermis*, cannot produce cellobiosidase	$\frac{ab}{ab}$ Sensitive to *Hexamermis*, cannot produce cellobiosidase

F2 phenotypes:	Resistant to *Hexamermis*, produce cellobiosidase	Sensitive to *Hexamermis*, cannot produce cellobiosidase	Resistant to *Hexamermis*, cannot produce cellobiosidase	Sensitive to *Hexamermis*, produce cellobiosidase
	Non-recombinant		Recombinant	

Mark scheme:

1. F_1 genotype
2. F_1 gametes (circled)
3. F_2 genotypes
4. F_2 genotypes correspond to phenotypes (allow shortened phenotype)
5. Indication of recombinant and non-recombinant **gametes**
   AND
   indication of recombinant and non-recombinant **phenotypes**

(e) A chi-squared analysis was performed for this cross to determine if it follows Mendelian laws of inheritance.

Table 4.1 shows a chi-square table.

degrees of freedom	probability, p				
	0.10	*0.05*	*0.02*	*0.01*	*0.001*
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

The calculated χ^2 value is found to be 659.40.

Using the calculated χ^2 value and Table 4.1, state what conclusions may be drawn from the result.

……..……..…[3]

1 Since the **calculated** χ^2 value 659.40 is **greater than critical** χ^2 value 7.82 at p = 0.05
/ At χ^2 value of 659.40, p value < 0.001, which is **smaller than 0.05** ;

2 The results of the χ^2 test suggest that there is a **significant difference** between the observed and the expected values (at the 5% level) ;

Any difference between the observed and the expected values is **not due to chance** ;
[Reject: reject null hypothesis, as there is no null hypothesis listed in the first place]

3 (Mendelian laws of inheritance is not followed) The predicted phenotype ratio of 9:3:3:1 is incorrect

/There is no independent assortment of the two genes ;

[Total: 12]

QUESTION 5

Fig. 5.1 is a diagram showing the structure of a section of a DNA molecule.

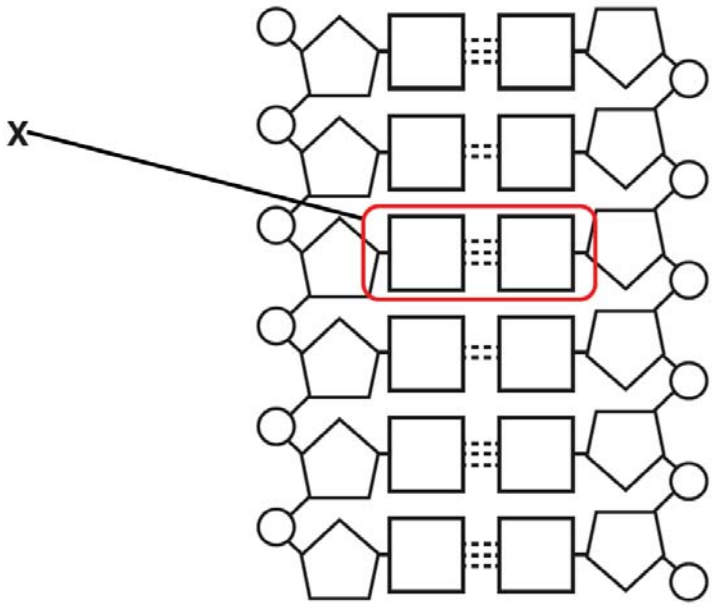


Fig. 5.1

(a) Name the two bases forming the base pair at **X** in Fig. 5.1 **and** give a reason for your answer.

……..……...[2]

1 cytosine and guanine ; [**REJECT**: C and G without spelling in full]
2 **three hydrogen bonds** between the bases

(b) The genomes of prokaryotic and eukaryotic cells contain chromosomes which are made of mainly of DNA molecules which may be associated with proteins.

With reference to organization of genes, describe one difference between prokaryotes and eukaryotes.

……..[1]

1 Ref. In prokaryotes, **several** structural **genes** with related functions under the **control of one promoter** (in an operon) ; in eukaryotes, **each gene** is under the control of **one promoter**;

[Reject: presence of operons in prokaryotes vs no operons in eukaryotes, as it is too vague]

[Reject: answers related to histones associating to DNA, question is on organization of genes, and not genome]

(c) Telomeres are found at the ends of chromsomes in eukaryotes. Outline the functions of telomeres.

……..[2]

Any two from:

1 Serves as **disposable buffer to protect the coding DNA from gene erosion** during DNA replication [as DNA shortens with each round of replication (end-replication problem) to prevent loss of genes] ;
2 Together with associated <u>proteins</u>; **protect** ends of chromosomes from being **degraded by (**exo**)nucleases** ;
3 Together with associated <u>proteins</u>; prevents **end-joining of chromosome ends** which may lead to chromosomal mutations ;
4 Together with associated <u>proteins</u>; preventing **unintentional cell death** as telomeric DNA and associated specific proteins {somehow prevent the <u>staggered ends</u> of the daughter molecule from activating the cell's systems for monitoring <u>DNA damage</u> / the ends of a DNA molecule "seen" as a <u>double-strand break</u> may otherwise trigger signal transduction pathways leading to <u>cell cycle arrest</u> or <u>cell death</u>} ;

[**REJECT**: prevent end-replication problem as the problem still occurs]

(d) The differentiation of a eukaryotic stem cell into a specialized cell is controlled by many genes.

Fig. 5.2 summarises the interactions of some of these genes. The arrows represent the genes being switched on.

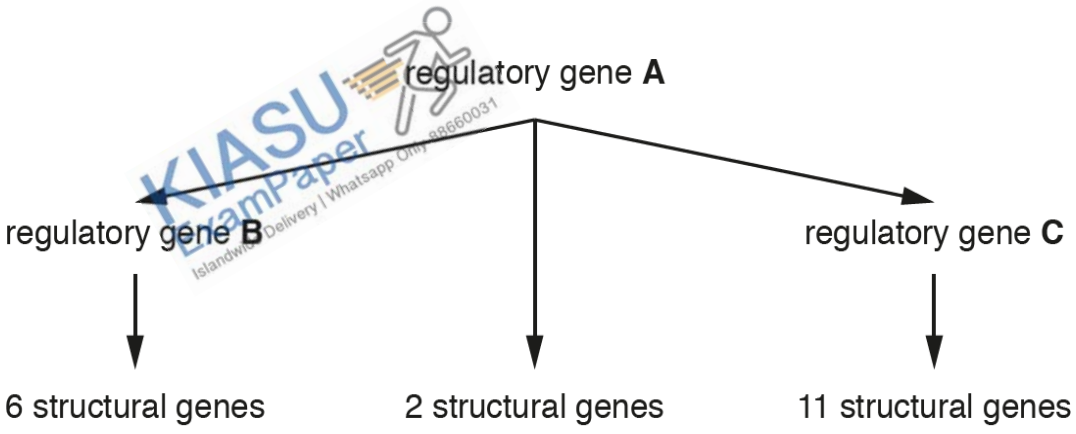


Fig. 5.2

With reference to Fig. 5.2, explain how genes such as **A**, **B** and **C** are able to switch on other genes.

……..[4]

1 *ref. to* (gene A / B / C codes for) transcription factors / specific examples e.g. activators *(protein)* ;

AND

Any two {fr point 2 – 4 / fr point 5 – 7}

2 (General) TF binds to <u>promoter</u> ;

3 ref to binding of RNA polymerase (to promoter) with the aid of TFs ;

4 (so) mRNA is made / transcription occurs ;

OR

5 (Specific) TF / activator binds to <u>enhancer</u>; [Reject: repressor binds to silencer]

6 ref to **more efficient** binding of RNA polymerase (to promoter) ;

7 (so) mRNA is made / transcription occurs at a **faster** rate;

AND

8 Quote any 1 from Fig 5.2:

- gene **A** codes for TF which switches on {4 genes / genes **B** and **C** and 2 other genes} ;
- gene **B** codes for TF which switches on 6 genes ;
- gene **C** codes for TF which switches on 11 genes

Also accept:

1 *ref. to* (gene A / B / C codes for) <u>demethylase / acetyl transferase</u>

AND

2 Demethylate DNA

3 Ref. loosening of DNA

4 Ref. easy access of DNA by RNA polymerase

OR

5 Acetylate lysine residues of histone tails
(Linker DNA cannot interact with histone tails to form nucleosomes)

6 Ref. loosening of DNA

7 Ref. easy access of DNA by RNA polymerase

AND

8 Quote any 1 from Fig 5.2:

- gene **A** codes for TF which switches on {4 genes / genes **B** and **C** and 2 other genes} ;
- gene **B** codes for TF which switches on 6 genes ;
- gene **C** codes for TF which switches on 11 genes

(e) In prokaryotes, a cluster of functionally-related genes under the control of one promoter is organised into an operon. An example is the *lac* operon.

The *lac* operon is a section of DNA present in the genome of *Escherichia coli*. The structural genes of the *lac* operon are only fully expressed when the bacteria are exposed to high lactose concentrations.

Fig. 5.3 is a diagram showing the *lac* operon and a nearby region of the *E. coli* genome.

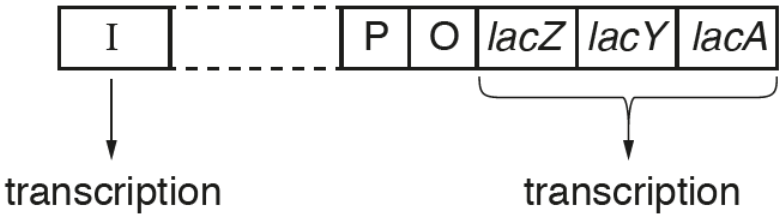


Fig. 5.3

(i) Fig. 5.3 shows how the *lac* operon consists of structural genes and regulatory sequences.

Use Fig. 5.3 to identify two structural genes.

Complete Table 5.1 to name each structural gene and its product.

Table 5.1

structural gene	Name of gene product

(ii) Gene I is an example of a gene that undergoes constitutive expression.

Explain why it is necessary for some genes to be constitutively expressed.
……[1]

1 Gene **product needed all the time** for essential cell functions
/

2 [With reference to Gene I product] Ref. Regulatory proteins coded by Gene I will be **present at all times** to regulate transcription of structural genes **when needed**

[Reject: gene products degraded easily, thus the need to express the genes all the time ➔ being degraded easily does not mean there is a need for the protein]

(iii) Describe the effect of the product of gene I on the functioning of the *lac* operon.

……..[3]

1 Gene I codes for a repressor protein that binds to the operator ;
2 Block access of RNA polymerase to structural genes / RNA polymerase **unable** to bind to promoter ;
3 Ref. no {transcription / expression / mRNA synthesis}, of (named) structural genes;

(f) If *E. coli* is put into a nutrient medium containing lactose, some enzymes are synthesised. These are described as inducible enzymes.

(i) Explain what is meant by an *inducible enzyme*.

……[1]

1 Inducible enzymes are enzymes whose **synthesis** is **stimulated** only in the presence of an {inducer / substrate / e.g. lactose in the lac operon};

[Reject: inducible enzymes are involved in catabolic pathways as it does not define what is inducible enzyme]
[Reject: e.g. tryptophan as it is part of repressible operon which has enzymes whose synthesis is turned off in the presence of the end-product]

(ii) The structural genes of the *lac* operon are **not** expressed when lactose is absent.

Suggest **one** reason why this is beneficial to *E. coli*.

……..[1]

1 Ref. **no waste of** {amino acids / ATP / nucleotides / energy}; [Reject: resources as it is too vague]

[Total: 17]

QUESTION 6

Viruses share common structural features. Some viruses, such as Human Immunodeficiency Virus (HIV), also have an outer envelope as part of their structure.

(a) List two other key structural features of viruses.

……[2]

1 Capsid / protein coat

2 RNA genome [ref. to HIV]
/ DNA or RNA genome [ref. to general] [Accept: nucleic acid]

[***REJECT*** : ref. to capsomeres (which are protein subunits which are monomers and not structure) ; size range e.g 15 nm to 1000 nm ; (some) are enveloped (which is already in Q stem)]; glycoproteins (is a component of envelope);]

[Reject: answers related to **absence** of structures e.g. lack of ribosomes]

(b) HIV only infects certain types of cell, for example, the helper T-lymphocytes . These cells have CD4 receptor proteins in their cell surface membrane. HIV has glycoproteins embedded in its outer envelope.

HIV can remain in a dormant state within infected immune system cells for many years. A person diagnosed as HIV-positive (HIV+) has the virus but does not have symptoms of HIV/AIDS.

(i) The glycoproteins are important in allowing HIV to only infect certain types of cell. Explain the roles of these glycoproteins.

……[2]

1 gp 120 on HIV envelope {**recognises** / has **complementary 3D conformation** to CD4 receptors} and **binds** to CD4 receptors (on helper T cells (and macrophages (host cells) and also co-receptors (e.g. CCR5 or CXCR4))

2 (This binding) triggers an **allosteric/conformation change in gp41** on the HIV envelope ;
gp 41 pierces through the host cell surface membrane, causing fusion of the HIV envelope and host plasma membrane ;

(ii) Explain why there can be many years (up to ten years) between infection and the onset of symptoms.

……[2]

(viral RNA undergoes reverse transcription to form DNA)

1 Viral (c)DNA becomes part of the host cell's DNA / genome / chromosome to become provirus ;

2 (provirus) persist in a **latent** state for many years; {**replicating** passively together with the **host** DNA / Ref. no expression of provirus} (before activation) ;

(c) Research showed that people with HIV are at higher risk of certain cancers compared with individuals without HIV. These cancers include Kaposi's sarcoma, lung cancer and cervical cancer etc.

Kaposi's sarcoma is a rare form of cancer that develops in the cells that line the mouth, nose, throat and blood vessels. It causes red or brown tumours, or lesions, on the skin or mucous membranes. These tumours can appear in other areas of the body such as the legs, lymph nodes and digestive tract.

(i) Suggest the one change to specific genes for HIV infections to increase the risk of developing cancer.

……[1]

1 (virus causes) <u>mutation</u> of host <u>proto-oncogene (Accept: example *ras* gene)</u> / <u>tumour suppressor genes (Accept: example *p53* gene)</u> ;

2 Ref virus **insert** viral DNA which contains <u>oncogenes</u>
(resulting in production of over-active gene product)

3 Ref virus **insert** viral DNA which **disrupt** {tumour suppressor/p53} gene
(resulting in {expression / production} of non-functional gene product)

[***REJECT***: insert more active viral promoter upstream of proto-oncogenes to result in over –expression ➔ focus is more on changes to structure of gene, and promoter is not part of a gene]

(ii) Outline how tumours can appear in other areas of the body in Kaposi's sarcoma.

……[3]

1 (Some mutations cause) cells to {no longer exhibit **anchorage dependence** / loss of cell adhesion} / {**loss of contact inhibition** / density-dependence} ;

AND
cells undergo **uncontrolled cell divisions** ;

2 Mutations can also lead to {**angiogenesis** / formation of new network of blood vessels} to the cancer cells ;

3 These allow {**metastasis** to occur / cancer cells are able to **break loose** and **travel** in the **bloodstream**} and invade other tissues to form secondary tumors ;

[Total: 10]

QUESTION 7

Fig. 7.1 shows the electron micrograph of an organelle found in a plant cell.

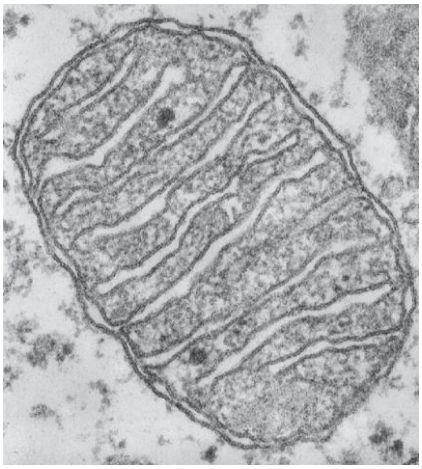


Fig. 7.1

(a) Certain reactions bring about the release of carbon dioxide in the organelle in **Fig. 7.1**.

State the type of reactions. Identify the stage(s) of aerobic respiration and location(s) where the reactions occur.

…….....[2]

Type of reactions…. (1) Decarboxylation
Stage(s) of aerobic respiration…. (2) Link reaction ; and (3) Krebs cycle
Location(s)…. (4) Mitochondrial matrix

1 Require all 4 points to get 2m
2-3 points to get 1m
1 point, no marks

(b) In plants, another organelle is involved in the uptake of carbon dioxide.

An enzyme RuBP carboxylase is involved in the process. Interestingly, it was found that the active site of this enzyme can be bound by either carbon dioxide or oxygen gas, with higher affinity for oxygen gas.

The entry of oxygen gas into the active site of RuBP carboxylase is detrimental for the plant.

Explain why.

…….....[2]

1 Oxygen gas is a competitive inhibitor of RuBP carboxylase, binds to active site of enzyme, to **prevent carbon dioxide** from binding ;
2 Plant cannot undergo carbon fixation, (no PGA formed and) **no PGAL can leave** the **Calvin cycle** to make **carbohydrates**; (plant may die)

(c) In humans, certain tissues e.g. muscles can undergo anaerobic respiration if conditions make it necessary.

(i) Explain why there will be no production of ATP in the mitochondria during such conditions.

……[4]

[Oxidative phosphorylation]

1 At **no oxygen concentrations** (condition), less/no oxygen will be available to serve as the **final electron acceptor** of the electron transport chain
2 Oxidative phosphorylation, Krebs cycle, link reaction will not occur
3 (With less/no oxygen to accept electrons) **less/no NADH and $FADH_2$** will **donate** electrons to the ETC
4 **Less/no electrons transferred** along the ETC
5 **Less/no energy released to pump H^+** from mitochondrial matrix across inner mitochondrial membrane into intermembrane space
6 No **proton gradient** generated
7 **Less/no diffusion of H^+ ions** from intermembrane space back into matrix of mitochondria
8 **Less/no ATP synthesis** from ADP and Pi by ATP synthase (during oxidative phosphorylation)

[Krebs cycle]

9 **Substrate level phosphorylation** does not occur in Krebs cycle; due to a **lack** of regeneration of NAD+ and FAD;

[***REJECT***: answers related to glycolysis (as context is in the mitochondria)]

(ii) During anaerobic respiration, pyruvate is converted to lactate. Explain the significance of this conversion.

……[2]

1 Pyruvate {is reduced by NADH / accepts **hydrogen** atom from NADH} to form lactate; **regenerate** NAD^+ in the process;
2 **Synthesis of** 2 nett ATP per glucose **can continue** (via substrate-level phosphorylation) during glycolysis

[Total: 10]

QUESTION 8

The greater racket-tailed drongo, *Dicrurus paradiseus,* is an insect-eating bird found in tropical broadleaved forests in southern Asia from Kashmir, India and Sri Lanka east to Indonesia.

Fig. 8.1 shows the geographic variation in the form of the crest among populations of the greater racket-tailed drongo.

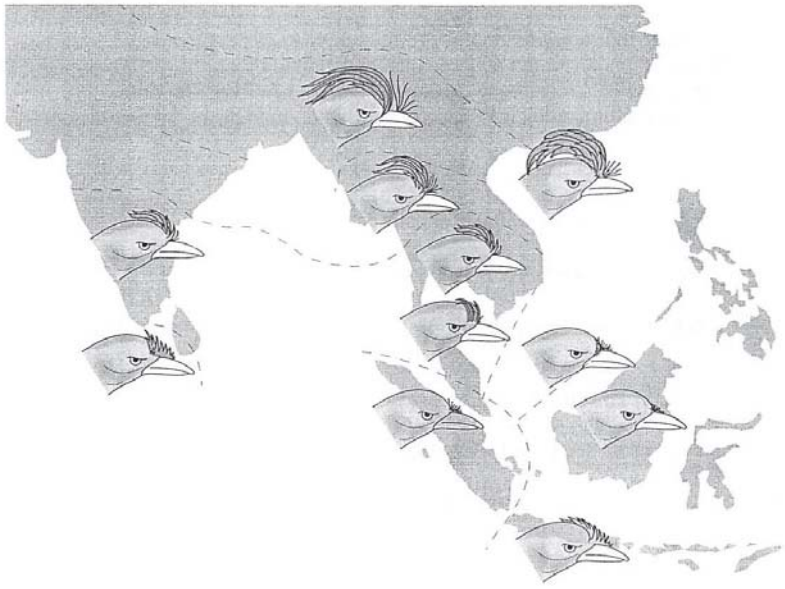


Fig. 8.1

(a) Explain how the distinct phenotypic differences between the populations may have arisen.

…….....[6]

1 **Geographical isolation** occurring between drongo populations + e.g. Drongo populations separated as **broadleaved woodland is not continuous** / Also separated by **islands** ;
2 There is disruption of gene flow / no interbreeding between drogo populations
3 **Genetic variations** exist among the drongo populations ; due to spontaneous mutations ;
4 **Different selection pressures** in different habitats ;
5 (more) Individuals with a **selective advantage** in the particular environment **survived** till reproductive age ; and pass on their alleles to offspring ; [***REJECT***: characteristics/traits passed on to offspring]
6 **Change in allele frequency** of gene pool **over time** ;
7 Other evolutionary agents such **genetic drift** / founder's effect and bottleneck effect occur ;

[***REJECT***: allopatric speciation as **question did not state that the sub-populations have evolved into different species. They are the same species according to the name** *Dicrurus paradiseus*]

(b) Suggest why these populations of greater racket-tailed drongos are classified as a single species .

…….....[2]

1 *[biological species concept]* capable of **interbreeding** ; to produce **fertile and viable offspring** ;
2 *[morphogical species concept]* **similar morphological /anatomical /physiological features** ;
3 *[genetic species concept]* **high homology** between **DNA/amino acid sequence of common gene** between members of the population ;
4 *[phylogenetic species concept]* smallest group of organisms that **shares** a **most recent** common ancestor;

[***REJECT***: occupy same niche as there could be convergent evolution]
[***REJECT***: the 2 populations share a common ancestor ➔ different species can also share common ancestor]

Phylogenetic trees are constructed using molecular data instead of morphological data.

(c) Explain the advantages of using molecular evidences in determining phylogeny

…….....[4]

[Any 4]

1 Molecular evidence is **quantifiable** ; in abundance and open to **statistical** analysis ;
2 Molecular evidence is **objective** ; and described in an **unambiguous** manner as it is based strictly on heritable material ;
3 Molecular evidence is **not affected by convergent evolution** ; (Morphological evidence could be due to convergence/ some morphological characteristics may be analogous)
4 Molecular evidence is **based strictly on heritable material** ; **not** affected by **environmental** factors ;
5 **Greater number of organisms can be compared** with the use of molecular evidence as they have certain molecular traits that are common such as common genes / rRNA sequence / fundamental proteins ;
6 **Greater number of characters can be compared** when using molecular evidences ; DNA information provides **abundance of data** for analysis. (Morphological traits are few and it is often difficult to assess homology for less complex structures)

[Total: 12]

QUESTION 9

The immune system is the body's defense against infectious organisms.

Macrophages of the immune system are heavily involved in the persistence of *Mycobacterium tuberculosis* bacteria in the alveoli tissues during progression of tuberculosis (TB) disease.

Fig. 9.1 shows a macrophage engulfing a pathogen.

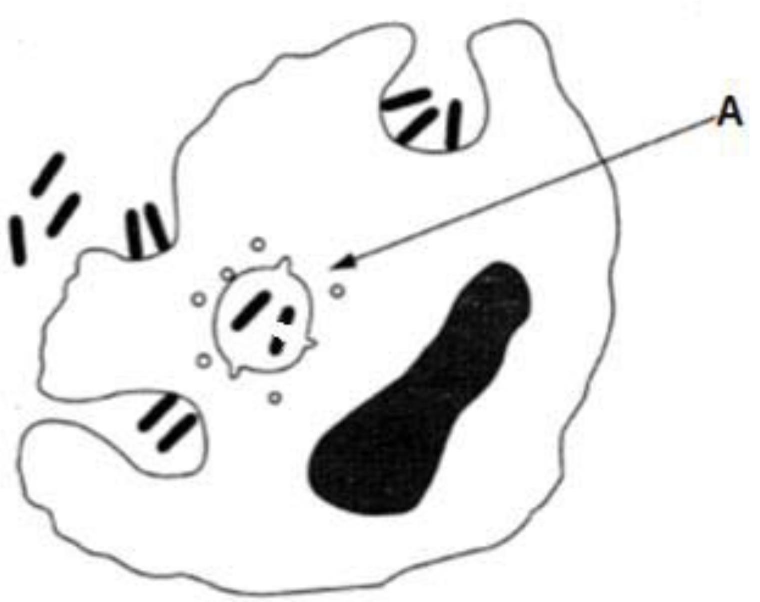


Fig. 9.1

(a) With reference to a named cellular organelle, describe step A.

……………………………………………………………………………………………………[2]

1 Lysosomes **fused** with **phagosomes/endocytic vesicle/endosome containing bacteria**

2 **hydrolytic enzymes**, (e.g. proteases) in lysosomes will then **hydrolyze** the bacteria

(b) Explain how the structure of antibodies, raised by prior vaccinations, may help macrophages engulf *Mycobacterium tuberculosis* bacteria.

……………………………………………………………………………………………………[1]

(Variable region / antigen binding site of antibodies recognise and bind to bacteria / antigen of complementary shape)

1 Constant region of antibodies; [function] are **recognised and bound by** (receptors on) macrophages (to allow subsequent engulfment of the bacteria)

(c) Explain why Acquired Immuno Deficiency Syndrome (AIDS) patients who are tested positive for *Mycobacterium tuberculosis* bacteria are more likely to experience TB related symptoms in the lungs e.g. chest pains and wheezing / difficulty in breathing.

……..……..……..……..…[2]

1 In a **immunosuppressed** person (with HIV/AIDS), dormant *M. tuberculosis* is more likely to become **active** (to progress from latent stage to activeTB)

2 Bacteria itself / other immune cells which release toxins, **destroy alveoli/**causes cavities in the lungs ; this leads to **less surface area** for diffusion of gases.

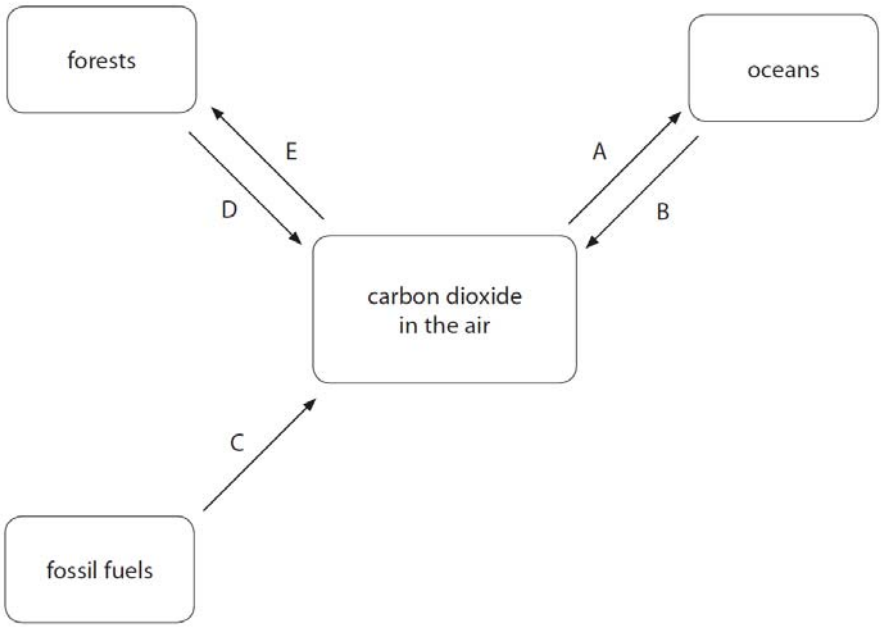
OR

2. Bacteria itself / other immune cells which release toxins, **destroy alveoli**/causes cavities in the lungs; form **pockets of pus** ; this **increases diffusion distance** between alveolar sac and alveolar capillaries

[Total: 5]

QUESTION 10

The diagram below shows part of the carbon cycle. The processes A, B, C, D and E, transfer carbon.



(a) Explain how carbon dioxide is removed from the air into the oceans by process A.

……..[2]

1 Ref. carbon dioxide **dissolves** (in the water / in the oceans) ;

2 for {calvin cycle /carbon fixation / light-independent reaction / photosynthesis} of {seaweed / algae / (phyto)plankton / autrophs / aquatic plants};

3 for formation of <u>calcium carbonate</u> which is used to synthesize **shells of aquatic organisms**;

(b) The table below shows how much carbon is being transferred by each of the processes in the diagram.

Process	A	B	C	D	E
Mass of carbon transferred / au	338	332	23	444	450

(i) Calculate how much more carbon is entering the air than is leaving it.

Show your working. [1]

CO_2 entering the air = 332 + 23 + 444 = 799

CO_2 leaving the air = 338 + 450 = 788

Ans: CO_2 entering the air- CO_2 leaving the air = (B+C+D) – (A+E) = <u>799 – 788 = 11 au</u>

(ii) Describe two human activities that contribute to increased emission of carbon dioxide.

……..[2]

1 Ref. using/**burning** of {fossil fuels / named fossil fuel / forests / equivalent}; (releasing / producing carbon dioxide)

2 Ref. **deforestation**;
(resulting in less {photosynthesis / carbon fixation / light independent reaction / equivalent}) ;

3 Ref. **food choices** e.g. consumption of more meat ; **increase livestock rearing** in farms (increased release of carbon dioxide by the livestock)

[Total: 5]

Civics Group	A Level Index Number	Name (use BLOCK LETTERS)	**H2**

ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS

H2 BIOLOGY **9744/03**

Paper 3 (Mark Scheme)

Thursday 19th September 2019 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 on the question paper.

Section B (Essay Question)
Answer **one** essay question.
Write your answers in the spaces provided on the question paper.

All working for numerical answers must be shown.

For Examiners' Use	
Section A	
1	/34
2	/10
3	/6
Section B	
4 or 5	/25
Total	**/75**

This document consists of **20** printed pages.

[Turn over

Section A

Answer **all** *questions*.

QUESTION 1

Blood is a bodily fluid in humans and other animals that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those same cells. The main components of blood include red blood cells, white blood cells and platelets.

Blood group is a classification of blood, based on the presence of antigenic substances on the surface of red blood cells. A total of 36 human blood group systems and 346 antigens are now recognized by the International Society of Blood Transfusion.

The most commonly known blood group system is the ABO system, an autosomal system which determines someone's blood type for suitability in blood transfusion.

(a) (i) Explain the type of variation which the blood group characteristic exhibits.

.....[2]

1. [Type of variation] Discontinuous variation;

   [Explain] Any one of the following:
2. Different blood groups are **{**discrete / distinct from one another / no overlap**}** between blood groups ;
3. Blood groups are **qualitative** ;
4. Unaffected by environment ;
5. Affected by one gene ;

(ii) John has blood group O while his wife Susan has blood group A. Susan's father has blood group O. State the probability of this couple having a son with blood group O.

.....[1]

1. Probability = ¼ / 0.25 [Accept: 25%]

Working for reference:

Probability (child with blood group O) = ½
Probability (son) = ½
Probability (children with blood group O) and probability (son) = ½ x ½ = **¼**

Man: I^oI^o x Woman I^AI^o
Offspring: I^oI^o, I^AI^o

(iii) John and Susan are individuals belonging to the same species, *Homo sapiens*.

Describe a molecular technique, in general, to confirm that two organisms are the same species.

.....[2]

1. [method] Ref. alignment to **comparison** of DNA or amino acid sequence of a **common** gene (present in both organisms);
2. [analysis] **High levels of homology** between the sequences (will confirm that the 2 organisms are still the same species); / % **difference no more than 2%** between the 2 organisms;

(iv) A specific gene was isolated from John and the DNA molecule was then made single-stranded.

This same process was repeated for Susan. Subsequently, one single strand from John's DNA and one single strand from Susan's DNA were hydribised together to form a hybrid DNA molecule.

It was observed that the temperature needed to separate this hybrid DNA is very high. Explain why.

.....[2]

1. The high homology in their gene sequence results in a **high number** of <u>hydrogen bonds</u> between **complementary bases**;
2. Therefore, (higher temperature is required to provide higher amount of heat, resulting in) the higher the amount of <u>kinetic energy</u> is required to break the hydrogen bonds to separate the DNA strands, (and hence the temperature at which denaturation occurred is very high.);

(b) Fig. 1.1 shows how blood cells are differentiated from blood stem cells from the bone marrow.

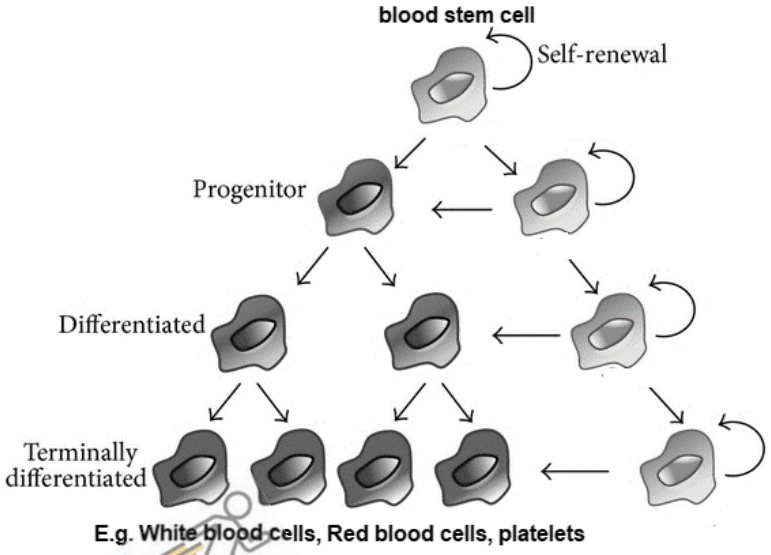


Fig. 1.1

(i) Explain why white blood cells are no longer able to differentiate further into other cell types while blood stem cells are still able to.

.....[2]

White blood cells are terminally differentiated while blood stem cells are undifferentiated due to:

1. Ref. differences in **expression** and **silencing** of genes / Ref. **differential gene expression** between blood stem cells and white blood cells;
2. resulting in **{**production of **proteins** which result in the ability of blood stem cells to differentiate**}** / **{**lack of such proteins in white blood cells to differentiate**}** / **{**different proteins in white blood cells to differentiate**}** ;

(ii) Fig. 1.1 also shows blood stem cells undergoing self-renewal which involves DNA replication before cellular division to form new stem cells.

During DNA replication, deoxyribonucleotides are polymerised to form daughter DNA molecules. Each base of a deoxyribonucleotide has a different **molecular structure** and therefore a different mass.

Name the two DNA bases that have the lowest masses and explain your answer.

.....[2]

1. Cytosine **and** Thymine ;
   [Reject: Uracil] [Reject: C and T abbreviations]

2. They are pyrimidines which consist of a single carbon-nitrogen ring **;**
   Unlike purines (adenine and guanine), which have two carbon-nitrogen rings **;**

(iii) Outline the process of DNA replication.

.....[5]

1. DNA helicase recognises and binds to the specific DNA sequence in origin of replication (ori), causing the DNA molecule to unwind and unzip **;** by **breaking** the hydrogen bonds between the bases ;
2. DNA primase [Reject: RNA primase] attached to each DNA template strand to synthesise RNA primer molecules ;
3. RNA primer molecules have base sequences **complementary** to the base sequences of DNA template strand ;
4. DNA polymerase (III) adds (free deoxyribo)nucleotides to 3' OH ends of primers and synthesises new strands of DNA in a 5' to 3' direction **;** formation of a phosphodiester bond between adjacent deoxyribonucleotides
5. One strand, called the leading strand, is synthesised in **continuous** long sections. The other strand, called the lagging strand, is synthesised **{discontinuously** / in the form of Okazaki fragments**}** ;

6. DNA polymerase (I) **hydrolyses** the RNA **primers** and the gaps (left by hydrolysed RNA primers) are **replaced with** complementary **deoxyriboucleotides** on both strands.
7. DNA ligase catalysed the phosphodiester bonds between Okazaki fragments to form the (continuous sequence in) lagging strand.

[5 max]

(iv) Bacteria is a good candidate for scientists to investigate about DNA replication. In 1958, an experiment was published by Meselson and Stahl investigating the way in which DNA replicates.

Suggest why bacteria were used in this experiment.

……[1]

1. They have **short** life cycles / **{**many generations of bacteria can be cultured/produced**}** in a **short** period of time ;
2. They are **easy to grow** and maintain in culture ;
3. Ref. **{**only one main chromosome / smaller genome**} ;** easy to manipulate or observe;

(v) *Escherichia coli* bacteria were grown in a medium containing $^{15}NH_4Cl$. After very many generations, virtually all of the bacteria DNA contained ^{15}N and the DNA was described as 'heavy'.

The bacteria were then transferred to a medium containing $^{14}NH_4Cl$. A sample of bacteria was removed after the bacteria had divided once (first generation).

Further samples of bacteria were removed after they had divided again (second generation) and after they had divided once more (third generation).

The bacterial DNA from each generation was extracted and the **percentage of DNA strands containing ^{15}N (heavy) DNA in each sample was determined.**

From your knowledge of DNA replication, complete Table 1.1 to show the percentage of %**^{15}N** in each sample for second and third generation.

Table 1.1

	E. coli generation		
	first	second	third
% of DNA strands containing ^{15}N in each sample	50	25	12.5

[2]

Working for reference:

(15-15) ➔ (14-15) (14-15) ➔ (14-14) (14-15) (14-14) (14-15)

2/4 strands has

2/8 strands has

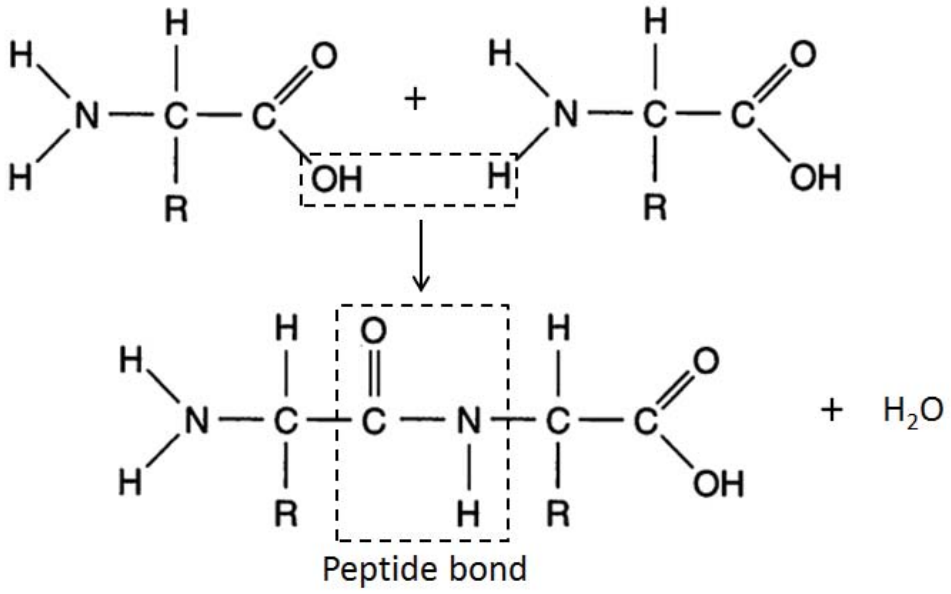
➔ (14-14) (14-14) (14-14) (14-15) (14-14) (14-14) (14-14) (14-15)

2/16 strands has

(c) Haemoglobin is a protein found in red blood cells that transport oxygen around the body.

(i) Draw an **annotated** diagram to show how a peptide bond is formed when two amino acids are joined together during translation.

…… [2]



1. General structure of **2 amino acids ;** Correct dipeptide **;** with N terminus first **;**
2. Labelled peptide bond **;** Molecule of water (released from condensation) ;

(ii) Every amino acid has an R group or variable region that gives it its properties.

Glutamic acid is a polar amino acid and is therefore hydrophilic.

Fig. 1.2 shows part of a cell membrane.

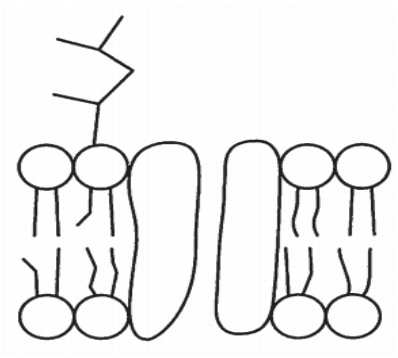
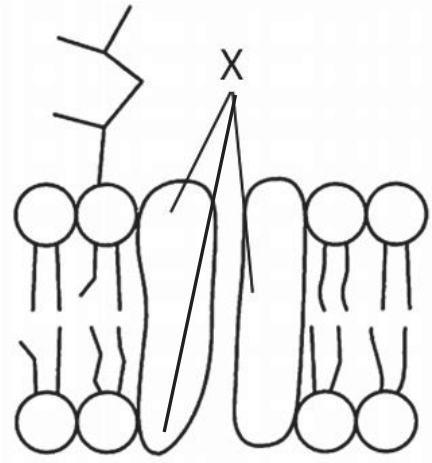


Fig. 1.2

On Fig. 1.2, use labeling lines and the letter X to label **two** different locations where you could expect to find glutamic acid.

……[2]



1. Location 1 – on region of transmembrane protein facing aqueous environments of the cytosol or extracellular environment / on region of transmembrane protein near to polar phosphate head of phospholipid bilayer.
2. Location 2 – on region of transmembrane protein facing aqueous pore ;

(iii) Describe the quaternary structure of haemoglobin.

……[2]

[Quaternary structure]

1. 2α chains and 2β chains associate together to form a tetramer;
2. Ref. interchain interactions such as ionic bonds, hydrogen bonds and hydrophobic interactions ***[name at least 2]*** [Reject**:** disulfide bond] between the **R groups of amino acids** from different subunits are involved;

(d) Sickle cell anaemia is a genetic disease caused by a base substitution in the gene coding for haemoglobin. This base substitution removes a restriction site for the restriction enzyme *MstII*.

The disease can be detected in an unborn child by obtaining a few fetal cells. A small section of DNA that could contain the base substitution is isolated and amplified using Polymerase Chain Reaction (PCR).

Fig. 1.3 shows how the restriction enzyme, *MstII*, cuts the DNA of the normal allele (Hb^A) and mutant allele (Hb^S) into fragments.

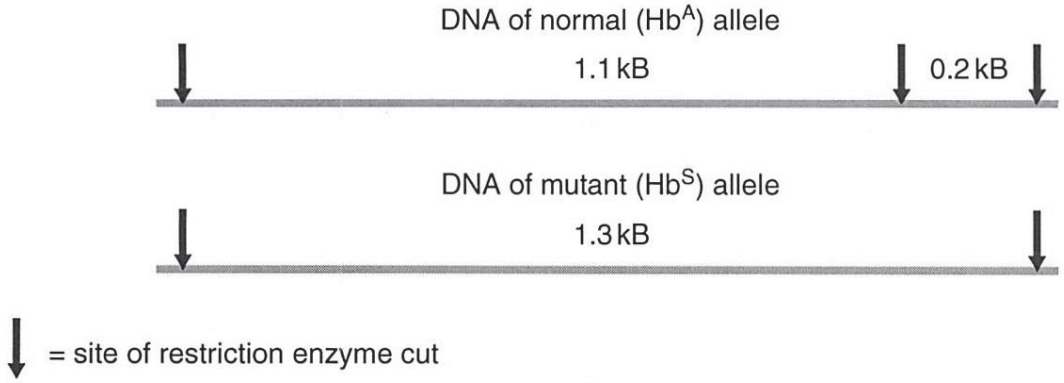


Fig. 1.3

(i) Explain why a single base substitution will result in the removal of one restriction site.

.....[2]

1. Ref. change in one base result in **change in 3D conformation** of the restriction site (on DNA) ;
2. **no longer complementary to** active site of restriction enzyme;
   [Reject "restriction enzymes only recognises specific DNA sequence" Too vague without stating mechanism]

Fig. 1.4 shows the patterns that are made visible after gel electrophoresis has been carried out using samples of DNA cut as shown in Fig. 1.3. The DNA samples are from three foetuses, one who is homozygous (Hb^A Hb^A), one who is heterozygous (Hb^A Hb^S) and one who is homozygous (Hb^S Hb^S).

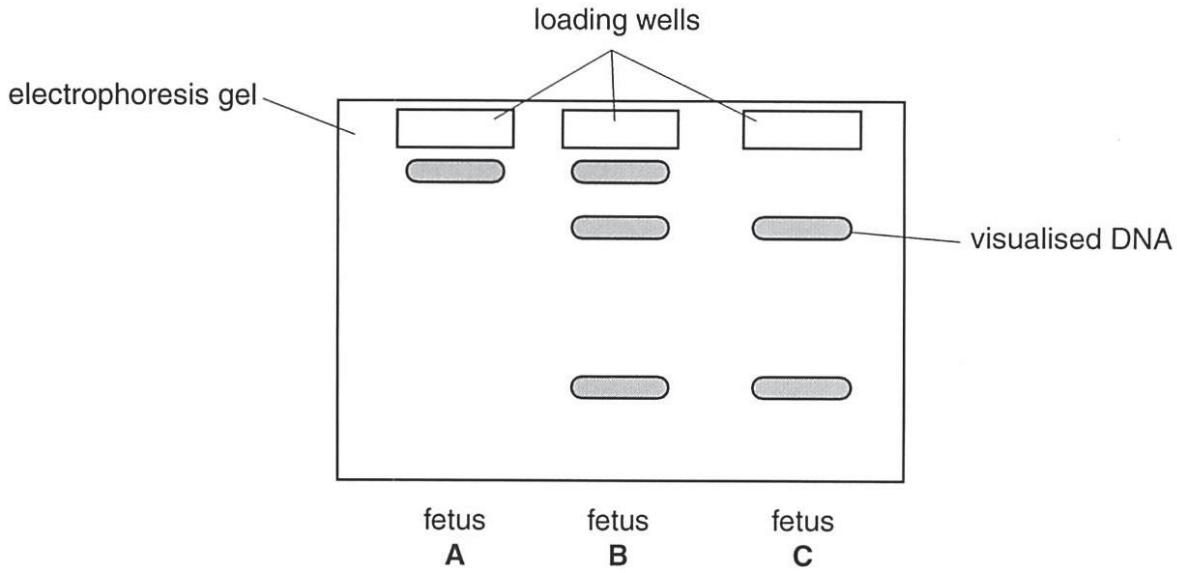


Fig. 1.4

(ii) Identify the genotypes of the foetuses labelled **A** and **B**.

A ..... B ..... [2]

1. A: Hb^S Hb^S
2. B: Hb^A Hb^S

(iii) Explain why individual B has high evolutionary fitness in malaria-stricken areas.

.....[3]

Heterozygote advantage in Hb^AHb^S individuals

1. *[types of haemoglobin present in individual]* Individual B (with genotype Hb^AHb^S) produces **both** normal and abnormal haemoglobin (in each red blood cell)

2. *[about parasite entering RBC causing sickle cell shape]* When malaria **parasite** invade the blood (and causes decreased oxygen levels due to their respiration), haemoglobin

S inside the red blood cells caused the **cells to become sickled-shaped** (Reject: haemoglobin is sickled) ;

3. *[effects of changes in RBC shape on parasite]* such cells are **{quickly destroyed** by the body / **hemolyse easily} ; {**stopping the infection / parasites are killed (together with the sickle-shape RBC)**}** ;

   / The **slowdown** in blood flow also **hampered the parasite's ability to travel** and rapidly infect new cells *[decrease parasites' infection]*

4. *[link to natural selection]* Ref. selective advantage of heterozygotes; and are able to **survive** and **reproduce**, **pass down** (Hb^S and Hb^A) **alleles** to offspring in malaria-infected areas.

(e) A new anti-malaria drug was discovered. A statistical t-test was performed on a total of **10 Singaporean subjects** to investigate if this drug can result in significant improvements in the relief of certain symptoms compared to the control group (receiving no dosage of the drug). There are 5 subjects in the control group and 5 subjects in the experimental group receiving the drug.

The description of the human subjects are included in **Table 1.2.**

Table 1.2

Control group			
	Gender	**Age / years old**	**Race**
Subject number 1	Female	41	Chinese
Subject number 2	Male	55	Chinese
Subject number 3	Male	50	Chinese
Subject number 4	Female	62	Malay
Subject number 5	Male	39	Chinese
Experimental group			
	Gender	**Age / years old**	**Race**
Subject number 6	Male	21	Chinese
Subject number 7	Male	24	Chinese
Subject number 8	Male	30	Chinese
Subject number 9	Male	27	Chinese
Subject number 10	Female	25	Chinese

Table of t critical values

df	.10	.05
1	3.078	6.314
2	1.886	2.920
3	1.638	2.353
4	1.533	2.132
5	1.476	2.015
6	1.440	1.943
7	1.415	1.895
8	1.397	1.860
9	1.383	1.833
10	1.372	1.812

The t-score was calculated to be 5.514.

Using the calculated t-score, the table of t critical values, and **Table 1.2**, discuss if the conclusion that this anti-malaria drug is effective is valid.

…….[2]

[Yes, effective]

(Degree of Freedom = total number of subjects – 2 = 10 – 2 = 8);

1. $t_{calculated}$ of 5.514 is **greater than** $t_{critical}$ = 1.860 at **p=0.05**; thus, there is a **significant difference** between control and experimental groups;

[No, conclusion is not valid] (Any one)

2. Sample size of 5 per condition is **too small** and not reliable **;** more tests need to be done on more subjects) ;
3. Ref. **sample biased** towards **{**mostly Chinese / one race**} ;** cannot extrapolate effectiveness on other races;
4. Ref. **unfair comparison** in **terms of age** between control and experimental groups **;** subjects in the control group are considerably older than that in experimental groups;
5. Ref. subjects are **predominantly males ;** need to test on more females;
6. Ref. **only Singaporeans** are sampled **;** need to extend to other countries;

[Total: 34]

QUESTION 2

Antibodies are produced naturally by B lymphocytes in the human body, after exposure to foreign antigens.

(a) B lymphocytes are known to have slightly different genome as compared to other nucleated cells in the body. Suggest **one** reason why.

……[2]

1. Mature B cells have different DNA sequences due to **somatic recombination** / VDJ recombination (occurring in developing B cells) ;
2. where **DNA arrangements** of the V and J segments of the gene coding for the variable (V) domain of the antibody's light chain / V, D and J segments of the gene coding for variable (V) domain of the antibody's heavy chain occurs; [Ignore C segments]

Other possible phrasing: "One V segment and one J segment are spliced (V-J joining), with removal of all the DNA between them."

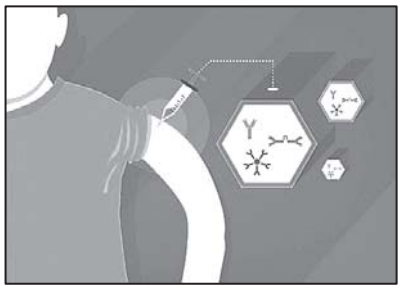
OR

1. Activated B cells have different DNA sequences due to somatic hypermutation ;
2. where random **point mutations** are introduced at a high rate in the genes coding for the variable (V) domains of both light and heavy chains ;

OR

1. Activated B cells have different DNA sequences due to class switching ;
2. where particular gene segments coding for the constant / C domains of the **heavy chain** get retained (and others removed) ;

Fig. 2.1 shows the process of obtaining antibodies using mice as a "production vessel".



Injection of antibodies into person

Fig. 2.1

In this process, the same antigen A is injected multiple times at regular intervals into the mice before collection of their blood to isolate the antibodies. Such isolated antibodies may then be injected into a person to achieve immunity.

(b)(i) State the type of immunity conferred by the injected antibodies.

……[1]

1. Passive **;** artificial/acquired immunity
   [Reject : adaptive/active immunity]

(ii) Explain why such type of immunity is not long-lasting.

……[1]

1. Ref. no production of memory (B) cells
2. Ref. protein nature of (injected) antibodies which allow for possible degradation

(iii) Suggest why antibodies were collected from the blood after "the same antigen A is injected multiple times at regular intervals into the mice".

……[1]

1. Ref. to obtain **higher** yield **;** due to launch of **secondary** immune response (in mice injected multiple times with antigen)

(iv) Comment on one ethical implication of using mice for large-scale antibody production.

……[1]

(Multiple) Injections of antigen into mice:

1. (may cause severe inflammation / bleeding in the animals)
   result in **{**severe distress / discomfort / health risks**}** in animals ;

   Ref**. repeated use** of **same** animal to produce high amounts of antibodies
2. results in **lower life span** due to diversion of resources ;

[Reject: lack of respect for animals' life / anything relating to religion / invasiveness of procedure (without explanation) which are vague answer]

[Reject: killing of mice to retrieve blood containing antibodies because Fig 2.1 did not state that the mice will be killed to withdraw blood.]

[Accept: abuse of animals as answer provided elaboration is given such as repeated jabbing of the same animal.]

Actual abuse of animals refers to the commitment of acts that deliberately or intentionally to cause harm without benefitting mankind.

(c) A team of students proposed a method to use prokaryotes instead of mice to make antibodies. In this proposed method, genes for specific antibodies are introduced into prokaryote cells (e.g. bacteria), which will then express the genes to make the antibodies.

However, the production of fully functional antibodies in prokaryotic cells is expected to be unsuccessful.
Explain why.

……[2]

1. **Lack** of **spliceosomes** in prokaryotes **;** to allow **post-transcriptional** modification (resulting in introns not removed) ;
   OR
2. **Lack** of Rough Endoplasmic Reticulum / Golgi apparatus in prokaryotes **;** to allow for **post-translational** modification of polypeptide chains ;

   [Compulsory]
3. Ref. to fold into correct 3D conformation / tertiary structure / association of light and heavy polypeptide chains by forming disulfide bonds;

   AVP:
4. Prokaryotic RNA polymerase is unable to recognize the promoter/termination sequence of eukaryotic transcription unit **;** for expression of gene ;

(d) During an immune response, cells divide by mitosis. Describe the significance of mitosis in an immune response.

……[2]

1. Ref. T and B cells with receptors complementary in shape to the antigen (will undergo mitosis)
2. during clonal **expansion /** produce **many** clones / **increase** in number of **genetically identical** (immune) cells (primary response) ;
3. many **plasma cells** to produce more **antibodies** (that recognizes the same antigen shape)
   / many **cytotoxic T cells** to detect and **destroy infected cells** (presenting the same antigen shape)
   / many **helper T cells** to **activate specific CD8 T cells and B cells** (that recognizes the same antigen shape) ;
   [Reject: faster response due to more selected T and B cells from mitosis as more cells result in *greater magnitude* of primary immune response but not faster response]
4. Ref. memory cells also undergo mitosis to achieve **rapid secondary response;**

[Total: 10]

QUESTION 3

Reef-building corals are marine invertebrates found in shallow, clear, tropical oceans. The corals secrete an exoskeleton of calcium carbonate that becomes the underlying structure of the coral reef ecosystem.

(a) Explain why the areas of sea containing coral reefs are susceptible to increased temperature resulting from global climate change.

……[1]

1 shallow water **heat up quicker** than that in deeper bodies of water
/ shallow water subjected to **extreme temperature fluctuations**
(hence, coral bleaching can occur easily for coral grew near the surface of the sea)

Zooxanthellae are a group of unicellular algae from the genus *Symbiodinium* that live within the cells of reef-building corals. The relationship has been described as mutualistic since it is beneficial to both coral and zooxanthellae.

(b) Evidence shows that the mutualistic relationship between zooxanthellae and reef building corals has evolved by free-living algae invading corals that did not contain algae.

(i) Suggest the benefits **to the zooxanthellae** of their association with the corals.

……[2]

1 (Zooxanthellae) get **physical support** to obtain light ;
2 carbon dioxide (from respiration of corals) for photosynthesis ;
3 {food caught / suspension feeding / catching prey} by coral / nitrogen from nitrogenous wastes of coral polyps ; provides nutrients needed for growth of algae
Note: Coral should be catching food/prey, digest them and the wastes from digestion by coral provide the necessary nutrients for zooxanhellae
4 **protection** from predation ;
/ **protection** from extreme conditions ;

(ii) Corals that do not need zooxanthellae can live at a greater depth than reef-building corals.

Explain why this is so.

……[2]

1 Reef-building corals with algae / zooxanthellae need to **photosynthesise**; thus lesser depth allows **penetration by light;**

2 [**compulsory**] Coral without zooxanthellae has **no reliance on light** / Coral without zooxanthellae are able to survive at greater depth where there is **less light** ;
3 AVP: e.g
different feeding methods ;
deeper waters (may be) nutrient rich

Under conditions of stress, the relationship between the reef-building corals and the zooxanthellae can break down. Loss of zooxanthellae and the subsequent whitening that occurs, shown in Fig. 3.1, is known as coral bleaching. Coral bleaching can lead to death of the coral.

Fig. 3.1

Increased sea temperature associated with global climate change is known to be an environmental stress that can cause coral bleaching. The temperature range for healthy survival of reef-building coral is 25 °C – 29 °C.

(c) Suggest **one** reason why permanent loss of zooxanthellae can lead to death of the coral.

……..[1]

[Any ONE]

1 **decreased** source of **sugars** derived from **photosynthesis** by zooxanthellae ;
2 **loss** of (main) source of (chemical) energy, ATP, derived **from respiration** using sugars (from photosynthesis);
3 **loss** of **protective** algal layer from harmful effects of sunlight ;
4 **loss** of **inorganic ions** for deposition of skeleton that algae obtain from sea ;
[Reject : lack of oxygen by zooxanthellae for coral's respiration]

[Total: 6]

Section B

Answer **one** question only in this section.

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

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

Your answers must be in continuous prose, where appropriate.

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

4 **(a)** Explain how various factors can affect the rate of respiration. [10]

(b) Discuss the various roles of hydrogen bonding in ensuring the continuity of life, using named examples where relevant. [15]

[Total: 25]

5 **(a)** Describe how the *Trp* operon operates in the absence of tryptophan as well as in the presence of tryptophan. [10]

(b) Explain how Penicillin works in treating bacterial infections. Discuss how Penicillin-resistance may arise in a bacteria population, with reference to the key processes involved. [15]

[Total: 25]

Mark Scheme

[Direct recall Q – From SAJC 2019 Notes]

4 (a) Explain how various factors can affect the rate of respiration. [10]

1. Many proteins (E.g electron carriers in ETC) and enzymes (E.g. phosphofructokinase) are involved in cellular respiration.

A. Substrate concentration*

2. *[Description]* Increasing substrate concentration will **increase** the rate of respiration until rate reaches the **maximum / plateau** ;
3. *[Explanation]* (Increasing substrate concentration will **increase** the rate of respiration as) there is **more substrate available** for the enzymatic reactions to occur at the various stages of cellular respiration ;
4. *[Explanation]* (Rate of respiration will reach maximum) when **enzyme concentration become the new limiting factor** / active sites of enzymes are all **fully occupied**.

B. Type of substrate*

5. *[Description of relationship]* Respiration using **simple sugars** e.g glucose, galactose etc *(must give 1 e.g)* will proceed at a **higher rate** than those that use **disaccharide** e.g maltose / **complex sugars** e.g **starch, amylose, amylopectin, glycogen** *(must give 1 e.g)*.
6. *[Explanation]* Glucose is used as the **respiratory substrate** in glycolysis.
7. *[Explanation]* This is because a **longer time is needed to first break down** the complex sugar **into glucose** using enzymes such as maltase and amylase

C. Temperature*

8. *[Description]* Increasing temperature will **increase** the rate of respiration until rate reaches the **maximum** at optimum temperature and beyond optimum temperature, rate **decrease** drastically/sharply ;
9. *[Explanation]* At **low** temperature, cellular respiration rate is insignificant as enzymes are inactive / low kinetic energy ;
10. *[Explanation]* *(*The rate of respiration **increases** with increasing temperature to an optimum temperature) as kinetic energy increases and frequency of effective collisions between substrate and enzymes increases ;
11. *[Explanation]* (**Beyond the optimum** temperature, respiration rate decreases) as enzymes involved in respiration becomes denatured / **loses specific 3D conformation** of active site **;** due to **thermal agitation** ;

D. pH

12. *[Description]* At **optimum pH**, cellular respiration rate is at the **highest** ; At **pH below and above** the optimum pH, rate **decreases** ;
13. *[Explanation]* (Change in pH, thus change in H^+ and OH^-) **disrupts** ionic and hydrogen bonds *(both bonds required, no additional bonds allowed)* between R group of amino acid residues that hold the enzyme structure together;
14. *[Explanation]* **Beyond the optimum** pH, respiration rate decreases as enzymes involved in respiration becomes denatured / **loses specific 3D conformation** of active site; (Thus, rate of enzyme activity is reduced.)

E. Amount of oxygen

15. *[Description]* The amount of oxygen affects the rate of **aerobic** respiration (but does not affect organisms that carry out anaerobic respiration).
16. *[Explanation]* Oxygen is used as the final electron acceptor at the end of the electron transport chain (ETC) at the inner mitochondria membrane.
17. *[Explanation]* Without oxygen, **flow of electrons** down the ETC **halts** and oxidative phosphorylation, Kreb cycle and Link reaction **stops** too.

F. Amount of water

18. *[Description]* The rate of respiration **decreases** with **decreasing amount of water** available.
19. *[Explanation]* This is because enzymes in respiration require **water as a medium** to work.

G. State of cell

20. *[Description]* **Young and developing cells** (E.g neurons and cells at the root of human hair) undergo a **higher** rate of respiration compared to **dormant cells** such as those in plant seeds.
21. *[Explanation]* (Young and developing cells) require more **ATP** for cellular activities **;** e.g cell division ;

22. **QwC: [1m]** Clear organised flow without ambiguity AND at least 2 marks awarded for **three** different factors (A – F).

4 (b) Discuss the various roles of hydrogen bonding in ensuring the continuity of life, using named examples where relevant.

[15]

A) [Role in maintaining protein structure]

1. For maintaining {secondary structures / α-helices and β-pleated sheets} in proteins, formed **between** peptide bonds **/** –CO group of one amino acid and –NH group of another amino acid (in the same chain) ;

2. For maintaining tertiary/quaternary structure of proteins, formed between polar R groups of amino acid residues ;
3. *[Named example with elaboration – max 1 mark]* ***Ref. to*** hydrogen bonds present between the three polypeptide chains of a tropocollagen molecule / ***ref. to*** structure of haemoglobin e.g mainly α-helixes in α- and β-chains or holding of 4 subunits comprises of 2 α- and 2 β-chains of haemoglobin / (***ref. to*** GPLR – *awarded under markpoint 11*) ;

4. Specific 3D conformation of proteins dictates their specific functions
5. *[Named **1** example – max 1 mark]* ***Ref. to*** enzyme e.g. DNA polymerase, lipase **; *ref to*** function of respective enzyme ;

B) [Role in enzyme-substrate interaction]

6. To allow substrate to bind weakly to the active site of enzyme
7. *[Named **1** example – max 1 mark]* ***Ref. to*** a enzyme-substrate pair ; e.g. amylase and starch.

C) [Role in structural support]

8. Many hydrogen bonds present in biological molecules can result in high tensile strength, therefore provide structural support ;
9. *[Named **1** example – max 1 mark]* Cellulose has hydrogen bonds between cellulose chains to produce cellulose fibres
   [**DO NOT award** for collagen as hydrogen bonds are found only within tropocollagen and hydrogen bonds are only one aspect that contribute to the tensile strength in collagen fibre – other aspects are staggered arrangement of tropocollagen, covalent bonds involving lysine and hydroxylysine of tropocollagen];

D) [Role in solubility]

10. To allow (hydrophilic / polar / charged) substances to be **soluble in aqueous environment**
11. *[Named **1** example – max 1 mark]* ***Ref. to*** named globular protein e.g haemoglobin / ***Ref. to*** named enzyme **;** having **{**hydrophilic / polar / charged**}** R-groups of amino acid residues **projecting outwards from** surface of protein

E) [Role in holding proteins in cell membranes]

12. Hydrogen bonds formed between **{**hydrophilic/polar**}** phosphate heads of phospholipids and **{**hydrophilic/polar/charged**}** R groups of amino acids of membrane proteins, helps to hold the protein in place in membrane.
13. *[Named **1** example – max 1 mark]* ***Ref. to*** transmembrane protein embedded in membrane e.g. Receptor tyrosine kinase (RTK) / G-protein Linked Receptor (GPLR)

F) [Role of H-bonds between complementary base pairs in nucleic acids]

14. Allows complementary base pairing to occur in nucleic acid interactions
15. Adenine (A) binds to Thymine (T) / Uracil (U) via 2 hydrogen bonds **;** Cytosine (C) binds to Guanine (G) via 3 hydrogen bonds

*[Allow **1** Named example for molecule – max 2 marks]*

- [***E.g.*** In DNA]

16. Hydrogen bonds stabilize double helical DNA molecule **;**
17. Role of storing genetic information.

- [***E.g.*** In tRNA]

18. Intra-molecular hydrogen bonding in tRNA allows tRNA to fold into a clover-leaf structure
19. ***Ref.*** *to* role of tRNA – carries amino acids to the ribosome for synthesis of polypeptide

- [***E.g.*** In rRNA]

20. Intra-molecular hydrogen bonding in rRNA allows rRNA to fold into a precise 3D structure to complex with ribosomal proteins to form ribosome
21. ***Ref.*** *to* role of ribosome – translation machinery

- [***E.g.***. In snRNA]

22. Intra-molecular hydrogen bonding in snRNA allows **snRNA** to fold into a precise 3D structure to complex with spliceosomal **proteins** to form spliceosome
23. ***Ref.*** *to* role of spliceosome – splicing of primary mRNA transcript to produce mature mRNA

- [***E.g.*** In Telomerase RNA]

24. Intra-molecular hydrogen bonding in telomerase RNA allows **telomerase RNA** to fold into a precise 3D structure to complex with **protein** (TERT) to form the telomerase enzyme
25. *Ref. to* role of telomerase – restore telomere length to ensure infinite division in stem cells

*[Allow **1** Named example for process – max 1 mark]*

- [***E.g.*** During DNA replication]

26. Important in DNA replication, where daughter DNA strand is synthesized via adding complementary deoxyribonucleotides to template DNA to ensure accurate transmission of genetic information.

- [***E.g.*** During Transcription]

27. Important in transcription, where RNA is synthesized via adding complementary ribonucleotides to template DNA

- [***E.g.*** During Translation]

28. Important in translation, where codons on mRNA complementary base pair with anticodon on tRNA to ensure correct sequence of amino acids forms the polypeptide

G) [Role of H bonds in carbohydrate structure]

29. H bonds helps maintain the helical structure in amylose

30. *AVP*

31. **QwC: [1m]** Clear organised flow without ambiguity AND at least 1 mark awarded for **THREE** different roles *(any three from items **A** to **F**)* of hydrogen bonds, each role with one named example.

5 (a) Describe how the *Trp* operon operates in the absence of tryptophan as well as in the presence of tryptophan. [10]

1 The Trp repressor protein coded by the regulatory gene (*trpR*) is **constitutively expressed**, normally in its inactive (non DNA-binding) form ;

A) IN THE ABSENCE OF TRYPTOPHAN

2 In absence of tryptophan, Trp repressor **does not bind** to the *trp* operator ;
3 RNA polymerase recognises and **binds** to the promoter of the *trp* ;
4 and **{initiation** of transcription / **expression}** of structural genes, *trpE*, *trpD*, *trpC*, *trpB* and *trpA* ;
(trp operon is switched **ON**);
5 Repressible **enzymes,** used in a series of reactions that form intermediates used to form tryptophan (a pathway for tryptophan biosynthesis), are synthesized.

B) IN THE PRESENCE OF TRYPTOPHAN

6 In presence of tryptophan which act as a co-repressor, tryptophan **binds** to the allosteric site of Trp repressor,
7 **alters** its 3D conformation at the DNA-binding site of Trp repressor ; and **activate** the repressor ;
8 (active) Trp repressor now **binds** to the *trp* operator ;
9 **prevents** RNA polymerase **{**from recognising and **binding** to the promoter of the *trp* / **accessing** the structural genes**}** ;
10 No **{initiation** of transcription / **expression}** of structural genes, *trpE*, *trpD*, *trpC*, *trpB* and *trpA* ;
(trp operon is switched **OFF**);
11 Repressible **enzymes,** used in a series of reactions that form intermediates used to form tryptophan (a pathway for tryptophan biosynthesis), are not synthesized.

12 **QwC: [1m]** Clear, organised flow without ambiguity AND at least **2 marks** awarded for **each** part (A) – (B).

5 (b) Explain how Penicillin works in treating bacterial infections. Discuss how Penicillin-resistance may arise in a bacteria population, with reference to the key processes involved. [15]

A) Mode of action of Penicillin:

1 Penicillin is an antibiotic that acts to **inhibit the bacterial growth / kill bacteria** ;
2 Bacterial transpeptidases catalyse the **formation of cross-links between peptidoglycans** in bacterial cell walls ;
3 Ref. to **irreversible** competitive inhibition / complementary in 3D conformation to active site of enzyme (transpeptidases) but binds **irreversibly** ;
4 Thus, **cross-links** between peptidoglycans **do not form** and cell wall is **weakened** ;
5 Ref to osmotic lysis / when bacteria takes in water by osmosis, the **increased turgor pressure** causes cell to burst ;

B) Gaining Penicillin-resistance - VGT:

6 **Spontaneous** DNA mutation in a bacteria cell **;** gave rise to penicillin-resistance gene **;**
7 **Ref. to** *suggested* mode of action of protein coded by penicillin-resistance gene eg. enzyme that breaks down penicillin, rendering penicillin non-functional ;
8 Bacteria with the penicillin-resistance gene **pass it down to their progeny** via binary fission (Vertical gene transfer).

C) Gaining Penicillin-resistance - HGT:

Transformation, transduction, Conjugation also enables the transfer of penicillin-resistance gene between the bacteria cells.

9 Transformation occurs when competent bacterial cells take up naked DNA, that coded for penicillin-resistance, from the environment.
10 General transduction occurs, where a **{T4**/lytic bacteriophage**}** accidentally transfer genes from one bacterium to another, after the host bacteria's penicillin-resistance gene was **accidentally packaged** within the {viral capsid / bacteriophage}.
11 Specialised transduction occurs, where a **{lambda(λ)**/lysogenic bacteriophage**}** accidentally transfer genes from one bacterium to another, after the host bacteria's penicillin-resistance gene was accidentally **excised** together with the (integrated) viral genome.
12 Conjugation occurs, where the F plasmid containing the penicillin-resistance gene, was transferred from a **F^+ cell to F^- cell** via the sex pilus.
13 (Following transformation, transduction, Conjugation,) homologous recombination or site-specific integration may occur in the recipient bacteria, thus conferring penicillin-resistance phenotype (to the recipient bacteria).

D) Gaining Penicillin-resistance – Natural Selection:

14 Presence of penicillin in environment acts as a (directional) selection pressure.

15 Non-resistant bacteria {are **selected against** / have selective disadvantage}
OR
Bacteria which are resistant to penicillin {are **selected for** / have a **selective advantage**} ;

16 Penicillin resistant bacteria survive, reproduce and pass down the **allele** coding for penicillin-resistance (Reject: pass down trait) to **subsequent generations** of bacterial cells (during binary fission);

17 **Over many generations**, **frequency of allele** coding for penicillin-resistance **increases** in the gene pool of bacteria.
(Thus, penicillin-resistance is exhibited by majority of bacteria.)

18 **QwC: [1m]** Clear, organised flow without ambiguity **AND** at least 2 mark awarded for item (A) **AND** at least 2 mark awarded for **each** of *any two* from items (B) – (D).
Possible combinations as follow:
(A), (B), (D) or
(A), (C), (D) or
(A), (B), (C)

Civics Group		Full Name (use BLOCK LETTERS)

Centre number / Index Number	

H2

ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATION

H2 BIOLOGY **9744/04**

Paper 4: Practical Exam (Mark Scheme)

Tuesday 17th September 2019 2 hours 30 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use a HB pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

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

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

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

IMPORTANT INFORMATION TO CANDIDATES:

Candidates with access to **microscope** at the start of the paper are given the **first 1h 15 min** to use them. Please answer **QUESTION 3** within this time frame.

Candidates with no access to microscope at the start of the paper will be given access **1h 15min after the start of the paper**. You may proceed with **QUESTION 1** first.

Candidates can attempt **QUESTION 2** at any juncture of the paper.

Shift
Laboratory

For Examiner's Use	
1	/ 23
2	/ 12
3	/ 20
Total	**/ 55**

This document consists of **21** printed pages and x blank page

SAJC 2019 JC2 PRELIMINARY EXAMINATION

Paper 4: Practical Exam
(Mark Scheme)

Answer **all** questions

QUESTION 1

You are advised to:

- *Read through the entire question first*
- *Prepare a table to record your results in **(b)(ii)***

  ***before** starting the investigation.*

In this question, you will investigate the effect of substrate concentration on the rate of hydrolysis of a disaccharide, sucrose.

The enzyme **E** catalyses the hydrolysis (breakdown) of sucrose to fructose and glucose.

The products of the hydrolysis of sucrose will change the colour of potassium manganate(VII) solution, **P**, from purple to colourless.

You are required to:

- prepare a simple dilution of sucrose solution
- investigate the action of **E** on the different concentrations of sucrose solution
- record the time taken to reach the end-point for each concentration of sucrose solution

You are provided with:

- 30.0 cm^3 of 10.0 % sucrose solution, labelled **S**,
- 50.0 cm^3 of distilled water, labelled **W**,
- 10.0 cm^3 of 1 mol dm^{-3} sulfuric acid, labelled **A,** which is an irritant
- 10.0 cm^3 of 1.0 % enzyme solution, labelled **E**, which is an irritant
- 20.0 cm^3 of 0.01 % potassium manganate(VII) solution, labelled **P**, which is a low risk irritant

Safety:

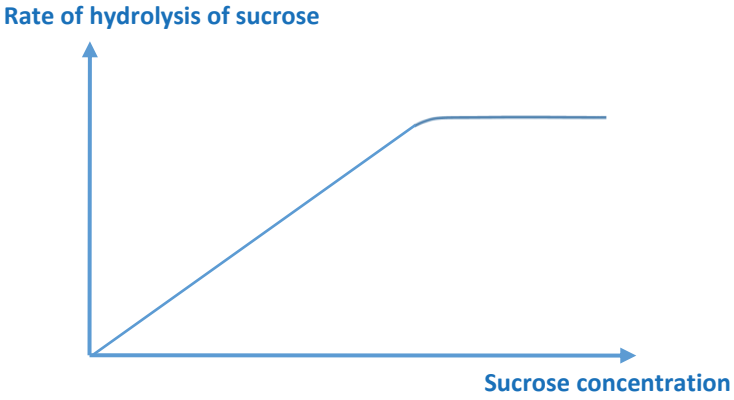
- It is recommended that you wear suitable eye protection.
- If **A**, **E** or **P** come into contact with your skin, wash off immediately under running water.

(a) Sketch a fully-labelled graph to show the expected relationship between the rate of hydrolysis of sucrose by enzyme **E** and sucrose concentration, as sucrose concentration increases. Assume that all other conditions are kept constant.

No units for axes are required.

……[2]

Graph of rate of hydrolysis of sucrose against sucrose concentration



1. Correct axes labels on X-axis & Y-axis
   Accept: y-axis label - "Rate of hydrolysis"
   [Reject: y-axis label - "Rate", x-axis label - "substrate concentration" too vague.]

2. Correct shape of graph (linear to plateau), starting from origin
   Accept: curved instead of linear
   [Reject: All linear OR Plateau is not clear (Advice: plateau be drawn using ruler)]

   IGNORE: If (wrong) units is given.

Proceed as follows:

You are required to prepare different concentrations of the sucrose solution.

(b) Carry out **simple** dilutions of the sucrose solution, **S**, to obtain **five** different concentrations in which the concentration of sucrose is **reduced by 2.0 %** between each successive dilution.

Prepare 5.0 cm^3 for each concentration of sucrose solution, **using the small plastic containers provided.**

(i) Complete Table 1.1 to show how you will prepare the different concentrations of sucrose solution.

……[2]

Table 1.1

Concentration of sucrose solution / %	Volume of **S** / cm^3	Volume of **W** / cm^3
10.0	5.0	0.0
8.0	4.0	1.0
6.0	3.0	2.0
4.0	2.0	3.0
2.0	1.0	4.0

1. Correct 4 concentrations (accuracy to 1.d.p), with 2% reduction per dilution [Reject: if order is not descending, as specified by Question stem]

2. Correct volumes of **S** & **W** (accuracy to 1.dp)

Before proceeding further:

- Use the beaker labelled **Hot water** to collect approximately 200cm^3 of hot water from where it is provided in the laboratory.
- Use the beaker labelled **Cold water** to collect approximately 200cm^3 of tap water from the tap.

Read step 1 to step 13 before proceeding.

1. Prepare the concentrations of sucrose solution, as shown in Table. 1.1.

2. Label as many test-tubes as you require for all the sucrose solutions prepared in step 1.

3. Put 1.0 cm^3 of 10.0 % sucrose solution into the labelled test-tube.

4. Repeat step 3 with each of the other concentrations.

5. Using the water from the beakers labelled **hot water** and **cold water**, set up a water-bath at a temperature between 35 °C and 40 °C. Use hot water to adjust the temperature of the water-bath if it cools down too much.

*The reaction will start when **E** is added in step 6.*

6. Put 1.0 cm^3 of **E** into each test-tube. Shake gently to mix.

7. Put all of the test-tubes into the water-bath and start timing.

8. Leave the test-tubes in the water-bath for **8 minutes**.
   During this period, it is not necessary to maintain the temperature of the water-bath.

*During this incubation period, continue with **(b)(iv)** and the rest of Question 1.*

9. At 8 minutes, remove all test-tubes from the water-bath and **immediately** put 1.0 cm^3 of **A** into each of the test-tubes. Shake gently to mix. Leave the test-tubes on the test-tube rack.

10. Label a clean test-tube as **Z**.
Put 1.0 cm^3 of **E** and 4.0 cm^3 of **W** into the test-tube. Shake gently to mix.
Test-tube **Z** will serve as the reference for the colourless end-point.

11. Put 1.0 cm^3 of **P** into the test-tube containing 10.0 % sucrose solution. Start timing. Shake gently to mix.

12. Check on the colour of the test-tube up till a maximum 5 minutes.

Record in **(b)(ii)** the time taken for the test-tube to reach the end-point, as shown by the contents of test-tube **Z**.

13. Repeat steps 11 to 12 for each of the other concentrations of sucrose.

Also, calculate the (relative) rate of hydrolysis of sucrose and record in **(b)(ii)**.

If the end-point has not been reached after 5 minutes, **stop timing** and record the time taken as 'more than 300' and the rate as 'zero'.

(ii) Record your results in a suitable format in the space given.

……[4]

Table showing effects of different sucrose concentration on the time taken for P to completely decolourise, to calculate the rate of hydrolysis of sucrose

Sucrose Concentration / %	Time taken for P to completely decolourise / s	(Relative) Rate of hydrolysis of sucrose / x 10^{-2} s^{-1}	OR	(Relative) Rate of hydrolysis of sucrose / x 10^{-1} s^{-1}
10.0	**4**	**25**		**2.5**
8.0	**4**	**25**		**2.5**
6.0	**5**	**20**		**2.0**
4.0	**8**	**13**		**1.3**
2.0	**10**	**10**		**1.0**

1. **Independent variable**: presented on leftmost column with appropriate **heading and unit**
Reject: "Concentration" (too vague)

2. **Measured variable & Dependent variable**: separate columns with appropriate **headings and units**
Accept: "Time taken for test-tube to reach end point"
Reject: "Time taken" (too vague)

3. **Precision of data:**
    - Independent Variable: In 1.dp
      AND
    - Raw data: In seconds (**Accept** whole no. only),
      AND
    - Rate of hydrolysis of sucrose:
        - In *standard form* (**Accept:** whole no. or 1.dp),
        - **Reject**: If answer is NOT is standard form, E.g 0.2 (This will result in many of the values being the same, if rounded based on precision rule)
        - If time taken is stated as '*more than 5*', only accept the rate as '*zero*'. Reject '0'.

    Marker's Guidance: Can accept if standard form was given in the table

4. Observations **recorded** for **all** 5 concentrations (Acceptable range: 0-30s) + correct **Trend** : Earlier change in colour for highest sucrose concentration.

    Marker's Guidance: "Range of value should be with reference to teacher's expt value"
    Reject: If student indicates time taken as 'more than 300' and the rate as 'zero', this was not shown in teacher expt.

(iii) Discuss what your results suggest about the relationship predicted in **(a)**.
....[2]

(If experimental results match predicted relationship)

1. [Comparison of experimental results with Prediction] Pattern of results **shows same pattern** as predicted in (a);
2. [Implication] Which **increases the confidence** in the hypothesis / proposed relationship;

OR

(If experimental results only match the initial predicted increase but plateau is absent)

1. [Comparison of experimental results with Prediction] Pattern of results **shows same initial increase** as predicted in (a) initially, **but plateau is not reached**;
2. [Implication] **Decreases confidence** in the predicted relationship / **Further results** (at higher sucrose concentrations) will need to be **collected** in order to further evaluate the relationship;

OR

(If experimental results does not match predicted relationship)

1. [Comparison of experimental results with Prediction] **No clear pattern** in the results / **results do not match** at high / low sucrose concentrations;
2. [Implication] **Decreases confidence** in the predicted relationship / **experiment should be repeated** to check on the reproducibility of results;

Reject: "Proving results… / confirming results… / concluded that results are true/right/correct / concluded that results are valid" [Mark point 2]

(iv) Explain the purpose of step 9, where solution **A** was added to the mixture.
……………………………………………………………………………………….[1]

Sulfuric acid denatures the enzyme ; which **stops/quench** the reaction.

(v) Suggest why solution **P** is expected to (eventually) decolourise, when it was added to the mixture in step 11.
……………………………………………………………………………………….[1]

Fructose and glucose are reducing sugars ;
Which will **reduce** the (oxidising agent) potassium manganate(VII)
/ reverse argument (on oxidation of the reducing sugars) ;

(vi) Confidence in the results of this experiment may be limited by lack of replication and repeats.

Apart from conducting replicates and repeats, identify **one** other significant source of error in this experiment. Also, describe **one** method to overcome / reduce this source of error.
……………………………………………………………………………………….[2]

Any pair

1. **[Error 1] Lack of (negative) control** performed ;
2. **[method to overcome] Description**: 'replace sucrose solution with **equal volume / 1.0 cm^3** of distilled water'
   OR
   'replace enzyme solution with **equal volume / 1.0 cm^3** of distilled water / boiled and cooled enzyme solution'
   (, keeping all other experimental conditions the same) ;
   [**Reject**: 'Carry out control', too vague]

   OR

3. **[Error 2] Lack of equilibration step** ;
4. **[method to overcome]** Put sucrose solution and enzyme solution in **separate** test tubes and incubate in water bath for **3 minutes** (*need to suggest an appropriate duration, e.g 3 to 5 min for 1h experiment*) for equilibration, **before** adding them together to start reaction ;

   OR

5. **[Error 3] Difficulty** in **judging** colour change / colour **identification** of end-point is **subjective** ;
   [Reject: "Colour is subjective".]
6. **[method to overcome]** Use a **colourimeter or UV spectrometer** to measure the absorbance of the contents in the cuvettes (By fixing the end-point at the specific absorbance value for test-tube **Z** (cloudy clear colour))
   [**REJECT**: Use of a colour chart as reference, as Tube **Z** already acted as the reference)]

OR

7. **[Error 4]** Temperature of water bath was **not kept constant** (during step 8) ;
8. **[method to overcome]** Use a thermostatically controlled water bath to keep the temperature constant
   OR
   keep temperature of water bath constant via **manual adjustment**, using hot water, cold water and thermometer.

   [Note: It is advised to also include the specific temperature that the water bath is maintained at.]

9. **[Error 5] Time lag** for {addition of enzyme / **E** / step 6} to all 5 test-tubes OR **Time lag** for {addition of acid / **A** / step 9} to all 5 test-tubes ;
10. **[method to overcome]** *Ref* to **time staggering /** do step 6 to 9 for 1 test-tube at a time ;

11. **[Error 6]** *Ref* that the suggested range of values for sucrose concentration (in protocol) was insufficient to determine the full predicted/theoretical trend ;
12. **[method to overcome] Increase** the **range of values** for sucrose concentration AND suggest appropriate range of values for improvement (Reject: 100%) ;

13. **AVP**

Reject:

- Operator error. E.g. Wrong dilution done, parallax error.
- pH value is not kept constant. [Acid has to be added to end reaction, presence of pH buffer will affect this step. Thus, this answer is not applicable for this experiment.]

(c) A student carried out a similar experiment to investigate the effect of pH on the activity of an enzyme.

The rate of enzyme activity was measured when the solution was at different pH values.

All other variables were kept constant.

The results are shown in Table 1.2.

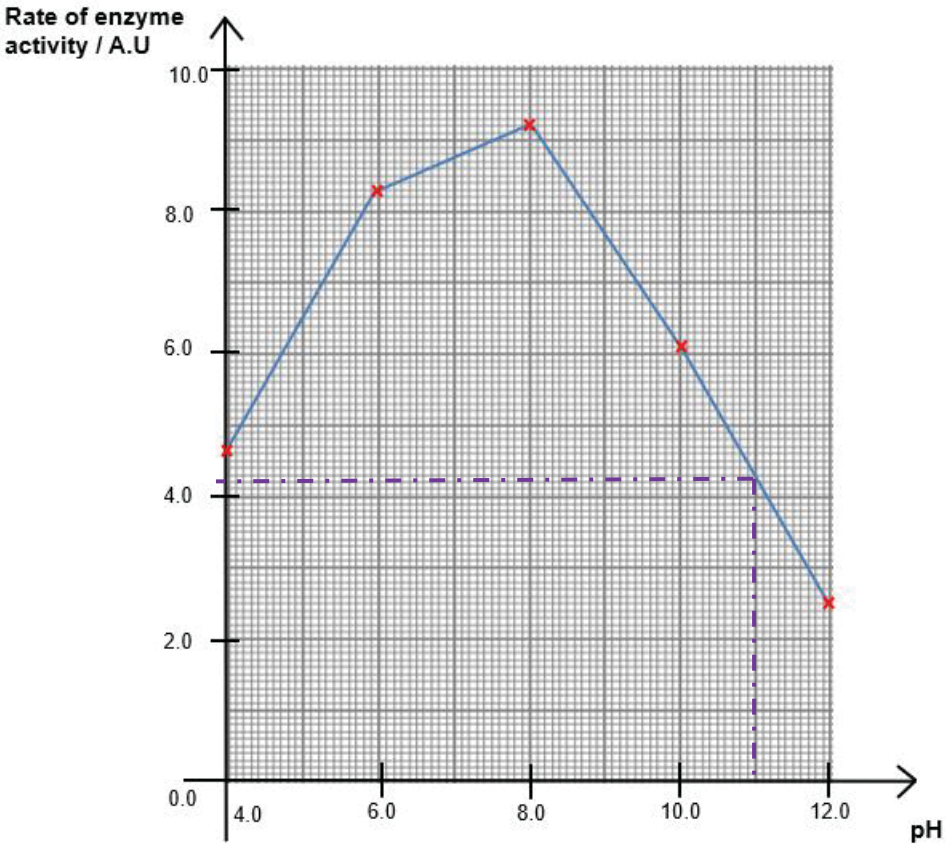
Table 1.2

pH	**rate of enzyme activity / arbitrary units (A.U.)**
4.0	4.6
6.0	8.3
8.0	9.2
10.0	6.1
12.0	2.5

(i) Use the grid to plot a graph of the results shown in Table 1.2.

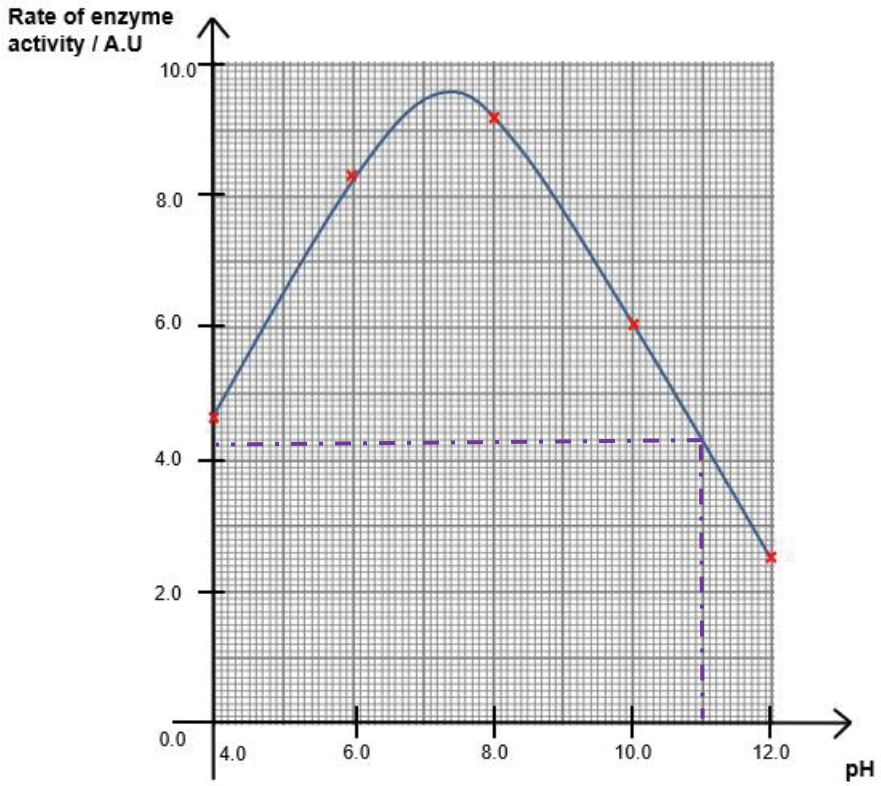
……[4]

Graph of rate of enzyme activity against pH



OR

Graph of rate of enzyme activity against pH



1. **Scale:** Sensible scale with graph occupying <u>at least 1/2 the grid</u> on both x- and y-axes + <u>equidistant divisions</u> on axes ;
2. **Axes & Units**: <u>Independent</u> variable (pH) on <u>x-axis</u> and <u>dependent</u> variable (rate of enzyme activity) on <u>y-axis</u> ; only units for y-axis required (A.U.) ;
   Ignore: Precision / d.p
3. **Plot**: <u>Accurate plotting</u> of points to nearest half a small square ;
   Marker's Instructions: <u>Allow ECF</u> even if Axes/Units (2) mark is not awarded.
4. **Graph**: Smooth **curve** drawn, <u>without extrapolation</u> beyond plotted points ;
   Accept: If student indicate a point a outlier/anomaly.
   Accept: Point-by-point joining, ruled lines only.
   Reject: Best-fit straight line / hybrid (curve & straight line) drawn

   Marker's Guidance: Max 1 mark (mark point 3 – Plot) for students who inverted the axes.

(ii) Using your graph, find the rate of enzyme activity which would be achieved if the pH of the solution was **11.0**.

Clearly indicate your working.

Rate of enzyme activity = ...A.U. [1]

1 Correct reading from student's **own** graph (precision to half a small square), + need to clearly <u>annotate lines</u> on graph (= workings)

Accept correct answer expressed to 1 d.p *or* 2.d.p (to nearest 0.05, = half the smallest grid). E.g 4.3 or 4.25 (From the sample graph)

(iii) Describe and explain the effect of increasing the pH from 8.0 to 12.0 on the rate of enzyme activity.

……..[4]

[**Describe]** – **Compulsory Point**

1. As pH **increases** from 8.0 to 12.0, the rate of enzyme activity **decreases** (sharply) from **9.2 to 2.5 A.U**. (data must be quoted)**;**

[Explanation] – Max 3

2. Change in pH of solution results **change in** concentration of H^+ and OH^- ;
3. (Above the optimal pH,) the **ionic charges** of (acidic and basic) R groups of amino acid residues are **altered** ;
4. This **disrupts** ionic and hydrogen bonds (*both bonds required*) holding the enzyme structure together;
   [Reject: hydrophilic (too vague)]
   [Reject: hydrophobic, covalent bond]
5. Specific **3D conformation** of active site is **altered** / active site is denatured / charge of active site / catalytic groups is **modified** ;
6. (Lower effective enzymes concentration), thus **lower** frequency of effective collisions between enzyme and substrates
   / **reduced** enzyme-substrate complex formation per unit time ;

(Thus, rate of enzyme activity is reduced.)

[Total: 23]

QUESTION 2

A student wants to investigate the effect of temperature on the rate of digestion of sucrose, catalysed by enzyme sucrase.

Based on your knowledge of food tests, choose a relevant food test for this investigation.

Design an experiment to determine the effect of temperature on the **absolute rate** of sucrose digestion.

Your planning must be based on the assumption that you have been provided with the following equipment and apparatus which you **must** use.

You are provided with:

- 1% sucrase solution
- 1% sucrose suspension
- Benedict's solution
- Spectrophotometer
- Cuvettes
- Glass rod
- Stop watch
- Bunsen burner, tripod, gauze
- Access to hot water (80^{o}C – 90^{o}C)
- Supply of cool tap water
- Thermometer
- Distilled water
- Normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagrams, if necessary,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimize any risks associated with the proposed experiment.

[Total: 12]

MARK SCHEME

Introduction

✓ **Theoretical background: [A – 2M Max]**

1 As temperature increases (up to the optimum temperature), enzyme and substrate molecules have higher kinetic energy, resulting in **higher frequency of effective collisions** between enzyme and substrate

2 More ES complexes formed per unit time / thus more products formed per unit time (so rate of reaction increases).

3 Increasing temperature will cause more thermal agitation ; above the optimum temperature, this **disrupts hydrogen bonds, ionic bonds and hydrophobic interactions** (any 2 types of bond stated) between R-groups of amino acid# residues in the enzyme.

4 Enzyme loses specific 3D conformation of active site# / denatured / less ES complexes formed per unit time / hence less products formed per unit time (so rate of reaction decreases).

Any 2 for 1 mark

✓ **Rationale of set up:**

5 The rate of sucrase reaction can be determined by monitoring the {concentration of reducing sugars / glucose & fructose} formed by using the **Benedict's test**.
/ The higher the rate of reaction, the **higher** {the concentration of reducing sugars / glucose & fructose} present, so more brick-red precipitate is formed from Benedict's test.

6 The quantity of brick-red precipitate can be monitored using a spectrophotometer. The higher the quantity of precipitate, the higher the absorbance values.

✓ **Hypothesis [B - 1 M]:**

- The rate of digestion of sucrose catalysed by sucrase should **increase** as temperature increases,
- and **decrease drastically** as temperature increases beyond optimum temperature.

Variables [C – 2M]

✓ **Independent variable:** Temperature /°C (30°C, 40°C, 50°C, 60°C and 70°C)
[At least 5 logical values (20 – 100°C); regular intervals; Correct unit]

1M

✓ **Dependent variable:** Absolute rate of sucrose digestion, measured by absorbance of mixture per unit time / AU s^{-1}
[Correct term & unit]

✓ **Other Variables to be kept <u>constant</u>: [Apparatus & quantity to be indicated]**

Any 2 for 1 mark

1 Concentration of enzyme (sucrase) used;
   - o use the <u>same</u> 1% sucrase **stock solution** + same <u>volume</u> of **1.0 cm^3** measured by <u>syringe</u>

2 Concentration of substrate (sucrose) used;
   - o use the <u>same</u> 1% sucrose **stock solution** + same <u>volume</u> of **5.0 cm^3** measured by <u>syringe</u>

3 Volume of test solution / Benedict's solution,
   - o use **2.0 cm^3**, measured by <u>syringe</u>

4 Duration of incubation / Benedict's test;
   - o <u>2 minutes</u>, using a <u>stop watch</u>

5 pH;
use a <u>pH buffer</u> adjusted to the optimum pH of sucrase (E.g. 7.0)

✓ **<u>Control</u>: [D – 1M, both set-up description + rationale]**

- **Set-Up 1:** Replace <u>sucrase</u> with **equal volume** / **1.0 cm^3** of <u>boiled and cooled sucrase / distilled water</u>, keeping all <u>other experimental conditions the same</u>.

  (Expected results: Benedict solution remains blue, no precipitate formed.)

- **Rationale:** This is to ensure that any changes in **{absorbance value obtained / quantity of precipitate formed}** is due to the **enzymatic activity of sucrase** at different temperatures and not due to other factors.

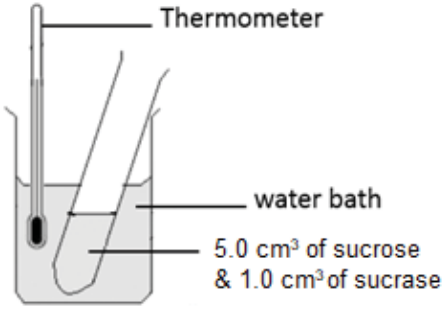
OR

- **Set-Up 2:** Replace <u>sucrose</u> solution with **equal volume** / **5.0 cm^3** of <u>distilled water</u>, keeping all <u>other experimental conditions the same</u>.

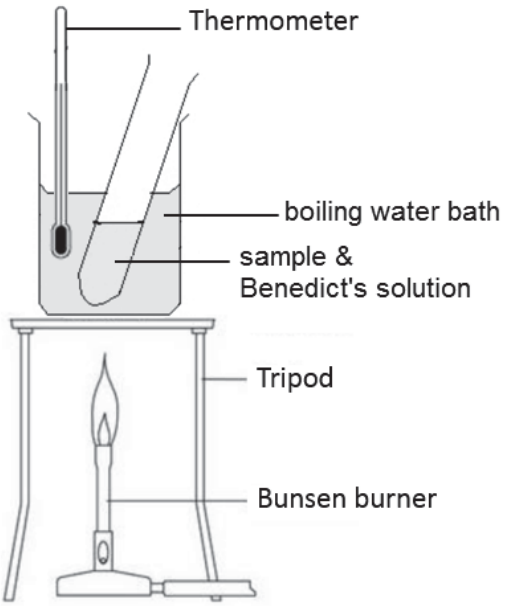
  (Expected results: Benedict solution remains blue, no precipitate formed.)

- **Rationale:** This is to ensure that any changes in **{absorbance value obtained / quantity of precipitate formed}** is due to the **digestion of sucrose** (by sucrase) at different temperatures and not due to other factors.

✓ **<u>Labelled Diagram</u> [E - 1M, labels needed]**



OR



<u>Set up for Incubation</u>

<u>Set up for Benedict's test</u>

<u>Procedure</u>: [Apparatus and quantity stated] – 5M

1. Prepare a 30°C water bath using a mixture of hot and cold water. Use the thermometer to ensure the correct temperature is obtained.
2. Using a syringe, fill a boiling tube with 5.0 cm^3 of 1.0 % sucrose solution.
3. Using a syringe, fill a test tube with 1.0 cm^3 of 1.0 % sucrase solution.

4. *Incubate the boiling tube and test tube containing their respective solutions in a water bath set at **30°C** and allow **1 min** for the contents to **equilibrate**.

5. After equilibration, transfer the 1.0 cm^3 1% sucrase solution from the test tube to the boiling tube containing the 1% sucrose solution.
6. Stir the reaction mixture thoroughly using a clean glass rod and start the stopwatch immediately.
7. Incubate the reaction mixture in the water bath maintained at 30°C for 2 min.

8. *After 2 min, <u>stop the reaction</u> by placing the reaction mixture in <u>boiling water</u> for 1 min.

9. *Remove **2.0 cm^3** of **reaction mixture** from the boiling tube and transfer it to a clean test tube.
10. *Perform the **Benedict's test** on this reaction mixture.
    - Add **equal volume** <u>of Benedict's solution</u> to the reaction mixture in the test tube using a syringe.
    - Place the test tube in the <u>boiling water bath</u> for **2 min**.
    - (After 2 min, carefully remove the tubes from the boiling water and place them in a rack.)

11. Cool the test tube by immersing it in a beaker of tap water for 30s.

12. *(Use a clean, dry glass rod to stir the contents of the tube and) pour 2cm^3 of the **suspension** into a cuvette.
13. *Fill another cuvette with 2cm^3 of distilled water / Benedict's solution and place it in the spectrophotometer. Press the **zero** button. Remove the cuvette.
14. *Place the cuvette containing the suspension in the spectrophotometer, press the **test/start** button and record absorbance value.

15. Repeat steps 1 - 14 for each other temperatures, 40°C, 50°C, 60°C and 70°C respectively.

16. *To ensure **reliability** of results, perform 2 more replicates for **each temperature**.
17. *To ensure **reproducibility** of data, repeat the entire experiment (steps 1 – 16) twice using **freshly prepared reagents and new apparatus**.

✓ **[F - 1M] Point 4:** Description of Equilibration step (before mixing enzyme and substrate) + specific temperature + duration.
✓ **[G - 1M] Point 8:** Description of how to stop enzyme reaction.
✓ **[H - 1M] Point 9-10:** Description of Benedict's test (equal vol.).
✓ **[I - 1M] Point 12-14:** Description of using spectrophotometer.
✓ **[J - 1M] Point 15 &17:**Performing replicates & repeats

✓ **Table of results: [K - 1M]**

Table of Absorbance at various Temperatures

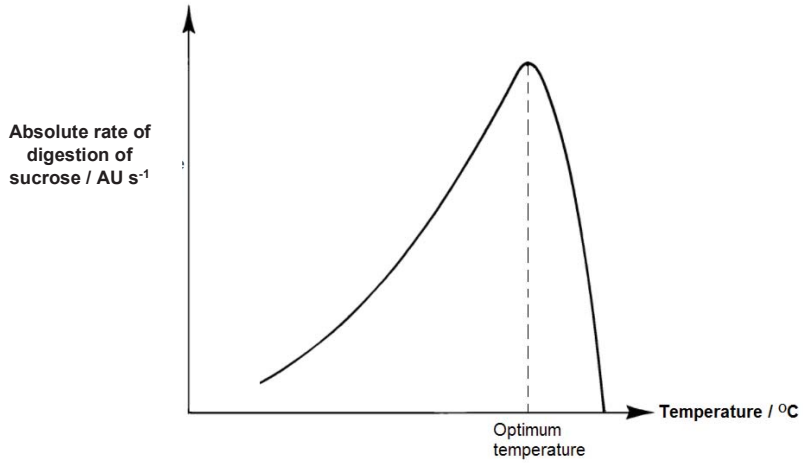
Temperature /°C	Absorbance of Mixture / AU				Absolute rate of digestion of sucrose / AU s^{-1}
	1st Replicate	2nd Replicate	3rd Replicate	Average	
30.0					
40.0					
50.0					
60.0					
70.0					

Table must contain:

1 Correct **table headings** with suitable units
2 **Independent variable** to be represented on left-most column of the table, with 5 values to be indicated
3 Include **triplicates** and **average** columns

✓ **Graph: [L - 1M]**

Graph of rate of digestion of sucrose by sucrase against Temperature



Graph must contain:

1 Correct **axes headings** with suitable **units**
2 Correct **shape** of graph (Gentle increase in rate before optimum & drastic drop in rate after optimum temp (**without tapering at high temperature**). Last part of graph to touch x-axis.
Note: Optimum temperature label NOT required)

✓ **Risks & Precautions: [M - 1M (Need 2x pairs)]**

Risk	Precaution
1. Hot water / boiling water bath may cause **scalding** *OR* **Burnt** by Bunsen burner / tripod stand	**Handle** hot water baths / Bunsen burner **with care.**
2. Hot liquid may **splurt out** from boiling tube, during heating	**Direct** the mouth of boiling tube **away** from self and others.
3. Glassware can break and cause **cuts / injuries**	Exercise {**caution / care**} when handling glassware / **Dispose** of broken glassware promptly and safely.
4. Benedict's solution / sucrase solution causes eye *OR* skin **irritation**	(For preventing eye irritation) Wear safety googles. *OR* (For preventing skin irritation) Wear gloves.
5. **Electrocution** by spectrophotometer, due to wet hands	Ensure that **hands are dry** when using the electrical appliances. / **Clean up any spills**.

[Total: 12]

⇨ Total for planning = **15** marking points for MAX 12 marks

QUESTION 3

For this question, you will require access to a light microscope (with an eyepiece graticule) and the plastic container labelled M, which contains both a stage micrometer and specimen slide S1.

You are provided with a plastic container containing a stalk from an aquatic plant, submerged in distilled water.

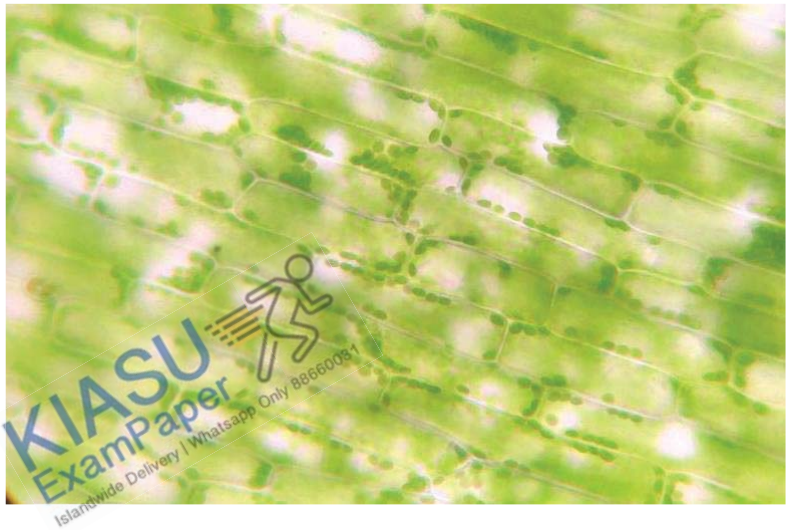
1. Use the scissors and forceps to carefully remove a leaf from the stalk.
2. Use the mounting needle and forceps to carefully mount the specimen on a microscope slide.
3. Add 1 drop of **distilled water**.
4. Gently cover the specimen with a cover slip, and use a paper towel to absorb any excess fluid.

(a) Observe your slide under the low-power (10X) and followed by high-power objective lens (40X) of your microscope.

Use the space below to make a **high-power detailed drawing** of **3** adjoining cells.

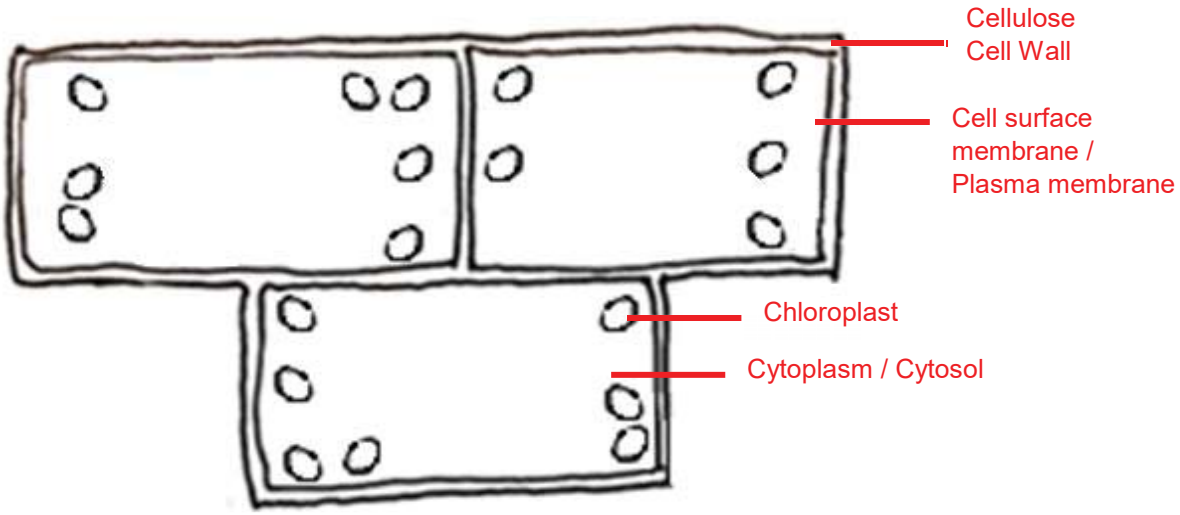
Label **3** different structures observed in your drawing.

……[4]



(40X)

High power / Detailed drawing of three plant cells (400X magnification)



1. **Title:** Correct title & **overall** magnification stated
   + **Size: Size** of drawing is sufficiently large (at least 1/2 of space provided) ;
   [**Reject**: Type of lens used e.g. 40x.]

2. **Shape**: 2 lines for cell wall ; + numerous chloroplasts drawn ; + Presence of **shared cell wall** + **3** adjoining cells. ;
   [**Reject**: Separate cell walls, >3 or <3 cells drawn.]

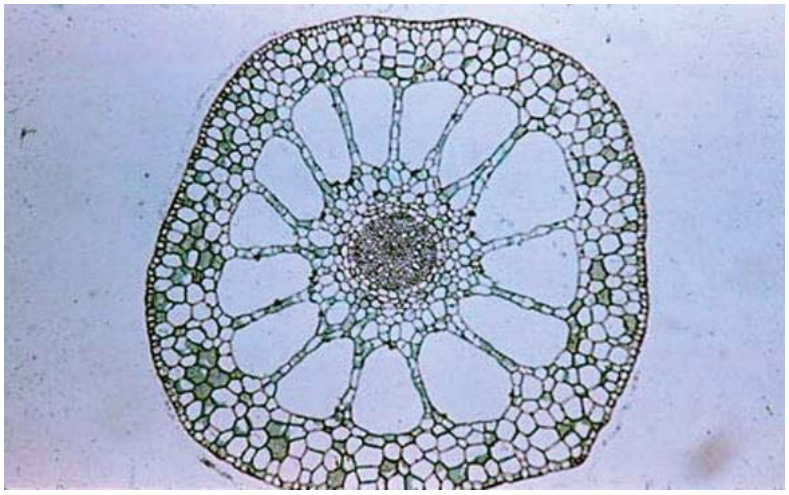
3. **Quality**: Cells drawn with **clear, continuous lines** + No shading ;

4. **Labels**: At least 3x correct labelling of cell structures.
   - (Cellulose) Cell wall ;
   - plasma membrane / cell **surface** membrane ;
   - chloroplast ;
   - cytoplasm / cytosol ;

(b) Slide **S1** is a microscope slide of a stained transverse section through a plant stem. This stem also grows submerged in water and contains air spaces.

You are not expected to be familiar with this specimen.

Observe **S1** under the low-power of your microscope.



Draw a **plan diagram** of a region of the stem on slide **S1**, as shown by the shaded area of Fig. 3.1. Within this part of the stem there will be a number of air spaces.

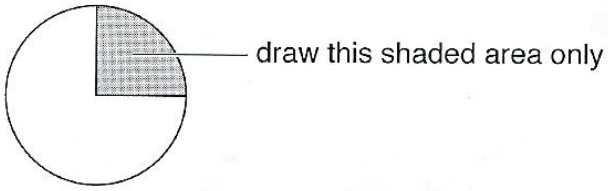


Fig. 3.1

A plan diagram shows the arrangement of the different tissues. Your drawing should show the correct shape and proportion of the tissues and air spaces.

……[4]

Plan Diagram of specimen S1 (100x magnification)

1. **Title:** Correct title & magnification stated
   + Size: Size of drawing is sufficiently large (at least 1/2 of space provided) ;

2. **Layers:** At least 2 lines for outer epidermis ; + at least 3 air spaces drawn ; + at least 2 lines for cells surrounding air spaces ; + center vascular bundle indicated

3. **Proportion:** Correct proportion where outer epidermis is thinner than inner layer in stem + upper right quadrant of specimen
   (**Reject**: drawing entire specimen or wrong quadrant.)

4. **Quality**: **No** individual **cells drawn** + no shading + no fuzzy and broken lines;

(c) You are required to measure the length of **one** air space in the stem on slide **S1**, under **10x** objective lens.

When viewing slide **S1** under the microscope, select **one** air space in the stem located in the same region as your drawing in **(b)**, as shown by the shaded area of Fig. 3.2.

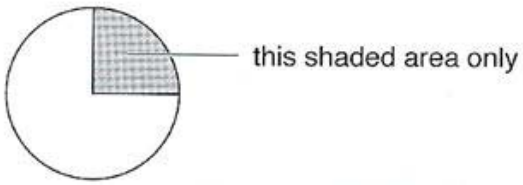


Fig. 3.2

(i) Before measuring the length of the selected air space, calibration of the eyepiece graticule needs to be conducted, under **10x** objective lens.

It is given that the length of each stage micrometer division is **0.01 mm**.

Describe the method to calibrate the eyepiece graticule.

……[3]

1. **Place** stage micrometer on the stage of the microscope and position stage scale such that it is **superimposed** on / **aligned next to** the smaller **eyepiece scale** under low power objective lens (x10) ;

2. **Count** the number of **eyepiece unit/s** that **fit within 1 stage micrometer division**.

3. **Calculate** the length of each **eyepiece unit** by dividing the length of 1 **stage micrometer division** (e.g. 0.01mm) by the number of eyepiece units that fit within it (e.g. 1).

(ii) Based on your steps indicated in **(c)(i),** conduct the actual calibration for your eyepiece graticule under **10x** objective lens.

Find the actual length of **one** eyepiece graticule division.

Show all your workings clearly.

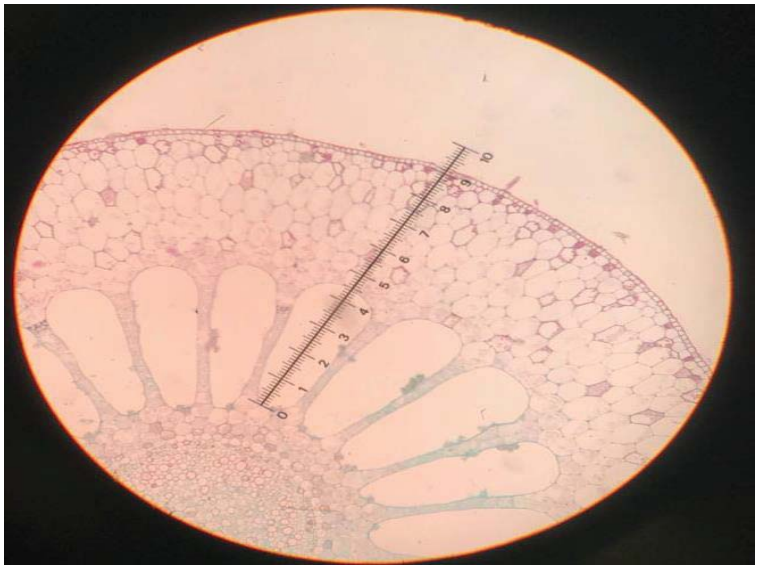
Ratio = **1** stage **micrometer** divison : **1** epu ;

Length of 1 eyepiece graticule division = 0.01mm x 1/1 = **10 µm**
[**Reject**: Answer in mm]
[**Reject**: No workings shown to derive final answer]

Actual length of 1 eyepiece graticule division = …… µm [1]

(iii) Using the information found in **(c)(ii)**, calculate the actual length of the selected airspace in the stem in slide **S1,** under **10x** objective lens

Show all your workings clearly.



Actual length of air space = …… µm [2]

Measurement under 10x objective lens:

1. Number of eyepiece graticule divisions = **45** [Acceptable range: 30 – 90]
   (Note: different slides will have varied sizes)

2. Size of air space = Number of eyepiece graticule divisions x 10µm*
   = 45 x 10µm = **450 µm**

[**Reject**: Answer in mm]

(iv) Using the information found in **(c)(iii)**, calculate the magnification of your drawing of the air space in **(b)**.

Show all the steps in your working clearly.

Magnification = ...X [2]

Answer based on student's **own** drawing in **(b)**

$$\text{Magnification of drawing} = \frac{\text{Size of drawing}}{\text{Actual size of specimen}}$$

1. **Application** of correct formula used with values & units shown ; correct final answer (in 3.S.F)

E.g Magnification = **3.2 cm / 450 µm**

= 32000 µm / 450 µm

= **71.1** x

2. **Working**: Student to indicate on drawing in **(b)** the specific airspace measured with correct units
   [**Reject**: If breadth is measured]

(d) Fig. 3.3 is a photomicrograph of a stained transverse section through a stem of a different aquatic plant species. It also contains air spaces.

You are not expected to be familiar with this specimen.

(i) Observe the stem in Fig. 3.3 in comparison to that of slide **S1**.

You will use Fig. 3.3 to describe **two** observable differences between the stem in Fig. 3.3 and the stem in **S1**:

- Draw label lines to two different features between the stem in Fig. 3.3 and the stem in **S1** and use only the labels **X** and **Y**.
- Complete Table 3.1 to describe how each feature on the stem in Fig. 3.3 differs from the stem in **S1**.

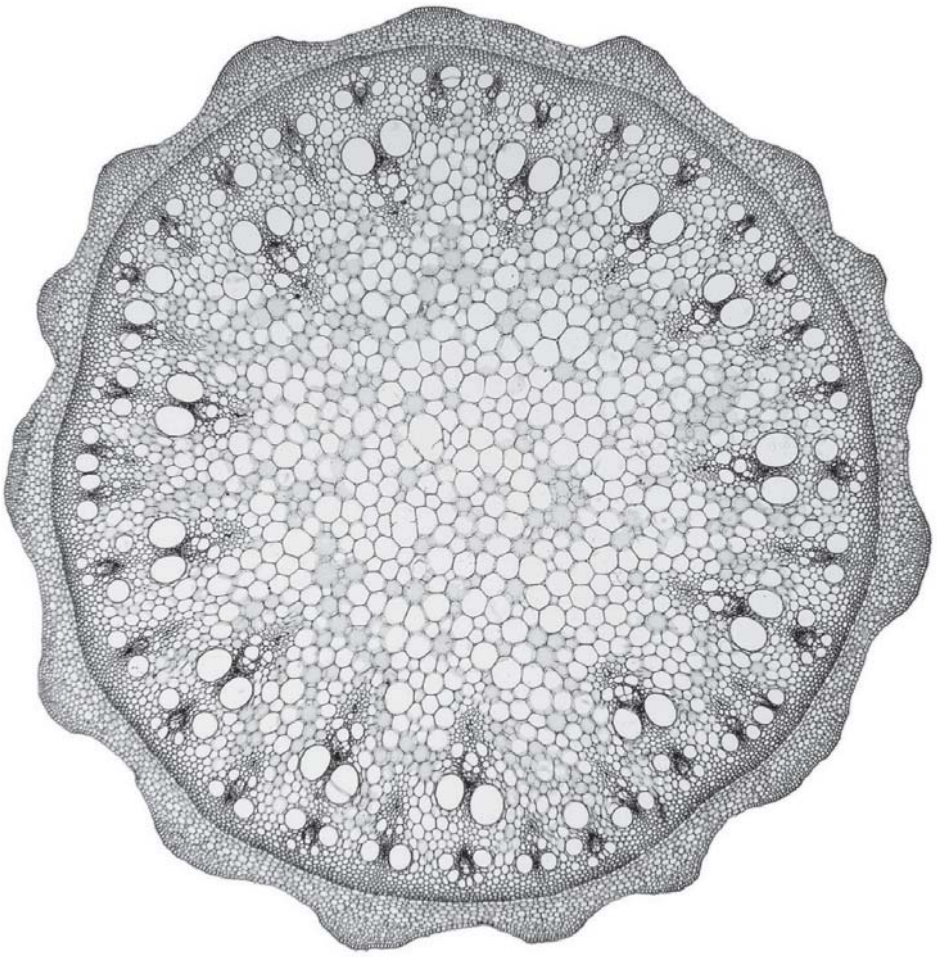


Fig. 3.3

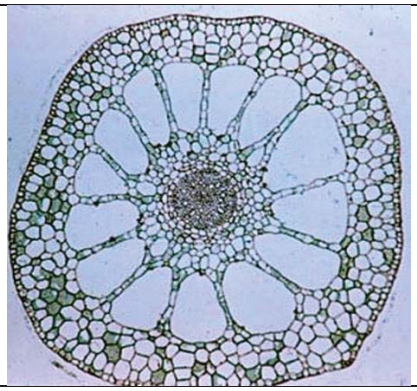
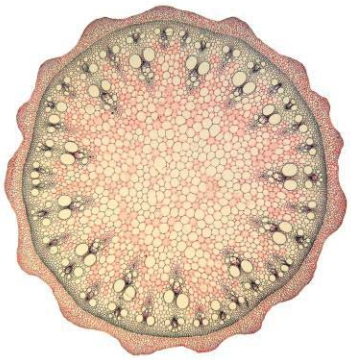
Table 3.1

Feature	Slide S1	Fig. 3.3
X		
Y		

[3]

1. Any 1 correct observable differences **;**
2. Any 1 other correct observable differences **;**
3. Uses 2 label lines **+** correct position **+** use letters **X** and **Y ;**

   Marker's Guidance: Award mark point 3 only when mark point 1 & 2 are correct / vague.

Feature	Slide S1	Fig. 3.3
		
1	**Outer surface** of stem is **smooth**	**Outer surface** of stem is **irregular** / **rough**
2	**Outer surface** of stem is **thin.**	**Outer surface** of stem is **thick.**
3	Air spaces are **very large** / **lesser in number / elongated**	Air spaces are **tiny** / **numerous / circular**
4	Air spaces are **arranged in 1 ring**	Air spaces are **arranged in 2 rings**
5	Air spaces are **arranged singly**	Air spaces are **arranged in pairs**
6	Vascular bundles are located at **centre** of the stem	Vascular bundles are located near the **periphery** of the stem

(ii) Suggest **one** advantage of having air spaces in stems of aquatic plants, as shown in slide **S1** and Fig 3.3.

……[1]

Any one:

1. To allow for **buoyancy** / for the plant to **float** on the surface of water ;
2. To allow for **gaseous exchange** (Aerenchyma enhances internal circulation of air in the plant) ;

[Total: 20]

~ END OF PAPER 4 ~