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**DUNMAN HIGH SCHOOL**  
**Preliminary Examination**  
**Year 6**

**H1 BIOLOGY**

8875/02

Paper 2 Structured and Free-Response Questions

**14 September 2017**

**2 hours**

Additional Materials: Writing paper

**INSTRUCTIONS TO CANDIDATES:**

DO NOT TURN THIS PAGE OVER UNTIL YOU ARE TOLD TO DO SO.

READ THESE NOTES CAREFULLY.

**Section B Structured Questions**

Answer **all** questions.

Write your answers on space provided in the Question Paper.

**Section C Free-Response Questions**

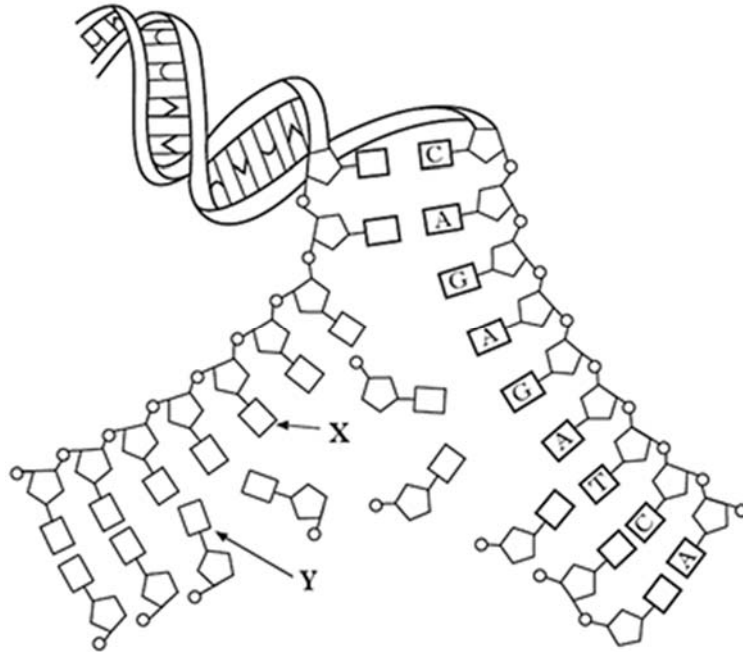
Answer **one** question. Your answer to Section C must be in continuous prose, where appropriate. Write your answers on the writing paper provided.

**Answer each part (a) and (b) on a fresh piece of writing paper.**

For Examiner's Use	
<b>Section A [30]</b>	
<b>Section B [40]</b>	
<b>1</b>	<b>/ 7</b>
<b>2</b>	<b>/ 8</b>
<b>3</b>	<b>/ 5</b>
<b>4</b>	<b>/ 7</b>
<b>5</b>	<b>/ 6</b>
<b>6</b>	<b>/ 7</b>
<b>Section C [20]</b>	
<b>1 / 2</b>	
<b>Total [90]</b>	

This document consists of **15** printed pages and **1** blank page.

**[Turn over**

**Section B: Structured Questions (40 marks)**Answer **all** questions in this section.*For  
Examiner's  
use***Question 1****(a)** **Fig. 1** shows replication of a part of the glucagon receptor gene.**Fig. 1****(i)** Name the bases labelled **X** and **Y** on **Fig. 1**. [1]**X****Y****(ii)** Explain how **Fig. 1** shows semi-conservative replication DNA. [3]

**(b)** Contrast the elongation stage in DNA replication with translation. [3]

*For  
Examiner's  
use*


**Total:[7]**

## Question 2

For  
Examiner's  
use

Fig. 2 shows the early development of a human embryo after fertilisation.

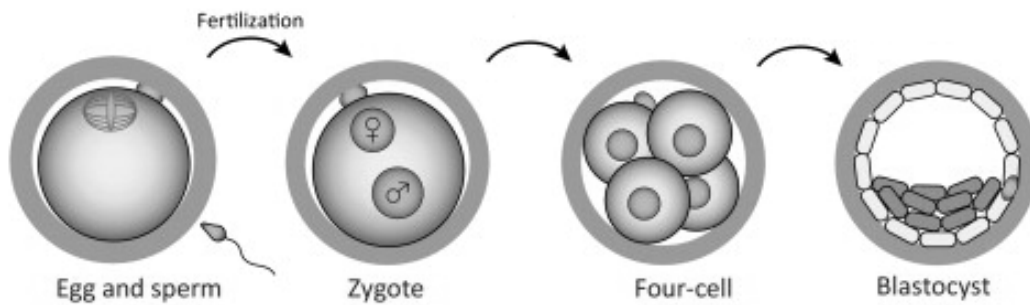
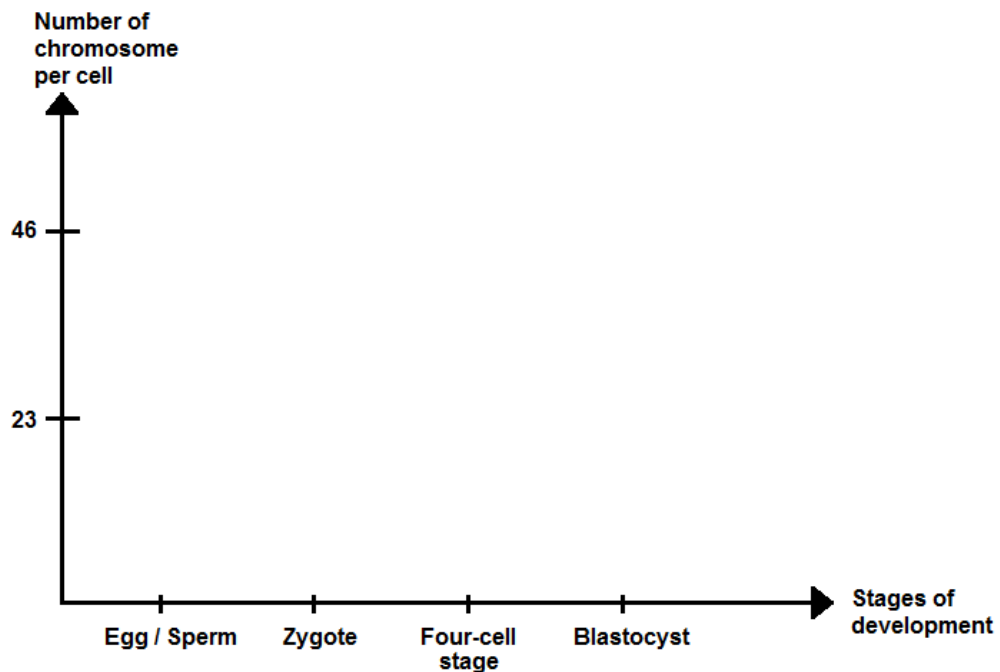


Fig. 2

- (b) (i) Name the type of cell division undergone by the zygote to form the four-cell stage. [1]

- (ii) Plot accurately, in the graph below, the number of chromosome per cell for the four stages of development. [1]



Hematopoietic stem cells divide **asymmetrically** to give specialized cells such as the red blood cells.

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- (b) (i) Explain the term "**asymmetrically**". [1]

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- (ii) How are hematopoietic stem cells different from their specialized cells? [2]

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- (c) Haemoglobin A (HbA) is the oxygen carrier protein that is found in normal red blood cells. HbS is found in sickle-shaped red blood cells.

**Table 2.1**

Hb A $\beta$ globin	val – his – leu – thr – pro – glu – glu –lys.....
Hb S $\beta$ globin	val – his – leu – thr – pro – val – glu –lys.....

- (i) **Table 2.1** shows a segment of the HbA and HbS polypeptide sequence. Identify this mutation. [1]

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**Table 2.2** shows the DNA triplet code.

**Table 2.2**

		Second Letter				
		T	C	A	G	
First Letter	T	TTT } Phe TTC } TTA } Leu TTG }	TCT } TCC } Ser TCA } TCG }	TAT } Tyr TAC } TAA Stop TAG Stop	TGT } Cys TGC } TGA Stop TGG Trp	T C A G
	C	CTT } CTC } Leu CTA } CTG }	CCT } CCC } Pro CCA } CCG }	CAT } His CAC } CAA } Gln CAG }	CGT } CGC } Arg CGA } CGG }	T C A G
	A	ATT } ATC } Ile ATA } ATG Met	ACT } ACC } Thr ACA } ACG }	AAT } Asn AAC } AAA } Lys AAG }	AGT } Ser AGC } AGA } Arg AGG }	T C A G
	G	GTT } GTC } Val GTA } GTG }	GCT } GCC } Ala GCA } GCG }	GAT } Asp GAC } GAA } Glu GAG }	GGT } GGC } Gly GGA } GGG }	T C A G

- (ii) With reference to **Table 2.1** and **2.2**, Explain the **minimum** number of mutation that resulted in HbS. [2]

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**Total: [8]**

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**Question 3**

Cats possess a gene for producing tails. The tailless Manx phenotype in cats is produced by an allele that is lethal in the homozygous state. The Manx allele  $M^L$  severely interferes with normal spinal development. In heterozygotes ( $M^L M$ ), this results in the absence of tail.

Female cats are homogametic while male cats are heterogametic. The gene for black/orange/tortoiseshell coat colour is located on X chromosome and has two alleles  $X^O$  and  $X^o$ . Table below shows the genotypes of cats of different colours.

$X^o X^o, X^o Y$	Black coated female, male
$X^O X^O, X^O Y$	Orange coated female, male
$X^O X^o$	Tortoiseshell (intermingled black and orange in fur) in female only

The table below shows the genotypes of two cats.

	Female cat	Male cat
<b>Coat colour</b>	Orange	black
<b>tail</b>	No tail	No tail
<b>Genotype</b>	$X^O X^O M^L M$	$X^o Y M^L M$

Construct a genetic diagram to illustrate the outcome of the above cross on the next page.  
[5]



Answer Question 3 on this page.

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**Total: [5]**

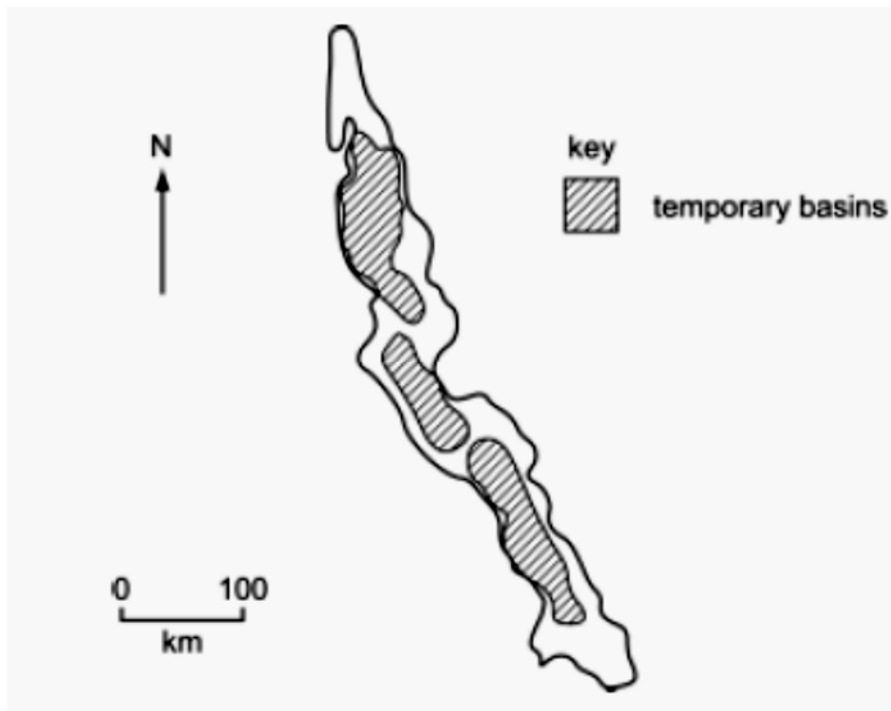
**Question 4**

In Lake Tanganyika in Africa, there are six species of fish of the genus *Tropheus* and a much larger number of distinctly coloured subspecies of each of the six species. *Tropheus* species are small fish that are confined to isolated rocky habitats around the shores of Lake Tanganyika.

The six species evolved during the primary radiation phase when the lake was first filled, about 1.25 million years ago. They arose from river dwelling ancestors and then filled all available niches in the lake.

Secondary radiations into the many subspecies occurred during the last 200 000 years. Sometime during this period, the water level in the lake fell, resulting in the formation of three separate lake basins. These basins persisted for many thousands of years before the water level rose again.

**Fig. 4** shows an outline map of the lake and the location of the three temporary basins caused by lowering of lake levels.



**Fig. 4**

- (a) Explain how natural selection could have caused the evolution of the six closely related species in the primary radiation. [4]

*For  
Examiner's  
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- (b) Outline how each type of homology (anatomical, embryological and molecular) supports Darwin's theory of descent with modification. [3]

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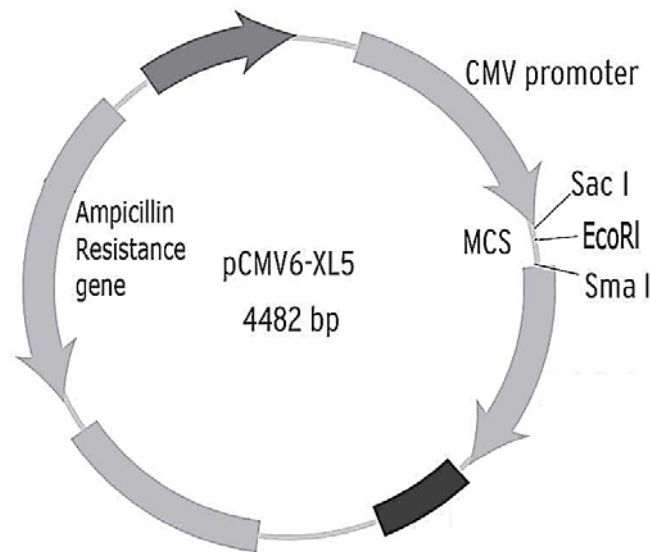
**Total:[7]**

**Question 5**

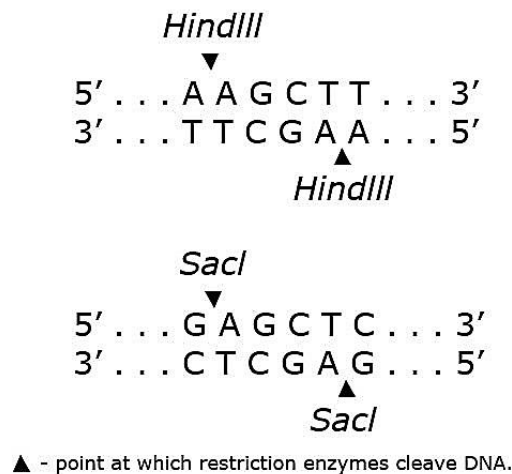
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**Fig. 5.1** shows the pCMV6-XL5 plasmid. It is a plasmid with a multiple cloning site (MCS) that lies downstream of the CMV promoter. This plasmid can be inserted into both eukaryotic and prokaryotic host cells. The arrows denote the direction in which the genes are transcribed.

An artificially-synthesised human Growth hormone (hGH) gene with flanking HindIII restriction site sequences was created. The restriction sites for the restriction enzymes HindIII and SacI are shown in **Fig. 5.2**.



**Fig. 5.1**



**Fig. 5.2**

- (a) With reference to **Fig. 5.1** and **Fig. 5.2**, explain how the hGH gene can be inserted into pCMV6-XL5. [3]

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- (b) The final step in determining the presence of the hGH gene involves the use of a radioactive gene probe.

Explain why there is a need to use a radioactive gene probe, instead of selecting using ampicillin. [2]

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- (c) State one problem of cloning human genes in bacteria. [1]

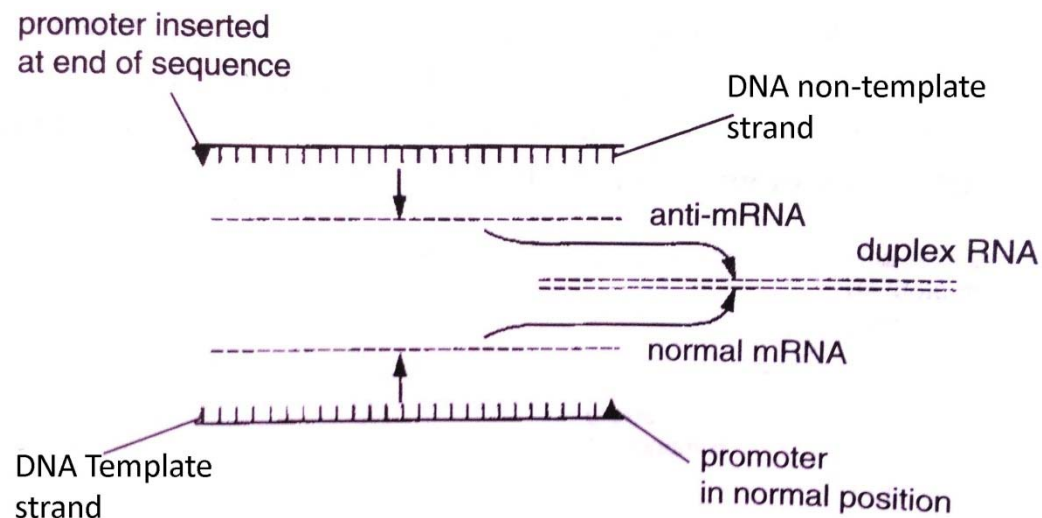
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**Total:[6]**

**Question 6**

Scientists have identified the pectinase gene encoding an enzyme involved in the ripening of the tomatoes and have developed a genetic modification for the FlavrSavr tomatoes using an antisense RNA technology. During normal transcription, only one strand of a DNA is transcribed to mRNA. The complementary strand of DNA is the 'non-template' strand, which is not normally transcribed. By inserting a promoter at the end of a non-template sequence, thus forming an anti-mRNA gene, RNA transcription can occur from it. The sequence of events is shown **Fig. 6**.

**Fig. 6**

- (a) With reference to the **Fig. 6**, explain how duplex RNA is formed. [2]

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- (b)** Explain how this genetic modification on the tomato plant benefits the farmers and merchants. [3]

*For  
Examiner's  
use*

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- (c)** Outline the ethical implications of transgenic plants. [2]

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**Total: [7]**

**Section C: Free-Response Question (20 marks)**

Answer only **one** question.

Write your answers on the writing paper provided.

**Answer each part (a) and (b) on a fresh piece of writing 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.

A **NIL RETURN** is required.

**Question 1**

**(a)** Describe the various roles of RNA in eukaryotes. [10]

**(b)** Describe ATP synthesis in respiration. [10]

**Total: [20]**

**OR**

**Question 2**

**(a)** Describe the various bonds and their importance in carbohydrates. [10]

**(b)** Describe the differences between Calvin and Krebs cycles. [10]

**Total: [20]**

**END OF PAPER**





**DUNMAN HIGH SCHOOL  
PRELIMINARY EXAMINATION 2017  
YEAR SIX  
H1 BIOLOGY (8875)**

**Suggested Answers**

**Question 1**

**(a)(i)**

X – Cytosine

Y – Thymine

**(a)(ii)**

- parental strand acts as template for the synthesis of the new strand
- parental strand CAGAGATCA will result in the newly synthesised strand with sequences GTCTCTAGT
- newly synthesised daughter DNA molecule consists of one original strand and one newly synthesised strand

**(b)**

- The enzyme required for elongation in DNA replication is DNA polymerase while the enzyme involved in translation is peptidyl transferase
- The bonds catalysed between subunits of monomers in DNA replication is phosphodiester bond while the bonds catalyzed for translation is peptide bonds
- The monomers used for DNA replication is deoxyribonucleotides while the monomers for translation is amino acids

**Question 2**

**a(i)**

Mitosis

**a(ii)**

1M correct plot

1M joining the dots with a straight line

**(b) (i)**

The parental stem cell divides to give 2 different cells. One remains as a stem cell while the other differentiate into a specialized cell

**(b) (ii)**

- Hematopoietic stem cell is undifferentiated while its specialised cells are differentiated to have a specific function / structure
- Stem cell can divide and renew itself indefinitely / without limit but red blood cells cannot divide

**c(i)**

missense mutation

**c(ii)**

- **1 nucleotide** change from A to U
- Changes the codon from GAA / GAG, coding for Glu, to GTA / GTG, coding for Val

**Question 3**

Parental phenotypes: Orange, no tail female x Black, no tail male

Parental genotype:  $X^O X^O M^L M$  x  $X^O Y M^L M$

Gametes formed:  $(X^O M^L)$   $(X^O M)$  x  $(X^O M^L)$   $(X^O M)$   $(Y M^L)$   $(Y M)$  ☒

F<sub>1</sub> genotypes:

	$(X^O M^L)$	$(X^O M)$	$(Y M^L)$	$(Y M)$
$(X^O M^L)$	$X^O X^O M^L M^L$	$X^O X^O M^L M$	$X^O Y M^L M^L$	$X^O Y M^L M$
$(X^O M)$	$X^O X^O M^L M$	$X^O X^O M M$	$X^O Y M^L M$	$X^O Y M M$

☒

F<sub>1</sub> genotypes:  $X^O X^O M^L M^L$  (died)  $2X^O X^O M^L M$   $X^O X^O M M$   $2X^O Y M^L M$   $X^O Y M M$   
 $X^O Y M^L M^L$  (died)

F<sub>1</sub> phenotypes: Tortoiseshell No tail female : Tortoiseshell **Normal** tail female : Orange No tail male : Orange **Normal** tail male

F<sub>1</sub> phenotypic ratio: 2 : 1 : 2 : 1 ☒

**Question 4**

(a)

- Variations in population due to random mutation resulting in different alleles;
- primary radiation phase, different niches in the lake with different selection pressure;
- fish with at selective advantage survive and reproduce viable offspring, passing on advantageous genes/alleles to the next generation;
- accumulation of many genetic changes over a long period of time to evolve into different species;
- geographical isolation/ accept hundreds of km apart thus no gene flow between different populations;

**4 max**

**(b)**

- Anatomy homology can be used to support Darwin's Theory by comparing anatomy, observing vestigial organ and Imperfect adaptations. These physical traits can be used to hypothesize the relatedness of species
- Comparative embryology reveals additional anatomical homologies not visible in adult organisms. All vertebrate embryos look very similar during the earlier stages of development, including having gill pouches and tails
- In Molecular homology, as the descendants evolve independently, more and more differences are accumulated in their DNA. Two species that are more distantly related have more differences in their DNA whereas two species that are more closely related share a more similarities in their DNA

**Question 5****(a)**

- Cleave gene using HindIII to generate sticky ends
- Cleave plasmid with SacI to generate complementary sticky ends to the HindIII sticky ends flanking the hGH gene
- Mix the cleaved gene and plasmid together and add DNA ligase to seal the nicks / form phosphodiester bond between gene and plasmid

**(b)**

- Gene probe identifies bacterial colonies that contain hGH gene
- However, ampicillin selects for all transformed bacteria containing either re-annealed plasmid or recombinant plasmid

**(c)**

- Introns in human gene which cannot be spliced out in bacteria and resulting in the protein produced to be non-functional
- Lack of organelles in bacteria such as the Golgi apparatus for final chemical modification of proteins such as glycosylation / phosphorylation resulting in the protein produced to be non-functional

**Question 6****(a)**

- DNA non-template strand with the inserted promoter is transcribed in the GM tomato plant to form the anti-mRNA
- anti-mRNA and the normal mRNA binds via hydrogen bonds between complementary base pairs of A-U and G-C to form duplex RNA

**(b)**

- The pectin in the GM tomato plant breaks down more slowly
- Hence the tomatoes can be harvested later to allow production of bigger / better quality fruits for sale for increased profit
- The delay in ripening also allowed the tomatoes to have a longer shelf-life so that they can be sold for more profit

(c)

- Animal genes may be introduced to plant genomes, leading to concern of vegetarians and some religious groups which followers are not allowed to consume certain animals
- GM plants grown as crops may lead to consumers having allergies as foreign proteins are produced in the plants, companies need to label their GM crops for consumers to make informed choices
- development and growing of GM crops requires large amounts of funds and technology which only large companies have access to, monopolizing agriculture, resulting in inequality against small scale farmers
- AVP;

**2 max****Essay****1a** Describe the various roles of RNA in eukaryotes. [10]

## mRNA

1. role in transferring genetic information from nucleus to cytoplasm
2. DNA triplet codes are carried in the form of codons in mRNA
3. Each codon corresponds to one amino acid

## tRNA

4. role in carrying the corresponding amino acid to ribosome to match with the condon in translation
5. 3'end binds to corresponding amino acid via covalent bond Attached by to amino acid by aminoacyl tRNA synthetase
6. Contains anti-codon which is complementary to codon on mRNA for translation

## rRNA

7. Role in forming ribosome for translation
8. makes up peptidyl transferase which catalysed peptide bond between adjacent amino acid
9. align tRNA and mRNA in ribosome

## RNA primer

10. providing 3'OH group for addition of complementary deoxyribonucleotide to growing DNA strand
11. Synthesize by primase

## RNA template in telomerase

12. Role in lengthening telomere
13. Expressed in stem cells

**1b Describe ATP synthesis in respiration. [10]**

1. ATP is synthesized by substrate level photophosphorylation and oxidative phosphorylation
2. ATP is synthesized during glycolysis, in the cytoplasm, and during Krebs cycle in the mitochondrial matrix
3. 4 ATP / 2 net ATP is synthesized per glucose molecule during glycolysis
4. In anaerobic respiration, ATP is synthesized only by substrate level phosphorylation in glycolysis
5. In the Krebs cycle, 2 ATP is synthesized per glucose when succinyl-CoA is converted to succinate
6. NAD and FAD are reduced during glycolysis, link reaction and Krebs cycle
7. Reduced NAD and FAD donates electrons to the electron transport chain on the inner mitochondrial membrane
8. As electrons are transported along a series of electron carriers of progressively lower energy levels, some energy is used to pump  $H^+$  from the matrix to the intermembrane space
9. This creates a proton gradient across the inner mitochondrial membrane, driving protons to diffuse down its concentration gradient via ATP synthase on the inner mitochondrial membrane.
10. ATP synthase harness the proton motive force for phosphorylation of ADP to ATP
11.  $O_2$  is the final electron carrier of the electron transport chain.
12. 3 ATP is synthesized per reduced NAD and 2 ATP per reduced FAD.

**2a** Describe the various bonds and their importance in carbohydrates. [10]

1. Form glycosidic bond by condensation with elimination of one water molecule

$\alpha(1\rightarrow4)$  glycosidic bond

2. Form between anomeric carbon 1 of  $\alpha$  glucose and carbon 4 of the other
3. Chain coils helically
4. resulting in a more compact shape for storage

hydrogen bond

5. intra-chain H-bonding between hydroxyl groups helps stabilise helical structure

$\alpha(1\rightarrow6)$  glycosidic bond

6. occurs at branch points
7. more compact for storage

$\beta(1\rightarrow4)$  glycosidic bond

8. form between  $\beta$  glucose which has  $180^\circ$  rotation of alternating glucose residues
9. forms linear structure of cellulose chain

hydrogen bond

10. Hydroxyl groups project outwards, alternately from both sides of each chain, allowing for the formation of hydrogen bonds between adjacent chains, thus establishing a rigid cross-linking between the chains.
11. great tensile strength in cell wall

**2b** Describe the differences between Calvin and Krebs cycles. [10]

Marking Point		Krebs cycle	Calvin cycle
1	Location	Mitochondrial matrix	Chloroplast stroma
2	Substrate	Acetyl-CoA and oxaloacetate combines to form citrate	CO <sub>2</sub> and Ribulose biphosphate (RuBP)
3	Products	Each glucose molecule gives rise to: 6 NADH 2 FADH <sub>2</sub> 2 ATP 4 CO <sub>2</sub>	For every 3 molecules of CO <sub>2</sub> that enter the cycle, one triose phosphate / G3P is made
4	Regenerated / Starting material	Oxaloacetate is the starting material that is eventually regenerated	Ribulose biphosphate (RuBP) is the starting material that is eventually regenerated
5, 6	ATP	Produced via substrate level phosphorylation	Used in reduction of glycerate-3-phosphate where energy is required through hydrolysis of ATP
7, 8	Electron carriers / donors	Use NAD <sup>+</sup> and FAD for the oxidation of the intermediates of the cycle by serving as electron acceptors	Uses NADPH / reduced NADP <sup>+</sup> to reduce glycerate-3-phosphate to triose phosphate by serving as electron donors
9	Overall	Catabolic	Anabolic
10, 11	Role of CO <sub>2</sub>	CO <sub>2</sub> is released as a result of decarboxylation reactions	Required for carbon fixation. CO <sub>2</sub> is used to convert Ribulose biphosphate (RuBP) to form an unstable 6C compound that breaks down to form glycerate-3-phosphate
12	Role of O <sub>2</sub>	Occurs only when O <sub>2</sub> is present	Does not require O <sub>2</sub>