Class Adm No

Candidate Name: _____

H

millennia institute

2017 Promotional Examination II
Pre-university 2

Biology Higher 1 8875/01

18 September 2017

1 hour

Additional Materials: Optical answer sheet

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, Adm No. and class on all the papers you hand in.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Paper 1
There are **thirty** questions in this paper. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Multiple Choice Answer Sheet.

Calculators may be used.

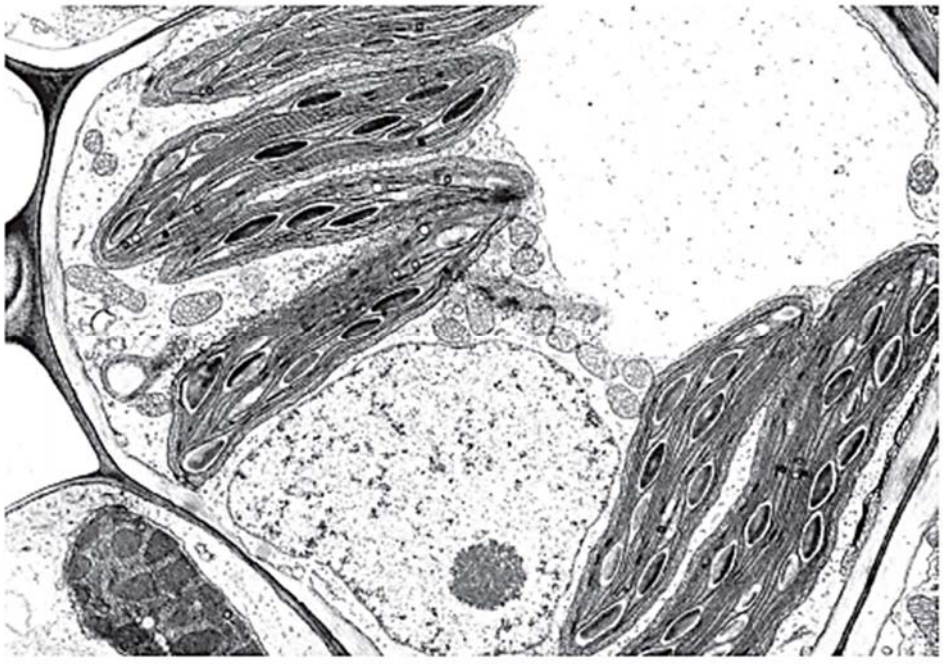
Answer **all** questions

1. A student was tasked to observe a root hair cell using an electron microscope. He was asked to confirm the presence or absence of the cellular structures within the root hair cell.

Which option best describes his observations?

	Structure with a double membrane, inside which are stacks of flattened membranes	Area near the nucleus containing a pair of structures that are composed of microtubules	Structure with a double membrane with inner membrane infolded	Network of tubular-shaped membranous sacs with no ribosomes visible on outer surface of membranes
A	Present	Present	Present	Absent
B	Present	Absent	Absent	Present
C	Absent	Present	Present	Present
D	Absent	Absent	Present	Present

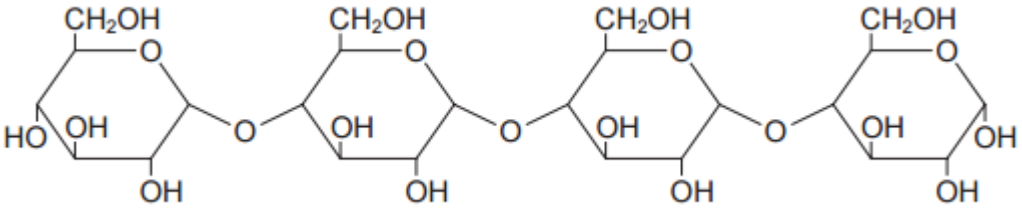
2. The magnification of this electron micrograph is 5000X.



What is the actual size of the nucleolus?

A 0.2 µm
B 0.5 µm
C 2 µm
D 20 µm

3. The diagram shows a section of the starch molecule.

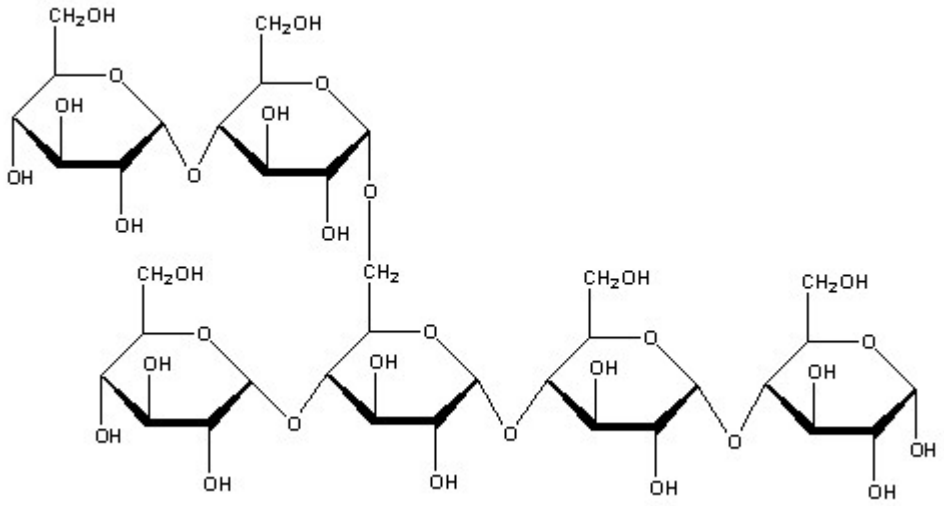


Which of the following procedures could be performed in order to test for the presence of the reducing sugars in amylose?

I add amylase and then heat with Benedict's reagent
II add maltase and then heat with Benedict's reagent
III boil with ethanol and then heat with Benedict's reagent
IV boil with hydrochloric acid, neutralise and then heat with Benedict's reagent

A I and IV only
B II and IV only
C II and III only
D I, II and IV only

4. The diagram shows part of a polysaccharide.



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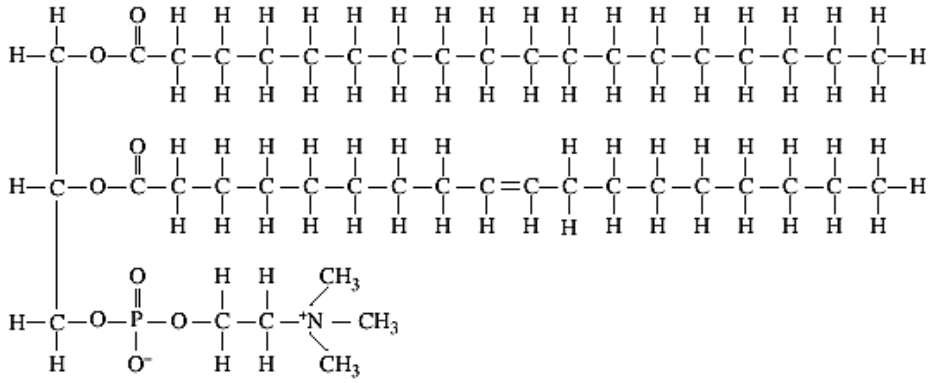
If all the glycosidic bonds in this molecule are hydrolysed, how many water molecules will be used and how many separate glucose molecules will be produced?

#

	Number of water molecules used	Number of glucose molecules produced
A	1	0
B	4	5
C	4	6
D	5	6

5. The diagram shows a lipid molecule.



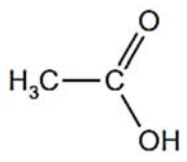
Which option best describes the products of hydrolysis?

A One molecule of glycerol and one molecule of saturated fatty acid
B One molecule of glycerol and two molecules of saturated fatty acid
C One molecule of glycerol, an unsaturated fatty acid molecule and one molecule of saturated fatty acid
D One molecule of glycerol and two unsaturated fatty acid molecules

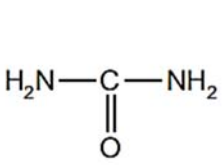
6. The diagram shows different biomolecules present in a plant cell.

Which molecule is an essential component of Rubisco that are necessary for photosynthesis?

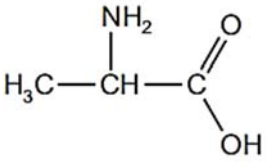
A



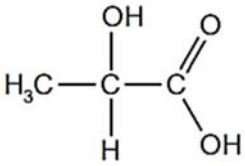
B



C



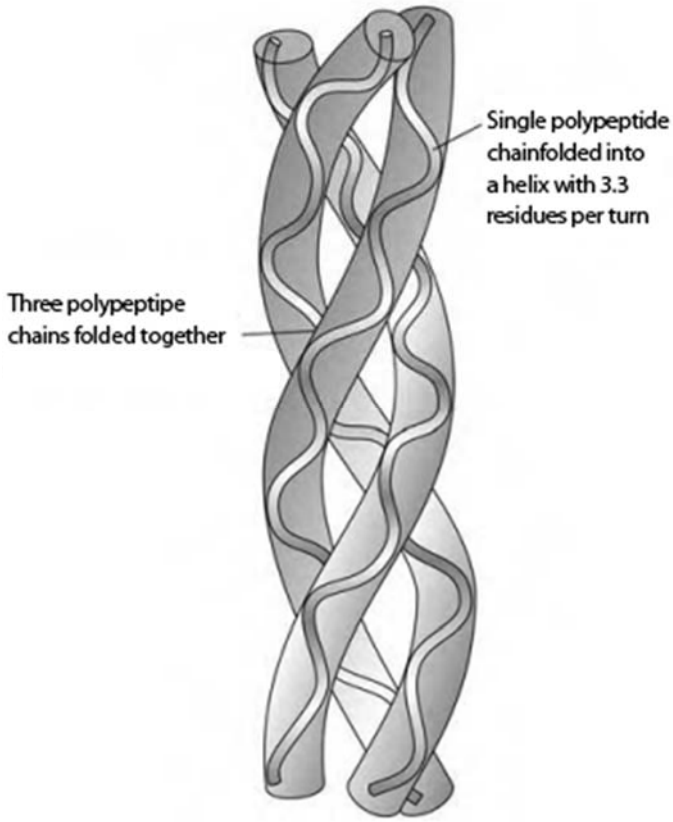
D



7. How many different types of penta-peptides could be formed using the 20 commonly known amino acids?

A 5^4
B 20^5
C 5^{20}
D 20^4

8. The diagram shows a fibrous protein that is commonly found in connective tissues of mammals.



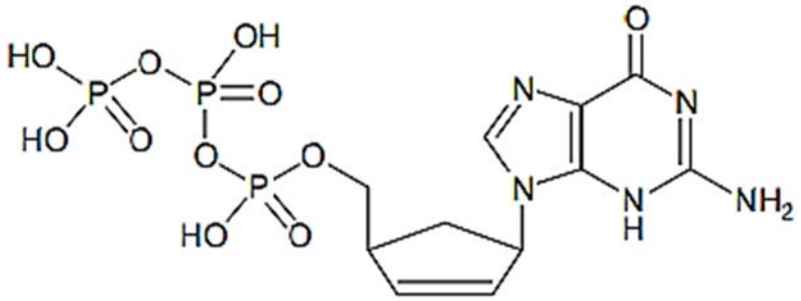
Which statement best describes the fibrous protein?

A The small size of the R-groups of amino acid residues in each chain allows the chains to come close together to form hydrogen bonds.
B Hydroxyl groups projecting in all directions from each chain allow hydrogen bonds to form and result in bundling of the chains to form microfibrils.
C Double bonds present in each chain allow the chains to adopt helical structure.
D Complementary base pairing occurs through the formation of hydrogen bonds between chains.

9. Which statement correctly describes the globular protein that is responsible for the oxygen-carrying capacity of the red blood cells?

A The protein comprises four polypeptide chains and each polypeptide chain contains a prosthetic group of amino acids surrounding an iron ion.
B The protein comprises four polypeptide chains with non-polar R groups of the amino acid residues projected towards the centre within each subunit.
C The protein can carry a total of four oxygen atoms.
D The iron ion in the prosthetic group of each subunit combines irreversibly with oxygen.

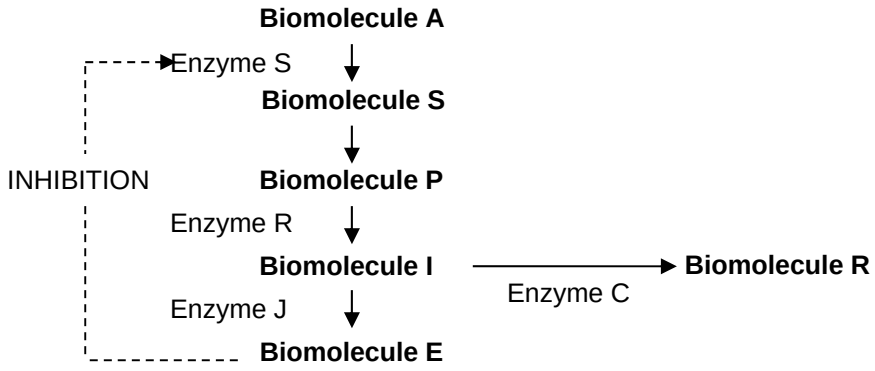
10. The diagram shows the molecular structure of compound X that can inhibit RNA polymerase. It is an analogue of a naturally occurring nucleic acid monomer.



Which statement is true about compound X?

A Compound X is a non-competitive inhibitor.
B Increasing concentration of the naturally occurring monomer cannot reverse the inhibition by compound X.
C The naturally occurring monomer contains a purine base.
D The naturally occurring monomer contains a pyrimidine base.

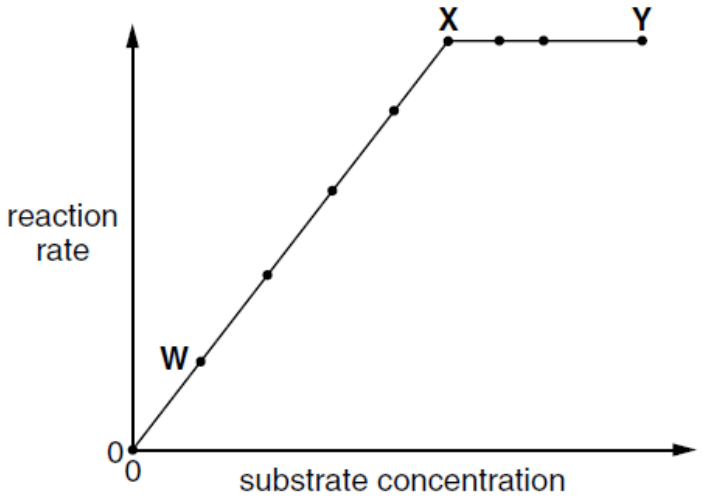
11. A hypothetical metabolic pathway is shown in figure below.



Which changes in enzyme activity will result in the greatest increase in the yield of Biomolecule **R**?

	Enzyme	Change in activity	Enzyme	Change in activity
A	S	Decrease	J	Decrease
B	C	Decrease	R	Increase
C	J	Increase	C	Increase
D	R	Increase	J	Decrease

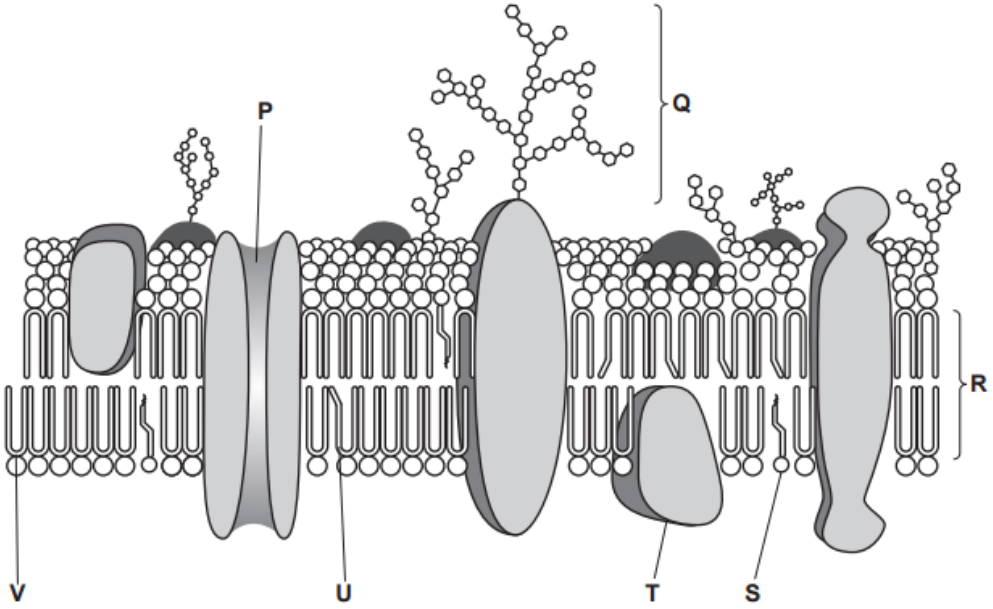
12. The graph shows the effect of substrate concentration on the rate of decomposition of hydrogen peroxide. The catalase concentration is keep constant.



Which statement about the graph is correct?

A Between **X** and **Y**, the number of enzyme molecules is limiting.
B Between **W** and **X**, the number of enzyme molecules is limiting.
C Between **X** and **Y**, the number of substrate molecules is limiting.
D Between **X** and **Y**, the product concentration remains the same.

13. The diagram shows a section through a cell surface membrane from a pancreatic beta cell.



The cell surface membrane of a phagocytic cell has a higher fluidity compared to the pancreatic beta cell.

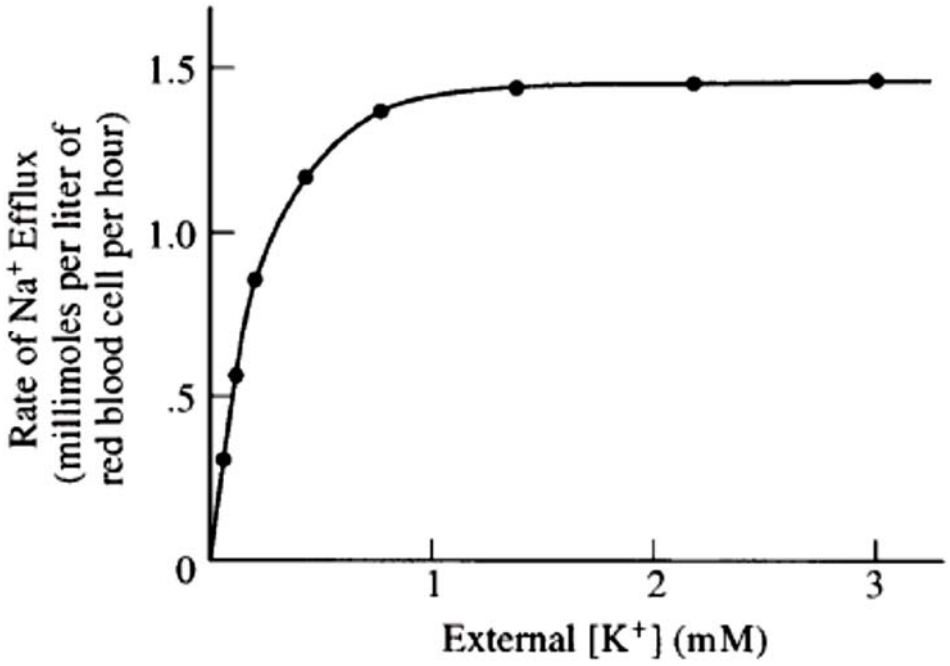
What is the most likely difference that will be observed between a phagocytic cell and pancreatic beta cell?

A Higher proportion of component **U** and a lower proportion of component **V**
B Higher proportion of component **S** and a higher proportion of component **T**
C An increased distance across **R** and a higher proportion of component **V**
D Complete absence of component **Q** and a higher proportion of component **P**

14. A student wanted to investigate the rate of efflux of sodium ions in mammalian cells. A freshly isolated population of mammalian cells was rapidly loaded with radioactive sodium and then subdivided into equally sized samples.

The samples were incubated in isotonic solution containing 10mM sodium chloride and varying concentrations of potassium chloride. The other variables were kept constant throughout this experiment.

The graph depicts the relationship between the rates at which sodium ion left the cells and the extracellular potassium ion concentration.



Which statement best accounts for the plateau in the rate of sodium ion efflux at about 1.0 mM external potassium ion concentration?

A Potassium ions occupy all the potassium-binding sites on the sodium-potassium pumps.
B Potassium ions compete with sodium ions for transport.
C Potassium ions make the membrane impermeable to sodium.
D Potassium ions bind ATP and thereby lowering the substrate concentration.

15. The table below shows the number of chromosomes in each gamete after meiosis and cytokinesis have taken place in two different human germ cells.

Gametes I-IV were formed from human germ cell **X**, whereas gametes V - VIII were formed from human germ cell **Y**.

Human germ cell **X**		Human germ cell **Y**	
Gametes	**Number of chromosomes**	**Gametes**	**Number of chromosomes**
I	22	V	23
II	24	VI	23
III	24	VII	22
IV	22	VIII	24

Which description is consistent with the data shown in the table above?

A Non-disjunction occurs for all 23 pairs of homologous chromosomes in germ cell **X**.

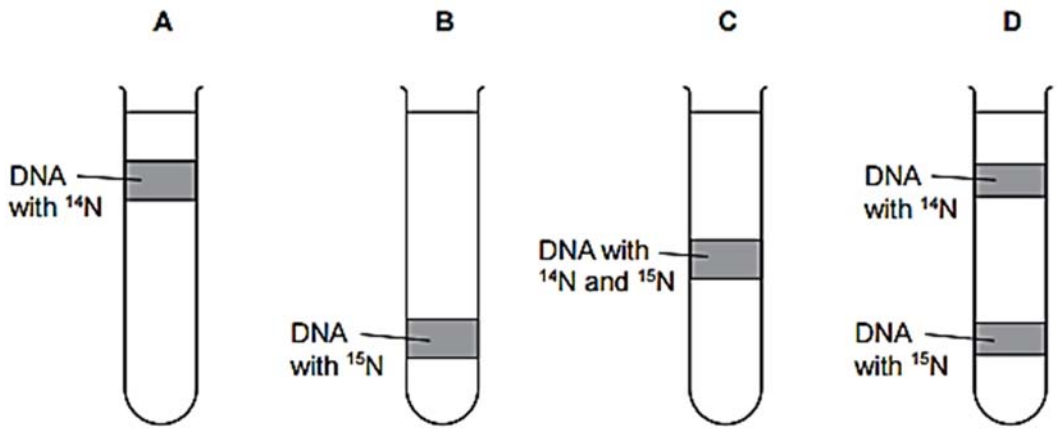
B Non-disjunction occurs for a pair of chromatids during anaphase II in germ cell **X**.

C Centromere of a pair of chromatids failed to divide during anaphase II in germ cell **Y**.

D A pair of homologous chromosomes fail to separate during anaphase I in germ cell **Y**.

16. Escherichia coli were originally grown for many generations in a medium containing a heavy isotope of nitrogen, ^{15}N. They were then transferred to a medium containing the light isotope of nitrogen, ^{14}N.

Which option shows the correct predicted results after the cells are allowed to divide once in the medium with the light isotope?



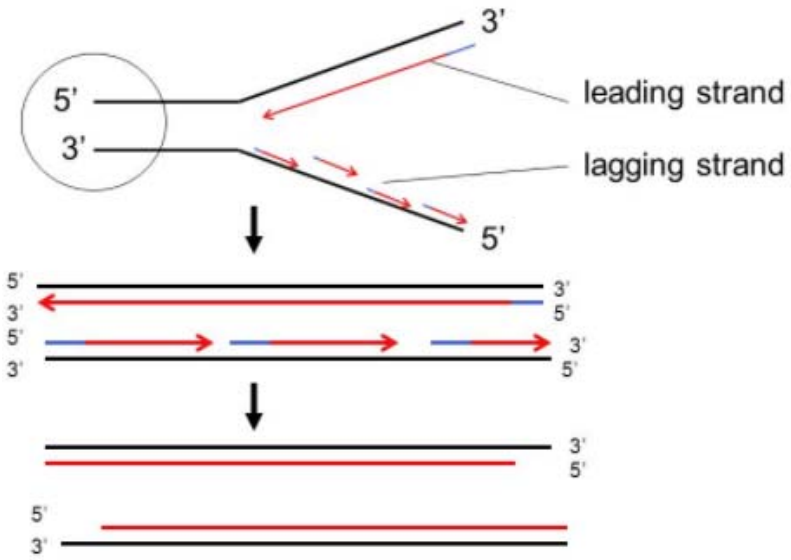
17. The following events occur during transcription.

I Bonds break between complementary bases.
II Bonds form between complementary bases.
III Sugar-phosphate bonds form.
IV Free ribonucleotides pair with complementary nucleotides.

Which events would have occurred twice before the mRNA leaves the nucleus?

A I and II only
B I, III and IV only
C II, III and IV only
D All of the above

18. The diagram illustrates the end-replication problem during DNA replication.



Which statements are **false** about end-replication problem of DNA?

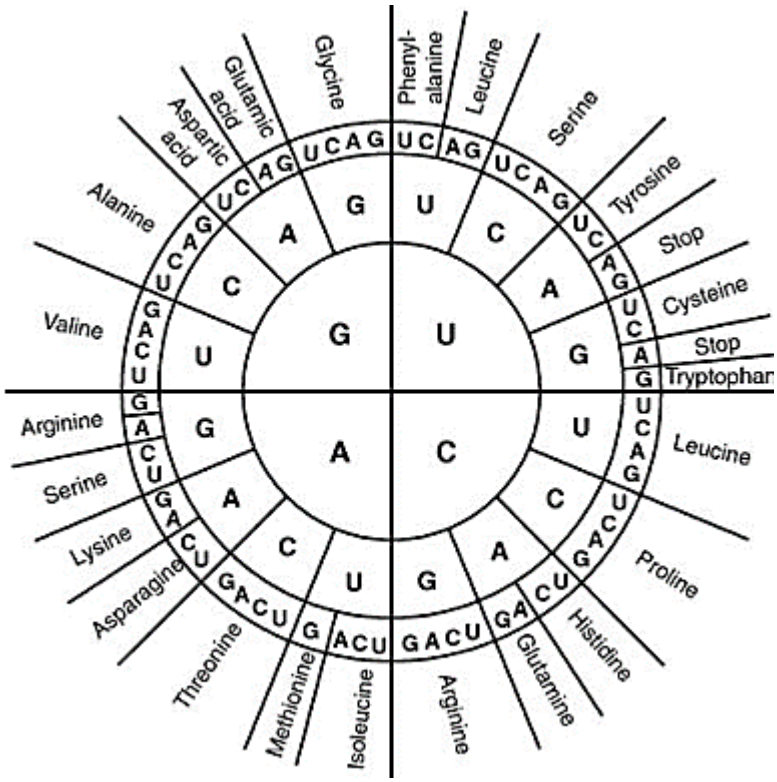
I When a linear DNA molecule replicates, a gap is left at the 3' end of each new strand because DNA polymerase can only add nucleotides to a 5' end.
II Repeated rounds of replication produce shorter and shorter DNA molecules.
III Telomerase prevents the end-replication problem from occurring.
IV Prokaryotes do not have the end-replication problem.

A I and II only
B I and III only
C II and III only
D III and IV only

19. Five different amino acids form the following sequence in a section of the polypeptide chain X:

Aspartic acid--Histidine--Glutamine--Cysteine--Histidine--Lysine--Aspartic acid

The diagram below shows the mRNA codon code.



What is the DNA base sequences in the template strand of the gene coding for the given section of X?

A 3’ CTAGTGGTTACAGTGTTGCTA 5’
B 3’ CTAGTGGTTACAGTGTTCCTA 5’
C 3’ CTAGTGGTTTCTGTGTTGCTA 5’
D 3’ CTAGTGGTTACAGTGTTCCTT 5’

[Turn over

20. The sequence below shows an mRNA segment produced from a gene section bearing one point mutation.

5'-ACCGUAGCAGCU-3'

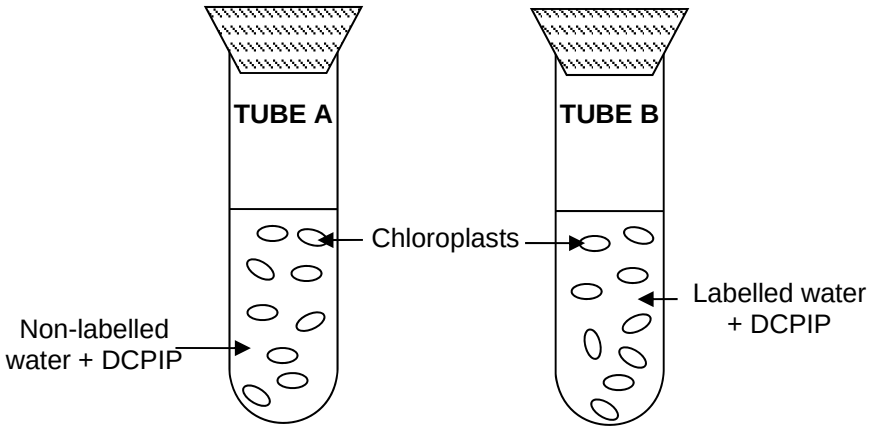
What is the sequence of the corresponding DNA coding strand prior to the mutation?

A 5'-AGCTGCTACGGT-3'
B 5'-ACCGTAGCAGCT-3'
C 5'-ACCGGAGCAGCT-3'
D 5'-AGCTGCTCCGGT-3'

21. The experimental setup below is used to investigate the light-dependent reaction of photosynthesis. Chloroplasts are placed in test tubes containing ^{18}O-labeled water ($H_2{}^{18}O$) and non-labeled water ($H_2{}^{16}O$) respectively.

A few drops of DCPIP, a proton acceptor, are added to each test-tube. DCPIP will decolourise when it is reduced. This colourless DCPIP can be reoxidised to blue.

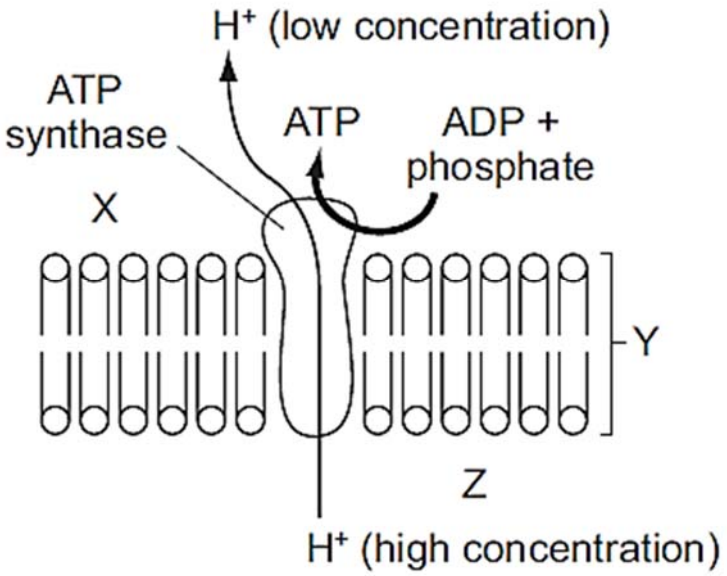
Both test tubes are exposed to light for 20 minutes.



Which row correctly identifies the results of the two test tubes at the end of the experiment?

	TUBE A		TUBE B	
	Gas evolved	**DCPIP colour**	**Gas evolved**	**DCPIP colour**
A	$^{16}O_2$	Colourless	$^{18}O_2$	Colourless
B	$^{16}O_2$	Blue	$^{16}O_2$	Colourless
C	$^{16}O_2$	Colourless	$^{16}O_2$	Colourless
D	$^{16}O_2$	Blue	$^{18}O_2$	Blue

22. The diagram shows a membrane in a eukaryotic cell.



Which statement would be true of the diagram?

A X is the stroma, Y is the thylakoid membrane and the diagram shows ATP synthesis in a mitochondrion.

B Y is the thylakoid membrane, Z is the cytosol and the diagram shows ATP synthesis in a chloroplast.

C Z is the intermembrane space, X is the matrix and the diagram shows ATP synthesis in a mitochondrion.

D X is the intermembrane space, Y is the inner mitochondrial membrane and the diagram shows ATP synthesis in a chloroplast.

23. A student set up six different test tubes containing animal tissue preparation to investigate different aspects of respiration. The test tubes are then incubated at optimal conditions.

The set-ups are shown below.

Tube	Contents
1	Glucose + homogenised cells
2	Glucose + mitochondria
3	Glucose + cytoplasm lacking organelles
4	Pyruvate + homogenised cells
5	Pyruvate + mitochondria
6	Pyruvate + cytoplasm lacking organelles

Which test tubes would produce carbon dioxide?

A 1, 2 and 3 only
B 1, 4 and 5 only
C 2, 4 and 6 only
D 4, 5 and 6 only

24. In *Drosophilia melanogaster*, the loci for the recessive allele for curly wings and the recessive allele for hairy bristles are located on different chromosomes.

A pure-breeding fly with wild-type wings and wild-type bristles is crossed with a fly with curly wings and hairy bristles. The F1 generation all had wild-type wings and wild-type bristles. Two of the F1 were crossed and produced 416 offspring.

Which row correctly identifies the numbers of each phenotype in the F2 generation?

	Phenotype			
	Wild-type wings Wild-type bristles	Wild-type wings Hairy bristles	Curly wings Wild-type bristles	Curly wings Hairy bristles
A	226	46	44	100
B	312	0	0	104
C	338	0	0	78
D	232	78	82	24

25. Mr and Mrs Li, who are homozygous for blood type A and blood type B respectively, have a son with blood group AB and haemophilia. Neither parent has haemophilia.

What is the probability that the second child of these parents will be a girl with blood group AB and no haemophilia?

A 1
B 1 in 2
C 1 in 4
D 1 in 8

26. Which statement(s) correctly describe(s) Darwinian evolutionary theory?

I Advantageous traits acquired during the lifetime of an individual is likely to be inherited.

II In competition for survival, the more aggressive animals always survive better.

III Species perfectly adapted to a stable environment will continue to evolve.

IV Variation between individuals of a species is essential for evolutionary change.

A IV only

B II and III only

C III and IV only

D I, II and IV only

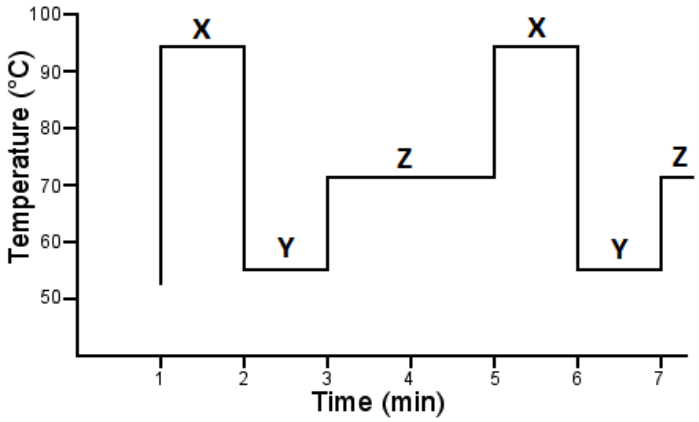
27. Two areas of molecular biology that have received considerable attention in evolutionary studies are the genetic code and cytochrome C. Cytochrome C is an essential component of all respiratory electron transport chains.

Which statements lend evidence to support the ideas that all living organisms are related and there is a single, rather than multiple, origin of life?

I The almost universal nature of the genetic code is a result of evolutionary convergence from multiple lineages.
II The sequence of amino acids in cytochrome C is similar in organisms that are from similar environments or with similar metabolic demands.
III Majority of living organisms on earth have the same, or similar, amino acid sequences for cytochrome C.
IV When transferred into a very dissimilar organism, a gene coding for cytochrome C will lead to the expression of a protein that will function in the other organism.

A I and II only
B II and III only
C III and IV only
D I, III and IV only

28. The diagram below shows the changes in temperature in a thermal cycler over time during polymerase chain reaction.



Which statements are true of the graph shown above?

I Elongation of new strands occurs during **Y**.
II Double stranded DNA template denatures into single strands during **X**.
III Taq polymerase functions optimally at **Z**.
IV DNA primers are annealed to the DNA template during **X**.

A I and IV only
B II and III only
C II and IV only
D I, II and III only

29. The human genome project (HGP) was successfully completed on 14 April 2003. HGP was an international scientific research project with the goal of determining the sequence of nucleotide base pairs that make up human DNA, and of identifying and mapping all of the genes of the human genome from both a physical and a functional standpoint.

Several ethical concerns on HGP were raised by the public and scientific community

Which statement is **not** an ethical concern of the HGP?

A Anxiety may arise in patients when genetic testing is conducted for diseases with no medical treatment currently available.
B If genetic sequences are patented, it will increase the cost of genetic research and treatment.
C Mankind is tampering with nature when the human genome is modified.
D The use of genetic test results may lead to discrimination of individuals by insurance companies and employers.

30. Stem cells are found in many tissues that require frequent tissue replacement such as the skin, the intestine or the blood.

However, within their own environments, a bone marrow cell cannot be induced to produce a skin cell and a skin cell cannot be induced to produce a bone marrow cell.

Which statement explains this?

A Different stem cells have only the genes required for their particular cell line.
B Genes not required for a particular cell line are methylated.
C Genes not required for a particular cell line are removed using restriction enzymes.
D mRNA that is not required for a particular cell line is destroyed.

End of Paper

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Class Adm No

Candidate Name: _____

H

millennia institute

2017 Promotional Examination II
Pre-university 2

Biology Higher 1 8875/01

18 September 2017

1 hour

Additional Materials: Optical answer sheet

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Write your name, Adm No. and class on all the papers you hand in.
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Paper 1
There are **thirty** questions in this paper. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Multiple Choice Answer Sheet.

Calculators may be used.

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

#

Class Adm No

Candidate Name: _____

H

millennia institute

2017 Promotional Examination II
Pre-University 2

H1 Biology 8875/02

Paper 2 **12 September 2017**

Additional material: writing papers **2 hours**

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your Admission number and name 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 diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the space provided in the question paper.

Section B
Answer **any one** question in the writing papers provided.

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

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
Total	

Answer **all** questions in this section.

1. Measurement of cellular DNA content and the analysis of the cell cycle can be performed by flow cytometry. The DNA content of retinal cells of zebrafish is analysed and Fig. 1.1 show the number of cells at different stages of the cell cycle.

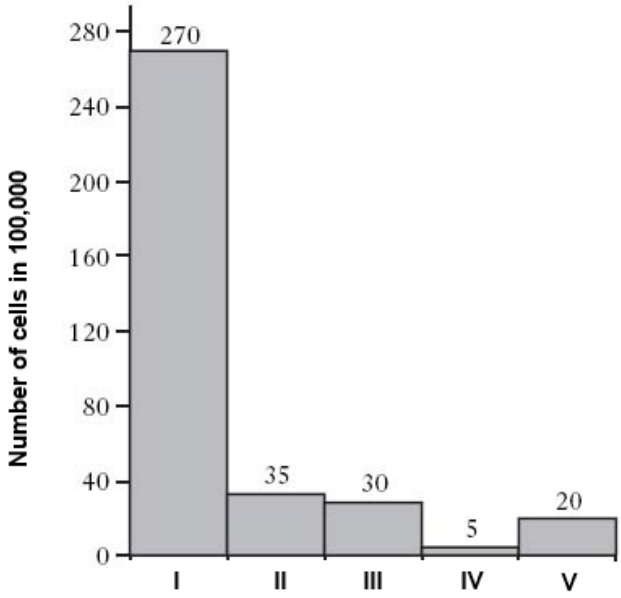

Fig. 1.1

(a)

(i) Identify which stage (**I** to **V**) correspond to interphase.

……[1]

(ii) Suggest a reason for your answer in **(a)(i).**

……

……[1]

(iii) Explain the importance of DNA replication before mitosis.

……

……

……[2]

Fig. 1.2 shows the electronmicrographs of three zebrafish retinal cells (**A** to **C**). Each cell is undergoing a different stage of mitosis.

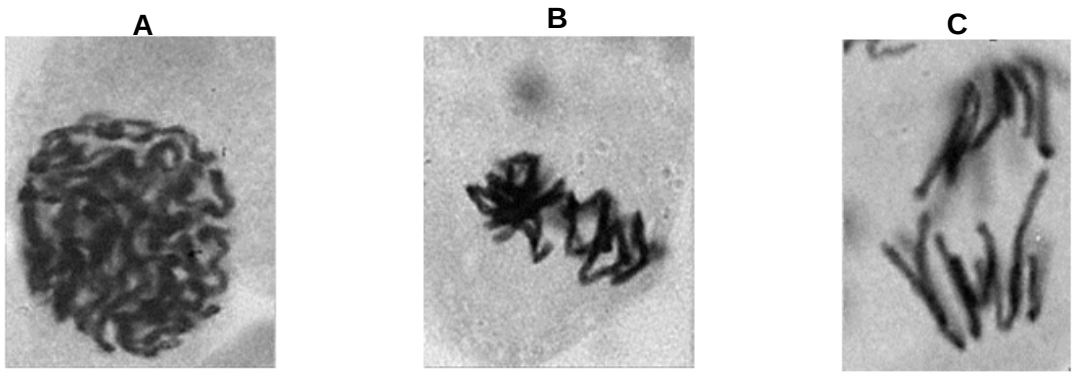

Fig. 1.2

(b)

(i) Identify stages of mitosis that cell **A** and **B** is undergoing.

……[1]

(ii) State the visible features in cell **A** and **B** that enabled your identification in **(b)(i)**.

……

……

……[2]

[Turn over

Fig. 1.3 shows the changes in the DNA amount during the meiotic cell cycle of the germ cells in zebrafish.

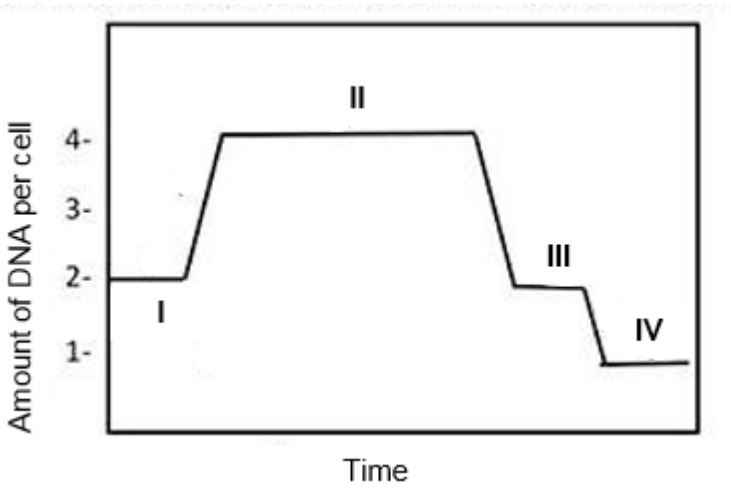

Fig. 1.3

(c) With reference to Fig. 1.3, explain the changes in DNA amount from stage **II** to **IV**.

……

……

……

……

……**[3]**

[Total: 10]

2. In recent years, numerous biochemical and genetic studies have demonstrated that peptide signalling plays a greater than anticipated role in various aspects of plant growth and development. A substantial proportion of these plant peptides are secretory and act as local signals mediating cell-to-cell communication.

Fig 2.1 and Fig. 2.2 show two different membrane-bound organelles found in shoot apical meristematic cells.

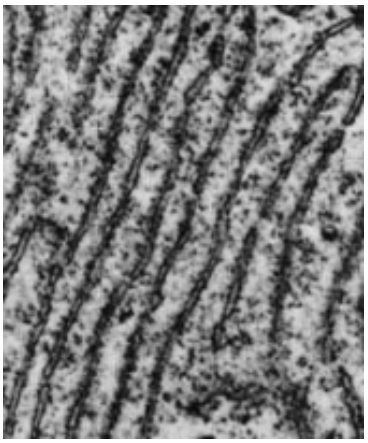

Fig 2.1

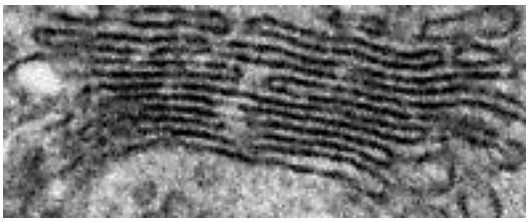

Fig. 2.2

(a) Describe how the two organelles in Fig 2.1 and Fig. 2.2 work together in the production and secretion of plant peptides.

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……**[3]**

[Turn over

Fig. 2.3 shows the process of protein synthesis that takes place on the organelle shown in Fig. 2.1.

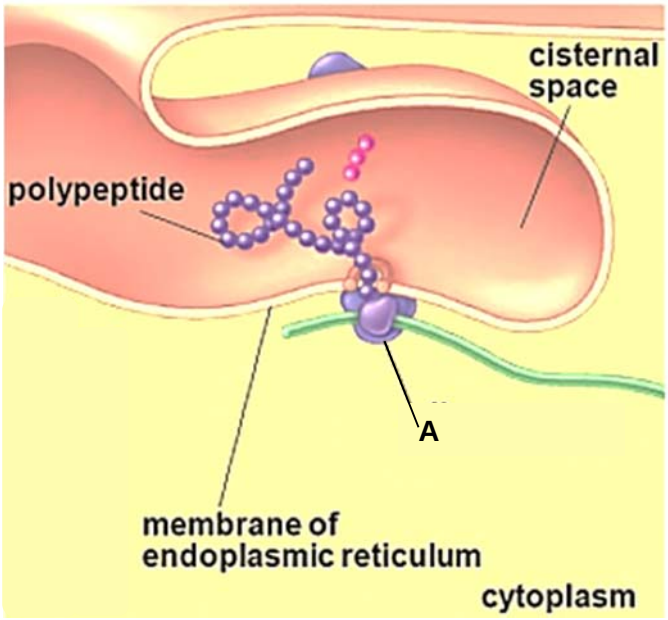

Fig. 2.3

(b) Describe how the structure of **A** is adapted to its role in the process shown in Fig. 2.3.

……

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……**[3]**

Fig. 2.4 shows the role of tRNA in the process of protein translation while Fig. 2.5 shows the genetic code in terms of the mRNA codons sequence.

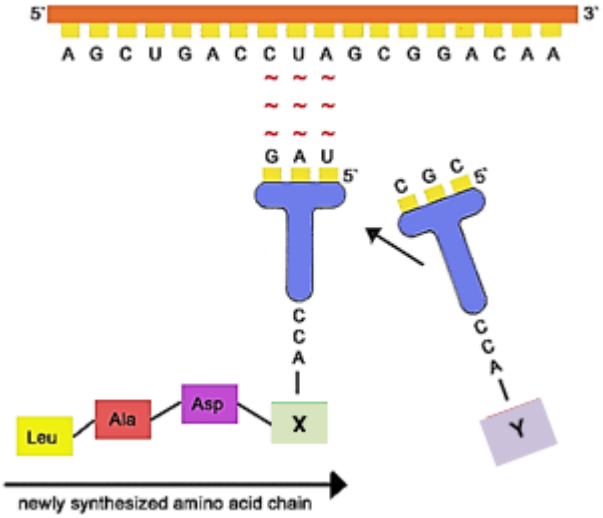

Fig. 2.4

Second Letter

1st letter	U		C		A		G		3rd letter
U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys	U
	UUC		UCC		UAC		UGC		C
	UUA	Leu	UCA		UAA	Stop	UGA	Stop	A
	UUG		UCG		UAG	Stop	UGG	Trp	G
C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Gln	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lys	AGA	Arg	A
	AUG	Met	ACG		AAG		AGG		G
G	GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glu	GGA		A
	GUG		GCG		GAG		GGG		G

Fig. 2.5

(c) With reference to Fig. 2.4 and Fig. 2.5, identify amino acid **X** and **Y**.

X: .....

Y: ..... **[1]**

[Turn over

The palisade mesophyll cells of plant contain numerous chloroplasts. Fig. 2.6 shows an electron-micrograph of a chloroplast in plant cell.

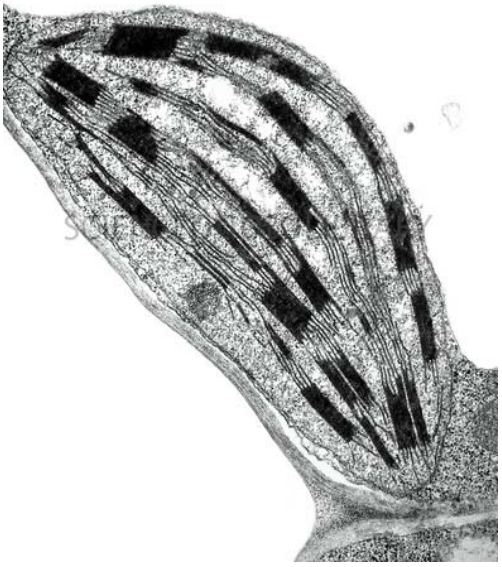

Fig. 2.6

(d) Draw an arrow and label the structure where light-dependent reactions occurs in the chloroplast. **[1]**

The rate of decolourisation of DCPIP in the Hill Reaction is a measure of the rate of the light-dependent stages of photosynthesis. DCPIP, a blue dye, acts as an electron acceptor and becomes colourless when reduced, allowing any reducing agent produced by the chloroplasts to be detected.

A suspension of chloroplasts was made by grinding fresh leaves in buffer solution and centrifuging the mixture. Tubes were then prepared and treated in the following way and the results of this investigation is shown in Table 2.1.

Table 2.1

Tubes	**Content**	**Condition**	**Colour**	
			Start	**After 15 min**
A	3 cm^3 chloroplast suspension 8 cm^3 DCPIP	Illuminated strongly	Blue-green	Green
B	3 cm^3 buffer solution 8 cm^3 DCPIP	Illuminated strongly	Blue	Blue
C	3 cm^3 chloroplast suspension 8 cm^3 DCPIP	Left in the dark	Blue-green	Blue-green

(e) Using your knowledge of light-dependent reactions, account for the results shown in Table 2.1.

……

……

……

……

……

……

……

……**[4]**

[Total: 12]

[Turn over

3. Haemophilia A, also called factor VIII (FVIII) deficiency or classic haemophilia, is a genetic disorder caused by missing or defective factor VIII, a clotting protein. This genetic disorder is characterised by episodes of internal and external bleeding in affected individuals.

According to the United States Centers for Disease Control and Prevention, haemophilia occurs in approximately 1 in 5,000 live births. There are about 20,000 people with haemophilia in the United States. All races and ethnic groups are affected.

Fig. 3.1 shows a pedigree of a family with history of haemophilia A. The FVIII gene was first isolated from each individual using Polymerase Chain Reaction (PCR). The PCR products were then digested using restriction enzymes and the resulting fragments separated by gel electrophoresis. Fig. 3.2 shows the results of the gel electrophoresis for some of the individuals.

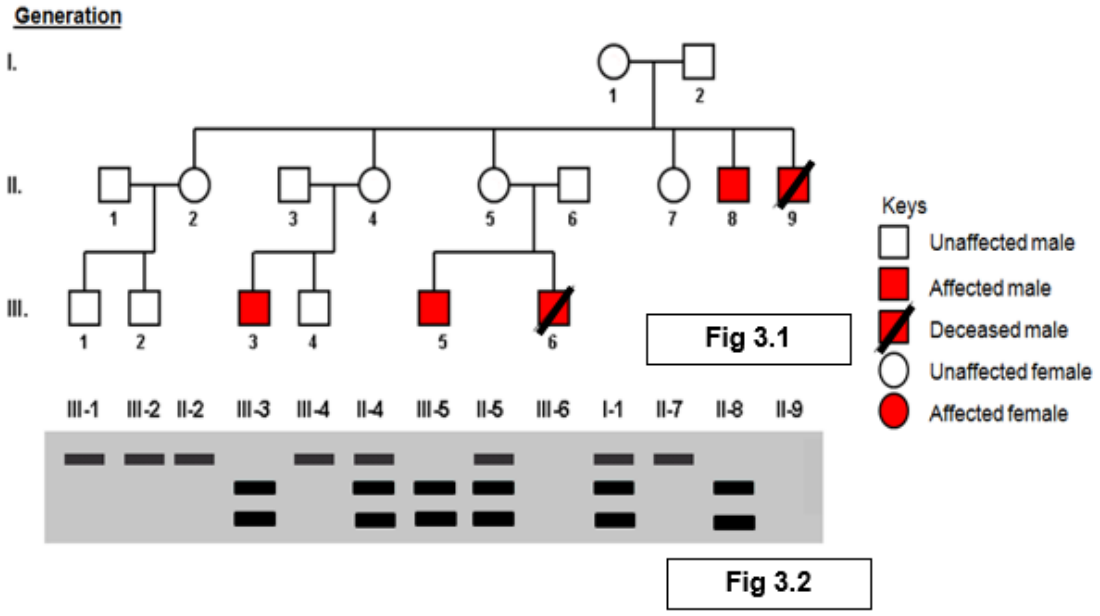

Fig 3.1

Fig 3.2

(a) With reference to Fig. 3.1 and Fig. 3.2, state two pieces of evidence that confirm that haemophilia A is an X-linked recessive disorder.

……

……

……**[2]**

Individual II-3 and II-4 do not exhibit the symptoms of haemophilia A and they are heterozygous for both blood type A and B respectively. III-3, who is the son of II-3 and II-4, suffers from haemophilia A and has a blood type is AB.

(b) With reference to Fig. 3.1 and Fig. 3.2, construct a genetic cross diagram to explain how II-3 and II-4 can result in a child with haemophilia A and blood type AB.

[5]

[Total: 7]

[Turn over

4. MRSA is a variety of *Staphylococcus aureus*. It is difficult to treat infections caused by this type of bacteria because it is resistant to methicillin and to some other antibiotics. As a result, some patients who are already very ill may die if they become infected with MRSA.

(a) Describe how natural selection makes MRSA resistant to the commonly used antibiotics.

……

……

……

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……

……

……**[4]**

Antibiotic resistance genes have been employed widely in recombinant DNA technology to produce transgenic bacteria containing human genes.

To produce insulin for medical uses, human insulin genes are transferred into bacteria. Plasmids containing two antibiotic resistance genes, one coding for resistance to tetracycline and one for resistance to ampicillin, are used to carry out this transfer.

Table 4.1 shows the actions of four different restriction enzymes, which might be used in the production of a recombinant DNA molecule, and the source of these enzymes.

Table 4.1

Organism	Restriction enzyme	Target DNA sequences (cleavage sites shown by arrow linings)
Escherichia coli RY 13	*Eco*RI	5′ G ↑A A T T C 3′ 3′ C T T A A↓ G 5′
Bacillus amyloliquefaciens	*BamH*I	5′ G ↑G A T C C 3′ 3′ C C T A G ↓G 5′
Providencia stuartii	*Pst*I	5′ C T G C A ↑G 3′ 3′ G ↓A C G T C 5′
Haemophilus influenzae	*Hind*II	5′ G T Py ↑ Pu A C 3′ 3′ C A Pu ↓ Py T G 5′

(b) With reference to Table 4.1, explain why *Eco*RI, *BamH*I and *PstI* are more suitable for use in the cloning of human insulin gene than *Hind*II.

……

……

……**[2]**

[Turn over

After the fragments of human DNA and the cut plasmids were mixed together, several types of plasmid were formed. The different types of plasmid are shown in Fig 4.1.

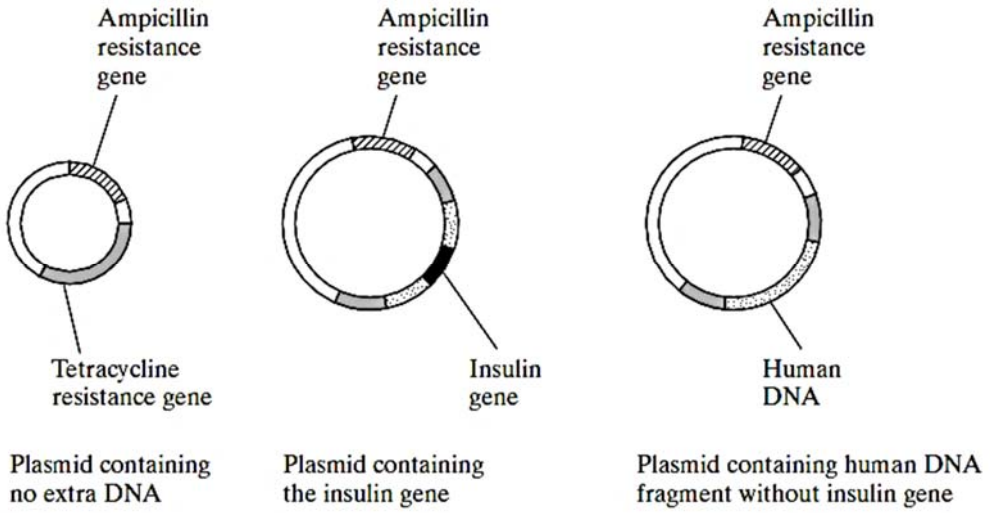

Fig 4.1

(c) State another property of the plasmid not shown in Fig. 4.1 that enables it to be used as a cloning vector.

……[1]

(d) Explain how it is possible to distinguish between bacteria, which have taken up a plasmid with human DNA and those, which have taken up a plasmid without any extra DNA.

……

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……

……

……[4]

[Total: 11]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a), (b)** etc., as indicated in the question.

5.

(a) Compare the structure and role of deoxyribonucleic acid and ribonucleic acid. **[6]**

(b) Using named examples, explain how anatomical, embryological and molecular homology supports Darwin's theory of natural selection. **[7]**

(c) Using named examples, discuss the importance of genetic engineering in solving the global demand for food. **[7]**

[Total: 20]

6.

(a) Relate the structure of haemoglobin to its function in animals. **[6]**

(b) Explain the small yield of ATP produced by anaerobic respiration in mammals. **[6]**

(c) Restriction digest is usually performed prior to agarose gel electrophoresis.

With reference to the principles of gel electrophoresis, discuss why the incubation time for restriction digest of the plasmid DNA is important in obtaining accurate results from gel electrophoresis. **[8]**

[Total: 20]

End of Paper

Class Adm No

Candidate Name: _____

H

millennia institute

2017 Promotional Examination II

Pre-University 2

H1 Biology 8875/02

Paper 2 **12 September 2017**

2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your Admission number and name 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 diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

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

For Examiner's Use	
Section A	
1	
2	
3	
Section B	
Total	

This question paper consists of 14 printed pages including 1 blank page.

[Turn over

Answer **all** questions in this section.

1. Measurement of cellular DNA content and the analysis of the cell cycle can be performed by flow cytometry. The DNA content of retinal cells of zebrafish is analysed and Fig. 1.1 show the number of cells at different stages of the cell cycle.

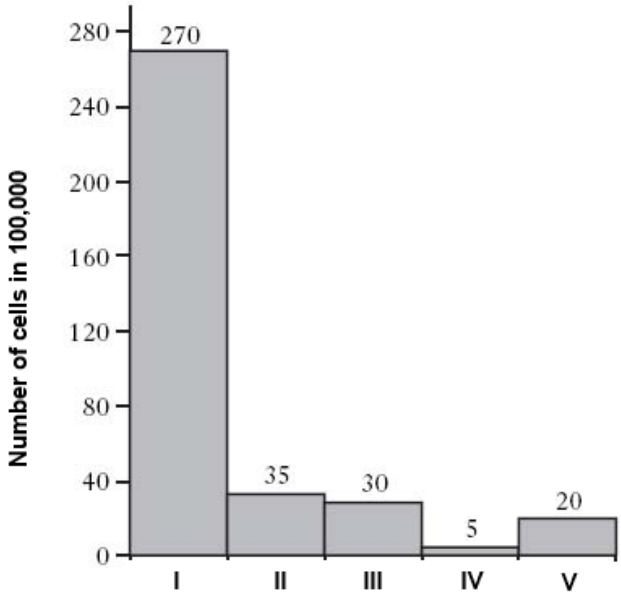

Fig. 1.1

(a)

(i) Identify which stage (**I** to **V**) correspond to interphase.

I

;; for 1 mark, max is 1 mark

]

(ii) Suggest a reason for your answer in **(a)(i).**

Interphase has the longest duration/consist of G1, S and G2 phases, so more cells will be found in the interphase;
; for 1 mark, max is 1 mark

(iii) Explain the importance of DNA replication before mitosis

DNA replication results in each chromosome consists of 2 genetically identical sister chromatids joined at centromere during prophase and metaphase;
The daughter cells are genetically identical because they receive a copy of exact/same DNA molecule/same number and type of chromosomes;
Maintain genetic stability;

; for 1 mark, max is 2 marks

Fig. 1.2 shows the electronmicrographs of three zebrafish retinal cells (**A** to **C**). Each cell is undergoing a different stage of mitosis.

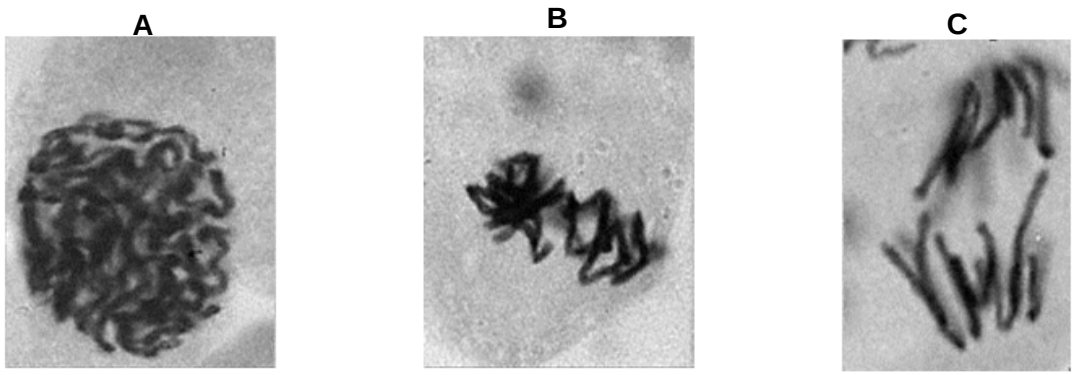

Fig. 1.2

(b)

(i) Identify stages of mitosis that cell **A** and **B** is undergoing.

A: prophase;
B: metaphase;

;; for 1 mark, max is 1 mark

(ii) State the visible features in cell **A** and **B** that enabled your identification in **(b)(i).**

Stage A
Chromatin fibres condense to become discrete chromosomes, which are visible;
Absence of nuclear membrane/envelope;

Stage B
Chromosomes start to align in a single row/singly at metaphase plate/equator of the spindle;
;; for 1 mark, max is 2 marks

Fig. 1.3 shows the changes in the DNA amount during the meiotic cell cycle of the germ cells in zebrafish.

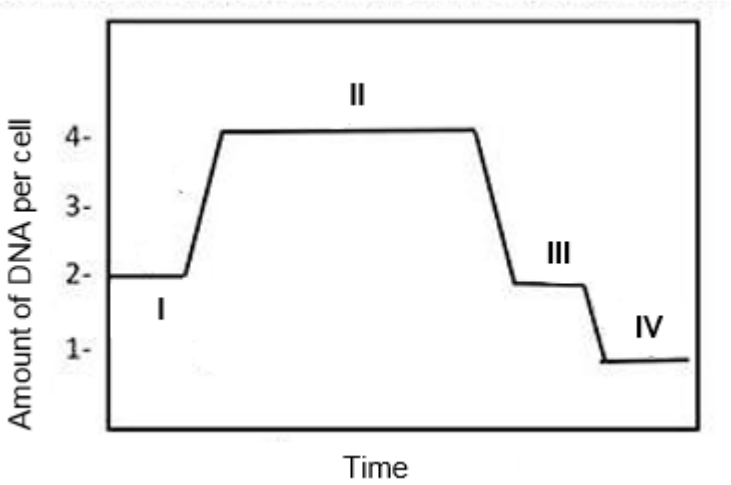

Fig. 1.3

(c) With reference to Fig. 1.3, explain the changes in DNA amount from stage **II** to **IV.**

Stage II correspond to meiosis I while Stage III correspond to meiosis II;
The amount of DNA in each cell remain constant during meiosis I and II because the germ cell has not divided/cytokinesis has not occurred, which occur at the end of meiosis I and II;

; for 1 mark, max is 1 mark

The amount of DNA in each cell is halved at the end of meiosis I due to the separation of the homologous chromosomes during anaphase I;
The amount of DNA in each cell is halved again at the end of meiosis II due to the separation of chromatids during anaphase II;

; for 1 mark, max is 2 marks

[Total: 10]

2. In recent years, numerous biochemical and genetic studies have demonstrated that peptide signalling plays a greater than anticipated role in various aspects of plant growth and development. A substantial proportion of these plant peptides are secretory and act as local signals mediating cell-to-cell communication.

Fig 2.1 and Fig. 2.2 show two different membrane-bound organelles found in shoot apical meristematic cells.

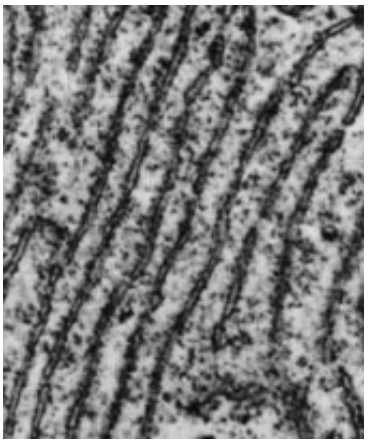

Fig 2.1

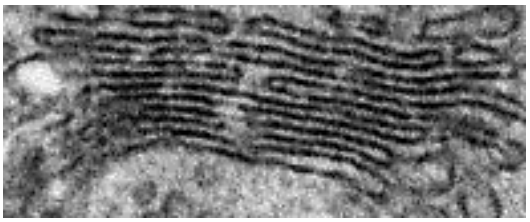

Fig. 2.2

(a) Describe how the two organelles in Fig 2.1 and Fig. 2.2 work together in the production and secretion of plant peptides.

The bound/fixed ribosomes on the rough endoplasmic reticulum synthesise polypeptides/translation, which enters the RER lumen to be modified and folded;
Transport vesicles containing the proteins bud off from the RER and fuse with the cis face of the golgi apparatus;
GA is involved in chemical modification for e.g. glycosylation, sorting and packaging of the proteins;
Secretory vesicles bud off from the trans face of the GA;
Fuse with the cell surface membrane to release the plant peptides via exocytosis;

; for 1 mark, max is 3 marks

……

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……**[3]**

Fig. 2.3 shows the process of protein synthesis that takes place on the organelle shown in Fig. 2.1.

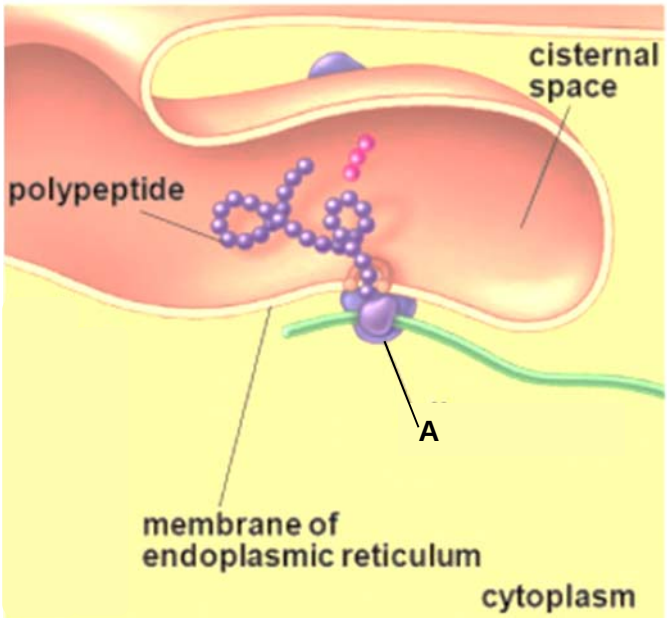

Fig. 2.3

(b) Describe how the structure of **A** is adapted to its role in the process shown in Fig. 2.3.

Small ribosomal subunit able to recognise and bind to 5' end/start codon on mRNA to initiate translation;
Large ribosomal subunit contains A site, P site and E site;
P site contains the initiator tRNA/tRNA with the growing polypeptide chain attached;
A site is for the binding of incoming aminoacyl-tRNA;
E site is for tRNA to be released from ribosome;
Attachment of large ribosomal subunit holds the translation initiation complex in place;
Large ribosomal subunit contains peptidyl transferase + to catalyse formation of peptide bonds between amino acids;

; for 1 mark, max is 3 marks

[3]

Fig. 2.4 shows the role of tRNA in the process of protein translation while Fig. 2.5 shows the genetic code in terms of the mRNA codons sequence.

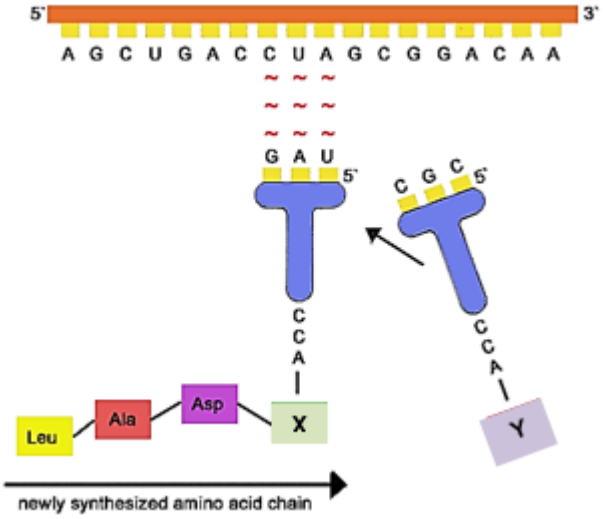

Fig. 2.4

	Second Letter: U		Second Letter: C		Second Letter: A		Second Letter: G		
1st letter: U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys	3rd letter: U
	UUC		UCC		UAC		UGC		C
	UUA	Leu	UCA		UAA	Stop	UGA	Stop	A
	UUG		UCG		UAG	Stop	UGG	Trp	G
C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Gln	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lys	AGA	Arg	A
	AUG	Met	ACG		AAG		AGG		G
G	GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glu	GGA		A
	GUG		GCG		GAG		GGG		G

Fig. 2.5

(c) With reference to Fig. 2.4 and Fig. 2.5, identify amino acid **X** and **Y**.

X: … X: leucine;
Y: Alanine;

Y: … ;; for 1 mark

[1]

[Turn over

The palisade mesophyll cells of plant contain numerous chloroplasts. Fig. 2.6 shows an electron-micograph of a chloroplast in plant cell.

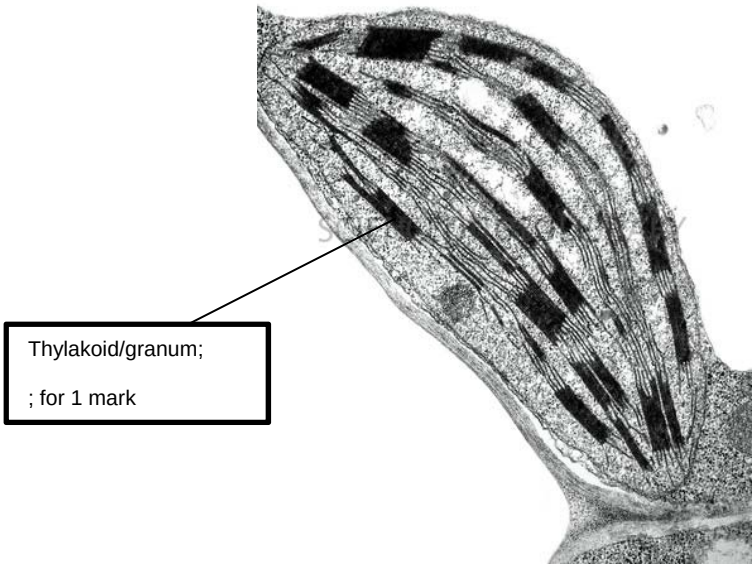

Fig. 2.6

(d) Draw an arrow and labelled the structure where light-dependent reactions occurs in the chloroplast. **[1]**

The rate of decolourisation of DCPIP in the Hill Reaction is a measure of the rate of the light-dependent stages of photosynthesis. DCPIP, a blue dye, acts as an electron acceptor and becomes colourless when reduced, allowing any reducing agent produced by the chloroplasts to be detected.

A suspension of chloroplasts was made by grinding fresh leaves in buffer solution and centrifuging the mixture. Tubes were then prepared and treated in the following way and the results of this investigation is shown in Table 2.1.

Table 2.1

Tubes	**Content**	**Condition**	**Colour**	
			Start	**After 15 min**
A	3 cm^3 chloroplast suspension 8 cm^3 DCPIP	Illuminated strongly	Blue-green	Green
B	3 cm^3 buffer solution 8 cm^3 DCPIP	Illuminated strongly	Blue	Blue
C	3 cm^3 chloroplast suspension 8 cm^3 DCPIP	Left in the dark	Blue-green	Blue-green

(e) Using your knowledge of light-dependent reactions, account for the results shown in Table 2.1.

DCPIP acts like final hydrogen ion/electron acceptor/NADP+ in non-cyclic photophosphorylation/light-dependent reactions;
; for 1 mark, max is 1 mark
Tube A: When light and chloroplast suspension are present, photo-excited electrons from water/PSII/PSI;
Electrons are passed along the electron transport chain to reduce DCPIP;
There is light-dependent reactions + decolourising/changing it from blue to colourless, solution turn green due to the colour of chloroplast/chlorophyll;
; for 1 mark. max is 1 mark

However, when tube C is placed in the dark/absence of light, DCPIP remained blue, indicating that it is not being reduced, thus no photoactivation in the dark;
; for 1 mark. max is 1 mark

Tube B is a control and shows that DCPIP is reduced and decolourised by the photoactivation/non-cyclic photophosphorylation/light-dependent reactions in the chloroplast suspension;
; for 1 mark, max is 1 mark

……

……**[4]**

[Total: 12]

3. Haemophilia A, also called factor VIII (FVIII) deficiency or classic haemophilia, is a genetic disorder caused by missing or defective factor VIII, a clotting protein. This genetic disorder is characterised by episodes of internal and external bleeding in affected individuals.

According to the United States Centers for Disease Control and Prevention, haemophilia occurs in approximately 1 in 5,000 live births. There are about 20,000 people with haemophilia in the United States. All races and ethnic groups are affected.

Fig. 3.1 shows a pedigree of a family with history of haemophilia A. The FVIII gene was first isolated from each individual using Polymerase Chain Reaction (PCR). The PCR products were then digested using restriction enzymes and the resulting fragments separated by gel electrophoresis. Fig. 3.2 shows the results of the gel electrophoresis for some of the individuals.

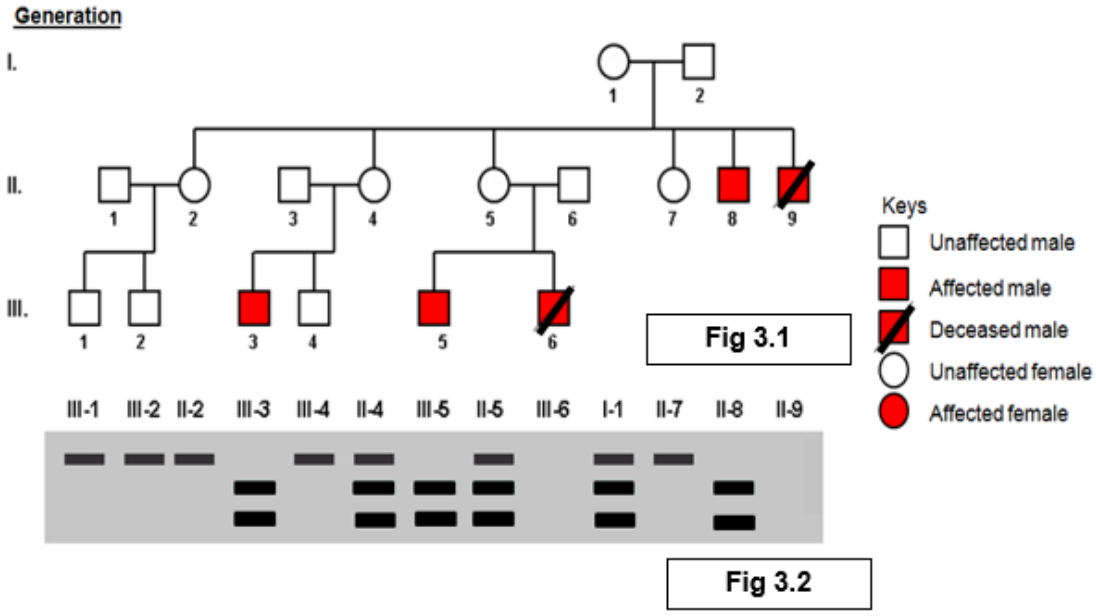

Fig 3.1

Fig 3.2

(a) With reference to Fig. 3.1 and Fig. 3.2, state two pieces of evidence that confirm that haemophilia A is an X-linked recessive disorder.

X-linked because:
More males affected than females;
Or
Phenotypically normal female/mother unaffected by the disorder/carrier females, only affected sons and daughters not affected + e.g.:
I-1 not affected/carrier/heterozygous, II-8 and II-9 are affected while II-2, II-4, II-5 and II-7 unaffected;
Or
II-4 not affected/carrier/heterozygous, III-3 affected;
Or
II-5 unaffected/carrier/heterozygous but III-5 and III-6 are affected;

; for 1 mark, max is 1 mark

Recessive because:
Identification of which band correspond to mutant and normal allele;
Phenotypically normal parents can produce an affected child + e.g.
I-1 and I-2 gives rise to II-8 and II-9;
II-3 and II-4 gives rise to III-3;
II-5 and II-6 gives rise to III-5 and III-6;
; for 1 mark, max is 1 mark

Individual II-3 and II-4 do not exhibit the symptoms of haemophilia A and they are heterozygous for both blood type A and B respectively. III-3, who is the son of II-3 and II-4, suffers from haemophilia A and has a blood type is AB.

(b) With reference to Fig. 3.1 and Fig. 3.2, construct a genetic cross diagram to explain how II-3 and II-4 can result in a child with haemophilia A and blood type AB.

Let X^H be the allele on the X-chromosome that code for normal blood clotting factor
Let X^h be the allele on the X-chromosome that codes for the defective blood clotting factor
Let I^A be the allele coding for blood type A
Let I^B be the allele coding for blood type B
Let I^O be the allele coding for blood type O

Parental phenotype	Male, unaffected				Female, unaffected			
Parental genotype	$X^HYI^AI^O$				$X^HX^h\ I^BI^O$			
Gamete	X^HI^A	X^HI^O	YI^A	YI^O	X^HI^B	X^HI^O	X^hI^B	X^hI^O
Punette's square		X^HI^B	X^HI^o		X^hI^B		X^hI^o	
	X^HI^A	$X^HX^HI^AI^B$ Female, normal, blood type AB	$X^HX^HI^AI^o$ Female, normal, blood type A		$X^HX^hI^AI^B$ Female, normal, blood type AB		$X^HX^hI^AI^o$ Female, normal, blood type A	
	X^HI^o	$X^HX^HI^BI^o$ Female, normal, blood type B	$X^HX^HI^oI^o$ Female, normal, blood type O		$X^HX^hI^BI^o$ Female, normal, blood type B		$X^HX^hI^oI^o$ Female, normal, blood type O	
	YI^A	$X^HYI^AI^B$ Male, normal, blood type AB	$X^HYI^AI^o$ Male, normal, blood type A		$X^hYI^AI^B$ Male, affected, blood type AB		$X^hYI^AI^o$ Male, affected, blood type A	
	YI^o	$X^HYI^BI^o$ Male, normal, blood type B	$X^HYI^oI^o$ Male, normal, blood type O		$X^hYI^BI^o$ Male, affected, blood type B		$X^hYI^oI^o$ Male, affected, blood type O	
F1 genotype	$X^HX^HI^AI^B$, $X^HX^hI^AI^B$	$X^HX^HI^AI^o$, $X^HX^hI^AI^o$,	$X^HX^HI^BI^o$, $X^HX^hI^BI^o$	$X^HX^HI^oI^o$. $X^HX^hI^oI^o$	$X^HYI^AI^B$	$X^HYI^AI^o$	$X^HYI^BI^o$	$X^HYI^oI^o$
F1 phenotype	Female, normal, blood type AB	Female, normal, blood type A	Female, normal, blood type B	Female, normal, blood type O	Male, normal, blood type AB	Male, normal, blood type A	Male, normal, blood type B	Male, normal, blood type O
F1 genotype	$X^hYI^AI^B$	$X^hYI^AI^o$	$X^hYI^BI^o$	$X^hYI^oI^o$				
F1 phenotype	Male, affected, blood type AB	Male, affected, blood type A	Male, affected, blood type B	Male, affected, blood type O				
Phenotypic ratio	Female, Normal, Blood type AB 2 :	Female, normal, blood type A 2 :	Female, normal, blood type B 2 :	Female, normal, blood type O 2 :	Male, normal, blood type AB 1 :	Male, normal, blood type A 1 :		
	Male, normal, blood type B 1 :	Male, normal, blood type O 1 :	Male, affected, blood type AB 1 :	Male, affected, blood type A 1 :	Male, affected, blood type B 1 :	Male, affected, blood type O 1		

Correct parental phenotypes and genotypes;
Correct gametes drawn;
Correct punette's square drawn including phenotypes;
Correct F1 phenotypes and genotypes;
Correct phenotypic ratio

[5]
[Total: 7]

[Turn over

For Examiner's Use

4. MRSA is a variety of *Staphylococcus aureus*. It is difficult to treat infections caused by this type of bacteria because it is resistant to methicillin and to some other antibiotics. As a result, some patients who are already very ill may die if they become infected with MRSA.

(a) Describe how natural selection makes MRSA resistant to the commonly used antibiotics.

Pre-existing genetic variations in the bacterial population due to random mutations;
Antibiotic resistant gene / allele already existing in gene pool of bacterial population;
Selection pressure of antibiotic/methicillin being exerted on bacterial population;
Resistant bacteria are at the selective advantage and are able to survive and reproduce to pass down the allele for antibiotic resistance to their offspring;
Or
Non-resistant bacteria are selected against and cannot survive and reproduce to pass down the allele for antibiotic resistance to their offspring;

Over time, frequency of antibiotic resistance allele in the bacterial population increases;
As a result, the population of resistant bacteria increases. Thus, make MRSA resistant to the commonly used antibiotics;

; for 1 mark, max is 4 marks

…
…
…
…
…

……

……**[4]**

Antibiotic resistance genes have been employed widely in recombinant DNA technology to produce transgenic bacteria containing human genes.

To produce insulin for medical uses, human insulin genes are transferred into bacteria. Plasmids containing two antibiotic resistance genes, one coding for resistance to tetracycline and one for resistance to ampicillin, are used to carry out this transfer.

Table 4.1 shows the actions of four different restriction enzymes, which might be used in the production of a recombinant DNA molecule, and the source of these enzymes.

Table 4.1

Organism	Restriction enzyme	Target DNA sequences (cleavage sites shown by arrow linings)
Escherichia coli RY 13	*Eco*RI	5′ G ↑A A T T C 3′ 3′ C T T A A↓ G 5′
Bacillus amyloliquefaciens	*BamH*I	5′ G ↑G A T C C 3′ 3′ C C T A G ↓ G 5′
Providencia stuartii	*Pst*I	5′ C T G C A ↑ G 3′ 3′ G ↓ A C G T C 5′
Haemophilus influenzae	*Hind*II	5′ G T Py ↑ Pu A C 3′ 3′ C A Pu ↓ Py T G 5′

(b) With reference to Table 4.1, explain why *EcoR*I, *BamH*I and *PstI* are more suitable for use in the cloning of human insulin gene than *Hind*II.

*EcoR*I, *BamH*I and *PstI* make staggered cuts in DNA to produce sticky ends on the human insulin gene and plasmid;
Upon mixing together, the insulin gene and the plasmid can then annealed through complementary base-pairing via hydrogen bond formation;

; for 1 mark, max is 1 mark

*Hind*II produces blunt ends;
Decrease efficiency/require additional steps of producing recombinant DNA molecules as linker DNA must be added for reannealing of the gene of interest and vector;
*Hind*II has restriction site/sequence that is not specific, may cut at multiple sites/another antibiotic resistant gene;

*Hind*II restriction site is not specific hence it may cut the plasmid at multiple locations, the gene of interest could be inserted into multiple locations/sites in the plasmid;

; for 1 mark, max is 1 mark

[Turn over

After the fragments of human DNA and the cut plasmids were mixed together, several types of plasmid were formed. The different types of plasmid are shown in Fig 4.1.

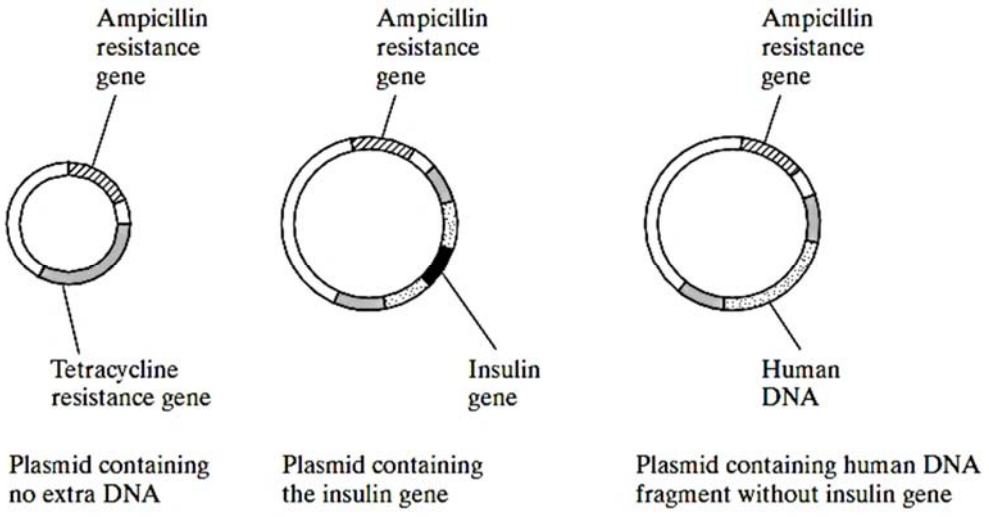

Fig 4.1

(c) State another property of the plasmid not shown in Fig. 4.1 that enables it to be used as a cloning vector.

Origin of replication;
Multiple cloning site/restriction sites;

; for 1 mark, max is 1 mark

(d) Explain how it is possible to distinguish between bacteria, which have taken up a plasmid with human DNA and those, which have taken up a plasmid without any extra DNA.

Plate the bacteria on nutrient agar plate containing ampicillin;
Only bacteria that have taken up the plasmid/both reannealed and recombinant plasmids can survive due to the presence of ampicillin resistance gene;
Using pad/velvet surface to transfer bacteria via replica plating onto a nutrient agar plate containing tetracycline;
For bacteria with human DNA, tetracycline gene is disrupted by insertion of the human DNA, and is no longer functional;
Comparing the colonies on the agar plate with ampicillin and those colonies growing on agar plate with tetracycline;

; for 1 mark, max is 3 marks

Bacteria with human DNA grow on agar plate with ampicillin but are killed by tetracycline on agar plate containing tetracycline;
Bacteria with no extra DNA in plasmid/reannealed plasmid can survive on agar plate containing tetracycline;

; for 1 mark, max is 1 mark

[Total: 11]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a), (b)** etc., as indicated in the question.

5.

(a) Compare the structure and role of deoxyribonucleic acid and ribonucleic acid. **[6]**

Feature	DNA	RNA
Similarities: • Both contain nucleotide monomers that is made up of nitrogenous base, pentose sugar and a phosphate group; • Both are polynucleotides and can form complementary base pairing between C-G and A-T(DNA) or A-U (RNA); • In complementary base-pairing for both DNA and RNA, same number of H-bonds form between C-G and A-T / A-U; • Same phosphodiester bonds joining the adjacent nucleotides/sugar-phosphate backbone; ; for 1 mark, Max is 2 marks		
Differences:		
Type of nucleotide monomer	Deoxyribonucleotide;	Ribonucleotide;
Type of pentose sugar	Deoxyribose;	Ribose;
Type of nitrogenous bases	Adenine, guanine, cytosine and thymine;	Adenine, guanine, cytosine and uracil;
Ratio of nitrogenous bases	Ratio of adenine to thymine, and cytosine to guanine is 1:1 for all DNA molecules;	Ratio of adenine to uracil, and cytosine to guanine varies/differs from one RNA molecule to another;
Structure	With the exception of the DNA in some viruses, DNA is always double helix/double-stranded/2 polynucleotide chains;	With the exception of the RNA in some viruses, RNA is always single-stranded/one polynucleotide chain;
Types of molecules	There is only one type of DNA;	There are three types of RNA, namely mRNA, rRNA and tRNA;
Size	Large molecule with more nucleotides;	Relatively small molecule with fewer nucleotide;
Role	A template for DNA replication and transcription;	mRNA: A template for protein synthesis/translation; Or tRNA: form complementary base pair with codons on mRNA to bring the corresponding activated amino acids to the ribosome/for translation elongation; Or rRNA: complex with protein to become ribosomal subunits/ribosome;
;; for 1 mark, max is 4 marks		

[Turn over

(b) Using named examples, explain how anatomical, embryological and molecular homology supports Darwin's theory of natural selection. **[7]**

- Anatomy, embryological and molecular homology provide evidences supporting evolution as a process of modifying the characteristics present in an ancestral organism by natural selection in its descendants over time;

Anatomical homology (max 2m)

- An example of an anatomical homology is that of the number and arrangement of bones in the forelimbs of mammals/ pentadactyl limb of mammals;
- The forelimbs of all mammals, including humans, cats, whales and bats, show the same arrangement of bones from the shoulder to the tips of the digits, even though these appendages have very different functions: lifting, walking, swimming and flying;
- Similarity is due to their descent from a common ancestor with the same basic structural plan that has been modified to allow the forelimb to adapt to a certain method of locomotion in a particular environment;
  OR

- Vestigial structures which are reduced or non-functional but shows homology to functioning structures in other species**;**
- such as appendix in human, pelvis and leg bones of snakes;
- Reflect descent with modification from a shared/common ancestor;
- when structure loses function as the selection pressure that selects for it is no longer present;

Embryological homology (max 2m)

- The embryological development of all vertebrates share remarkable similarities;
- All vertebrates embryos share the presence of a post anal tail / pharyngeal pouches / 2-chambered heart/segmented myotomes [mention at least 2 traits];

- Pharyngeal pouches in mammalian embryos are the equivalent/similar to gills in fish embryos at early developmental stages;
- become parts of the ears and throat in humans and other mammals and gills in fishes;

  Or
- 2-chambered heart is retained in fish but develops into 3-chambered heart in amphibians and 4-chambered heart in mammals;
- Similarities during early embryonic development in different vertebrate species can be explained if they descended from a common ancestor /;

Molecular homology (max 2m)

- All forms of life use the same genetic language of DNA and RNA/genetic code is universal. ;
- Likely that all species descended from common ancestors that used the same genetic code;
- Closely related species have more similar DNA/RNA/amino acid sequences in the homologous genes / proteins;
- Differences are a result of accumulated DNA mutations as descendants evolve independently/evolve along different lineages;
- Similarity in nucleotide base sequences is seen in both coding regions but also non-coding region of the DNA genome;

(c) Using named examples, discuss the importance of genetic engineering in solving the global demand for food. **[7]**

- Increase yield by genetically modifying food crops that will result in decreased losses caused by pesticides, fungal infestation, viruses, bacterial infection and pests;

Introduction of genes that code for proteins that confer insecticidal resistance
- Example: Genetically engineered crop plants that express the Bt-toxin gene from the bacteria *Bacillus thuringiensis* produce Bt-toxin protein which kills insect larvae feeding on the plant;

Introduction of genes that code for proteins that confer herbicidal resistance
- Example: Genetically engineered crop plants that are resistant to herbicides by introducing the herbicide/glyphosate resistance gene;
- When herbicide is applied to the field, the weeds are eliminated but not the herbicide resistance crop plants;

Introduction of genes that code for proteins that confer viral resistance;
- E.g., tobacco plant can be made resistant to the tobacco mosaic virus by expressing the coat protein gene of a virus;

Introduction of genes that code for growth hormones;
- Example: The Atlantic salmon has been genetically modified by the addition of a growth hormone gene from a Pacific Chinook salmon and an active promoter from an ocean pout placed upstream of the growth hormone gene;
- The insertion of the growth hormone gene results in faster growth rate and yield of the salmon, thereby increasing the supply of salmon;

Introduction of genes that delayed ripening
- Flavr Savr tomatoes are engineered to include a gene for antisense mRNA to polygalacturonase gene to reduce expression of polygalacturonase;
- This will result in delayed ripening allowing crops to be stored for longer period of time;

AVP;

; for 1 mark, max is 7 marks

[Turn over

6.

(a) Relate the structure of haemoglobin to its function in animals. **[6]**

HAEMOGLOBIN	
Structure	Function
Presence of non-polar amino acids, formation of a hydrophobic cleft, containing a haem binding site/region;	This provides a hydrophobic environment for the haem group to function;
Each subunit/polypeptide bears one haem prosthetic group containing Fe^{2+} ion; Each haem group contains an Fe^{2+} ion within a porphyrin ring;	Fe^{2+} ion is able to bind/combine reversibly to oxygen accounting for the oxygen-transporting ability of haemoglobin;
Each haemoglobin molecule carries 4 prosthetic haem group;	Each molecule can bind to/transport 4 oxygen molecules. This increases the oxygen-carrying capacity of red blood cell;
Amino acid residues found on the surface are generally hydrophilic/polar;	This allows haemoglobin to be a soluble globular protein in aqueous medium;
Binding of oxygen to 1 of the 4 subunits resulting in conformational changes in the remaining subunits/polypeptides;	This allows the other subunits to more readily bind to oxygen; Or Reference to cooperativity;

; for 1 mark, max is 3 marks
Structure and function must be correctly matched to be awarded the mark

(b) Explain the small yield of ATP produced by anaerobic respiration in mammals. **[6]**

Oxygen is the final electron acceptor of electron transport chain;
No oxygen means no movement of electron along ETC, no oxidative phosphorylation, no Krebs cycle and link reactions;
Oxidative phosphorylation produces 34 ATP per glucose molecules;
; for 1 mark, max is 2 marks

Incomplete/partial oxidation of glucose during anaerobic respiration in the absence of oxygen;
During glycolysis, 1 molecule of glucose is broken down to 2 molecules of pyruvate;
Glycolysis produces net yield of 2 ATP only and 2 reduced NAD/NADH per glucose molecule;
ATP production during glycolysis occur via substrate level phosphorylation;
No ATP is produced during lactate fermentation;
During lactate fermentation, pyruvate will be reduced to lactate by lactate dehydrogenase;
Reduced NAD/NADH is needed during lactate fermentation and NAD+ is regenerated so that glycolysis can continue to occur;
; for 1 mark, max is 4 marks

(c) Restriction digest is usually performed prior to agarose gel electrophoresis.

With reference to the principles of gel electrophoresis, discuss why the incubation time for restriction digest of the plasmid DNA is important in obtaining accurate results from gel electrophoresis. **[8]**

- DNA molecules are negatively charged due to the presence of negatively charged phosphate groups;
- When placed in an agarose gel with an electric current passing through it, DNA molecules will move towards the positive electrode/anode;
- Movement/migration of DNA molecules towards the positive electrode is impeded by agarose gel;
- The agarose gel forms a cross-linked matrix and functions as a 'molecular sieve' as the matrix forms little pores through which DNA must travel;
- DNA molecules will be separated into bands according to size/molecular mass and shape;
- Larger DNA molecules have more difficulty/encounter more resistance moving through the pores of the agarose gel;
- The larger DNA molecules move/migrate through the agarose gel at a slower rate/vice versa;
- Supercoiled DNA migrates the fastest, followed by the linear DNA. Circular DNA migrates the slowest;

; for 1 mark, max is 4 marks

- If the duration of restriction digestion is too long, it may result in the restriction enzymes cutting at unspecific sequences of the plasmid other than at the restriction sites;
- This affects the reliability and accuracy of the results as more fragments will be generated and more bands will be observed after gel electrophoresis;
- The fragments will also be smaller in size and will encounter less resistance, thus the band positions will be found closer to the anode;
- If the duration of restriction digestion is too short, it may result in the incomplete restriction digestion of the DNA;
- This affects the reliability and accuracy of the results as the total number of fragments will be lesser than actual, and fewer bands will be observed after gel electrophoresis;
- The plasmid may not be completely cut, resulting in circular DNA with 1 strand cut at 1 place;
- This leads a higher band position than usual as circular DNA encounter more resistance than linear DNA;
- Some plasmids may not be cut at all and may undergo supercoiling;
- This leads to lower band position than usual as supercoiled plasmid encounter the lesser resistance than linear DNA.

; for 1 mark, max is 4 marks

[Turn over