Class Adm No

Candidate Name: _____

H

millennia institute

2019 Preliminary Exams
Pre-University 3

BIOLOGY **9744/01**

Paper 1 Multiple Choice **23 September 2019**

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.

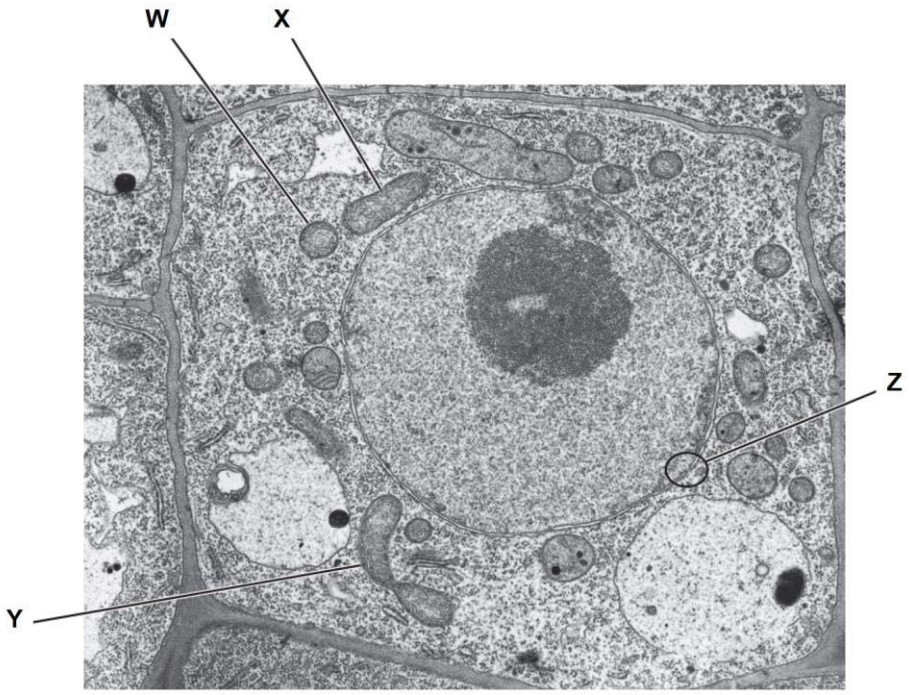
There are **thirty** questions in this paper. Answer **all** questions. For each question, there are four possible answers, **A**, **B**, **C** and **D**.
Choose the one you consider correct and record your choice in soft pencil on the separate answer sheet.

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.
The use of an approved scientific calculator is expected, where appropriate

This question paper consists of 25 printed pages

[Turn over

1. The figure below shows an electron micrograph of a cell from the root of thale cress, *Arabidopsis thaliana*.

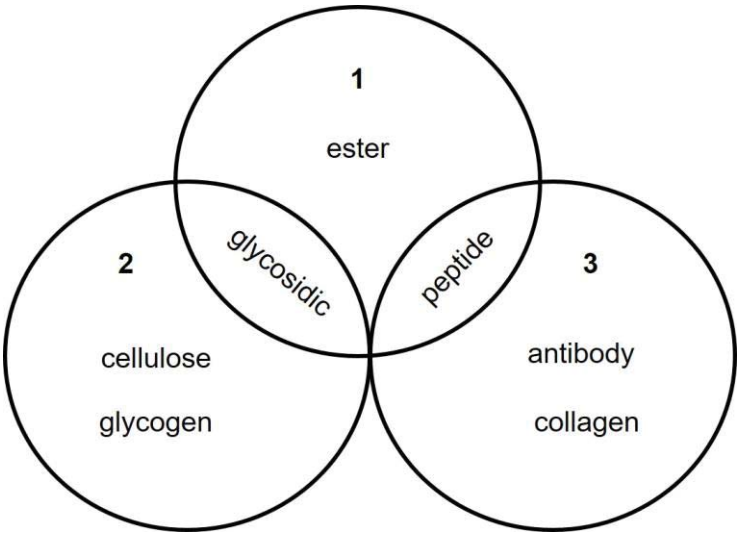


Which of the following statement(s) is/are true?

I **W** and **X** are both mitochondrion that are oriented differently.
II **Y** is a mitochondrion undergoing mitosis.
III **Z** is a phospholipid bilayer that regulates movement of substances.
IV There are no chloroplast present in the cell.

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

2. The diagram shows the relationships between some important molecules and bonds found in living organisms.

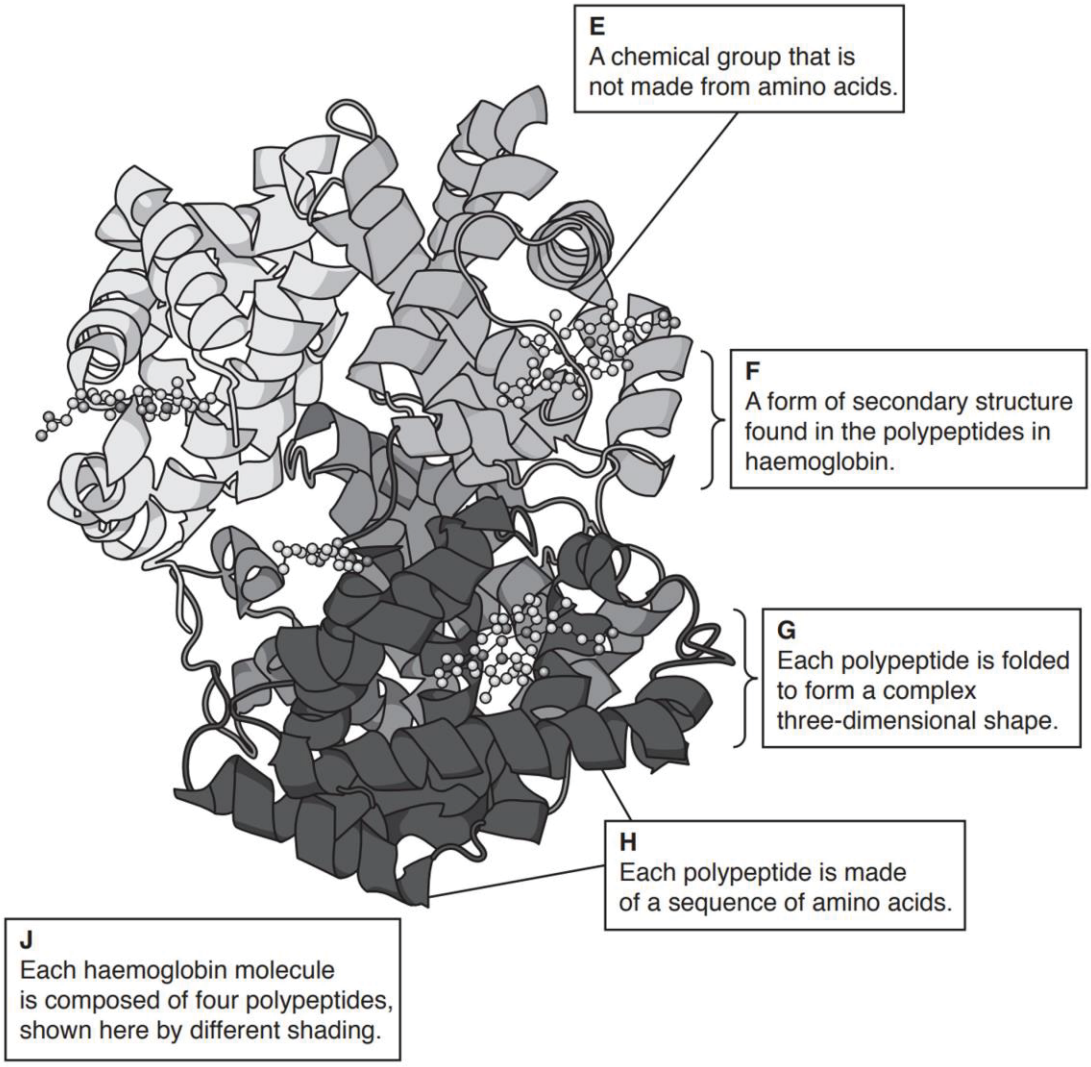


What is represented by circles numbered **1**, **2** and **3**?

	1	2	3
A	bonds formed by condensation	carbohydrates	proteins
B	bonds formed by condensation	proteins	lipids
C	bonds formed by hydrolysis	lipids	proteins
D	bonds formed by hydrolysis	proteins	carbohydrates

[Turn over

3. The following diagram shows a ribbon model of a molecule of haemoglobin.



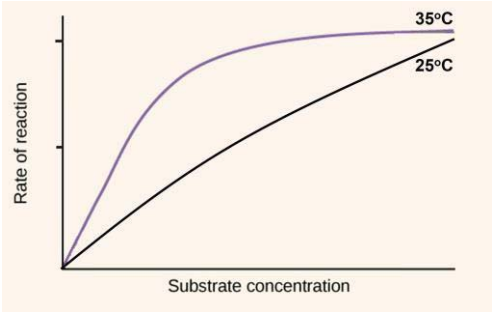
Which of the following terms correctly match to the description given in the boxes?

	E	F	G	H	J
A	haem	α-helix	quaternary structure	primary structure	tertiary structure
B	haem	β-helix	quaternary structure	primary structure	tertiary structure
C	haem	α-helix	tertiary structure	primary structure	quaternary structure
D	haem	α-helix	tertiary structure	peptide bond	quaternary structure

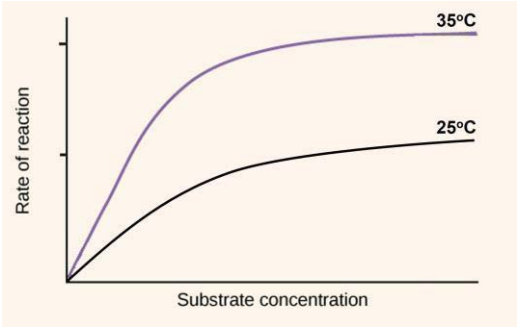
4. A student investigated the effect of substrate concentration on the rate of enzyme-catalysed reaction at the optimum temperature of 35°C. Subsequently, he repeated the experiment, but lowered the temperature to 25°C.

Which of the following correctly shows the result of the two sets of experiments?

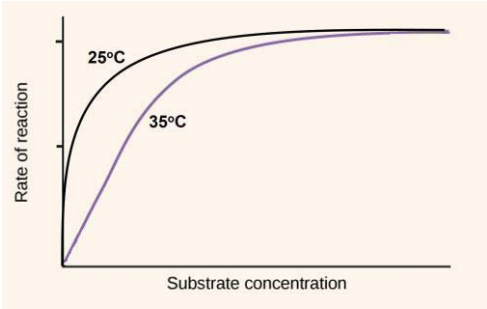
A



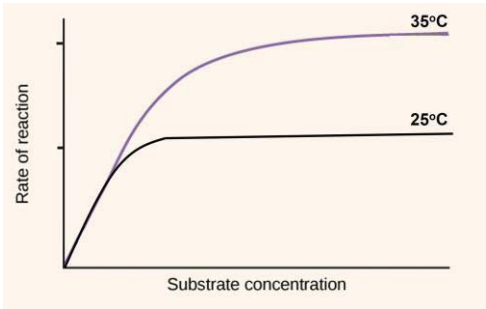
B



C



D



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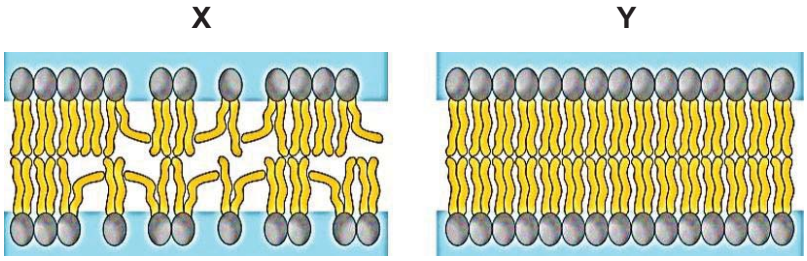
5. The following shows the structure of membrane in a plant cell during different seasons of the year.



Which of the following is true?

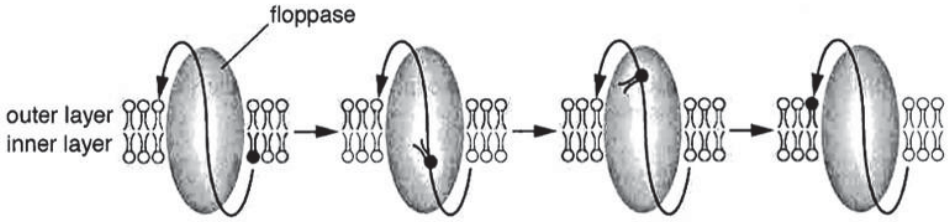
A **X** shows the membrane during summer, as it is more fluid to prevent membrane from melting.

B **Y** shows the membrane during summer, as it is more viscous to prevent membrane from melting.

C **X** shows the membrane during winter, as it is more viscous to prevent membrane from freezing.

D **Y** shows the membrane during winter, as it is more fluid to prevent membrane from freezing.

6. The following figure shows floppase, a protein found on the cell surface membrane that functions to move phospholipids from the inner layer to the outer layer.



Which of the following statements are likely to be correct?

I The presence of the hydrophilic phosphate head limits the diffusion of phospholipids between layers.

II Floppase provides a hydrophobic channel to facilitate the movement of phospholipids from inner to outer layer.

III Floppase ensures that the membrane layers are symmetrical.

IV Floppase has the ability to diffuse laterally within the membrane.

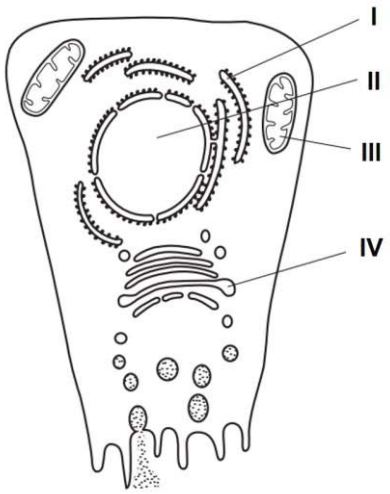
A **I** and **IV** only

B **II** and **III** only

C **I, II** and **III** only

D **I**, **II** and **IV** only

7. Radioactively-labelled nucleotides are introduced into a cell.



In which cell structures will the radioactivity first become concentrated?

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

8. DNA and RNA both contain nucleotides with adenine.

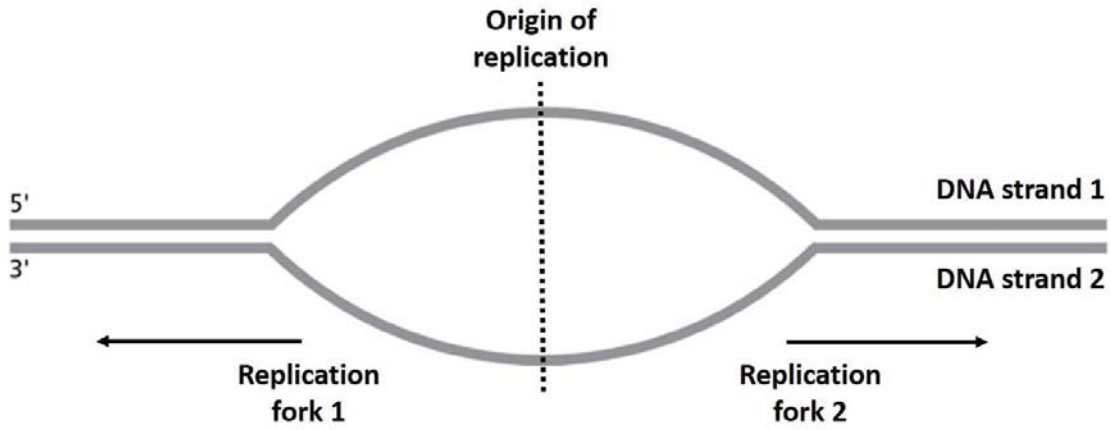
Which of the following below is true, regarding a DNA nucleotide with adenine, a RNA nucleotide with adenine and ATP?

I All three contains nitrogen.
II All three contains three phosphate groups.
III Only DNA nucleotide with adenine has a deoxyribose, while the other two contains ribose.
IV Both DNA and RNA nucleotide with adenine can be broken down to release energy for the synthesis of ATP.

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

[Turn over

9. The following diagram shows a replication bubble section of an eukaryotic DNA molecule undergoing DNA replication.



Which statements regarding the replication of DNA are correct?

I At replication fork 1, synthesis of the daughter strand of DNA strand 2 requires multiple RNA primers.

II At replication fork 2, synthesis of the daughter strand of DNA strand 2 is continuous.

III Daughter strands of both DNA strands 1 and 2 will face the end replication problem.

IV At the end of replication, a pair of homologous chromosome is formed.

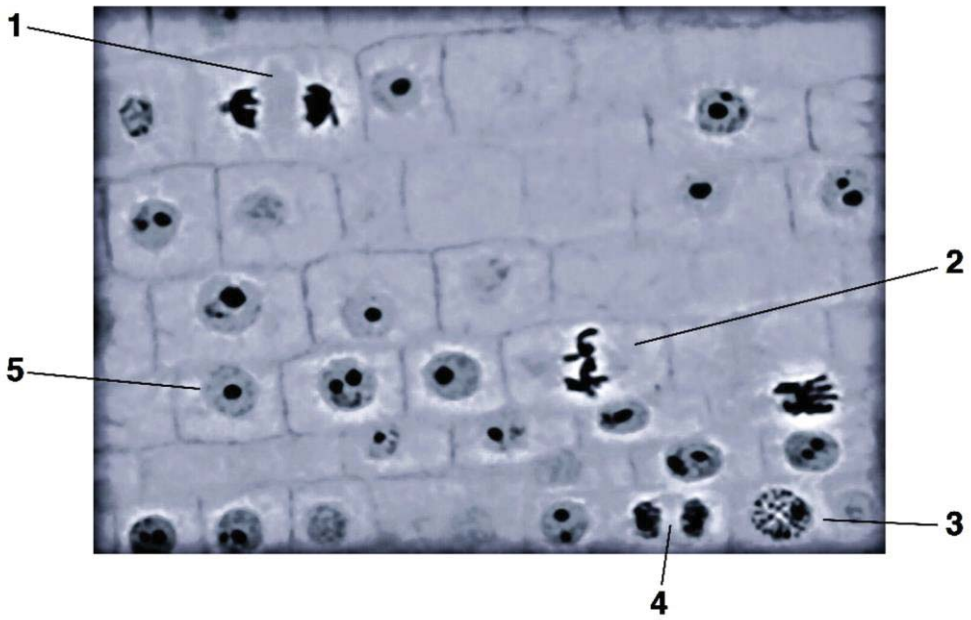
A **I** and **II** only

B **II** and **IV** only

C **I, II** and **III** only

D **I**, **III** and **IV** only

10. The figure below is a photomicrograph showing some cells in interphase and some cells in different stages of mitosis.

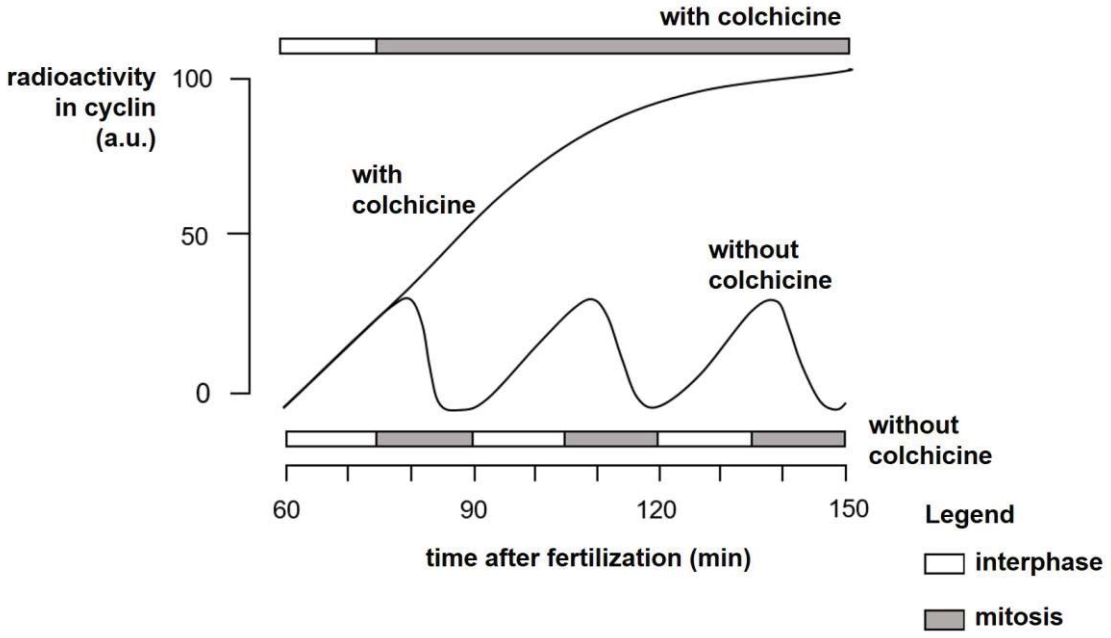


Which of the following correctly identifies events occurring at each stage?

	1	2	3	4	5
A	identical sister chromatids pulled apart	chromosome aligned in one row	spindle fibres begin to form	nuclear envelope reassembling	elevated rate of transcription and translation
B	homologous chromosomes pulled apart	homologous chromosome aligned in two rows	crossing over between non-sister chromatids	chromosome condenses back to chromatin	elevated rate of transcription and translation
C	homologous chromosomes pulled apart	homologous chromosome aligned in two rows	spindle fibres begin to form	nuclear envelope reassembling	DNA replication
D	non-identical sister chromatids pulled apart	chromosome aligned in one row	crossing over between non-sister chromatids	chromosome decondenses back to chromatin	DNA replication

[Turn over

11. A study on the effect of colchicine on mitotic cell cycle was carried out using clam embryos. The study involved two setups, one with colchicine and one without colchicine. A sample was obtained from both setups at every five minutes interval to identify the stage of mitotic cell cycle that the cell is currently at. The study also used radioactively labelled amino acids to monitor cyclin levels. The results are shown in the diagram below.



Which of the following can in inferred from the results?

I In the absence of colchicine, the cell entered a new mitotic cell cycle every 30 minutes.

II In the presence of colchicine, the cell is continuously dividing without leaving mitosis.

III High levels of cyclin is required for entry to mitosis while low levels is required for the cell to complete mitosis.

IV Presence of colchicine prevents the degradation of cyclin.

A **I** and **II** only

B **I** and **IV** only

C **II** and **III** only

D **I**, **III** and **IV** only

12. A karyotype study showed that an embryo has an abnormal number of sex chromosomes, XXY.

Which of the following statement(s) regarding the formation XXY embryo is/are true?

I Non-disjunction could have occurred during meiosis in either parent, but not both.
II Non-disjunction can only occur during meiosis in the mother.
III Non-disjunction can occur during either meiosis I or meiosis II of either parent.
IV One of the parental gamete was diploid while the other was haploid.

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

13. Three events that may result in cancer are listed.

- mutation in a tumour suppressor gene
- translocation of a proto-oncogene
- exposure to carcinogens and ionising radiation that increase the rate of mutation

K-ras and *c-myc* are proto-oncogenes. The inheritance of mutated alleles of either of these genes increases the risk of pancreatic cancer.

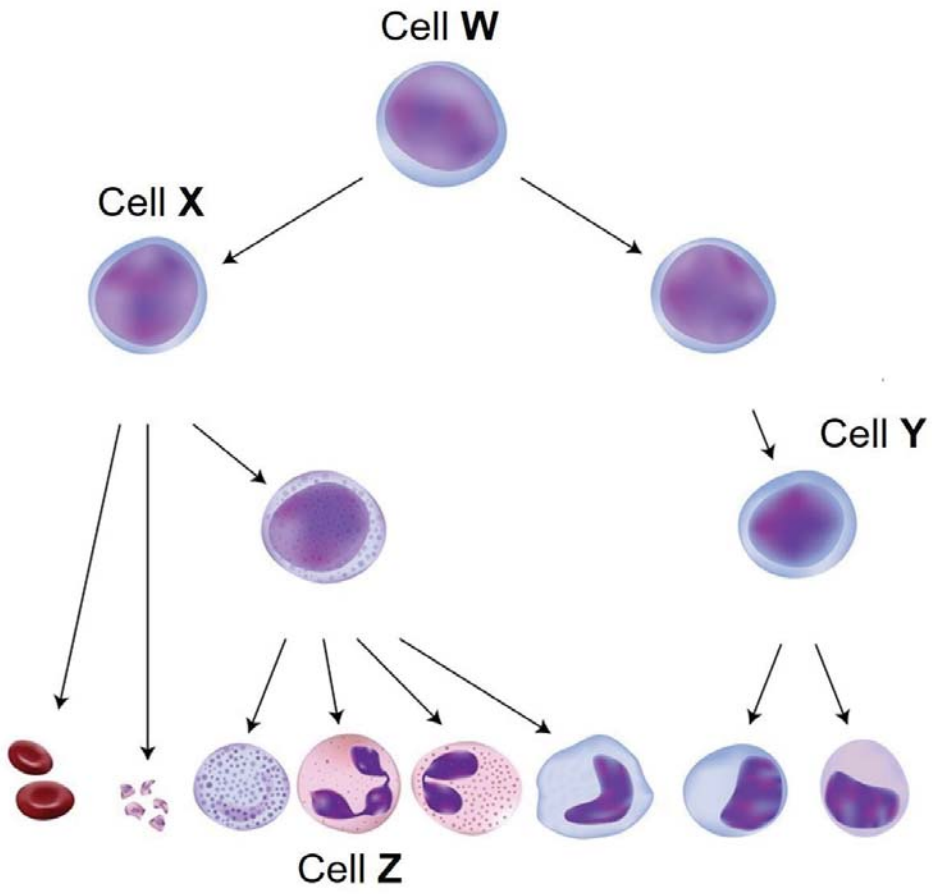
Which of these statements best explain why only some of the people who inherit either of these mutated alleles develop pancreatic cancer?

I Pancreatic cancer requires the inheritance of both mutated *k-ras* and *c-myc* alleles to develop.
II Exposure to carcinogens and ionising radiation varies largely among individuals.
III Mutations to tumour suppressor genes and proto-oncogenes accumulate randomly with age.
IV All three events must happen for pancreatic cancer to develop.

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

[Turn over

14. The following figure shows the production of all blood cells from Cell **W**.



Which of the following statement is true?

A Cell **W** does not have the ability to self-renew.

B Cell **X** is multipotent .

C Cell **Y** is unipotent.

D Cell **Z** is a specialised cell and has more genes than cell **W**, **X** and **Y**.

15. Which of the following correctly describes HIV and influenza virus?

	Attachment		Entry		Genome	
	HIV	influenza	HIV	influenza	HIV	influenza
A	GP120 on sialic acid containing receptor	haemagglutinin on CD4 receptor	receptor mediated endocytosis	membrane fusion	DNA	RNA
B	haemagglutinin on CD4 receptor	GP120 on sialic acid containing receptor	membrane fusion	membrane fusion	RNA	RNA
C	GP120 on CD4 receptor	Neuraminidase on sialic acid containing receptor	membrane fusion	receptor mediated endocytosis	DNA	RNA
D	GP120 on CD4 receptor	haemagglutinin on sialic acid containing receptor	membrane fusion	receptor mediated endocytosis	RNA	RNA

16. Which of the following correctly outlines the sequential steps involved in using southern blot to identify a specific gene from an extracted DNA sample?

A Gel electrophoresis, incubating with radioactive gene probe, transferring band to nitrocellulose membrane, visualisation via autoradiography.

B Gel electrophoresis, transferring band to nitrocellulose membrane, incubating with radioactive gene probe, visualisation via autoradiography.

C Gel electrophoresis, transferring band to nitrocellulose membrane, incubating with ethidium bromide, visualisation via UV light.

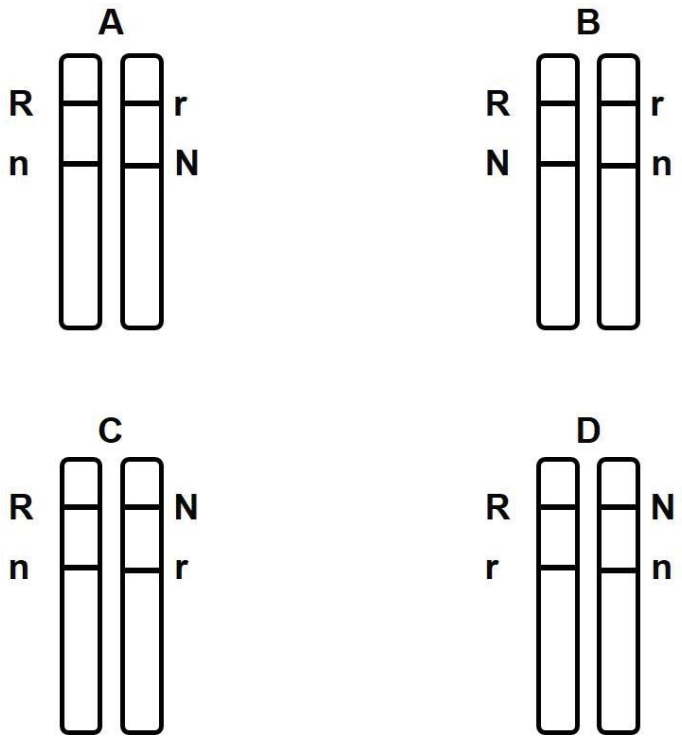
D Gel electrophoresis, incubating with ethidium bromide, transferring band to nitrocellulose membrane, visualisation via UV light.

[Turn over

17. In fruit flies the eye colour gene has two alleles, allele **R** coding for red eyes is dominant over allele **r** coding for purple eyes. The gene coding for wing type also has two alleles, allele **N** for normal wings and allele **n** for vestigial wings. Pure breeding fruit flies with red eyes and normal wings were crossed with pure breeding fruit flies with purple eyes and vestigial wings. F1 offspring obtained was then bred with fruit flies with purple eyes and vestigial wings. The results of the cross is shown below:

phenotype	number
red eyes and normal wings	23
red eyes and vestigial wings	235
purple eyes and normal wings	226
purple eyes and vestigial wings	16

Which of the following shows the likely location of the two genes and arrangement of the alleles in the F1 offspring?



18. The following are information regarding Fabry disease.

- It is a rare genetic disease
- Individuals with the disease lack the enzyme alpha galactosidase that results in the accumulation of a glycolipid in the blood vessels, tissues and organs, causing impairment of proper functions.
- It is found more commonly in males than females.
- Some females that appear normal can pass the disease on to their children.
- Some females that appear normal may show symptoms occasionally.

Which of the following can be inferred from the information provided?

I The gene coding for the enzyme alpha galactosidase is on the X chromosome.
II Females that have two normal alleles may occasionally show symptoms of the disease.
III Symptoms of the disease would be widespread throughout and not isolated to any body parts.
IV The mutant allele causing the disease is a recessive allele.

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

[Turn over

19. In sweet pea plants, the trait for purple flowers **P** is dominant to the trait for red flowers **p**. Similarly, the trait for long pollen, **L** is dominant to the trait for round pollen ***l***. A dihybrid cross was carried out followed by a chi-squared test. The p-value obtained was 0.12.

Which of the following shows the correct expected ratio, degree of freedom and interpretation of result for the chi-squared test at 5% level of significance?

	expected ratio	**degree of freedom**	**interpretation of result**
A	9:3:3:1	3	There is a 12% probability that the difference is not due to chance. The difference is significant and is different from the expected ratio.
B	1:1:1:1	3	There is an 88% probability that the difference is due to chance. The difference is insignificant and is the same as the expected ratio.
C	1:1:1:1	2	There is an 88% probability that the difference is not due to chance. The difference is significant and is different from the expected ratio.
D	9:3:3:1	3	There is a 12% probability that the difference is due to chance. The difference is insignificant and is the same as the expected ratio.

20. Lac operon present in bacteria responds to the changes in concentration of glucose and lactose. In a study, the following mutants were generated.

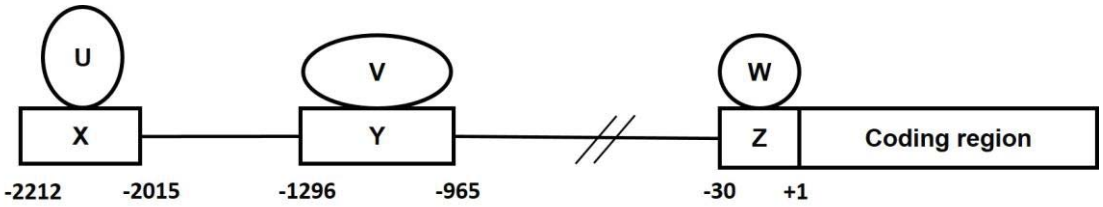
I Lac repressor does not bind to allolactose.
II Operator sequence is mutated, lac repressor is unable to bind.
III CAP remains active in the absence of cAMP.
IV CAP binding site is mutated, activated CAP is unable to bind.

Which of the following mutation combinations would give the indicated outcome in the presence of glucose and absence of lactose?

	constantly active at a high level	constantly active at a low level	constantly inactivated
A	**II** and **III**	**I** and **IV**	**II**
B	**II** and **III**	**II** and **IV**	**I**
C	**II** and **IV**	**I** and **III**	**IV**
D	**II** and **IV**	**II** and **III**	**I**

[Turn over

21. The following diagram shows an eukaryotic gene and the non-coding region upstream of it. Three non-coding regions **X**, **Y** and **Z** have been identified as binding sites for protein **U**, **V** and **W** respectively. To investigate the function of regions **X**, **Y** and **Z**, deletion study was carried out. The results are shown in the following table.



nucleotides deleted	amount of mRNA (a.u.)
none	244
-30 to 0	0
-1296 to -965	436
-2212 to -2015	57

Based on the results, what is the likely identity of region **X**, **Y** and **Z** and protein **U**, **V** and **W**?

	X	**Y**	**Z**	**U**	**V**	**W**
A	enhancer	silencer	promoter	activator	repressor	RNA polymerase
B	activator	repressor	promoter	enhancer	silencer	RNA polymerase
C	enhancer	operator	promoter	inducer	repressor	RNA polymerase
D	enhancer	silencer	origin of transcription	activator	repressor	DNA polymerase

22. Which of the following combinations isolated in a test-tube would allow mitochondria to begin ATP synthesis?

A mitochondria + ADP + P_i + pyruvate
B mitochondria + ADP + P_i + glucose + oxygen
C mitochondria + ADP + P_i + high concentration of protons (H^+)
D mitochondria + ADP + P_i + NAD^+ + FAD

23. F.F blackman carried out a series of experiments that measured the rate of photosynthesis for plants that were either exposed to light continuously or exposed to alternating periods of light and darkness. The total period of exposure to light was the same for all plants. All other factors were kept constant. The results were as follows:

- More photosynthesis resulted from brief flashes of light than from continuous exposure to light.
- Separating the flashes of light by longer intervals resulted in more photosynthesis.
- When the flashes of light were made shorter, there was no less photosynthesis.

Which of the following are valid inferences based on the information provided?

I Photosynthesis involves a stage that does not directly depend on light availability.
II The stage of photosynthesis that requires light reaches its maximum rate almost instantaneously.
III Rate of photosynthesis would increase with less light exposure.
IV The stage of photosynthesis that needs light depends on a substance produced by a different stage.

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

[Turn over

24. Mutant alleles that cause medical conditions negatively affect the health of the individuals. Some homozygous for specific mutant alleles would lead to death of the individuals before birth.

Which of the following could be reasons why these mutant alleles could still be passed on to subsequent generations?

I The mutant allele could provide selective advantage that increases the individual's fitness under a specific selection pressure.

II The symptoms of the medical condition are only expressed after the individual's reproductive age.

III Medical advances allows individuals to better cope with the medical condition and avoid cases of homozygous mutant.

IV Dominant normal allele masks the effect of the recessive mutant allele.

A **I** and **III** only

B **I** and **IV** only

C **II** and **IV** only

D **I**, **II** and **IV** only

25. The Eurasian blackcap, *Sylvia atricapilla* is a migratory bird that spends its summers in Germany where it breeds. Prior to 1960s, during winter, they would migrate southwest to Spain where they would spend their winter. Their migratory direction is determined genetically. In the 1960s, backyard bird feeding became popular in Britain, *S. atricapilla* that happen to migrate to Britain were able to survive winter successfully, thereafter returning to Germany in the summer to breed. The figure shows the two migratory routes of *S. atricapilla.*

In 2009, researchers found that there were significant genetic and morphological difference between *S. articapilla* that took different migratory routes.

Which of the following could account for the difference?

I *S. atricapilla* had the preference to mate with others that follow the same migration route, preventing gene flow of those that took different migratory routes.

II The different migratory route resulted in geographical isolation of the *S. atricapilla* population, preventing gene flow of those that took different migratory routes.

III The different migratory route resulted in a postzygotic barrier in which offspring resulting from parents that took different migratory routes were sterile.

IV *S. atricapilla* that migrated to Britain could return to Germany earlier to breed, whereas those that migrated to Spain arrived later to breed, resulting in temporal isolation.

A **I** and **III** only

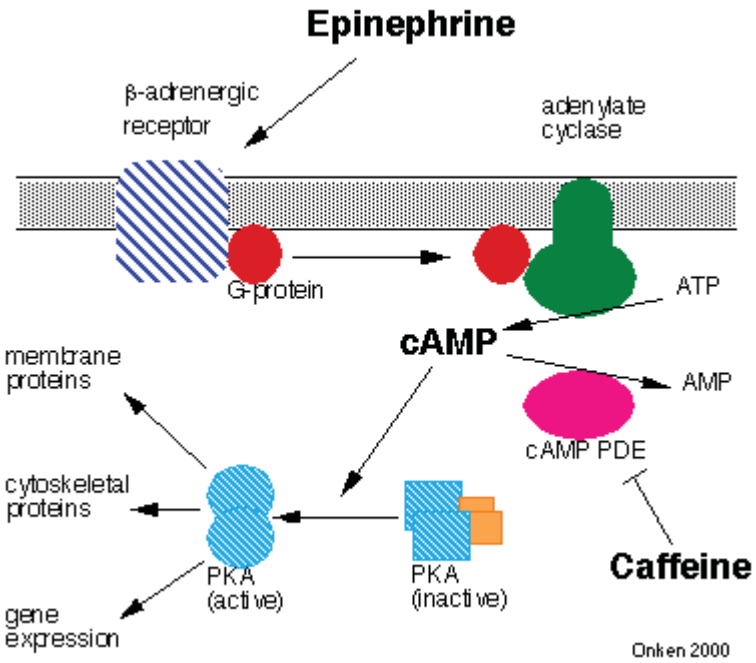
B **I** and **IV** only

C **II**, **III** and **IV** only

D **I**, **II** and **IV** only

[Turn over

26. Epinephrine (adrenaline) signalling in heart muscle cells causes changes in gene expression and membrane proteins to control the contractions and regulate heart function. One of which is an increase in rate of heartbeat. One side-effect of high caffeine dose is increase in rate of heartbeat. The following diagram shows how caffine is involved in the signalling pathway of epinephrine.



Based on the information provided, which of the following statement(s) is/are true?

I In the presence of caffine, epinephrine signalling will be prolonged even after epinephrine is no longer bound to the receptor.

II cAMP activates PKA via phosphorylation, leading to a phosphorylation cascade that amplifies the epinephrine signal.

III Activated PKA translocates into the nucleus to act as an enhancer binding to the activator to up regulate gene expression.

IV Presence of caffeine alone will be sufficient to trigger epinephrine signalling pathway.

A **I** only

B **I** and **II** only

C **II** and **III** only

D **I**, **III** and **IV** only

27. Bacillus Calmette-Guérin (BCG) vaccine is a vaccine primarily used against tuberculosis.

Which of the following statement is correct about tuberculosis?

A Vaccinated individuals will be able to mount a stronger response against the actual infection as the vaccine is long lasting and remains in the body for life.

B People infected with tuberculosis will not be infectious if the disease is in the latent phase.

C During the latent phase of tuberculosis, *Mycobacterium tuberculosis* integrates its DNA into the chromosome of macrophages.

D Transmission of the disease will increase with a larger percentage of the population being administered with the BCG vaccine.

28. Which of the following is not a limitation of using live-attenuated vaccines?

A It is not suitable for individuals with weakened immune system.

B It is not stable for transport to developing countries.

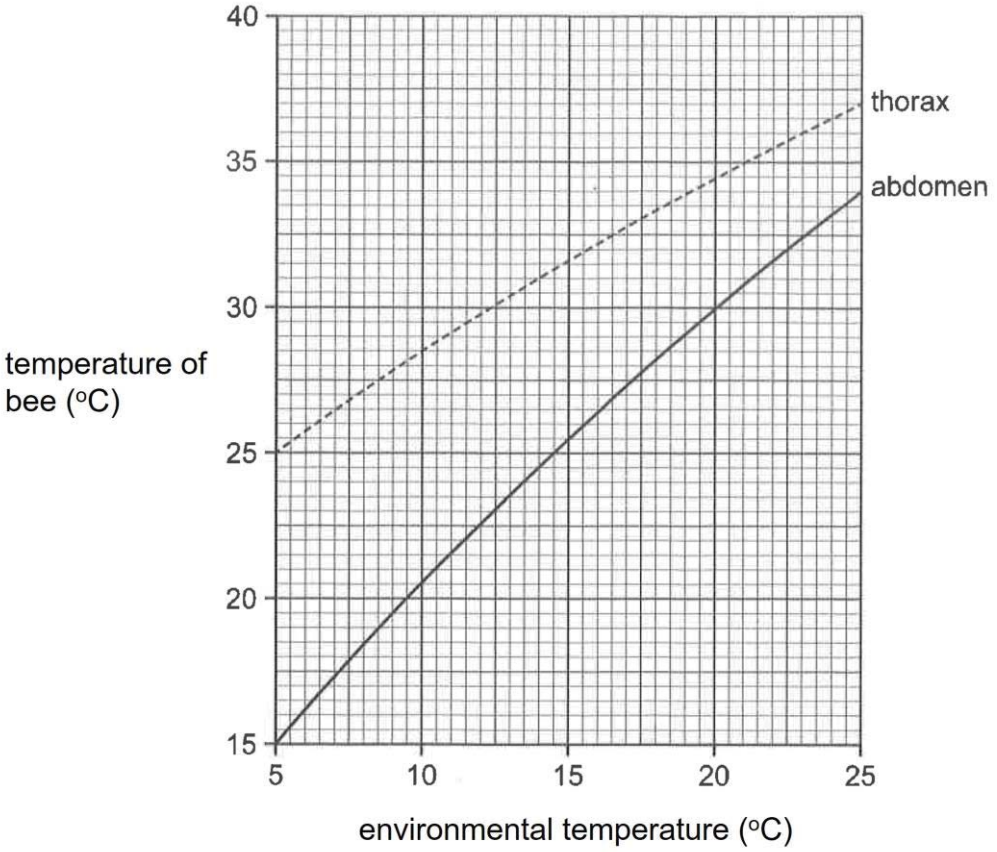
C It is challenging to ensure that it is both safe and able to stimulate the immune system sufficiently.

D It hijacks the host cell machinery to replicate, causing symptoms like fever and rash.

[Turn over

29. The bee, *Anthophora plumipes*, is common in the UK. It is active in the spring, when environmental temperature often varies widely. The bee can only fly when the temperature of the flight muscles in its thorax is sufficiently high.

The temperatures of both thorax and abdomen were measured during flight at a range of environmental temperatures. The results are shown in the graph.



Which statements are correct conclusions from the graph and information given?

I The bees are able to fly in a temperature range of at least 20°C.

II At environmental temperatures between 5°C and 25°C, the temperatures during flight of both the thorax and abdomen are higher than the environmental temperature.

III The bees can warm their flight muscles so that they can fly at low environmental temperatures.

IV Heat is generated in the abdomen and passed to the thorax.

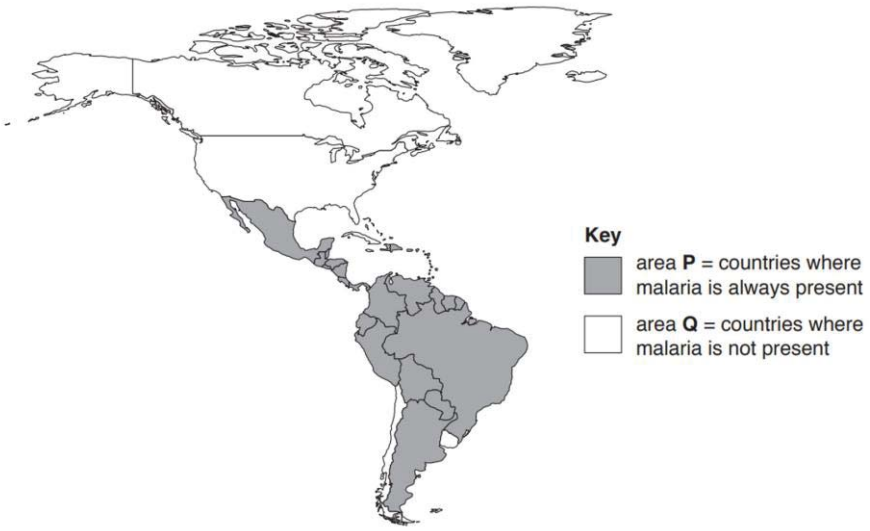
A **I** and **II** only

B **II** and **III** only

C **III** and **IV** only

D All of the above

30. The following figure shows the distribution of malaria in the Americas in 2012.



Which of the following factors could be limiting the distribution of malaria to area **P**?

I Climate in area **P** is optimal for growth for *Anopheles* mosquitoes.

II Area **Q** has a good control to drain stagnant water.

III The percentage of the population that is vaccinated in area **Q** remains relatively high over 90%.

IV Climate in area **P** is cool enough for the survival of *Plasmodium* during extrinsic incubation period.

A **I** and **III** only

B **II** and **IV** only

C **I**, **II** and **III** only

D All of the above

End of Paper

Candidate Name: _____

Class	Adm No

H

millennia institute

2019 Preliminary Exams
Pre-University 3

BIOLOGY **9744/02**

Paper 2 Structured Questions **17 September 2019**

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 in the question booklet.

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	
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7	
8	
Total	

This question paper consists of 25 printed pages, including 1 blank page.

[Turn over

Answer **all** questions in this section.

1. Fig. 1.1 shows the structure of a prokaryotic cell.

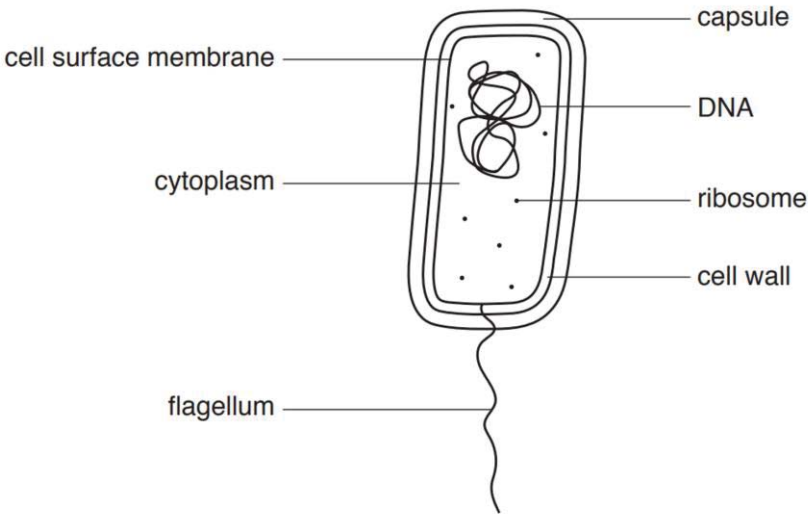

Fig. 1.1

Fig. 1.1 has not been fully labelled to confirm that the cell is prokaryotic.

(a) State what other information could be added to two of the labels to confirm that this cell is prokaryotic and not eukaryotic.

.....

.....

.....

.....**[2]**

Binary fission is one of the most common method of cell division in prokaryotes, while eukaryotes divide via the mitotic cell division.

(b) Describe one similarity and one difference between binary fission and mitotic cell division.

.....

.....

.....

.....**[2]**

(c) Penicillin is an antibiotic that is commonly used to treat bacterial infection. Penicillin works by disrupting the function of the enzyme involved in the synthesis of bacterial cell wall.

(i) State the enzyme that penicillin targets in bacteria.

……..**[1]**

Molecular studies have found that penicillin is able to form a permanent covalent bond with the active site of the target enzyme. Fig. 1.2 shows the effect of substrate concentration against the rate of cell wall synthesis with and without penicillin.

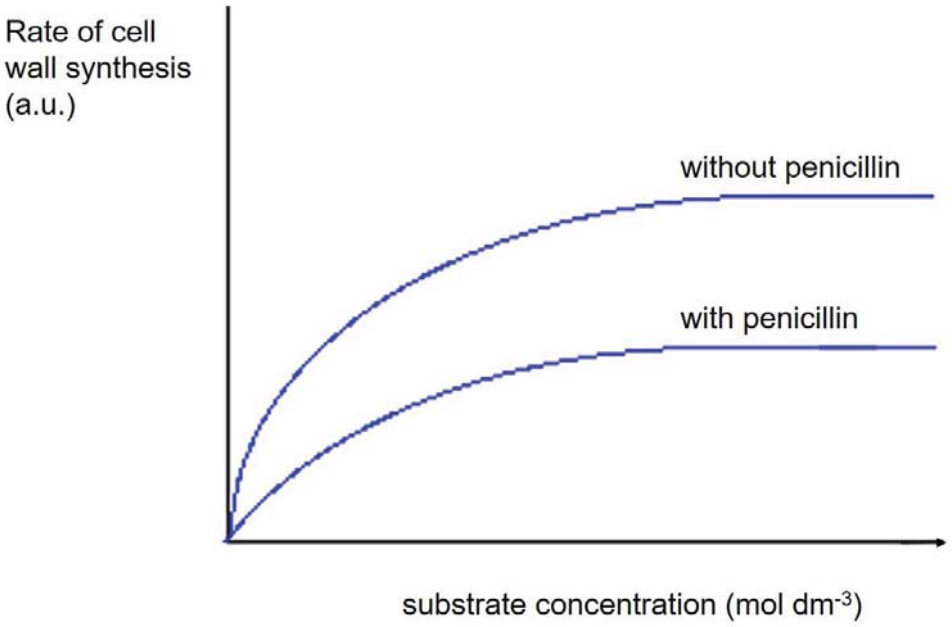

Fig. 1.2

(ii) Account for the difference in the graph with penicillin.

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……..**[4]**

[Total: 9]

[Turn over

2. Table 2.1 shows two processes in which ATP is synthesised in photosynthesis.

Table 2.1

	Energy conversion	Electron donor	Final electron acceptor
Cyclic photophosphorylation		P700	
Non-cyclic photophosphorylation		Water	

(a) Fill in the blanks in Table 2.1. **[3]**

In cellular respiration, ATP is synthesised via substrate-level phosphorylation and oxidative phosphorylation

(b) State the cellular location(s) for each of the reactions:

Substrate-level phosphorylation

……**[1]**

Oxidative phosphorylation

……**[1]**

Both chloroplast and mitochondria have the ability to synthesise ATP.

(c) Explain why a plant cell cannot rely on the ATP synthesised in chloroplast for all its energy requirement.

……

……

……

……**[2]**

Calvin cycle occurs during photosynthesis, while Krebs cycle occurs during cellular respiration.

(d) Explain why both Calvin cycle and Krebs cycle are termed as a 'cycle'.

……

……

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……**[2]**

[Total: 9]

[Turn over

3. Cystic fibrosis is a recessive genetic disease. The extent of the disease is dependent on the type of mutation that occurred in the *CFTR* gene. Table 3.1 shows a class I mutation that accounts for about 20% of cystic fibrosis occurrences. The nucleotide sequence for DNA codon 539 to 544 of the template strand in 5 'to 3' direction is shown for both the normal and mutant sequence.

Table 3.1

5'	codon	539	540	541	542	543	544	3'
	normal	TCC	ACC	TTC	TCC	AAG	AAC	
	mutant	TCC	ACC	TTC	TCA	AAG	AAC	

(a) With reference to Table 3.1,

(i) identify the type of mutation that occurred.

.....**[1]**

(ii) describe the effect of this mutation on the structure of CFTR synthesised.

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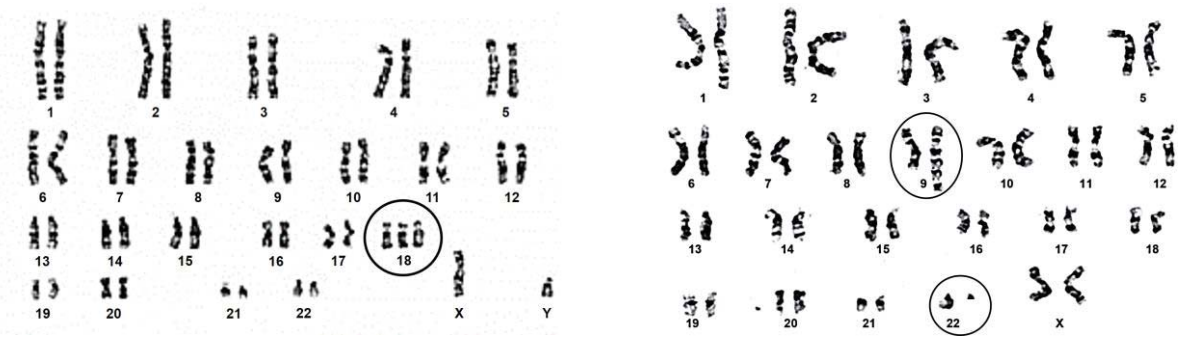
.....**[4]**

(b) Fig. 3.1 shows the karyotype of two individuals, **A** and **B**, suffering from two different genetic diseases.



A **B**

Fig. 3.1

The chromosomes were stained using Giemsa stain that forms dark and light bands based on the structure of the chromosome.

(i) Suggest the structure of the chromosome that appears as dark and light bands.

Light bands .....

.....**[1]**

Dark bands .....

.....**[1]**

The mutation in individual **A** and **B** is circled in Fig. 3.1.

(ii) With reference to Fig. 3.1, distinguish between the type of mutation seen in individual **A** and **B**.

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.....**[2]**

[Total: 9]

[Turn over

4. James Watson, Francis Crick along with the help of Rosalind Franklin and Erwin Chargaff deduced the structure of DNA.

(a) Erwin Chargaff found that the proportions of the bases A, T, C and G were different in different species, but within each species:

- the proportion of A was equal to the proportion of T
- the proportion of G was equal to the proportion of C.

The four bases found in DNA can be classified as purine or pyrimidine.

(i) Identify which bases are purine and pyrimidine.

purine **……**

pyrimidine **……**

[2]

(ii) Explain how Chargaff's findings helped Watson and Crick work out the structure of DNA.

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……

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……

……[3]

Control of gene expression is crucial in controlling the amount of protein product within the cell, such that resources are utilised efficiently.

(b) Table 4.1 shows different ways in which gene expression can be controlled.

Complete Table 4.1 by indicating the mechanism and explanation.

Table 4.1

mechanism	**effect on amount of protein product produced (increase / decrease)**	**explanation**
	increase	neutralises charge on lysine residues, causes DNA to be less tightly coiled around histone
lengthening of mRNA poly-A-tail	increase	
synthesising a short RNA molecule that is complementary to start of mRNA	decrease	
	decrease	targeted proteins are degraded by proteasome

[4]

[Turn over

Testosterone is a steroid hormone produced naturally by the body. In males, one of the target cell for testosterone is the prostate cell, which plays a role in the development of male characteristics.

Both testosterone and insulin are ligands that bind to specific receptors.

(c) Distinguish between the structure of testosterone and insulin.

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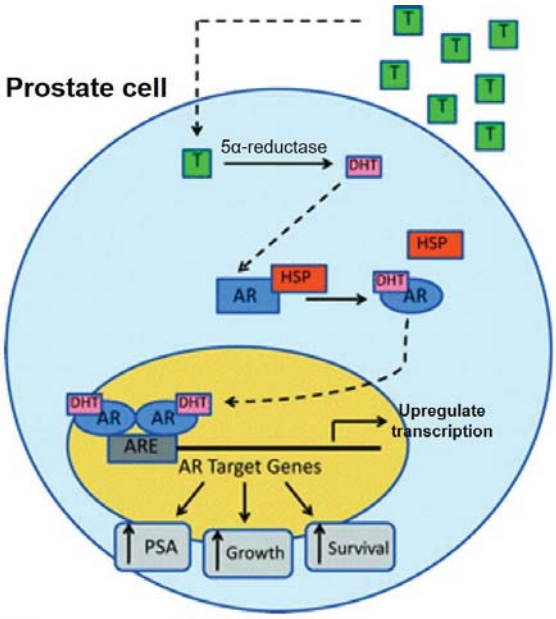
.....**[2]**

Fig. 4.1 shows testosterone signalling in a prostate cell.



Legend:

T	Testosterone
DHT	Dihydrotestosterone
HSP	Heat shock protein
AR HSP	Inactive androgen receptor (AR) bound by heat shock protein (HSP)
DHT AR	Activated androgen receptor (AR) bound by dihydrotestosterone (DHT)
ARE	Androgen response element (control element)
PSA	Prostate specific antigen

Fig. 4.1

(d) Prostate cancer is one of the most common cancer among men. In some prostate cancer, it is common to find a mutant form of the androgen receptor (AR) that cannot be bound by heat shock protein (HSP), as such it is always in its active form.

(i) Using your knowledge of cancer development, state the class of gene that a normal androgen receptor gene belongs to.

.....**[1]**

Prostate specific antigen (PSA) is a protein secreted by prostate cells. It is required for the normal functioning of the male sex organ. In prostate cancer detection, a common method is to detect for elevated levels of PSA.

(ii) With reference to Fig. 4.1, describe how a mutated androgen receptor could lead to elevated levels of PSA.

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.....**[4]**

[Turn over

Mutant androgen receptor is just one of many other mutations found in prostate cancer.

(iii) Explain why multiple mutations are required in the development of cancer.

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.....**[4]**

[Total: 20]

5. In pigeons, the sex chromosomes are termed as Z chromosome and W chromosome. Male pigeons are homogametic, ZZ while female pigeons are heterogametic, ZW. *Tyrp1* gene is located on the Z chromosome and the gene determines feather colours in pigeons. There are three alleles of *Tyrp1* gene:

$\mathbf{Z^{BA}}$ coding for ash-red feathers
$\mathbf{Z^{B+}}$ coding for blue feathers
$\mathbf{Z^{b}}$ coding for brown feathers

Table 5.1 shows three different crosses and the resulting phenotypes of offspring.

Table 5.1

Parental phenotype		**offspring phenotype**	
male	**female**	**male**	**female**
pure bred blue	ash-red	all ash-red	all blue
pure bred brown	blue	all blue	all brown
pure bred ash-red	brown	all ash-red	

(a) With reference to the information provided and Table 5.1, state one possible genotype for a non-pure bred male pigeon with ash-red feathers.

……[1]

Another gene on an autosomal chromosome, *Sox10*, codes for an activator to *Tyrp1* gene. Dominant allele **E** codes for a functional activator, while recessive allele **e** codes for a non-functional activator. When *Tyrp1* gene is not expressed, the pigeon feather turns red.

(b) State the type of interaction between *Sox10* gene and *Tyrp1* gene.

……[1]

[Turn over

Pure-breeding male with ash-red feathers was crossed with a red female. The resulting F1 generation all had ash-red feathers. F1 generation was then allowed to interbreed. The results are shown in Table 5.2.

Table 5.2

phenotype	number
ash-red	898
brown	294
red	408

(c) Draw a genetic diagram to show the cross between F1 generation.

[5]

[Total: 7]

6. In an attempt to directly observe and record data for speciation, a group of scientist studied a species of lytic phage, EvoC. Phages are known to attach to bacteria via binding of specific receptors. LamB and OmpF are examples of such receptors expressed by *Escherichia coli (E. coli)*. Uniquely, EvoC is able to recognise and bind to either LamB or OmpF, thereby able to infect *E. coli* that expresses either of the specific receptor, LamB or OmpF.

(a) Phages that infects a same species of bacteria are classified under one species.

(i) State the species concept used to define the phage.

.....[1]

Viruses are known to have high mutation rates. Despite not having a mechanism for sexual reproduction, advantageous mutations can still be spread via genetic recombination.

(ii) Using your knowledge of bacteriophage reproductive cycle, suggest how genetic recombination can occur in a population of bacteriophage.

.....

.....[1]

[Turn over

The group of scientists genetically modified *E. coli* such that it only expresses either one of the receptor. They then created two separate set-ups in an attempt to observe speciation:

- **Group A**: Phage EvoC + *E. coli* expressing only LamB receptor.
- **Group B**: Phage EvoC + *E. coli* expressing only OmpF receptor.

Phages in group **A** and **B** were then allowed to propagate in isolation. The results are as follows:

- **Group A**: All viral progenies now only specifically infect *E. coli* expressing LamB receptor and are unable to infect *E. coli* expressing OmpF receptor.
- **Group B**: All viral progenies now only specifically infect *E. coli* expressing OmpF receptor and are unable to infect *E. coli* expressing LamB receptor.

(b) State the type of speciation that the group of scientists are modelling.

.....[1]

To find an explanation for the observation, the group of scientists then went on to measure the rate of absorption to the receptors in the original EvoC phages and the progenies from Group **A** and **B**. The results are shown in Fig. 6.1.

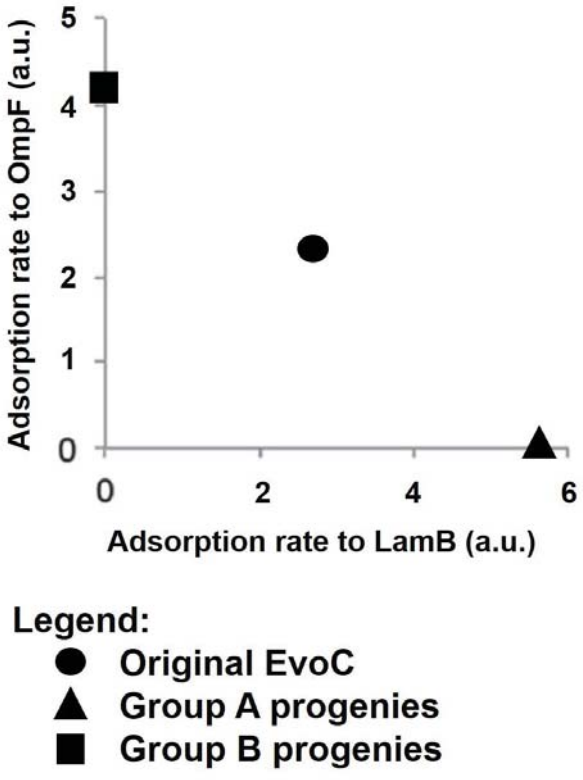

Fig. 6.1

(c) With reference to Fig. 6.1 and the information provided,

(i) state the selection pressure acting on EvoC phages in this experiment.

……..……

……..**[1]**

(ii) state which trait was selected against in group **A**.

Group **A** ……..

……..**[1]**

(iii) based on your answers in **c(i)** and **c(ii)**, explain the results obtained from group **A**.

……..

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……..

……..**[4]**

(iv) justify if speciation has occurred.

……..

……..

……..

……..**[2]**

(v) Suggest a reason why the scientists chose to use phage to study speciation.

……..……

……..**[1]**

[Total: 12]

[Turn over

7. Table 7.1 shows different stages in the life cycle of a female *Aedes aegypti* (*A. aegypti)*.

Table 7.1

Stage	Aquatic	Terrestrial	Able to transmit dengue virus
Eggs			
Larva			
Pupa			
Adult			

(a) Place a tick (✓) in appropriate boxes that applies to each stage. **[2]**

Fig. 7.1 shows the dengue virus (DENV) infection and its reproductive cycle in *A. aegypti*.

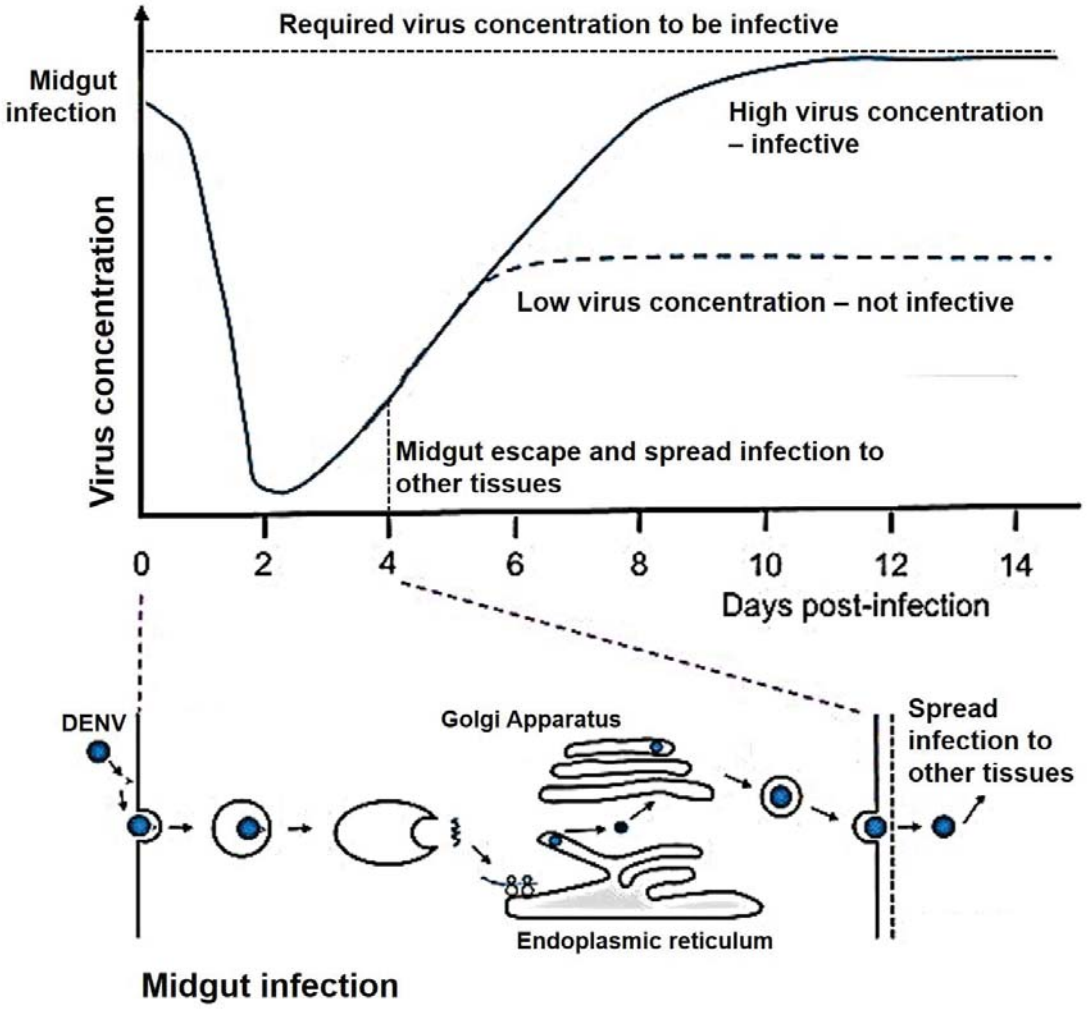

Fig. 7.1

The period between midgut infection and becoming infective is termed as the 'extrinsic incubation period'.

(b) With reference to Fig. 7.1,

(i) account for the change in virus concentration upon midgut infection to when *A. aegypti* is considered infective.

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.....**[3]**

(ii) compare the reproductive cycle of DENV and influenza.

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.....**[4]**

[Turn over

Fig. 7.2 shows the development of a primary dengue infection with timing of diagnostic test.

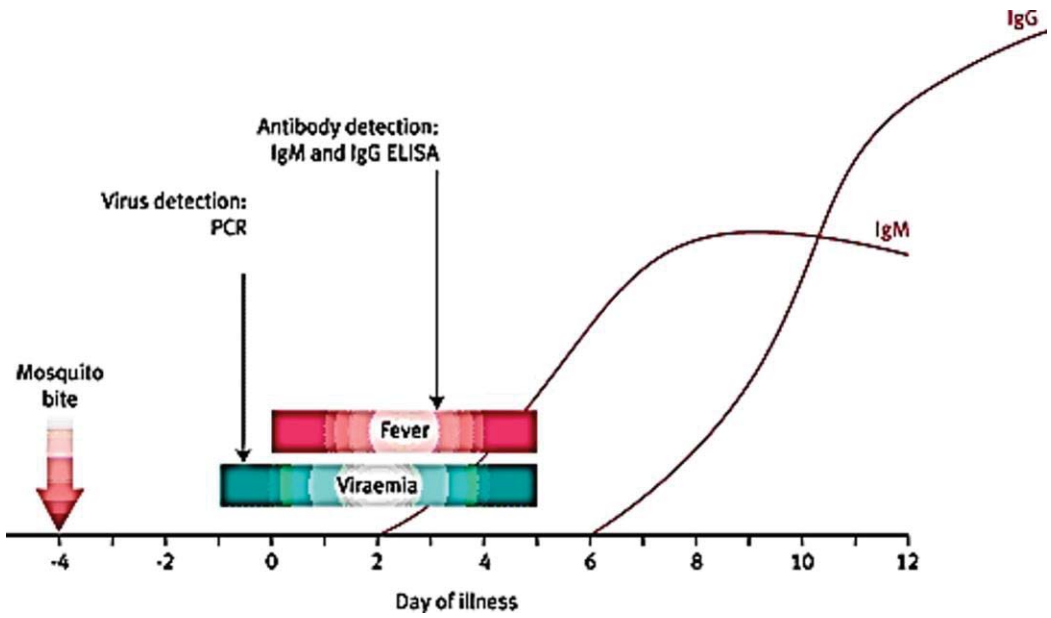

Fig. 7.2

(c) Polymerase chain reaction (PCR) and gel electrophoresis can be carried out on a sample of DNA extracted from the patient's blood to identify the presence of DENV.

PCR is a powerful molecular technique as it is able to amplify a target sequence from a mixture of DNA.

(i) Identify the type of blood cell that would contain the patient's DNA.

.....**[1]**

(ii) Describe how PCR is able to specifically amplify DENV DNA only.

.....

.....

.....

.....**[2]**

The PCR products can be visualised to analyse the results.

(iii) State how the PCR products can be visualised without the use of probes.

.....

.....**[1]**

(iv) Based on the method stated in **c(iii)**, describe what would be the expected result for a patient with DENV infection.

.....

.....**[1]**

(v) Suggest why PCR would only be effective at least three days after infection.

.....

.....**[1]**

IgM was produced on day 2 of illness, while IgG was produced on day 6 of illness

(vi) With reference to Fig. 7.2, describe the process occurring between day 2 and day 6 of illness causing the production of IgG.

.....

.....

.....

.....

.....

.....**[3]**

[Turn over

(d) In the space provided below, draw a labelled diagram of an antibody.

[4]

(e) Patients who recover from the infection by one particular serotype of DENV gain lifetime immunity against that particular serotype.

(i) State the type of immunity achieved.

……..……[1]

(ii) Explain why patients would only be immune to the same serotype but not to all DENV serotypes.

……...

……...

……...

……..[2]

[Total: 25]

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8. Global atmospheric carbon dioxide level has been rising at an accelerating rate over the past decade, causing changes in climate.

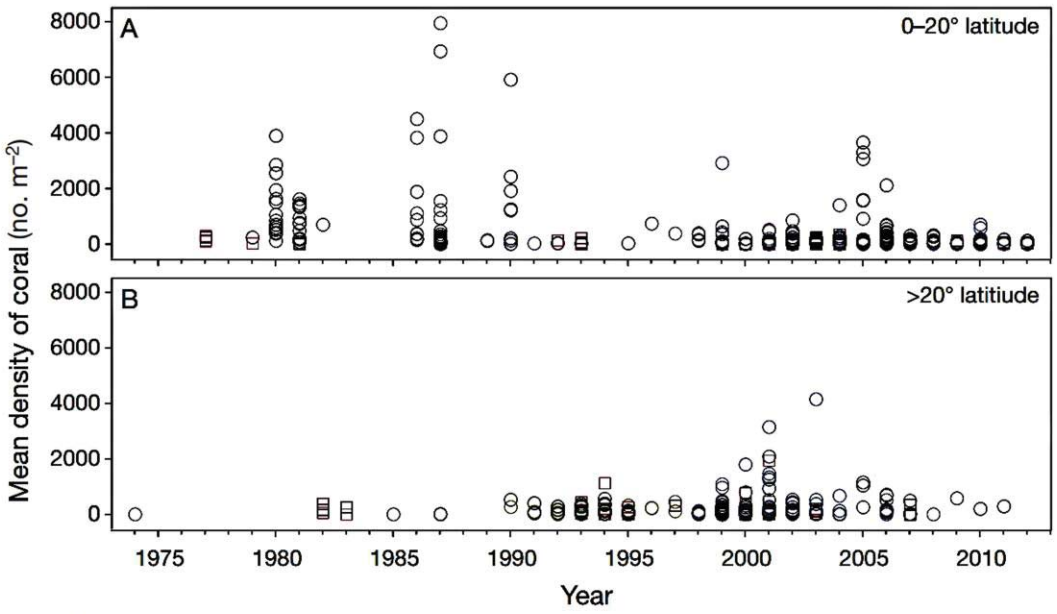
Carbon dioxide is one of the major greenhouse gases, whereas compared to oxygen, oxygen is not classified as a greenhouse gas.

(a) Describe the property of carbon dioxide for it to be classified as a greenhouse gas.

.....

.....**[1]**

Due to increase in greenhouse gases, global temperature has been on the rise, including the oceans. Marine organisms like corals are temperature sensitive. Fig. 8.1 shows the distribution of corals over a period of time.



Data point indicates different locations within the latitude range

Fig. 8.1

(b) With reference to Fig. 8.1, describe how the distribution of corals has changed from 1975 to 2010.

.....

.....

.....

.....**[2]**

(c) Explain why the change in distribution occurred.

.....

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.....**[4]**

(d) Suggest possible impacts due to the change in distribution of corals.

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.....**[2]**

[Total: 9]

End of Paper

Candidate Name: _____

Class	Adm No

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2019 Preliminary Exams
Pre-University 3

BIOLOGY **9744/03**

Paper 3 Long Structured and Free-response Questions **19 September 2019**

2 hours

Additional Materials: Writing Paper

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 on the Question Paper.

Section B
Answer any **one** question on writing paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
Section B	
Total	

This question paper consists of 19 printed pages, including 1 blank page.
[Turn over

Section A

Answer **all** questions in this section.

1. The immune system plays an active role in the prevention of cancer development. Fig. 1.1 shows how an immune cell interacts with a cancer cell.

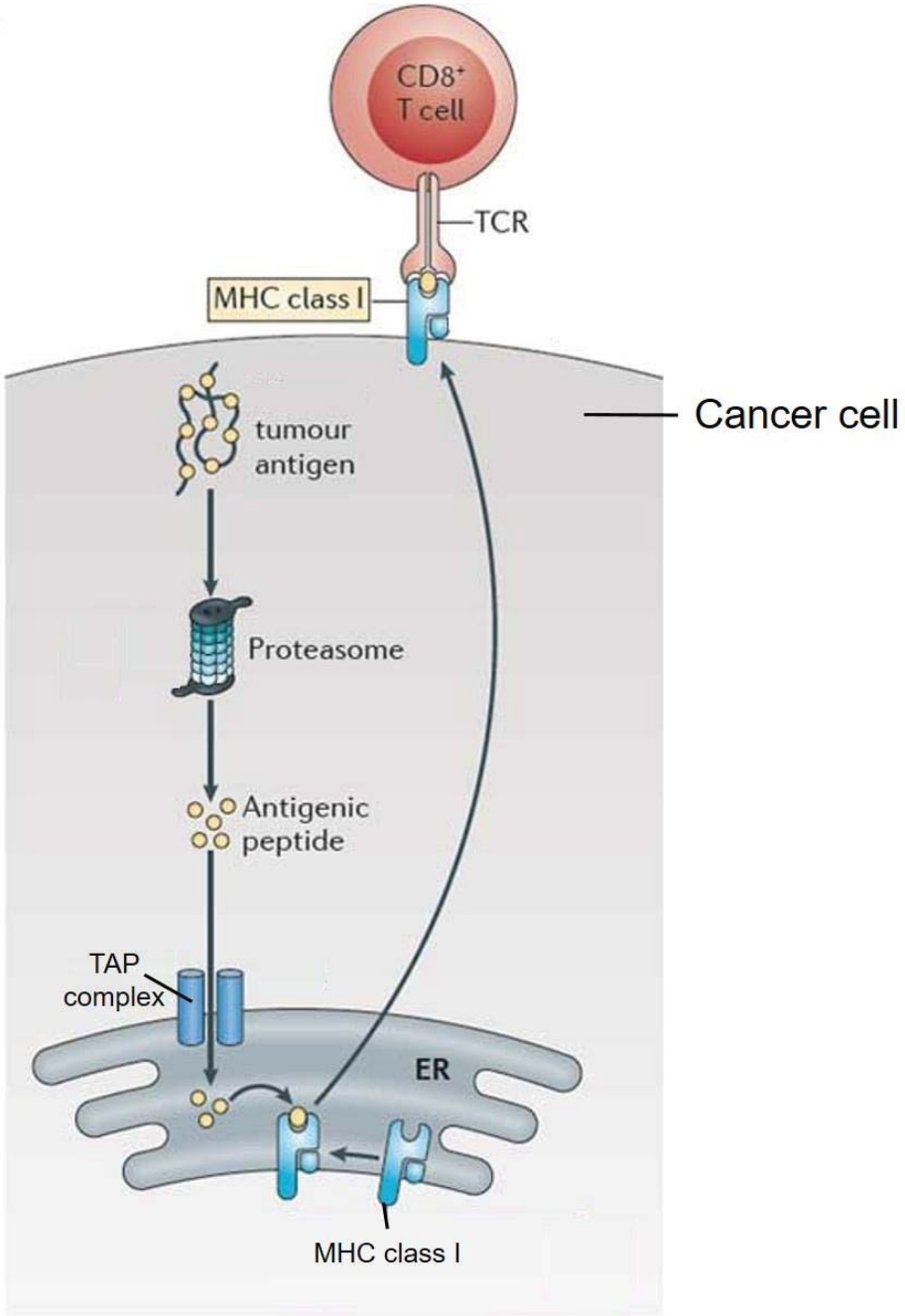

Fig. 1.1

(a) Define the term, 'antigen'.

.....[1]

The immune system is able to identify normal cells as the antigen displayed on the cell surface is normal and termed as self-antigen. However, in cancer cells, instead of displaying self-antigens, they display tumour antigens and thus are recognised as foreign by the immune system.

(b) Account for the presence of tumour antigen within cancer cells.

…….

…….

…….

…….**[2]**

(c) With reference to Fig. 1.1, describe how the cancer cell presents tumour antigen.

…….

…….

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…….

…….**[4]**

It is important that the immune cells do not recognise and bind to normal cells displaying self-antigens.

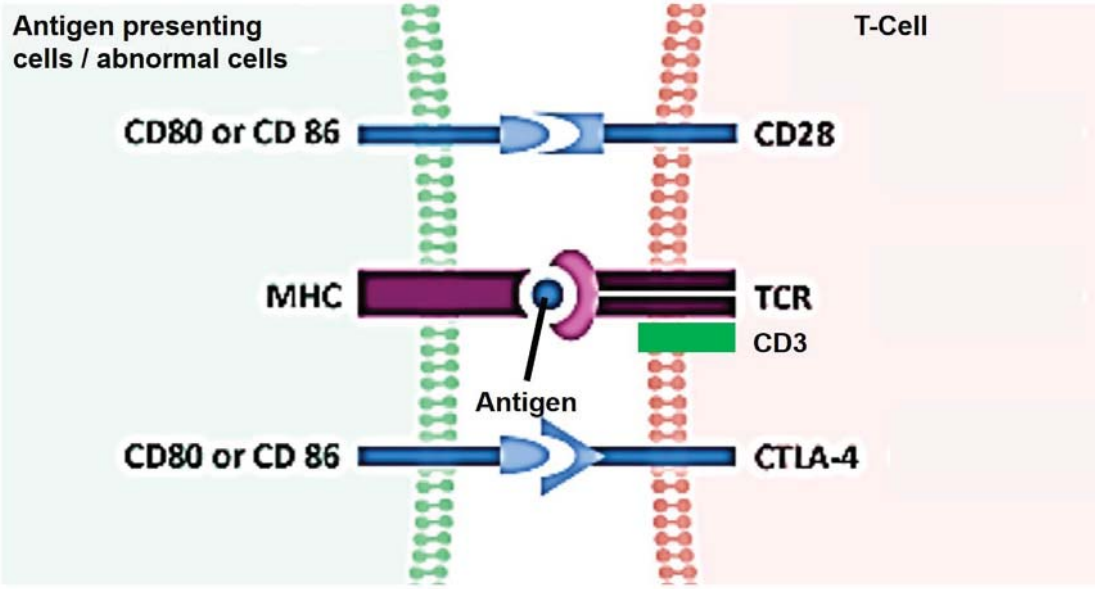
(d) State how the immune cell in Fig. 1.1 is able to specifically recognise only cancer cells.

…….

…….**[1]**

[Turn over

The activation of T-cells is highly regulated. There are various receptors on T-cells that play a role in the regulation of T-cell activation. The various receptors along with their ligands are shown in Fig. 1.2.



Receptors:
CD28 : Cluster of differentiation 28
TCR : T-cell receptor
CD3 : Cluster of differentiation 3 (co-receptor associated with TCR)
CTLA-4 : Cytotoxic T-lymphocyte-associated protein 4

Fig. 1.2

To investigate the roles of CD28 and CTLA-4 receptor in the activation of T-cells, the following three monoclonal antibodies were used. Table 1.1 shows the target and effects of the three monoclonal antibodies.

Table 1.1

monoclonal antibody	**target**	**effect**
anti-CD28	CD28 receptor on T-cells	mimics ligand binding and activates CD28 receptor
anti-CTLA-4	CTLA-4 receptor on T-cells	mimics ligand binding and activates CTLA-4 receptor
anti-CD3	co-receptor CD3 associated with TCR on T-cells	mimics ligand binding and activates co-receptor CD3 which triggers the activation of TCR

A population of T-cells were harvested from mice and exposed to different sets of the three monoclonal antibodies. The number of activated T-cells were then quantified using radioactivity in terms of counts per minute (cpm). Fig. 1.3 shows the results.

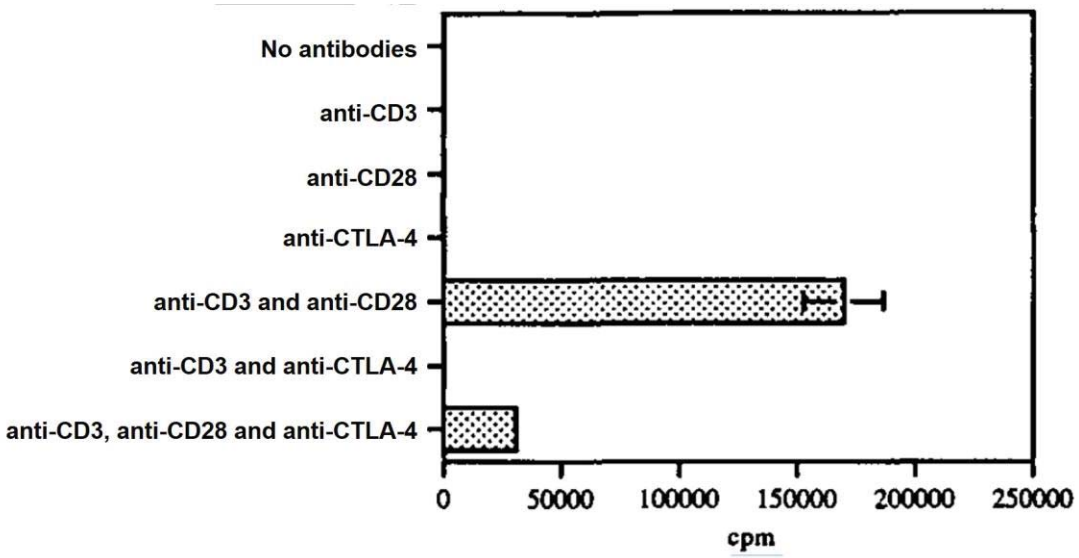


Fig. 1.3

(e) The activated T-cells generated upon successful activation are all genetically identical.

(i) State the process that accounts for the large increase in numbers of activated T-cells upon successful activation.

……**[1]**

(ii) Explain how one activated T-cell can give rise to a population of genetically identical daughter cell.

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……**[4]**

[Turn over

It is hypothesised that CD28 receptor and CTLA-4 receptor could regulate activation of T-cells by either providing co-activation or inhibitory signals.

(f) With reference to Fig. 1.3, fill in the box below with a (✓) to indicate the effect of the receptors on T-cell activation.

Receptor	Provides co-activation signal	Provides inhibitory signal
CD28		
CTLA-4		

[2]

Programmed death-1 (PD-1) is another receptor on T-cells that controls an immune checkpoint. When bound by its ligand, programmed cell death-ligand 1 (PD-L1), it suppresses $CD8^+$ T-cell activation and function. A study was carried out to compare the concentration of PD-L1 protein in normal and cancer lung cells. The results are shown in Fig. 1.4.

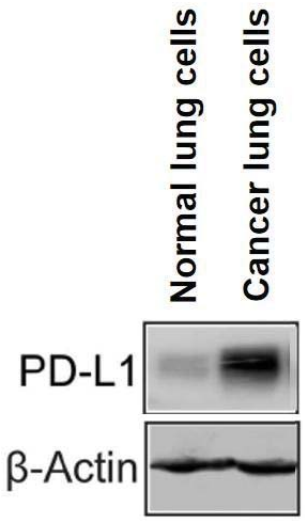

Fig. 1.4

β-actin is a housekeeping protein and its concentration is relatively the same in normal and cancer cell types. In this experiment, the density of the band will vary with the volume of sample added.

(g) Suggest the purpose of showing the level of β-actin protein in each sample.

…….

…….**[1]**

To investigate the cause for elevated levels of PD-L1, the levels of mRNA and DNA methylation of *PD-L1* gene promoter region were compared. The results are shown in Fig. 1.5.

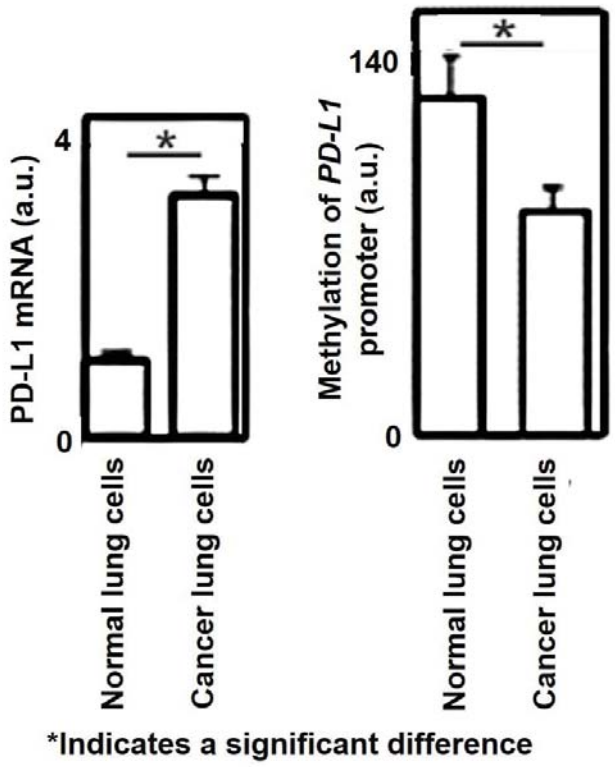

Fig. 1.5

(h) With reference to Fig. 1.5, account for the levels of PD-L1 mRNA and methylation of *PD-L1* gene promoter region.

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…….

……**[4]**

[Turn over

Other studies have shown that cancer cells in the early stages have lower levels of PD-L1 protein as compared to cancer cells in the later stages.

(i) Using your knowledge of natural selection, explain why cancer cells in later stages have higher levels of PD-L1 protein.

…….

…….

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…….**[4]**

In 2018, the Nobel Prize for medicine was awarded to a pair of scientist who showed that by inhibiting CTLA-4 and PD-1 receptors, it can boost the immune system in the fight against cancer. They used two monoclonal antibodies, the targets and effects are shown in Table 1.2.

Table 1.2

monoclonal antibody	target	effect
ipilimumab	binds specifically to CTLA-4 receptor	inhibits receptor by preventing the binding of actual ligand
nivolumab	binds specifically to PD-1 receptor	

Clinical trials for the combination use of these two monoclonal antibodies have shown promising results.

(j) With reference to Fig. 1.2 and Table 1.2, explain why using an antibody specific for CTLA-4 ligand is not as useful as using ipilimumab, which targets the CTLA-4 receptor.

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…….

…….[2]

[Total: 26]

[Turn over

2. Fig. 2.1 shows United Kingdom's methane emissions by source from 1990 to 2010.

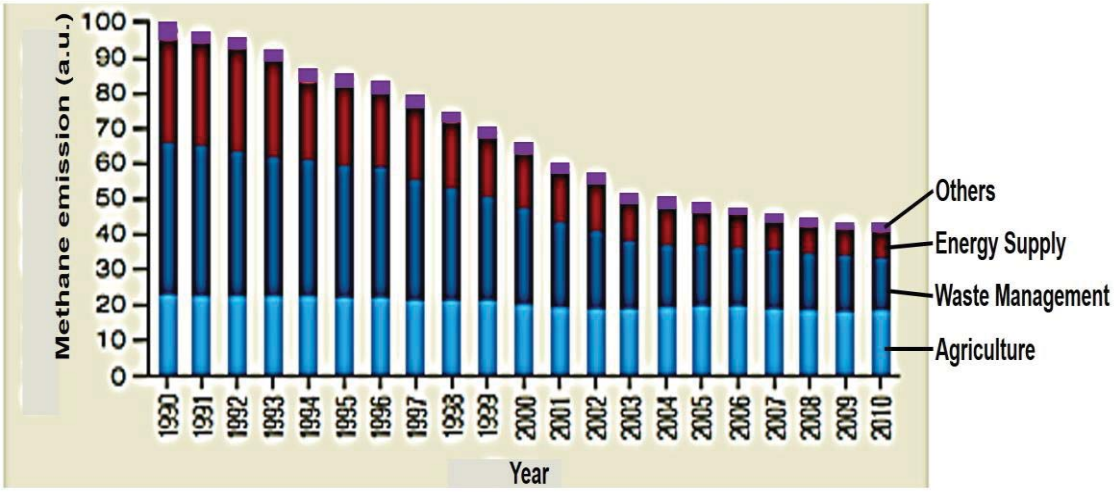

Fig. 2.1

With reference to Fig. 2.1,

(a) State one factor that would fall under the 'Others' category.

……

……**[1]**

(b) Comment on the change in methane emissions in the United Kingdom from 1990 to 2010.

……

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……**[3]**

Hydroxyl radical is a naturally occurring molecule in the atmosphere. It is one of the strongest oxidant in the atmosphere. It was coined as the “detergent of the atmosphere”, as it is able to break down harmful gases in the atmosphere via oxidation. An example is its ability to oxidise and break down methane:

(c) State two anthropogenic sources of methane emission.

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……**[2]**

(d) With reference to the information provided, discuss the extent to which hydroxyl radical is able to mitigate enhanced global warming resulting from the rising level of methane emission.

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……**[3]**

[Turn over

A rising concern due to climate change is the spread of infectious disease. The H5N1 avian influenza virus outbreak in 2006 and Zika virus outbreak in 2015 are examples of infectious diseases. H5N1 avian influenza is an air-borned disease that can be transmitted from human to human. It was first transmitted to humans by birds. Zika virus is a mosquito-borned disease that is mainly transmitted by the mosquito, *Aedes aegypti*.

(e) Compare between infectious and genetic disease.

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……**[2]**

The H5N1 influenza strain was unexpected in 2006, as such there was no vaccine prepared against it. This resulted in a pandemic with global outbreak of the disease.

(f) State the process that led to the formation of the H5N1 influenza strain.

……**[1]**

Fig. 2.2 shows the range of outbreak for H5N1 avian influenza, while Fig. 2.3 shows the range of outbreak for Zika virus.

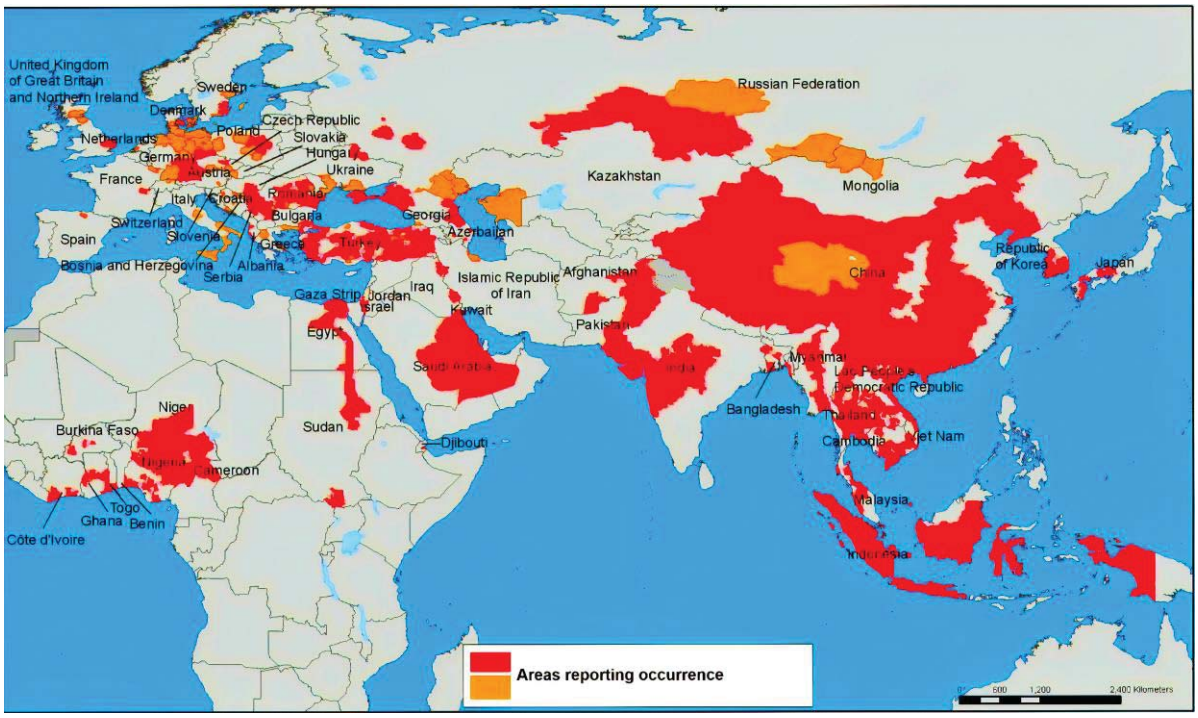

Fig. 2.2

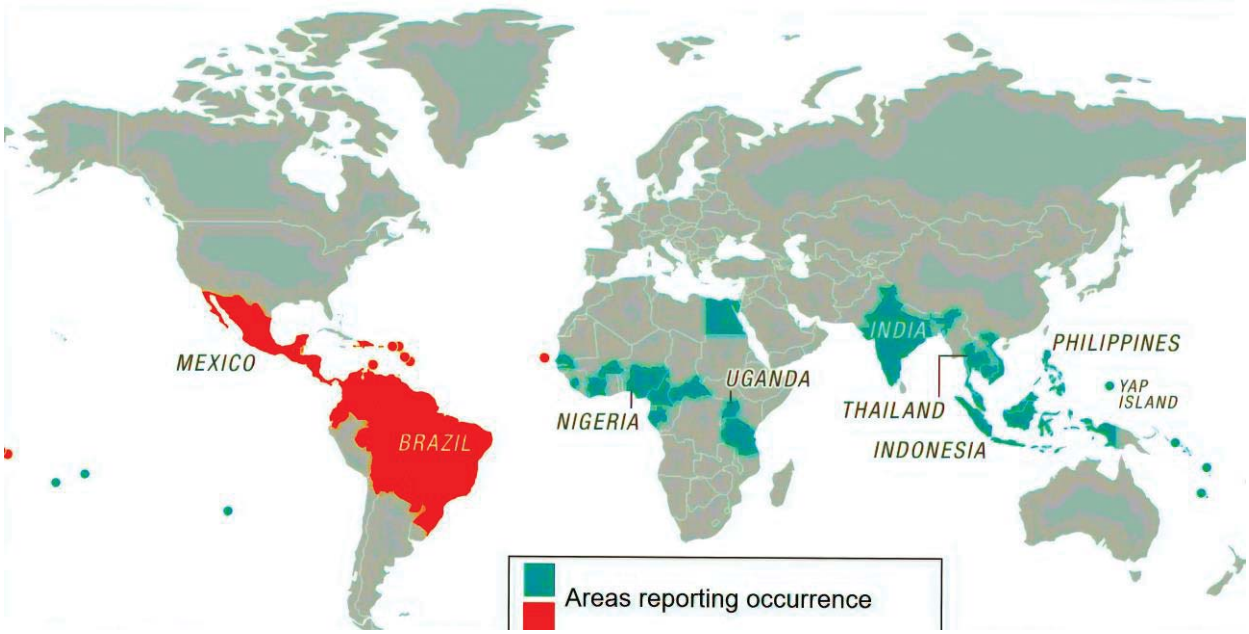

Fig. 2.3

[Turn over

(g) **(i)** With reference to Fig. 2.2 and Fig. 2.3, account for the difference in the extent of outbreak of both infectious diseases.

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……**[3]**

Due to prompt and collective international effort, the Zika virus outbreak was successfully brought under control by 2016. The status of Zika virus is still being strictly monitored by the World Health Organisation.

(ii) With rising global temperature, predict and explain how might a future Zika outbreak be compared to the outbreak in 2015.

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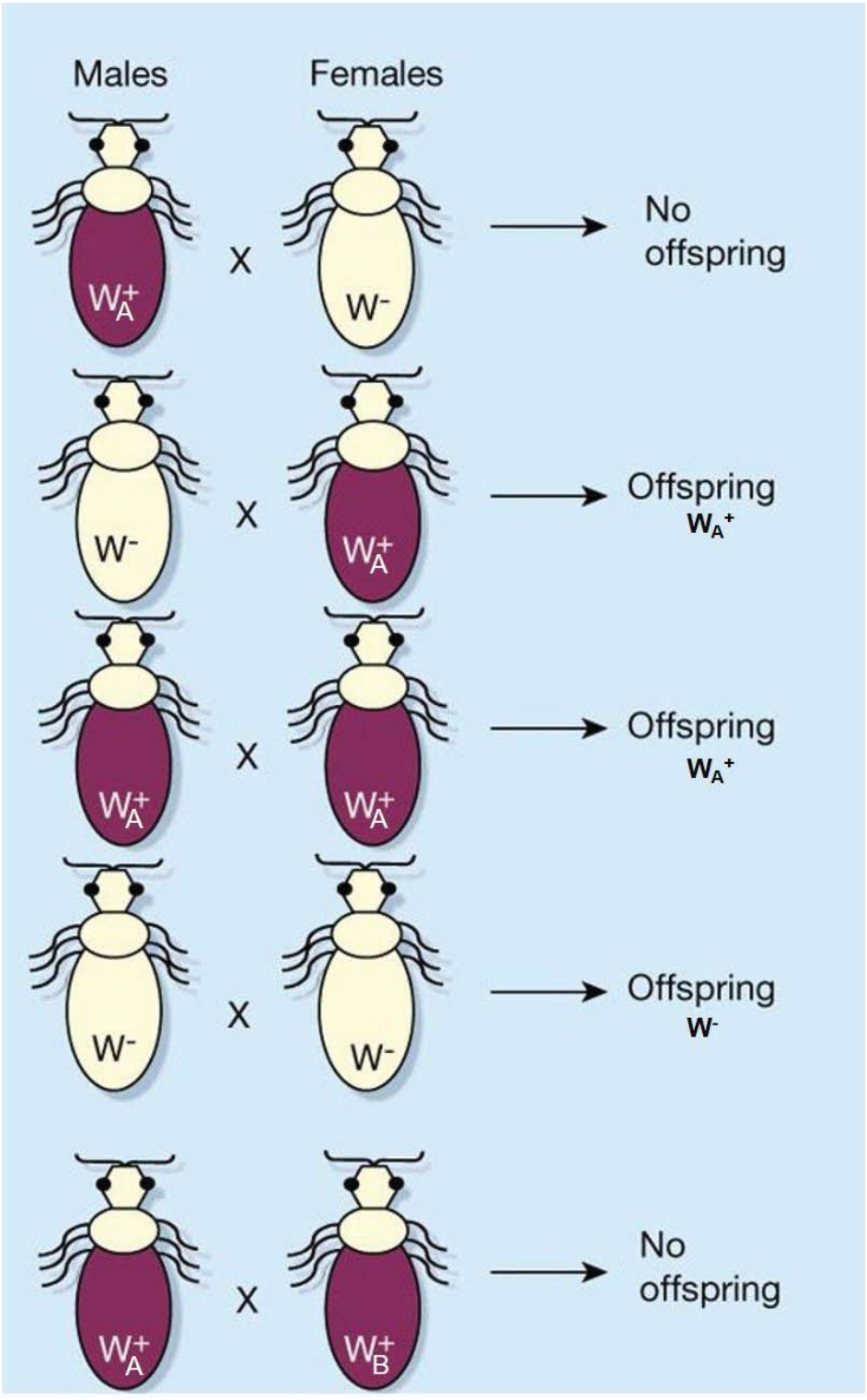
……**[4]**

Blank Page

Wolbachia is a gram-negative parasitic bacteria that largely infects insects and is reliant on the female host to transmit subsequent generations to the hosts' offspring. There are a variety of strains of *Wolbachia* in nature. Fig. 2.4 shows the outcomes of mating for insects infected with *Wolbachia*.



W_A^+: Presence of *Wolbachia* strain **A**
W_B^+: Presence of *Wolbachia* strain **B**
W^- : Absence of any *Wolbachia* strains

Fig. 2.4

Currently, *Wolbachia* is not naturally found to infect *Aedes aegypti*. In Singapore, the National Environment Agency (NEA) is carrying out field trials by releasing male *Aedes aegypti* infected with *Wolbachia* into zones that are at high risk of dengue fever.

(h) **(i)** With reference to Fig. 2.4 and your own knowledge, explain why NEA does not release female *Aedes aegypti* infected with *Wolbachia.*

……

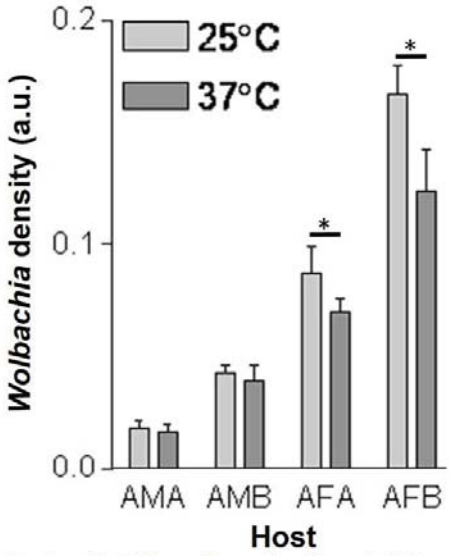
……

……

……**[2]**

[Turn over

Due to the predicted rise in global temperature, studies have been carried out to investigate the effect of temperature on the growth of *Wolbachia* within *Aedes aegypti*. The results are shown in Fig. 2.5, growth of *Wolbachia* is measured in terms of density (a.u.).



* Indicates that there is a significant difference

Key:
AMA – Adult Male infected with *Wolbachia* strain A
AMB – Adult Male infected with *Wolbachia* strain B
AFA – Adult Female infected with *Wolbachia* strain A
AFB – Adult Female infected with *Wolbachia* strain B

Fig. 2.5

(ii) With reference to Fig. 2.4 and Fig. 2.5, justify if the use of *Wolbachia* would still be viable in the future with warmer temperatures.

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.....**[2]**

(iii) Suggest why temperatures beyond 37°C would not be of a significant concern for the use of Wolbachia to reduce *Aedes aegypti* population.

.....

.....**[1]**

[Total: 24]

Section B

Answer **one** question in this section.

Write your answers to the question on the separate writing paper provided.

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

Your answers must be in continuous pose, where appropriate.

Your answers must be set out in parts **(a)** and **(b)**, as indicated in the question.

3 **(a)** In Himalayan rabbits the *tyrosinase* gene codes for the enzyme tyrosinase that catalyses the conversion of tyrosine to melanin, a black pigment responsible for black fur in Himalayan rabbits. The Himalayan rabbit fur colour changes with the seasons.

With reference to the mode of action of enzyme, explain how the environment determines the fur colour of Himalayan rabbit and describe the evolutionary advantage for this trait. **[15]**

(b) The development and activation of B-cells and development of cancer cells can be seen as an evolutionary process in terms of how different triggers or cellular functions acts as selection pressure to select for specific cells to divide.

With reference to your knowledge in evolution, compare the development and activation of B-cells and the development of cancer cells. .

[10]

[Total: 25]

4 **(a)** Metabolic processes are dependent on the movement of various substrates and products. The mode of transport is dependent on the nature of the molecule.

With reference to named examples, discuss the role of different modes of cellular transport in plants.

[15]

(b) Climate change is not of a big concern, as with rising carbon dioxide level and temperatures, the rate of photosynthesis in plants increases. As such, carbon dioxide level and temperature will eventually decrease again.

Discuss the validity of this argument. **[10]**

[Total: 25]

End of Paper

Class | Adm No

Candidate Name: _____

H

millennia institute

2019 Preliminary Exams

Pre-university 3

BIOLOGY HIGHER 2 **9744/04**

Paper 4 Practical **3 September 2019**

Candidates answer on the Question Paper **2 hour 30 minutes**

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams and graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Answer all questions in the spaces provided on the Question Paper.

The use of 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.

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This question paper consists of 26 printed pages, including 2 blank pages

[Turn over

Candidates with access to microscope at the start of the paper are given the **first 45 minutes** to use it. Please answer **QUESTION 2** within this time frame.

Candidates with no access to microscope at the start of the paper will be given access 1 hour 45 minutes after the start of the paper. You may proceed with **QUESTION 1** first.

Answer **all** questions

1. In this question you will investigate the effect of carbon dioxide (CO_2) concentration on the rate of photosynthesis in leaf disks.

(a) Sketch a fully-labelled graph to show the expected relationship between the rate of photosynthesis and CO_2 concentration, as CO_2 concentration increases.

Explain the shape of your graph.

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.....**[4]**

In your investigation, sodium bicarbonate solution will be a source of dissolved carbon dioxide. Carbon dioxide concentration will be controlled by varying the concentration of sodium bicarbonate solution.

You are provided with:

Labelled	contents	hazard	Volume(cm^3)
S	1% sodium bicarbonate solution	Irritant Harmful	200
D	Liquid detergent	Irritant Harmful	5
L	Leaves soaked in water and wrapped in aluminum*	none	-

**keep leaves in the dark by ensuring aluminum is covering the beaker when not in use*

(b) You are required to make simple dilutions of the 1% sodium bicarbonate solution, **S**. You will need to prepare 50 cm^3 for each concentration.

Decide four other concentrations of sodium bicarbonate solution to prepare using simple dilutions of **S**.

Draw a table to show how you will prepare four other concentrations, including the provided 1% sodium bicarbonate solution.

[3]

Read through steps 1 to 7 and prepare a table to record your results in d(ii), before starting the investigation.

Proceed as follows:

1 Prepare all the concentrations of sodium bicarbonate solution as decided in **(b)** using the beakers provided.

2 Using the Pasteur pipette, add 1 drop of liquid detergent to each of the sodium bicarbonate solution. **Gently** stir the solution with a glass rod, ensure that **no bubbles** are formed.

3 Place one leaf onto the white tile and press the cork borer against it to make a leaf disk. You will require four leaf disks. **Avoid** major leaf veins. *You should be able to obtain 4 leaf disks from 1 leaf.*

4 Remove the piston of a $10cm^3$ syringe and place the four leaf disks into the syringe barrel.

5 Replace the piston and push on the piston until only a small volume of air remains. **Be careful** to ensure that the leaf disks are not crushed. Use a piece of aluminum to wrap around the syringe, keeping the leaf disks in the dark.

6 Repeat steps **3** to **5** for the other four syringes. You should have a total of five syringes, each with four leaf disks in them.

7 Using one of the five prepared syringes, remove the aluminum foil and draw from the 1% sodium bicarbonate solution until the syringe is roughly half-filled. Ensure no air bubbles are present.

(c) Invert the syringe and observe the position of the leaf disks, re-wrap the syringe with the same piece of aluminum. Label the position of the leaf disks in Fig. 1.1 with a cross (**X**). Explain your answer.

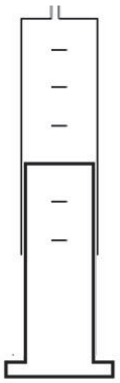

Fig. 1.1

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……**[2]**

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8 Repeat step **7** for the four other concentrations of sodium bicarbonate respectively. Ensuring that you wrap each syringe with aluminum to keep the leaf disks in the dark.

9 Using the syringe with 1% sodium bicarbonate, hold it in the inverted position and remove the aluminum cover. Place a finger over the opening and press against it firmly.

10 Pull piston back while keeping your finger tightly sealing the opening, hold for 10 seconds, as shown in Fig. 1.2(a). While holding, shake the syringe gently to ensure that the leaf disks remain suspended in the solution and are not stuck to the sides of the syringe.

11 Release the piston and push the piston as much as possible while keeping your finger tightly over the opening of the syringe, as shown in Fig. 1.2(b).

12 Remove your finger from the opening of the syringe, all the leaf disks should be at the bottom of the syringe, as shown in Fig. 1.2(c). *If not all the leaf disks are at the bottom, repeat steps **10** to **12** for a **maximum of two more times**. If the leaf disks are still not at the bottom, use the Pasteur pipette, add 2 to 3 drops of detergent into the 1% sodium bicarbonate solution in the beaker, and repeat steps **3** to **12** using a set of new leaf disks.*

13 Immediately cover the syringe with the same piece of aluminum foil to ensure that the leaf disks are not exposed to light.

14 Repeat steps **9** to **13** for the other syringes.

15 Remove the aluminum from the syringe containing 1% sodium bicarbonate and place it over the beaker containing 1% sodium bicarbonate, remove the piston and gently pour the 1% sodium bicarbonate along with the leaf disks into the beaker.

16 Repeat step **15** for the other syringes. Ensure that there are no overlapping leaf disks in each beaker.

17 Place all the beakers under the lamp and start the stopwatch immediately. Ensure that the light source is as close to each beaker as possible.

18 For 15 minutes, at every minute interval, record the number of floating leaf disks in each beaker.

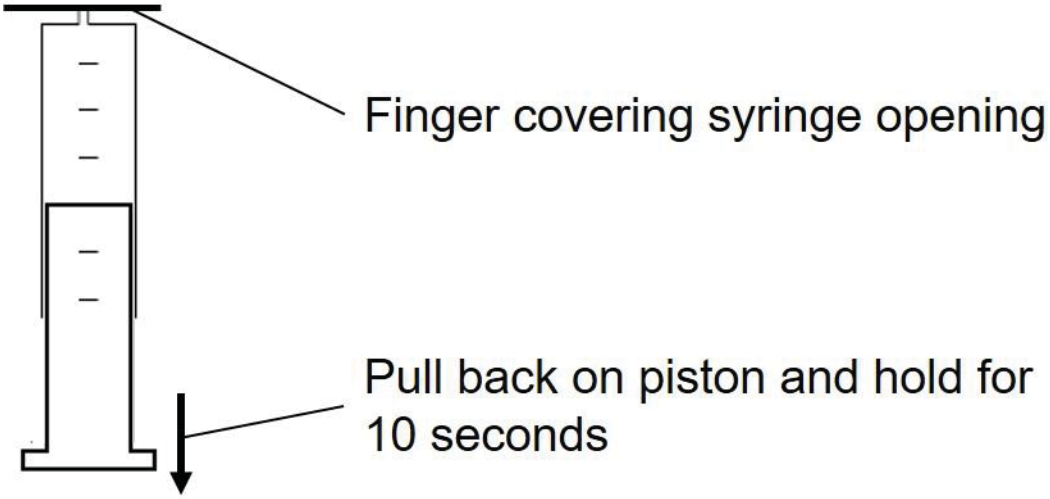

Fig. 1.2(a)

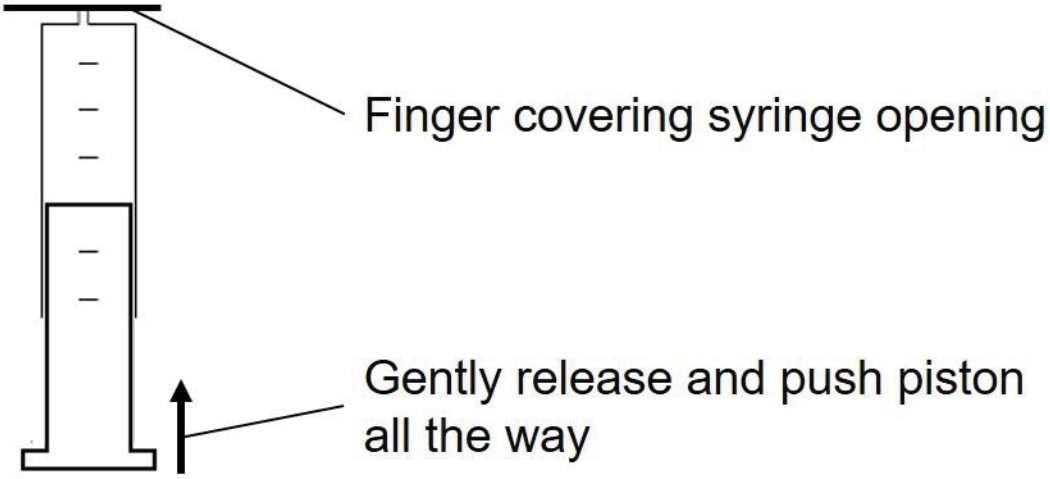

Fig. 1.2(b)

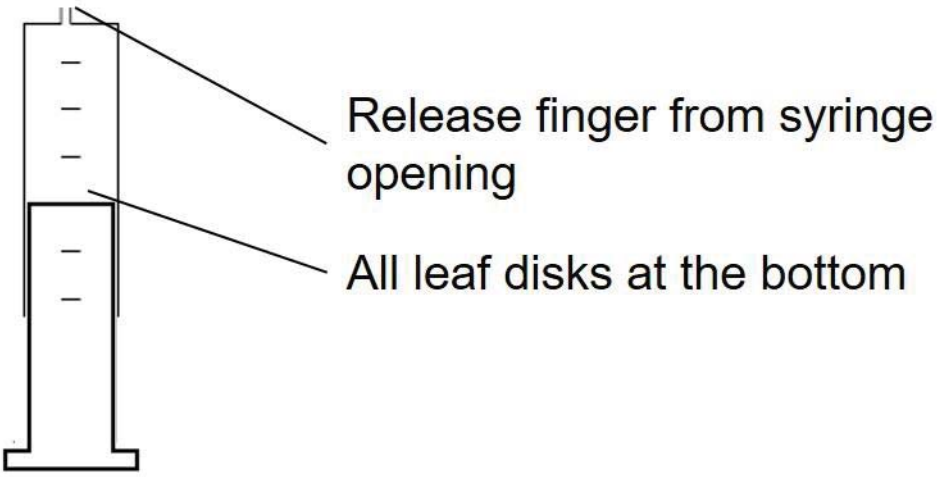

Fig. 1.2(c)

(d) (i) State the product of photosynthesis that causes the leaf disks to float.

…… **[1]**

(ii) Record your results in an appropriate table in the space below. Your table should include the initial time point of 0 minute.

[3]

(e) The rate of photosynthesis can be estimated by the time taken for 50% of the leaf disks to float, termed as the effective time, ET_{50}.

(i) Using your results from **d(ii)**, estimate the ET_{50} for each sodium bicarbonate concentration to the closest 0.5 minute.

[1]

(ii) Assuming each leaf disks were cut to the exact same area, state two other reasons that could contribute to the difference in time taken to float.

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.....**[2]**

ET_{50} is similar to the median time taken for the leaf disks to float.

(iii) Based on your data obtained in **d(ii)**, justify if the use of ET_{50} or mean time would be a better indication of rate of photosynthesis.

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.....**[2]**

(f) (i) One experimental error in this investigation was the lack of control, describe a suitable control that could have been used in this investigation.

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.....**[1]**

(ii) Besides the lack of control setup, state two other limitations in this investigation.

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.....**[2]**

(iii) Predict and explain what would happen to the floating leaf disks if you were to cover the beaker with aluminum foil to prevent exposure of light over a period of time.

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.....**[2]**

Blank Page

[Turn over

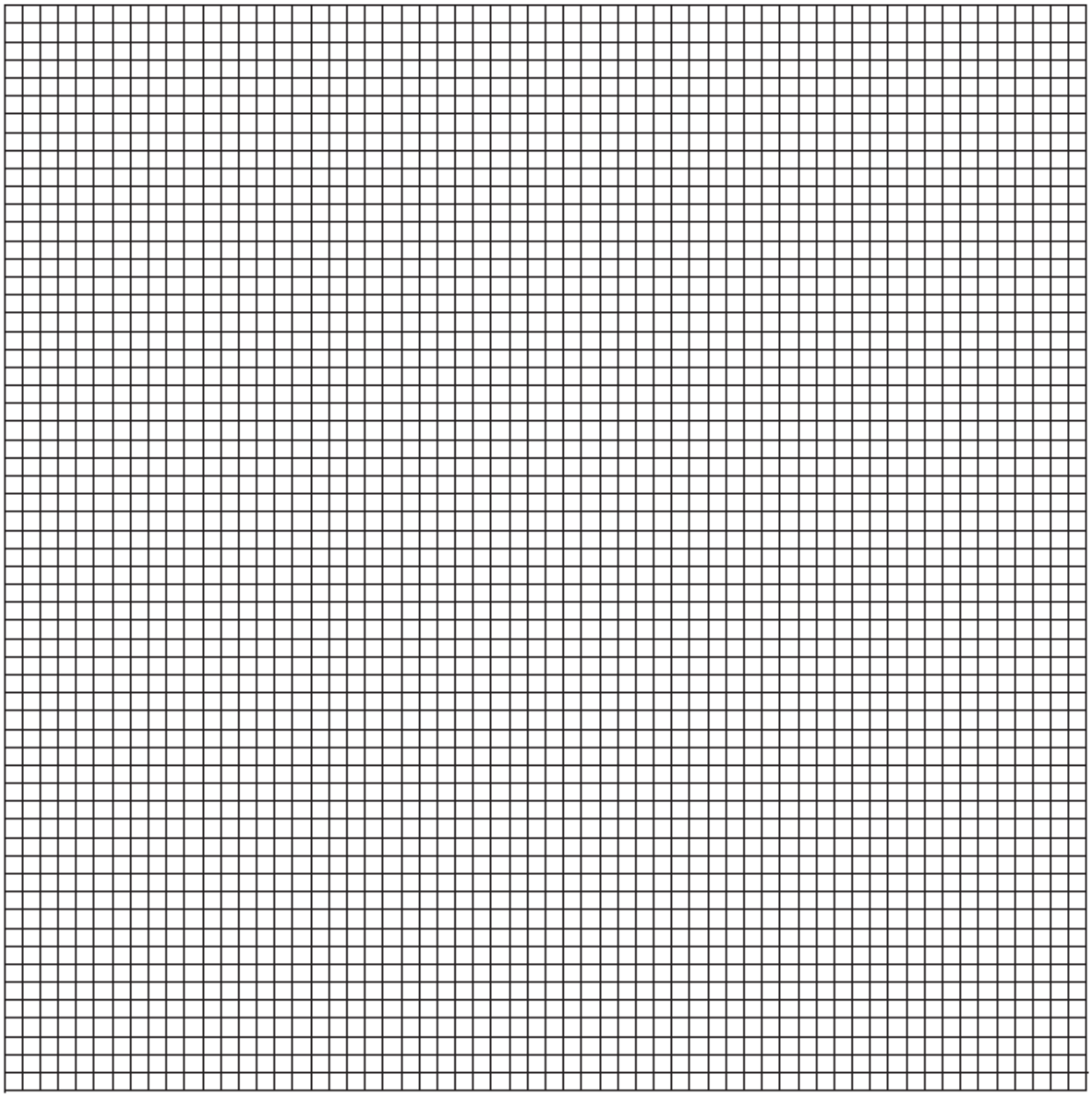
A student carried out a similar experiment as the one above except that he investigated the effect of light intensity on the rate of photosynthesis in a different plant species.

He calculated the ET_{50} values and subsequently $1/ET_{50}$ which is directly proportional to the rate of photosynthesis. The results are shown in Table 1.1.

Table 1.1

Light intensity (lx)	**Effective time, ET_{50} (min)**				**1/Average ET_{50} (min^{-1})**
	Replicate 1	**Replicate 2**	**Replicate 3**	**Average**	
2000	18.5	18.0	19.0	18.5	0.0541
4000	16.0	17.0	16.5	16.5	0.0606
6000	14.5	15.0	14.0	14.5	0.0690
8000	12.0	12.5	13.0	12.5	0.0800
10 000	10.5	11.5	11.0	11.0	0.0909

(iv) Draw a graph of the student's results on the following grid to show the effect of light intensity on rate of photosynthesis.



[3]

[Total: 26]

2. You will investigate starch grains from different types of plant in this question.

You are provided with starch grains from two different types of plant, labelled **F** and **G**.

Starch grains from different plants can differ in shape and size. You are required to:

- observe and draw starch grains from two different types of plant
- compare the starch grains from these two different types of plant

Proceed as follows:

1 Using a pipette, stir the sample gently and place two drops of **F** onto a clean and dry microscope slide.

2 Cover the microscope slide with a coverslip and use a paper towel to remove any excess liquid.

3 View the slide using the microscope.

4 Using an appropriate magnification, select three starch grains that differ in size.

5 Make a large drawing in **(a)(i)** of the three starch grains that you have selected.

6 Repeat steps 1 to 5 for sample **G**.

(a) (i) Make a large drawing of the three starch grains from **F** and the three starch grains from **G**. Calculate the actual size of one starch grain from **F** and **G** respectively.

Sample **F:**

Sample **G:**

[4]

[Turn over

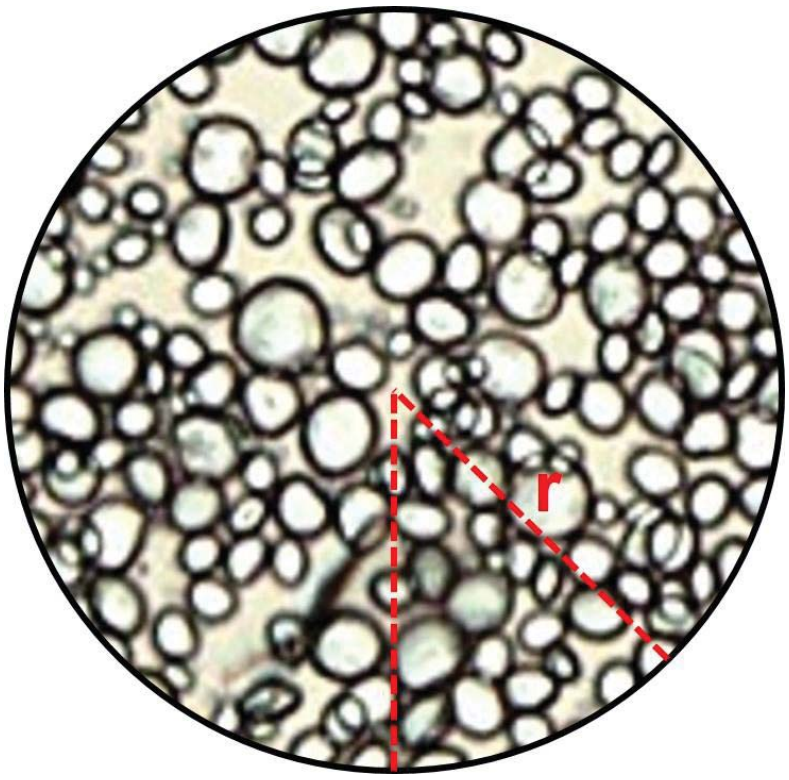
(ii) Describe three observable differences between starch grains from **F** and **G**.

F	G

[3]

Fig. 2.1 is a photomicrograph of starch grains from another plant type in a field of view.

Fig. 2.1 shows many starch grains. There are too many starch grains to count, so the technique of sampling may be used to estimate the number of starch grains in the field of view.



Magnification x400

Fig. 2.1

A sample should be counted in a known smaller area and then the result could be multiplied to obtain an estimate of the number of starch grains in the whole field of view. For example, if the number of starch grains is counted in an eighth of the area of the field of view then this number would be multiplied by 8 to obtain the total number in the area of the field of view.

One eighth of the area of the field of view has been marked out by two dashed lines in Fig. 2.1.

(b) (i) Count and record the sample number of starch grains in the eighth of the area of the field of view.

- Mark clearly on Fig. 2.1 each of the starch grains counted.
- Estimate the number of starch grains in the whole field of view.

You will lose marks if you do not show your working.

number of starch grains in the field of view **…….. [2]**

To find the area of the field of view you need to calculate the **actual length** of line **r**, the radius of the circle.

(ii) Using the magnification on Fig. 2.1, calculate the **actual length** of line **r** in μm.

actual length **……μm [1]**

(iv) Using the actual length of line **r**, calculate the area of the field of view by applying the formula for the area of a circle:

area of a circle πr^2

$\pi = 3.14$

$r =$ radius of field of view

area of field of view **……μm^2 [1]**

(iv) Calculate the number of starch grains per μm^2 using your answers from **b(i)** and **b(iii)**. You will lose marks if you do not show your working.

number of starch grains per μm^2 **……μm^2 [2]**

(c) A student observed 10 storage cells of the two different types of plants **F** and **G** respectively to quantify the average number of starch grains found in the two types of plants. The results are shown in Table 2.1.

(i) State a statistical test that could have been used to determine whether the difference in number of starch grains between plants **F** and **G** is significant.

……[1]

(ii) A summary of the student's results is shown in Table 2.1

Table 2.1

mean number of starch grains		**significance of difference**
plant F	**plant G**	
11	12	$p > 0.05$

With reference to Table 2.1, comment on what the results show.

……

……

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……[2]

[Total: 16]

3. Under anaerobic conditions, yeast cells break down glucose to produce ethanol and carbon dioxide. When carbon dioxide dissolves, it forms a weak acid. The activity of the yeast cells can be determined by measuring the change in pH using Universal Indicator paper. The colour chart for the Universal Indicator paper is shown in Fig. 3.1.

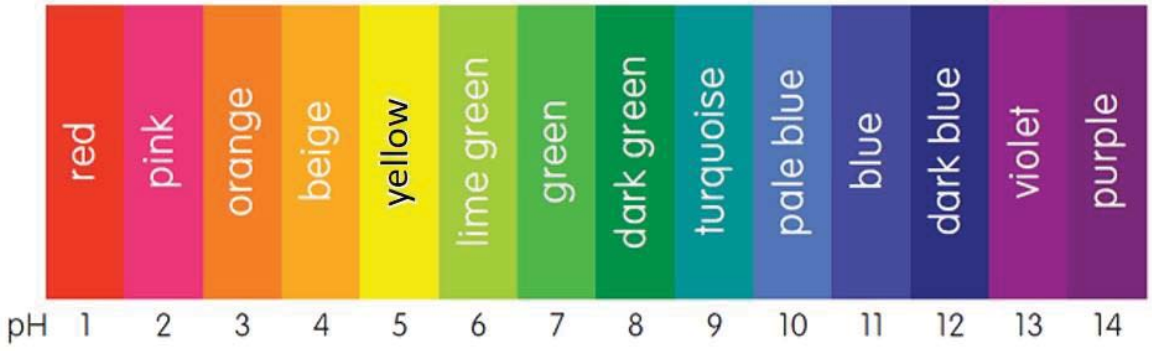

Fig. 3.1

A yeast suspension is assumed to be of neutral pH.

As yeast cells continues to breakdown glucose, the concentration of ethanol rises to a toxic level that kills the yeast cells.

You are to plan an experiment to investigate the highest concentration of ethanol that is tolerable by yeast cells.

The following are optimal condition for the growth of 1g of yeast:

- Temperature of 45^{o}C
- 10cm^{3} of 1% glucose solution

The pH of the yeast mixture can be obtained by using a glass rod to remove a drop of the mixture and touching a piece of the Universal Indicator paper. You should obtain two sets of pH readings:

1. Prior the addition of ethanol
2. Six minutes after the addition of ethanol

The difference in pH between these two readings would allow you to infer the effect of ethanol.

[Turn over

In your plan, you must use:

- Dried yeast
- 1% glucose solution
- 15% ethanol
- Glass rod
- Universal Indicator paper
- White tile
- Stopwatch

You may select from the following apparatus in the design of your experiment:

- normal laboratory glassware e.g. test tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, etc
- syringes
- thermostatically controlled water bath
- weighing balance

Your plan should:

- have a clear and helpful structure such that the method you used is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- 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 repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimize any risks associated with the proposed experiment.

[Total: 13]

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End of Paper

Class Adm No

Candidate Name: _____

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millennia institute

2019 Preliminary Exams
Pre-University 3

BIOLOGY **9744/01**

Paper 1 Multiple Choice **23 September 2019**

1 hour

Additional Materials: Optical Answer Sheet

READ THESE INSTRUCTIONS FIRST

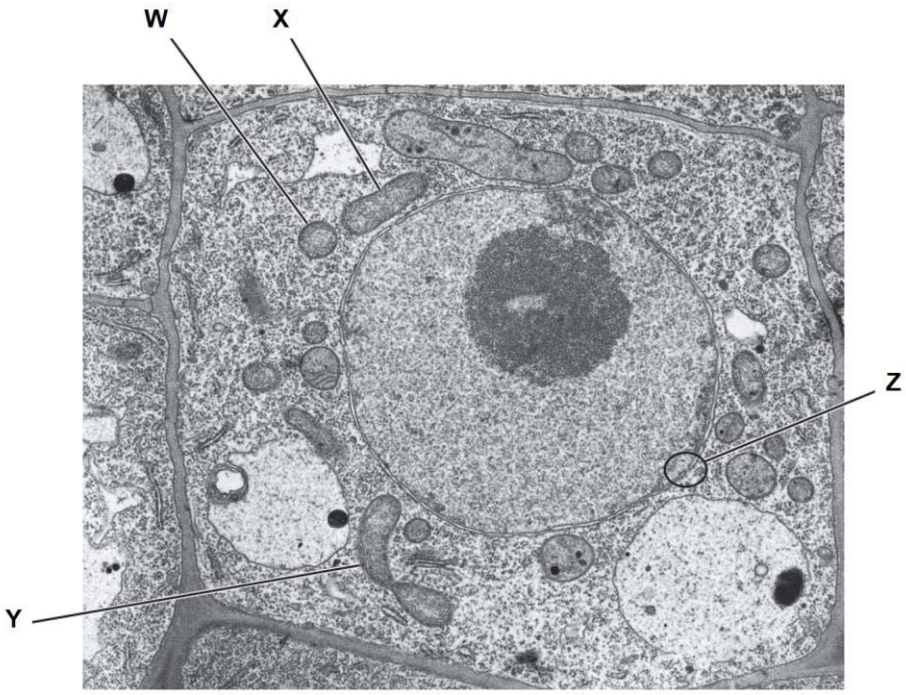
Do not open this booklet until you are told to do so.
Write your name, Adm No. and class on all the papers you hand in.

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 answer sheet.

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.
The use of an approved scientific calculator is expected, where appropriate

1. The figure below shows an electron micrograph of a cell from the root of thale cress, *Arabidopsis thaliana*.

Ans : C



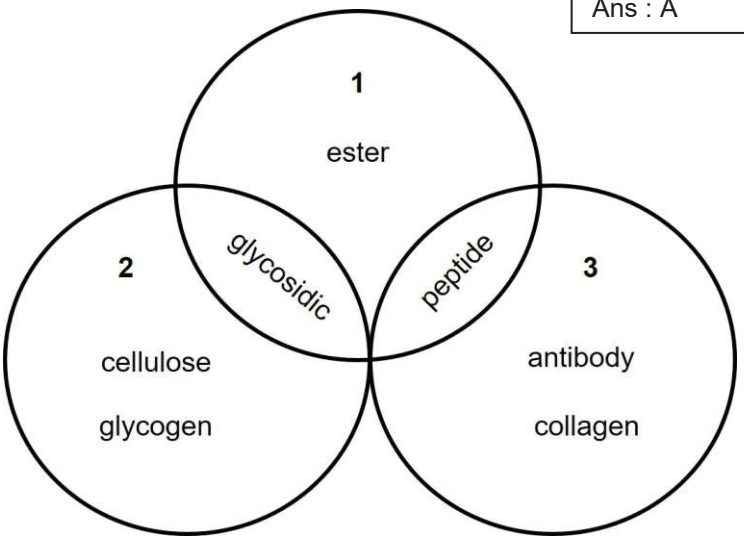
Which of the following statement(s) is/are true?

I **W** and **X** are both mitochondrion that are oriented differently.
II **Y** is a mitochondrion undergoing mitosis.
III **Z** is a phospholipid bilayer that regulates movement of substances.
IV There are no chloroplast present in the cell.

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

2. The diagram shows the relationships between some important molecules and bonds found in living organisms.

Ans : A

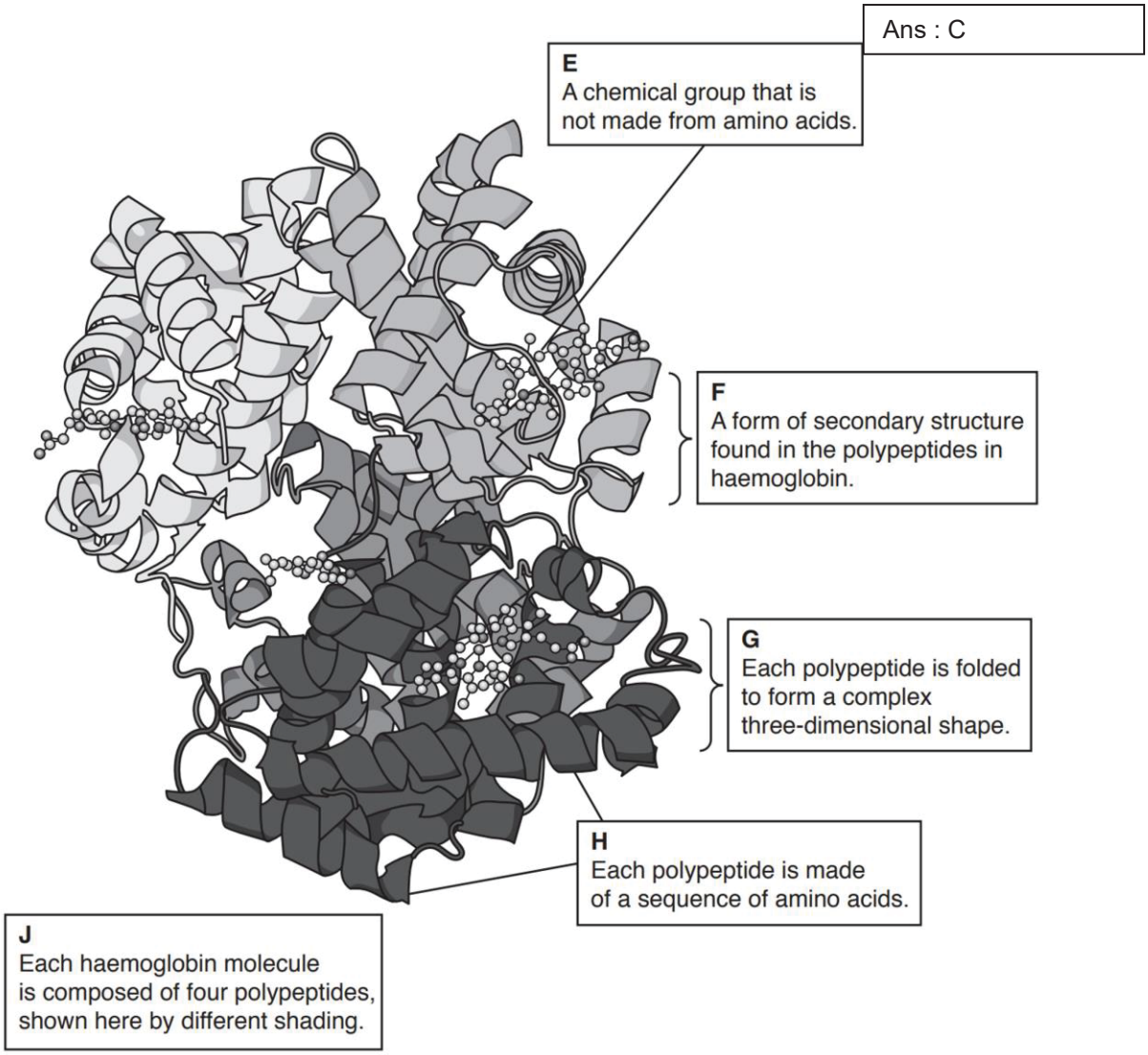


What is represented by circles numbered **1**, **2** and **3**?

	1	2	3
A	bonds formed by condensation	carbohydrates	proteins
B	bonds formed by condensation	proteins	lipids
C	bonds formed by hydrolysis	lipids	proteins
D	bonds formed by hydrolysis	proteins	carbohydrates

3. The following diagram shows a ribbon model of a molecule of haemoglobin.

Ans : C



Which of the following terms correctly match to the description given in the boxes?

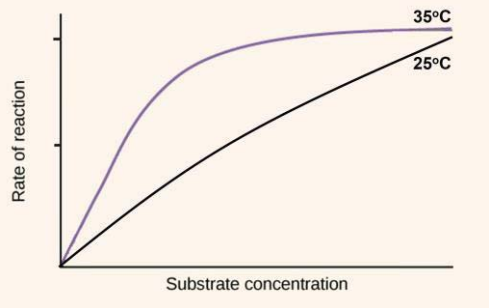
	E	F	G	H	J
A	haem	α-helix	quaternary structure	primary structure	tertiary structure
B	haem	β-helix	quaternary structure	primary structure	tertiary structure
C	haem	α-helix	tertiary structure	primary structure	quaternary structure
D	haem	α-helix	tertiary structure	peptide bond	quaternary structure

4. A student investigated the effect of substrate concentration on the rate of enzyme-catalysed reaction at the optimum temperature of 35°C. Subsequently, he repeated the experiment, but lowered the temperature to 25°C.

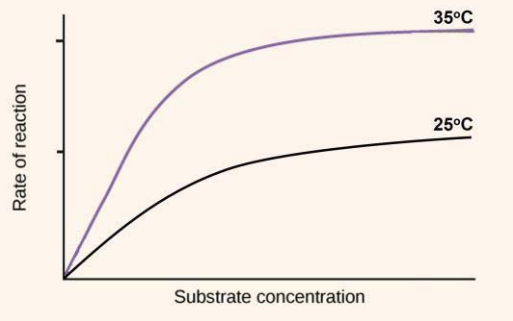
Ans : B

Which of the following correctly shows the result of the two sets of experiments?

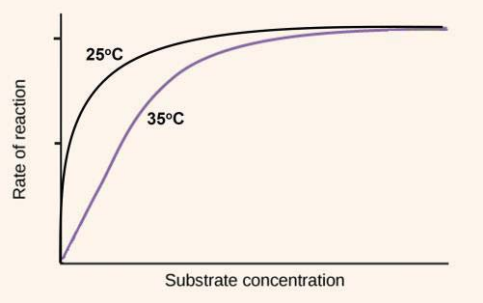
A



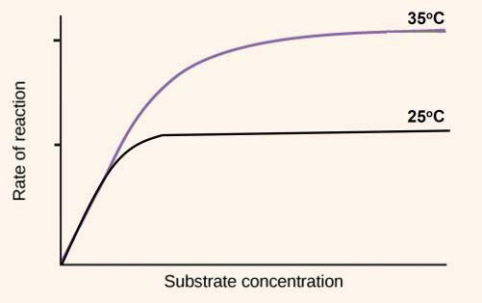
B



C

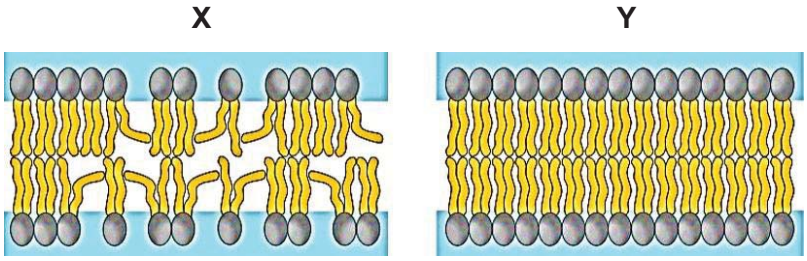


D



5. The following shows the structure of membrane in a plant cell during different seasons of the year.

Ans : B



Which of the following is true?

A **X** shows the membrane during summer, as it is more fluid to prevent membrane from melting.

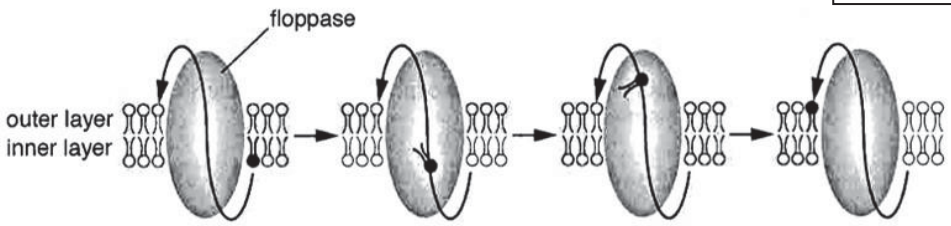
B **Y** shows the membrane during summer, as it is more viscous to prevent membrane from melting.

C **X** shows the membrane during winter, as it is more viscous to prevent membrane from freezing.

D **Y** shows the membrane during winter, as it is more fluid to prevent membrane from freezing.

6. The following figure shows floppase, a protein found on the cell surface membrane that functions to move phospholipids from the inner layer to the outer layer.

Ans : A



Which of the following statements are likely to be correct?

I The presence of the hydrophilic phosphate head limits the diffusion of phospholipids between layers.

II Floppase provides a hydrophobic channel to facilitate the movement of phospholipids from inner to outer layer.

III Floppase ensures that the membrane layers are symmetrical.

IV Floppase has the ability to diffuse laterally within the membrane.

A **I** and **IV** only

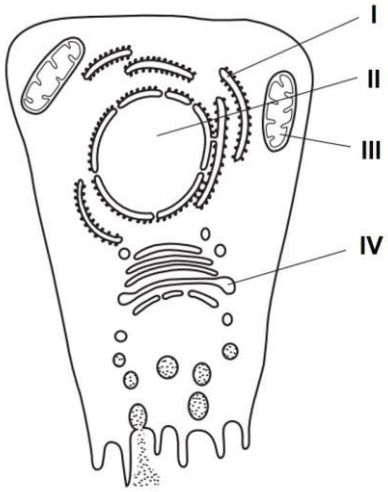
B **II** and **III** only

C **I, II** and **III** only

D **I**, **II** and **IV** only

7. Radioactively-labelled nucleotides are introduced into a cell.

Ans : C



In which cell structures will the radioactivity first become concentrated?

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

8. DNA and RNA both contain nucleotides with adenine.

Which of the following below is true, regarding a DNA nucleotide with adenine, a RNA nucleotide with adenine, and ATP?

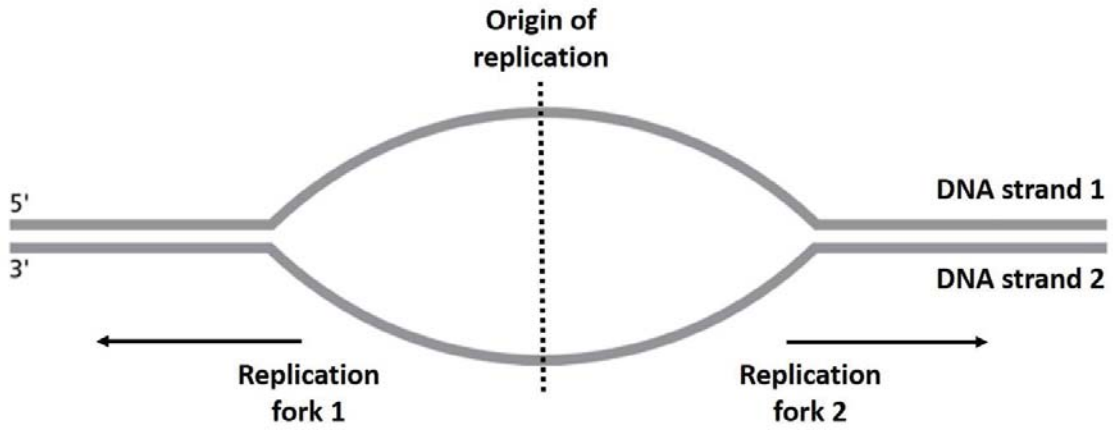
Ans : A

I All three contain nitrogen.
II All three contain three phosphate groups.
III Only DNA nucleotide with adenine has a deoxyribose, while the other two contains ribose.
IV Both DNA and RNA nucleotide with adenine can be broken down to release energy for the synthesis of ATP.

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

9. The following diagram shows a replication bubble section of an eukaryotic DNA molecule undergoing DNA replication.

Ans : C



Which statements regarding the replication of DNA are correct?

I At replication fork 1, synthesis of the daughter strand of DNA strand 2 requires multiple RNA primers.

II At replication fork 2, synthesis of the daughter strand of DNA strand 2 is continuous.

III Daughter strands of both DNA strands 1 and 2 will face the end replication problem.

IV At the end of replication, a pair of homologous chromosome is formed.

A **I** and **II** only

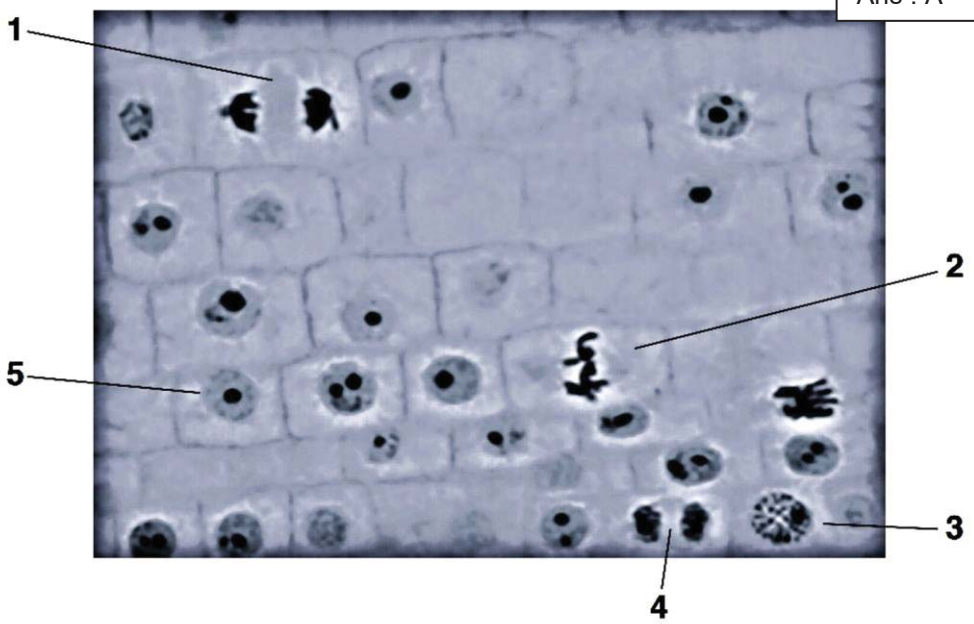
B **II** and **IV** only

C **I, II** and **III** only

D **I**, **III** and **IV** only

10. The figure below is a photomicrograph showing some cells in interphase and some cells in different stages of mitosis.

Ans : A

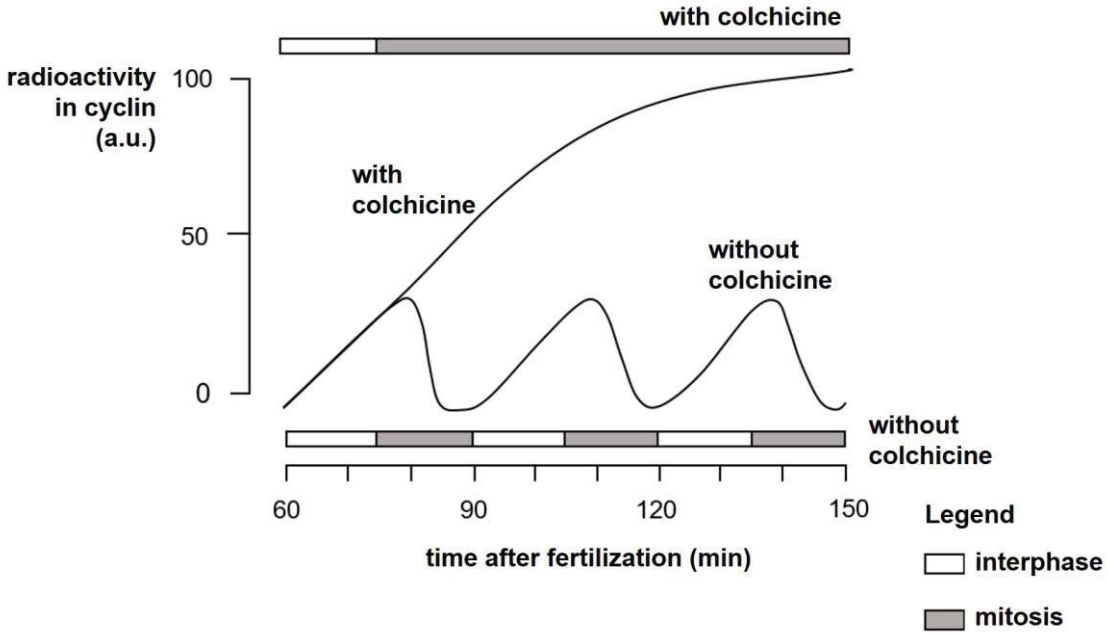


Which of the following correctly identifies events occurring at each stage?

	1	2	3	4	5
A	identical sister chromatids pulled apart	chromosome aligned in one row	spindle fibres begin to form	nuclear envelope reassembling	elevated rate of transcription and translation
B	homologous chromosomes pulled apart	homologous chromosome aligned in two rows	crossing over between non-sister chromatids	chromosome condenses back to chromatin	elevated rate of transcription and translation
C	homologous chromosomes pulled apart	homologous chromosome aligned in two rows	spindle fibres begin to form	nuclear envelope reassembling	DNA replication
D	non-identical sister chromatids pulled apart	chromosome aligned in one row	crossing over between non-sister chromatids	chromosome decondenses back to chromatin	DNA replication

11. A study on the effect of colchicine on mitotic cell cycle was carried out using clam embryos. The study involved two setups, one with colchicine and one without colchicine. A sample was obtained from both setups at every five minutes interval to identify the stage of mitotic cell cycle that the cell is currently at. The study also used radioactively labelled amino acids to monitor cyclin levels. The results are shown in the diagram below.

Ans : D



Which of the following can in inferred from the results?

I In the absence of colchicine, the cell entered a new mitotic cell cycle every 30 minutes.

II In the presence of colchicine, the cell is continuously dividing without leaving mitosis.

III High levels of cyclin is required for entry to mitosis while low levels is required for the cell to complete mitosis.

IV Presence of colchicine prevents the degradation of cyclin.

A **I** and **II** only

B **I** and **IV** only

C **II** and **III** only

D **I**, **III** and **IV** only

12. A karyotype study showed that an embryo has an abnormal number of sex chromosomes, XXY.

Ans : B

Which of the following statement(s) regarding the formation XXY embryo is/are true?

I Non-disjunction could have occurred during meiosis in either parent, but not both.
II Non-disjunction can only occur during meiosis in the mother.
III Non-disjunction can occur during either meiosis I or meiosis II of either parent.
IV One of the parental gamete was diploid while the other was haploid.

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

13. Three events that may result in cancer are listed.

Ans : B

- mutation in a tumour suppressor gene
- translocation of a proto-oncogene
- exposure to carcinogens and ionising radiation that increase the rate of mutation

K-ras and *c-myc* are proto-oncogenes. The inheritance of mutated alleles of either of these genes increases the risk of pancreatic cancer.

Which of these statements best explain why only some of the people who inherit either of these mutated alleles develop pancreatic cancer?

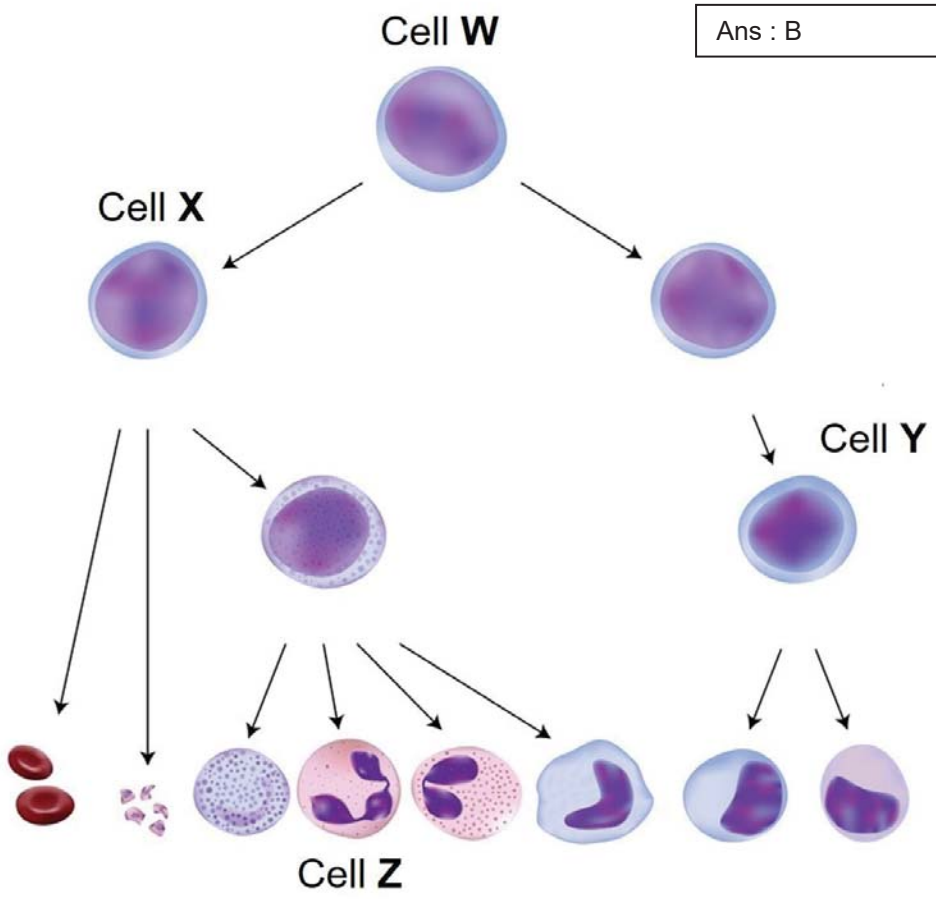
I Pancreatic cancer requires the inheritance of both mutated *k-ras* and *c-myc* alleles to develop.
II Exposure to carcinogens and ionising radiation varies largely among individuals.
III Mutations to tumour suppressor genes and proto-oncogenes accumulate randomly with age.
IV All three events must happen for pancreatic cancer to develop.

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

[Turn over

14. The following figure shows the production of all blood cells from Cell **W**.

Ans : B



Which of the following statement is true?

A Cell **W** does not have the ability to self-renew.

B Cell **X** is multipotent .

C Cell **Y** is unipotent.

D Cell **Z** is a specialised cell and has more genes than cell **W**, **X** and **Y**.

15. Which of the following correctly describes HIV and influenza virus?

Ans : D

	Attachment		Entry			
	HIV	influenza	HIV	influenza	HIV	influenza
A	GP120 on sialic acid containing receptor	haemagglutinin on CD4 receptor	receptor mediated endocytosis	membrane fusion	DNA	RNA
B	haemagglutinin on CD4 receptor	GP120 on sialic acid containing receptor	membrane fusion	membrane fusion	RNA	RNA
C	GP120 on CD4 receptor	Neuraminidase on sialic acid containing receptor	membrane fusion	receptor mediated endocytosis	DNA	RNA
D	GP120 on CD4 receptor	haemagglutinin on sialic acid containing receptor	membrane fusion	receptor mediated endocytosis	RNA	RNA

16. Which of the following correctly outlines the sequential steps involved in using southern blot to identify a specific gene from an extracted DNA sample?

Ans : B

A Gel electrophoresis, incubating with radioactive gene probe, transferring band to nitrocellulose membrane, visualisation via autoradiography.

B Gel electrophoresis, transferring band to nitrocellulose membrane, incubating with radioactive gene probe, visualisation via autoradiography.

C Gel electrophoresis, transferring band to nitrocellulose membrane, incubating with ethidium bromide, visualisation via UV light.

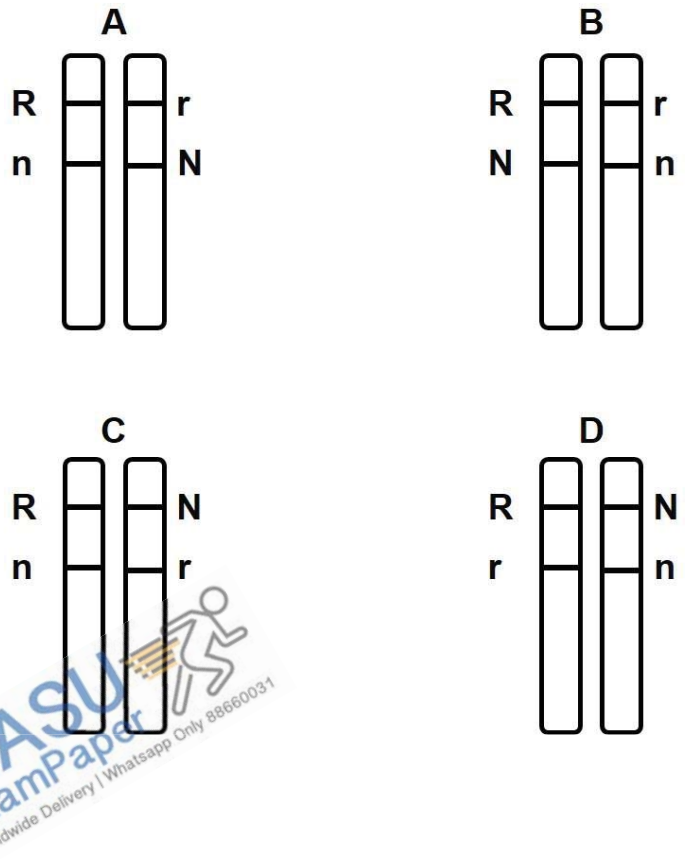
D Gel electrophoresis, incubating with ethidium bromide, transferring band to nitrocellulose membrane, visualisation via UV light.

17. In fruit flies the eye colour gene has two alleles, allele **R** coding for red eyes is dominant over allele **r** coding for purple eyes. The gene coding for wing type also has two alleles, allele **N** for normal wings and allele **n** for vestigial wings. Pure breeding fruit flies with red eyes and normal wings were crossed with pure breeding fruit flies with purple eyes and vestigial wings. F1 offspring obtained was then bred with fruit flies with purple eyes and vestigial wings. The results of the cross is shown below:

Ans : A

phenotype	number
red eyes and normal wings	23
red eyes and vestigial wings	235
purple eyes and normal wings	226
purple eyes and vestigial wings	16

Which of the following shows the likely location of the two genes and arrangement of the alleles in the F1 offspring?



18. The following are information regarding Fabry disease.

Ans : D

- It is a rare genetic disease
- Individuals with the disease lack the enzyme alpha galactosidase that results in the accumulation of a glycolipid in the blood vessels, tissues and organs, causing impairment of proper functions.
- It is found more commonly in males than females.
- Some females that appear normal can pass the disease on to their children.
- Some females that appear normal may show symptoms occasionally.

Which of the following can be inferred from the information provided?

I The gene coding for the enzyme alpha galactosidase is on the X chromosome.
II Females that have two normal alleles may occasionally show symptoms of the disease.
III Symptoms of the disease would be widespread throughout and not isolated to any body parts.
IV The mutant allele causing the disease is a recessive allele.

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

19. In sweet pea plants, the trait for purple flowers **P** is dominant to the trait for red flowers **p**. Similarly, the trait for long pollen, **L** is dominant to the trait for round pollen ***l***. A dihybrid cross was carried out followed by a chi-squared test. The p-value obtained was 0.12.

Which of the following shows the correct expected ratio, degree of freedom and interpretation of result for the chi-squared test at 5% level of significance?

	expected ratio	**degree of freedom**	**interpretation of result**
A	9:3:3:1	3	There is a 12% probability that the difference is not due to chance. The difference is significant and is different from the expected ratio.
B	1:1:1:1	3	There is an 88% probability that the difference is due to chance. The difference is insignificant and is the same as the expected ratio.
C	1:1:1:1	2	There is an 88% probability that the difference is not due to chance. The difference is significant and is different from the expected ratio.
D	9:3:3:1	3	There is a 12% probability that the difference is due to chance. The difference is insignificant and is the same as the expected ratio.

Ans : D

20. Lac operon present in bacteria responds to the changes in concentration of glucose and lactose. In a study, the following mutants were generated.

Ans : B

I Lac repressor does not bind to allolactose.

II Operator sequence is mutated, lac repressor is unable to bind.

III CAP remains active in the absence of cAMP.

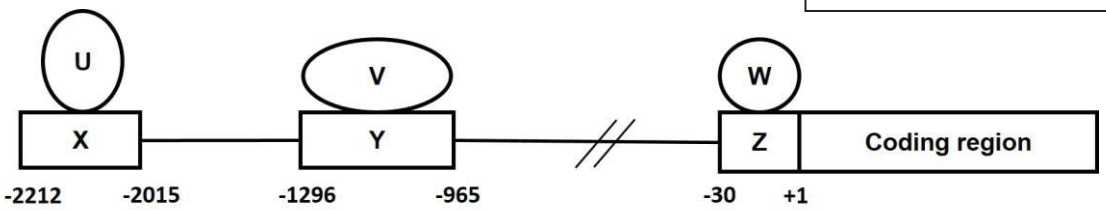
IV CAP binding site is mutated, activated CAP is unable to bind.

Which of the following mutation combinations would give the indicated outcome in the presence of glucose and absence of lactose?

	constantly active at a high level	constantly active at a low level	constantly inactivated
A	**II** and **III**	**I** and **IV**	**II**
B	**II** and **III**	**II** and **IV**	**I**
C	**II** and **IV**	**I** and **III**	**IV**
D	**II** and **IV**	**II** and **III**	**I**

21. The following diagram shows an eukaryotic gene and the non-coding region upstream of it. Three non-coding regions **X**, **Y** and **Z** have been identified as binding sites for protein **U**, **V** and **W** respectively. To investigate the function of regions **X**, **Y** and **Z**, deletion study was carried out. The results are shown in the following table.

Ans : A



nucleotides deleted	amount of mRNA (a.u.)
none	244
-30 to 0	0
-1296 to -965	436
-2212 to -2015	57

Based on the results, what is the likely identity of region **X**, **Y** and **Z** and protein **U**, **V** and **W**?

	X	**Y**	**Z**	**U**	**V**	**W**
A	enhancer	silencer	promoter	activator	repressor	RNA polymerase
B	activator	repressor	promoter	enhancer	silencer	RNA polymerase
C	enhancer	operator	promoter	inducer	repressor	RNA polymerase
D	enhancer	silencer	origin of transcription	activator	repressor	DNA polymerase

22. Which of the following combinations isolated in a test-tube would allow mitochondria to begin ATP synthesis?

Ans: C

A mitochondria + ADP + P_i + pyruvate

B mitochondria + ADP + P_i + glucose + oxygen

C mitochondria + ADP + P_i + high concentration of protons (H^+)

D mitochondria + ADP + P_i + NAD^+ + FAD

23. F.F blackman carried out a series of experiments that measured the rate of photosynthesis for plants that were either exposed to light continuously or exposed to alternating periods of light and darkness. The total period of exposure to light was the same for all plants. All other factors were kept constant. The results were as follows:

- More photosynthesis resulted from brief flashes of light than from continuous exposure to light.
- Separating the flashes of light by longer intervals resulted in more photosynthesis.
- When the flashes of light were made shorter, there was no less photosynthesis.

Which of the following are valid inferences based on the information provided?

I Photosynthesis involves a stage that does not directly depend on light availability.

II The stage of photosynthesis that requires light reaches its maximum rate almost instantaneously.

III Rate of photosynthesis would increase with less light exposure.

IV The stage of photosynthesis that needs light depends on a substance produced by a different stage.

Ans : D

A **I** and **IV** only

B **II** and **III** only

C **I**, **II** and **III** only

D **I**, **II** and **IV** only

24. Mutant alleles that cause medical conditions negatively affect the health of the individuals. Some homozygous for specific mutant alleles would lead to death of the individuals before birth.

Which of the following could be reasons why these mutant alleles could still be passed on to subsequent generations?

I The mutant allele could provide selective advantage that increases the individual's fitness under a specific selection pressure.

II The symptoms of the medical condition are only expressed after the individual's reproductive age.

III Medical advances allows individuals to better cope with the medical condition and avoid cases of homozygous mutant.

IV Dominant normal allele masks the effect of the recessive mutant allele.

A **I** and **III** only

B **I** and **IV** only

C **II** and **IV** only

D **I**, **II** and **IV** only

Ans : D

25. The Eurasian blackcap, *Sylvia atricapilla* is a migratory bird that spends its summers in Germany where it breeds. Prior to 1960s, during winter, they would migrate southwest to Spain where they would spend their winter. Their migratory direction is determined genetically. In the 1960s, backyard bird feeding became popular in Britain, *S. atricapilla* that happen to migrate to Britain were able to survive winter successfully, thereafter returning to Germany in the summer to breed. The figure shows the two migratory routes of *S. atricapilla.*

In 2009, researchers found that there were significant genetic and morphological difference between *S. articapilla* that took different migratory routes.

Which of the following could account for the difference?

I *S. atricapilla* had the preference to mate with others that follow the same migration route, preventing gene flow of those that took different migratory routes.

II The different migratory route resulted in geographical isolation of the *S. atricapilla* population, preventing gene flow of those that took different migratory routes.

III The different migratory route resulted in a postzygotic barrier in which offspring resulting from parents that took different migratory routes were sterile.

IV *S. atricapilla* that migrated to Britain could return to Germany earlier to breed, whereas those that migrated to Spain arrived later to breed, resulting in temporal isolation.

A **I** and **III** only

B **I** and **IV** only

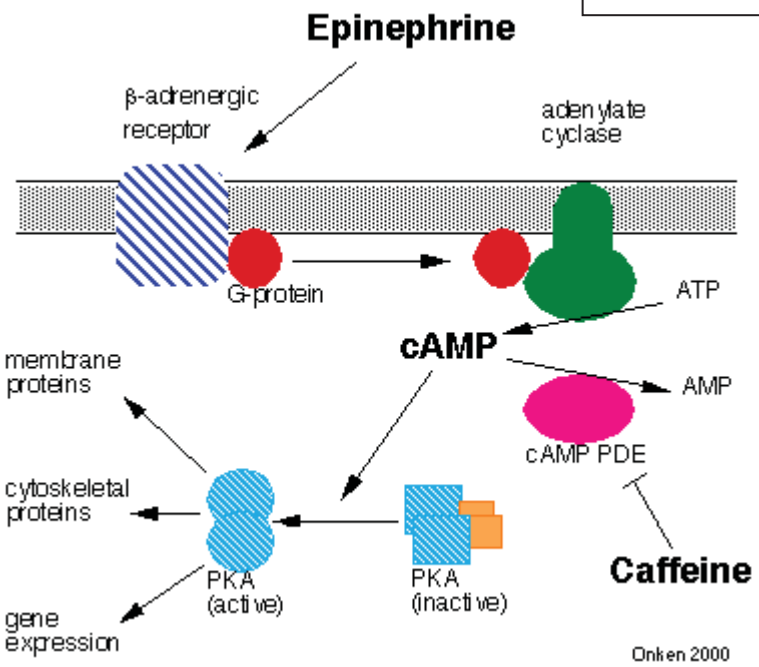
C **II**, **III** and **IV** only

D **I**, **II** and **IV** only

Ans : B

26. Epinephrine (adrenaline) signalling in heart muscle cells causes changes in gene expression and membrane proteins to control the contractions and regulate heart function. One of which is an increase in rate of heartbeat. One side-effect of high caffeine dose is increase in rate of heartbeat. The following diagram shows how caffine is involved in the signalling pathway of epinephrine.

Ans : A



Based on the information provided, which of the following statement(s) is/are true?

I In the presence of caffine, epinephrine signalling will be prolonged even after epinephrine is no longer bound to the receptor.

II cAMP activates PKA via phosphorylation, leading to a phosphorylation cascade that amplifies the epinephrine signal.

III Activated PKA translocates into the nucleus to act as an enhancer binding to the activator to up regulate gene expression.

IV Presence of caffeine alone will be sufficient to trigger epinephrine signalling pathway.

A **I** only

B **I** and **II** only

C **II** and **III** only

D **I**, **III** and **IV** only

27. Bacillus Calmette-Guérin (BCG) vaccine is a vaccine primarily used against tuberculosis.

Which of the following statement is correct about tuberculosis? Ans : B

A Vaccinated individuals will be able to mount a stronger response against the actual infection as the vaccine is long lasting and remains in the body for life.

B People infected with tuberculosis will not be infectious if the disease is in the latent phase.

C During the latent phase of tuberculosis, *Mycobacterium tuberculosis* integrates its DNA into the chromosome of macrophages.

D Transmission of the disease will increase with a larger percentage of the population being administered with the BCG vaccine.

28. Which of the following is not a limitation of using live-attenuated vaccines?

Ans : D

A It is not suitable for individuals with weakened immune system.

B It is not stable for transport to developing countries.

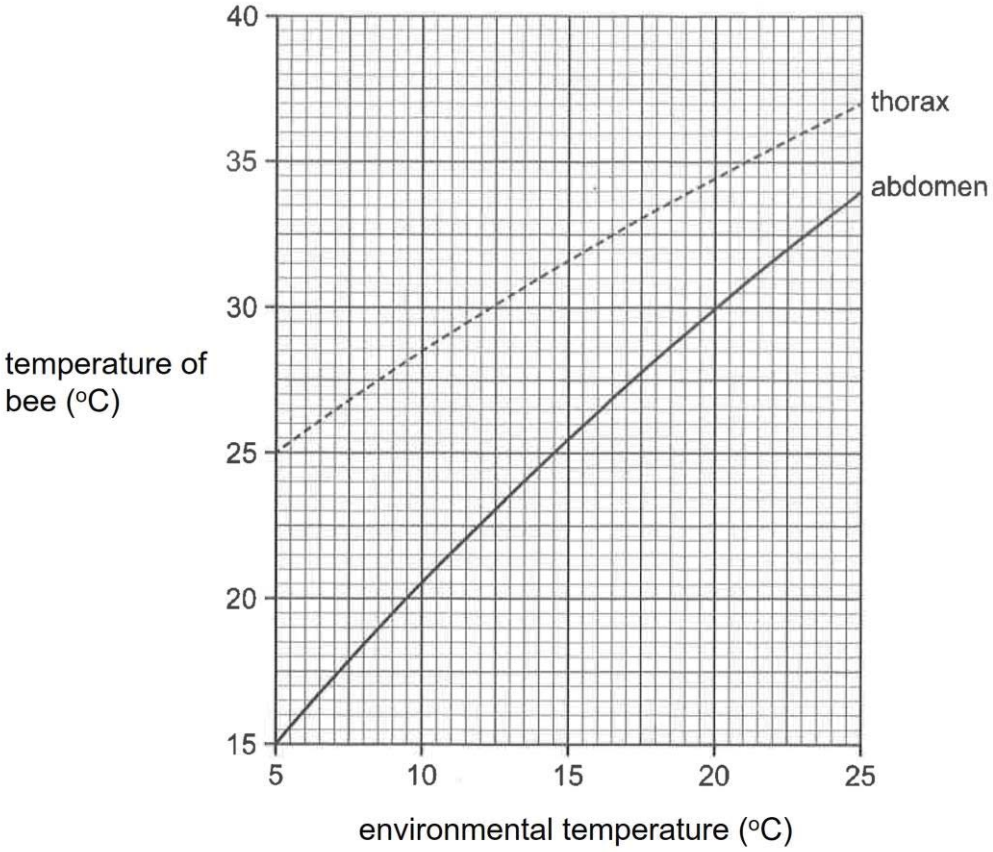
C It is challenging to ensure that it is both safe and able to stimulate the immune system sufficiently.

D It hijacks the host cell machinery to replicate, causing symptoms like fever and rash.

29. The bee, *Anthophora plumipes*, is common in the UK. It is active in the spring, when environmental temperature often varies widely. The bee can only fly when the temperature of the flight muscles in its thorax is sufficiently high.

Ans : B

The temperatures of both thorax and abdomen were measured during flight at a range of environmental temperatures. The results are shown in the graph.



Which statements are correct conclusions from the graph and information given?

I The bees are able to fly in a temperature range of at least 20°C.

II At environmental temperatures between 5°C and 25°C, the temperatures during flight of both the thorax and abdomen are higher than the environmental temperature.

III The bees can warm their flight muscles so that they can fly at low environmental temperatures.

IV Heat is generated in the abdomen and passed to the thorax.

A **I** and **II** only

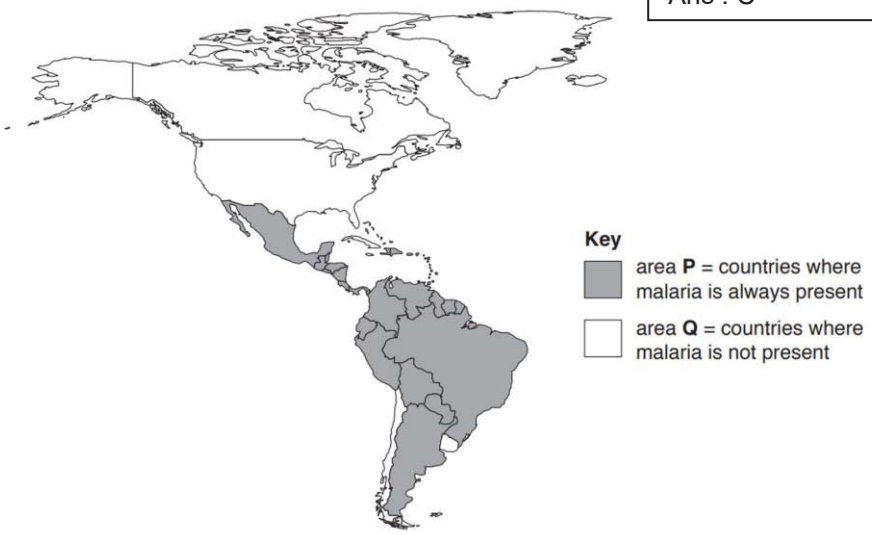
B **II** and **III** only

C **III** and **IV** only

D All of the above

30. The following figure shows the distribution of malaria in the Americas in 2012.

Ans : C



Which of the following factors could be limiting the distribution of malaria to area **P**?

I Climate in area **P** is optimal for growth for *Anopheles* mosquitoes.

II Area **Q** has a good control to drain stagnant water.

III The percentage of the population that is vaccinated in area **Q** remains relatively high over 90%.

IV Climate in area **P** is cool enough for the survival of *Plasmodium* during extrinsic incubation period.

A **I** and **III** only

B **II** and **IV** only

C **I**, **II** and **III** only

D All of the above

End of Paper

Class Adm No

Candidate Name: _____

H

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2019 Preliminary Exams
Pre-University 3

BIOLOGY **9744/02**

Paper 2 Structured Questions **17 September 2019**

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 in the question booklet.

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	
1	
2	
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6	
7	
8	
Total	

Answer **all** questions in this section.

1. Fig. 1.1 shows the structure of a prokaryotic cell.

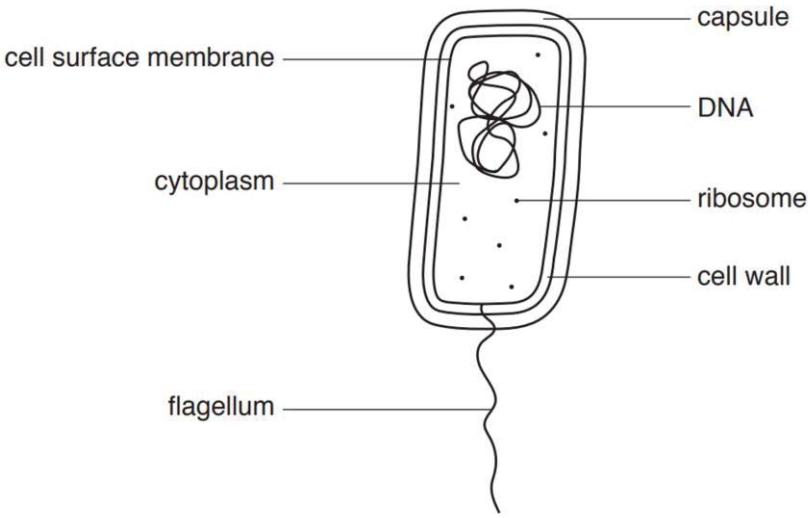


Fig. 1.1

Fig. 1.1 has not been fully labelled to confirm that the cell is prokaryotic.

(a) State what other information could be added to two of the labels to confirm that this cell is prokaryotic and not eukaryotic.

1. Peptidoglycan cell wall /non-cellulose cell wall;
2. Naked /circular DNA / free in cytoplasm / lack histones;
3. 70S ribosome;
; for 1 mark, max 2 marks

…….
…….
…….
…….**[2]**

Similarities

1. Both involves DNA replication;
2. The cell grows larger prior to division;
3. Replicated chromosomal DNA is equally divided to daughter cells / Both processes form two genetically identical daughter cells;
; for 1 mark, max 1 mark

Differences

4. In binary fission there is no disintegration of nuclear envelope, while in mitosis, disintegration of nuclear envelope occurs during prophase;
5. In binary fission, each duplicated DNA molecules are attached to opposite poles of the plasma membrane, whereas in mitosis, spindle fibres formed to attach to the centromere where sister chromatids are joined together to separate the sister chromatids during anaphase;
6. Binary fission does not have distinct cellular phases while mitotic cell cycle is made up of G1, S, G2 and M phase;
7. In binary fission, DNA replication occurs simultaneously as cell divides, whereas in mitotic cell cycle, DNA replication is completed in S-phase before the cell proceeds to divide;
8. In mitosis, chromatin condenses into chromosome during prophase, whereas there is no condensation of DNA during binary fission;
9. Mitotic cell cycle requires a longer time as compared to binary fission /ORA;
; for 1 mark, max 1 mark

(c) Penicillin is an antibiotic that is commonly used to treat bacterial infection. Penicillin works by disrupting the function of the enzyme involved in the synthesis of bacterial cell wall.

Transpeptidase;
; for 1 mark

……..**[1]**

Molecular studies have found that penicillin is able to form a permanent covalent bond with the active site of the target enzyme. Fig. 1.2 shows the effect of substrate concentration against the rate of cell wall synthesis with and without penicillin.

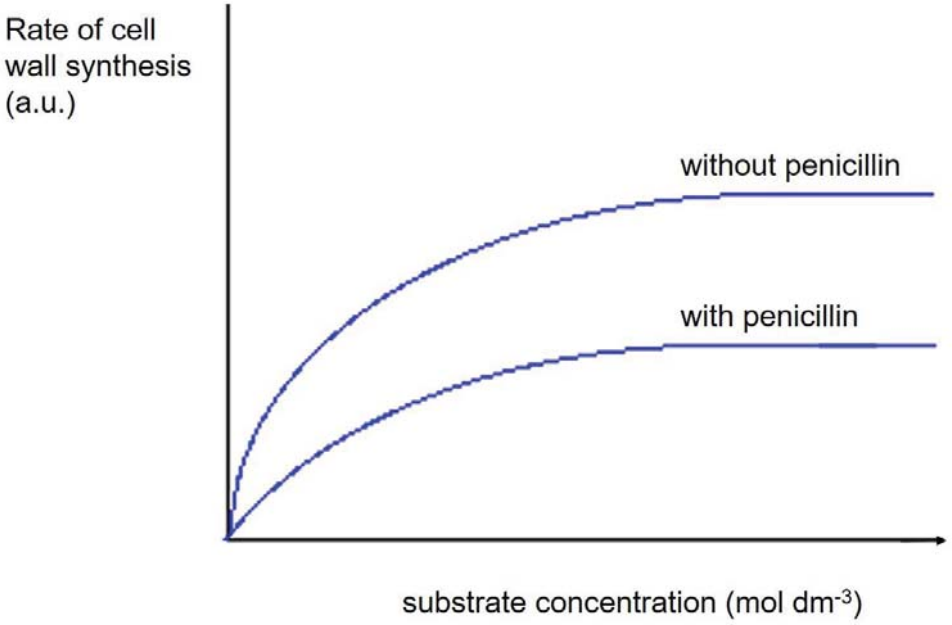


Fig. 1.2

(ii) Account for the difference in the graph with penicillin.

1. Lower rate of cell wall synthesis at every substrate concentration;
2. Formation of covalent bond causes penicillin to act like a non-competitive inhibitor / inhibits transpeptidase permanently;
3. Increasing substrate concentration is unable to overcome the inhibition;
; for 1 mark, max 2 marks
4. Structure of penicillin is complementary to shape of active site of transpeptidase;
5. Decreases number of effective transpeptidase / substrate unable to bind to transpeptidase;
6. Decrease rate of effective collision at every substrate concentration;
7. Decrease rate of ES complex formation / no. of ES complexes formed per unit time at every substrate concentration;
; for 1 mark, max 2 marks

……**[4]**

[Total: 9]

[Turn over

2. Table 2.1 shows two processes in which ATP is synthesised in photosynthesis.

Table 2.1

	Energy conversion	Electron donor	Final electron acceptor
Cyclic photophosphorylation	Light energy to chemical energy; ; for 1 mark	P700	PSI / P700; ;for 1 mark
Non-cyclic photophosphorylation		Water	$NADP^+$; ;for 1 mark

(a) Fill in the blanks in Table 2.1. **[3]**

In cellular respiration, ATP is synthesised via substrate-level phosphorylation and oxidative phosphorylation

(b) State the cellular location(s) for each of the reactions:

Substrate-level phosphorylation

Cytosol AND mitochondrial matrix; ; for 1 mark **[1]**

Oxidative phosphorylation

Inner mitochondrial membrane; ; for 1 mark **[1]**

Both chloroplast and mitochondria have the ability to synthesise ATP.

(c) Explain why a plant cell cannot rely on the ATP synthesised in chloroplast for all its energy requirement.

1. ATP synthesised during the light dependent stage is used for Calvin cycle to convert inorganic carbon into organic carbon / carbon fixation / reduction; ; for 1 mark
2. Plants would not be able to survive in prolonged period of darkness / night /OWTTE;
3. ATP synthesised in chloroplast is not transported out of the chloroplast;
4. ATP synthesised by chloroplast is not sufficient; ; for 1 mark, max 1 mark **[2]**

Calvin cycle occurs during photosynthesis, while Krebs cycle occurs during cellular respiration.

(d) Explain why both Calvin cycle and Krebs cycle are termed as a 'cycle'.

1. Initial reactants of Calvin cycle and Krebs cycle are <u>regenerated</u>;
2. <u>Ribulose bisphosphate/RuBP</u> in Calvin cycle AND <u>oxaloacetate</u> in Krebs cycle;
3. No clear end-product;
; for 1 mark

[2]

[Total: 9]

3. Cystic fibrosis is a recessive genetic disease. The extent of the disease is dependent on the type of mutation that occurred in the *CFTR* gene. Table 3.1 shows a class I mutation that accounts for about 20% of cystic fibrosis occurrences. The nucleotide sequence for DNA codon 539 to 544 of the template strand in 5 'to 3' direction is shown for both the normal and mutant sequence.

Table 3.1

5'	codon	539	540	541	542	543	544	3'
	normal	TCC	ACC	TTC	TCC	AAG	AAC	
	mutant	TCC	ACC	TTC	TCA	AAG	AAC	

(a) With reference to Table 3.1,

substitution of "C" for "A" on the 3rd base of the 542nd codon;
; for 1 mark

.[1]

(ii) describe the effect of this mutation on the structure of CFTR synthesised.

1. Nonsense mutation; (R:missense)
2. Substitution in Codon 542 caused it to code for a pre-mature stop codon, 5'-UGA-3';
3. During translation, this will result in a truncated/shorter polypeptide;
4. Primary structure / number of amino acid of polypeptide chain is affected,
5. which alters the folding and 3D conformation of CFTR;
; for 1 mark

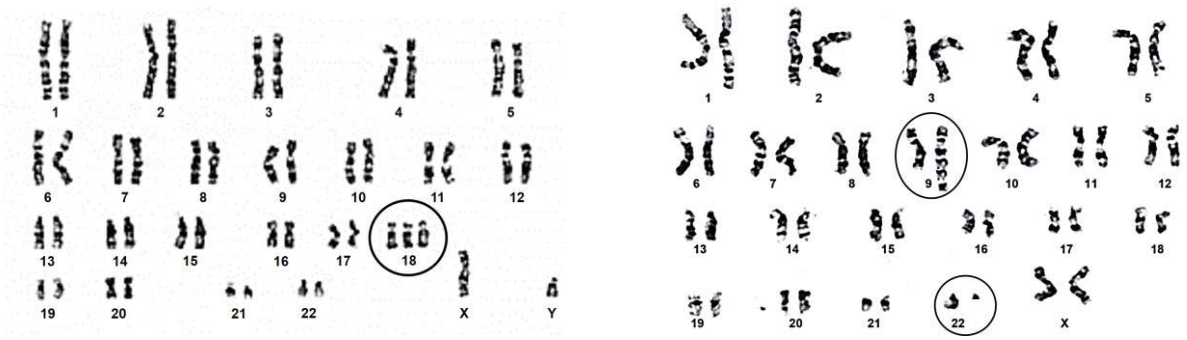
.....

.....

.....

.....**[4]**

(b) Fig. 3.1 shows the karyotype of two individuals, **A** and **B**, suffering from two different genetic diseases.



A **B**

Fig. 3.1

The chromosomes were stained using Giemsa stain that forms dark and light bands based on the structure of the chromosome.

(i) Suggest the structure of the chromosome that appears as dark and light bands.

Light bands: Euchromatin / loosely packed;
Dark bands: Heterochromatin / tightly packed;
; for 1 mark

[1]

The mutation in individual **A** and **B** is circled in Fig. 3.1.

(ii) With reference to Fig. 3.1, distinguish between the type of mutation seen in individual **A** and **B**.

1. A is a numerical /aneuploidy chromosomal mutation whereas B is a structural chromosomal mutation;
2. A shows trisomy 18 / three copies of chromosome 18, whereas B shows a chromosomal translocation between chromosome 22 and 9;
; for 1 mark

[2]

[Total: 9]

4. James Watson, Francis Crick along with the help of Rosalind Franklin and Erwin Chargaff deduced the structure of DNA.

(a) Erwin Chargaff found that the proportions of the bases A, T, C and G were different in different species, but within each species:

- the proportion of A was equal to the proportion of T
- the proportion of G was equal to the proportion of C.

The four bases found in DNA can be classified as purine or pyrimidine.

(i) Identify which bases are purine and pyrimidine.

purine ……

pyrimidine

Purine: A and G;
Pyrimidine: C and T;
; for 1 mark

[2]

(ii) Explain how Chargaff's findings helped Watson and Crick work out the structure of DNA.

1. There is complementary base pairing within the DNA molecule;
2. A with T AND G with C / each purine base paired with another pyrimidine base;
3. Held by hydrogen bonds;
4. Which leads to the deduction that DNA molecule contains 2 strands / double helix;
5. Distance between strands remains the same / uniform width between the 2 strands;
; for 1 mark, max 3 marks

[3]

Control of gene expression is crucial in controlling the amount of protein product within the cell, such that resources are utilised efficiently.

(b) Table 4.1 shows different ways in which gene expression can be controlled.

Complete Table 4.1 by indicating the mechanism and explanation.

Table 4.1

mechanism	**effect on amount of protein product produced (increase / decrease)**	**explanation**
Histone acetylation / methylation; ; for 1 mark	increase	neutralises charge on lysine residues, Increase half-life / stability of mRNA, which increases amount of polypeptides translated from it; ; for 1 mark
lengthening of mRNA poly-A-tail	increase	
synthesising a short RNA molecule that is complementary to start of mRNA	decrease	ribosome unable to bind mRNA / no translation; ; for 1 mark
Addition of ubiquitin tag to protein / ubiquitylation; ; for 1 mark	decrease	targeted proteins are degraded by proteasome

[4]

Testosterone is a steroid hormone produced naturally by the body. In males, one of the target cell for testosterone is the prostate cell, which plays a role in the development of male characteristics.

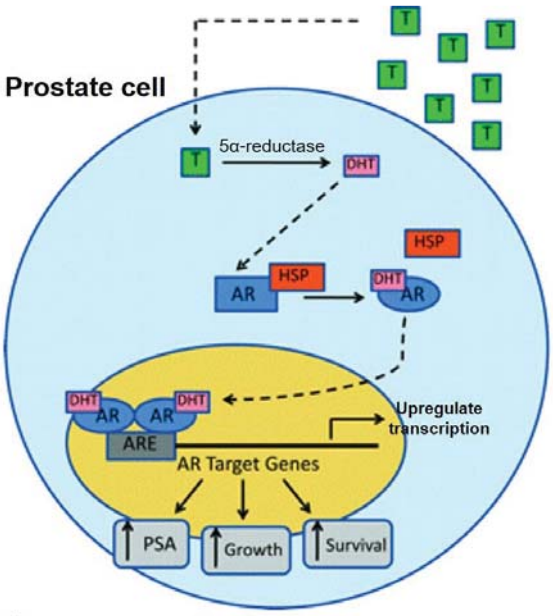
Both testosterone and insulin are ligands that bind to specific receptors.

(c) Distinguish between the structure of testosterone and insulin.

1. Testosterone is a lipid, whereas insulin is a protein;
2. Testosterone is hydrophobic, whereas insulin is hydrophilic;
3. Testosterone is relatively smaller compared to insulin /ORA;
4. Testosterone is not a polymer / not made up of monomers, whereas insulin is a polymer made up of amino acids / is a polypeptide;
; for 1 mark, max 2 marks

[2]

Fig. 4.1 shows testosterone signalling in a prostate cell.



Legend:

T	Testosterone
DHT	Dihydrotestosterone
HSP	Heat shock protein
AR HSP	Inactive androgen receptor (AR) bound by heat shock protein (HSP)
DHT AR	Activated androgen receptor (AR) bound by dihydrotestosterone (DHT)
ARE	Androgen response element (control element)
PSA	Prostate specific antigen

Fig. 4.1

(d) Prostate cancer is one of the most common cancer among men. In some prostate cancer, it is common to find a mutant form of the androgen receptor (AR) that cannot be bound by heat shock protein (HSP), as such it is always in its active form.

(i) Using your knowledge of cancer development, state the class of gene that a normal androgen receptor gene belongs to.

Proto-oncogene;
; for 1 mark

[1]

Prostate specific antigen (PSA) is a protein secreted by prostate cells. It is required for the normal functioning of the male sex organ. In prostate cancer detection, a common method is to detect for elevated levels of PSA.

(ii) With reference to Fig. 4.1, describe how a mutated androgen receptor could lead to elevated levels of PSA.

1. Gain-of-function mutation to androgen receptor causes it to be constitutively active / activated without presence of testosterone / OWTTE;
2. It is able to constantly dimerise and enter the nucleus;
3. Functioning as an activator, by binding onto androgen response element,
4. Androgen response element is an enhancer to specific genes like the gene coding for PSA;
; for 1 mark, max 3 marks
5. Leading to upregulation of transcription of gene coding for PSA;
; for 1 mark

[4]

Mutant androgen receptor is just one of many other mutations found in prostate cancer.

(iii) Ex ncer.

1. Cancer is a multistep model disease;
2. Accumulation of mutations to both proto-oncogenes and tumour suppressor genes are required;
3. Gain-of-function mutations to one proto-oncogene converting it to oncogene;
4. Loss-of-function mutations to tumour suppressor genes;
5. Activation of telomerase gene / angiogenesis / metastasis;
6. Causes cell cycle checkpoints to be defective / dysregulation in cell cycle / ignore apoptotic signal / ignore cell death, allowing accumulation of further mutations;
   ; for 1 mark, max 3 marks
7. Eventually leading to uncontrolled cell division (R: uncontrolled growth);
   ; for 1 mark

[4]

[Total: 20]

5. In pigeons, the sex chromosomes are termed as Z chromosome and W chromosome. Male pigeons are homogametic, ZZ while female pigeons are heterogametic, ZW. *Tyrp1* gene is located on the Z chromosome and the gene determines feather colours in pigeons. There are three alleles of *Tyrp1* gene:

$\mathbf{Z^{BA}}$ coding for ash-red feathers
$\mathbf{Z^{B+}}$ coding for blue feathers
$\mathbf{Z^{b}}$ coding for brown feathers

Table 5.1 shows three different crosses and the resulting phenotypes of offspring.

Table 5.1

Parental phenotype		**offspring phenotype**	
male	**female**	**male**	**female**
pure bred blue	ash-red	all ash-red	all blue
pure bred brown	blue	all blue	all brown
pure bred ash-red	brown	all ash-red	

(a) With reference to the information provided and Table 5.1, state one possible genotype for a non-pure bred male pigeon with ash-red feathers.

$Z^{BA}Z^{B+}$/ $Z^{BA}Z^{b}$;
; for 1 mark **…[1]**

Another gene on an autosomal chromosome, *Sox10*, codes for an activator to *Tyrp1* gene. Dominant allele **E** codes for a functional activator, while recessive allele **e** codes for a non-functional activator. When *Tyrp1* gene is not expressed, the pigeon feather turns red.

(b) State the type of interaction between *Sox10* gene and *Tyrp1* gene.

…. (Recessive) epistasis;
; for 1 mark **……[1]**

Pure-breeding male with ash-red feathers was crossed with a red female. The resulting F1 generation all had ash-red feathers. F1 generation was then allowed to interbreed. The results are shown in Table 5.2.

Table 5.2

phenotype	number
ash-red	898
brown	294
red	408

(c) Draw a genetic diagram to show the cross between F1 generation.

Parental phenotype ash-red, male ash-red, female

Parental genotype $EeZ^{BA}Z^{b}$ $EeZ^{BA}W$

Gametes EZ^{BA} EZ^{b} eZ^{BA} eZ^{b} EZ^{BA} EW eZ^{BA} eW

Punnett square

	EZ^{BA}	EW	eZ^{BA}	eW
EZ^{BA}	$EEZ^{BA}Z^{BA}$ ash-red	$EEZ^{BA}W$ ash-red	$EeZ^{BA}Z^{BA}$ ash-red	$EeZ^{BA}W$ ash-red
EZ^{b}	$EEZ^{BA}Z^{b}$ ash-red	$EEZ^{b}W$ brown	$EeZ^{BA}Z^{b}$ ash-red	$EeZ^{b}W$ brown
eZ^{BA}	$EeZ^{BA}Z^{BA}$ ash-red	$EeZ^{BA}W$ ash-red	$eeZ^{BA}Z^{BA}$ red	$eeZ^{BA}W$ red
eZ^{b}	$EeZ^{BA}Z^{b}$ ash-red	$EeZ^{b}W$ brown	$eeZ^{BA}Z^{b}$ red	$eeZ^{b}W$ red

Offspring genotype

$EEZ^{BA}Z^{BA}$
$EEZ^{BA}Z^{b}$
$EEZ^{BA}W$
2 $EeZ^{BA}W$
2 $EeZ^{BA}Z^{BA}$
2 $EeZ^{BA}Z^{b}$
$EEZ^{b}W$
2 $EeZ^{b}W$
$eeZ^{BA}Z^{BA}$
$eeZ^{BA}W$
$eeZ^{BA}Z^{b}$
$eeZ^{b}W$

Offspring phenotype ash-red brown red

Offspring phenotypic ratio 9 3 4

1. Correct parental genotype;
2. Correct gametes;
3. Correct Punnett square;
4. Correct matching of offspring genotype and phenotype;
5. Correct offspring ratio (9:3:4);
; for 1 mark

6. In an attempt to directly observe and record data for speciation, a group of scientist studied a species of lytic phage, EvoC. Phages are known to attach to bacteria via binding of specific receptors. LamB and OmpF are examples of such receptors expressed by *Escherichia coli (E. coli)*. Uniquely, EvoC is able to recognise and bind to either LamB or OmpF, thereby able to infect *E. coli* that expresses either of the specific receptor, LamB or OmpF.

(a) Phages that infects a same species of bacteria are classified under one species.

(i) State the species concept used to define the phage.

Ecological species concept;
; for 1 mark

[1]

Viruses are known to have high mutation rates. Despite not having a mechanism for sexual reproduction, advantageous mutations can still be spread via genetic recombination.

(ii) Using your knowledge of bacteriophage reproductive cycle, suggest how genetic recombination can occur in a population of bacteriophage.

1. When individual phage of the same species <u>infects the same bacteria / host</u>;
2. Ref. to transduction with recipient host already infected with a phage (R: transformation/ conjugation)
; for 1 mark, max 1 mark

[1]

The group of scientists genetically modified *E. coli* such that it only expresses either one of the receptor. They then created two separate set-ups in an attempt to observe speciation:

- **Group A**: Phage EvoC + *E. coli* expressing only LamB receptor.
- **Group B**: Phage EvoC + *E. coli* expressing only OmpF receptor.

Phages in group **A** and **B** were then allowed to propagate in isolation. The results are as follows:

- **Group A**: All viral progenies now only specifically infect *E. coli* expressing LamB receptor and are unable to infect *E. coli* expressing OmpF receptor.
- **Group B**: All viral progenies now only specifically infect *E. coli* expressing OmpF receptor and are unable to infect *E. coli* expressing LamB receptor.

(b) State the type of speciation that the group of scientists are modelling.

Allopatric speciation;
; for 1 mark

.....**[1]**

To find an explanation for the observation, the group of scientists then went on to measure the rate of absorption to the receptors in the original EvoC phages and the progenies from Group **A** and **B**. The results are shown in Fig. 6.1.

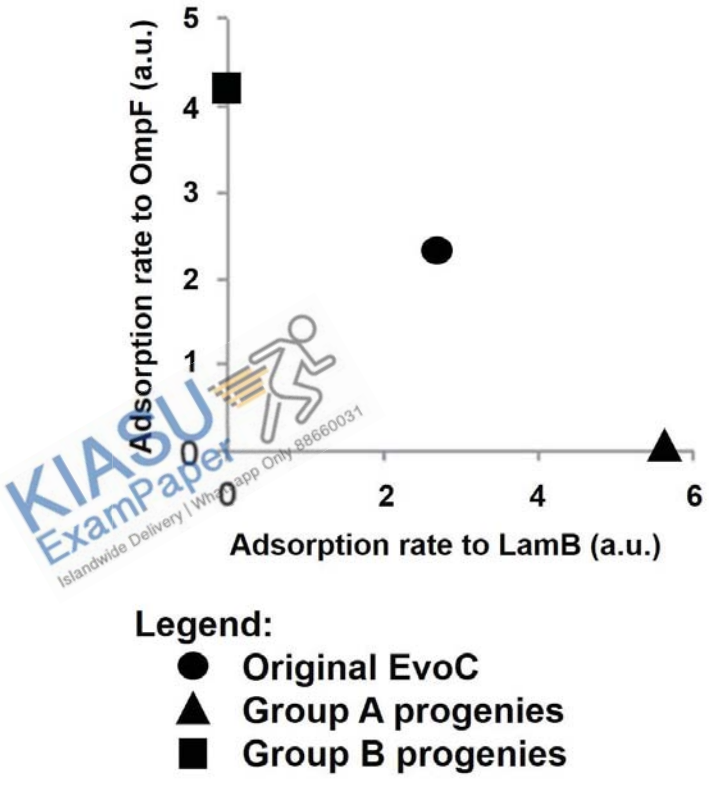


Fig. 6.1

(c) ith reference to Fig. 6.1 and the information provided,

(i) state the selection pressure acting on EvoC phages in this experiment.

Type of bacteria receptor present;
; for 1 mark

[1]

(ii) state which trait was selected against in group **A**.

Group **A** ….. Adsorption to OmpF receptor;
; for 1 mark

[1]

(iii) based on your answers in **c(i)** and **c(ii)**, explain the results obtained from group **A**.

1. EvoC adsorption rate to both OmpF and LamB were at similar rates;
2. Genetic variation due to random mutation was present in initial EvoC populations, some EvoC adsorption rate to OmpF/LamB was slightly faster/slower /OWTTE ;
3. Allele coding for adsorption to OmpF was selected against, as its expression was considered a waste of resources;
4. Allele coding for higher adsorption to LamB was selected for, as it confer a faster rate of reproduction;
5. Allele coding for adsorption to OmpF was not passed down to subsequent viral progenies;
6. Allele coding for higher adsorption rate to LamB was passed down to subsequent viral progenies;
7. As the two groups were kept separated, there was no gene flow;
8. Increase in allele frequency for adsorption to LamB while decrease in allele frequency for adsorption to OmpF;
9. Ref to directional selection;
10. Group A accumulate its own genetic differences and eventually, group A progenies specialised in adsorption to LamB / lost ability in adsorption to OmpF /OWTTE;
; for 1 mark, max 4 marks

(iv) justify if speciation has occurred.

1. Yes, speciation has occurred;
2. Group A progenies and group B progenies can only infect E.coli that expresses LamB only and OmpF only respectively / ORA;
OR
3. No, speciation did not occur;
4. EvoC can still infect *E.coli* that expresses both LamB and OmpF;
; for 1 mark

]

(v) Suggest a reason why the scientists chose to use phage to study speciation.

Fast generation time /OWTTE;
; for 1 mark

]

[Total: 12]

7. Table 7.1 shows different stages in the life cycle of a female *Aedes aegypti* (*A. aegypti)*.

Table 7.1

Stage	Aquatic	Terrestrial	Able to transmit dengue virus
Eggs	✓		
Larva	✓		
Pupa	✓		
Adult		✓	✓

1. Correct identification of aquatic and terrestrial stages;
2. Correct identification of only adult being capable of transmitting dengue virus;
; for 1 mark

(a) Place a tick (✓) in appropriate boxes that applies to each stage. **[2]**

Fig. 7.1 shows the dengue virus (DENV) infection and its reproductive cycle in *A. aegypti*.

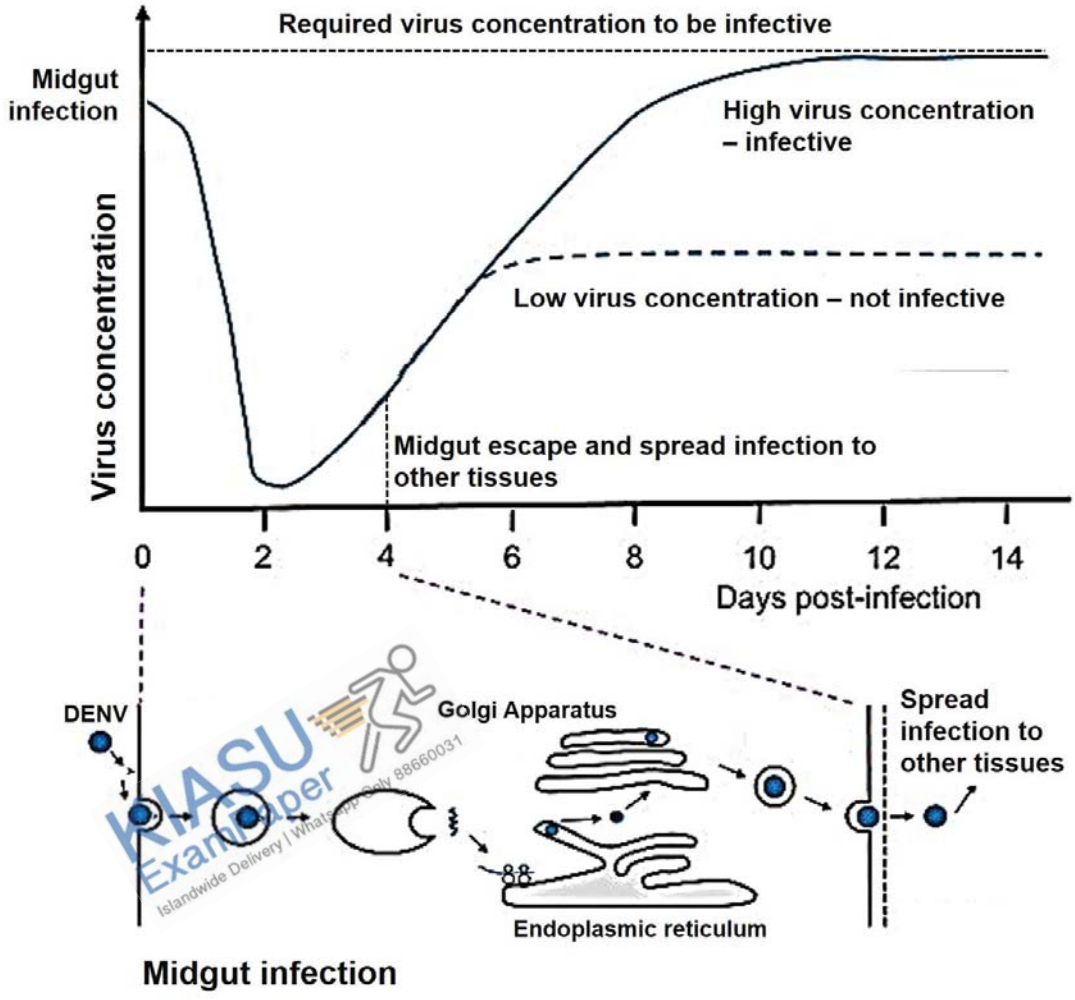


Fig. 7.1

The period between midgut infection and becoming infective is termed as the 'extrinsic incubation period'.

(b) With reference to Fig. 7.1,

(i) account for the change in virus concentration upon midgut infection to when *A. aegypti* is considered infective.

1. Virus concentration decreased drastically upon infection to 2 days post-infection, as virus are entering mid-gut epithelium cells / digested by enzymes in gut;
2. 2 more days is required for viral replication before virus concentration is high enough to be spread to other tissues / OWTTE;
3. As DENV is spread to other tissues, it continues to replicate, further increasing virus concentration;
4. When virus concetration gets high enough to infective level at day 10 is when *A. aegypti* is considered to be infective;
5. Ref to virus reaches salivary gland of *A. aegypti* by day 10;
; for 1 mark, max 3 marks

.....
.....
.....
.....
.....
....**[3]**

(ii) compare the reproductive cycle of DENV and influenza.

Similarities

1. Both enters via receptor-mediated endocytosis;
2. Both forms an endocytic vesicle that fuses with viral membrane to release nucleocapsid;
3. Both involves uncoating / degradation of nucleocapsid to release viral RNA;
4. Both involves viral RNA dependent RNA polymerase to synthesise new viral RNA
5. Both hijacks bound ribosomes on RER to synthesise viral proteins;
; for 1 mark, max 2 marks

Differences

6. Dengue virus E glycoprotein binds to specific glycoprotein receptors on host cell surface membrane, whereas for influenza hemagglutinin binds to sialic acid containing receptor;
7. Dengue viral envelope proteins are embedded on RER, whereas influenza envelope proteins are embedded on host cell surface membrane;
8. Dengue nucleocapsid is assembled near RER and subsequently enters RER, whereas influenza nucleocapsid is assembled beneath cell surface membrane and does not enter the RER;
9. Dengue virus obtained its envelope after budding off from RER, whereas influenza obtains it envelope only after budding off from host cell;
10. Dengue virus is matured after leaving Golgi apparatus, whereas influenza is only matured after leaving host cell;
11. Dengue virus leaves host via exocytosis, whereas influenza leaves by budding;
; for 1 mark, max 2 marks

.....
.....
.....
.....
.....
.....
....**[4]**

Fig. 7.2 shows the development of a primary dengue infection with timing of diagnostic test.

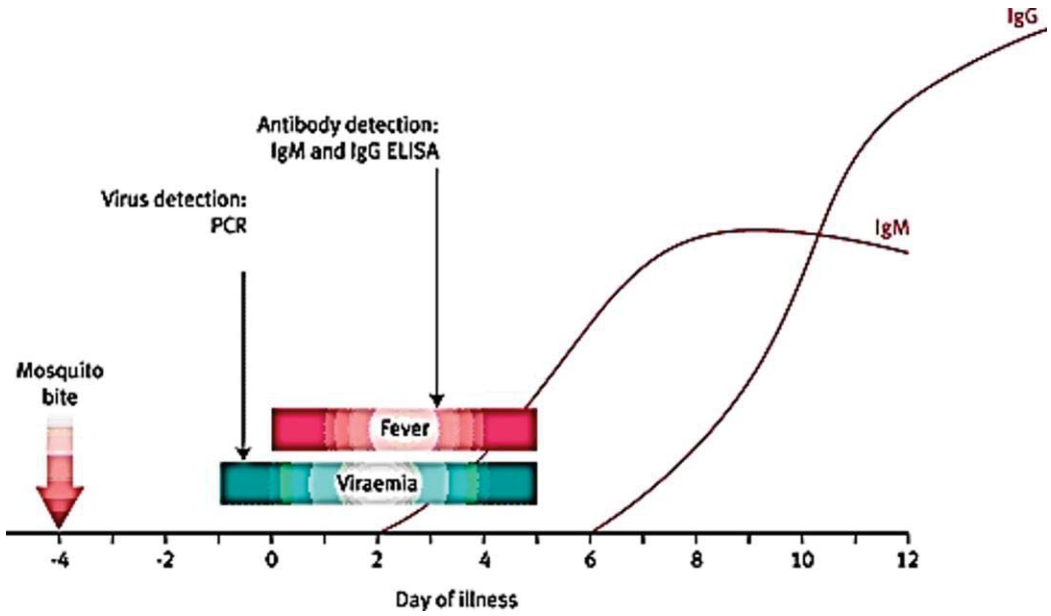


Fig. 7.2

(c) Polymerase chain reaction (PCR) and gel electrophoresis can be carried out on a sample of DNA extracted from the patient's blood to identify the presence of DENV.

PCR is a powerful molecular technique as it is able to amplify a target sequence from a mixture of DNA.

(i) Identify the type of blood cell that would contain the patient's DNA.

White blood cells / lymphocytes;
; for 1 mark

.....[1]

(ii) Describe how PCR is able to specifically amplify DENV DNA only.

1. Using a pair of forward and reverse primer;
2. that is complementary to a specific region found only on DENV genome / flanking DENV genome / OWTTE;
3. Provides free 3'–OH end that restricts Taq polymerase to elongate only the target sequence /OWTTE;

; for 1 mark, max 2 marks

.
.
.
]

The PCR products can be visualised to analyse the results.

(iii) State how the PCR products can be visualised without the use of probes.

Stain DNA using ethidium bromide and visualise using UV light;
; for 1 mark

[1]

(iv) Based on the method stated in **c(iii)**, describe what would be the expected result for a patient with DENV infection.

Presence of a thick band;
; for 1 mark

[1]

(v) Suggest why PCR would only be effective at least three days after infection.

1. Virus concentrations are too low to be detected / primers are unable to bind;
2. PCR would give a false negative / OWTTE;
; for 1 mark, max 1 mark

[1]

IgM was produced on day 2 of illness, while IgG was produced on day 6 of illness

(vi) With reference to Fig. 7.2, describe the process occurring between day 2 and day 6 of illness causing the production of IgG.

1. Class switching;
; for 1 mark
2. Signalled by cytokines released from CD4+ T-helper cells;
3. Gene locus containing constant gene segments undergoes DNA recombination;
4. Gene segment coding for IgG is selected and looped, excising /remove gene segments in between;
5. Resulting in the expression of the selected IgG gene segment in the heavy chain to produce IgG;
6. Recombination is catalysed by activation-induced cytidine deaminase;
; for 1 mark, max 2 marks

[3]

(d) In the space provided below, draw a labelled diagram of an antibody.

1. Y-shaped, 4 polypeptide chain, with heavy and light chain labelled;
2. 3 disulphide bonds (1 between heavy chain, 1 between each heavy and light chain);
3. C and V region of heavy and light chain correctly labelled OR Fc and Fab region labelled;
4. Antigen binding site labelled;
; for 1 mark

[4]

(e) Patients who recover from the infection by one particular serotype of DENV gain lifetime immunity against that particular serotype.

(i) State the type of immunity achieved.

Natural active immunity;
; for 1 mark

[1]

(ii) Explain why patients would only be immune to the same serotype but not to all DENV serotypes.

1. Different DENV serotypes have different epitopes / antigens;
2. The receptors on memory T and B cells formed by the initial serotype are only complementary to epitope present on antigens of the initial serotypes;
3. Receptors are not complementary to epitopes present on antigens of other serotypes / absence of memory T and B cells specific for other serotypes
; for 1 mark

[2]

[Total: 25]

Blank Page

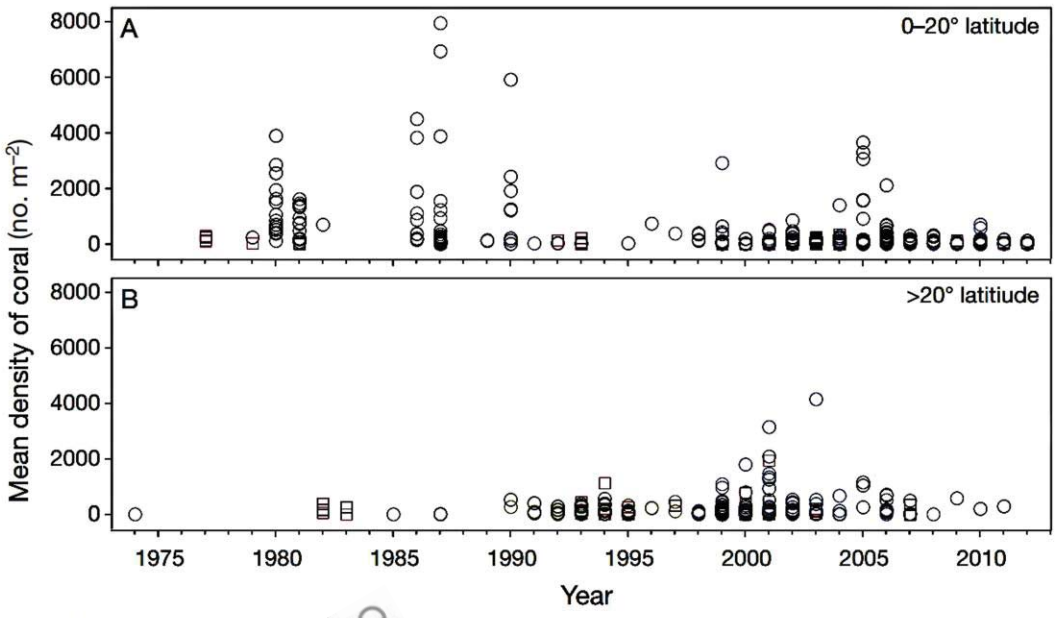
8. Global atmospheric carbon dioxide level has been rising at an accelerating rate over the past decade, causing changes in climate.

Carbon dioxide is one of the major greenhouse gases, whereas compared to oxygen, oxygen is not classified as a greenhouse gas.

(a) Describe the property of carbon dioxide for it to be classified as a greenhouse gas.

Able to absorb solar radiation;
; for 1 mark

Due to increase in greenhouse gases, global temperature has been on the rise, including the oceans. Marine organisms like corals are temperature sensitive. Fig. 8.1 shows the distribution of corals over a period of time.



Data point indicates different locations within the latitude range

Fig. 8.1

(b) With reference to Fig. 8.1, describe the distribution of corals from 1975 to 2010.

1. Corals have shifted from low latitudes / equator region / tropics from 1975 to higher latitudes / beyond tropics / sub-tropics in 2010;
; for 1 mark
2. Coral density was higher in low latitudes / equator region / tropics, whereas coral density was low in higher latitudes / beyond tropics / sub-tropics from 1975 to 1990;
3. Coral density decreased in low latitudes / equator region / tropics, whereas coral density increased in higher latitudes / beyond tropics / sub-tropics from 1990 onwards;
4. There were much more corals in both latitudes in 1987 as compared to 2010;
5. At low latitudes, coral density decreased from 1975 to 2010;
6. At higher latitudes, coral density increased from 1975 to 2010;
; for 1 mark, max 1 mark

(c) Explain why the change in distribution occurred.

1. Low latitude got warmer, warmer water placed corals under heat stress / cause coral bleaching;
2. High temperature disrupts photosynthesis in zooxanthellae, causing excess products that become toxic;
3. Which damages metabolism of coral polyp, which expels zooxanthellae;
4. Corals and zooxanthellae are in a symbiotic relationship, without nutrients provided by zooxanthellae, corals eventually die;
5. New polyps are unable to grow in low latitudes;
   ; for 1 mark, max 3 marks
6. High latitudes with previously non-suitable temperature becomes warm enough /OWTTE;
7. Polyps that drift to higher latitudes are able grow and develop a healthy relationship with zooxanthellae;
   ; for 1 mark

[4]

(d) Suggest possible impacts due to the change in distribution of corals.

1. As corals are habitats to other organisms, they may be a shift in biodiversity from low latitudes to higher latitudes /OWTTE;
2. Loss of biodiversity;
3. Loss of coastal protection in tropics region;
4. Change in global food supply distribution of fishes that depends on corals;
5. Shift in tourism
6. Loss of biomedicine
7. AVP
   ; for 1 mark, max 2 marks

[2]

[Total: 9]

End of Paper

Class Adm No

Candidate Name: _____

H

millennia institute

2019 Preliminary Exams
Pre-University 3

BIOLOGY **9744/03**

Paper 3 Long Structured and Free-response Questions **19 September 2019**

2 hours

Additional Materials: Writing Paper

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 on the Question Paper.

Section B
Answer any **one** question on writing paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
Section B	
Total	

This question paper consists of 21 printed pages, including 1 blank page.

[Turn over

Section A

Answer **all** questions in this section.

1. The immune system plays an active role in the prevention of cancer development. Fig. 1.1 shows how an immune cell interacts with a cancer cell.

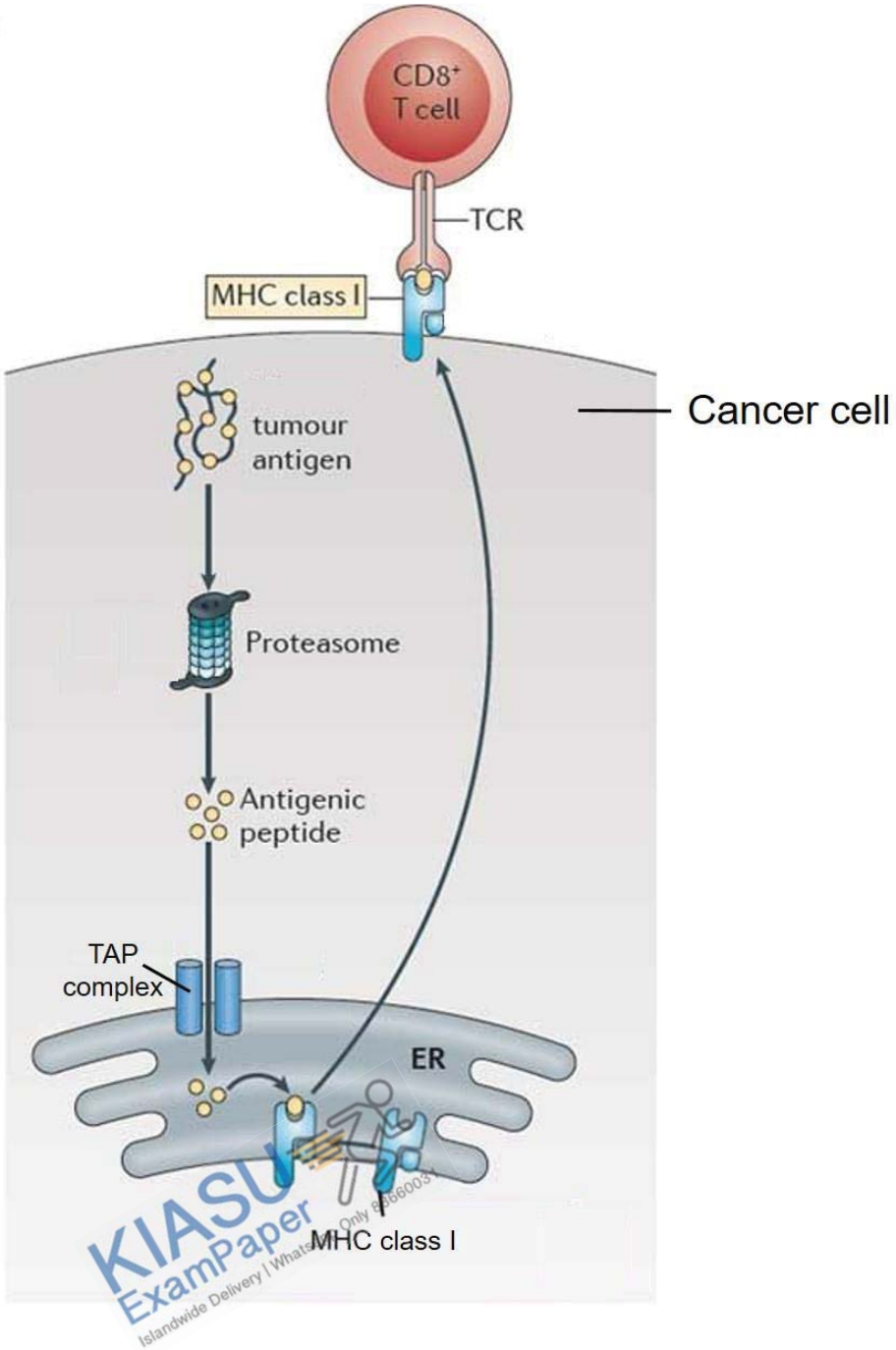


Fig. 1.1

(a) Define the term, 'antigen'.

1. any foreign molecule that is specifically recognised and responded by immune cells; **.....[1]**

The immune system is able to identify normal cells as the antigen displayed on the cell surface is normal and termed as self-antigen. However, in cancer cells, instead of displaying self-antigens, they display tumour antigens and thus are recognised as foreign by the immune system.

(b) Account for the presence of tumour antigen within cancer cells.

1. Mutation occurred that altered the nucleotide sequence / coding region of normal proteins;
; for 1 mark
2. Cause a change in amino acid sequence / primary structure of protein coded / express / translate an abnormal/non-functional protien;
3. Result in a different folding / 3D conformation / function of the normal protein;
; for 1 mark, max 1 mark

[2]

(c) With reference to Fig. 1.1, describe how the cancer cell presents tumour antigen.

1. Tumour antigen is hydrolysed / degraded into smaller antigenic peptides by proteasome;
2. Antigenic peptide is transported into the rough endoplasmic reticulum /ER by TAP complex;
3. Antigenic peptide is mounted onto / binds MHC class I, forming a Class I MHC:peptide complex;
4. Class I MHC:peptide complex is packed into a secretory vesicle which is then transported to the cell surface membrane
5. The secretory vesicle fuses with the cell surface membrane, embedding the Class I MHC:peptide complex on the cell surface membrane;
; for 1 mark, max 4 marks

[4]

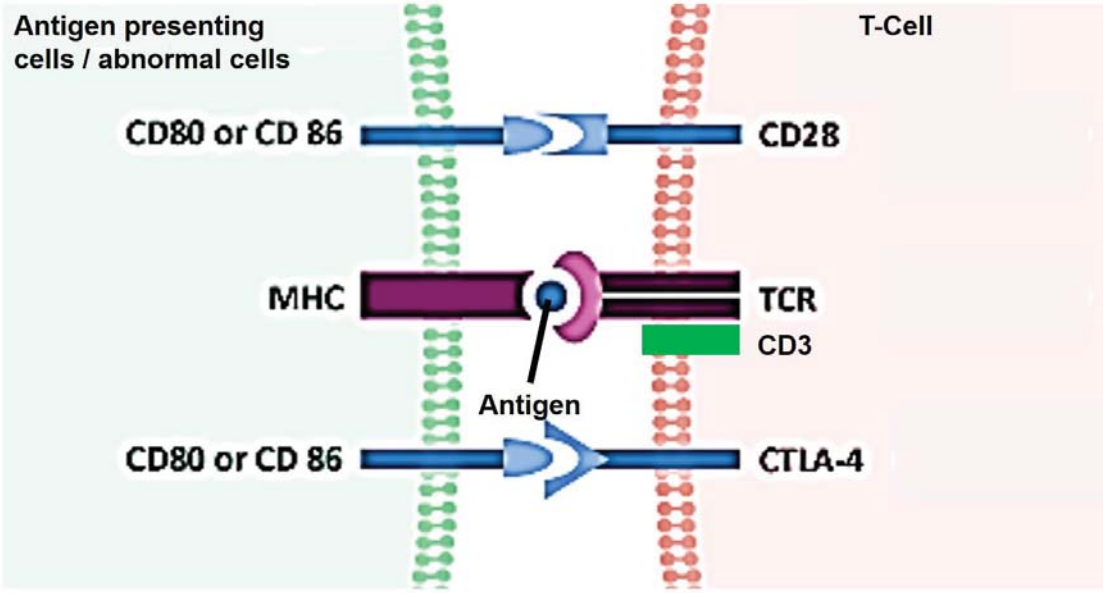
It is important that the immune cells do not recognise and bind to normal cells displaying self-antigens.

(d) State how the immune cell in Fig. 1.1 is able to specifically recognise only cancer cells.

- T-cell receptor has an unique antigen binding site that is complementary to the shape of a specific epitope on the antigenic peptide;

[1]

The activation of T-cells is highly regulated. There are various receptors on T-cells that play a role in the regulation of T-cell activation. The various receptors along with their ligands are shown in Fig. 1.2.



Receptors:
CD28 : Cluster of differentiation 28
TCR : T-cell receptor
CD3 : Cluster of differentiation 3 (co-receptor associated with TCR)
CTLA-4 : Cytotoxic T-lymphocyte-associated protein 4

Fig. 1.2

To investigate the roles of CD28 and CTLA-4 receptor in the activation of T-cells, the following three monoclonal antibodies were used. Table 1.1 shows the target and effects of the three monoclonal antibodies.

Table 1.1

monoclonal antibody	**target**	**effect**
anti-CD28	CD28 receptor on T-cells	mimics ligand binding and activates CD28 receptor
anti-CTLA-4	CTLA-4 receptor on T-cells	mimics ligand binding and activates CTLA-4 receptor
anti-CD3	co-receptor CD3 associated with TCR on T-cells	mimics ligand binding and activates co-receptor CD3 which triggers the activation of TCR

A population of T-cells were harvested from mice and exposed to different sets of the three monoclonal antibodies. The number of activated T-cells were then quantified using radioactivity in terms of counts per minute (cpm). Fig. 1.3 shows the results.

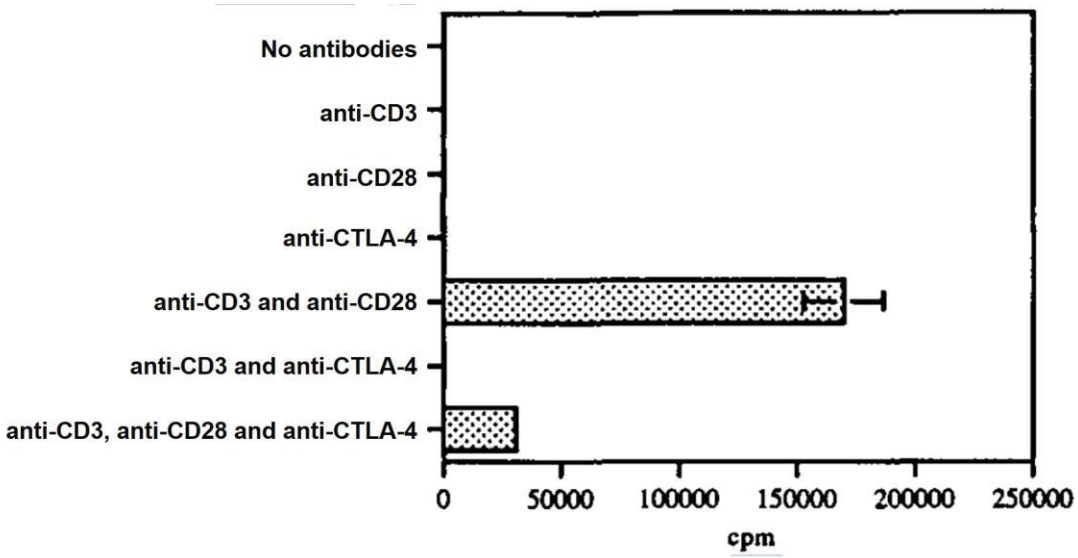


Fig. 1.3

(e) The activated T-cells generated upon successful activation are all genetically identical.

(i) State the process that accounts for the large increase in numbers of activated T-cells upon successful activation.

1. clonal expansion
; for 1 mark

[1]

(ii) Explain how one activated T-cell can give rise to a population of genetically identical daughter cell.

1. Mitosis;
2. DNA replication occurs during S-phase that doubles the DNA content / forms genetically identical sister chromatids;
3. Chromosomes line up along the metaphase plate and sister chromatids are pulled apart / centromere separates;
4. move towards opposite poles;
5. Ensures that the sister chromatids are dividedly even between the 2 daughter cells;
; for 1 mark, max 4 marks

[4]

It is hypothesised that CD28 receptor and CTLA-4 receptor could regulate activation of T-cells by either providing co-activation or inhibitory signals.

(f) With reference to Fig. 1.3, fill in the box below with a (✓) to indicate the effect of the receptors on T-cell activation.

Receptor	Provides co-activation signal	Provides inhibitory signal
CD28	✓	
CTLA-4		✓

CD28: coactivation;
CTLA-4: inhibitory;
; for 1 mark

[2]

Programmed death-1 (PD-1) is another receptor on T-cells that controls an immune checkpoint. When bound by its ligand, programmed cell death-ligand 1 (PD-L1), it suppresses $CD8^+$ T-cell activation and function. A study was carried out to compare the concentration of PD-L1 protein in normal and cancer lung cells. The results are shown in Fig. 1.4.

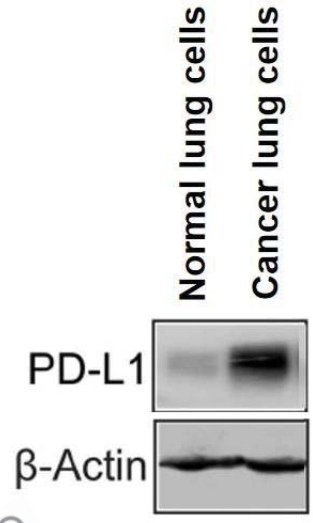


Fig. 1.4

β-actin is a housekeeping protein and its concentration is relatively the same in normal and cancer cell types. In this experiment, the density of the band will vary with the volume of sample added.

(g) Suggest the purpose of showing the level of β-actin protein in each sample.

1. If the band for B-actin is equally thick/dense for all sample, it would show that equal volumes of each sample were injected, allowing for a valid comparison in band thickness/density of the protein of interest; / OWTTE
2. Positive <u>control</u>;
; for 1 mark,

…… ..[1]

To investigate the cause for elevated levels of PD-L1, the levels of mRNA and DNA methylation of *PD-L1* gene promoter region were compared. The results are shown in Fig. 1.5.

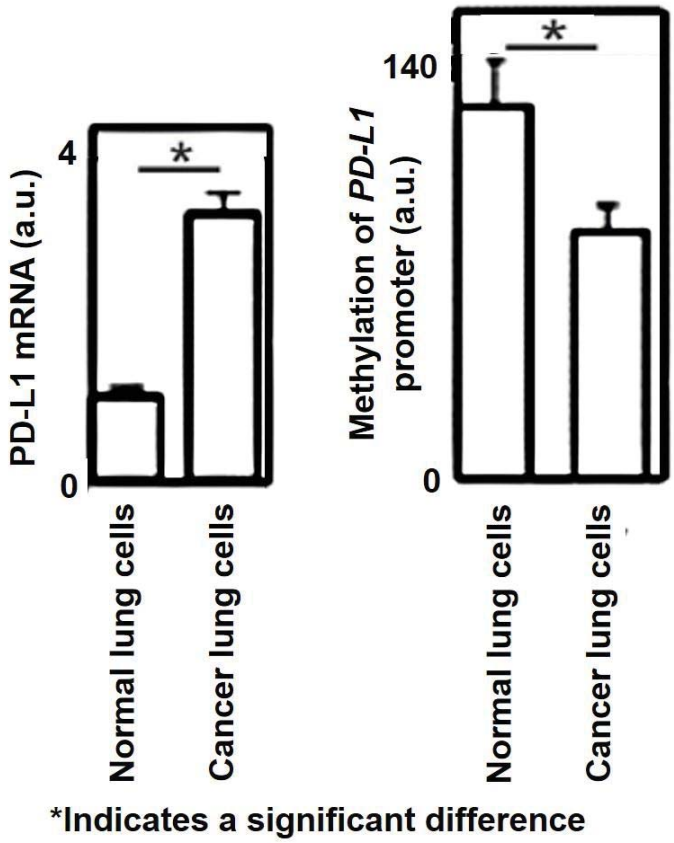


Fig. 1.5

(h) With reference to Fig. 1.5, account for the levels of PD-L1 mRNA and methylation of *PD-L1* gene promoter region.

1. Promoter region of cancer lung cells are significantly <u>less methylated</u> compared to normal lung cells / ORA;
   ; for 1 mark
2. DNA methylation causes chromatin to be <u>tightly coiled</u> /converts euchromatin to heterochromatin;
3. With lower levels of DNA methylation, promoter region PD-L1 gene of cancer lung cells is <u>more loosely coiled</u> compared to normal lung cells / ORA;
   ; for 1 mark, max 1 mark
4. Which allows easier <u>binding of RNA polymerases and general transcription factors / increase rate of transcription initiation complex formation</u>,
5. increasing the rate of transcription /ORA;
6. Therefore the PD-L1 mRNA levels of cancer lung cells is <u>significantly higher</u> than that of the normal cells / ORA;
   ; for 1 mark

…[4]

over

Other studies have shown that cancer cells in the early stages have lower levels of PD-L1 protein as compared to cancer cells in the later stages.

(i) Using your knowledge of natural selection, explain why cancer cells in later stages have higher levels of PD-L1 protein.

1. Pre-existing genetic variation due to random mutations is present among initial population of cancer cells;
2. Cancer cells that have mutations that led to higher levels of PD-L1 were at a selective advantage,
3. These cells manage to avoid apoptosis by cytotoxic $CD8^+$ T-cells / Cytotoxic $CD8^+$ T-cells present the selection pressure;
4. Able to successfully divide and give rise to daughter cancer cells via mitosis, passing on the mutation;
5. Over time the mutations for higher levels of PD-L1 accumulates in the cancer cell population / directional selection;

; for 1 mark, max 4 marks

[4]

In 2018, the Nobel Prize for medicine was awarded to a pair of scientist who showed that by inhibiting CTLA-4 and PD-1 receptors, it can boost the immune system in the fight against cancer. They used two monoclonal antibodies, the targets and effects are shown in Table 1.2.

Table 1.2

monoclonal antibody	target	effect
ipilimumab	binds specifically to CTLA-4 receptor	inhibits receptor by preventing the binding of actual ligand
nivolumab	binds specifically to PD-1 receptor	

Clinical trials for the combination use of these two monoclonal antibodies have shown promising results.

(j) With reference to Fig. 1.2 and Table 1.2, explain why using an antibody specific for CTLA-4 ligand is not as useful as using ipilimumab, which targets the CTLA-4 receptor.

1. Both CTLA-4 and CD28 binds to the same ligand, CD80/CD86;
2. Using an antibody against CD80 or CD86, would prevent it from binding /activating CD28; ……
3. This would prevent the activation of T-cells, weakening the immune system; ……
; for 1 mark, max 2 marks ……
OR
4. Cancer cells have higher rate of mutation than normal cells; …[2]
5. Ligand CD80/CD86 of cancer cell may be mutated at a faster rate, as such the antibody specific for it previously may no longer be complementary;
; for 1 mark, max 2 marks : 26]
OR
6. Idea that if ligand CD80/CD86 out numbers the dose of antibody;
7. Some cancer cell may still be able to inhibit T-cells;
; for 1 mark, max 2 marks

2. Fig. 2.1 shows United Kingdom's methane emissions by source from 1990 to 2010.

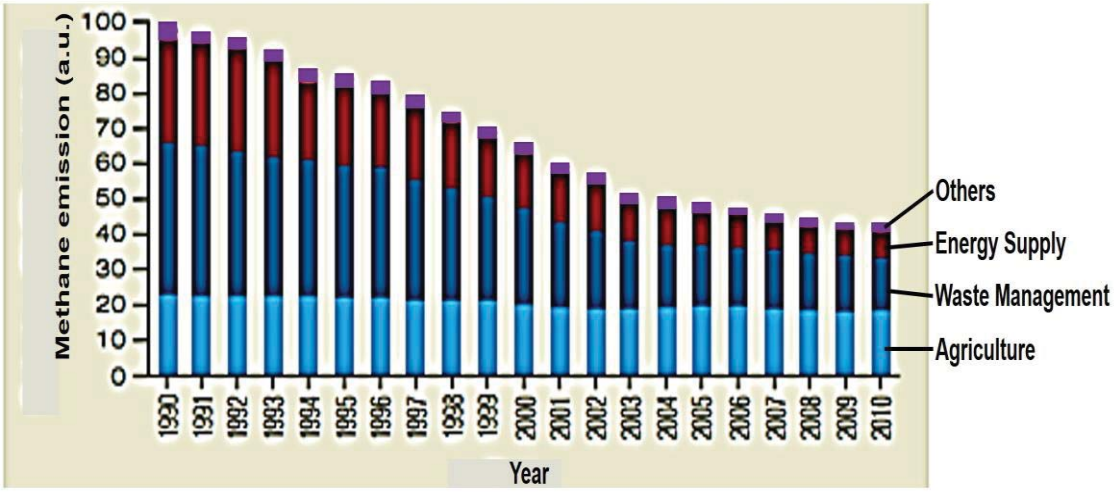


Fig. 2.1

With reference to Fig. 2.1,

(a) State one factor that would fall under the 'Others' category.

Natural source from <u>wetlands/marshes</u> / microbes in the <u>ocean</u> / <u>melting of permafrost</u>; ; for 1 mark

[1]

(b) Comment on the change in methane emissions in the United Kingdom from 1990 to 2010.

1. Methane emissions decreased from around 100 a.u. to 40 a.u.;
2. Methane emissions from <u>energy supply / waste management decreased</u>;
3. Methane emissions from agriculture remained relatively constant at around 20 a.u.;
4. Majority of methane emission only comes from energy supply waste management and agriculture;
5. In 1990, the largest contributing factor to methane emission was waste management, but in 2010, it is agriculture / reverse;
6. Ref to improve in technology / policies for cleaner energy source / better waste management; ; for 1 mark, max 3 marks

[3]

Hydroxyl radical is a naturally occurring molecule in the atmosphere. It is one of the strongest oxidant in the atmosphere. It was coined as the "detergent of the atmosphere", as it is able to break down harmful gases in the atmosphere via oxidation. An example is its ability to oxidise and break down methane:

methane + hydroxyl radical ⟶ carbon dioxide + ozone + water

(c) State two anthropogenic sources of methane emission.

1. Agriculture / enteric fermentation from ruminants;
2. Burning of fossil fuels for energy;
3. Extraction / transportation / storage of fossil fuels;
4. Landfills / manure, sewage treatment;
; for 1 mark, max 2 marks

(d) With reference to the information provided, discuss the extent to which hydroxyl radical is able to mitigate enhanced global warming resulting from the rising level of methane emission.

1. Hydroxyl radical is able to mitigate the effects of rising levels of methane emission to a large extent (valid stand);
; for 1 mark

2. It is able to breakdown methane and lower its concentration in the atmosphere, reducing the amount of solar radiation absorbed /OWTTE;
3. However it <u>produces carbon dioxide in the process</u>, which is a greenhouse gas that will still absorb and trap solar radiation;
4. But <u>carbon dioxide absorbs much less solar radiation</u> as compared to methane;
; for 1 mark, max 2 marks

A rising concern due to climate change is the spread of infectious disease. The H5N1 avian influenza virus outbreak in 2006 and Zika virus outbreak in 2015 are examples of infectious diseases. H5N1 avian influenza is an air-borned disease that can be transmitted from human to human. It was first transmitted to humans by birds. Zika

edes

.....

.....

.....

....[2]

ccine

prepared against it. This resulted in a pandemic with global outbreak of the disease.

(f) State the process that led to the formation of the H5N1 influenza strain.

...

Antigenic shift;
; for 1 mark

.....[1]

Similarities
1. Both causes abnormal / disrupts cellular functions;
; for 1 mark, max 1 mark

Differences
2. Infectious diseases are caused by foreign pathogens, whereas genetic diseases are caused by mutations to the DNA;
3. Infectious diseases can be cured by removal of the pathogens, whereas genetic diseases are cannot be cured, with the exception of gene therapy;
4. Infectious diseases can be spread by various means like through vectors / air-borne, however genetic diseases cannot be spread, only inherited.
5. Genetic diseases can be inherited, whereas infectious diseases cannot;
6. Vaccination can prevent infectious diseases, whereas there is no prevention for genetic diseases;
; for 1 mark, max 1 mark

Fig. 2.2 shows the range of outbreak for H5N1 avian influenza, while Fig. 2.3 shows the range of outbreak for Zika virus.

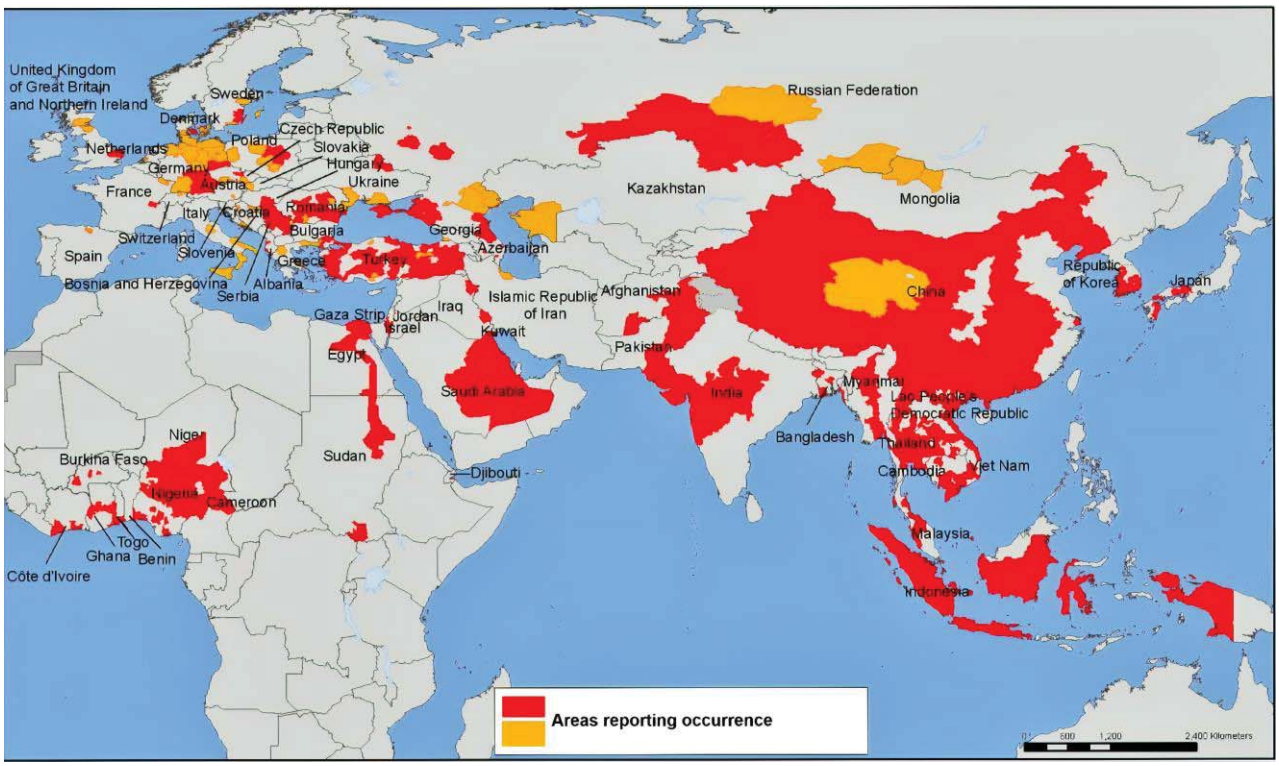


Fig. 2.2

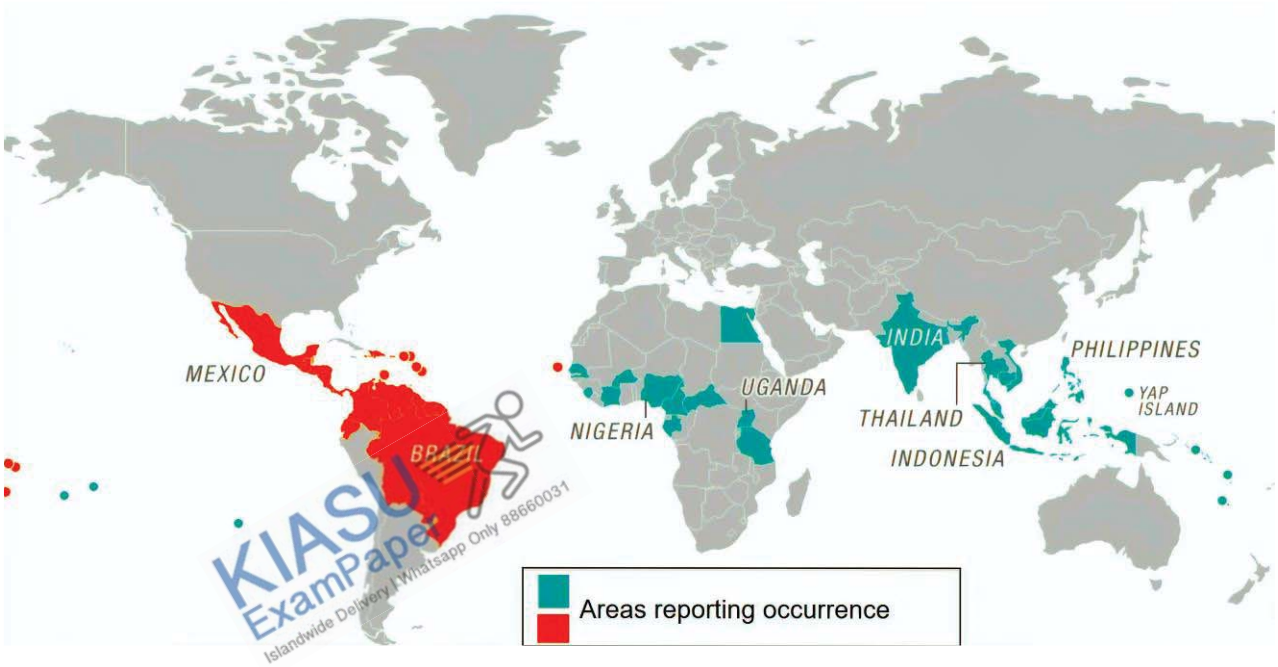


Fig. 2.3

(g) **(i)** With reference to Fig. 2.2 and Fig. 2.3, account for the difference in the extent of outbreak of both infectious diseases.

1. H5N1 virus outbreak covered a much <u>larger geographical location</u> as compared to Zika virus /ORA;
2. H5N1 virus outbreak was <u>more widespread globally</u>, whereas Zika virus outbreak was <u>confined</u> mostly within the <u>tropics;</u>
   ; for 1 mark, max 1 mark

3. Zika virus is a mosquito-borne disease that requires the mosquito as a vector to spread, as such it is <u>confined within the tropics where the vector is found</u> /OWTTE;
4. Whereas for H5N1, it is an air-borne disease which can be transmitted from human to human, the <u>ability to travel breaks down the geographical barrier</u> and allow for the virus to be transmitted globally /OWTTE;
   ; for 1 mark

[3]

was

ictly

monitored by the World Health Organisation.

(ii) With rising global temperature, predict and explain how might a future Zika outbreak be compared to the outbreak in 2015.

1. Future outbreak may spread beyond the tropics /to higher latitudes / pole-wards;
2. Outbreaks would be <u>more widespread / more people being infected</u>;
3. Spread to <u>higher altitudes</u>;
   ; for 1 mark, max 2 marks

4. As <u>temperatures</u> beyond the tropics and at higher altitude <u>increases</u> such that it is <u>suitable for mosquito growth and development</u>, allowing mosquitoes to survive beyond the tropics and at higher altitudes;
5. Increase in temperature <u>increases the metabolism and life cycle of mosquitoes</u>, which would lead to increase in number of vectors for Zika virus / increase frequency of bites;
6. Ref to probability the tropics may get too hot for survival of mosquito and thus resulting in a decrease in Zika in the tropics
   ; for 1 mark

[4]

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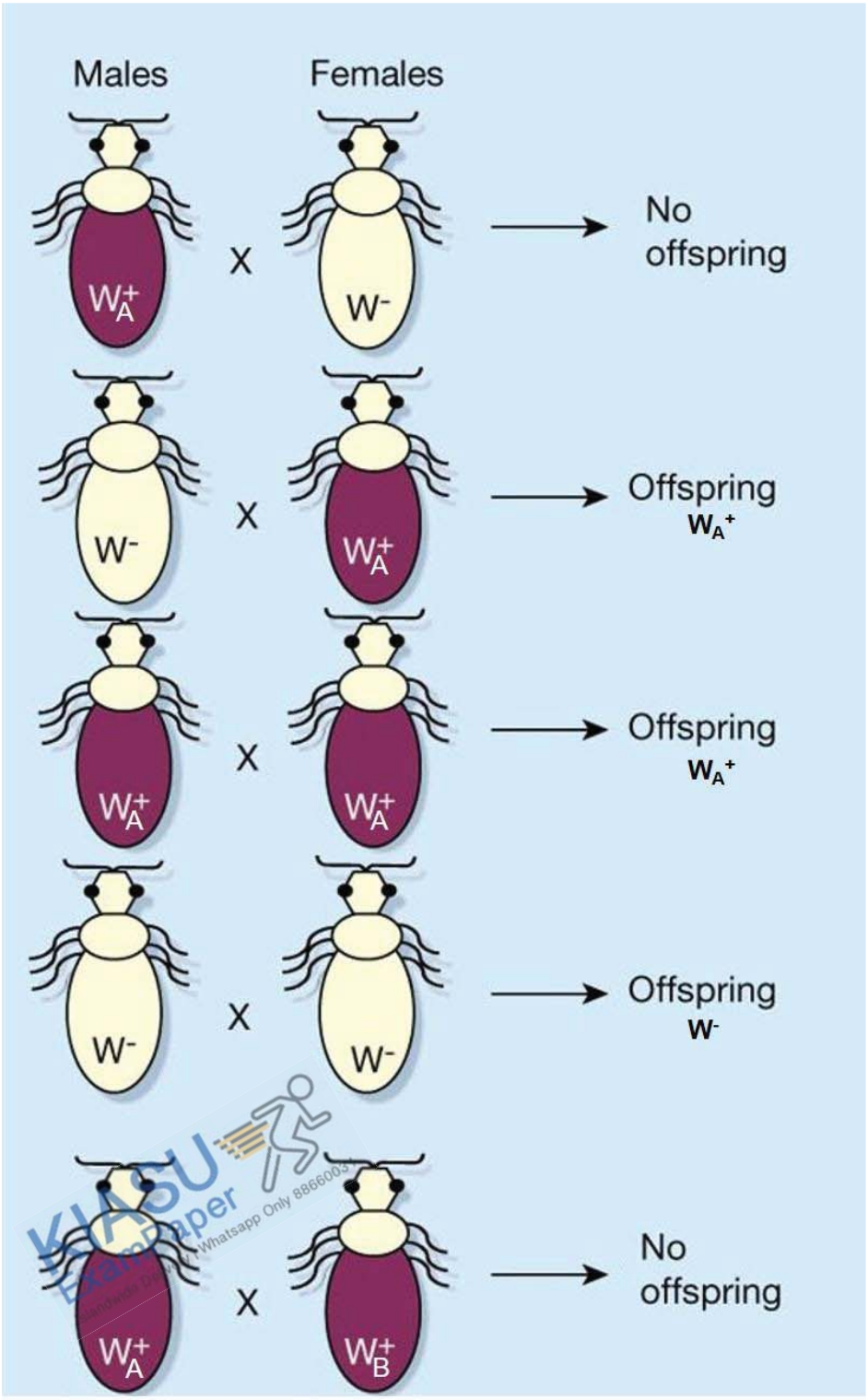
Wolbachia is a gram-negative parasitic bacteria that largely infects insects and is reliant on the female host to transmit subsequent generations to the hosts' offspring. There are a variety of strains of *Wolbachia* in nature. Fig. 2.4 shows the outcomes of mating for insects infected with *Wolbachia*.



W_A^+: Presence of *Wolbachia* strain **A**
W_B^+: Presence of *Wolbachia* strain **B**
W^- : Absence of any *Wolbachia* strains

Fig. 2.4

Currently, *Wolbachia* is not naturally found to infect *Aedes aegypti*. In Singapore, the National Environment Agency (NEA) is carrying out field trials by releasing male *Aedes aegypti* infected with *Wolbachia* into zones that are at high risk of dengue fever.

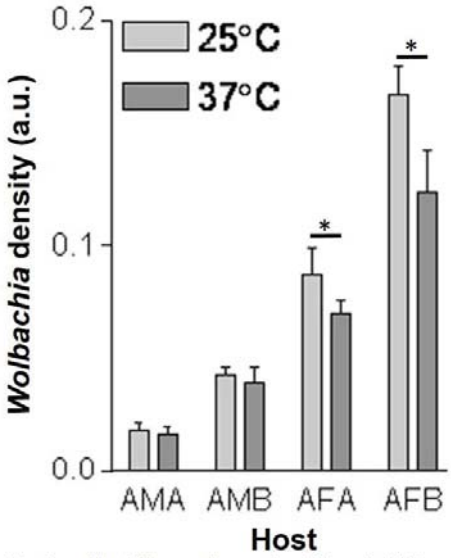
(h) **(i)** With reference to Fig. 2.4 and your own knowledge, explain why NEA does not release female *Aedes aegypti* infected with *Wolbachia.*

1. Female *Aedes aegypti* infected with Wolbachia <u>will be able to produce viable offspring with infected or non-infected male *Aedes aegypti*</u>;
2. as such the population will not be reduced / OWTTE;
3. As only female *Aedes aegypti* bite to obtain blood meals, increasing number of female *Aedes aegypti* <u>will facilitate a faster spread of Dengue virus;</u>

; for 1 mark

[2]

Due to the predicted rise in global temperature, studies have been carried out to investigate the effect of temperature on the growth of *Wolbachia* within *Aedes aegypti*. The results are shown in Fig. 2.5, growth of *Wolbachia* is measured in terms of density (a.u.).



* Indicates that there is a significant difference

Key:
AMA – Adult Male infected with *Wolbachia* strain A
AMB – Adult Male infected with *Wolbachia* strain B
AFA – Adult Female infected with *Wolbachia* strain A
AFB – Adult Female infected with *Wolbachia* strain B

Fig. 2.5

(ii) …uld

1. It would still be viable;
   ; for 1 mark
2. There is no significant difference in Wolbachia density in male Aedes aegypti at 25°C and 37°C;
   ; for 1 mark

…..
…..
……
……**[2]**

(iii) Suggest why temperatures beyond 37°C would not be of a significant concern for the use of Wolbachia to reduce *Aedes aegypti* population.

Temperatures beyond 37°C would be too hot for the survival of *Aedes aegypti*, the population of decrease naturally without the use of Wolbachia /OWTTE;
; for 1 mark

……
…**[1]**

[Total: 24]

Section B

Answer **one** question in this section.

Write your answers to the question on the separate writing paper provided.

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

Your answers must be in continuous pose, where appropriate.

Your answers must be set out in parts **(a)** and **(b)**, as indicated in the question.

3 **(a)** In Himalayan rabbits the *tyrosinase* gene codes for the enzyme tyrosinase that catalyses the conversion of tyrosine to melanin, a black pigment responsible for black fur in Himalayan rabbits. The Himalayan rabbit fur colour changes with the seasons.

With reference to the mode of action of enzyme, explain how the environment determines the fur colour of Himalayan rabbit and describe the evolutionary advantage for this trait. **[15]**

(b) The development and activation of B-cells and development of cancer cells can be seen as an evolutionary process in terms of how different triggers or cellular functions acts as selection pressure to select for specific cells to divide.

With reference to your knowledge in evolution, compare the development and activation of B-cells and the development of cancer cells.

[10]

[Total: 25]

4 **(a)** Metabolic processes are dependent on the movement of various substrates and products. The mode of transport is dependent on the nature of the molecule.

With reference to named examples, discuss the roles of different modes of cellular transport in plants.

[15]

(b) Climate change is not of a big concern, as with rising carbon dioxide level and temperatures, the rate of photosynthesis in plants increases. As such, carbon dioxide level and temperature will eventually decrease again.

Discuss the validity of this argument. **[10]**

[Total: 25]

End of Paper

3(a) In Himalayan rabbits the *tyrosinase* gene codes for the enzyme tyrosinase that catalyses the conversion of tyrosine to melanin via a series of reactions, a black pigment responsible for black fur in Himalayan rabbits. The Himalayan rabbit fur colours changes with the season.

With reference to the mode of action of enzyme, explain how the environment determines the fur colour of Himalayan rabbit and describe the evolutionary advantage for this trait. [15]

1 The enzyme tyrosinase binds to tyrosine via the lock and key hypothesis;
2 where tyrosinase has an active site with a specific 3D conformation that is complementary to tyrosine;
OR
3 The enzyme tyrosinase binds to tyrosine via the induced-fit hypothesis;
4 Where the active site is initially not complementary to tyrosine, but upon initial substrate binding it induces a conformation change in tyrosinase such that the active site is now complementary to tyrosine;
; for 1 mark, max 2 marks

5 During winter / lower temperatures, tyrosinase is active;
6 Effective collision between tyrosinase and tyrosine results in the formation of the ES-complex;
7 Tyrosinase lowers the activation energy required for the conversion of tyrosine to melanin via
8 Proximity and orientation, where active site acts as a template for tyrosine / Bond strain, where critical bonds are stressed / providing favourable microenvironment to stabilise transition state / formation of temporary covalent bond; (any 1)
9 Product / melanin formed is no longer complementary to active site of tyrosinase and is released from the active site;
10 Tyrosinase remains unchanged and is ready to catalyse a new reaction again;
11 Build up of melanin causes Himalayan rabbit to be black; (allow e.c.f if student identifies black in summer)
; for 1 mark, max 4 marks

12 During summer / higher temperatures, tyrosinase is denatured;
13 R-group interactions like hydrogen bonds, ionic bonds and hydrophobic interactions are disrupted; (name at least 2)
14 Tyrosinase loses its 3D conformation / active site is lost;
15 Unable to bind tyrosine, no effective collision / formation of ES-complex

16 no product / melanin formed causes Himalayan rabbit to be white; (allow e.c.f if student identifies white in winter)
; for 1 mark, max 4 marks
(allow e.c.f it student identifies inactive enzyme at low temperature)

17 Ref to selection pressure as temperature of environment;

18 Black is better at absorbing heat;

19 As such, being black during winter allow Himalayan rabbits to trap more heat and stay warm; (allow e.c.f if student mention that rabbits are black in summer for camouflage)

20 White is better at reflecting heat;

21 As such, being white during summer allow Himalayan rabbits to reflect / lose heat and stay cool; (allow e.c.f if student mention that rabbits are white in winter for camouflage)

22 Allows Himalayan rabbits to survive throughout the seasons to maturity and mate to produce viable offspring;
; for 1 mark

QWC: Answer correct identifies Himalayan rabbit fur colour at different season / temperature and is able to link to active / denatured tyrosinase and also include valid evolutionary advantage

(b) The development and activation of B-cells and development of cancer cells can be seen as an evolutionary process in terms of how different triggers or cellular functions acts as selection pressure to select for specific cells to divide.

With reference to your knowledge in evolution, compare the development and activation of B-cells and the development of cancer cells. [10]

Similarities

1 Both B-cells and cancer cells divide by mitosis;

2 During clonal expansion of B-cells, somatic hypermutation occurs, which involves random point mutations, similarly in the development of cancer cells, random mutations can occur and begin to accumulate;

3 Both activated B-cells and cancer cells pass on the favourable mutation to daughter cells;

4 Both memory B-cells and cancer cells are long lived due to activation of telomerase gene to maintain telomere length;

5 AVP

; for 1 mark

		Development and activation of B-cells	**Development of Cancer**
6	Location of development	Bone marrow	Not restricted to any cellular location
7	Location of activation	Lymph node	Not restricted to any cellular location
8	Source of Genetic Variation	somatic recombination / V(D)J recombination	random mutations
9	Initial selection Pressure	self-antigen / specific epitope on antigen	Cell cycle check points / tumour suppressor proteins / immune system
10	Trait at selective advantage	complementary binding of antigen binding site of B-cell receptor with specific epitope on specific antigen	gain-of-function mutation in proto-oncogenes to oncogenes / loss-of-function mutation in tumour suppressor genes

11	Additional signal required for development	antigen presentation via MHC class II to $CD4^+$ T-helper cell and cytokines released by $CD4^+$ T-helper cells	Accumulation of mutations to proto-oncogenes and tumour suppressor genes Mutation to activate Telomerase Mutations to signal for angiogenesis
12	Signal for clonal expansion	cytokines released by $CD4^+$ T-helper cells	Dysregulated cell cycle checkpoints / constant signal by oncogenes / absence of stop signal by tumour suppressor gene
13	Mutations during clonal expansion	Somatic hypermutation to variable region of light and heavy chains	Random mutations
		majority are single base substitutions / Gene mutation	Can be of any type, gene mutation and chromosomal mutation
14	Selection pressure after clonal expansion	Binding affinity to antigen	Cell cycle check points / tumour suppressor proteins / immune system
15	Trait at selective advantage	Increased affinity to antigen / affinity maturation	Further accumulation of mutations to proto-oncogenes and tumour suppressor genes / Mutation to activate Telomerase/ Mutations to signal for angiogenesis
16	Events after selection	class switching to allow the generation of different immunoglobulins;	No class switching / accumulating more mutations
17	Events after selection	Differentiates to plasma cells and memory cells	Does not differentiate
18	Signal for cell division	Plasma cell no longer divides / memory cell will only undergo clonal expansion again upon	Uncontrolled / constant signal by oncogenes /

		secondary infection / binding of antigen again	absence of stop signal by tumour suppressor gene
19	Life-span of cells	Plasma cells are short lived, but memory B cells are long lived	Cancer cells with activated telomerase are long lived
20	Mobility of cells	Plasma cells and memory B cells are mobile in both the blood and lymphatic system / found at lymph nodes	Cancer cell requires mutation to signal for metastasis

QWC: Answer includes at least 2 differences and 1 similarity.

4(a) Metabolic processes are dependent on the movement of various substrates and products. The mode of transport is dependent on the nature of the molecule.

With reference to named examples, discuss the role of different modes of cellular transport in plants. [15]

Passive Transport

1 Passive transport does not require energy where molecules diffuses down a concentration gradient / from a region of higher concentration to a region of lower concentration;

2 Simple diffusion is for small, non-polar molecules that are able to diffuse through the hydrophobic core of cell membrane;

3 Carbon dioxide diffuses into plant cell surface membrane and through chloroplast membranes to the stroma, where it is a substrate for Calvin cycle;

4 Oxygen diffuses into plant cell surface membrane and through mitochondrial membranes to mitochondrial matrix, where it acts as the final electron acceptor for cellular respiration;

5 Facilitated diffusion is for small, polar/hydrophilic molecules that are unable to diffuse through the hydrophobic core of cell membrane;

6 Interior of protein channels / carrier proteins are lined with amino acids with hydrophilic R-group that provides a hydrophilic channel for the diffusion of polar/hydrophilic molecules;

7 H^+ diffuses though proton channel associated with ATP synthase from thylakoid lumen /space to stroma;

8 releasing energy for the synthesis of ATP during photophosphorylation;

9 H^+ diffuses through proton channel associated with ATP synthase from intermembrane space to mitochondrial matrix;

10 releasing energy for the synthesis of ATP during oxidative phosphorylation;

11 Osmosis is the movement of water molecules from a region of higher water potential to a region of lower water potential across a partially permeable membrane;

12 Aquaporin are specific channels for the osmosis of water molecules;

13 Water enters plant cells and reaches thylakoid membranes where it undergoes photolysis, releasing electrons / act as electron donor for photophosphorylation;

14 Water is formed in the mitochondrial matrix when oxygen, the final electron acceptor accepts the electron to form water, water leaves the mitochondrial matrix;

15 AVP (valid molecule, correct mode of transport and correct role stated, e.g. pre-mRNA, tRNA, ribosomal proteins, ribosomal subunits, glucose, pyruvate etc.)

; for 1 mark, max 8 marks

Active Transport

16 Active transport requires energy, which can be via the hydrolysis of ATP to pump molecules against their concentration gradient / from a region of lower concentration to a region of higher concentration;

17 Protein pump pumps H^+ from the stroma to thylakoid lumen/space to establish a proton gradient for chemiosmosis during photophosphorylation;

18 Protein pump pumps H^+ from the matrix to intermembrane space to establish a proton gradient for chemiosmosis during oxidative phosphorylation;

19 Proton pump pumps H^+ from cytoplasm into lysosome to maintain an acidic environment/pH in the lysosome;

20 Bulk transport involves the formation of vesicles for the transport of large molecules;

21 Proteins synthesised by bound ribosomes on RER is transported to Golgi apparatus via transport vesicles where it fuses with cis face of Golgi apparatus;

22 Proteins modified by Golgi apparatus buds of the trans face as secretory vesicles which is transported to the cell surface membrane;

23 where it fuses and is released out of the cell / embedded on membrane;

24 During cytokinesis of cell division, newly synthesised cellulose are packed in to vesicles;

25 where they fuse at the plane of division to form the cell plate, which eventually forms the new cell wall for divided daughter cells

26 AVP

; for 1 mark, max 6 marks

QWC: Answer covers at least 2 types of passive transport and 1 active transport with valid named example.

(b) Climate change is not of a big concern, as with rising carbon dioxide level and temperatures, the rate of photosynthesis in plants increases. As such, carbon dioxide levels and temperature will eventually decrease again.

Discuss the validity of this argument. [10]

Valid

1 Carbon dioxide concentration is a limiting factor in photosynthesis, the fixing of carbon dioxide by rubisco is the rate determining step in Calvin cycle, increase in carbon dioxide concentration will increase the rate of photosynthesis;

2 Plants may respond to higher carbon dioxide levels by increasing number of mesophyll cells / chloroplast, resulting in more carbon dioxide intake;

3 Plants may respond to higher carbon dioxide levels by decreasing stomata density, plants can grow more efficiently with fewer stomata, since each individual stomata will be able to bring in more carbon dioxide;

4 Plants may respond to higher carbon dioxide levels by increasing length and number of roots, to allow plants to absorb more water to meet demand of increase rate of photosynthesis;

5 Photosynthesis is largely catalysed by enzymes like rubisco, as such increase in temperature increases kinetic energy and the rate of effective collision, increasing the rate of photosynthesis;

6 With an increase in rate of photosynthesis, more carbon dioxide will be removed from the atmosphere, decreasing the concentration of greenhouse gas, resulting in lowering of global temperature;

; for 1 mark

Not Valid

7 However, this statement does not take into account anthropogenic / man-made sources of carbon dioxide;

8 the rate at which carbon dioxide is released into the atmosphere via anthropogenic sources is far greater than the rate which plants can capture carbon dioxide /OWTTE;

9 Deforestation lead to the destruction of forest as carbon sinks, releasing large amounts of carbon dioxide into the atmosphere and at the same time;

10 reducing the population of trees that captures carbon dioxide/ OWTTE;

11 As such, despite rise in carbon dioxide, temperatures are rising too fast for plants to successfully adapt;

12 Different vegetation survive in different zone of climate / optimum temperature;

13 With higher temperature, rate of transpiration in plants increases, when rate of water loss is greater than rate of water absorption the plant undergoes wilting;

14 Plants can respond to higher temperature by the closure of stomata, as guard cells become flaccid to reduce water loss, however will reduce the amount of carbon dioxide entering the cell;

15 Plants may respond to higher temperature by decreasing stomata density to reduce water loss by transpiration, which may reduce the amount of carbon dioxide entering the cell;

16 Plants may respond to higher temperature by reducing number of leaf to reduce water loss via transpiration, however, this will also reduce the amount of carbon dioxide taken in by the plant;

17 Hence, higher temperature will cause a decrease in the rate of photosynthesis which is also essential for the plant's survival;

18 Plants are immobile, if their pollen / seeds are not dispersed to more cooler and suitable regions / higher altitudes / higher latitudes, they will face extinction;

19 Plants that are successful in dispersing to more suitable regions will cause a shift in biome, however plants that are already in artic regions / highest altitude will not be able to disperse to cooler regions, as such will face extinction;

20 Rising carbon dioxide and temperatures can also result in excessive rainfall leading to floods or draughts that would affect growth of vegetation.

21 Rising temperature may also favour higher survival and reproduction of pests that can damage plants;

22 AVP

; for 1 mark, max 6 marks

QWC: Answers shows reasoning for both valid and non-valid, AND coming to an overall conclusion that the argument is largely invalid

Class Adm No

Candidate Name: _____

H

millennia institute

2019 Preliminary Exams

Pre-university 3

BIOLOGY HIGHER 2 **9744/04**

Paper 4 Practical **3 September 2019**

Candidates answer on the Question Paper **2 hour 30 minutes**

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams and graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Answer all questions in the spaces provided on the Question Paper.

The use of 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.

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This question paper consists of 26 printed pages, including 2 blank pages

[Turn over

Candidates with access to microscope at the start of the paper are given the **first 45 minutes** to use it. Please answer **QUESTION 2** within this time frame.

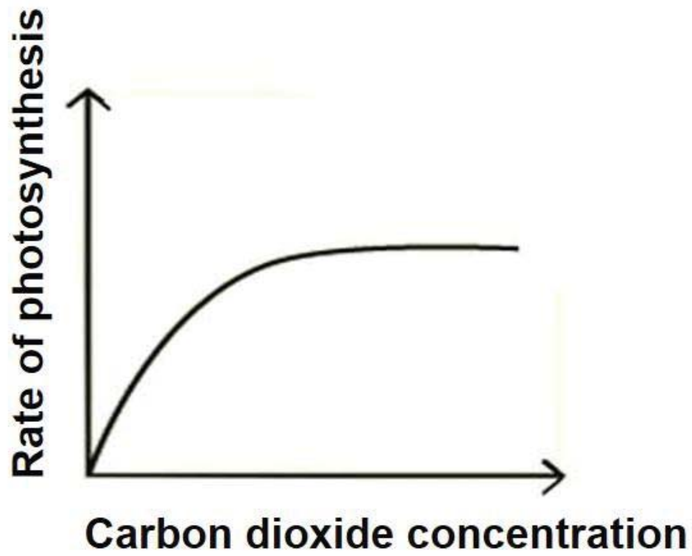
Candidates with no access to microscope at the start of the paper will be given access 1 hour 45 minutes after the start of the paper. You may proceed with **QUESTION 1** first.

Answer **all** questions

1. In this question you will investigate the effect of carbon dioxide (CO_2) concentration on the rate of photosynthesis in leaf disks.

(a) Sketch a fully-labelled graph to show the expected relationship between the rate of photosynthesis and CO_2 concentration, as CO_2 concentration increases.

Explain the shape of your graph.



Graph

1. Y-axis labelled rate of photosynthesis AND X-axis labelled carbon dioxide concentration (no units required);
2. Line starts at origin (0,0) with positive gradient AND then levels off;

;for 1 mark

Explanation

3. As carbon dioxide concentration increases, the rate of effective collision with rubisco increases / ES-complex formation, increasing the rate of Calvin cycle;

; for 1 mark

4. At higher concentrations, rubisco is saturated;

OR

5. carbon dioxide is no longer a limiting factor / some other factor limits the rate of photosynthesis;

; for 1 mark

[4]

In your investigation, sodium bicarbonate solution will be a source of dissolved carbon dioxide. Carbon dioxide concentration will be controlled by varying the concentration of sodium bicarbonate solution.

You are provided with:

Labelled	contents	hazard	Volume(cm^3)
S	1% sodium bicarbonate solution	Irritant Harmful	200
D	Liquid detergent	Irritant Harmful	5
L	Leaves soaked in water and wrapped in aluminum*	none	-

**keep leaves in the dark by ensuring aluminum is covering the beaker when not in use*

(b) You are required to make simple dilutions of the 1% sodium bicarbonate solution, **S**. You will need to prepare 50 cm^3 for each concentration.

Decide four other concentrations of sodium bicarbonate solution to prepare using simple dilutions of **S**.

Draw a table to show how you will prepare four other concentrations, including the provided 1% sodium bicarbonate solution.

sodium bicarbonate concentration (%)	Volume of 1% sodium bicarbonate solution, **S** (cm^3)	Volume of distilled water, **W** (cm^3)	Final volume (cm^3)
1.0	50	0	50
0.8	40	10	50
0.6	30	20	50
0.4	20	30	50
0.2	10	40	50

1. At least 4 other suitable concentrations of S;
2. Correct volume of S;
3. Correct total volume of 50cm^3 for each concentration;

MMO

[3]

[Turn over

Read through steps 1 to 7 and prepare a table to record your results in d(ii), before starting the investigation.

Proceed as follows:

1 Prepare all the concentrations of sodium bicarbonate solution as decided in **(b)** using the beakers provided.

2 Using the Pasteur pipette, add 1 drop of liquid detergent to each of the sodium bicarbonate solution. **Gently** stir the solution with a glass rod, ensure that **no bubbles** are formed.

3 Place one leaf onto the white tile and press the cork borer against it to make a leaf disk. You will require four leaf disks. **Avoid** major leaf veins. *You should be able to obtain 4 leaf disks from 1 leaf.*

4 Remove the piston of a 10cm^3 syringe and place the four leaf disks into the syringe barrel.

5 Replace the piston and push on the piston until only a small volume of air remains. **Be careful** to ensure that the leaf disks are not crushed. Use a piece of aluminum to wrap around the syringe, keeping the leaf disks in the dark.

6 Repeat steps **3** to **5** for the other four syringes. You should have a total of five syringes, each with four leaf disks in them.

7 Using one of the five prepared syringes, remove the aluminum foil and draw from the 1% sodium bicarbonate solution until the syringe is roughly half-filled. Ensure no air bubbles are present.

(c) Invert the syringe and observe the position of the leaf disks, re-wrap the syringe with the same piece of aluminum. Label the position of the leaf disks in Fig. 1.1 with a cross (**X**). Explain your answer.

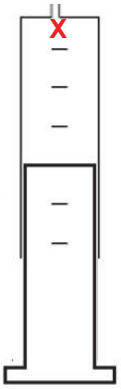


Fig. 1.1

…

…

…

ACE

1. 'X' is labelled at the top;
2. Air spaces are present in the spongy mesophyll / lower density due to air present in leaf;
; for 1 mark

…

…

…**[2]**

Blank Page

8 Repeat step **7** for the four other concentrations of sodium bicarbonate respectively. Ensuring that you wrap each syringe with aluminum to keep the leaf disks in the dark.

9 Using the syringe with 1% sodium bicarbonate, hold it in the inverted position and remove the aluminum cover. Place a finger over the opening and press against it firmly.

10 Pull piston back while keeping your finger tightly sealing the opening, hold for 10 seconds, as shown in Fig. 1.2(a). While holding, shake the syringe gently to ensure that the leaf disks remain suspended in the solution and are not stuck to the sides of the syringe.

11 Release the piston and push the piston as much as possible while keeping your finger tightly over the opening of the syringe, as shown in Fig. 1.2(b).

12 Remove your finger from the opening of the syringe, all the leaf disks should be at the bottom of the syringe, as shown in Fig. 1.2(c). *If not all the leaf disks are at the bottom, repeat steps **10** to **12** for a **maximum of two more times**. If the leaf disks are still not at the bottom, use the Pasteur pipette, add 2 to 3 drops of detergent into the 1% sodium bicarbonate solution in the beaker, and repeat steps **3** to **12** using a set of new leaf disks.*

13 Immediately cover the syringe with the same piece of aluminum foil to ensure that the leaf disks are not exposed to light.

14 Repeat steps **9** to **13** for the other syringes.

15 Remove the aluminum from the syringe containing 1% sodium bicarbonate and place it over the beaker containing 1% sodium bicarbonate, remove the piston and gently pour the 1% sodium bicarbonate along with the leaf disks into the beaker.

16 Repeat step **15** for the other syringes. Ensure that there are no overlapping leaf disks in each beaker.

17 Place all the beakers under the lamp and start the stopwatch immediately. Ensure that the light source is as close to each beaker as possible.

18 For 15 minutes, at every minute interval, record the number of floating leaf disks in each beaker.

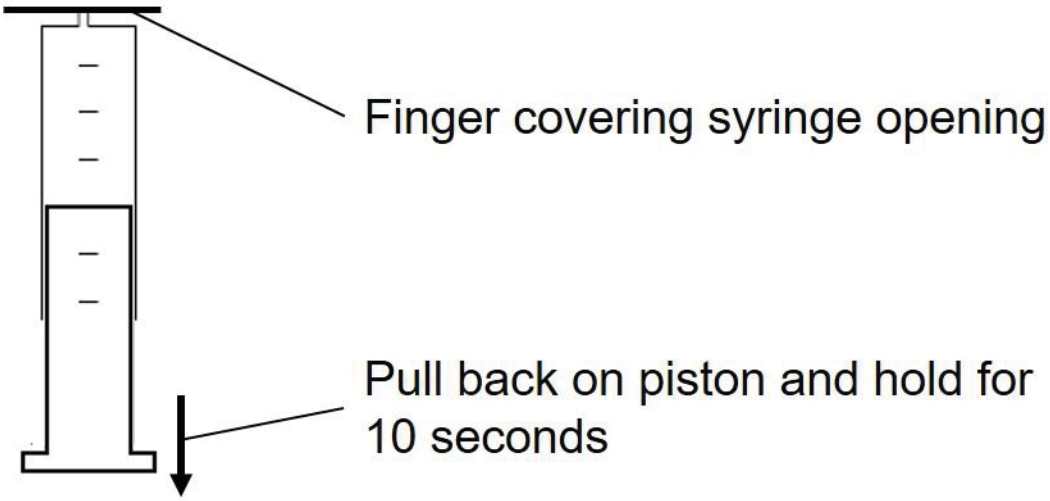


Fig. 1.2(a)

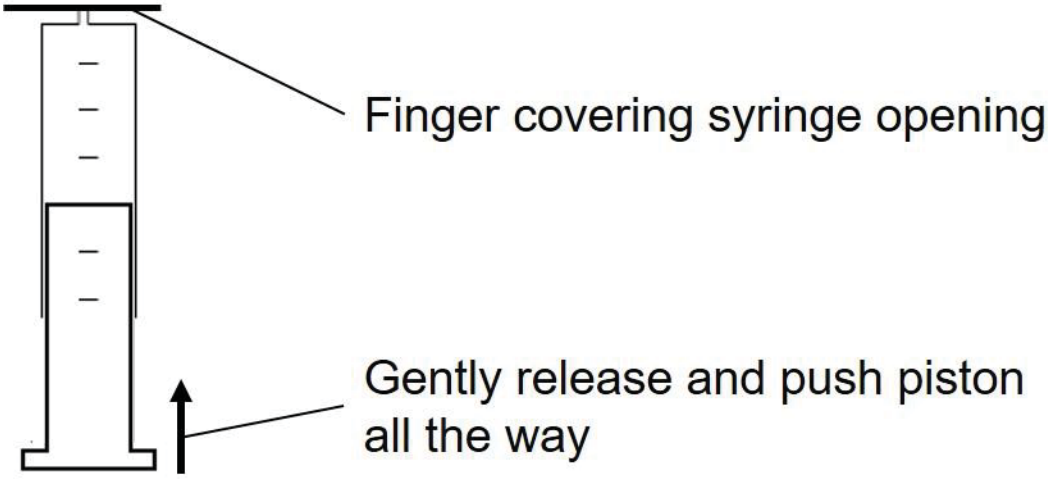


Fig. 1.2(b)

Fig. 1.2(c)

(d) (i) State the product of photosynthesis that causes the leaf disks to float.

ACE
Oxygen gas / O_2;
; for 1 mark

.... **[1]**

(ii) Record your results in an appropriate table in the space below. Your table should include the initial time point of 0 minute.

PDO

Concentration of sodium bicarbonate (%)	Number of floating leaf disk at each minute interval															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.0	0	0	0	0	1	4	4	4	4	4	4	4	4	4	4	4
0.8	0	0	0	1	2	2	2	2	3	3	4	4	4	4	4	4
0.6	0	0	0	0	1	1	1	2	3	3	3	3	3	3	3	4
0.4	0	0	0	0	0	1	1	1	2	2	2	3	3	3	3	4
0.2	0	0	0	0	0	0	0	1	4	4	4	4	4	4	4	4

1. Table with appropriate headings;
2. Table includes timing from 0 to 15 minutes;
3. Recording at every minute for all concentrations;

[3]

(e) The rate of photosynthesis can be estimated by the time taken for 50% of the leaf disks to float, termed as the effective time, ET_{50}.

(i) Using your results from **d(ii)**, estimate the ET_{50} for each sodium bicarbonate concentration to the closest 0.5 minute.

Concentration of sodium bicarbonate (%)	ET_{50} (min)
1.0	4.5
0.8	4.0
0.6	7.0
0.4	8.0
0.2	7.5

ACE
;correct identification of time taken for 2 leaf disks to float, if 2 is not recorded then an estimate between the two time points where 2 leaf floats, all correct ans for 1 mark;

[1]

(ii) Assuming each leaf disks were cut to the exact same area, state two other reasons that could contribute to the difference in time taken to float.

.....

.....

.....

.....

ACE
1. Difference in number of chloroplast present;
2. Difference in thickness of leaf disks;
3. Difference in number of stomata present;
4. Difference in age of the leaves;
5. AVP
; for 1 mark, max 2 marks

ET_{50} is similar

(iii) Based on your data obtained in **d(ii)**, justify if the use of ET_{50} or mean time would be a better indication of rate of photosynthesis.

.....

.....

.....

.....

ACE
1. Mean time would be better, as there are no extreme data points;
2. Mean time would be able to take into account all data points and not be skewed /OWTTE;
OR
3. ET_{50} would be better, as there are extreme data points;
4. Median would not be skewed by the presence of these extreme data points, as such it would be a better measure of central tendency /OWTTE;
; for 1 mark, max 2 marks

[2]

Turn over

(f) (i) One experimental error in this investigation was the lack of control, describe a suitable

P

1. Replace sodium bicarbonate solution with distilled water;
2. Boiled and cooled leaf disks;
3. Replace leaf disks with filter paper disks;
; for 1 mark, max 1 mark

.....
.....
.[1]

(ii) Besides the lack of control setup, state two other limitations in this investigation.

ACE

1. There was lag time between placing each set of leaf disks into the respective beaker of sodium bicarbonate solution, causing the first beaker to be exposed to light earlier;
2. 1 minute interval may be too long to accurately measure the time taken for leaf disks to float;
3. The five beakers were not equally exposed to the light source;
4. AVP
; for 1 mark, max 2 marks

.....
.....
.....
.[2]

(iii) ver the beaker with aluminium foil to prevent exposure of light over a period of time.

ACE

1. The leaf disks will sink back to the bottom;
; for 1 mark
2. The oxygen produced by photosynthesis will be used for aerobic respiration in the mitochondria;
3. Rate of respiration more than rate of photosynthesis;
4. Oxygen is consumed for respiration at a faster rate than being produced by photosynthesis
; for 1 mark, max 2 marks

.....
.....
.....
..[2]

Blank Page

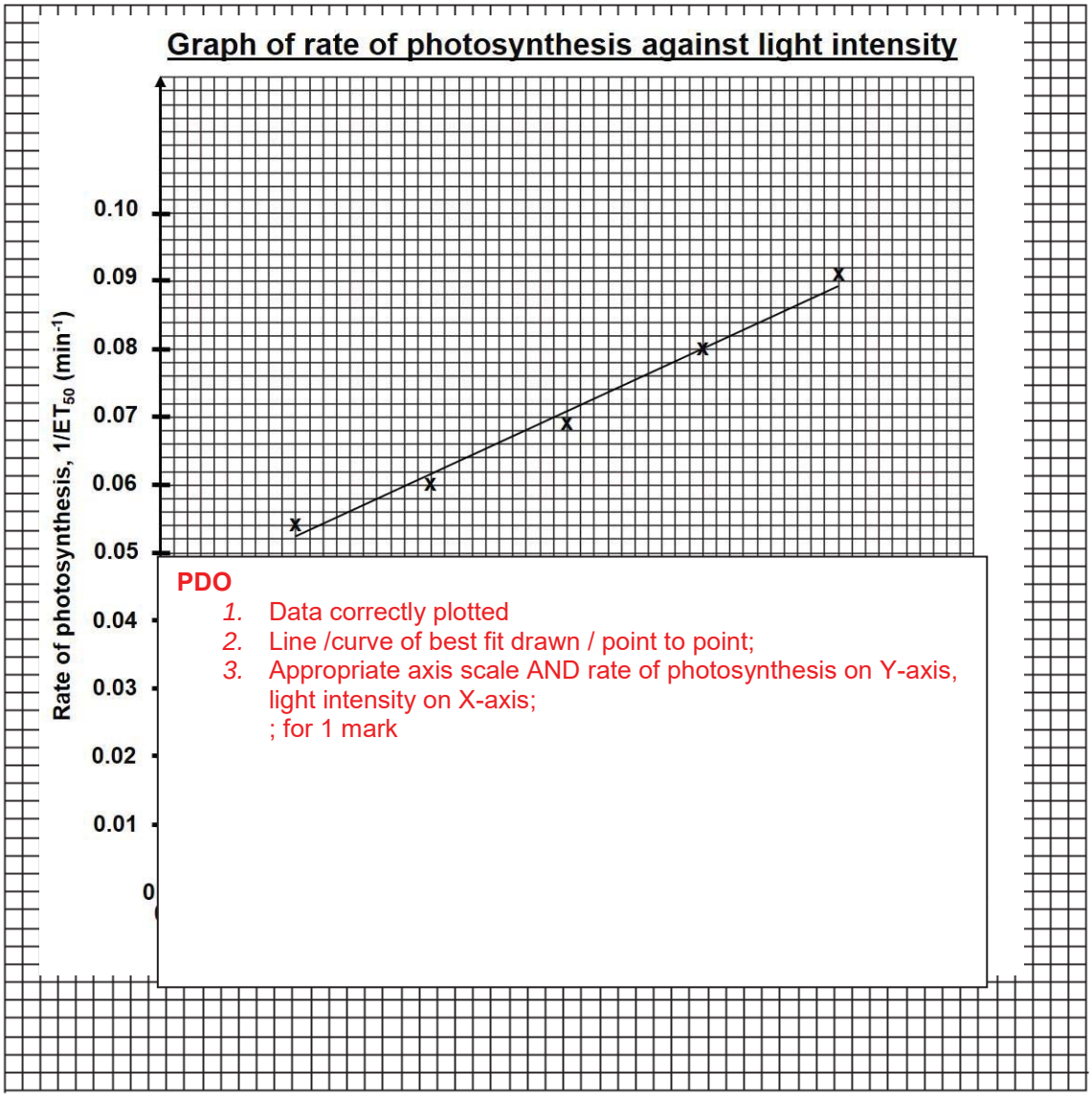
A student carried out a similar experiment as the one above except that he investigated the effect of light intensity on the rate of photosynthesis in a different plant species.

He calculated the ET_{50} values and subsequently $1/ET_{50}$ which is directly proportional to the rate of photosynthesis. The results are shown in Table 1.1.

Table 1.1

Light intensity (lx)	Effective time, ET_{50} (min)				1/Average ET_{50} (min^{-1})
	Replicate 1	Replicate 2	Replicate 3	Average	
2000	18.5	18.0	19.0	18.5	0.0541
4000	16.0	17.0	16.5	16.5	0.0606
6000	14.5	15.0	14.0	14.5	0.0690
8000	12.0	12.5	13.0	12.5	0.0800
10 000	10.5	11.5	11.0	11.0	0.0909

(iv) Draw a graph of the student's results on the following grid to show the effect of light intensity on rate of photosynthesis.



[3]

[Total: 26]

2. You will investigate starch grains from different types of plant in this question.

You are provided with starch grains from two different types of plant, labelled **F** and **G**.

Starch grains from different plants can differ in shape and size. You are required to:

- observe and draw starch grains from two different types of plant
- compare the starch grains from these two different types of plant

Proceed as follows:

1 Using a pipette, stir the sample gently and place two drops of **F** onto a clean and dry microscope slide.

2 Cover the microscope slide with a coverslip and use a paper towel to remove any excess liquid.

3 View the slide using the microscope.

4 Using an appropriate magnification, select three starch grains that differ in size.

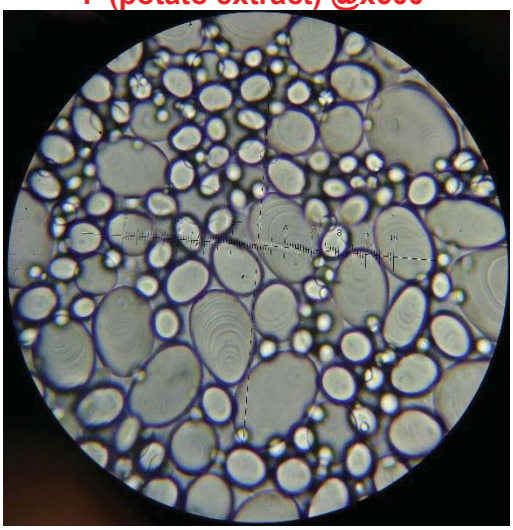
5 Make a large drawing in **(a)(i)** of the three starch grains that you have selected.

6 Repeat steps 1 to 5 for sample **G**.

(a) (i) Make a large drawing of the three starch grains from **F** and the three starch grains from **G**. Calculate the actual size of one starch grain from **F** and **G** respectively.

Sample **F:**

F (potato extract) @x600



Sample **G:**

G (Glutinous rice floor) @x600

PDO

1. clear smooth lines with no overlaps and whole drawing occupies at least ¾ of space
2. 3 starch grains drawn of appropriate shape for both F (round/oval) and G (more angular)
3. appropriate size for F (with working): accept 7μm to 90μm (largest grain should be larger than G)
4. appropriate size for G (with working): accept 5μm to 10μm

h over

[4]

(ii) Describe three observable differences between starch grains from **F** and **G**.

F	G

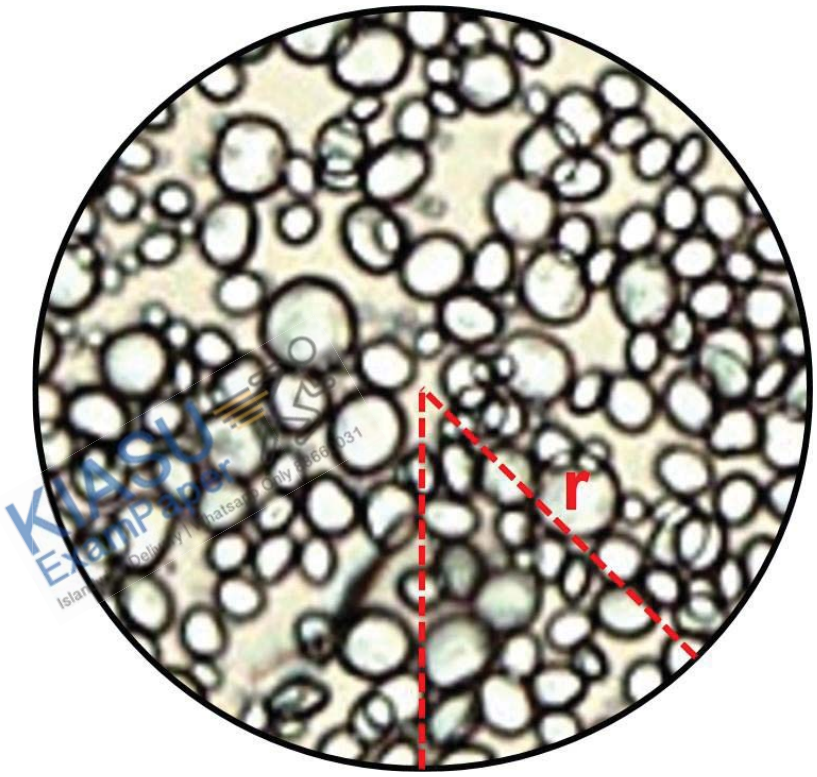
PDO

1. Larger in size vs smaller in size (allow e.c.f);
2. Round in shape vs angular/squarish
3. Larger variation in size vs similar sized
4. AVP

[3]

Fig. 2.1 is a photomicrograph of starch grains from another plant type in a field of view.

Fig. 2.1 shows many starch grains. There are too many starch grains to count, so the technique of sampling may be used to estimate the number of starch grains in the field of view.



Magnification x400

Fig. 2.1

A sample should be counted in a known smaller area and then the result could be multiplied to obtain an estimate of the number of starch grains in the whole field of view. For example, if the number of starch grains is counted in an eighth of the area of the field of view then this number would be multiplied by 8 to obtain the total number in the area of the field of view.

One eighth of the area of the field of view has been marked out by two dashed lines in Fig. 2.1.

(b) (i) Count and record the sample number of starch grains in the eighth of the area of the field of view.

- Mark clearly on Fig. 2.1 each of the starch grains counted.
- Estimate the number of starch grains in the whole field of view.

You will lose marks if you do not show your working.

PDO

1. Accept 16-24
2. Correct calculation and correct final answer (counted value x 8)

number of starch grains in the field of view ..... **[2]**

To find the area of the field of view you need to calculate the **actual length** of line **r**, the radius of the circle.

(ii) Using the magnification on Fig. 2.1, calculate the **actual length** of line **r** in μm.

PDO

Drawing length = 4.9 to 5.1cm

Actual length = 122.5 to 127.5um (1 d.p) or 123um to 128um (3 s.f.);

actual length .....**μm [1]**

(iii) Using the actual length of line **r**, calculate the area of the field of view by applying the formula for the area of a circle:

area of a circle πr^2

$\pi = 3.14$

$r =$ radius of field of view

PDO

Correct working and Ans, Accept: 47 119.6 um^2 to 51 044.6 um^2;

Allow e.c.f if b(ii) is wrong

area of field of view .....**μm^2 [1]**

(iv) Calculate the number of starch grains per μm^2 using your answers from **b(i)** and **b(iii)**. You will lose marks if you do not show your working.

PDO

1. Starch grain density = number of estimated starch grain / actual area of field of view;
2. Correct Ans;

Allow e.c.f if part b(i) to b(iii) are wrong.

number of starch grains per μm^2 .....**μm^2 [2]**

(c) A student observed 10 storage cells of the two different types of plants **F** and **G** respectively to quantify the average number of starch grains found in the two types of plants. The results are shown in Table 2.1.

(i) State a statistical test that could have been used to determine whether the difference in number of starch grains between plants **F** and **G** is significant.

ACE
T-test
; for 1 mark

.....**[1]**

(ii) A summary of the student's results is shown in Table 2.1

Table 2.1

mean number of starch grains		significance of difference
plant F	plant G	
11	12	$p > 0.05$

With reference to Table 2.1, comment on what the results show.

ACE

1. There is no significant difference between the number of starch grains between plant F and G;
2. Since $p > 0.05$, there is more than 5% chance that the difference observed is due to chance;
; for 1 mark

.....
.....
.....
.....**[2]**

[Total: 16]

3. Under anaerobic conditions, yeast cells break down glucose to produce ethanol and carbon dioxide. When carbon dioxide dissolves, it forms a weak acid. The activity of the yeast cells can be determined by measuring the change in pH using Universal Indicator paper. The colour chart for the Universal Indicator paper is shown in Fig. 3.1.

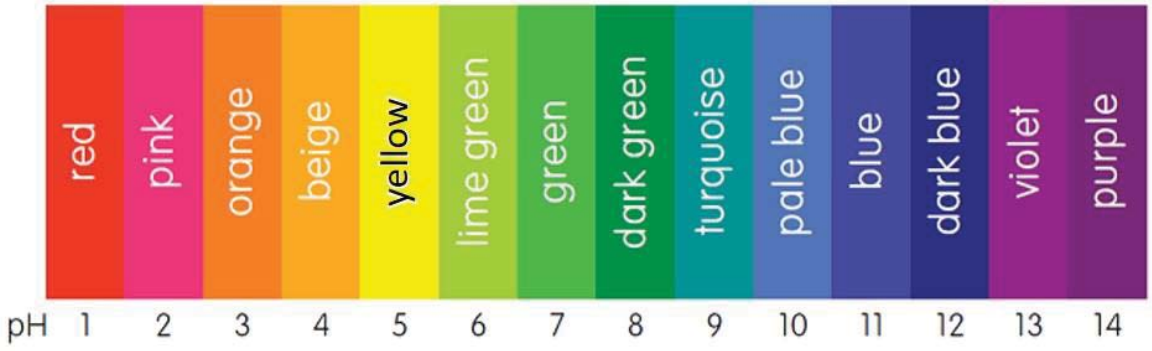


Fig. 3.1

A yeast suspension is assumed to be of neutral pH.

As yeast cells continues to breakdown glucose, the concentration of ethanol rises to a toxic level that kills the yeast cells.

You are to plan an experiment to investigate the highest concentration of ethanol that is tolerable by yeast cells.

The following are optimal condition for the growth of 1g of yeast:

- Temperature of 45ºC
- $10cm^3$ of 1% glucose solution

The pH of the yeast mixture can be obtained by using a glass rod to remove a drop of the mixture and touching a piece of the Universal Indicator paper. You should obtain two sets of pH readings:

1. Prior the addition of ethanol
2. Six minutes after the addition of ethanol

The difference in pH between these two readings would allow you to infer the effect of ethanol.

In your plan, you must use:

- Dried yeast
- 1% glucose solution
- 15% ethanol
- Glass rod
- Universal Indicator paper
- thermostatically controlled water bath
- weighing balance
- White tile
- Stopwatch
- Spatula

You may select from the following apparatus in the design of your experiment:

- normal laboratory glassware e.g. test tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, etc
- syringes

Your plan should:

1. have a clear and helpful structure such that the method you used is able to be repeated by anyone reading it
2. be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
3. identify the independent and dependent variables
4. describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
5. include layout of results tables and graphs with clear headings and labels
6. use the correct technical and scientific terms
7. include reference to safety measures to minimize any risks associated with the proposed experiment.

[Total: 13]

P
Aim:

To investigate the highest tolerable ethanol concentration in yeast.

Theory (max 4 marks)

Knowledge
T1. During aerobic cellular respiration, carbon dioxide is released as waste product during link reaction and Krebs cycle / oxidative decarboxylation;
T2. During anaerobic cellular respiration, yeast undergoes ethanol fermentation where pyruvate is converted to ethanol, releasing carbon dioxide and regenerating NAD^+;
T3. When carbon dioxide is produced, it dissociates to form a weak acid, carbonic acid, causing a drop in pH;
; for 1 mark, max 1 mark
T4. Ethanol is an amphipathic molecule that is able to disrupt the integrity of cell membrane, thereby killing yeasts;
; for 1 mark

Variables
T5. Independent variable: Ethanol concentration
Dependent variable: pH of yeast mixture / Colour of Universal Indicator paper;
; for 1 mark (both IV and DV)
T6. Constant variables: temperature, initial pH, mass of yeast used, volume of 1% glucose (any 2)
; for 1 mark (at least 2 CV)

Hypothesis
T7. How to determine highest tolerable ethanol concentration: Highest ethanol concentration that still produces a colour change in the indicator / by plotting a graph of change in pH against ethanol concentration and finding the ethanol concentration just before
; for 1 mark (either award here or at results)

Procedure (6 marks)
1. Prepare 5 different concentrations of ethanol via serial dilution;

ethanol concentration (%)	stock solution (%)	volume of stock solution (cm^3)	volume of distilled water (cm^3)	final volume for use (cm^3)
15	15	40	0	20
7.5	15	20	20	20
3.75	7.5	20	20	20
1.875	3.75	20	20	20
0.9375	1.875	20	20	40
0	-	-	20	20

; correct serial dilution for 1 mark (at least 5 concentrations)(Accept simple dilution)

2. Set the thermostatically controlled water bath to 45°C.
3. Using a spatula, add 1g of dried yeast to a test tube and add $10cm^3$ of 1% glucose solution, mix well with glass rod.
; specify 1g of dry yeast to $10cm^3$ of 1% glucose

4. Incubate the yeast mixture in the water bath for 5 minutes.
; 1 mark (at least 2 minutes incubation, water bath at 45°C)

5. Place 2 strips of Universal Indicator paper on a white tile.
6. After 5 minutes, use a glass rod to remove a drop from the test-tube and touch 1 strip of Universal Indicator paper with the end of the glass rod, observe and record the colour of the Universal Indicator paper.
7. Compare the colour with the pH colour chart and record the pH.
   ; 1 mark (appropriate description of using glass rod to test pH)

8. Transfer 10cm^3 of 15% ethanol into the test-tube with yeast mixture, shake gently to mix and return it to the water-bath.
9. Start the stopwatch.
10. Use a paper towel to wipe the end of the glass rod clean.
11. After 6 minutes, repeat step **6** and **7**.
12. Repeat step 3 to 11 for the other 4 concentrations of ethanol.
13. Control is setup by replacing ethanol with equal volume of distilled water to ensure that the difference in pH change is due to the presence of ethanol.
    ; 1 mark (appropriate control)

14. Conduct 3 replicates for each ethanol concentration to ensure no anomalies and repeat the entire experiment with fresh batch of reagents once to ensure reproducibility.
    ; 1 mark (replicates and repeats)

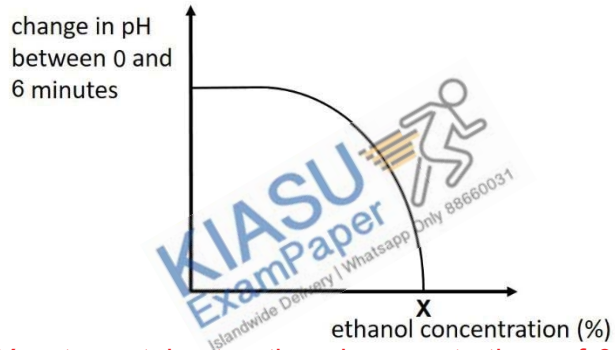
Results (2 marks)

Table

ethanol concentration (%)	0 minutes							6 minutes							difference in pH at 0 and 6 minutes
	colour of universal indicator			pH of yeast mixture			average pH	colour of universal indicator at 6 minutes			pH of yeast mixture at 6 minutes			average pH	
	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3		Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3		
15															
7.5															
3.75															
1.875															
0.9375															
0															

R1. Table shows replicates for 6 minutes readings (acceptable if no replicates for 0 minutes)
R2. Table shows how to obtain difference in pH with proper units (can award if this is mentioned in the numbered steps)
; max 1

Graph



Yeast can tolerate ethanol concentrations of 0% to X%, therefore the highest tolerable ethanol concentration would be just slightly under X%;

R2. correct axis and general shape of graph
R3. indicates highest tolerable ethanol concentration (if not awarded at the start in theory section)
; max 1

Risk Assessment (1 mark)

RA1. Ethanol is highly flammable, ensure work area has no open flame;
RA2. Ensure hands are dry when operating thermostatically controlled water-bath to prevent electrocution;
RA3. Handle all glassware with care to prevent breakage;
RA4. Wear gloves when handling microorganisms;
RA5. AVP
; for 1 mark, max 1 mark