TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
JC2 2018

CANDIDATE NAME										
CENTRE NUMBER	S					INDEX NUMBER				
CLASS	C	G			/	1	7			

H2 BIOLOGY

Multiple Choice

9744/01

Wednesday 14 September 2018
1 hour

Additional materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

Read the instructions on the Multiple Choice Answer Sheet very carefully.

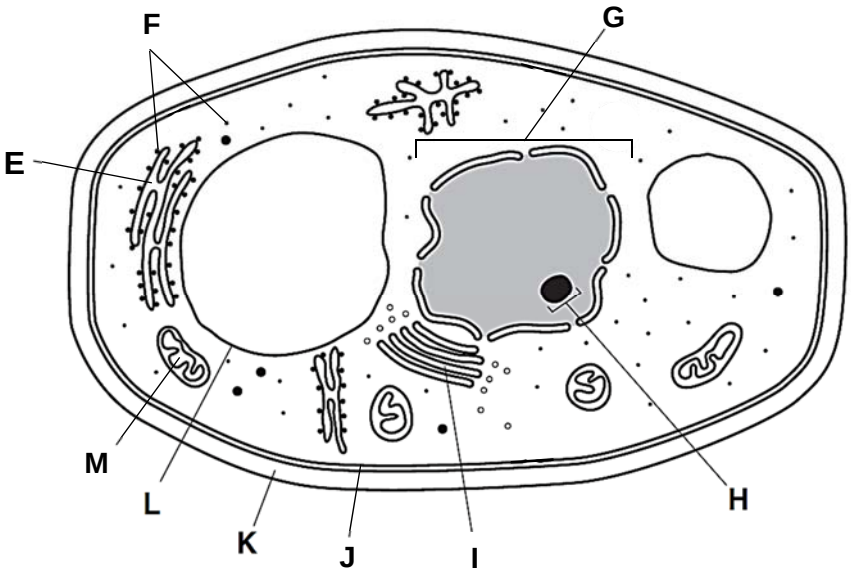
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

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

Section A

Answer **all** the questions in this section.

1 Tuberculosis and candidiasis are two opportunistic infections that may develop during AIDS. Candidiasis is caused by *Candida albicans*, a yeast-like fungus that lives in human lungs. The figure below shows the structure of *Candida*.



Which of the structure(s) can also be found in the causative agent that causes tuberculosis?

A None

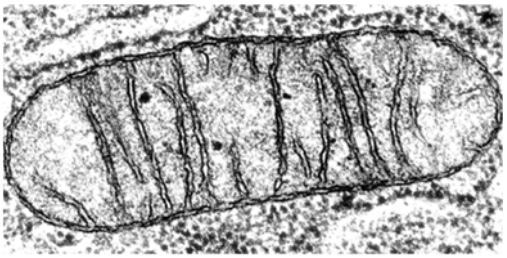
B **F** only

C **F**, **J**, **K** only

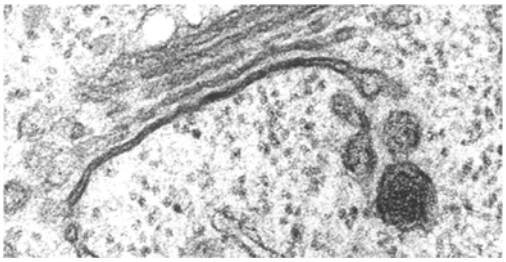
D **H**, **J**, **K** only

2 The images below show the electron micrographs of some organelles found in eukaryotic cells.

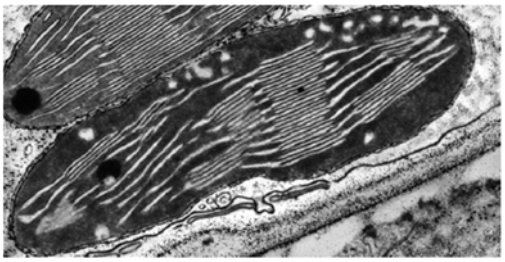
P



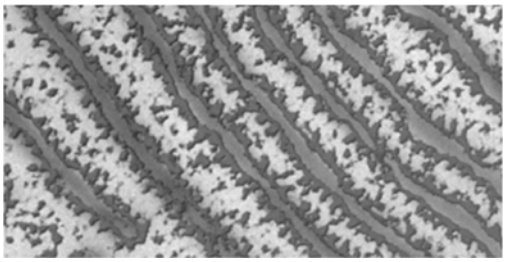
Q



R



S



The following statements are descriptions of membranous cell structures.

1 formed by a single membrane and enclosing a large fluid-filled space and regulating the osmotic pressure of the cell

2 formed by a single membrane and enclosing inactivated enzymes

3 formed by a single membrane that has flattened sacs and tubular structures inter-connected throughout the cell, sometimes with a complex of nucleic acid and protein attached

4 formed by a single membrane that has tubular structures and containing enzymes to add carbohydrate side chains to proteins

5 formed by two membranes and internal membranes that contain pigments

6 formed by two membranes whereby the inner membrane is folded extensively

7 formed by two membranes, the outer membrane is continuous with another membranous organelle

Which of the following row correctly matches the descriptions of the cell structures?

	P	Q	R	S
A	5	3	6	1
B	5	2	4	7
C	6	4	5	3
D	7	1	2	6

3 Particular biological molecules react with chemicals called reagents to give distinct colour changes. The colour depends on the kind of biological molecule and the type of reagent used, as shown in the following table.

chemical reagent	biological molecule	colour change observed
L	protein	violet
M	lipid	red
N	nucleic acid	green

A researcher added different reagents to some isolated ribosomes.

The colour change observed are

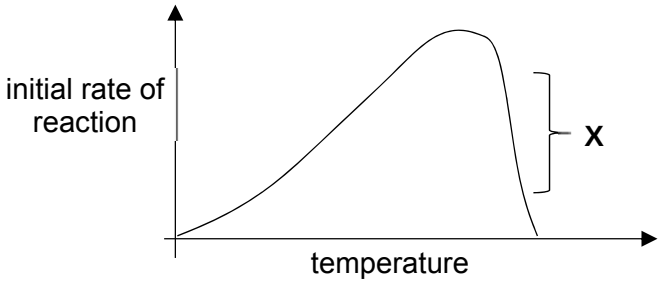
A green only.

B red and green.

C green and violet.

D violet, red and green.

4 The diagram shows the initial rate of reaction using constant amounts of substrate and enzyme at different temperatures.



What is the reason for the decline in the level of activity in region **X**?

A breaking of sulphur bridges and ionic bonds in the enzymes

B competition between substrate and product for the active site

C breaking of hydrogen bonds and hydrolysis of peptide bonds in the enzyme

D insufficient substrates to occupy all the active sites

5 Proteins in the cell surface membranes of human cells and mouse cells were labelled with red and green fluorescent dyes respectively.

When a human cell and a mouse cell were fused together, the red and green fluorescent dyes were at first found in different regions of the cell surface membrane of the hybrid cell, but after 40 minutes, they were evenly distributed in the entire cell surface membrane.

What explains this observation?

A All protein molecules in the cell surface membrane are fixed to structures within the cell, but phospholipid molecules move freely between them.

B Groups of protein and phospholipid molecules in the cell surface membrane are attached to each another and move together.

C Only protein molecules in the outer layer of the cell surface membrane can move freely between phospholipid molecules.

D Protein molecules in the outer layer of the cell surface membrane and those which span the bilayer can move freely between phospholipid molecules.

6 At prophase of mitosis, a eukaryote chromosome consists of two chromatids.

What is the structure of a single chromatid?

A one molecule of single-stranded DNA coiled around protein molecules

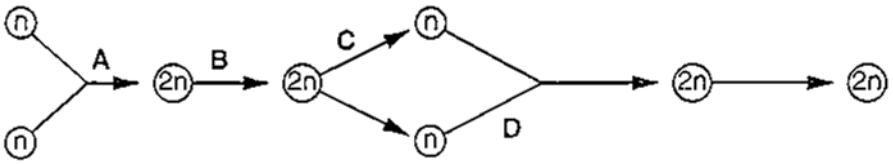
B two molecules of single-stranded DNA each coiled around protein molecules

C one double helix of DNA coiled around protein molecules

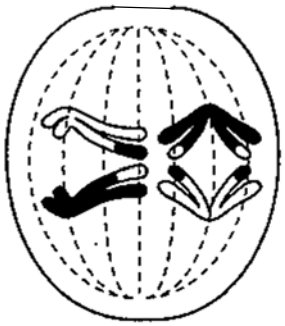
D two double helices of DNA each coiled around protein molecules

7 The diagram represents the life cycle of an animal.

At which stage in the life cycle does mitosis occur?

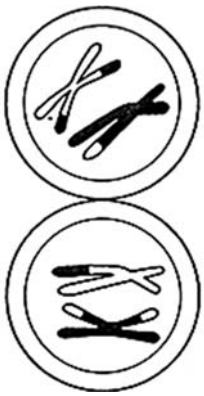


8 The diagram shows anaphase I of meiosis.

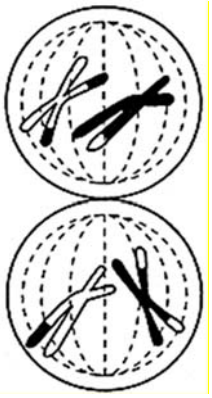


Which diagram shows metaphase II as meiosis continues in this cell?

A

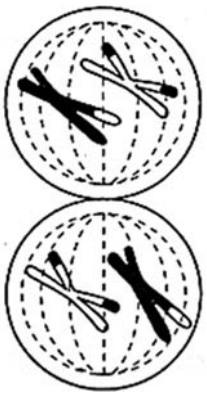


B



C

D



9 Stem cells are found in many tissues that require frequent cell replacement such as the skin, the intestine and the blood.

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

Which statement explains this?

A Different stem cells have only the genes required for their particular cell line.

B Genes not required for the differentiation of a particular cell line are methylated.

C Binding of repressor molecules prevents the expression of genes not required for a particular cell line.

D Expression of gene not required for a particular cell line is controlled at translational level.

10 The table shows the mode of action of two antibacterial drugs that can affect the synthesis of proteins.

antibacterial drug	rifampicin	streptomycin
mode of action	binds to RNA polymerase	causes errors in translation

If bacteria are treated with both drugs, what will be the immediate effects?

1 Transcription will stop, but non-functional proteins may continue to be synthesised.

2 If translation has started, proteins may be non-functional.

3 Translation will be inhibited.

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

11 A peptide consists of ten amino acids of four different kinds.

What is the theoretical minimum number of different kinds of tRNA molecules required to translate the mRNA for this peptide?

A 4

B 10

C 12

D 30

12 The *trp* operon is an example of which type of transcriptional regulation?

A A repressor is inactivated by the presence of the amino acid tryptophan

B An activator is activated by the presence of the amino acid tryptophan

C A repressor is activated by the presence of the amino acid tryptophan

D An activator is inactivated by the presence of the amino acid tryptophan

13 Which of the following statements correctly describes telomerase?

A Telomerase carries its own DNA template.

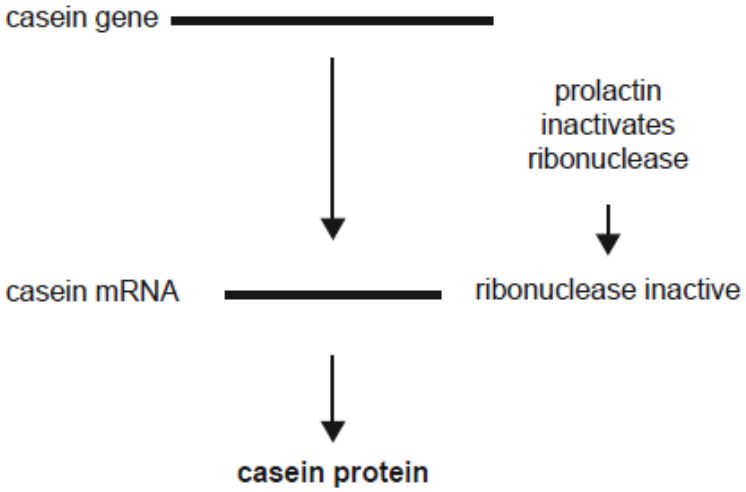
B Inactivation of telomerase contributes to the extended life span of cancer cells.

C Telomerase extends the 3' ends of the parental strand of linear chromosomes.

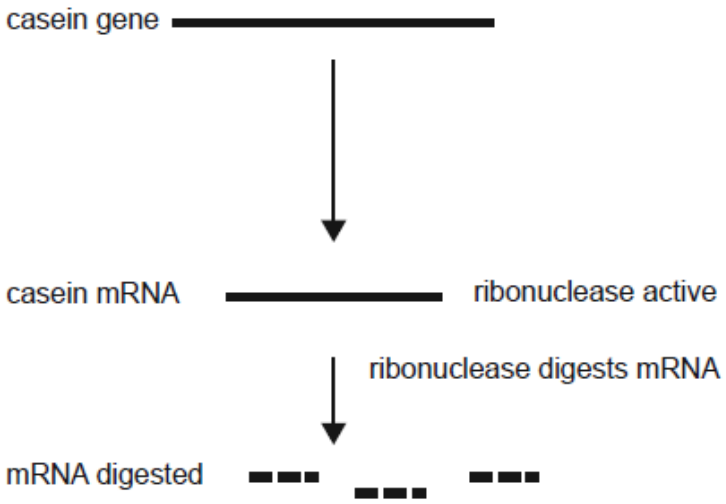
D Telomerase extends the 3' ends of the daughter strand of linear chromosomes.

14 Casein is a major protein found in mammalian milk.

When the mammals are producing milk, the pathway for the production of casein can be represented as shown in the diagram below.



When the mammals are not producing milk, the pathway can be represented as shown in the diagram below.



Which one of the following conclusions can be made from the information above?

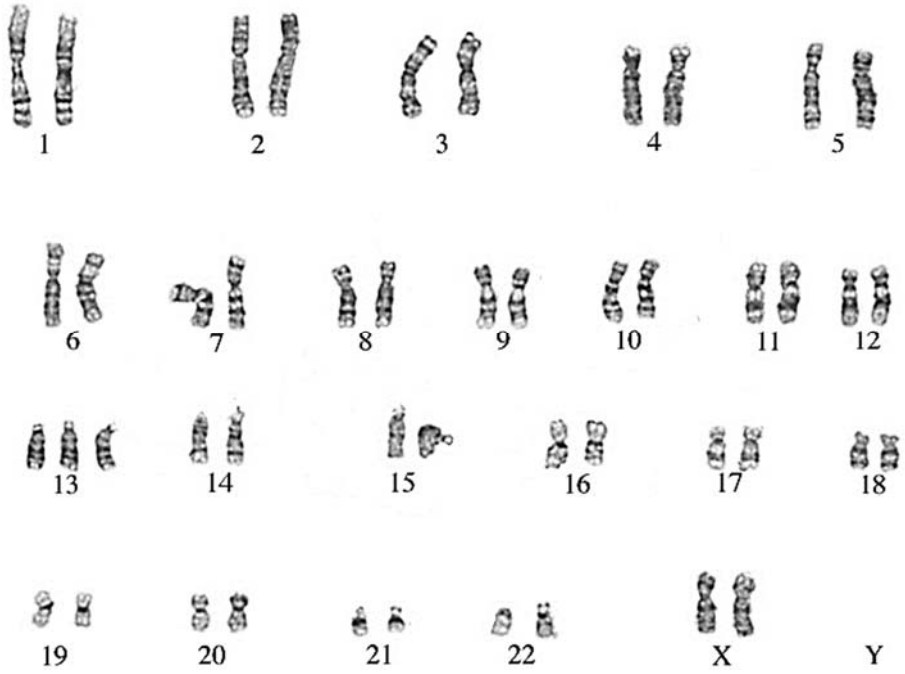
A Ribonuclease has the effect of turning on the casein gene.

B Casein is a repressor protein for milk production in mammals.

C The hormone prolactin allows for the expression of the casein gene.

D Mammals produce milk only in the absence of the hormone prolactin.

15 A newborn baby was diagnosed with Patau syndrome. The diagram below shows her chromosomes.



This is an example of

A frameshift mutation

B silent mutation

C aneuploidy

D polyploidy

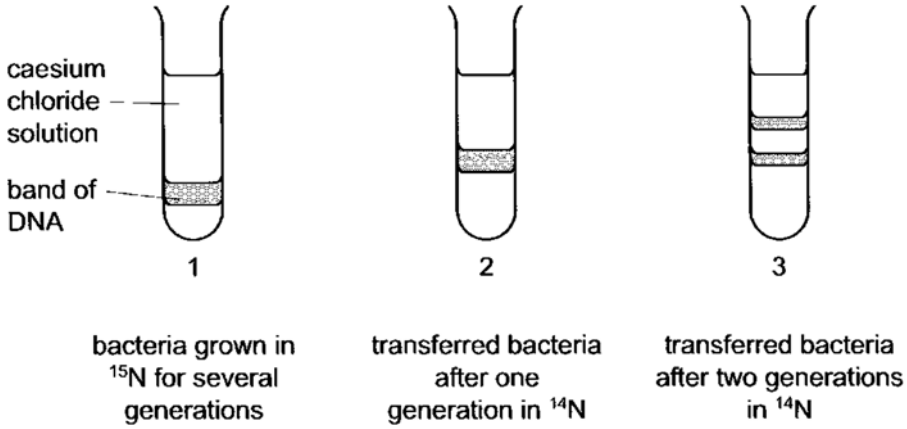
16 Carcinogen **W** can cause changes in tumour suppressor genes, **X**. This can lead to uncontrolled division and the formation of a tumour which may spread to other parts of the body via process **Y.**

Which of the following responses correctly identifies **W, X** and **Y**?

	W	**X**	**Y**
A	nicotine	*ras*	mutations
B	asbestos	*p53*	metastasis
C	tar	*ras*	metastasis
D	ethanol	*p53*	mutations

17 Bacteria grown in ^{15}N for many generations were transferred to ^{14}N for further replication. DNA from the bacteria was extracted and separated by density gradient centrifugation.

Their results are summarised in the following diagram.



Which of the following process accounts the different positions of the DNA band at different generations?

A binary fusion

B binary fission

C transformation

D mitosis

18 In rabbits, the color of body fat is controlled by a single gene with two alleles. The outcome of this trait is affected by the diet of the rabbit.

When raised on a standard vegetarian diet, the dominant allele confers white body fat, and the recessive allele confers yellow body fat.

However, when raised on a xanthophyll-free diet, the homozygous recessive animal has white body fat.

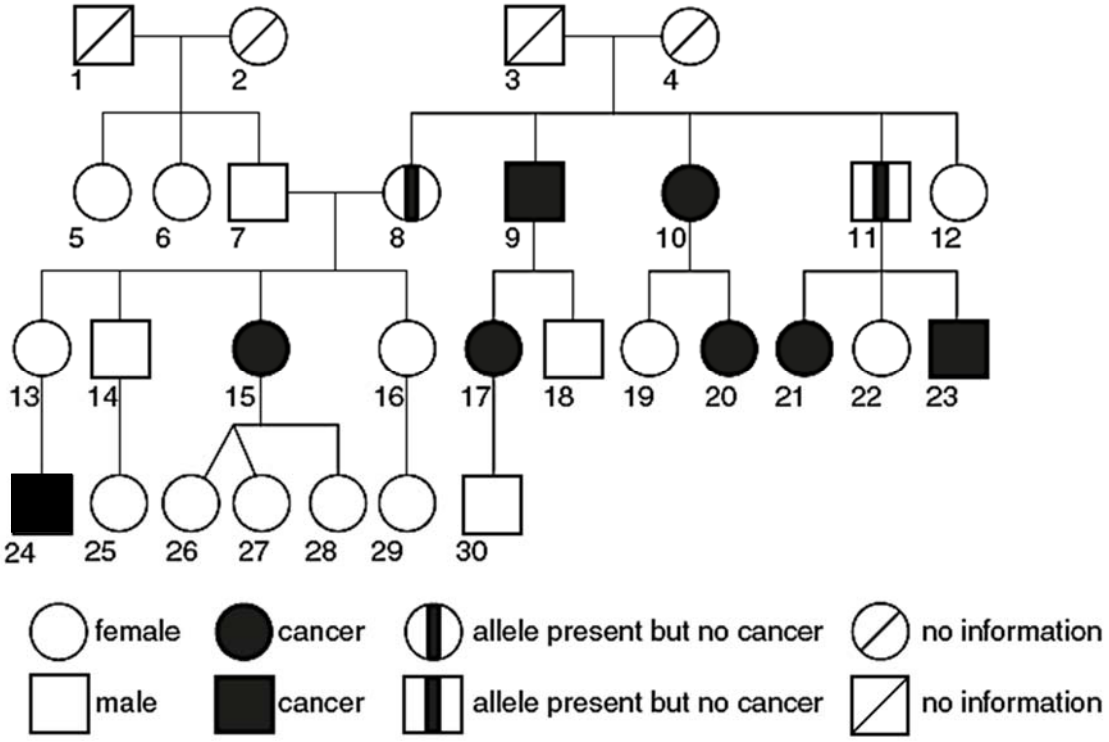
If a heterozygous animal is crossed to a rabbit with yellow body fat, what are the proportions of offspring with white and yellow body fat?

	raised on standard vegetarian diet	raised on xanthophyll-free vegetarian diet
A	1 white body fat : 1 yellow body fat	All white body fat
B	1 white body fat : 1 yellow body fat	1 white body fat : 1 yellow body fat
C	3 white body fat : 1 yellow body fat	1 white body fat : 1 yellow body fat
D	3 white body fat : 1 yellow body fat	3 white body fat : 1 yellow body fat

19 The BRCA2 protein is involved in suppressing the development of tumours. The gene that codes for this protein is on chromosome 13.

Several different dominant alleles of this gene, *BRCA2*, code for faulty versions of the protein. The presence of any one of these faulty alleles leads to an increased chance of developing several types of cancer, including breast cancer. Not everyone with one of these alleles develops cancer.

The pedigree (family tree) below shows the occurrence of cancers in four generations of a family. The presence of a faulty *BRCA2* allele was confirmed in person 15. The other individuals with cancer were not tested for the presence of the allele. For individuals 17 to 30, only one of their parents is shown in the pedigree. Individuals 24–30 are all under twelve years old.



Which one of the following statement is **not** correct?

A Individuals 8 and 11 have *BRCA2* allele and may develop cancer later in life.

B Individuals 8 to 11 may have inherited *BRCA2* allele from either of their parents.

C Individual 15 may have inherited one copy of *BRCA2* allele from her mother.

D Individual 24 may have inherited the *BRCA2* allele only from his mother and not his father.

20 The table below shows the results of the stomatal count investigation.

	number of stomata visible at ×100 magnification										mean number of stomata
sun leaves	21	24	36	24	15	18	27	33	18	24	24 ± 6
shade leaves	36	39	35	42	28	36	34	40	48	32	37 ± 6

The table below shows the critical values for a two-tailed *t*-test, where probability < 0.05.

degrees of freedom	8	9	10	18	19	20
probability 0.05	2.306	2.262	2.228	2.101	2.093	2.086

What conclusion can be made between the mean number of stomata of sun leaves and shade leaves?

A The calculated t-test value of 4.743 is greater than the critical t-test value of 2.306, hence the mean number of stomata of sun leaves is different from shade leaves.

B The calculated t-test value of 4.743 is greater than the critical t-test value of 2.262, hence the mean number of stomata of sun leaves is less than shade leaves.

C The calculated t-test value of 4.743 is greater than the critical t-test value of 2.101, hence the mean number of stomata of sun leaves is different from shade leaves.

D The calculated t-test value of 4.743 is greater than the critical t-test value of 2.093, hence the mean number of stomata of sun leaves is less than shade leaves.

21 Northern elephant seals, *Mirounga angustirostris*, were nearly hunted to extinction in the 1890s, with only about 20 individuals left at the end of the century. The population has now grown to more than 120 000.

In the 1890s, southern elephant seals, *Mirounga leonina*, were not as severely hunted and currently there are estimated to be 600 000 southern elephant seals.

Based on this information, it is true to say that

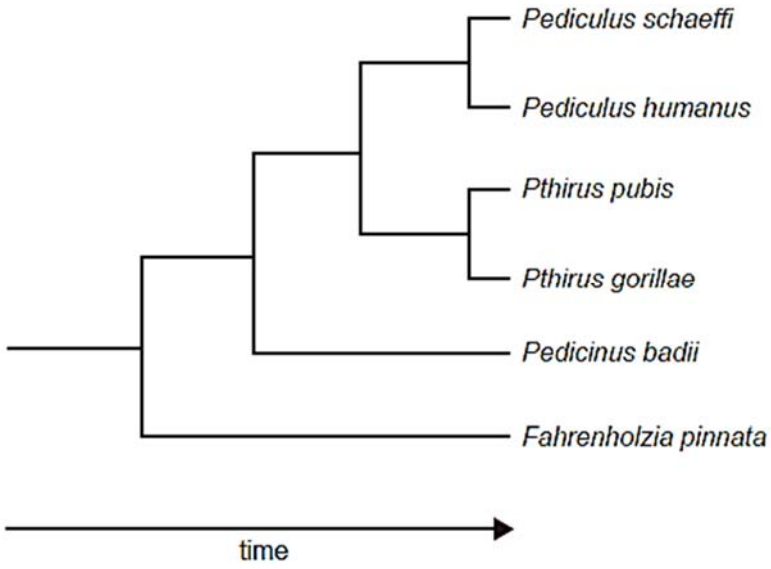
A northern elephant seals have evolved as a result of the 'founder effect'.

B northern elephant seals would show less genetic variation than southern elephant seals.

C southern elephant seals would have experienced greater genetic drift than northern elephant seals.

D the mutation rate in northern elephant seals would have been greater than in southern elephant seals.

22 The phylogenetic tree for different species of lice is shown below. The tree has been constructed based on molecular and morphological data.



This information suggests that

A *Pedicinus badii* shares a more recent common ancestor with *Pthirus gorillae* than with *Fahrenholzia pinnata*.

B *Pediculus humanus* is more closely related to *Pedicinus badii* than it is to *Pthirus pubis*.

C six species of lice have evolved by convergent evolution.

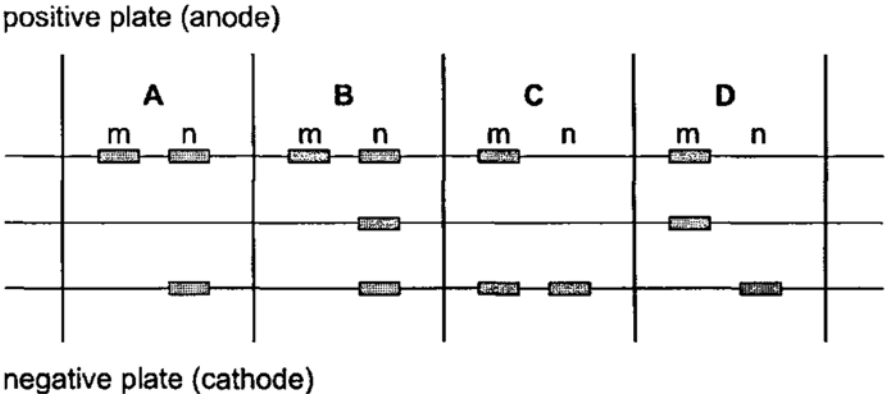
D *Pediculus schaeffi* is the ancestor of *Pediculus humanus*.

23 There are two forms of the seeds of the garden pea, *Pisum sativum*, one with a wrinkled skin and the other with a smooth skin.

Plants with wrinkled seeds have a recessive mutation caused by the insertion of an extra nucleotide sequence into a gene.

Two heterozygous pea plants were crossed. Two of the offspring (m and n) had the DNA for this gene removed and separated by electrophoresis.

Which pattern of bands shows a wrinkled phenotype and a smooth phenotype?



24 During aerobic respiration ATP can be formed by glycolysis and oxidative phosphorylation in the electron transport system.

In the complete oxidation of one molecule of glucose, approximately what percentage of ATP is formed by oxidative phosphorylation?

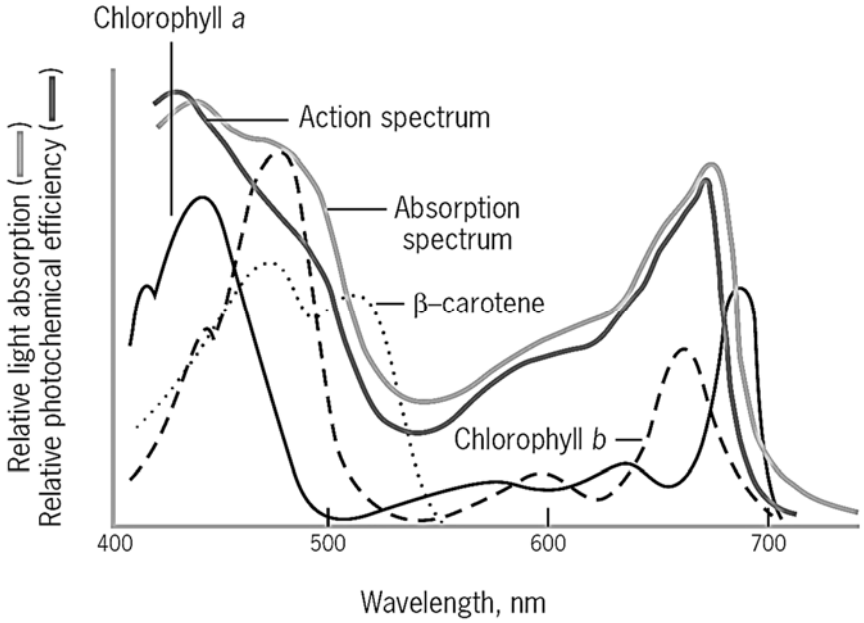
A 10%

B 25%

C 75%

D 90%

25 The figure below shows the absorption spectrum of the photosynthetic pigments of a flowering plant and its action spectrum.



What can be concluded from the graph above?

1 The relative light absorption will be higher at higher temperatures, as temperature is a limiting factor.

2 The green leaves reflect light of wavelength 550 nm, hence the photochemical efficiency is low.

3 The compensation point of β-carotene, whereby the rate of photosynthesis equals the rate of respiration, occurs at 550nm.

4 The accessory pigments chlorophyll b and β-carotene absorb light energy mostly at 480nm.

A 2 and 4

B 1, 2 and 3

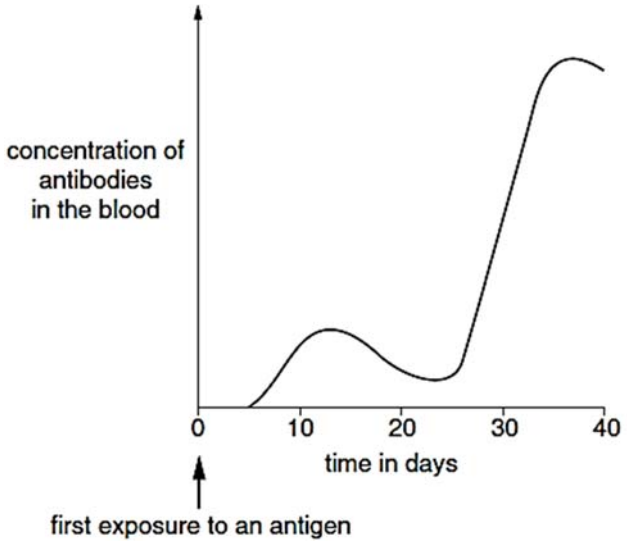
C 1, 3 and 4

D All of the above

26 Which of the following statement is true?

	blood glucose concentration	hormone secreted	receptor involved at target cell	cellular effect
A	increase above normal level	insulin	receptor tyrosine kinase	decrease in blood glucose concentration
B	decrease below normal level	glucagon	G-protein coupled receptor	decrease in blood glucose concentration
C	decrease below normal level	insulin	G-protein coupled receptor	increase in blood glucose concentration
D	increase above normal level	glucagon	receptor tyrosine kinase	increase in blood glucose concentration

27 The graph shows the amount of antibody produced in response to an antigen.



From the graph, which statement is correct?

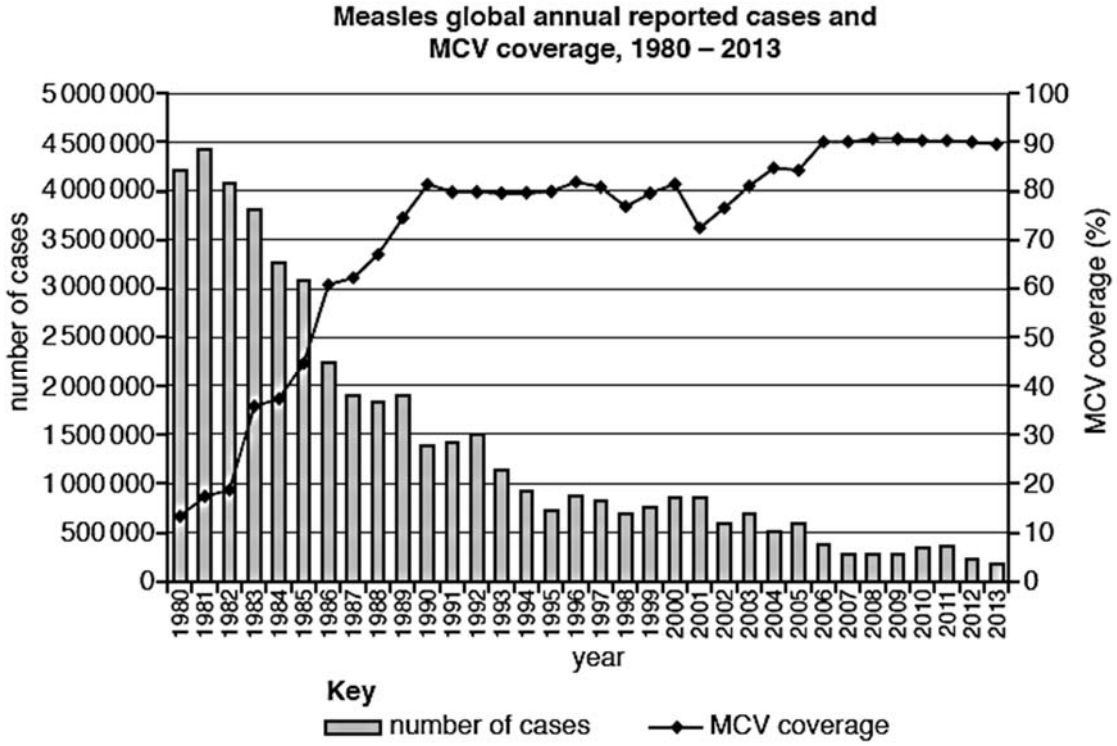
A It takes 35 days to achieve active immunity.

B Memory cells for this antigen are present in the body within 20 days.

C A second exposure to the antigen occurred on day 20.

D T helper cells are activated on day 12.

28 Measles is a serious disease that can be prevented by vaccination. The chart below shows the Measles-containing Vaccine (MCV) coverage and annual reported cases of measles between 1980 and 2013.



Which of the following statements is a correct interpretation of the chart?

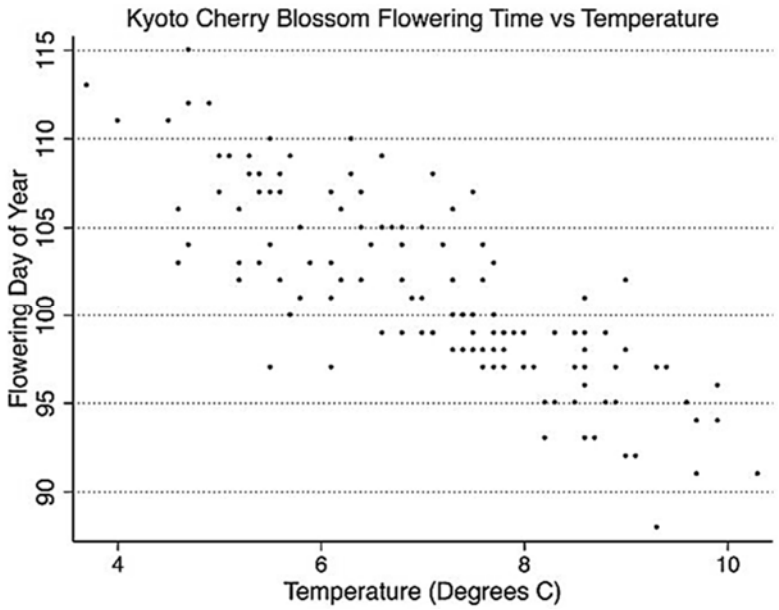
A The highest number of measles cases occurred when MCV coverage was at its lowest.

B An increase in herd immunity resulted in fewer deaths from measles.

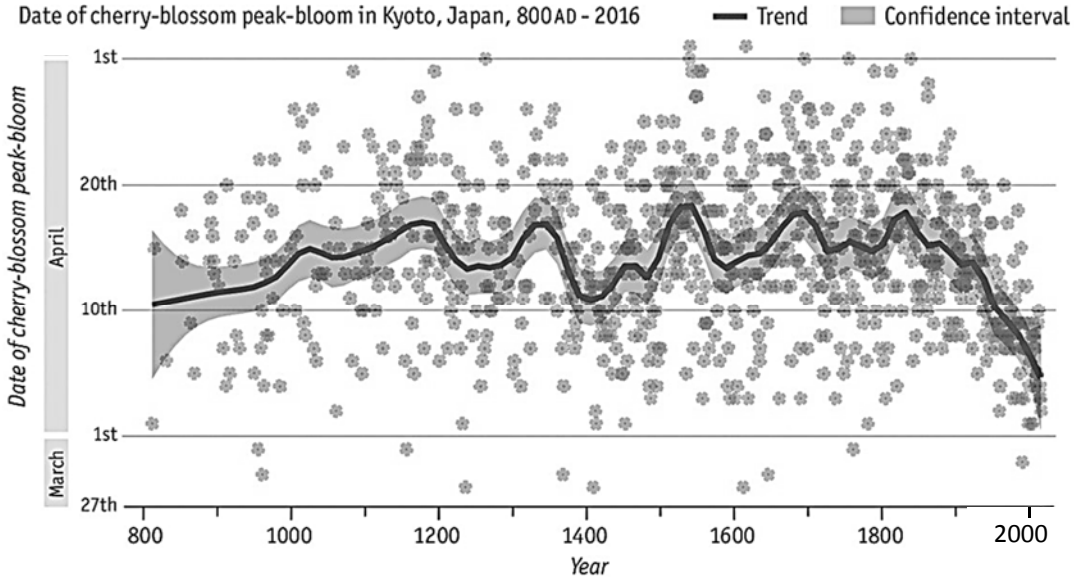
C A 80% MCV coverage resulted in fewer than half a million cases of measles each year.

D There is a positive correlation between the number of measles cases and the MCV coverage.

29 The effect of temperature on cherry blossom flowering time (day of the year) is shown below.



The records of timing of cherry blossoms in Japan from 800 A.D is shown below.



Which conclusions can be made from both graphs?

1 The peak of cherry blossoms has consistently been earlier since 1850. Cherry blossoms begin earlier as temperature increases from 4 to 10°C.

2 The temperature in Japan has been increasing since 800 A.D., resulting in later blooming and pollinators are unable to pollinate the cherry trees.

3 No conclusion can be made as the data points are scattered and lack clear trend.

A 1 only

B 2 only

C 3 only

D 1 and 2

30 An investigation was carried out to assess the effect of diet on the milk yield and methane production of cows. The cows in group **A** were fed a traditional diet and those in group **B** were fed the same diet with a mixture of chopped hay and straw added.

The table below shows the results of this investigation.

Group	Mean milk yield per cow/ dm^3 day^{-1}	Methane emission for each dm^3 milk produced / dm^3
A	24.0	30.0
B	27.6	24.0

Which of the following actions will help reduce the impact of global warming?

1 Decreasing consumption of beef and milk

2 Creating more foraging grounds to feed the cows

3 Adding chopped hay and straw to the cows' diet.

A 1 only

B 1 and 3 only

C 2 and 3 only

D All of the above

TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
JC 2 2018

CANDIDATE NAME									
CENTRE NUMBER	S					INDEX NUMBER				
CLASS	C	G			/	1	7		

H2 BIOLOGY

Paper 2 Structured Questions

9744/02
Friday 24 August 2018
2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number, index number and class in the spaces at the top of the page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
Do not use staples, paper clips, glue or correction fluid.

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

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

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

For Examiner's Use					
Q1	**/ 8**	**Q5**	**/ 10**	**Q9**	**/ 12**
Q2	**/ 11**	**Q6**	**/ 10**	**Q10**	**/ 8**
Q3	**/ 11**	**Q7**	**/ 5**	**Q11**	**/ 8**
Q4	**/ 7**	**Q8**	**/ 10**		
Total					**/ 100**

This document consists of **27** printed pages and **1** blank page.

Answer **all** the questions in this section.

1 Plants vary greatly in terms of size.

(a) Explain whether the cell theory is applicable to plants.

_____

_____

_____

_____

_____ [2]

Sugar molecules enter cells through transport proteins.

(b) Explain why transport proteins are required for the movement of sugar molecules, such as glucose and fructose, into cells.

_____

_____

_____

_____

_____ [2]

Some plant cells convert fructose and glucose into sucrose for transport from the leaves to the roots. Sucrose is moved into phloem sieve tubes as shown in Fig. 1.1.

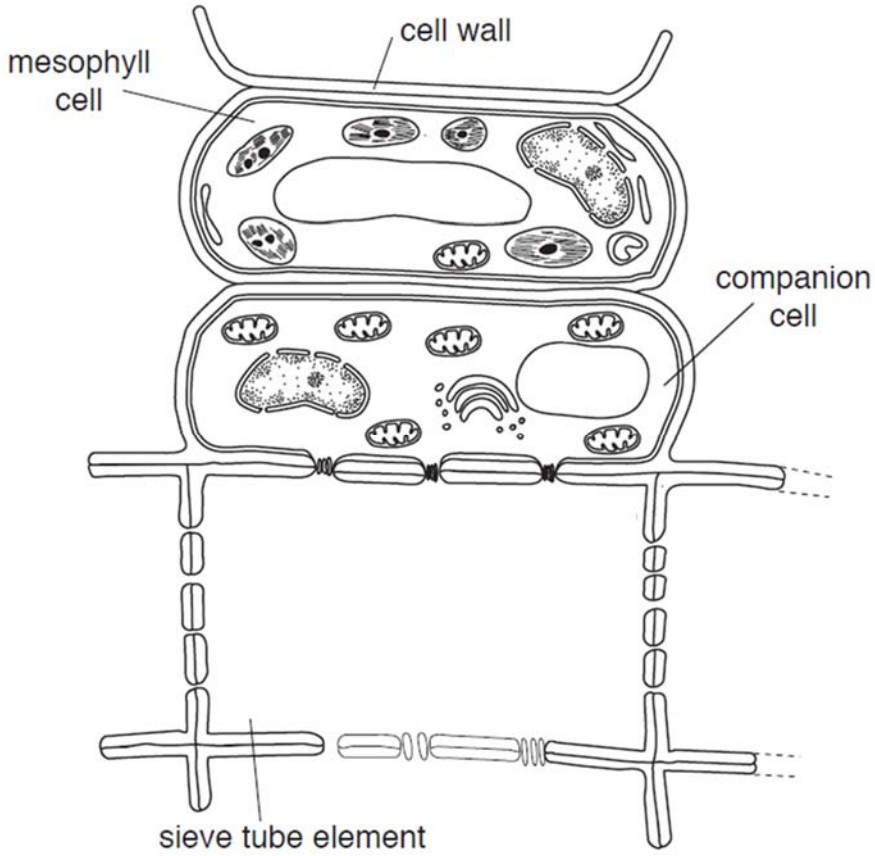


Fig. 1.1

Each cell has a specialized function.

(c) With reference to Fig. 1.1 and the information provided, state **one** difference between a mesophyll cell and companion cell.

_____

_____ [1]

Fig. 1.2 shows how sucrose is transported into the companion cell from the mesophyll cell.

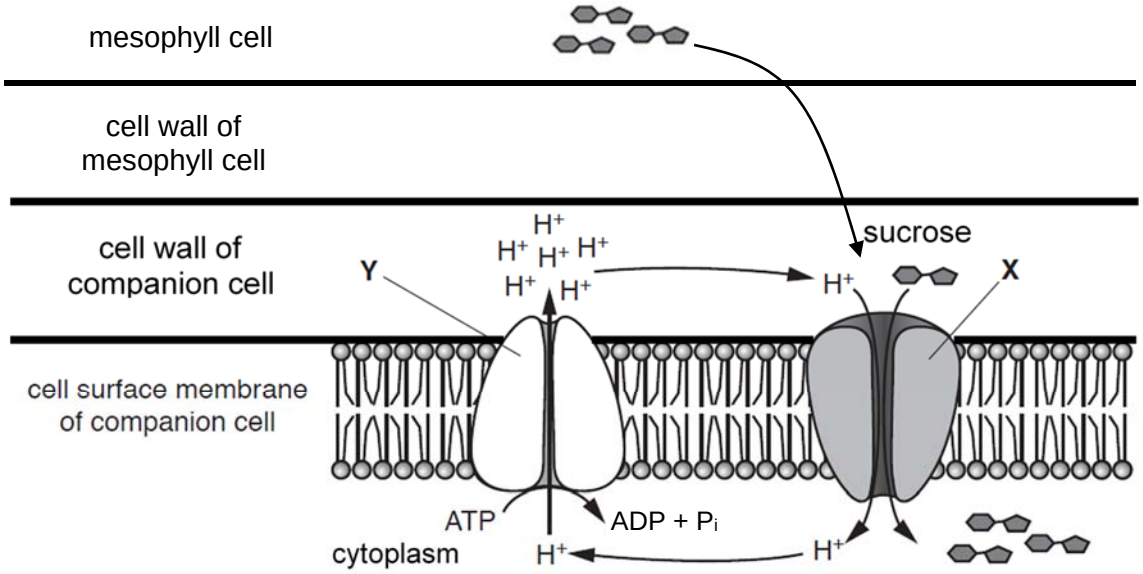


Fig. 1.2

(d) Using the information in Fig. 1.1 and Fig. 1.2, explain how sucrose moves into the companion cell.

_____

_____

_____

_____

_____

_____

_____ [3]

[Total: 8]

2 The yeast, *Saccharomyces cerevisiae*, is a single-celled, eukaryotic organism that is often used in the laboratory.

When yeast is mixed with a glucose solution, the yeast absorbs the glucose. Each molecule of glucose is then broken down into pyruvate molecules in exactly the same way as in any other eukaryotic organism.

(a) Outline the breakdown of glucose to pyruvate in this stage.

_____

_____

_____

_____

_____ [2]

Yeast cells sometimes carry out anaerobic respiration. Fig. 2.1 outlines the process of anaerobic respiration in yeast cells.

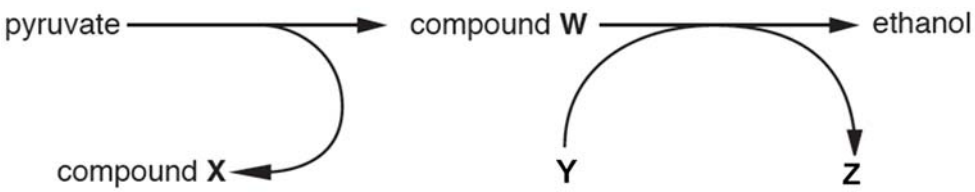


Fig. 2.1

(b) (i) Identify molecule **Z**.

_____ [1]

(ii) State why molecule **Y** is converted to **Z**.

_____

_____ [1]

Yeasts are often used in bread-making. The bread dough is kneaded to introduce and trap air so that the yeasts in the dough can respire aerobically. Besides carbon dioxide that is released during respiration, the evaporation of water or ethanol released during respiration also causes the dough to rise.

Table 2.1 shows the differences in the height of dough that was placed at different locations, after the dough was kneaded.

Table 2.1

Time / min	Height of dough / cm		
	Fridge	Room temperature	Next to window (hot day)
0	2.5	2.5	2.5
20	2.5	2.9	3.3
40	2.7	3.7	4.0
60	2.9	3.9	4.7
80	3.0	4.0	5.2
100	3.0	4.0	5.8
120	3.0	4.0	6.0

(c) (i) Account for the difference in the overall increase in the height of dough that was placed in the fridge with that placed next to the window.

[4]

(ii) Suggest why the increase in the height of dough that was placed at room temperature was higher between 0 and 40 minutes than between 40 minutes and 60 minutes.

_____

_____

_____

_____

_____ [2]

(iii) Suggest why the height of the dough that was placed at room temperature ceases to increase after 80 minutes.

_____

_____

_____ [1]

[Total: 11]

3 In maize plants, a gene locus for leaf colour and a gene locus for cob colour were studied.

A pure breeding maize plant with bronze leaves and brown cob was crossed with a pure breeding maize plant with green leaves and yellow cobs to produce F1 phenotypes.

All the F1 plants had bronze leaves and brown cobs.

(a) Define the term *locus*.

_____

_____ [1]

A test cross was conducted for these two loci using the F1 plant. Table 3.1 shows the results of this cross.

Table 3.1

Phenotype	Observed number (O)
bronze leaves and brown cobs	44
bronze leaves and yellow cobs	6
green leaves and brown cobs	7
green leaves and yellow cobs	43
Total	100

(b) (i) Use the symbols:

L bronze leaves; **l** green leaves; **B** brown cobs; **b** yellow cobs

State the phenotype of the test cross plant.

_____ [1]

(ii) Draw a genetic diagram to explain the results of this test cross.

[4]

Another type of maize plant produced a total of 381 grains, 216 purple and smooth, 79 purple and shrunken, 65 yellow and smooth and 21 yellow and shrunken.

A chi-squared test was carried out to test the significance of the differences between the observed and expected results.

Table 3.2 shows some calculations to obtain the chi-squared value.

Table 3.2

grain phenotype	observed number	expected number	$\frac{[\text{obs no.} - \text{exp no.}]^2}{\text{exp no.}}$
purple and smooth	216	381 × 9/16 = 214	4/214 = 0.019
purple and shrunken	79	381 × 3/16 = 71	64/71 = 0.901
yellow and smooth	65	381 × 3/16 = 71	36/71 = 0.507
yellow and shrunken	21		
Total number	381	χ^2 value	

(c) Complete the missing spaces in Table 3.2. [2]

Table 3.3 shows some critical values for chi-squared test at different probability levels.

Table 3.3

Degrees of freedom	**Probability, p**						
	0.50	***0.10***	***0.05***	***0.02***	***0.01***	***0.005***	***0.001***
1	0.46	2.71	3.84	5.41	6.64	7.88	10.83
2	1.39	4.61	5.99	7.82	9.21	10.60	13.82
3	2.37	6.25	7.82	9.84	11.35	12.84	16.27
4	3.36	7.78	9.49	11.67	13.28	14.86	18.47
5	4.35	9.24	11.07	13.33	15.09	16.75	20.51

(d) (i) Describe how the degrees of freedom was determined;

_____

_____ [1]

(ii) State the conclusion from the χ^2 value calculated in **(c)**.

_____

_____

_____

_____ [2]

[Total: 11]

End of Part 1

4 Fig. 4.1 shows the effect of increasing substrate concentration on the rate of a particular reaction in the presence and absence of an enzyme.

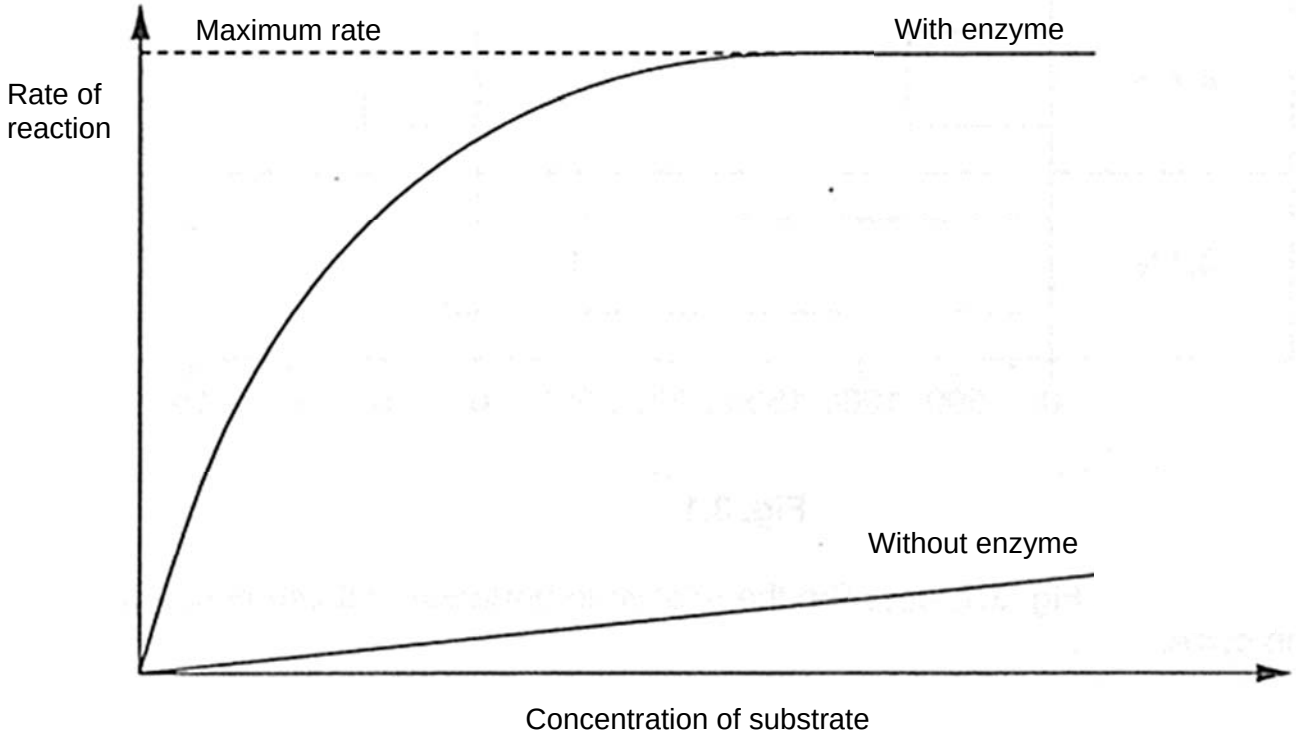


Fig. 4.1

(a) On Fig. 4.1, draw **two** labelled curves to show the effect on the rate of the enzyme catalysed reaction upon the addition of

(i) a competitive inhibitor;

(ii) a non-competitive inhibitor. [2]

(b) Explain the effect of a competitive inhibitor on the rate of enzyme activity.

_____

_____

_____

_____

_____

_____

_____ [3]

(c) State **two** differences between a competitive inhibitor and a non-competitive inhibitor.

_____

_____

_____

_____ [2]

[Total: 7]

5 Fig. 5.1 shows a stage in the mitotic cell cycle in an animal cell.

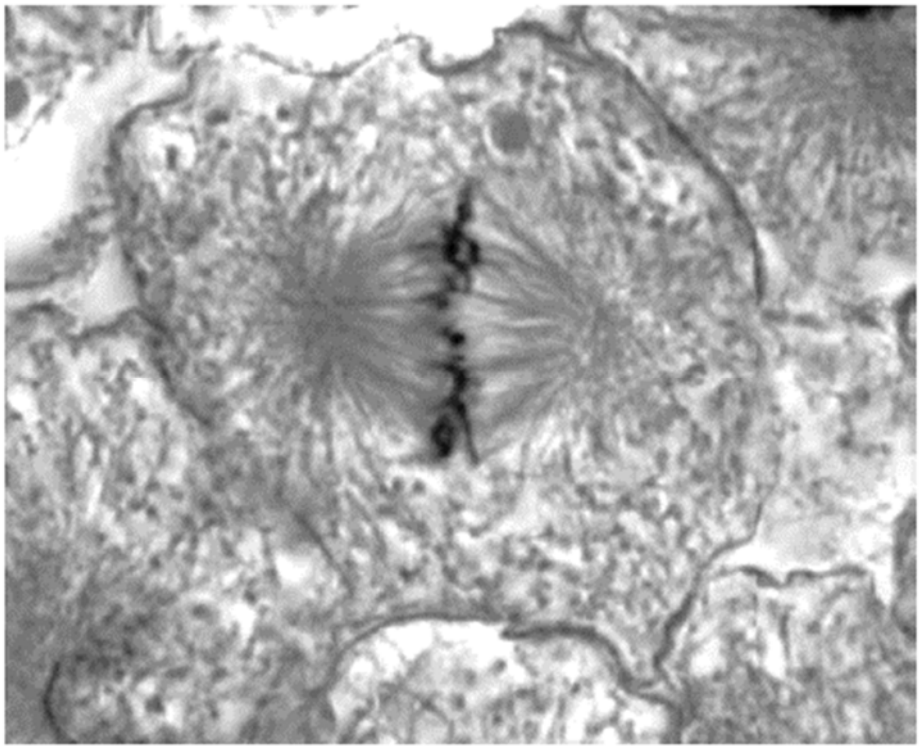


Fig. 5.1

(a) With reference of Fig. 5.1,

(i) identify the stage of mitosis;

_____ [1]

(ii) state two features which are characteristic of this stage.

_____

_____

_____

_____ [2]

(b) Distinguish between the terms haploid and diploid.

_____

_____

_____

_____ [2]

(c) Explain the importance of mitosis in organisms.

_____

_____

_____

_____

_____

_____

_____ [3]

(d) In many multicellular organisms, such as mammals, the time taken for the mitotic cell cycle varies considerably between different tissues, but is very carefully controlled in each cell.

Suggest the importance of this control in mammals.

_____

_____

_____

_____ [2]

[Total: 10]

6 *Staphylococcus aureus is* a bacterium that is resistant to most types of antibiotics, such as penicillin.

In a study to understand how bacteria gain antibiotic resistance, a strain of *E. coli* with no known antibiotic resistance was mixed with heat-killed *S. aureus* for 24 hours.

E. coli was then grown on Petri dish containing penicillin and the number of *E. coli* colonies were counted.

For the control, *E. coli* without *S. aureus* was grown on another Petri dish and the number of colonies were counted.

Fig 6.1 shows the result of the experiment.

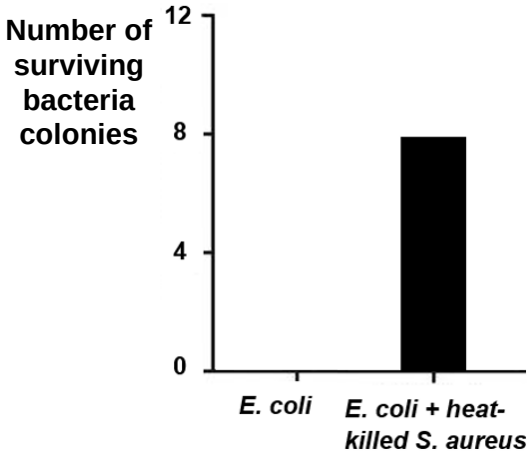


Fig. 6.1

(a) Identify the process that allows *E. coli to* become antibiotic resistant.

_____ [1]

(b) With reference to Fig. 6.1,

(i) describe the results observed;

_____

_____ [1]

(ii) Explain the results observed in **(b)(i)**.

_____

_____

_____

_____

_____ [2]

Fig. 6.2 shows another process by which antibiotic resistance genes can be passed from bacterium **A** to **B**.

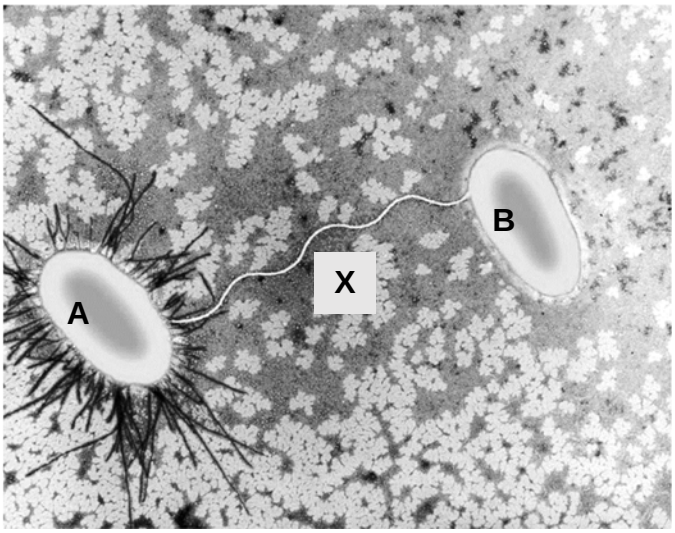


Fig. 6.2

(c) With reference to the process shown in Fig. 6.2,

(i) identify the nature of each bacterium;

Bacterium **A** : _____

Bacterium **B** : _____ [2]

(ii) identify structure **X.**

X : _____ [1]

(iii) Distinguish between the process of genetic recombination stated in **(a)** and in Fig. 6.2.

_____

_____

_____

_____

_____

_____

_____ [3]

[Total: 10]

7 In an investigation to study genetic variation, DNA was obtained from four varieties of the same invertebrate species.

The following technique was used:
- DNA was digested using a number of different restriction enzymes to obtain different fragments
- The fragments were separated by gel electrophoresis
- RNA probes were used to select DNA fragments with specific sequences

(a) Explain how RNA probes, used in this technique, select fragments of DNA.

_____

_____

_____

_____

_____ [2]

Fig. 7.1 shows the results after the RNA probes have bound to the selected DNA fragments.

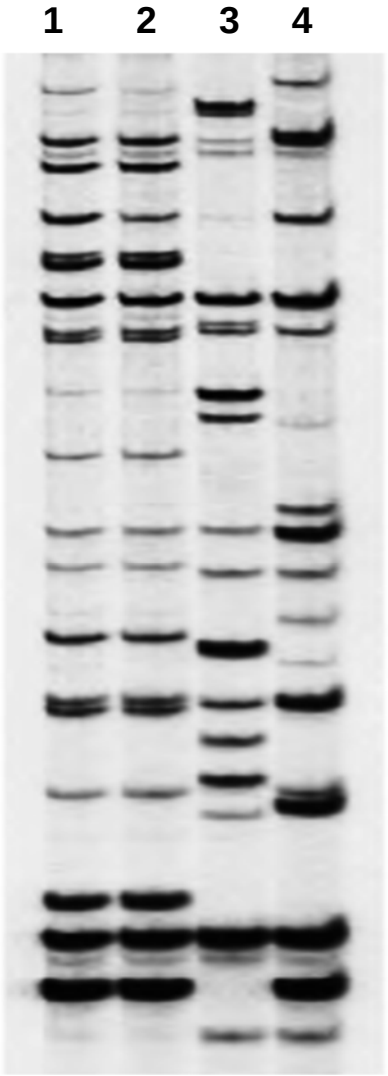


Fig. 7.1

(b) On Fig. 7.1,

(i) draw an arrow (➔), indicate **one** DNA fragment found in all four varieties where the RNA probe has bound; [1]

(ii) Identify the varieties which have the same genetic fingerprint and explain your answer.

_____

_____

_____

_____

_____ [2]

[Total: 5]

8 Table 8.1 shows some of the common fatty acids and their melting points.

Table 8.1

Symbol (number of carbon atoms : number of double bonds)	**Common Name**	**Melting point (ºC)**
Saturated fatty acids		
12 : 0	Lauric acid	44.2
14 : 0	Myristic acid	52
16 : 0	Palmitic acid	63.1
18 : 0	Stearic acid	69.6
20 : 0	Arachidic acid	75.4
22 : 0	Behenic acid	81
Unsaturated fatty acids		
16 : 1	Palmitoleic acid	-0.5
18 : 1	Oleic acid	13.4
18 : 2	Linoleic acid	-9
18 : 3	α-linolenic acid	-17
20 : 4	Arachnidonic acid	-49.5

(a) Arachidonic acid is a polyunsaturated fatty acid. Explain the term *polyunsaturated fatty acid.*

_____

_____ [1]

(b) With reference to Table 8.1,

(i) describe the effect of increasing number of carbon atoms in saturated fatty acids on the melting point;

_____

_____

_____

_____

_____

_____

_____ [3]

(ii) describe the effect of the presence of double bonds in fatty acids on the melting point;

_____

_____ [1]

(iii) explain the trend described in **b(ii)**.

_____

_____

_____

_____

_____

_____

_____

_____

_____ [4]

(c) Suggest where polyunsaturated fatty acids are usually found in nature.

_____

_____ [1]

[Total: 10]

9 Table 9.1 provides statements regarding the bonds found in four biological molecules.

Table 9.1

statement	protein	DNA	messenger RNA	cellulose
hydrogen bonds stabilise the molecule				
subunits are joined by peptide bonds				

(a) Complete Table 9.1 by indicating with a tick (✓) or a cross (×) whether the statements apply to proteins, DNA, messenger RNA and cellulose.

You should put a tick or a cross in each box of the table. [2]

(b) Telomeres are parts of chromosomes. Describe the function of telomeres.

[4]

(c) A piece of mRNA is 660 nucleotides long but the DNA coding strand from which it was transcribed is 870 nucleotides long.

(i) Explain this difference in number of nucleotides.

_____

_____ [1]

(ii) What is the maximum number of amino acids in the protein translated from this piece of mRNA? Explain your answer.

Number of amino acids _____

Explanation

_____

_____

_____ [2]

(d) Identify **one** other process that leads to the formation of mature mRNA and state its function.

_____

_____

_____

_____ [2]

(e) Describe **one** difference between the structure of mRNA and tRNA.

_____

_____ [1]

[Total: 12]

10 Unlike eukaryotes, prokaryotes have different mechanisms for controlling gene expression. Fig. 10.1 shows the Jacob and Monod model of gene expression in the *lac* operon of *Escherichia coli*.

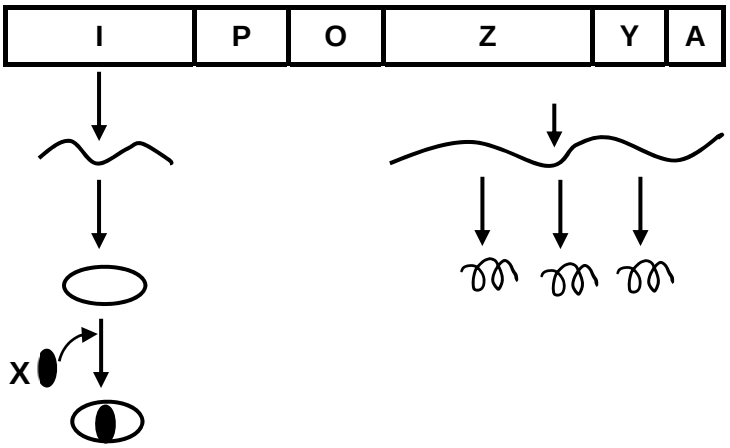


Fig. 10.1

(a) With reference to Fig. 10.1 identify,

(i) identify molecule **X**;

_____ [1]

(ii) identify region **I**.

_____ [1]

The regulation of *lac* operon in *E. coli* was investigated and wild-type *E. coli* were cultured in two different agar media.

X-gal was added to both agar media. It is a colourless substance that is converted to a blue compound by the enzyme, β-galactosidase.

Table 10.1 shows results of the investigation.

Table 10.1

Type of agar medium	**Colour of colony**
X-gal, lactose and no glucose	blue
X-gal, lactose and glucose	white

(b) Apart from the presence of an inactive *lac* repressor, explain the appearance of the colony when wild-type *E. coli* was cultured in lactose and X-gal without glucose.

[3]

In a separate experiment, scientists fused the *trp* operon with the *lac* operon as shown in Fig.10.2.

The *trp-lac* fusion operon was then inserted into a bacterial cell to replace the separate *trp* operon and *lac* operon such that the transformed bacterium only has the *trp-lac* fusion operon.

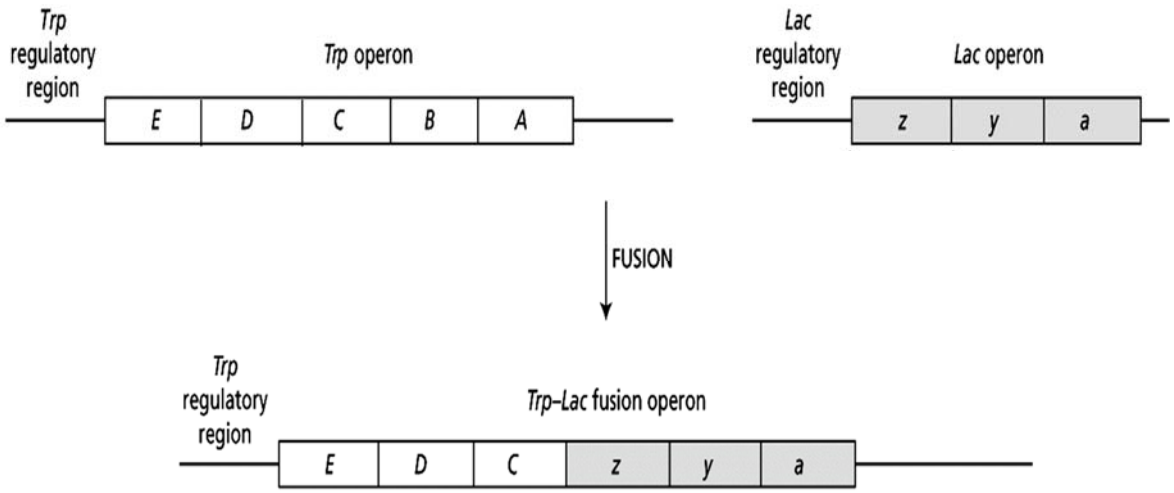


Fig. 10.2

(c) State and explain the conditions which must be present in order for β-galactosidase to be formed in the transformed bacterium with *trp-lac* fusion operon.

[3]

[Total: 8]

11 Relationships between different primates can be found by comparing their proteins and DNA.

The proteins of different species can be compared using immunological techniques.

The protein albumin obtained from a human was injected into a rabbit. The rabbit produced antibodies against the human albumin.

These antibodies were extracted from the rabbit and then added to samples of albumin obtained from four different animal species. Precipitation occurs when antibodies bind to albumin. The amount of precipitate produced in each sample was then measured and shown in Table 11.1.

Table 11.1

Species from which albumin was obtained	Amount of precipitate / arbitrary units
Rat	23
Chimpanzee	96
Marmoset	65
Trout	11

(a) Comment on what the results suggest about the evolutionary relationship between humans and the other species?

_____

_____

_____

_____

_____ [2]

Scientists also used DNA hybridisation to determine the evolutionary relationships between five species of primate.

The separation temperature is the temperature at which a molecule of double-stranded DNA separates into two single strands.

The scientists first recorded the mean separation temperature of DNA in which both strands were from the same species.

The scientists then recorded the mean decrease in separation temperature of DNA in which one of the strands was from another species. Their results are shown in Table 11.2.

Table 11.2

Primate	**Mean decrease in separation temperature / ºC**				
	Human	Chimpanzee	Gorilla	Orang-utan	Gibbon
Human					
Chimpanzee	1.7				
Gorilla	2.3	2.3			
Orang-utan	3.6	3.6	3.5		
Gibbon	4.8	4.8	4.7	4.9	

(b) When the scientists first recorded the mean separation temperature of DNA in which both strands were from the same species, differences in the separation temperature was observed. Suggest why this is so.

_____

_____ [1]

(c) With reference to Table 11.2,

(i) explain if the data suggests that gibbons are most distantly related to humans;

_____

_____

_____

_____

_____ [2]

(ii) The scientists assumed that the decreases in separation temperatures are directly proportional to the time since the evolutionary lines of these primates separated.

Gorillas are thought to have separated from orang-utans 20 million years ago. Use this information to calculate how long ago the evolutionary lines of humans and chimpanzees separated.

Show your working.

_____ million years [3]

[Total: 8]

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PRELIMINARY EXAMINATION
JC 2 2018

CANDIDATE NAME										
CENTRE NUMBER	S					INDEX NUMBER				
CLASS	C	G			/	1	7			

H2 BIOLOGY

Paper 2 Structured Questions

9744/02
Friday 24 August 2018
2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number, index number and class in the spaces at the top of the page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
Do not use staples, paper clips, glue or correction fluid.

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

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

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

For Examiner's Use					
Q1	**/ 8**	**Q5**	**/ 10**	**Q9**	**/ 12**
Q2	**/ 11**	**Q6**	**/ 10**	**Q10**	**/ 8**
Q3	**/ 11**	**Q7**	**/ 5**	**Q11**	**/ 8**
Q4	**/ 7**	**Q8**	**/ 10**		
Total					**/ 100**

This document consists of **27** printed pages and **1** blank page.

Answer **all** the questions in this section.

1 Plants vary greatly in terms of size.

(a) Explain whether the cell theory is applicable to plants. [2]

1. **Applicable.**
2. **Plants are living organisms, which are composed of (many, different plant) cells,**
3. **which are basic/ smallest unit of life.**
4. **All plant cells come from pre-existing plant cells via cell division (e.g. mitosis or meiosis).**

Sugar molecules enter cells through transport proteins.

(b) Explain why transport proteins are required for the movement of sugar molecules, such as glucose and fructose, into cells. [2]

1. **Glucose and fructose are polar molecules.**
2. **They are unable to cross**
3. **the hydrophobic core of the phospholipid bilayer.**
4. **Transport proteins shield them from hydrophobic core of plasma membrane (e.g. channel proteins provide a hydrophilic channel for their movement across the membrane).**

Some plant cells convert fructose and glucose into sucrose for transport from the leaves to the roots. Sucrose is moved into phloem sieve tubes as shown in Fig. 1.1.

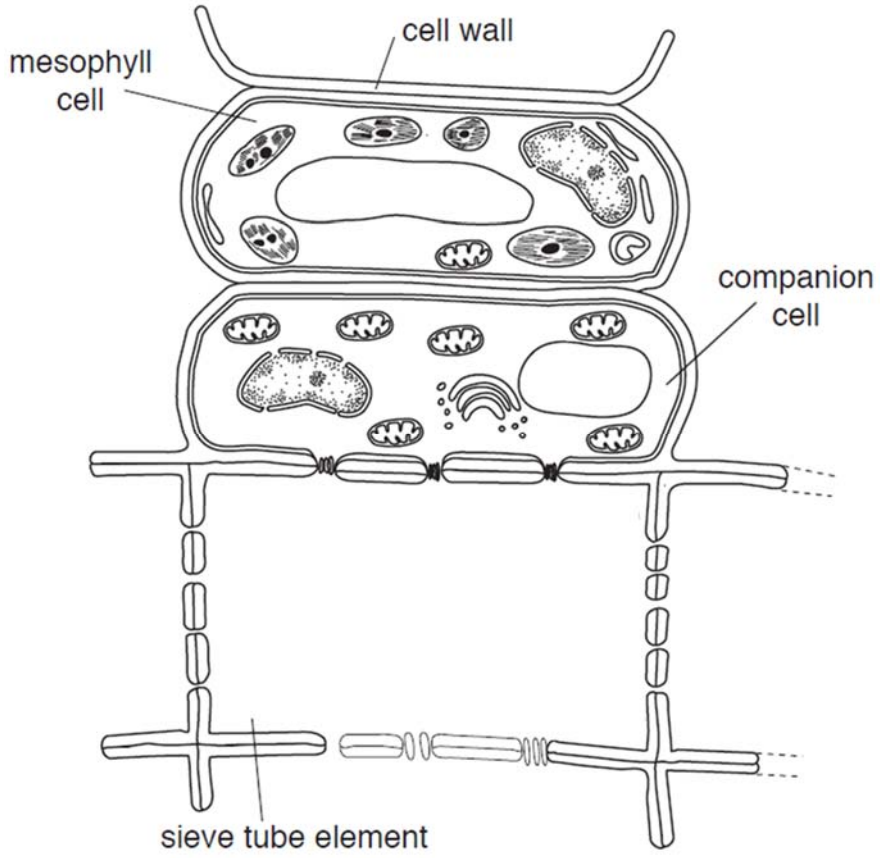


Fig. 1.1

Each cell has a specialized function.

(c) With reference to Fig. 1.1 and the information provided, state **one** difference between a mesophyll cell and companion cell. [1]

1. **Companion cells (6 mitochondria) have more mitochondria than mesophyll cells (1 mitochondrion). [1]**

   OR

   Mesophyll cells (5 chloroplasts) have chloroplasts whereas companion cells have none. [1]

Fig. 1.2 shows how sucrose is transported into the companion cell from the mesophyll cell.

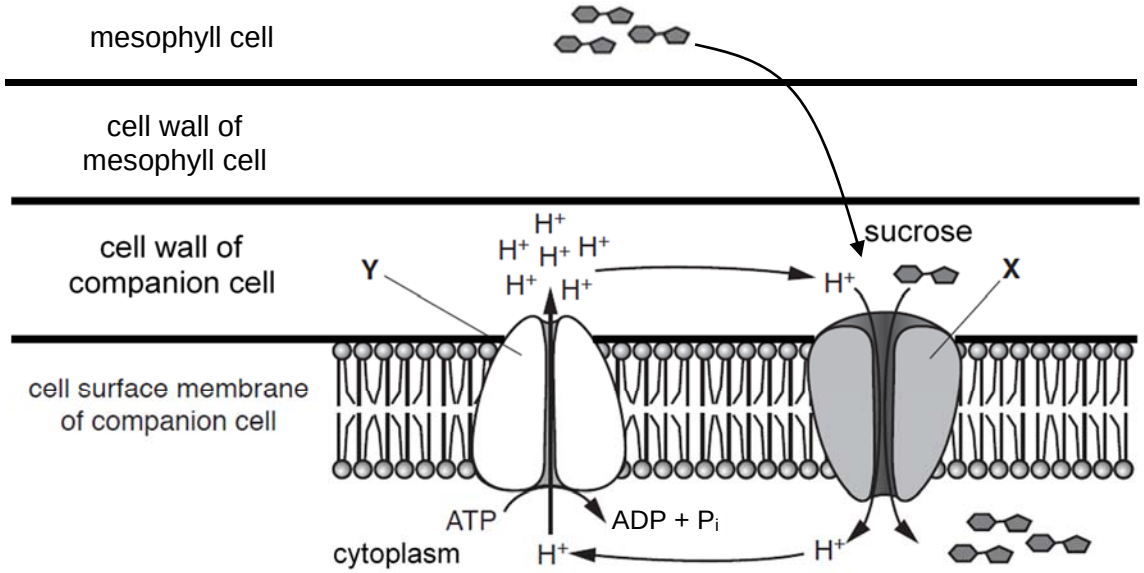


Fig. 1.2

(d) Using the information in Fig. 1.1 and Fig. 1.2, explain how sucrose moves into the companion cell. [3]

1. **Sucrose diffuses from mesophyll cell to the cell wall of companion cell.**

2. **Protons are actively pumped out from the cytoplasm of companion cell into its cell wall through carrier protein Y via active transport (hydrolysis of ATP). [1]**
   [Reject: Diffuse]

3. **Protons then diffuses from the cell wall of companion cells into the companion cell through transport protein X (cotransporter) via facilitated diffusion [1]**

4. **which is coupled with the transport of sucrose**
5. **against the sucrose concentration gradient.**

[Total: 8]

2 The yeast, *Saccharomyces cerevisiae*, is a single-celled, eukaryotic organism that is often used in the laboratory.

When yeast is mixed with a glucose solution, the yeast absorbs the glucose. Each molecule of glucose is then broken down into pyruvate molecules in exactly the same way as in any other eukaryotic organism.

(a) Outline the breakdown of glucose to pyruvate in this stage. [2]

Respiration Lecture Notes p.9, 10

1. **Glucose is broken to pyruvate during glycolysis.**
2. **Glucose is first phosphorylated to glucose-6-phosphate**
3. **which is (isomerized to fructose-6-phosphate and then phosphorylated to) converted to fructose-1,6-bisphophate**
4. **before being cleaved/ broken down into 2 three-carbon sugars (OR glyceraldehyde-3-phosphate and dihydroxyacetone phosphate),**
5. **which is then oxidised/ converted to form 2 molecules of pyruvate.**

Yeast cells sometimes carry out anaerobic respiration. Fig. 2.1 outlines the process of anaerobic respiration in yeast cells.

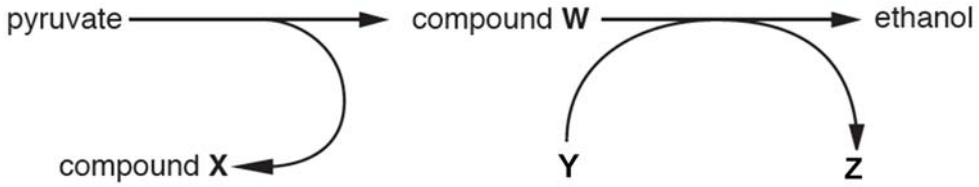


Fig. 2.1

(b) (i) Identify molecule **Z**. [1]

NAD or NAD^+

(ii) State why molecule **Y** is converted to **Z**. [1]

Respiration Lecture Notes p.26

1. **Regenerate NAD**
2. **required for glycolysis to continue.**

[Accept: Reduce compound W (ethanal) to ethanol]

Yeasts are often used in bread-making. The bread dough is kneaded to introduce and trap air so that the yeasts in the dough can respire aerobically. Besides carbon dioxide that is released during respiration, the evaporation of water or ethanol released during respiration also causes the dough to rise.

Table 2.1 shows the differences in the height of dough that was placed at different locations, after the dough was kneaded.

Table 2.1

Time / min	Height of dough / cm		
	Fridge	Room temperature	Next to window (hot day)
0	2.5	2.5	2.5
20	2.5	2.9	3.3
40	2.7	3.7	4.0
60	2.9	3.9	4.7
80	3.0	4.0	5.2
100	3.0	4.0	5.8
120	3.0	4.0	6.0

(c) (i) Account for the difference in the overall increase in the height of dough that was placed in the fridge with that placed next to the window. [4]

1. **The height of the dough when placed in the fridge (F) increases from 2.5 at 0 min to 3.0cm at 120 min**
   is LOWER than
   that when placed next to window (W) which increases from 2.5 to 6.0 cm. [1]

2. **The temperature of the dough in F is lower than that of W.**
3. **Hence, the kinetic energy of respiratory enzymes and substrates is lower.**
   [Accept: Enzymes are inactivated]

4. **The frequency of effective collisions between enzymes and substrates is lower**
5. **hence the rate of formation of enzyme-substrate complexes is lower.**

6. **The rate of respiratory enzyme activity / rate of respiration is lower.**
7. **and less carbon dioxide are released and less evaporation of water or ethanol, which causes the dough to rise less.**

(ii) Suggest why the increase in the height of dough that was placed at room temperature was higher between 0 and 40 minutes than between 40 minutes and 60 minutes. [2]

1. **The height of dough increases from 2.5 to 3.7cm between 0 and 40 min**
   is HIGHER than
   3.7 to 3.9cm between 40 and 60 minutes. [1]

WITH

2. **There are more oxygen between 0 and 40 min, hence the yeast undergoes aerobic respiration which releases more molecules of CO_2 (6 molecules of CO_2**

and 6 molecules of H_2O) than anaerobic respiration (2 molecules of CO_2 and 2 molecules of ethanol) from 40 minutes and 60 minutes. [1]

OR

There are more respiratory substrates at the start between 0 and 40 min, the rate of formation of enzyme-substrate complexes is higher, hence the rate of respiration is higher than between 40 minutes and 60 minutes. [1]

OR

From 40 minutes and 60 minutes, the yeast undergoes anaerobic respiration and high concentration of ethanol produced is toxic and kills the yeast. [1]

(iii) Suggest why the height of the dough that was placed at room temperature ceases to increase after 80 minutes. [1]

1. **The high concentration of ethanol produced is toxic and kills the yeast. [1]**

[Total: 11]

3 In maize plants, a gene locus for leaf colour and a gene locus for cob colour were studied.

A pure breeding maize plant with bronze leaves and brown cob was crossed with a pure breeding maize plant with green leaves and yellow cobs to produce F1 phenotypes.

All the F1 plants had bronze leaves and brown cobs.

(a) Define the term *locus*. [1]

Genetics I Lecture Notes p.4
1. **Fixed position/ location**
2. **on a particular chromosome**

A test cross was conducted for these two loci using the F1 plant. Table 3.1 shows the results of this cross.

Table 3.1

Phenotype	Observed number (O)
bronze leaves and brown cobs	44
bronze leaves and yellow cobs	6
green leaves and brown cobs	7
green leaves and yellow cobs	43
Total	100

(b) (i) State the phenotype of the test cross plant. [1]

Plant for green leaves and yellow cobs

(ii) Draw a genetic diagram to explain the results of this test cross. [4]

Use the symbols:
L bronze leaves; **l** green leaves; **B** brown cobs; **b** yellow cobs

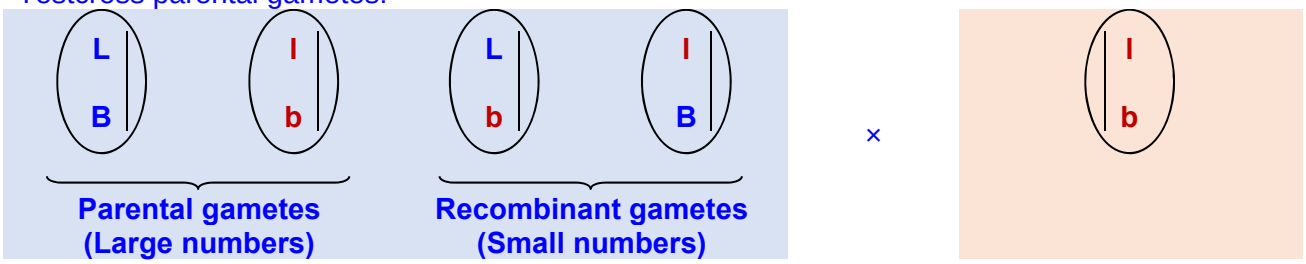
TESTCROSS

Parental phenotype and genotype [1]

Testcross parental phenotype:	Bronze leaves Brown cobs	×	Green leaves Yellow cobs
Testcross parental genotype:	**L** | **l** **B** | **b**	×	**l** | **l** **b** | **b**

Parental gametes [1]

Testcross parental gametes:



Punnett square, offspring genotype and phenotype, phenotypic ratio [2]

Offspring genotype:	**L** | **l** **B** | **b**		**l** | **l** **b** | **b**		**L** | **l** **b** | **b**		**l** | **l** **B** | **b**
Offspring phenotype:	Bronze leaves Brown cobs	:	Green leaves Yellow cobs		Bronze leaves Yellow cobs	:	Green leaves Brown cobs
Offspring phenotypic ratio:	1	:	1		1	:	1
Observed numbers:	44	:	43		6	:	7
	Large numbers Non-recombinant phenotype				Small numbers Recombinant phenotype		

Another type of maize plant produced a total of 381 grains, 216 purple and smooth, 79 purple and shrunken, 65 yellow and smooth and 21 yellow and shrunken.

A chi-squared test was carried out to test the significance of the differences between the observed and expected results.

Table 3.2 shows some calculations to obtain the chi-squared value.

Table 3.2

grain phenotype	observed number	expected number	$\frac{[\text{obs no.} - \text{exp no.}]^2}{\text{exp no.}}$
purple and smooth	216	381 × 9/16 = 214	4/214 = 0.019
purple and shrunken	79	381 × 3/16 = 71	64/71 = 0.901
yellow and smooth	65	381 × 3/16 = 71	36/71 = 0.507
yellow and shrunken	21		
Total number	381	χ^2 value	

(c) Complete the missing spaces in Table 3.2. [2]

grain phenotype	observed number	expected number	$\frac{[\text{obs no.} - \text{exp no.}]^2}{\text{exp no.}}$
purple and smooth	216	381 × 9/16 = 214	4/214 = 0.019
purple and shrunken	79	381 × 3/16 = 71	64/71 = 0.901
yellow and smooth	65	381 × 3/16 = 71	36/71 = 0.507
yellow and shrunken	21	**381 x 1/16 = 24**	**9/24 = 0.375**
Total number	381	χ^2 value	**1.80**

[1 for each row, allow ecf]

Table 3.3 shows some critical values for chi-squared test at different probability levels.

Table 3.3

Degrees of freedom	Probability, p						
	0.50	***0.10***	***0.05***	***0.02***	***0.01***	***0.005***	***0.001***
1	0.46	2.71	3.84	5.41	6.64	7.88	10.83
2	1.39	4.61	5.99	7.82	9.21	10.60	13.82
3	2.37	6.25	7.82	9.84	11.35	12.84	16.27
4	3.36	7.78	9.49	11.67	13.28	14.86	18.47
5	4.35	9.24	11.07	13.33	15.09	16.75	20.51

(d) (i) Describe how the degrees of freedom was determined; [1]

1. **The degree of freedom is total number of categories/ phenotypes (i.e. 4)**
2. **minus one.**

(ii) State the conclusion from the χ^2 value calculated in **(c)**. [2]

1. **For 3 degrees of freedom,**
2. **the calculated χ^2 value of 1.80 is less than the critical χ^2 value of 7.82.**
3. **The probability that the difference is due to chance is greater than 0.05.**
4. **The difference between observed numbers and expected ratio is not statistically significant and it is due to chance.**

[Total: 11]

End of Part 1

2018 PRELIMINARY EXAMINATION

H2 BIOLOGY PAPER 2 [PART 2]:

Structured Questions

Name: _____

Civics Group: _____/17

For Examiner's Use	
Q4	**/ 7**
Q5	**/ 10**
Q6	**/ 10**
Q7	**/ 5**

4 Fig. 4.1 shows the effect of increasing substrate concentration on the rate of a particular reaction in the presence and absence of an enzyme.

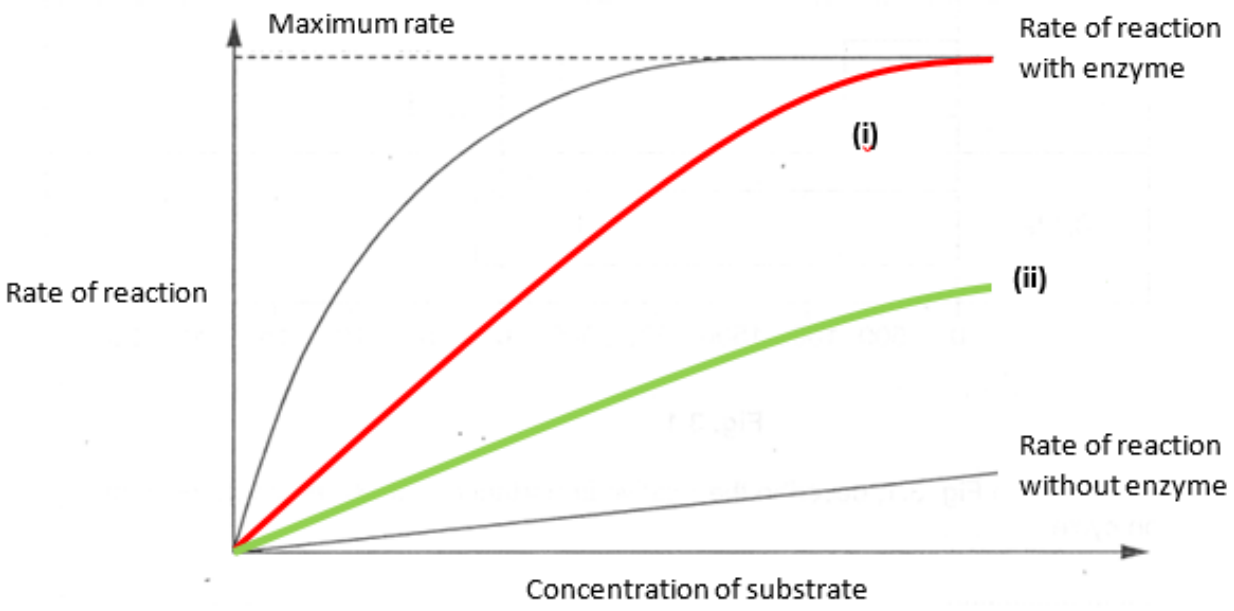


Fig. 4.1

(a) On Fig. 4.1, draw **two** labelled curves to show the effect on the rate of the enzyme catalysed reaction upon the addition of

(i) a competitive inhibitor;

(ii) a non-competitive inhibitor. [2]

(b) Explain the effect of a competitive inhibitor on the rate of enzyme activity. [3]

1. **Shape of inhibitor is similar in shape of substrate**
2. **Shape of inhibitor is complementary to the shape of active site**
3. **Competitive inhibitors compete with the substrate molecules for the active site and bind at the active site of the enzyme**

4. **blocking / prevents substrate molecules from binding to active site,**
5. **reducing**
   i. **number of enzyme-substrate complex formed per unit time**
   or
   ii. **rate of enzyme-substrate complex formation**
6. **thus decreasing rate of enzyme activity**

(c) State **two** differences between a competitive inhibitor and a non-competitive inhibitor. [2]

Point of comparison	competitive inhibitor	non-competitive inhibitor
Binding site	**Enzyme active site**	**region other than its active site / allosteric binding site**
Structure	**Structurally similar to substrate.**	**Structure not similar to substrate.**
Overcoming its effects	**Effects can be overcome by increasing substrate concentration**	**Effects cannot be overcome by increasing substrate concentration**

[Total: 7]

5 Fig. 5.1 shows a stage in the mitotic cell cycle in an animal cell.

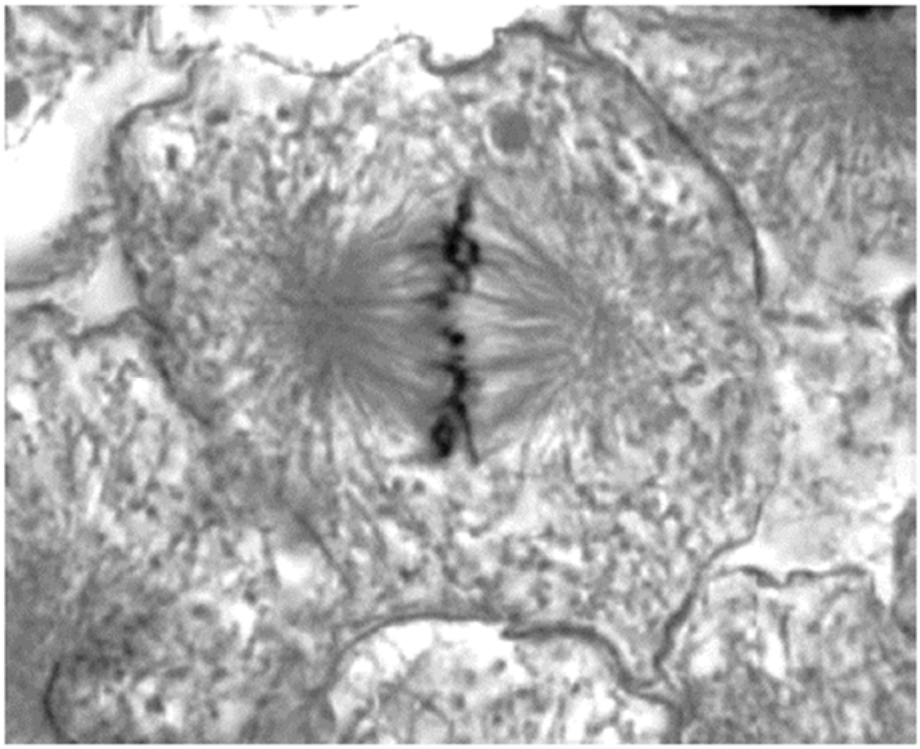


Fig. 5.1

(a) With reference of Fig. 5.1,

(i) identify the stage of mitosis; [1]

Metaphase

(ii) state two features which are characteristic of this stage. [2]

1. **Chromosomes line up at the equator of the cell/ metaphase plate. [1]**
2. **Centromere/kinetochore attached to spindle fibres/microtubles from the centrioles. [1]**
3. **Centrioles reach/located at poles of the cell. [1]**

(b) Distinguish between the terms haploid and diploid. [2]

1. **Haploid refers to only one set of chromosome being present in a cell,**
2. **Whereas diploid refers to cell having 2 sets of chromosomes,**

   OR
3. **Haploid condition consists of one member of each pair of homologous chromosome present.**
4. **Diploid condition consists of 2 sets of chromosomes, one set derived from each parent.**

(c) Explain the importance of mitosis in organisms. [3]

1. **maintains / same, genetic stability / number of chromosomes/ two sets of chromosomes / diploid / 2n /**
2. **produces daughter cells that are genetically identical**
3. **replacement of cells ;**
4. **repair of tissue ;**
5. **growth / increase in cell numbers ;**
6. **asexual reproduction;**

(d) In many multicellular organisms, such as mammals, the time taken for the mitotic cell cycle varies considerably between different tissues, but is very carefully controlled in each cell.

Suggest the importance of this control in mammals. [2]

1. **Prevent tumour/ cancer formation due to uncontrolled cell division. [1]**
2. **Only cells that are needed / functions are needed will be produced [1]**
3. **Allows for coordination of growth / limiting growth ; [1]**

[Total: 10]

6 *Staphylococcus aureus is* a bacterium that is resistant to most types of antibiotics, such as penicillin.

In a study to understand how bacteria gain antibiotic resistance, a strain of *E. coli* with no known antibiotic resistance was mixed with heat-killed *S. aureus* for 24 hours.

E. coli was then grown on Petri dish containing penicillin and the number of *E. coli* colonies were counted.

For the control, *E. coli* without *S. aureus* was grown on another Petri dish and the number of colonies were counted.

Fig 6.1 shows the result of the experiment.

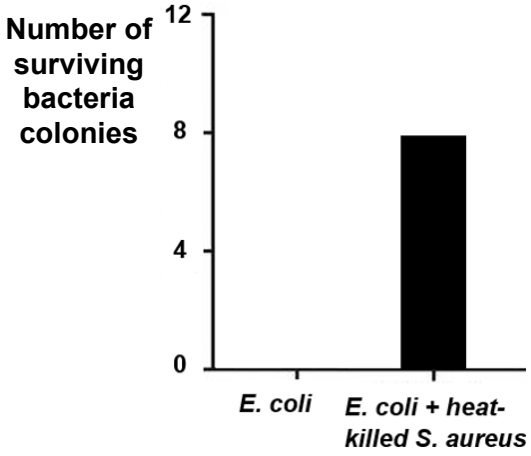


Fig. 6.1

(a) Identify the process that allows *E. coli to* become antibiotic resistant. [1]
Transformation

(b) With reference to Fig. 6.1,

(i) describe the results observed; [1]
- **After mixing heat-killed *S. aureus* and *E. coli*, the number of surviving *E. coli* colonies increased from 0 to 8 colonies/ml**

(ii) Explain the results observed in **(b)(i)**. [2]
1. **Heat - killed *S. aureus* released a piece of DNA that codes for penicillin resistance.**
2. **When mixed with the original E. coli, competent E. coli bacteria would take in this piece of DNA containing penicillin resistance.**
3. **The DNA is then integrated into the bacterial chromosome of the E. coli**
4. **and expressed, making it resistant to penicillin.**

Fig. 6.2 shows another process by which antibiotic resistance genes can be passed from bacterium **A** to **B**.

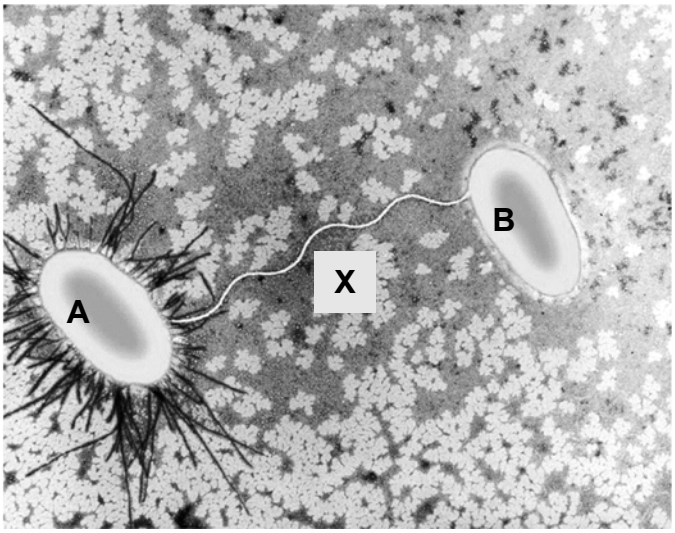


Fig. 6.2

(c) With reference to the process shown in Fig. 6.2,

(i) identify the nature of each bacterium; [2]
Bacterium **A** : **F+** (REJECT DONOR)
Bacterium **B** : **F-** (REJECT RECIPIENT)

(ii) identify structure **X.**
X : Conjugation bridge (REJECT SEX PILUS) [1]

(iii) Distinguish between the process of genetic recombination stated in **(a)** and in Fig. 6.2. [3]

	Transformation	Conjugation
Source of foreign DNA	**Naked foreign DNA from environment/ *S. Aureus***	**F plasmid in a F+ cell**
Type of bacterial cell needed for the process	**Competent bacteria cell**	**F+ cell**
Contact between cells	**Not required**	**required**
Description of Foreign DNA	**Any pieces of DNA.**	▪ **F plasmid**
Type of genes transferred	**Random**	▪ **Only genes found on the F plasmid**
Outcome of recipient bacterial cell	**Does not become F^+ cell**	▪ **Becomes a F^+ cell** ▪

[Total: 10]

7 In an investigation to study genetic variation, DNA was obtained from four varieties of the same invertebrate species.

The following technique was used:
- DNA was digested using a number of different restriction enzymes to obtain different fragments
- The fragments were separated by gel electrophoresis
- RNA probes were used to select DNA fragments with specific sequences

(a) Explain how RNA probes, used in this technique, select fragments of DNA. [2]

1. **RNA probes are single stranded and [1]**
2. **are complementary to a target sequence on a DNA fragment will hybridize with the probe. [1]**

Fig. 7.1 shows the results after the RNA probes have bound to the selected DNA fragments.

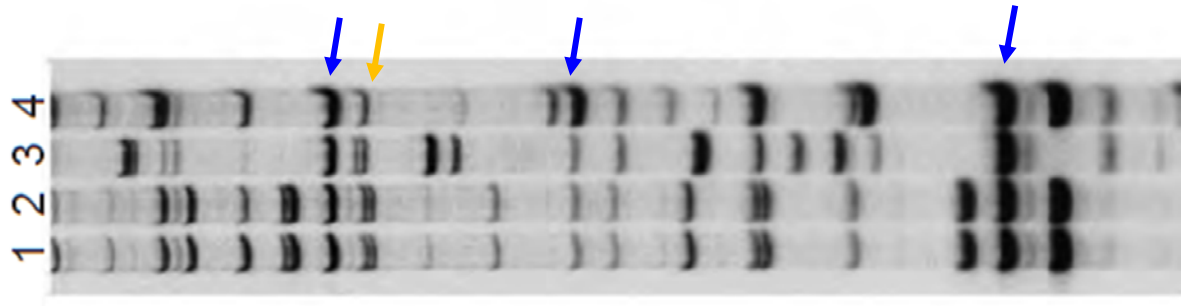


Fig. 7.1

Any row that has all 4 bands

(b) On Fig. 7.1,

(i) draw an arrow (➔), indicate **one** DNA fragment found in all four varieties where the RNA probe has bound; [1]

(ii) Identify the varieties which have the same genetic fingerprint and explain your answer.

1. **varieties 1 and 2;**
2. **they have, a very similar, pattern of DNA bands / DNA banding pattern**

[Total: 5]

End of Part 2

8 Table 8.1 shows some of the common fatty acids and their melting points.

Table 8.1

Symbol (number of carbon atoms : number of double bonds)	**Common Name**	**Melting point (°C)**
Saturated fatty acids		
12 : 0	Lauric acid	44.2
14 : 0	Myristic acid	52
16 : 0	Palmitic acid	63.1
18 : 0	Stearic acid	69.6
20 : 0	Arachidic acid	75.4
22 : 0	Behenic acid	81
Unsaturated fatty acids		
16 : 1	Palmitoleic acid	-0.5
18 : 1	Oleic acid	13.4
18 : 2	Linoleic acid	-9
18 : 3	α-linolenic acid	-17
20 : 4	Arachnidonic acid	-49.5

(a) Arachidonic acid is a polyunsaturated fatty acid. Explain the term *polyunsaturated fatty acid.* [1]

- **A fatty acid with many C=C double bonds.**
  Reject : many kinks

(b) With reference to Table 8.1,

(i) describe the effect of increasing number of carbon atoms in saturated fatty acids on the melting point; [3]

1. **As the number of carbon atoms increased 12 to 22, the melting point increased from 44.2 to 81 °C.**

2. **An initial increase of every 2 carbon atoms from 12 to 18 leads to a sharp increase in the melting point from 44.2 to 69.6 °C.**
3. **Further increase of every 2 cabon atoms from 18 to 22 lead to a lesser increase in melting point from 69.6 to 81°C.**
4. **As the number of carbon atoms increases, the melting point increases.**

(ii) describe the effect of the presence of double bonds in fatty acids on the melting point; [1]

1. **As the number of double bonds increases, the melting point decreases.**

2. **As the number of double bonds increased from 1 (in oleic acid) to 3 (in α-linolenic acid), the melting point decreased from 13.4 to -17 °C.**

(iii) explain the trend described in **b(ii)**. [4]

1. **Presence of double bonds results in the fatty acid molecules being bent/ kinked.**

2. **This means that the molecules cannot be closely packed together / less contact between molecules,**

3. **resulting in weaker hydrophobic interactions.**

4. **Therefore, less energy required to overcome the hydrophobic interactions / separate the fatty acid molecules during melting, resulting in the decrease in melting point.**

(c) Suggest where polyunsaturated fatty acids are usually found in nature. [1]

- **Vegetable oils**
- **Nuts**
- **Cold water fish**

[Total: 10]

9 Table 9.1 provides statements regarding the bonds found in four biological molecules.

Table 9.1

statement	protein	DNA	messenger RNA	cellulose
hydrogen bonds stabilise the molecule	✓	✓	×	✓
subunits are joined by peptide bonds	✓	×	×	×

(a) Complete Table 9.1 by indicating with a tick (✓) or a cross (×) whether the statements apply to proteins, DNA, messenger RNA and cellulose.

You should put a tick or a cross in each box of the table. [2]

(b) Telomeres are parts of chromosomes. Describe the function of telomeres. [4]

1a. **Protects the organism's genes from being lost with each cycle of DNA replication** / genetic material / DNA
1b. **due to gap at the 5' end of each replicated DNA strand / DNA shortened**

2a. **Protect chromosomal ends from degradation**
2b. **by binding proteins to form telomere caps.**

3a. **Prevents ends of chromosomes attaching** to **each other**
3a. **prevents apoptosis** / prevent chromosomal ends from activating cell's system for monitoring DNA damage.

4a. **Enables lengthening of telomeres** by
4b. providing a **recognition site** for the **enzyme telomerase.**

(c) A piece of mRNA is 660 nucleotides long but the DNA coding strand from which it was transcribed is 870 nucleotides long.

(i) Explain this difference in number of nucleotides. [1]
- **Introns present in DNA**
- **Introns absent in mRNA**

OR
- **introns removed by RNA splicing**

(ii) What is the maximum number of amino acids in the protein translated from this piece of mRNA? Explain your answer. [2]

Number of amino acids **220 OR 219**
Explanation

1. **3 bases code** for **1 amino acids**

(d) Identify **one** other process that leads to the formation of mature mRNA and state its function. [2]

1. Addition of 5' cap

[Significance]
2. **facilitate the binding of** Translation Initiation Factors and **small ribosomal subunit** for translation to occur.
OR
2. **facilitate the export of mature mRNA** from nucleus to cytoplasm for translation
OR
2. **protect the mature mRNA from degradation** by RNase in the cytoplasm

OR

1. Addition of 3' poly-A tail or 3' polyadenylation

[Significance]
2. **facilitate the export of mature mRNA** from nucleus to cytoplasm for translation
OR
3. **protect the mature mRNA from degradation** by RNase in the cytoplasm

(e) Describe **one** difference between the structure of mRNA and tRNA. [1]
Any one:
1. **mRNA** has **no base-pairing within** its **structure** while **tRNA** has **base**-**pairing between** regions to **fold back on itself**.
2. **mRNA** has **3' poly-A tail** while **tRNA** has **3' CCA end**.
3. **mRNA** does **not** have **hydrogen bonds** different regions of the single strand while **tRNA** has **hydrogen bonds** at different regions which cause it to **fold back on itself**.
4. **mRNA** is **linear** while **tRNA** **cloverleaf** shape;
5. **mRNA** has **no binding site for amino acids** while tRNA has.
6. **mRNA** **longer**/larger/more nucleotides than tRNA
7. **Mrna** **different** for **each gene**/many kinds, **only few/**20/64 **kinds of tRNA**;

[Total: 12]

10 Unlike eukaryotes, prokaryotes have different mechanisms for controlling gene expression. Fig. 10.1 shows the Jacob and Monod model of gene expression in the *lac* operon of *Escherichia coli*.

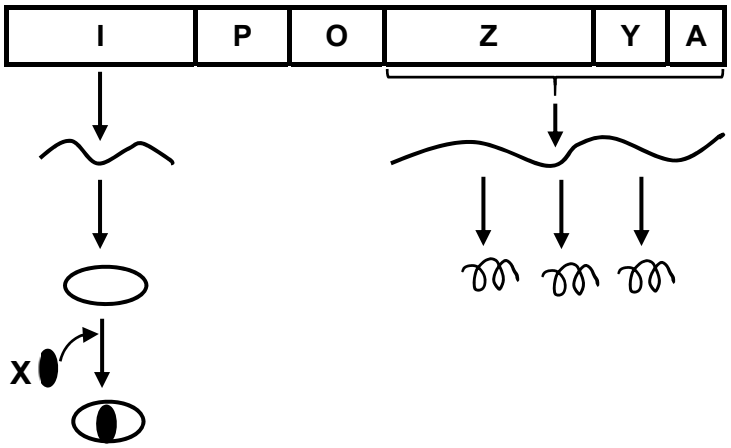


Fig. 10.1

(a) With reference to Fig. 10.1 identify,

(i) identify molecule **X**; [1]
- **allolactose**

(ii) identify region **I**. [1]
- **Regulatory gene / lac I gene / Repressor gene**

The regulation of *lac* operon in *E. coli* was investigated and wild-type *E. coli* were cultured in two different agar media.

X-gal was added to both agar media. It is a colourless substance that is converted to a blue compound by the enzyme, β-galactosidase.

Table 10.1 shows results of the investigation.

Table 10.1

Type of agar medium	Colour of colony
X-gal, lactose and no glucose	blue
X-gal, lactose and glucose	white

(b) Apart from the presence of an inactive *lac* repressor, explain the appearance of the colony when wild-type *E. coli* was cultured in lactose and X-gal without glucose. [3]

1. When glucose is absent, there is an **increase / high concentration** of **cAMP.**
2. **cAMP binds to** the allosteric site on **CAP (catabolite activator protein).**

3. The **CAP in active shape** and **binds to a CAP-binding site** at the upstream end of the *lac* promoter.

4. The **attachment of CAP bends the DNA**, which makes it easier for **RNA polymerase to bind to the promoter**.

5. The *Lac* operon is **transcribed.**

6. **High amount of β-galactosidase** is produced and breaks down the **colourless X-gal to a blue compound**.

In a separate experiment, scientists fused the *trp* operon with the *lac* operon as shown in Fig.10.2.

The *trp-lac* fusion operon was then inserted into a bacterial cell to replace the separate *trp* operon and *lac* operon such that the transformed bacterium only has the *trp-lac* fusion operon.

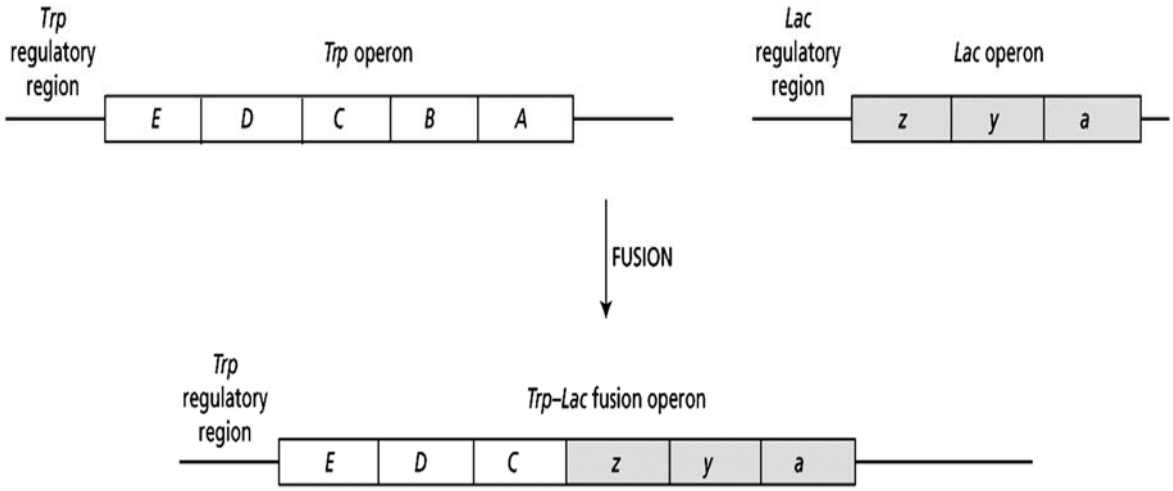


Fig. 10.2

(c) State and explain the conditions which must be present in order for β-galactosidase to be formed in the transformed bacterium with *trp-lac* fusion operon. [3]

1. **Tryptophan** of **very low levels** / **absent** from the medium.

2. ***trp* repressor** remains in the **inactive conformation** and

3. does **not bind** to **operator** and

4. **RNA polymerase** **binds** to **promoter**

5. **Transcription** of **both** ***trp*** **and** ***lac*** **structural** **genes** takes place.

6. Because the fused operon, ***lac* operon** under **control of *trp* regulatory region**.

B. No longer dependent on glucose or lactose levels.
7. Tryptophan must be very low levels / absent from the medium.

8. In the fused operon, the *lac* operon now under the control of the *trp* regulatory region.

9. If corepressor / tryptophan does not bind to the trp repressor,

10. trp repressor remains in the inactive conformation and does not bind to operator and

11. RNA polymerase binds to promoter

12. Transcription of structural genes and translation take place.

no longer dependent on glucose or lactose levels.

[Total: 8]

11 Relationships between different primates can be found by comparing their proteins and DNA.

The proteins of different species can be compared using immunological techniques.

The protein albumin obtained from a human was injected into a rabbit. The rabbit produced antibodies against the human albumin.

These antibodies were extracted from the rabbit and then added to samples of albumin obtained from four different animal species. Precipitation occurs when antibodies bind to albumin. The amount of precipitate produced in each sample was then measured and shown in Table 11.1.

Table 11.1

Species from which albumin was obtained	Amount of precipitate / arbitrary units
Rat	23
Chimpanzee	96
Marmoset	65
Trout	11

(a) Comment on what the results suggest about the evolutionary relationship between humans and the other species? [2]

1. **Human** is **most closely related** to **chimpanzee**, followed by **marmoset, rat** and **least closely related to trout**;
2. **Amount of precipitate formed with chimpanzee is the highest at 96a.u., followed by marmoset (65a.u), than rat (23a.u.)** and lowest is trout at 11a.u.

Scientists also used DNA hybridisation to determine the evolutionary relationships between five species of primate.

The separation temperature is the temperature at which a molecule of double-stranded DNA separates into two single strands.

The scientists first recorded the mean separation temperature of DNA in which both strands were from the same species.

The scientists then recorded the mean decrease in separation temperature of DNA in which one of the strands was from another species. Their results are shown in Table 11.2.

Table 11.2

Primate	Mean decrease in separation temperature / °C				
	Human	Chimpanzee	Gorilla	Orang-utan	Gibbon
Human					
Chimpanzee	1.7				
Gorilla	2.3	2.3			
Orang-utan	3.6	3.6	3.5		
Gibbon	4.8	4.8	4.7	4.9	

(b) When the scientists first recorded the mean separation temperature of DNA in which both strands were from the same species, differences in the separation temperature was observed. Suggest why this is so. [1]

- Individuals within same species have **different alleles** / **different base sequences** / (different) mutations / introns ;

(c) With reference to Table 11.2,

(i) explain if the data suggests that gibbons are most distantly related to humans; [2]

1. **Yes**
2. There is **largest** / highest **decrease** in **separation temperature** of **4.8 °C** compared to the other species
3. This means that there are **fewer complementary bases between** the **DNA strand** from **human** **compared to gibbon**.
4. **Fewer hydrogen bonds present**, **less energy** needed to **separate** the **strands**.

(ii) The scientists assumed that the decreases in separation temperatures are directly proportional to the time since the evolutionary lines of these primates separated.

Gorillas are thought to have separated from orang-utans 20 million years ago. Use this information to calculate how long ago the evolutionary lines of humans and chimpanzees separated.

Show your working. [3]

- **Answer in the range of 9.69 to 9.714286**

Working

- **3.5 °C represents 20 million years**
- **For 1 °C = 20, 000 000 ÷ 3.5 = 5.7 million years or 5,714 286 million years**
- **Humans and chimpanzees would have separated = 1.7 X 5.7 = 9.69 million years [1/2]**

_____ million years

[Total: 8]

TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
JC 2 2018

CANDIDATE NAME										
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H2 BIOLOGY

Paper 3 Long Structured and Free-response Questions

9744/03
Thursday 13 September 2018
2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Section A
Write your name, Centre Number, index number and class in the spaces at the top of the page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
Do not use staples, paper clips, glue or correction fluid.

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

Section B
Answer any **one** question in the spaces provided on the separate 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	
Q1	/14
Q2	/13
Q3	/23
Q4 / 5	/25
Total	/75

This document consists of **21** printed pages and **1** blank page.

Section A

Answer **all** the questions in this section.

1 Scientists investigated three genes, **C**, **D** and **E**, involved in controlling cell division. They studied the effect of mutations in these genes on the risk of developing lung cancer.

The scientists analysed genes **C**, **D** and **E** from healthy people and people with lung cancer.

- If a person had a normal allele for a gene, they used the symbol **N.**
- If a person had two mutant alleles for a gene, they used the symbol **M**.

They used their data to calculate the risk of developing lung cancer for people with different combinations of **N** and **M** alleles of the genes. A risk value of 1.00 indicates no increased risk.

Table 1.1 shows the scientists' results.

Table 1.1

Gene C	Gene D	Gene E	Risk of developing lung cancer
N	N	N	1.00
M	N	N	1.30
N	N	M	1.78
N	M	N	1.45

N = at least one copy of the normal allele is present
M = two copies of the mutant allele are present

(a) Suggest the relative importance of the mutant alleles of genes **C**, **D** and **E** on the risk of developing lung cancer. Explain your answer.

_____

_____

_____

_____

_____

_____ [3]

Chemotherapy is the use of a drugs, such as vinblastine, to treat cancer. The drug kills dividing cells. Fig. 1.1 shows the number of healthy cells and cancer cells in the blood of a patient receiving chemotherapy. The arrows labelled **F** to **I** show when the drug was given to the patient.

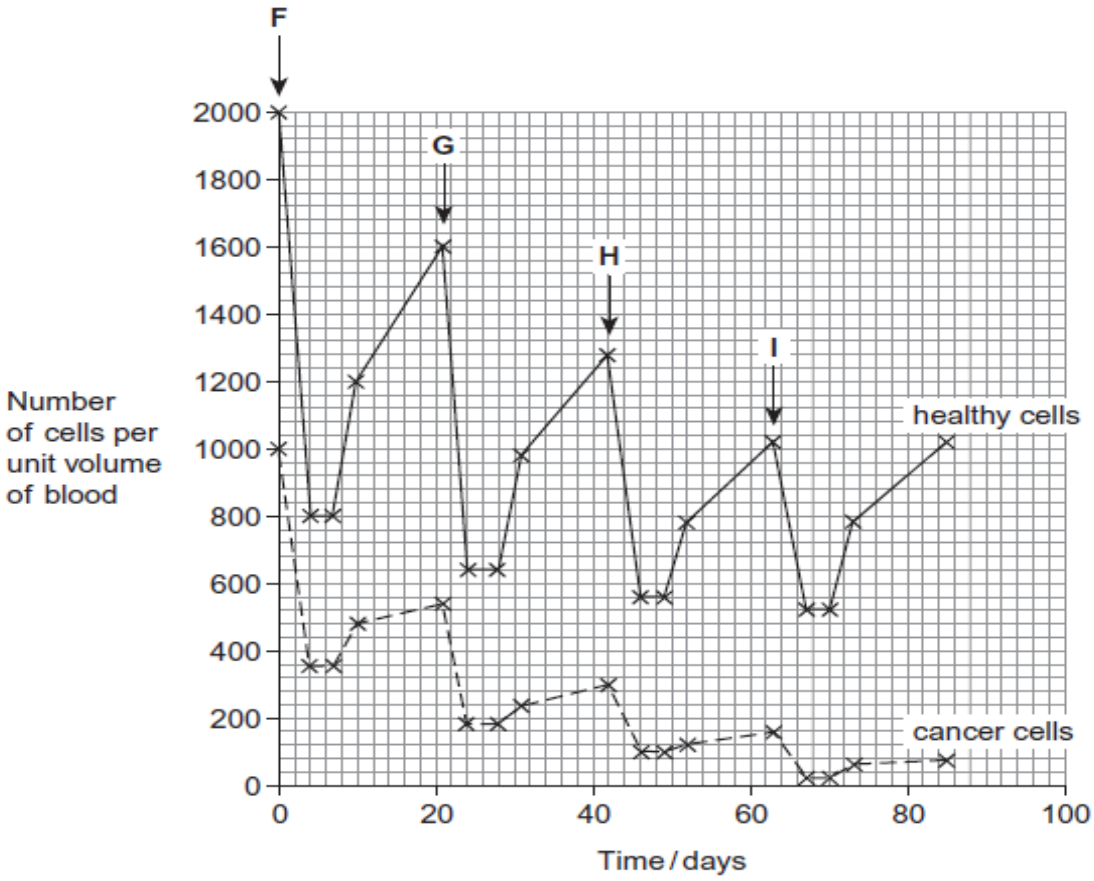

Fig. 1.1

(b) Calculate the rate at which healthy cells were killed between days 42 and 46.

_____ cells killed per unit volume of blood per day

[1]

(c) Describe **two** similarities and **one** difference in the response of healthy cells and cancer cells to the drug between times **F** and **G**.

[3]

(d) More cancer cells could be destroyed if the drug was given more frequently. Suggest why the drug was **not** given more frequently.

[2]

(e) State **two** ways in which cancer cells differ from normal healthy cells.

[2]

Vinblastine disrupts the formation of the spindle apparatus during mitosis.

(f) Explain how vinblastine exerts its effect as an anti-cancer drug.

_____

_____

_____

_____

_____

_____ [3]

[Total: 14]

2 The area over which the Arctic ice sheet extends varies throughout the year. Fig. 2.1 shows the variation in the extent of the Arctic ice sheet for the months of July to November for the years 1979 and 2009.

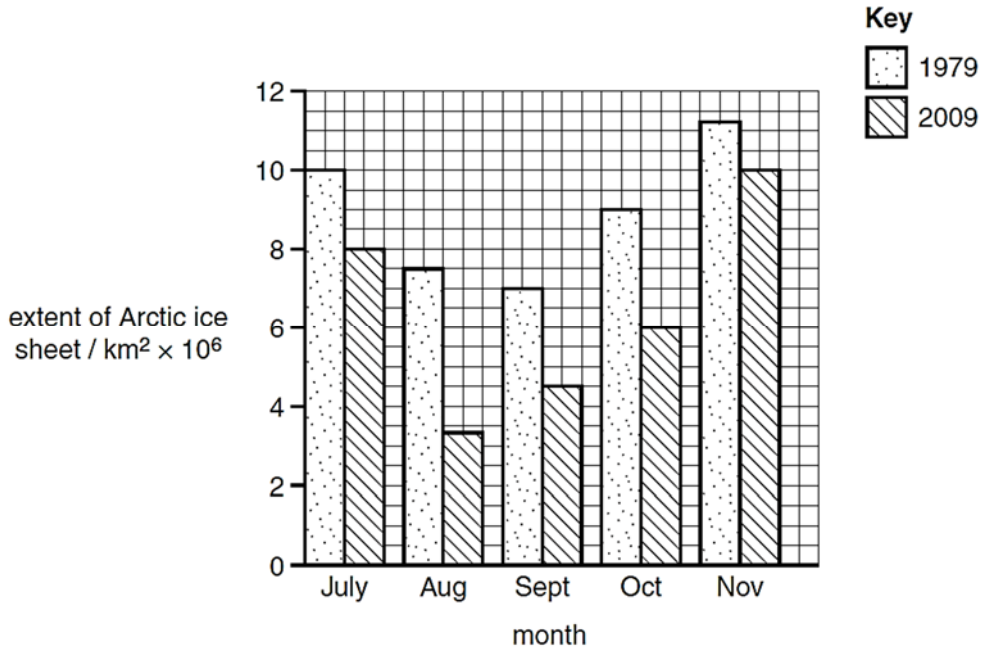

Fig. 2.1

(a) Calculate the percentage reduction in the area over which the ice sheet extends between 1979 and 2009 for the month of September.

[1]

(b) Suggest reasons for the reduction in the Arctic ice sheets from 1979 to 2009.

[2]

(c) The polar bear, *Ursus maritimus*, moves across the Arctic ice sheet to hunt prey such as seals. When seals surface to breathe at cone-shaped breathing holes on the sea ice, a hunting polar bear which is waiting by the breathing hole will smack the head of the seal with both of its front paws to stun it, before biting and dragging the seal onto the ice. This method of still-hunting minimizes energy consumption and is the most successful strategy of hunting.

In 2008 the government of the USA classified *U. maritimus* as an endangered species because it is under the threat of extinction.

Suggest how climate change could have caused *U. maritimus* to become an endangered species.

_____

_____

_____

_____

_____

_____ [2]

Climate change also affects plants.

Plants can be categorized based on the way they photosynthesize. Most plants are C3 plants because their first photosynthetic product is a three carbon compound. Examples of C3 plants include barley, oats, potato, rice, and wheat commonly grown in temperate regions.

On the other hand, C4 plants produce a four-carbon compound as their first photosynthetic product. Examples of C4 plants are common grass crops of tropical regions, such as maize, millet, sorghum and sugarcane.

The rate of carbon dioxide uptake at a range of carbon dioxide concentrations by barley, a C3 plant, and sugar cane, a C4 plant, were compared at two temperatures.

The results of the experiment are presented in Fig. 2.2.

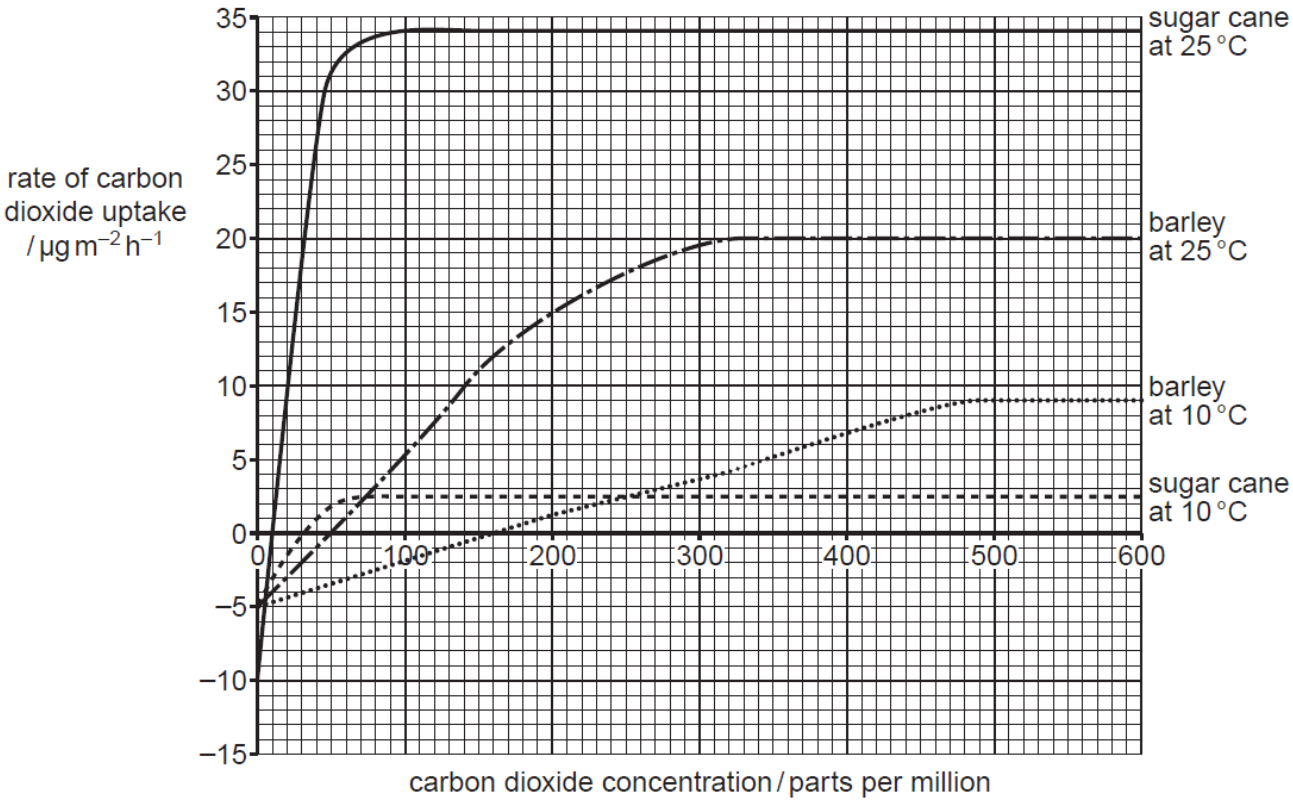

Fig. 2.2

The current carbon dioxide concentration in the atmosphere is more than 400 parts per million and it is likely to increase in the future. It is widely believed that the carbon dioxide concentration of the atmosphere affects the global mean surface temperature which in turn changes rainfall patterns.

Table 2.1 shows other data regarding three C3 and three C4 plants which are important crops.

Table 2.1

crop	mass of water absorbed per gram dry mass produced/ g
rice	682
potato	575
wheat	542
maize	350
millet	285
sorghum	204

With reference to Fig. 2.2 and Table 2.1,

(d) discuss the likely impact of the predicted changes in carbon dioxide concentration, global temperatures and rainfall patterns on the global distribution of C3 and C4 plants.

[4]

Climate change potentially affects the spread of diseases. Fig. 2.3 shows the worldwide distribution of dengue.

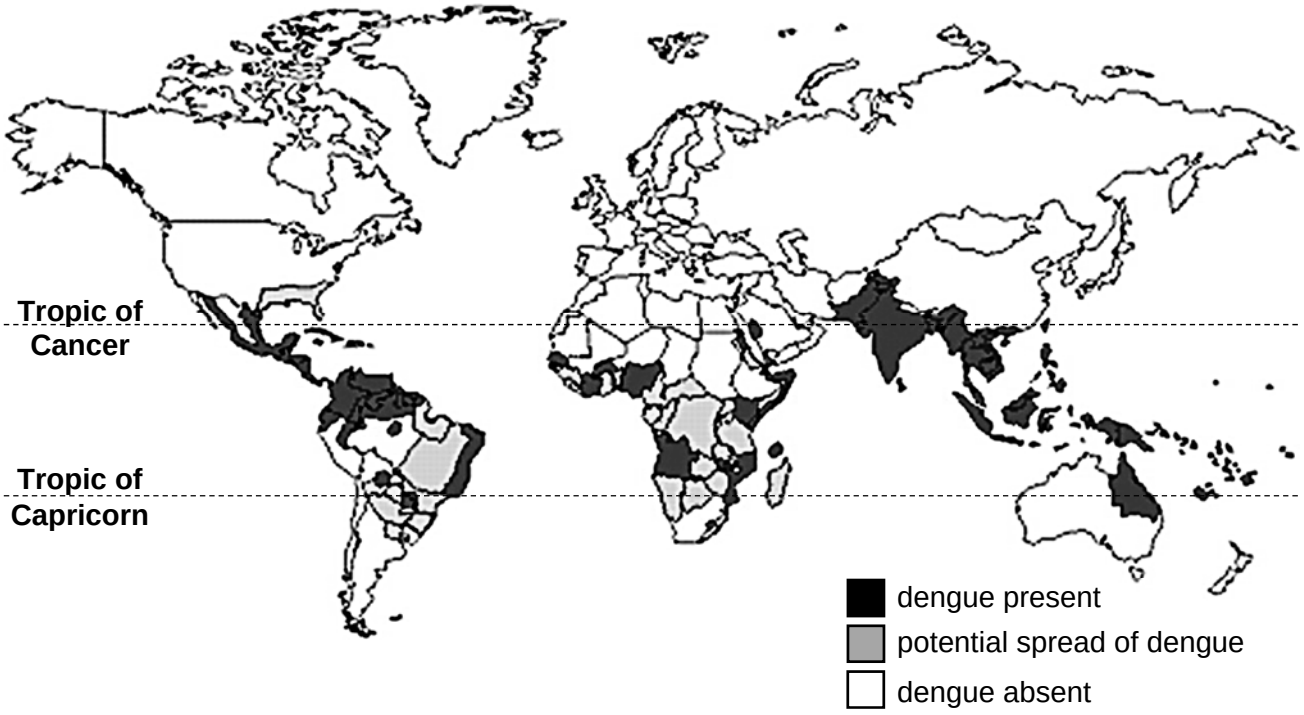

Fig. 2.3

(e) Describe how dengue is transmitted.

_____

_____

_____

_____ [2]

Unlike dengue, influenza is found across the whole world.

(f) Explain why dengue shows the distribution pattern shown in Fig. 2.3, but influenza is found everywhere.

_____

_____

_____

_____ [2]

[Total: 13]

3 Hepatitis is the inflammation of the liver and can be caused by a number of different hepatitis viruses. Presently, the only effective vaccines available are for hepatitis A and B.

(a) Outline the immune response that leads to the production of antibodies after vaccination.

_____

_____

_____

_____

_____

_____

_____

_____ [3]

(b) Describe how plasma cells produce and release antibodies.

[5]

Scientists observed that liver cells damaged by hepatitis infection switch on a gene known as the *Fas* gene, which caused infected liver cells to self-destruct.

This finding has led to pioneering research which produced a successful treatment for hepatitis in mice. The *Fas* gene was silenced using the technique of RNA interference.

This involved injecting mice infected with hepatitis with RNA molecules of 21 to 23 nucleotides in length. The sequence of this small interfering RNA (siRNA) matched part of the *Fas* gene. Once in the liver cell the two strands of the siRNA are separated so that one strand binds to the mRNA transcript of the *Fas* gene.

This caused the mRNA to be destroyed by enzymes, therefore preventing the gene product from being made. This therapy prevented liver cell death and considerably increased the survival of mice with hepatitis.

(c) **(i)** Describe **one** way in which the function of mRNA differs from that of DNA.

[1]

(ii) Suggest **one** way in which the structure of siRNA differs from mRNA.

[1]

(d) Describe how one strand of the siRNA can bind to the mRNA of the *Fas* gene.

_____

_____

_____

_____ [2]

The technique of RNA interference has also been used to slow down replication of HIV (Human Immunodeficiency Virus) *in vitro*. This is an important breakthrough in the treatment of AIDS as many countries are hit by the epidemic.

The siRNA is attached to a carrier molecule which binds to HIV protein on the plasma membrane of infected cell. This allows carrier with siRNA to enter human cell.

siRNA sequences that match the RNA genome of HIV can be used to trigger destruction of this RNA, preventing HIV from multiplying.

(e) The siRNA would **only** affect gene expression in cells infected with HIV. Suggest **one** reason why.

_____

_____

_____ [1]

Another approach is to use RNA interference to silence genes for cell surface receptors, such as the CD4 and CCR5 molecules on human white blood cells.

If these genes are not expressed, HIV cannot bind to and infect the white blood cells. Table 3.1 summarizes some information regarding the two cell surface receptors used by HIV to bind to and infect white blood cells.

Table 3.1

	cell surface receptor	
	CD4	**CCR5**
Type of cell with this receptor	T lymphocyte white blood cells which divide by mitosis	Macrophage cells which are long-lived and do not undergo mitosis

Experiments have been carried out where,

- siRNAs matching the CD4 mRNA were introduced into test tube populations of T lymphocytes;
- siRNAs matching the CCR5 mRNA were introduced into test tube populations of macrophages.

In both cases HIV was present and the presence of the siRNAs reduced its replication.

(f) Using Table 3.1, suggest with reasons which of the two test tube experiments would have a greater reduction in HIV replication.

_____

_____

_____

_____ [2]

Antibiotics are prescribed to people who have HIV/AIDS for the treatment of secondary infections such as bacterial infections.

(g) Describe the mode of action of antibiotics, such as penicillin, on bacteria.

_____

_____

_____

_____

_____

_____ [3]

(h) Explain why antibiotics are prescribed to treat secondary infections, but not HIV infection.

_____

_____

_____

_____ [2]

Antibiotic resistance could develop and the genes for antibiotic resistance could be transmitted between bacteria. Table 3.2 shows features of gene transmission.

Table 3.2

Statement	**Vertical**	**Horizontal**
Gene is replicated		
Gene can be passed to other species of bacteria		
Involves conjugation		

(i) Complete Table 3.2 by putting a tick in the box if the statement is correct for vertical or horizontal gene transmission. [1]

Apart from the devastating effects of HIV, in 2014, parts of West Africa were hit by an epidemic of Ebola fever. Most people who caught the disease died.

Scientist attempted to genetically synthesize an antibiotic as a possible drug to target the Ebola glycoprotein.

This drug was **only** used to treat two Americans who had been working as medics in Africa. Its use was controversial because the drug had not been tested on humans. At the time there were only a few doses of the drug available.

(j) **(i)** Suggest a reason why the decision was made to use the drug, even though it had not been tested.

_____

_____ [1]

(ii) Apart from the fact that drug had not been fully tested, give **one** reason why using the drug in the way described could be considered as unethical.

_____

_____ [1]

End of Part 2 [Total: 23]

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Section B

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

EITHER

4 **(a)** Describe the causes of variation and its biological importance and how variations are preserved in a population. [10]

(b) Justify the claim that all living organisms on Earth depend on phosphate. [15]

[Total: 25]

OR

5 **(a)** Biological specificity is one of the most widespread and characteristic properties of living organisms.

Biological specificity is most pronounced and best understood at the cellular and molecular levels of organization. Using named examples, explain the importance of shapes fitting together in cells and organisms. [13]

(b) Describe the effects of different types of mutations on the proteins of eukaryotes. [12]

[Total: 25]

TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
JC 2 2018

CANDIDATE NAME										
CENTRE NUMBER	S					INDEX NUMBER				
CLASS	C	G			/	1	7			

H2 BIOLOGY

Paper 3 Long Structured and Free-response Questions

9744/03
Thursday 13 September 2018
2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

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They used their data to calculate the risk of developing lung cancer for people with different combinations of **N** and **M** alleles of the genes. A risk value of 1.00 indicates no increased risk.

Table 1.1 shows the scientists' results.

Table 1.1

Gene C	Gene D	Gene E	Risk of developing lung cancer
N	N	N	1.00
M	N	N	1.30
N	N	M	1.78
N	M	N	1.45

N = at least one copy of the normal allele is present
M = two copies of the mutant allele are present

(a) Suggest the relative importance of the mutant alleles of genes **C**, **D** and **E** on the risk of developing lung cancer. Explain your answer. [3]

1. **Two copies of mutant allele E produces the highest risk of 1.78 [1]**
2. **While two copies of mutant allele D produces the second highest risk / second lowest of 1.45 [1]**
3. **Two copies of mutant allele C produces the lowest risk of 1.30 [1]**

Chemotherapy is the use of a drugs, such as vinblastine, to treat cancer. The drug kills dividing cells. Fig. 1.1 shows the number of healthy cells and cancer cells in the blood of a patient receiving chemotherapy. The arrows labelled **F** to **I** show when the drug was given to the patient.

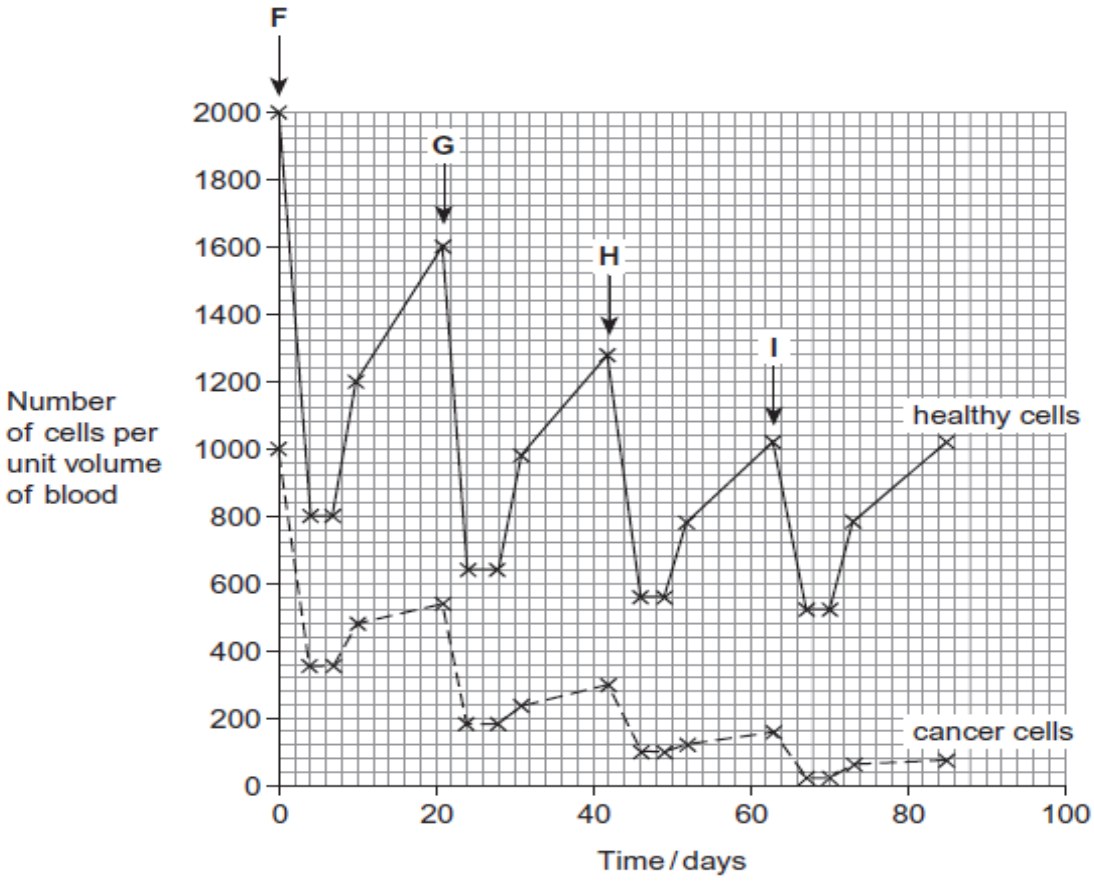


Fig. 1.1

(b) Calculate the rate at which healthy cells were killed between days 42 and 46.

1280 – 560 = 720
720 ÷ 4 = 180

180 cells killed per unit volume of blood per day

[1]

(c) Describe **two** similarities and **one** difference in the response of healthy cells and cancer cells to the drug between times **F** and **G**. [3]

Similarities:
Any two

1. **Both show a steep decrease in number of cells per unit volume from day 0 to 4.**
2. **For both, number of cells per unit volume remained constant from day 4 to 7.**
3. **Both show a steep increase in number of cells per unit volume from day 7 to 21.**
4. **Both show and overall net decrease [QF] in the number of cells per unit volume at time point G**
5. **Both have similar pattern of decrease, remain the same and then increase**

   OR

   Both showed a fluctuation of decrease, remaining the same and then increasing

Differences:

6. **There is greater decrease in number of healthy cells / more healthy cells were killed than cancer cells after the drug is given [QF].**
7. **There is greater increase in number of healthy cells during recovery period / more healthy cells are replaced during recovery period than cancer cells [QF].**

(d) More cancer cells could be destroyed if the drug was given more frequently. Suggest why the drug was **not** given more frequently. [2]

1. **Too many healthy cells are killed after each dose of drugs**
   OR
   It takes time to replace the number of healthy cells

2. **The person may die**
   OR
   have severe side effects if the drug was given more frequently / become immunocompromised

(e) State **two** ways in which cancer cells differ from normal healthy cells. [2]

Point of comparison	Cancer cell	Normal healthy cell
1. Apoptosis	Does not experience apoptosis	Undergoes apoptosis
2. Cell division	Uncontrolled	Controlled with various checkpoints.
3. Contact inhibition	Not affected	Affected.
4. Specialized cell	do not become specialized, but remain immature.	Able to differentiate into specialized cells.
5. Able to stimulate angiogenesis	yes	no
6. Able to metastasize	yes	no
7. Telomerase gene	expressed	Not expressed

Vinblastine disrupts the formation of the spindle apparatus during mitosis.

(f) Explain how vinblastine exerts its effect as an anti-cancer drug. [3]

1. **Cancer cells** carry out **mitosis repeatedly / uncontrolled cell division**

During mitosis (role of spindle fibres):

2. **Spindle fibres cannot attach to the kinetochore of the centromere of the chromosome.**

3. **Spindle fibres cannot align chromosomes at the equator of cell during metaphase**

4. **Spindle fibres cannot separate sister chromatids at the equator during anaphase**

5. The **disruption** of **spindle fibres formation** means that **metaphase** and **anaphase cannot take place**.

6. **Mitosis stops** and the **cancer cells stop dividing**, some cells **undergo apoptosis**.

[Total: 14]

2 The area over which the Arctic ice sheet extends varies throughout the year. Fig. 2.1 shows the variation in the extent of the Arctic ice sheet for the months of July to November for the years 1979 and 2009.

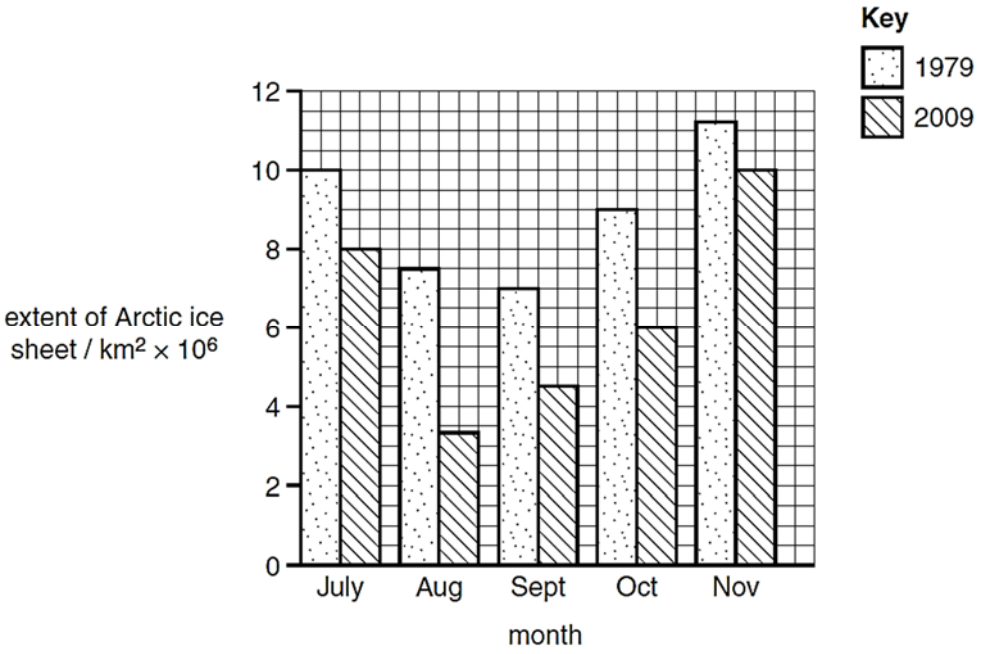


Fig. 2.1

(a) Calculate the percentage reduction in the area over which the ice sheet extends between 1979 and 2009 for the month of September. [1]

$$\textbf{Percentage reduction} = \frac{(4.5\times10^6 - 7\times10^6)}{7} \times 100\% = 35.7\%$$

(b) Suggest reasons for the reduction in the Arctic ice sheets from 1979 to 2009. [2]

Climate Change Part I Lecture Notes p.17

1. **Increased rate of deforestation / clearing of forest / reduction of carbon sink [1]**
2. **Increased burning of fossil fuels / energy consumption for homes, industries or transport [1]**
3. **Increased rearing of livestock [1]**

4. **Increase in concentration of greenhouses gases (carbon dioxide, methane) in the atmosphere results in more heat trapped, hence resulting in an increase in air, land and/ or sea temperature, leading to the melting of Arctic ice sheets / decrease in snowfall / ice sheets forms slower. [1]**

(c) The polar bear, *Ursus maritimus*, moves across the Arctic ice sheet to hunt prey such as seals. When seals surface to breathe at cone-shaped breathing holes on the sea ice, a hunting polar bear which is waiting by the breathing hole will smack the head of the seal with both of its front paws to stun it, before biting and dragging the seal onto the ice. This method of still-hunting minimizes energy consumption and is the most successful strategy of hunting.

In 2008 the government of the USA classified *U. maritimus* as an endangered species because it is under the threat of extinction.

Suggest how climate change could have caused *U. maritimus* to become an endangered species. [2]

1. **Global warming in the Arctic resulted in melting sea ice**
2. **and reduction in extent of ice sheets / loss of habitat for both seals and polar bears.**

3. **It also leads to more [i.e. initial stage] / less or bigger breathing holes [i.e. later stages when the ice melts and the breathing holes fuse]**
   OR
   The seals migrate to other cooler places / no longer breathe at breathing holes,

4. **therefore the polar bears are unable to still-hunt seals (only source of food) / use other hunting strategies that increases energy consumption, hence they starve and die.**

Climate change also affects plants.

Plants can be categorized based on the way they photosynthesize. Most plants are C3 plants because their first photosynthetic product is a three carbon compound. Examples of C3 plants include barley, oats, potato, rice, and wheat commonly grown in temperate regions.

On the other hand, C4 plants produce a four-carbon compound as their first photosynthetic product. Examples of C4 plants are common grass crops of tropical regions, such as maize, millet, sorghum and sugarcane.

The rate of carbon dioxide uptake at a range of carbon dioxide concentrations by barley, a C3 plant, and sugar cane, a C4 plant, were compared at two temperatures.

The results of the experiment are presented in Fig. 2.2.

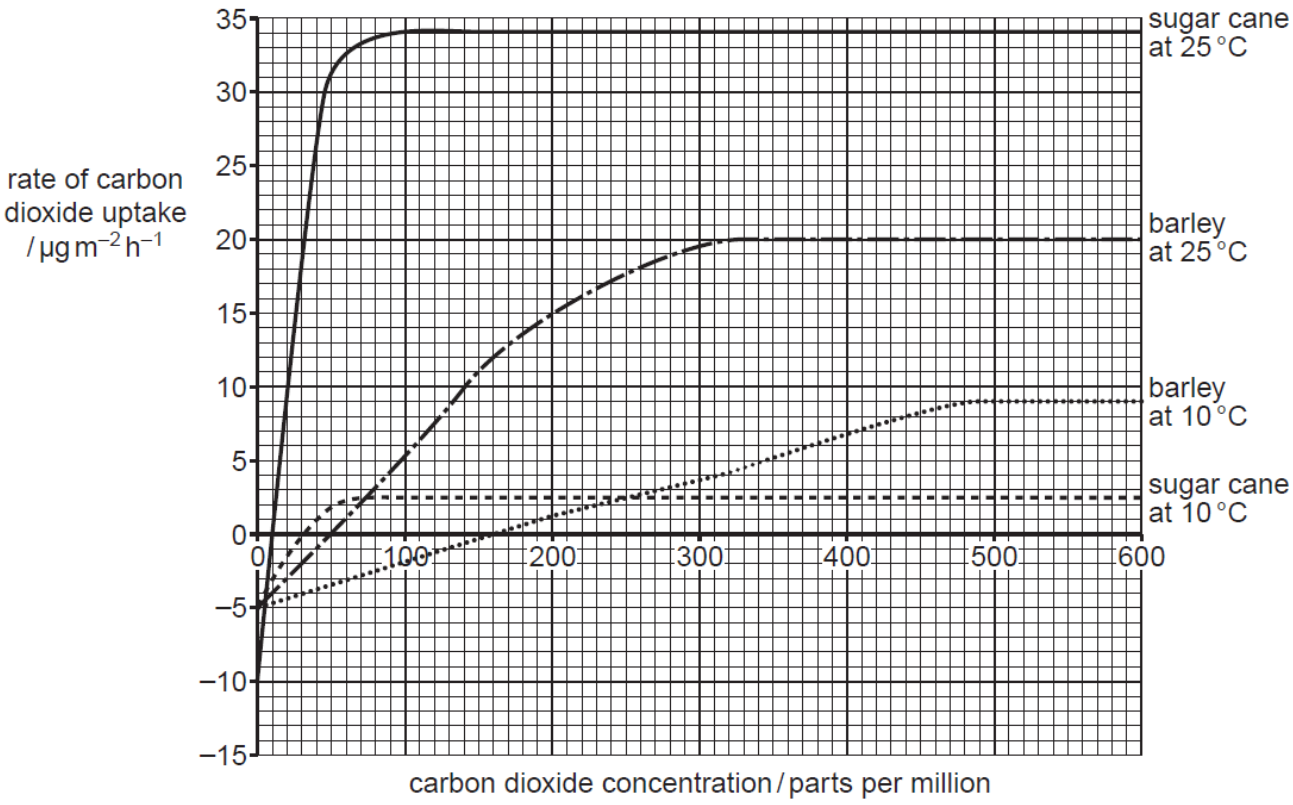


Fig. 2.2

The current carbon dioxide concentration in the atmosphere is more than 400 parts per million and it is likely to increase in the future. It is widely believed that the carbon dioxide concentration of the atmosphere affects the global mean surface temperature which in turn changes rainfall patterns.

Table 2.1 shows other data regarding three C3 and three C4 plants which are important crops.

Table 2.1

crop	mass of water absorbed per gram dry mass produced/ g
rice	682
potato	575
wheat	542
maize	350
millet	285
sorghum	204

With reference to Fig. 2.2 and Table 2.1,

(d) discuss the likely impact of the predicted changes in carbon dioxide concentration, global temperatures and rainfall patterns on the global distribution of C3 and C4 plants. [4]

1. **Increased in carbon dioxide concentration will likely increase temperature.**

2. **At high carbon dioxide concentration of 500 parts per million and high temperature of 25°C, the rate of photosynthesis for C4 plants / sugar cane at 34 $\mu gm^{-2}h^{-1}$ is HIGHER than that of C3 plants/ barley at 20 $\mu gm^{-2}h^{-1}$. [1]**
   [Accept: Maximum rate of photosynthesis. Reject: Peak]
   [Accept: Any high value of carbon dioxide concentration more than 400 ppm]

3. **Hence, both plants will grow well, but C4 plants are better adapted than C3 plants in hotter areas and their population will likely increase/ OWTTE.**
   [Accept: Reference to latitude (tropical / temperate) or altitude]

4. **Increased temperatures may result in lower rainfall in some places.**
   [Accept: Higher rainfall]
5. **C4 plants absorb between 204 to 350g of water which is LESS than C3 plants between 542 and 682g. [1]**
6. **Hence, C4 plants are better adapted than C3 plants in drier areas and their population will likely increase / OWTTE.**
   [Accept: Higher rainfall, C3 plants will grow better OR both plants will grow well]

7. **[Additional] However, predicted change in temperature over the next century is only small, therefore it may not make a lot of difference.**

Climate change potentially affects the spread of diseases. Fig. 2.3 shows the worldwide distribution of dengue.

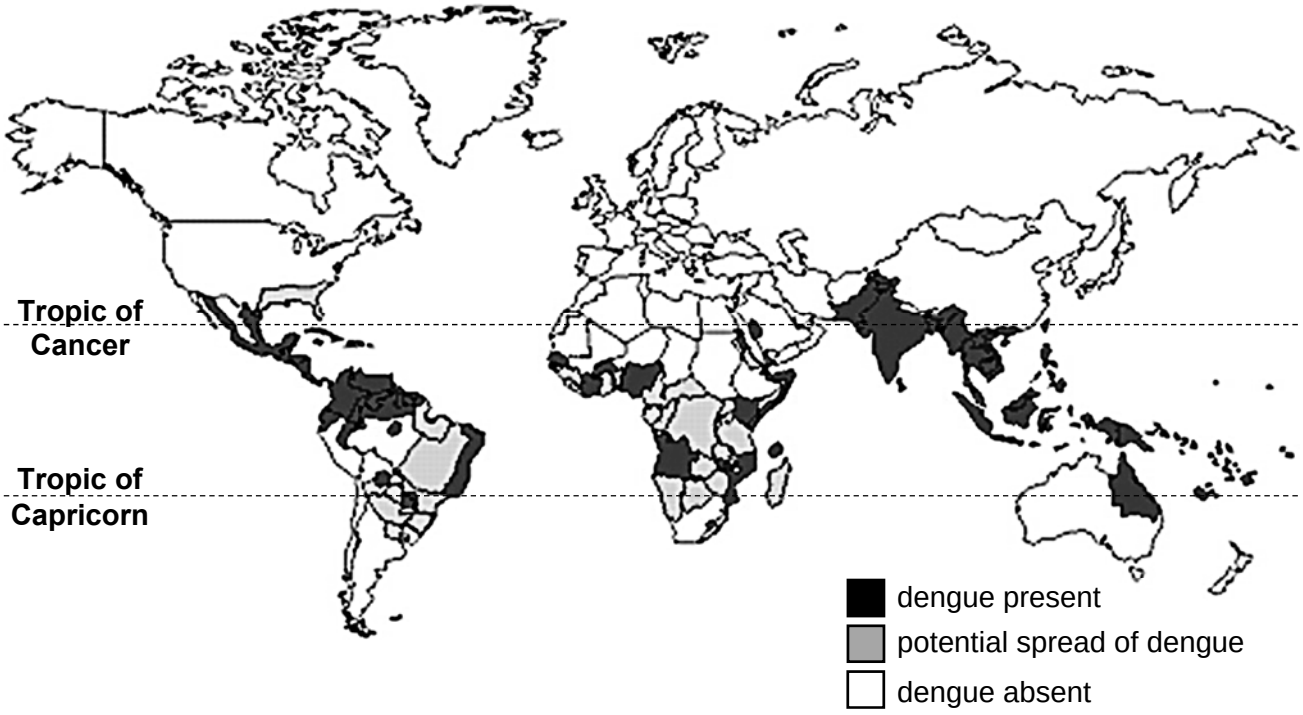


Fig. 2.3

(e) Describe how dengue is transmitted. [2]

1. **FEMALE**
2. ***Aedes* mosquito**
   [Reject: virus or bacteria]

3. **takes a blood meal from an infected person, and bites/ feeds on an uninfected person/ OWTTE. [1]**

4. **Dengue virus is transmitted in mosquito's saliva.**

Unlike dengue, influenza is found across the whole world.

(f) Explain why dengue shows the distribution pattern shown in Fig. 2.3, but influenza is found everywhere. [2]

1. **Dengue is vector-borne disease (i.e. caused by dengue virus and transmits / reproduces within *Aedes* mosquito)**
2. **which lives within the Tropics of Cancer and Capricorn [1]**
   OR hot and humid areas (at temperatures above 20°C) at a favourable temperature range for breeding / reproduction of mosquitoes,

3. **whereas influenza is air-borne disease / transmitted by respiratory droplets/ coughing/ sneezing,**
4. **and it is not limited by the range of the vector (i.e. hot and humid conditions) to be transmitted / spread to other parts of the world by infected travelers.**

5. **[Additional] Mosquitoes are prevalent in tropical region due to poor / non-existent mosquito control programmes/ OWTTE.**
6. **[Additional] Mosquitoes may also be resistant to insecticides.**

[Total: 13]

3 Hepatitis is the inflammation of the liver and can be caused by a number of different hepatitis viruses. Presently, the only effective vaccines available are for hepatitis A and B.

(a) Outline the immune response that leads to the production of antibodies after vaccination. [3]

1. Vaccination trigger active immunity / active immune response
2. Vaccine contains hepatitis antigen / hepatitis pathogen / virus;
3. Antigen presenting cells / macrophage present antigen to specific naive CD4 T cells and naive B cells
4. Helper T cells secrete cytokines
   Many students did not include this point.
5. Specific B cells activated to proliferate and differentiate into plasma cells and memory B cells.
6. Plasma B cells produce antibodies

(b) Describe how plasma cells produce and release antibodies. [5]

1. **Transcription** of **light** and **heavy chain gene** / **antibody gene** produces mRNA
2. **Pre-mRNA processing** take place.
3. **Ribosomes on rER translate mRNA**
4. **Anticodon** of **tRNA** **base pair** with **codons** on **mRNA** and bring **amino acids** / **ensure amino acids join in correct sequence.**
5. **Heavy** and **light chains** of **antibodies move** into **rER lumen**.
   [to award if student mention heavy and light chains later]
6. These are **enclosed** in **ER**/ transport **vesicle** which **pinch** / bud **off** from **ER**
7. **to** **cis face** of **Golgi apparatus** (GA).
8. **GA** **chemically modifies**, **sorts** and **transports** antibodies.
9. Heavy and light chains are **joined** by **disulfide** bonds and **glycosylated** as they move through the GA
10. The **secretory vesicle** **buds off** from **trans-face** of **GA**, **travels along microtubules** of **cytoskeleton**,
11. **fuse with** the **plasma membrane**. Thus, **releasing** the **antibodies** out of the cell via **exocytosis**.

Scientists observed that liver cells damaged by hepatitis infection switch on a gene known as the *Fas* gene, which caused infected liver cells to self-destruct.

This finding has led to pioneering research which produced a successful treatment for hepatitis in mice. The *Fas* gene was silenced using the technique of RNA interference.

This involved injecting mice infected with hepatitis with RNA molecules of 21 to 23 nucleotides in length. The sequence of this small interfering RNA (siRNA) matched part of the *Fas* gene. Once in the liver cell the two strands of the siRNA are separated so that one strand binds to the mRNA transcript of the *Fas* gene.

This caused the mRNA to be destroyed by enzymes, therefore preventing the gene product from being made. This therapy prevented liver cell death and considerably increased the survival of mice with hepatitis.

(c) **(i)** Describe **one** way in which the function of mRNA differs from that of DNA. [1]

1. mRNA is translated / used to synthesize protein while DNA is transcribed / used to synthesize mRNA;
   OR
   mRNA is used to synthesize protein while DNA is for the storage of genetic information

OR

2. mRNA contain short-term genetic information while DNA contain long term genetic information

(ii) Suggest **one** way in which the structure of siRNA differs from mRNA. [1]

1. siRNA has fewer nucleotides than mRNA / only matches part of gene.
   OR
2. siRNA double-stranded while mRNA is single-stranded

(d) Describe how one strand of the siRNA can bind to the mRNA of the *Fas* gene. [2]

1. Via complementary base-pairing between purines and pyrimidines; [1]
2. Adenine with uracil with 2 hydrogen bonds and;
3. cytosine with guanine with 3 hydrogen bonds

The technique of RNA interference has also been used to slow down replication of HIV (Human Immunodeficiency Virus) *in vitro*. This is an important breakthrough in the treatment of AIDS as many countries are hit by the epidemic.

The siRNA is attached to a carrier molecule which binds to HIV protein on the plasma membrane of infected cell. This allows carrier with siRNA to enter human cell.

siRNA sequences that match the RNA genome of HIV can be used to trigger destruction of this RNA, preventing HIV from multiplying.

(e) The siRNA would **only** affect gene expression in cells infected with HIV. Suggest **one** reason why. [1]

1. Only infected cells have HIV protein on surface;
2. So carrier only attaches to/specific to these cells/siRNA can only enter these cells
   OR
3. Only infected cells contain RNA of HIV
4. Base sequence of siRNA is only complementary to the HIV RNA to destroy it.

Another approach is to use RNA interference to silence genes for cell surface receptors, such as the CD4 and CCR5 molecules on human white blood cells.

If these genes are not expressed, HIV cannot bind to and infect the white blood cells. Table 3.1 summarizes some information regarding the two cell surface receptors used by HIV to bind to and infect white blood cells.

Table 3.1

	cell surface receptor	
	CD4	**CCR5**
Type of cell with this receptor	T lymphocyte white blood cells which divide by mitosis	Macrophage cells which are long-lived and do not undergo mitosis

Experiments have been carried out where,

- siRNAs matching the CD4 mRNA were introduced into test tube populations of T lymphocytes;

- siRNAs matching the CCR5 mRNA were introduced into test tube populations of macrophages.

In both cases HIV was present and the presence of the siRNAs reduced its replication.

(f) Using Table 3.1, suggest with reasons which of the two test tube experiments would have a greater reduction in HIV replication. [2]

Test tube containing CCR5 / macrophages

1. **only one treatment needed** for **macrophages / CCR5**;
2. because **siRNAs** has **longer effects** in **long-lived cells**;

3. whereas **siRNAs** diluted / **fewer per cell** when **lymphocytes divide**;
4. **repeat treatments needed** for lymphocytes / CD4;

Antibiotics are prescribed to people who have HIV/AIDS for the treatment of secondary infections such as bacterial infections.

(g) Describe the mode of action of antibiotics, such as penicillin, on bacteria. [3]

1. Penicillin binds irreversibly / inhibits to transpeptidase
2. thus inhibiting the cross-linking of two peptidoglycan chains.
3. Penicillin also stimulates the release of autolysins
4. and make small pores in the existing cell wall.
5. The cell wall of dividing bacterium weakens
6. Osmotic lysis occurs
   Reject : autolysis

(h) Explain why antibiotics are prescribed to treat secondary infections, but not HIV infection. [2]

1. People with HIV are very susceptible to bacterial infections due to weakened immune system

2. Antibiotics are only effective against bacteria
   Reject: microbes or micro-organisms instead of stating bacteria
   OR
3. Antibiotics not effective against viruses,
   Reject: this is only accepted if point four is present
   Reject: antibiotics prevent infection
   Reject: if did answer did not include “virus”

4. Viruses do not have cell walls, ribosomes or cell membranes that antibiotic work on
   Note: must state specific organelles.
   Reject: vague mention of cell machinery or virus is non-cellular.
   OR
5. viruses are within cells, idea that antibiotics cannot reach them.

Antibiotic resistance could develop and the genes for antibiotic resistance could be transmitted between bacteria. Table 3.2 shows features of gene transmission.

Table 3.2

Statement	Vertical	Horizontal
Gene is replicated	✓	✓
Gene can be passed to other species of bacteria		✓
Involves conjugation		✓

(i) Complete Table 3.2 by putting a tick in the box if the statement is correct for vertical or horizontal gene transmission. [1]

Apart from the devastating effects of HIV, in 2014, parts of West Africa were hit by an epidemic of Ebola fever. Most people who caught the disease died.

Scientist attempted to genetically synthesize an antibiotic as a possible drug to target the Ebola glycoprotein.

This drug was **only** used to treat two Americans who had been working as medics in Africa. Its use was controversial because the drug had not been tested on humans. At the time there were only a few doses of the drug available.

(j) **(i)** Suggest a reason why the decision was made to use the drug, even though it had not been tested. [1]

- The **Ebola infected individual** would have **died anyway**;

(ii) Apart from the fact that drug had not been fully tested, give **one** reason why using the drug in the way described could be considered as unethical. [1]

- The Americans had no more right to treatment than the Africans/owtte;

[Total: 23]

Section B

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

EITHER

(a) Describe the causes of variation and its biological importance and how variations are preserved in a population. [10]

CAUSES OF VARIATION		
A. Effects of Mutation [MAX : 2 marks]		**Remarks**
A1	▪ **Gene mutation** is **change** in **sequence** of **nucleotides** ▪ E.g. addition / substitution / deletion	▪ Reject: change in sequence of genes
A2	**Give** **rise** to **new** **alleles** [ONLY WAY]	▪ Note: Evolution does NOT give rise to new alleles. ▪ Reject: new genes are formed. ▪ Do NOT confuse genes and alleles
A3	**Effect** on **dominant allele** verses recessive alleles → giving rise to **different genotypes** and **phenotypes**	
A4	**Effect** of **mutation** **on polypeptide** / protein → change shape / change function	▪ Reject focus on non-functional protein
A5	**Chromosome** **mutation** - **change** in **number** and **structure** of **chromosomes**	
A6	**Multiple alleles** → many **different genotypes** possible	
B. Effects of meiosis [MAX : 2 marks]		
B1	**Crossing over** **between homologous chromosomes** during **prophase I**	▪ Many students wrote "crossing over between non-sister chromatids" ▪
B2	**Independent arrangement** and **separation** of **homologous chromosomes** at **metaphase I** and **anaphase I** **respectively**	▪ Reject: if left out "respectively"
B3	**Independent arrangement** of **chromosomes** at **metaphase II** and **separation of chromatids** at **anaphase II**	▪ Reject if students combine the metaphase and anaphase events – referring only to chromatids or chromosomes ▪ Reject if students combine metaphase I and metaphase II; then anaphase I and anaphase II
B4	**Random** **fusion** of **gametes**	▪ Do NOT confuse random fusion of gametes with random mating.
B5	**Give** **rise** to **new combinations of alleles**	▪ This must be written at least once.
C. Effects of Environment [MAX : 1 mark]		
C1	**Affects** **traits** showing **continuous variation**	
C2	**Presence** or **absence** of **nutrients** – affect animals	

C3	**Presence** of **Disease** – affects both plants and animals	
C4	**Light** – affects **plants** [amount of chlorophyll, thickness of leaves] **More light** – **more chlorophyll** needed to absorb UV rays More light – **leaf** can be **thicker**. Spongy mesophyll cells can still absorb sufficient light energy.	
C5	**Temperature** 5a. affects **animals** e.g. length of hair; colouration 5b. affects **plants** e.g. needle shape leaves to reduce water loss	
C6	Presence of **harmful chemicals** → cause mutations / diseases	
D. BIOLOGICAL IMPORTANCE OF VARIATION [MAX : 2 marks]		
D1	Variation **enables adaptation** – some are better adapted because of new alleles with new phenotypes	▪ Genetic variation does not ensure individuals are well adapted.
D2	Natural selection - **Variation within a population** is an **essential** pre-condition **for** evolution through **natural selection.**	▪ Selection pressure does not cause different species to have different alleles
D3	Natural Selection **selects existing favorable phenotype / selective advantage survive → reproduce → pass allele to offspring**	▪ Evolution does not give rise to new alleles / genes
D4	**Speciation** – when **geographical isolation** exists, new species formed over a **long period of time** with	
E. PRESERVING VARIATION [MAX : 3 marks]		
Relating to Diploidy:		
E1	**Diploid organisms** carries a **large amount** of **variation** in the form of **recessive alleles** in **heterozygotes**.	
E2	This **maintains genetic variation** in the form of **hidden recessive alleles** in **heterozygotes** / **Heterozygotes** maintain a **huge pool of alleles** that may not be suited for present conditions but could bring new benefits when the environment changes.	Awarded only if point 3 is written
E3	The **rarer** the **recessive allele**, the **greater** the **degree** of **protection** from natural selection /	
Relating to Heterozygote advantage:		
E4	Individuals who are **heterozygous** at a particular locus have **greater ability to survive** and **greater reproductive success than** any **homozygous** types.	Many students are not able to provide proper explanations
E5	This **maintains two or more alleles** at that locus by natural selection.	
E6	E.g. The **heterozygote** (HbAHbS) is **better able to survive than** either of the two **homozygotes** in the **presence of malaria**.	
Relating to Frequency Dependent Selection:		
E7	**Frequency-dependent selection** - type of **balancing selection** that **maintains two different phenotypic forms** in a population.	

E8	The **selective advantage** of a **phenotype decreases** when it **becomes too common**.	
E9	Provide a brief description of Batesian mimicry or Predator-prey interactions	
Relating to Neutral Variation		
E10	**Neutral variation** – provides a source of variation which can be of selective advantage when environment change	
[MAX : 1 mark each]		
F.	**GENETICALLY MODIFIED ORGANISMS** - new genes leads to new combinations of phenotypes in genetically modified organism	▪ Evolution does not give rise to new alleles / genes
G.	**FOUNDER'S EFFECT / BOTTLENECK EFFECT** - allele frequency change due to chance event - alleles are loss	
H.	**DIFFERENTIAL GENE EXPRESSION** - Differential gene expression → changes phenotypes → some are better able to adapt to environment.	
	QWC : paragraphing + A2 + B5 + D2 + E	
	Total marks : **A – 2** **B – 2** **C/F/G/H – 1** **D – 2** **E – 3**	

(b) Justify the claim that all living organisms on Earth depend on phosphate. [15]

Justify the claim that all living organisms on Earth depend on phosphate. [15]		
Big Idea: Membrane [max 3]		
A1	**Phospholipid molecule made up of 1 glycerol, 1 phosphate and 2 fatty acids chains helps in the formation of cell membrane**	
A2	**The hydrophobic core/ hydrophilic region allows the hydrophobic boundary to exist in an aqueous environment.** **OR** **idea of compartmentalisation**	
A3	**Control movement of substances, exocytosis/endocytosis** **or** **maintenance of a constant internal environment within the cell/ organelle/ maintenance of optimal/ high concentrations of reactants at specific sites**	
A4	**The fluidity of the phospholipid bilayer allows the formation; (eg of structures)** • **Transient pores** • **Pseudopodia** **For transport of substances into the cell**	
Big Idea: ATP [1 mark for different categories]		
B1	**Phosphate found in ATP**	
B2	**Energy is stored in the bonds of ATP which are broken/ hydrolyse/ currency of energy in the body**	

B3	ATP is hydrolysed to actively pump substances across the membrane during active transport	
B4	ATP is hydrolysed to provide energy for amino acid activation	
B5	ATP is hydrolysed to provide energy for post translational modification of amino acids	
B6	ATP used for phosphorylation of kinases/enzymes	
B7	ATP can be converted to cAMP by adenyl cyclase	
Big Idea: GTP [max 3]		
C1	Phosphate found in GTP	
C2	GTP provides energy for the translocation process of translation	
C3	GTP serves as intermediate for formation of ATP during substrate level phosphorylation	
C4	GTP present in GPCR, for activation of GPCR	
Big Idea: Photosynthesis [max 3]		
D1	Guilding principle: name of molecule + structure + role Ribulose-1,5-bisphosphate is required for carbon fixation to form glycerate-3-phosphate.	
D2	$NADP^+$ is the final electron acceptor of photophosphorylation OR is essential to reduce glycerate-3-phosphate to glyceraldehyde-3-phosphate in Calvin cycle.	
D3	Glyceraldehyde-3-phosphate is required to synthesize glucose, starch, and cellulose	
Big Idea: Nucleotides [no max marking]		
E1	Nucleotide – Phosphate group, pentose sugar, nitrogenous base	
E2	Phosphate group required for formation of phosphodiester bonds / sugar-phosphate backbone	
E3	Nucleic acids (e.g. DNA) stores genetic information	
E4	and are inherited by the offspring to ensure the continuity of the species	
E5	Phosphate groups negatively charged, allowing for wrapping of DNA around histones (stability of DNA)	
E6	mRNA codes for protein and is required for the synthesis of proteins	
E7	rRNA associated with small and large ribosomal subunit, needed for ribosome formation	
E8	tRNA with amino acid attached – needed for translation	
Big Idea: Glycolysis [max 2]		
F1	Phosphate needed for activation of glucose	
F2	Glucose - 1 – phosphate: (only 1) • Will not move out of the cell • Keep glucose levels in the cell low • Raise energy level of glucose for substrate level phosphorylation	
Big Idea: Cell signalling [max 3]		
G1	Phosphate needed for phosphorylation of RTK, activating it	
G2	Phosphate needed for conversion of GDP to GTP for activation of GPCR	
G3	Inositol triphosphate (IP_3) cause ligand-gated calcium channels for signal transduction	
G4	Phosphorylated proteins trigger signal transduction	
G5	Phosphorylation cascade leads to signal amplification	
Big Idea: O&C Prokaryotes		
H1	Phosphate found in cAMP binds to CAP, increases transcription of Lac operon	
H2	Phosphate in ATP needed to provide energy for the transportation of DNA moves across the plasma membrane during transformation	
QWC awarded only if points come from minimum 4 big ideas.		

[Total: 25]

OR

5 (a) Biological specificity is one of the most widespread and characteristic properties of living organisms.

Biological specificity is most pronounced and best understood at the cellular and molecular levels of organization. Using named examples, explain the importance of shapes fitting together in cells and organisms. [13]

[Define biological specificity] **[Max 1]**

1. **[Def: Definition] Shapes of molecules is complementary to shape of the other molecule, hence they can bind to each other.**

[Proteins] **[Max 1]**

2. **[PHbH: Haemoglobin Haem group] Oxygen binds to haem group of haemoglobin → Oxygen binds and dissociates → Transport of oxygen**

[Enzymes] **[Max 3]**

3. **[ELK: Lock and Key] Lock and key hypothesis → Shape of active site is exactly complementary to shape of substrate**
4. **[EAS: Active site] Shape of active site is complementary to shape of substrate → Bind to form ES complex → Catalytic function (Catabolic / Anabolic) → Product formation**
5. **[EIF: Induced Fit] Induced fit hypothesis → Shape of active site is complementary to shape of substrate, but slight conformational change to fit more snugly**
   [NOTE: Phrase the above statement very carefully! The substrate and enzyme are complementary in shape.]
6. **[EE: Enzyme Example] Named example of enzyme (e.g. maltase binds and hydrolyzes maltose to α-glucose)**
7. **[EP: Product] Once product is formed → Different shape → No longer remain bound at active site**
8. **[EAI: Allosteric site] Shape of activator / inhibitor is complementary to shape of allosteric site → Change conformation of enzyme and active site → Increase / Decrease rate of enzymatic reaction**
9. **[ECI: Competitive inhibitor] Shape of competitive inhibitor is complementary to shape of active site → Compete with substrate for active site and bind at active site → Decrease rate of enzymatic reaction**
10. **[ENCI: Non-competitive inhibitor] Shape of non-competitive inhibitor is complementary to shape of allosteric site / binds at site away from active site → Changes conformation of enzyme and active site → Decrease rate of enzymatic reaction / Regulate enzyme activity and conserve energy or resources**

[Transport] **[Max 1]**

11. **[TP: Transport protein] Specific transport proteins (channel protein, carrier protein) / Shape of binding site of carrier protein is complementary to shape of molecule → Facilitated diffusion / Active transport**
12. **[TRME: Receptor-mediated endocytosis] Shape of receptor is complementary to shape of molecule → Receptor mediated endocytosis**

[Cell Cycle] **[Max 1]**

13. [CSF: Spindle fibre] Attachment of spindle fibre to kinetochore on chromosome → Arrangement of chromosome in metaphase / Separation of chromosome or chromatids in anaphase
14. [CCDK: CDK] Shape of CDK is complementary to shape of cyclin → Stimulate cell division

[Photosynthesis / Respiration] [Max 2]

15. [EP / ER: Photosynthesis / Respiration] Shape of ATP synthase is complementary to shape of ADP and P_i → Synthesize ATP → Drive metabolic reaction
16. [EP: Photosynthesis] Shape of NADP reductase is complementary to shape of $NADP^+$ and H^+ → Synthesize NADPH → Carbon reduction in Calvin cycle
    [Accept: Other enzymes with substrates and functions stated]

[Nucleic acid: Complementary base pairing] [Max 2]

17. [NDNA: DNA] Complementary base pairing between DNA strands → Formation of double-stranded DNA helix → Stability of structure of DNA molecule
18. [NRep: Replication] Complementary base pairing between DNA parental and daughter strands → Template for DNA replication
19. [NPr: Proofreading] Complementary base pairing between DNA parental and daughter strands → Template for DNA repair / proofreading

20. [NT: Telomere] Complementary base pairing between free DNA nucleotides and telomerase RNA → Template for elongation of telomeres
    [Accept: Telomere (DNA) and telomeric RNA]

21. [NRNA: RNA] Complementary base pairing within tRNA → Structure of tRNA
    [Accept: rRNA, telomerase RNA]

22. [NTc: Transcription] Complementary base pairing between DNA template and mRNA → Template for mRNA synthesis / transcription
23. [NPTM: Post-transcriptional modification] Complementary base pairing between snRNA of spliceosome and DNA sequence at splice site → RNA splicing

24. [NTl: Translation] Complementary base pairing between codon of mRNA and anti-codon of tRNA → Translation / Synthesis of proteins

[Nucleic acid: Shape complementary in shape] [Max 3]

25. [PRep: Replication] Shape of DNA binding domain of helicase is complementary to shape of DNA sequence at Ori → Separate two parental strands
26. [PRep: Replication] Shape of DNA binding domain of primase / DNA polymerase / ligase is complementary to shape of 5' phosphate group of free (DNA) nucleotide and 3' OH group of adjacent nucleotide, as well as parental strand → Synthesize primers / Formation of phosphodiester bond between nucleotides of daughter strand / Seals nick between DNA fragments during replication
    [Accept: Proofreading ability of DNA polymerase]

27. [PTF: Transcription Factors] Shape of DNA binding domain of general transcription factor / activator / repressor is complementary to shape of DNA sequence at promoter / enhancer / silencer → Increase / Decrease rate of transcription
28. [PTc: Transcription] Shape of DNA binding domain of RNA polymerase is complementary to shape of 5' phosphate group of free RNA nucleotide and 3' OH group of adjacent nucleotide, as well as template strand → Formation of phosphodiester bond between nucleotides of mRNA during transcription

29. [PAA: Amino acid activation] Shape of amino acid + ATP + tRNA is complementary to shape of active site of aminoacyl-tRNA synthetase → Amino acid activation
30. [PIF: Translation Initiation Factors / Repressors] Shape of eIF / translational repressor is complementary to shape of mRNA sequence at 5' UTR / 3' UTR → Increase / Decrease rate of translation
31. [PPT: Peptidyl transferase] Shape of peptidyl transferase is complementary to shape of aminoacyl-tRNA → Formation of peptide bond between amino acids to form polypeptide during translation
32. [PRF: Release factor] Shape of release factor is complementary to shape of mRNA sequence at stop codon → Termination of translation

[Bacteria] [Max 2]

33. [PRE: Restriction enzyme] Shape of restriction site of restriction enzyme is complementary to shape of sequence at restriction site → Cut DNA at restriction site / Hydrolyse phosphodiester bonds

34. [PO: Operon] Shape of inducer / corepressor is complementary to shape of repressor → Switch on / off operon → Rapid response to changes in environment
35. [POR: Repressor] Shape of DNA binding domain of repressor is complementary to shape of DNA sequence at operator → Binding of active repressor at operator → Prevent transcription
36. [PCAP: CAP binding site] Shape of CAP is complementary to shape of CAP-binding site → Switch on operon
    [Accept: cAMP and CAP are complementary in shape]

[Cell Signalling] [Max 2]

37. [SR: Receptor] Shape of ligand is complementary to shape of receptor (e.g. insulin or glucagon receptor) → Signal reception → Cell signalling pathway
38. [SST: Signal transduction] Shape of second messenger is complementary to shape of effector protein → Cellular response
    [Accept: Any relay proteins, effector proteins, Ras]

[Pathogens and antibiotics] [Max 2]

39. [DP: Phage] Shape of tail fibre in phage is complementary to shape of receptors on surface of *E coli* → Binding of phage / Entry of phage DNA into host cell
    [Reject: Entry of phage]

40. [DI: Influenza] Shape of haemagglutinin in influenza virus is complementary to shape of sialic acid receptors on respiratory epithelial cells → Endocytosis / Entry of influenza virus into host cell
    OR
    [DH: HIV] Shape of gp120 / gp41 in HIV is complementary to shape of CD_4 receptors on immune cells / T-helper cells → Fusion of HIV viral envelope with plasma membrane of $CD4^+$ immune cells
    [Accept: Protease, Integrase, Reverse transcriptase]

41. [DB: Bacteria] Shape of antigen in pathogen (e.g. Pathogen Associated Molecular Pattern) is complementary to shape of receptors (e.g. Pattern Recognition Receptor) on immune cells → Elicit immune response / Trigger inflammatory response
    [Accept: Enzymes in transformation, conjugation, transduction]

42. [DAb: Antibiotics] Shape of penicillin is complementary to shape of transpeptidase in bacteria → Inhibit formation of peptide cross-links between peptidoglycan → Kill bacteria

[Immunology] [Max 2]

43. [IB: B-cell receptor] Shape of B cell receptor is complementary to shape of antigen → Elicit immune response / Activation of B cell
[Accept: Epitope of antigen]

44. [IT: T-cell receptor] Shape of T cell receptor is complementary to shape of antigenic peptide on MHC of antigen presenting cell (including B cell) → Activation of T and B cell OR Proliferation and activation → Adaptive immune response OR Formation of memory T and B cells
[Accept: NK cells]

45. [Ilg: Antibodies] Shape of antigen-binding site / variable region of antibodies is complementary to shape of antigen → Opsonization / Agglutination / Neutralisation of toxins / Complement activation / Antibody-dependent cytotoxicity

46. [IV: Vaccine] Shape of antigen in vaccine is complementary to shape of receptors on immune cells → Elicit immune response

[Others] [Max 1]

47. [CC: Cell-cell adhesion / Cell-cell recognition] Shape of glycoprotein / glycolipid / protein of one cell is complementary to the receptors of another cell → Cell-cell adhesion / Cell-cell recognition

[QWC] [Max 1]

48. [QWC] Paragraphing + At least 1 example of protein, enzyme and nucleic acid

(b) Describe the effects of different types of mutations on the proteins of eukaryotes. [12]

1 mark EACH:

[Gene Mutation] [Max 6]

1. [G: Gene mutation] Gene mutation is the change in nucleotide sequence / codon, and subsequently amino acid sequence

2. [S: Substitution] Substitution: Replacement of one or more nucleotides

3. [SM: Silent mutation] Silent mutation → Same amino acid → Protein structure and function not affected
4. [NC: Non-coding] Mutation in non-coding region → Same amino acid → Protein structure and function not affected
5. [SS: Splice site] Mutation in splice site → Spliceosome unable to bind → Unable to splice → Non-functional protein

6. [MM: Missense mutation] Missense mutation → Different codon that codes for different amino acid → Change in primary, secondary and tertiary structure → Protein structure and function may be affected / Non-functional protein / Solubility affected

7. [MC: Mutation at crucial site] If mutation occurs at crucial site / catalytic site / active site → Protein / Enzyme structure and function affected
[Accept: Mutation in control elements, centromere]
8. [MN: Mutation at non-crucial site] If mutation occurs at non-crucial site → Protein / Enzyme structure and function not greatly affected

9. [NM: Non-sense mutation] Nonsense mutation → Stop codon → Premature termination of translation → Truncated / Shorter non-functional protein

10. [ID: Insertion, Deletion] Insertion/ Deletion: Addition / Removal of nucleotide
11. [FSM: Frameshift mutation] Insertion/ Deletion: Addition / Removal of nucleotide (non-multiples of 3) → May result in frameshift mutations → Affects reading of codons / reading frame downstream of mutation → Sequence of amino acids downstream of mutation being completely altered → Non-functional protein / Shorter protein
12. [IDT: Insertion, Deletion of triplet bases] Insertion/ Deletion of nucleotide (multiples of 3) → Addition / Removal of (one) amino acid → No effect / Non-functional protein / Shorter protein

13. [GE: Example of gene mutation]
    - Substitution T changes to A in template strand of beta-globin gene → Hydrophilic glutamine changes to hydrophobic valine in haemoglobin → Hydrophobic region → Polymerization of HbS / Crystallization of HbS into rod-like fibres → Sickle cell anaemia
    - ras → unable to hydrolyse ATP → constant activation of cell signaling → uncontrolled cell division
    - Junctional diversity: Joining of V to D, D to J segments → Increase diversity of antibody variable region / antigen binding site in antibody
    - Somatic hypermutation → Greater diversity / repertoire of B cell receptor / antibodies → Increased possibility of greater binding affinity of antibody to antigen

[Chromosomal Aberration] [Max 6]

14. [C: Chromosomal aberration] Chromosome aberration is the change in structure or number of chromosome

[Changes in chromosomal structure]

15. [D: Duplication] Duplication → Set of genes repeated / Extra copy of genes → More protein products synthesized

16. [Del: Deletion] Deletion → Loss of a region of chromosome → Shorter chromosome missing certain genes → Proteins not synthesized / Loss-of-function

17. [I: Inversion] Inversion → Breaking and reattachment of chromosome in reverse orientation → Non-functional protein synthesized

18. [T: Translocation] Translocation → Breaking and joining of chromosome to another non-homologous chromosome
    WITH If chromosome is translocated to strong promoter → Overexpression of proteins (e.g. proto-oncogene → oncogene)
    OR
    If chromosome is translocated to a region which is transcriptionally not active / heavily methylated → Proteins not synthesised (e.g. mutated tumour suppressor genes)

[Changes in chromosomal numbers]

19. [A] Aneuploidy → Gain / Loss of one or more chromosomes → Can be lethal in animals
    WITH
    Loss of certain genes → Proteins in deleted regions not synthesized
    OR
    Extra copy of certain genes → More protein products synthesized

20. [P] Polyploidy → Gain / Loss of one or more SETS of chromosomes
    WITH

Loss of certain genes → Proteins in deleted regions not synthesized
OR
Extra copy of certain genes → More protein products synthesized

21. [CE: Example of chromosomal aberration]
    - e.g. Trisomy 21 → Down syndrome
    - e.g. Extra X chromosome → XXY (Klinefelter syndrome)

[Gain-of-function / Loss-of-function]

22. [GOF] e.g. Chromosome is translocated to strong promoter → Overexpression of proteins
23. [GOFE] e.g. *Ras* proto-oncogene mutated to oncogene → Hyperactive Ras protein (intrinsic GTPase unable to hydrolyse GTP) → Unable to terminate signal transduction → Uncontrolled cell division

24. [LOF] e.g. Chromosome is translocated to a region which is transcriptionally not active / heavily methylated → Proteins not synthesized
25. [LOFE] e.g. mutated *p53* tumour suppressor genes / DNA repair gene → Unable to detect or repair DNA damage / Initiate apoptosis → Uncontrolled cell division

[QWC] [Max 1]

26. Paragraphing + Gene mutation + Chromosomal mutation

[Total: 25]

TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
JC 2 2018

CANDIDATE NAME										
CENTRE NUMBER	S					INDEX NUMBER				
CLASS	C	G			/	1	7			

H2 BIOLOGY

Paper 4 Practical

9744/04
Monday 27 August 2018
2 hours 30 minutes

Candidates answer on the Question Paper
Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

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

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

Shift
Laboratory

For Examiner's Use	
1	/ 23
2	/ 13
3	/ 19
Total	/55

Answer **all** questions

1 Vitamin C, or ascorbic acid, is a water soluble antioxidant that plays a vital role in protecting the body from infection and disease.

It is not synthesised by the human body and must be acquired from dietary sources such as fruits and vegetables because many plant cells contain water soluble ascorbic acid.

You are provided with an extract from plant cells, **P**, which contains ascorbic acid.

Visking tubing, **V**, is selectively permeable, similar to a cell surface membrane, so that some biological molecules will diffuse through the wall of the tubing.

You are required to investigate the diffusion of ascorbic acid from **P** into the water surrounding the Visking tubing over a period of 15 minutes.

Fig. 1.1 shows the apparatus before the water was added.

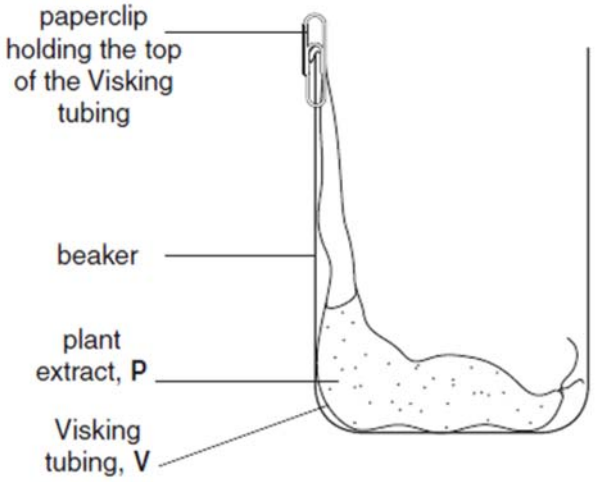


Fig. 1.1

(a) (i) Water is added to the beaker in Fig. 1.1.

Describe the expected trend in the concentration of ascorbic acid in the water over a period of 15 minutes. [1]

- As **time increases**, **concentration of ascorbic acid** **in** the **water increases**.

You are provided with:

Labelled	Contents	Hazard	Volume / cm^3
A	sample of water removed after 15 minutes	irritant	15
P	plant extract containing ascorbic acid	irritant	15
W	distilled water	none	100
I	iodine in potassium iodide solution	irritant	20
S	starch	none	20

Labelled	Details
V	15 cm length of Visking tubing in a beaker containing water

You must now read up to the end of step 23 before proceeding.

To compare the concentration of ascorbic acid in the samples you are required to find the **volume** of iodine solution, **I**, added to each sample until the end-point is reached.

The drops of **I** will be added one at a time using a small syringe.

To practise releasing drops from a small syringe:

1. Fill the syringe with 2 cm^3 of **I**.

2. Hold the syringe over an **empty** test-tube and push the plunger **gently** to release one drop at a time, as shown in Fig. 1.2.

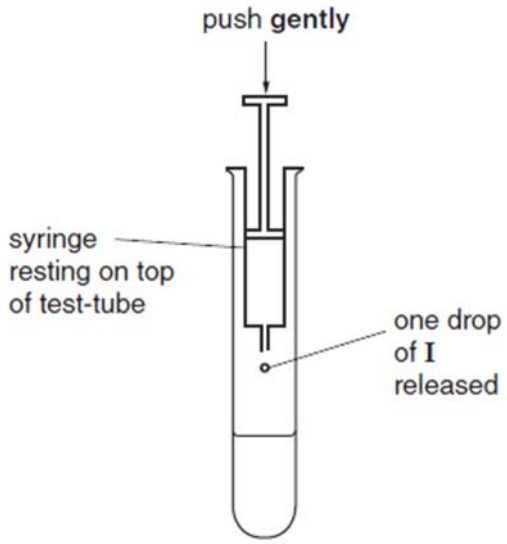


Fig. 1.2

To compare the concentration of ascorbic acid in the samples you will need to add drops of **I** until a blue colour appears. When this blue colour lasts for more than 10 seconds, this is the end-point and the **volume of I** that has been added should be recorded.

The apparatus in Fig. 1.1 was set up and water was added and left for 15 minutes.

Sample **A** was removed from the water in the beaker.

You are required to find the volume of **I** needed to reach the end-point for sample **A**.

Proceed as follows:

3. Put 1 cm^3 of **S** into a test-tube.

4. Put 3 cm^3 of the sample (e.g. **A**) into the same test-tube.

5. Shake the test-tube gently to mix the contents.

6. Fill the syringe, labelled **I**, with 2 cm^3 of **I**.

7. Wipe off any drops of **I** from the outside of the syringe with a paper towel.

8. Add **one** drop of **I** to the mixture in the test-tube as shown in Fig. 1.2.

9. Mix gently and if there is no colour change add another drop.

10. Continue adding drops, one at a time, until the blue colour appears.
Wait 10 seconds to see if the end-point has been reached. If the blue colour disappears then add another drop.

11. Repeat step 10 until the mixture stays blue for at least 10 seconds.

(ii) Record the **volume of I** needed to reach the end-point.

- Correct DP (1dp)
- Any reasonable volume

volume _____ [1]

You are required to:
- set up Visking tubing containing **P** as in Fig. 1.3
- decide the level of water to put into the beaker
- remove samples of the water surrounding the Visking tubing at **5 minute intervals** for 15 minutes
- compare the ascorbic acid concentrations in the samples.

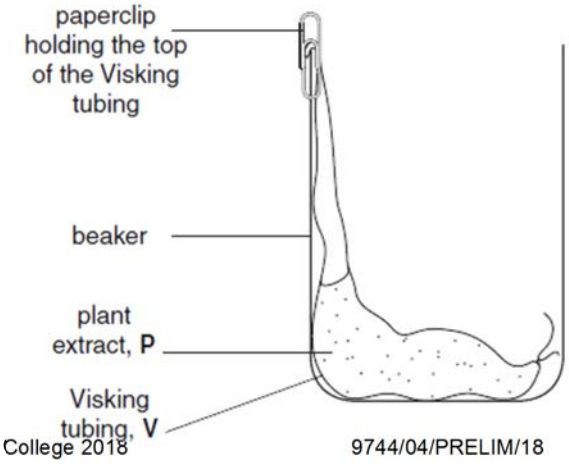


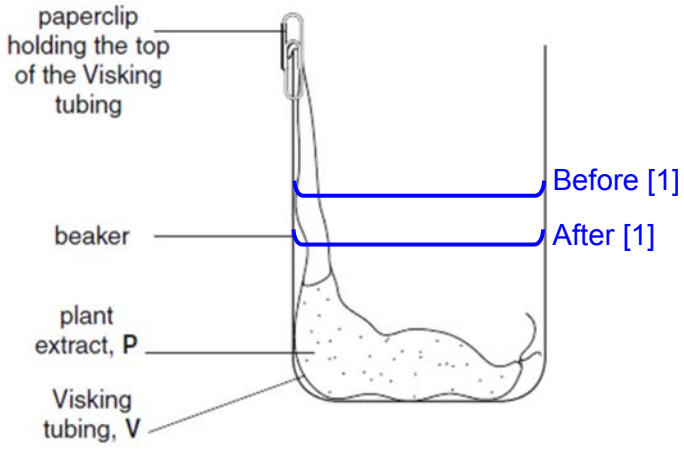
Fig. 1.3

Samples of water surrounding the Visking tubing will be removed for testing, so you need to take this into account when you decide the level of water to put into the beaker.

(iii) Draw on **Fig. 1.3** the level of the water
- before you remove any samples (label 'before'),
- after the total volume of water needed for all the tests has been removed (label 'after').

[2]

- **Two levels drawn** labelled – one **labelled** '**before'** & one **labelled** "**after**";
- The **level of "after" lower** than before;
- The **level of "after"** must still **cover contents** of Visking tubing ;



(iv) In order to compare the ascorbic acid concentrations, state **one** variable which you will need to standardise when finding the volume of **I** added to each sample.

Describe how you will standardise this variable.

variable :
- **volume of sample**
  OR
- **volume of starch**

description [1]
- **3cm^3 of sample measured with a syringe**
  OR
- **1cm^3 of starch added to the same test tube; measured with a syringe**

Proceed as follows:

12. Put **S**, as in step 3, into the four test-tubes you will require in order to test the samples of water.

13. Tie a knot in the Visking tubing as close as possible to one end so that it seals the end.

14. To open the other end, wet the Visking tubing and rub the tubing gently between your fingers.

15. Put 6 cm^3 of **P** into the open end of the Visking tubing.

16. Rinse the outside of the Visking tubing by dipping it into the water in the container labelled **V**.

17. Put the Visking tubing into an empty beaker as shown in Fig. 1.3.

18. Make sure the open end of the Visking tubing is held in place by a paperclip.
You will start timing as soon as you add **W** (**steps 19 and 20**).
You should read steps 19 to 23 before proceeding.

19. Put **W** into the beaker to the level you decided in **(iii)**.

20. Immediately start timing and remove the first sample of water (as in **step 4**) and put into a prepared test-tube (as in **step 12**).

21. Test the sample as in **steps 5 to 11**.

22. After 5 minutes, gently mix the water surrounding the Visking tubing and then remove the next sample, put it into a different (prepared) test-tube and repeat **steps 5 to 11**.

23. Repeat **step 22** for one more sample.

Record your results in **(a)(v)** on page 6.

(v) Prepare the space below and record your results. [5]

Time / min	volume of iodine to reach end-point / cm^3		
	Trial 1	Trial 2	average
0	0.2	0.2	0.2
5	0.8	0.9	0.9
10	1.4	1.4	1.4
15	1.9	2.0	2.0

CH: Column heading with UNITS – 1 mark

D : Different volume of iodine for different time interval + data for 4 different time intervals 1 mark

R : 2 readings – 1 mark

Tr : Trend – increase in vol of iodine as time increase – 1 mark

Pr : all values to one decimal place – 1 mark

(vi) Describe how the results support your expected trend as stated in **(a)(i)**. [1]

- Answer in agreement with answer to (a)(i)

This investigation provides results to compare the concentration of ascorbic acid in the samples.

(vii) If you had been provided with 1.0% ascorbic acid solution, suggest how you would modify this investigation to find the **percentage concentration** of ascorbic acid in the water after 15 minutes. [4]

1. perform a **serial dilution** or **simple dilution** of 1% to obtain a **total** of **5 concentrations of ascorbic acid**

2. **find** the **volume of iodine** to reach **end point** for **each concentration**

3. **plot** **percentage concentration on X-axis** and **time taken on the Y-axis**

4. **time taken** to reach end point for **each sample** of water is **located on** the **graph** and **read off** **percentage concentration** from the **X-axis**

(b) Iodine solution (iodine in potassium iodide solution) turns blue-black when starch is present in plant tissues.

However, as ascorbic acid is also found in plant tissues, some scientists investigated the effect of testing for starch with iodine solution when there was ascorbic acid present.

The concentration of ascorbic acid was 0.0001 mol dm^{-3} and the concentration of starch solution was standardised.

The percentage of starch which reacted with the iodine solution was measured.

The results are shown in Table 1.1.

Table 1.1

Volume of iodine solution / cm^3	**Percentage of starch which reacted with iodine solution**
0.0	0.0
0.5	2.0
1.5	5.0
2.0	36.0
2.5	68.0

(i) Plot a graph of the data shown in Table 1.1.

*You will need to consider the answer to **(b)(ii)** before you plot your graph.* [4]

Plot a graph of the data shown in Table 1.1.

*You will need to consider the answer to **(b)(ii)** before you plot your graph.* [4]

NOTE: 1 mark EACH

S – Scale

- **Mark axes at even interval.**
- **Drawn curve must cover 1/2 of graph paper (both x and y axes)**
- **Label origin (0,0) for BOTH axes**

P – Plotted points:

- **All points plotted accurately**

A – Axes labelled :

- **X axis: Volume of iodine solution/ cm^3**
- **Y-axis: Percentage of starch which reacted with iodine solution**

L – Line:

- **All the points joined point-to-point**

(ii) Estimate the volume of iodine solution needed for 100% of the starch to be reacted.

Show on your graph how you obtained the volume of iodine solution. [1]

volume of iodine solution **3.0** cm^3

Dotted lines on the graph to show how the value was obtained [½]

Volume stated [½]

(iii) Explain how the presence of ascorbic acid may affect the use of iodine solution as a test for the presence of starch in different plant tissues. [2]

1. **If there is too much ascorbic acid, all the iodine reacted with ascorbic acid and none left to react with starch. [1]**

2. **Need to find out the volume of ascorbic acid present before testing for starch to ensure that there is sufficient iodine available to react with starch. [1]**

(iv) A plant tissue contains 0.0001 mol dm^{-3} ascorbic acid and starch.

Suggest how you would make sure that the iodine test showed the presence of all the starch (100%). [1]

1. **Use $3cm^3$ or more than $3cm^3$ of iodine**

[Total: 23]

2 Yeast cells have transport proteins in their cell membranes for the uptake of nutrients from the surroundings. There are separate transport proteins for glucose and for maltose. When exposed to both glucose and maltose the transport protein for maltose is downregulated and is not produced.

Plan an investigation to find out whether or not the yeast transport proteins for glucose and maltose function at the same rate.

Glucose and maltose are both reducing sugars.

You are provided with the following materials. Choose your materials from this list.

You may **not** use any additional materials.

- 10% yeast suspension
- 10 g dm^{-3} glucose solution
- 10 g dm^{-3} maltose solution
- Benedict's solution
- dilute hydrochloric acid
- dilute sodium hydroxide solution and sodium hydrogencarbonate solution for neutralising
- beakers and flasks of different sizes
- stopwatch or electronic timer
- colorimeter and tubes
- centrifuge and centrifuge tubes
- thermometer
- thermostatically-controlled water baths
- pipettes and pipette fillers
- burettes and burette stands
- filter funnels and filter paper
- syringes
- glass rods for stirring
- test-tubes and boiling tubes
- test-tube and boiling tube racks

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary
- include a clear statement of the hypothesis or prediction
- 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 minimise any risks associated with the proposed experiment.

[Total: 13 marks]

[Independent variable] IV [MUST HAVE+ repeat with glucose/ maltose in methods: 1]
Independent variable: Types of sugar (glucose, maltose)

[Dependent variable]
Dependent variable: Absorbance value of yeast-sugar mixture after conducting Benedict's test for reducing sugar

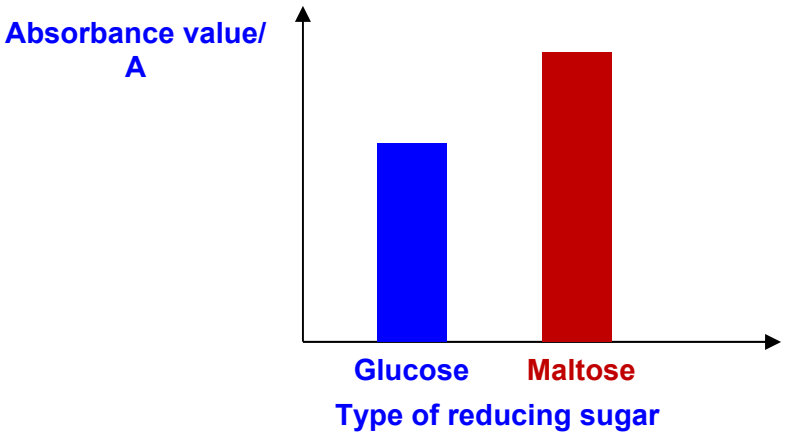
[Hypothesis/ Theory/ Trend] Tr [1]
1. Glucose is a monosaccharide, whereas maltose is a disaccharide, which is longer / larger (made of 2 α-glucose monomers) so it takes longer to transport maltose into the cell.
2. Furthermore, glucose is the preferred respiratory substrate as compared to maltose.
3. Hence, the rate of uptake of glucose is faster than rate of uptake of maltose.

4. Less glucose is found in the surrounding solution, hence the colour intensity of the Benedict's test and absorbance value will be lower, as compared to maltose.

[Table] T [1]

Type of sugar	Absorbance value/ A			
	Trial 1	Trial 2	Trial 3	Average
Glucose				
Maltose				

[Graph] G [1]



METHOD:
[Constant variable: Volume of yeast, sugar] V [1]
1. Using a 5mL syringe, add 2.0cm^3 of yeast into a boiling tube.
2. Using a 5mL syringe, add 2.0cm^3 of 10.0 gdm^{-3} glucose into another boiling tube.

[Equilibrate] Eq [1]
3. To equilibrate, incubate (both) boiling tubes separately in a thermostatically controlled water bath at 30°C for at least five minutes.

[Constant variable: Temperature] T° [1]
4. Mix/ Transfer the glucose to the boiling tube of yeast.
5. Immediately place the boiling tube back into the thermostatically controlled water bath at 30°C and start the stopwatch.

[Constant variable: Time] Ti [1]
[Filter] F [1]

6. After 5 minutes, remove the boiling tube and filter the content of the boiling tube using filter paper and filter funnel.
   [Alternative: Pour the content of the boiling tube into the centrifuge tube and place it in a centrifuge]

[Benedict's test] BT [MUST HAVE: 1]

7. Obtain/ Extract 2.0 cm^3 of filtrate and add it to 2.0 cm^3 of Benedict's solution in a boiling tube.
   [Accept: Supernatant/ fluid component obtained in step 6]
8. Place the boiling tube in a boiling water bath for 2 minutes.

[Data collection] DC [MUST HAVE: 1]

9. Transfer 2.0 cm^3 of the mixture to a colourimeter tube (i.e. cuvette) and place it into a colourimeter.
10. Record the absorbance value of the mixture.
    [Accept:
    - Time taken for mixture to change colour from blue to green
    - Mass of reducing sugars]

[Repeats for maltose] IV

11. Repeat steps 1 to 10 for maltose solution.

[Repeats/ Triplicate] RT [1]

12. Repeat steps 1 to 11 to obtain a total of three readings (triplicate) for using fresh samples of yeast, glucose, maltose.

[Rate] R [MUST HAVE: 1]

13. The rate of uptake of sugars can be obtained from the gradient of the graph.
    [Accept: 1 ÷ time taken, where appropriate]

[Control] C [1]

Control: Replace glucose or maltose with distilled water, and repeat the experiment, subject to the same experimental conditions.

[Safety Precaution] S [1]

PRECAUTION	RISK
1. Do not handle colourimeter with wet hands	to prevent electrocution (high risk).
2. Use a mitten/ insulated gloves	to prevent scalding/ burns when using the boiling water bath (medium risk).
3. Wear safety goggles and gloves to avoid contact with eyes and skin	as yeast is a microorganism/ biohazard (medium risk). OR as glucose/ maltose/ Benedict's solution is an irritant (medium risk).

3 The eyepiece graticule scale in your microscope may be used to measure the actual length of the layers of tissues or cells, if the scale has been calibrated against a stage micrometer.

(a) Using the stage micrometer, where one division is **0.1 mm**, calculate the actual length of one eyepiece graticule unit of 10X objective by completing step 1 and step 2.

Step 1

1 eyepiece graticule unit = **10 X 0.1** divided by **100** = **0.01** mm **[1]**

Step 2

Convert the answer to a measurement with the unit most suitable for use in light microscopy.

0.01 multiplied by $\mathbf{10^3}$ **[1]** = **10 µm [1]**

[3]

(b) Slide **T1** is a transverse section of a leaf.

You are not expected to be familiar with this specimen.

(i) Select a field of view so that you can observe and draw a large plan diagram of the part of the leaf indicated in Fig. 3.1.

You are required to use a sharp pencil for drawings.

Use **one** ruled label line **each** to label one layer of epidermis, xylem tissue and phloem tissue.
You should include only two vascular bundles.

You are expected to draw the correct shape and proportions of the different tissues.

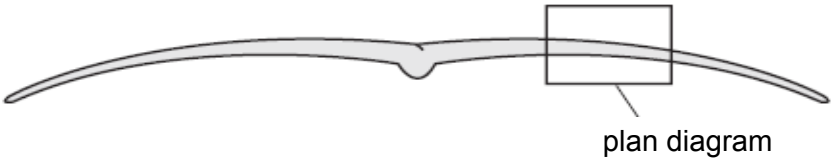
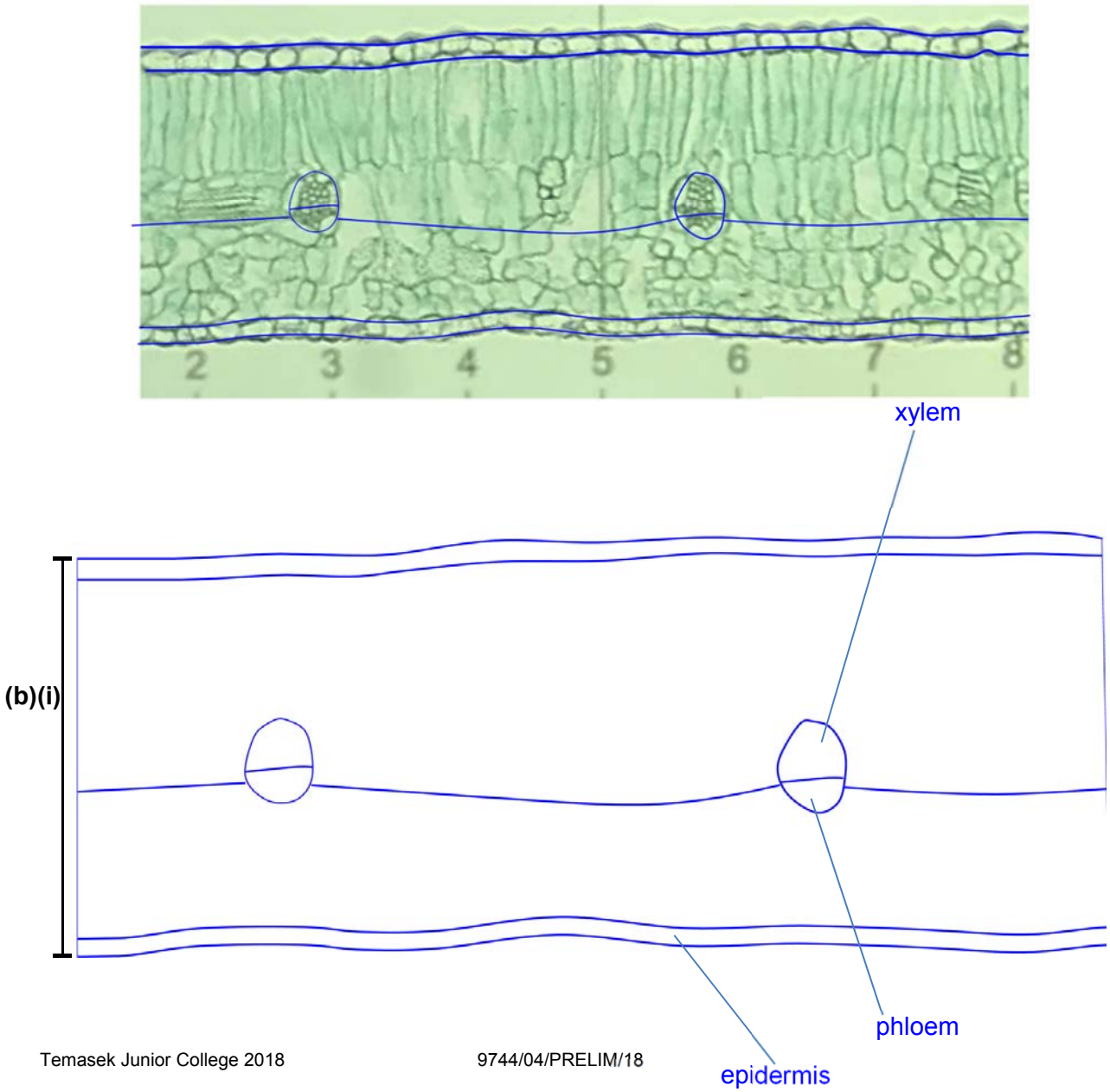


Fig. 3.1



M 1	1. clear, sharp, unbroken lines AND 2. no shading AND 3. LARGE SIZE [FILL MOST OF THE SPACE] AND 4. Must not use ruler for any part of the drawing (except labelling lines)	Reject - if drawn over the print of question - feathery lines - overlaps or gaps - any lines thicker than 1mm
M 2	1. no cells drawn AND 2. only correct section drawn AND 3. the 2 vertical lines at the left and right boundary must be drawn with ruler	Note: ▪ Must not draw box ▪ Vertical lines must not exceed the upper and lower epidermis
M 3	1. upper epidermis and lower epidermis drawn with two lines with distance 3 mm or closer for most of length. 2. Use a line to separate palisade and mesophyll layer 3. 2 vascular bundles drawn [correct shape]	Reject - if epidermal layers are too thick - if circles are drawn representing xylem vessels - if palisade layer is thinner than mesophyll layer
M 4	1. correct label with label line to epidermis, xylem and phloem tissues	Reject - if any label is biologically incorrect e.g. regions belonging to other organs or animals. • label within drawn area

[4]

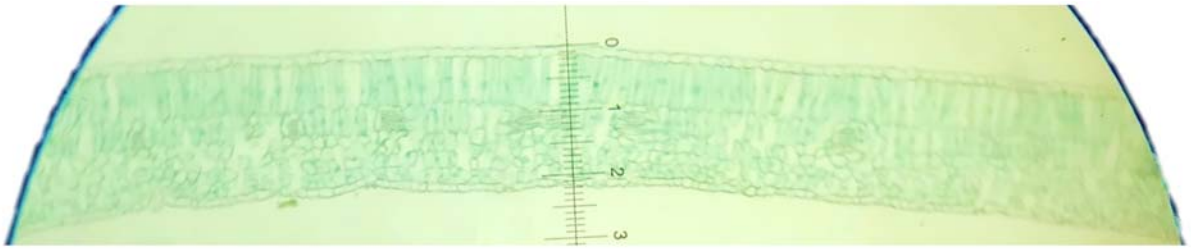
(ii) Using the eyepiece graticule, measure the actual thickness of the leaf lamina, under low power.

Measure the size of your drawing across the same point.

Draw a line on your drawing in **(b)(i)** to show where you made the measurement.

Calculate the magnification of your drawing.

Show your working.



Measurement of leaf lamina = 22 div

Actual size of leaf lamina = 22 X 10 µm

Length of drawing = 100mm

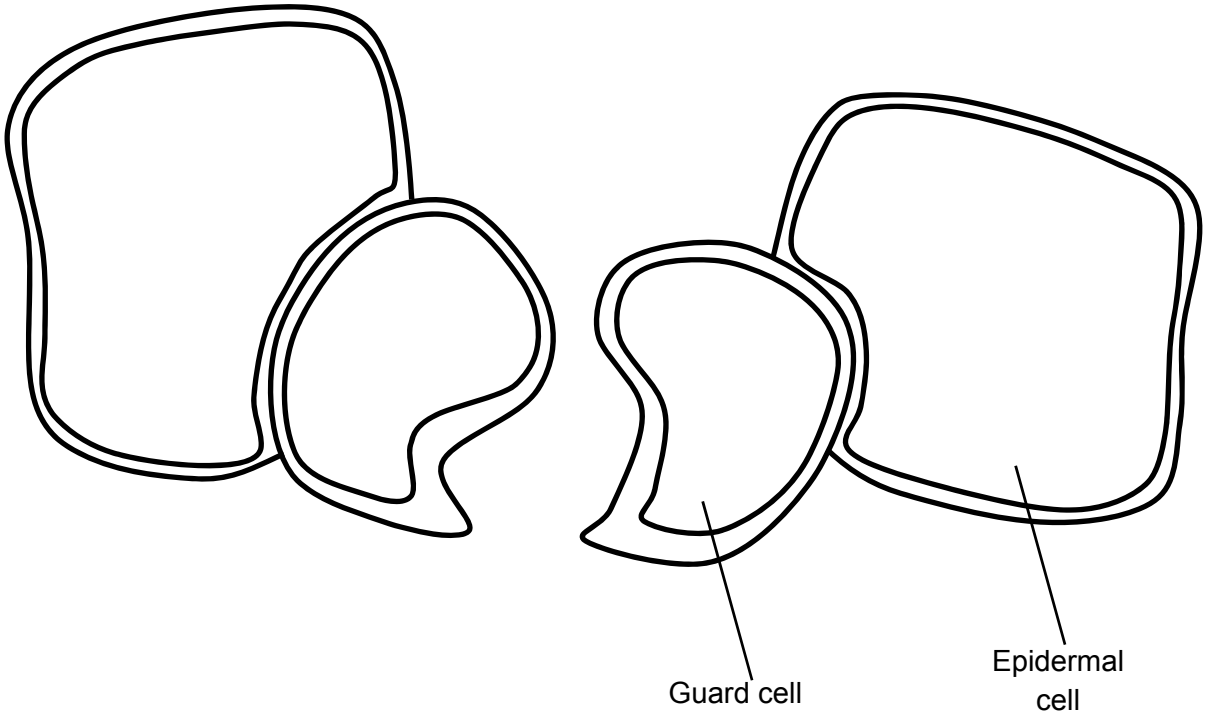
$$\textbf{Magnification} = \frac{\text{Size of image}}{\text{Actual size}}$$

$$= \frac{\textbf{100 X } \mathbf{10^3 \text{ µm}}}{\textbf{22 X 10 µm}}$$

magnification **X454** [2]

(iii) Stomata are found on the lower surface of the leaf in the specimen on slide **T1**. The pores are likely to be closed and you may have to search to find a clear example.

In the space below, make a high-power, labelled drawing of **two** guard cells and their adjacent epidermal cells.



M 1	1. clear, sharp, unbroken lines AND 2. NO shading AND 3. Use up as much of the space as possible for drawing the cells	Reject - if drawn over the print of question - feathery lines - overlaps or gaps - any lines more than 1mm
M 2	1. Cell walls drawn as double lines. 2. Separated by a space not more than 2mm.	Cells must be large
M 3	1. 2 guard cells (correct shape) AND 2. 2 epidermal cells 3. Guard cell must in contact with 1 epidermal cell	Reject: Guard cells drawn as 2 bean-shaped cells
M 4	1. Label guard cells & epidermal cells 2. Use ruler to draw label lines	

[4]

(c) Fig. 3.2 is a photomicrograph of a stained transverse section through another species of leaf.

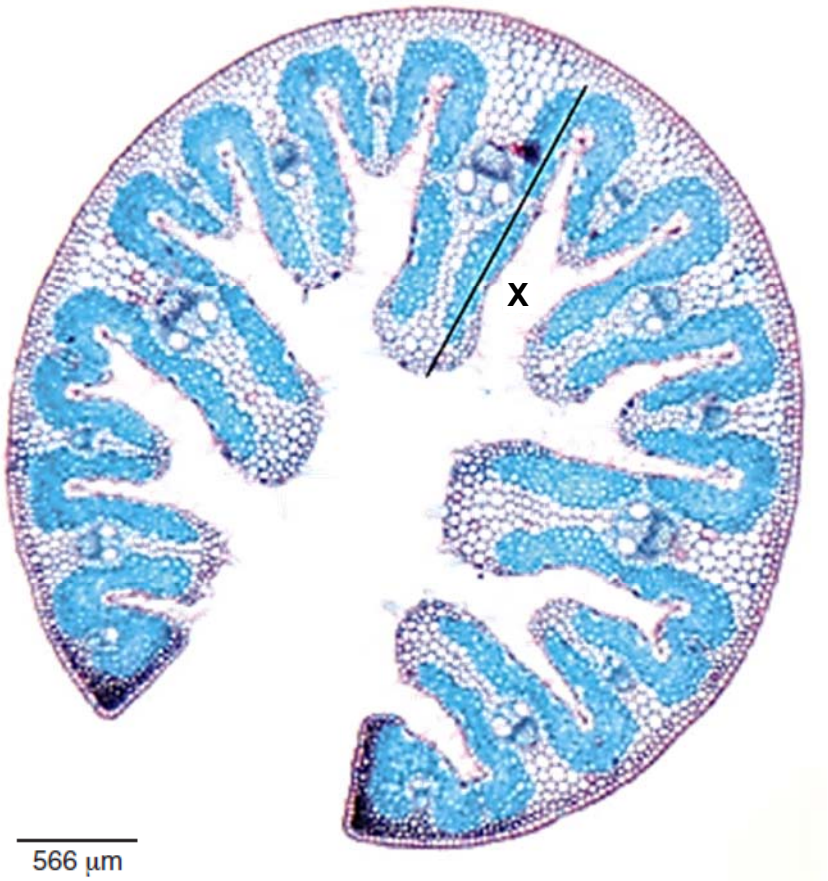


Fig. 3.2

(i) Calculate the actual length of the fold shown by line **X**, using the scale bar.

You may lose marks if you do not show your working or if you do not use appropriate units.

Scale bar = 16mm

16mm ≅ 566µm [1]

Length of line = 44mm = 44 X 10^3 µm

$$\textbf{Actual length} = \frac{\textbf{44 X } 10^3 \textbf{ X 566 µm}}{\textbf{16 X } 10^3 \textbf{ µm}} \quad \textbf{[1] = 1556.5 µm}$$

actual length **1556.5 µm [1]**

Fig. 3.3 is a magnified section of the leaf in Fig. 3.2.

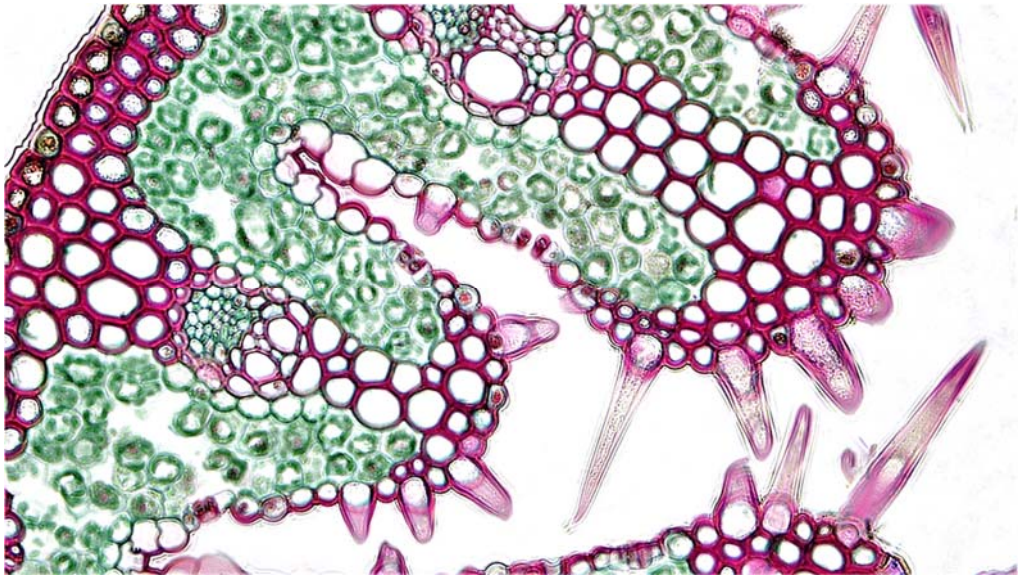


Fig. 3.3

(ii) Prepare the space below so that it is suitable for you to compare and contrast the location of stomata observed in specimen **T1** with Fig. 3.3.

Record your observations in the space that you have prepared.

Feature	T1	Fig. 3.3
Occurrence of stomata	Stomata only located on one epidermis for both	
Location of stomata	Lower epidermis	Upper epidermis
Location of stomata	Stomata exposed to external environment	Stomata hidden in folds of leaf
Frequency of stomata	Stomata evenly spread out	Not spread out, only occurs at folds
Presence of trichomes	Stomata not located next to trichomes	Located next to trichomes

[3]

[Total: 19]