TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME: _____

CIVICS GROUP: _____ ( )

H2 BIOLOGY

9744/01

Paper 1 Multiple Choice Questions

27 September 2019
1 hour

Additional material: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

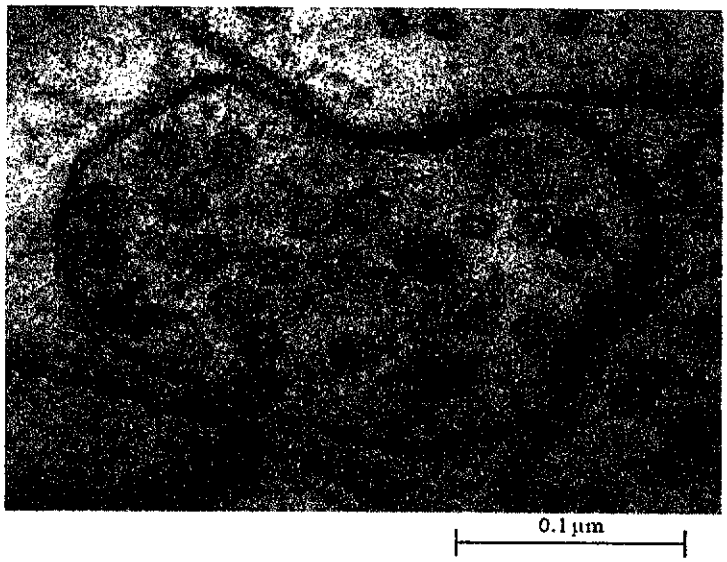
Do not open this booklet until you are told to do so.
Write your name, civics group and index number on the Multiple Choice Answer Sheet.
Do not use staples, paper clips, glue or correction fluid/tape.

There are **30** questions in this paper. Answer **all** questions. For each question, there are four possible answers labelled **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.

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

You may keep this booklet after the exam.

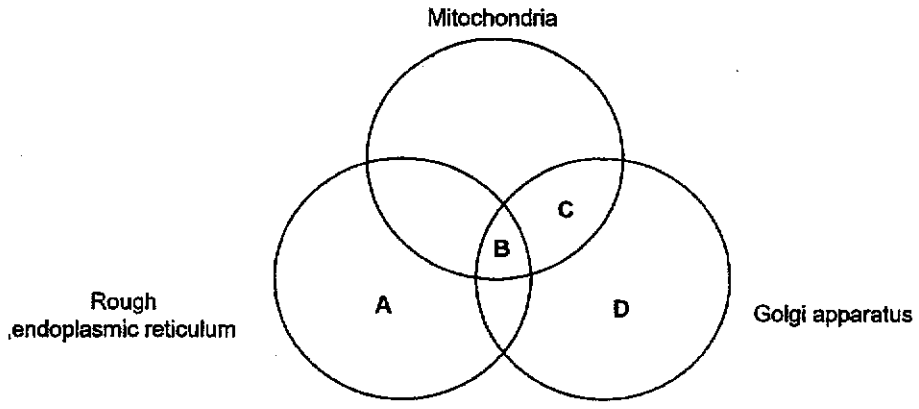
QUESTION 1
The figure below shows a neurone.



Calculate the magnification of the electron micrograph.

A. X 40,000 **B.** X 50,000 **C.** X 400,000 **D.** X 1,050,000

QUESTION 2
Which organelles are required for the formation and secretion of steroid hormones out of the cell?



QUESTION 3
Tests were performed on samples from a mixture of biological molecules:

- When iodine in potassium iodide solution was added to a sample, the mixture turned black.
- When the biuret test was carried out on another sample, the mixture turned purple.

Which biological molecules were in the mixture?

A. amylase and starch
B. cellulose and starch
C. phospholipid and cellulose
D. amylose and phospholipid

QUESTION 4
Which of the following feature(s) account for collagen having high tensile strength?

1 Strong covalent glycosidic bonds between monomers
2 Hydrogen bonds within a single chain
3 Covalent cross-links within each tropocollagen molecule
4 Staggered ends that overlap

A. 4 only B. 1 and 3 only C. 2 and 4 only D. All of the above

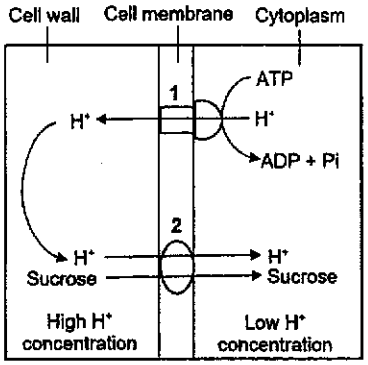
QUESTION 5
Some of the molecules found in animal tissues are grouped into three lists:

1 glucose, cholesterol, triglycerides, water
2 glycogen, antibodies, adenine, phospholipids
3 haemoglobin, carbon dioxide, mRNA, monosaccharides

Which lists include one or more molecules that always contain nitrogen atoms?

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

QUESTION 6
The diagram below illustrates the process of phloem loading with the help of proteins 1 and 2.

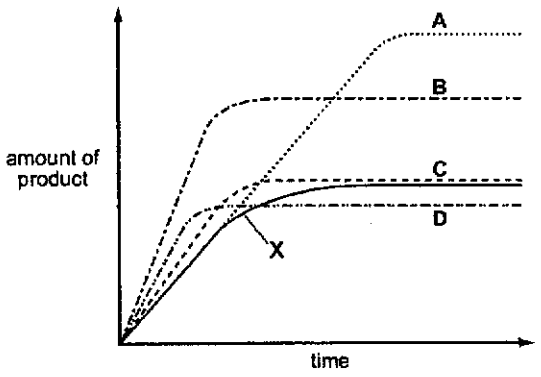


Which of the following accurately describes the type of transport occurring at proteins 1 and 2?

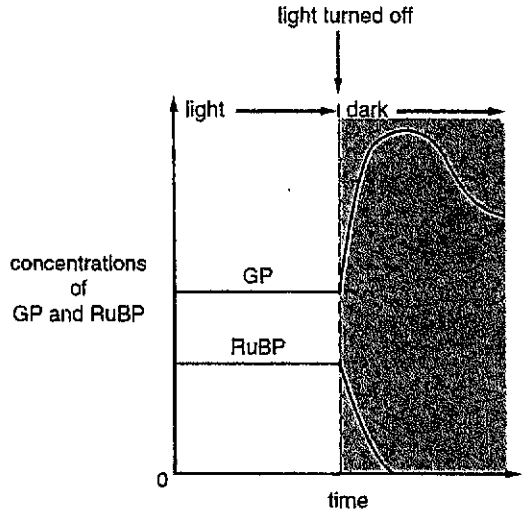
	Protein 1	Protein 2
A.	Simple diffusion	Active transport
B.	Active transport	Facilitated diffusion
C.	Facilitated diffusion	Facilitated diffusion
D.	Active transport	Simple diffusion

QUESTION 7
The curve X shows the activity of an enzyme at 25°C. Curves **A**, **B**, **C** and **D** show the effect of different conditions on the activity of the enzyme.

Which curve shows the effect of increasing the temperature by 10°C and adding additional substrate?



QUESTION 8
The figure below shows the changes in concentration of glycerate phosphate (GP) and ribulose bisphosphate (RuBP) extracted from samples taken from actively phosynthesising algae in an experimental chamber with excess carbon dioxide when the light source was turned off.



Which of the following statement(s) accurately account(s) for the change in concentrations of GP and RuBP?

1 In the presence of light, GP remains constant as the Calvin Cycle is inhibited by light
2 In the dark, GP increases as Rubisco catalyses the dephosphorylation of CO_2
3 In the dark, GP eventually decreases as CO_2 becomes the limiting factor
4 In the dark, RuBP decreases to zero as ATP is used up

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

QUESTION 9
Which of the following may be used as a measure for the rate of photosynthesis of a plant?

1 rate of oxygen produced
2 rate of carbon dioxide produced
3 rate of increase in plant biomass
4 rate of light absorbed

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

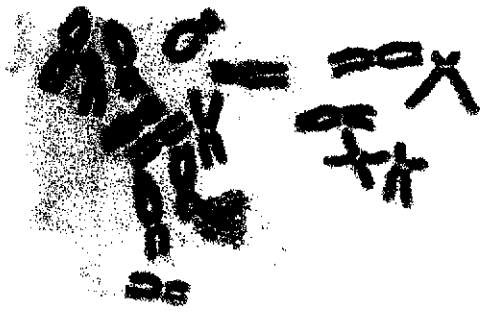
QUESTION 10
Which features of mitosis ensure that the genetic constitution of the cell is maintained?

1 The position of the chromosomes on the equator of the spindle
2 The longitudinal division of the centromeres
3 The DNA of the parent cells replicates before mitosis starts
4 The pulling apart of chromatids to opposite poles

A. 1, 2 and 3 only
B. 1, 2 and 4 only
C. 2, 3 and 4 only
D. All of the above

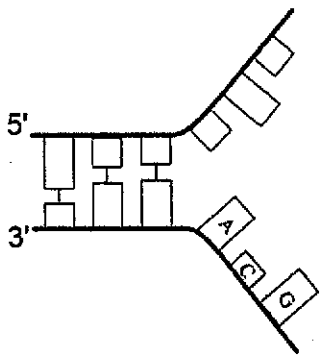
QUESTION 11
The figure below shows a diploid onion cell at metaphase during mitosis.

What are the final products when the onion cell undergoes meiosis?



A. 4 cells, each with 8 chromosomes
B. 2 cells, each with 8 chromosomes
C. 4 cells, each with 4 chromosomes
D. 2 cells, each with 16 chromosomes

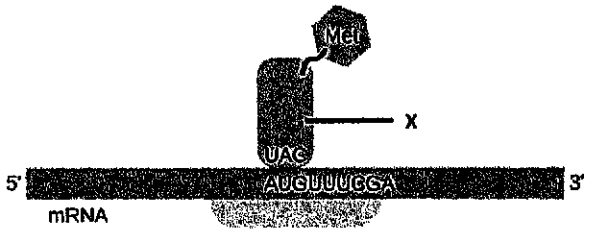
QUESTION 12
The diagram below illustrates DNA replication. Some of the bases are indicated.



In which direction is the replication fork moving and which bases would be required to initiate the replication of the section of DNA shown?

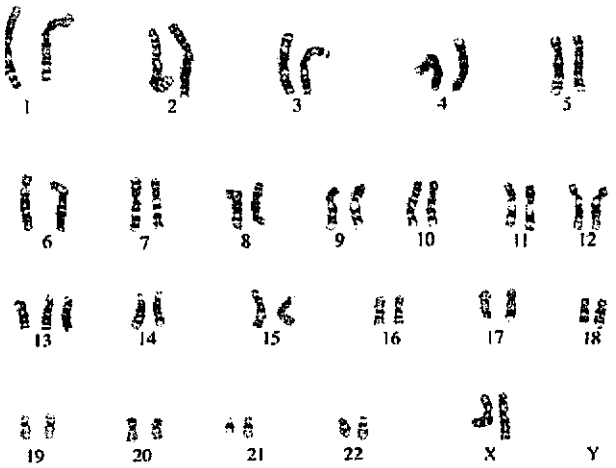
	Direction of movement of replication fork	Bases required
A.	Left to right	U, G and C
B.	Right to left	U, G and C
C.	Left to right	T, G and C
D.	Right to left	T, G and C

QUESTION 13
What sequence of processes is carried out by the structure labelled X during translation?



A. Combining with an amino acid and then binding to an anticodon
B. Binding to an anticodon and then combining with an amino acid
C. Binding to a codon and then combining with an amino acid
D. Combining with an amino acid and then binding to a codon

QUESTION 14
Which of the following statements may be concluded from this karyogram?

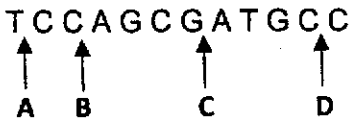


1 The person is male.
2 Non-disjunction has occurred.
3 A gene mutation has occurred in chromosome 3.
4 The person suffers from Down syndrome.

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

QUESTION 15
The diagram shows part of a non-template DNA strand which codes for four amino acids.

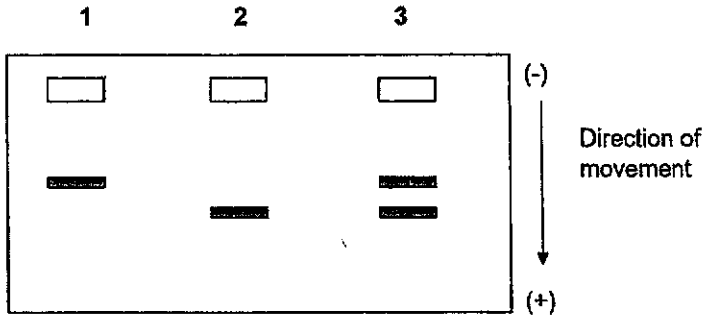
Where would a mutation of introducing a thymine nucleotide result in the termination of translation?



QUESTION 16

The β-globin gene can exist in two different alleles termed HbA (the normal allele) and HbS (the allele that causes sickle cell anaemia in homozygotes). The polypeptides that are coded for by these two alleles differ by one amino acid. Blood samples from 3 individuals were obtained and the **proteins** were separated by gel electrophoresis.

Using the gel pattern below, determine the genotypes of individuals **1** and **2**, and the reason for your identification.



	Genotype of 1	***Genotype of 2***	***Reason for identification***
A.	Hb^AHb^A	Hb^SHb^S	Since glutamic acid in the normal β-globin is negatively charged, it will move faster towards the opposite pole.
B.	Hb^SHb^S	Hb^AHb^A	Since valine in the normal β-globin is negatively charged, it will move faster towards the opposite pole.
C.	Hb^AHb^A	Hb^SHb^S	Since glutamic acid in the β-globin that causes sickle cell anaemia is negatively charged, it will move slower towards the opposite pole.
D.	Hb^SHb^S	Hb^AHb^A	Since valine in the β-globin that causes sickle cell anaemia is neutral, it will move slower towards the opposite pole.

QUESTION 17

The following table shows the genome size, number of genes and chromosome number for a variety of organisms.

organism	genome size (kilobp)	number of genes	chromosome number
E. coli	4,000	4,000	n = 1
Yeast	12,000	6,000	2n = 12
Amoeba	290,000,000	No data	500-1000 (possibly polyploid)
Mouse	3,000,000	No data	2n = 64
Rhesus monkey	3,000,000	No data	2n = 42
Fruit fly	137,000	14,000	2n = 8
Humans	3,000,000	30,000	2n = 46

From this data, it is possible to conclude that:

A. there is more non-coding DNA in humans than in bacteria.

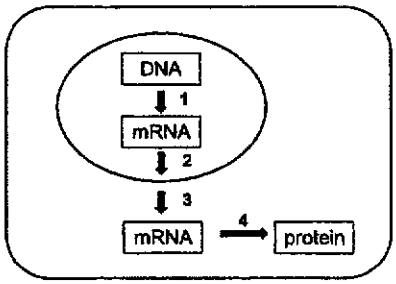
B. as chromosome number increases, so do the number of genes.

C. the mouse and the rhesus monkey will have the same number of genes.

D. the genome size relates to the complexity of an organism.

QUESTION 18

The diagram below shows the expression of a gene to its protein product in a eukaryotic cell.



Which of the following statements are **false**, with regards to gene expression in the above eukaryotic cell?

1 Acetylation of histones can enable stage 1 to occur.

2 Stage 1 does not take place when repressor binds to operator.

3 Demethylation of DNA can enable stage 1 to occur.

4 5' capping occurs in stage 2, and alternative splicing takes place in stage 3.

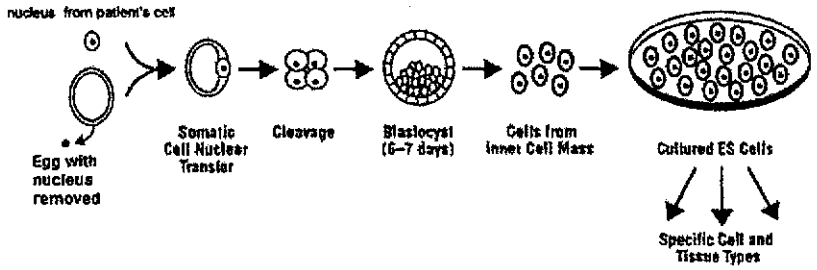
5 In stage 4, mRNA is read in the 3' to 5' direction while the protein is formed in 5' to 3' direction.

A. 1 and 3 B. 2 and 3 C. 2, 4 and 5 D. All of the above

QUESTION 19

Many people due to ethical reasons oppose the use of embryonic stem cells. Researchers have come up with a way of developing embryonic stem (ES) cells from the patient's cells. The cultured ES cells can then be used to treat the patient.

Figure below shows the process of this new method.



Which of the following statements about the method is **true**?

1 The embryonic stem cells cultured are pluripotent.

2 No embryo is destroyed in the process of harvesting the embryonic stem cells.

3 The patient will not show any immune response when specific cells types developed from the embryonic stem cells are introduced into the patient.

4 The ethical concern of the destruction of an embryo is no longer an issue as the embryonic cells come from the patient.

A. 1 and 2 only

B. 1 and 3 only

C. 2, 3 and 4 only

D. All of the above

QUESTION 20
Which of the following statement(s) regarding viruses is/are **incorrect**?

1 When viruses go through antigenic drift, two different strains of viruses infect a single host cell and recombined into a new virus.

2 The DNA-dependent RNA polymerases that are required for the replication of influenza viral genome in the host cell are of viral origin.

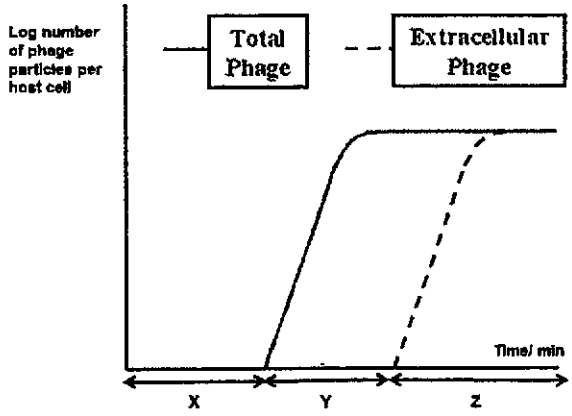
3 Cytotoxic T cells can kill virus-infected target cells by releasing perforins that create pores in the infected cell and lysozymes that activate enzymes that trigger apoptosis of the cell respectively.

4 The enzyme integrase is involved in the integration of viral DNA into the host cell genome in both the lambda phage and human immunodeficiency virus life cycles.

5 For the influenza virus to enter the host cell, haemagglutinin on the host cell membrane binds to a sialic acid receptor of the virus.

A. 2 only **B.** 1, 2 and 4 only. **C.** 1, 2, 3 and 5 only **D.** All of the above

QUESTION 21
The figure below shows a growth cycle of bacteriophages.



Which of the following is true about X, Y and Z of the growth cycle for T4 bacteriophage?

A. Period X is when the phage injects its viral RNA into host cell.

B. Period X is when hydrolysis of host cell occur.

C. Period Y is when host cell's DNA is hydrolysed into fragments

D. Period Z is when phage lysozymes digest the host's cell wall.

QUESTION 22

Malvidin is a plant pigment responsible for the colours of red grapes, cranberries and blueberries. The dominant allele, **M**, codes for an enzyme involved in the biosynthesis of malvidin. The presence of dominant allele, **D**, of another unlinked gene, results in the absence of malvidin production in plants, even when the enzyme is present whilst the recessive allele, **d**, does not affect malvidin production.

A plant heterozygous at both loci was self-pollinated and gave rise to the following progeny:

Plants with no malvidin production	160
Plants with malvidin production	40

The formula for the chi-squared (χ^2) test is given as follows:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

degrees of freedom	probability 0.05
1	3.84
2	5.99
3	7.82
4	9.49

Which conclusions may be drawn?

1 The expected phenotypic ratio for the self-pollination is 15:1.
2 The expected phenotypic ratio for the self-pollination is 3:1.
3 Difference between the observed and expected results is not significant.
4 The two genes controlling flower colour assort independently.
5 The difference is due to some factor such as linkage of the genes concerned.

A. 1, 4 and 5 **B.** 2, 3 and 4 **C.** 3 and 5 **D.** 3 and 4

QUESTION 23
Which of the following statements regarding quantitative inheritance of phenotypes are **false**?

1 The environment plays an important role in quantitative inheritance.
2 Different genes with multiple alleles do not contribute to quantitative variation.
3 Identifying quantitative trait loci is relatively straightforward.
4 Quantitative inheritance is also known as continuous variation.
5 Different alleles at a single gene locus have large effects on the phenotype.

A. 2, 3 and 5
B. 1, 2 and 3
C. 3 and 4
D. 2 and 5

QUESTION 24
Which of the following gives an accurate comparison between intracellular receptors and cell surface receptors?

	Intracellular receptors	**Cell surface receptors**
A.	May act as regulatory proteins and bind to DNA	May catalyse the phosphorylation of intracellular proteins
B.	Functions as the second messenger to activate other relay proteins	Binding of ligand always trigger the production of second messengers
C.	Ligands can be water-soluble or lipid-soluble	Ligands must be lipid-soluble
D.	Made up of only hydrophobic amino acids to allow the interaction with lipid-soluble ligands.	Made up of hydrophobic amino acids which interact with the phospholipids of the membrane

QUESTION 25
The followings are possible events that may lead to speciation.

1 Gene mutations
2 Increased gene flow
3 Natural selection
4 Geographical isolation (e.g. mountain or river)
5 Habitat differentiation within the same geographical location

The correct order of events that may lead to sympatric speciation is:

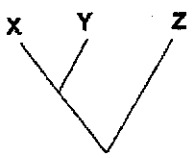
A. 4 → 1 → 3 **B.** 5 → 1 → 3 **C.** 4 → 2 → 3 **D.** 5 → 2 → 3

QUESTION 26
Cytochrome c is a protein found in most organisms. The amino acid sequence of this protein varies between species. The number of differences in the amino acid sequences in cytochrome c between three species of chordates, X, Y and Z are shown in the table below.

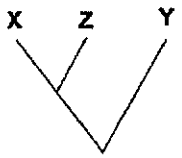
	species Y	species Z
species X	11	3
species Y		10

Based on this evidence, the phylogenetic tree that best represents the possible evolutionary relationships between the three species is:

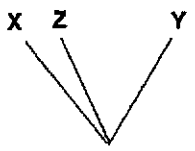
A.



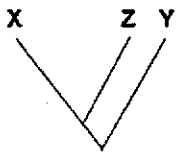
B.



C.



D.



QUESTION 27
A student wrote down four statements about antibodies.

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

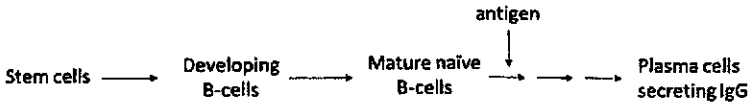
A. Their structure depends on peptide, hydrogen and disulfide bonds.

B. They are protein molecules with both tertiary and quaternary structure.

C. Four polypeptides are coded for by two different genes.

D. The great variation in antigen specificity is a result of alternative RNA splicing.

QUESTION 28
The flow chart below shows the development of a B-cell.



Which of the follow statements are **true** of the different cells above?

1 In a developing B-cell, somatic hypermutation produces different mature naïve B cells with different B-cell receptors.

2 The mature, naïve B-cell will be expressing IgM on its cell surface membrane.

3 From one stem cell, it is possible to obtain many different mature naïve B cells each specific for a different antigen.

4 The plasma cell is genetically identical to the stem cell.

A. 1 and 2

B. 1 and 3

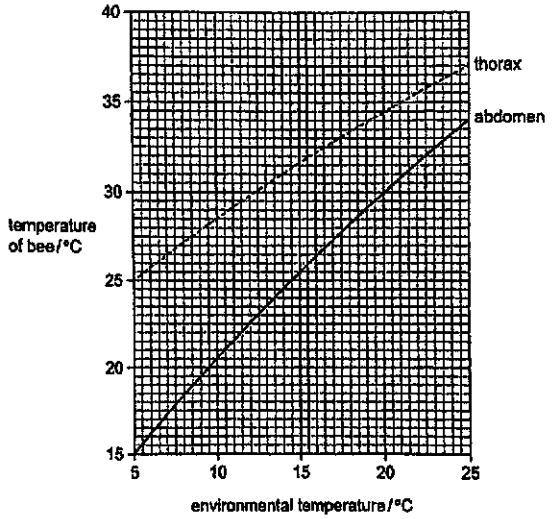
C. 2 and 3

D. 3 and 4

QUESTION 29

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

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



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

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

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

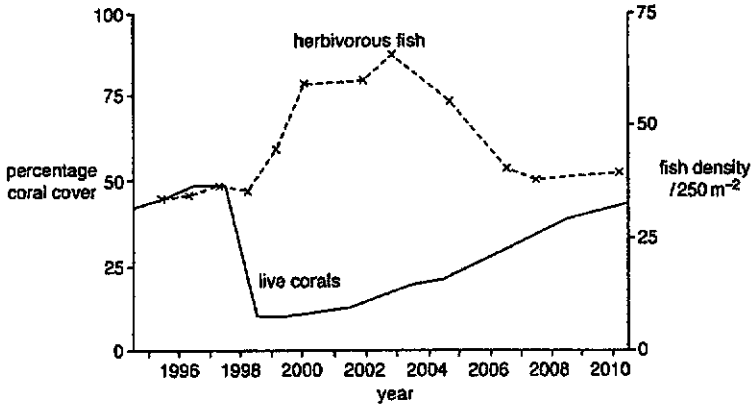
3 The bees can warm their flight muscles so that they can fly at low environmental temperatures.

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

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

QUESTION 30

The figure below shows the percentage cover of live corals and the density of herbivorous (plant-feeding) fish on a coral reef over a number of years.



Which of the following statements are possible reasons to explain the trends observed above?

1 Increase in ocean temperature causes the expulsion of zooplankton, resulting in coral bleaching, hence reduction of live corals between 1998 to 1999.

2 Ocean acidification causes a reduction in pH levels, which decreases calcification of corals, hence, reduction of live corals between 1998 to 1999.

3 Marine plants started to grow in the area previously occupied by the corals, serving as a food source for herbivorous fish, hence an increase in fish density in 1999.

4 Herbivorous fish helps to reduce the population size of plant species, clearing up areas for corals to grow again, resulting in an increase in live coral from 1999.

A. 1 and 2 only

B. 2 and 3 only

C. 2, 3 and 4 only

D. 1, 2, 3 and 4

End of Paper 1 ☺

TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME: _____

CIVICS GROUP: _____ ( )

H2 BIOLOGY **9744/02**

Paper 2 Structured Questions 20 September 2019

2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, index number and civics group in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid/tape.

Answer **all** questions in the spaces provided in 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	
1	/ 14
2	/ 14
3	/ 10
4	/ 7
5	/ 10
6	/ 12
7	/ 10
8	/ 8
9	/ 10
10	/ 5
Total	**/ 100**

QUESTION 1

Fig. 1.1 shows a yeast cell.

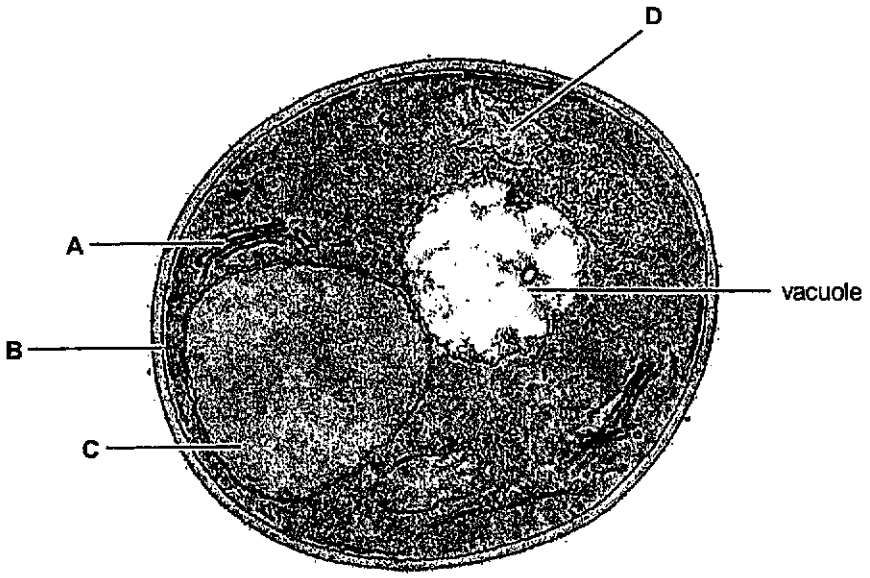


Fig. 1.1

(a) Compare the structures of organelles **C** and **D**. [2]

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(b) Explain how structures **A**, **B** and **D** are functionally related. [3]

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Fungal cells like yeast are bound by a thick cell wall made of chitin, a polysaccharide made of N-acetylglucosamine. Fig. 1.2 shows the structure of chitin.

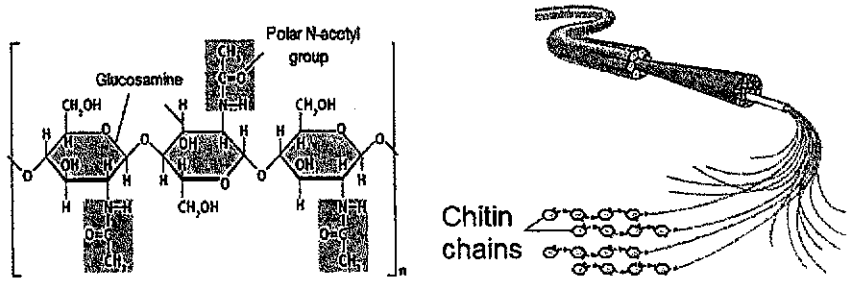

Fig. 1.2

(c) With reference to Fig 1.2, explain why chitin has high tensile strength. [4]

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Chitinase is an enzyme found in plants. It degrades chitin in fungal cell walls and exoskeletons of insects, protecting the plants against a range of pathogens.

(d) Describe one way in which chintinase lowers the activation energy and increases the rate of chitin hydrolysis. [1]

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A student isolated the chitinase gene from yeast cells and inserted it into *E. coli* cells for protein production. Chitinase from yeast and *E. coli* cells were then extracted and purified separately. The following observations were made by the student during this process:

- The amount of chitinase mRNA transcribed in yeast and *E. coli* cells was similar
- Chitinase produced in *E. coli* had a lower molecular weight than those produced in yeast cells

The student then tested the activity of chitinase produced from both cells. The result obtained is shown in Fig 1.3.

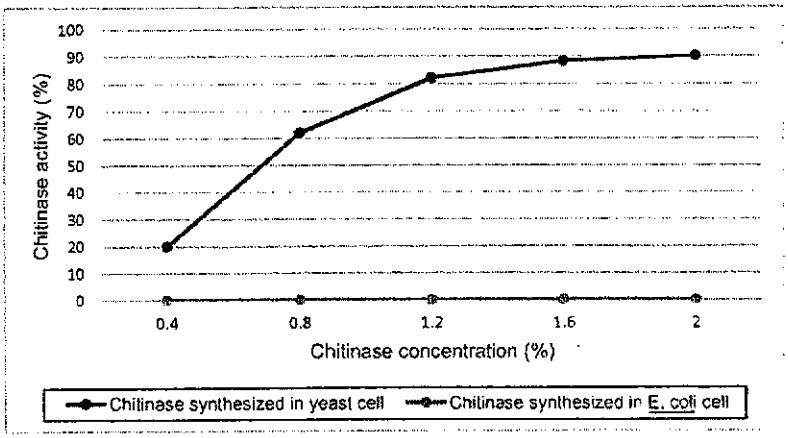

Fig. 1.3

(e) Assuming that no mutations have taken place, account for the results shown in Fig. 1.3. [4]

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[Total: 14]

QUESTION 2

Fig. 2.1 shows DNA replication occurring in a cell.

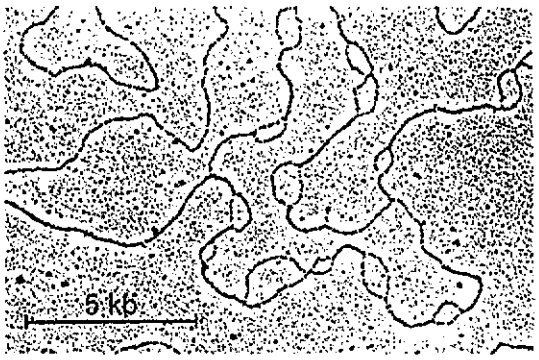

Fig. 2.1

(a) With reference to Fig. 2.1, explain if this cell is prokaryotic or eukaryotic. [1]

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Fig. 2.2 illustrates how DNA replication occurs at a replication fork.

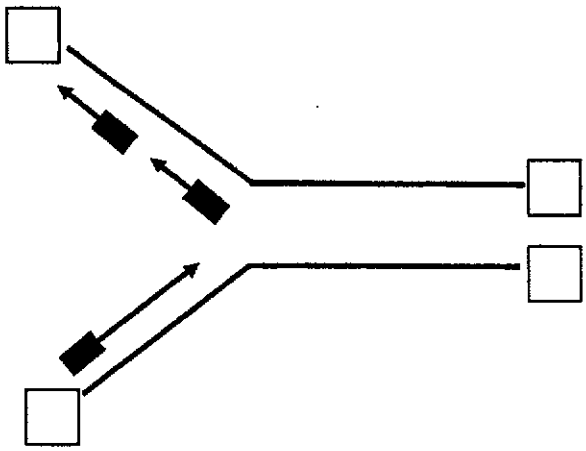

Fig. 2.2

(b) In the four boxes provided in Fig. 2.2, indicate the direction of the DNA template strands. [1]

(c) Fig. 2.2 shows the differences between the synthesis of two daughter strands.

With reference to Fig. 2.2, explain why DNA replication at each replication fork is described as *'asymmetrical'* replication. [4]

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Resveratrol is a natural compound found in many dietary plants and in red wine. It plays an important role in the prevention of many human pathological processes.

An experiment was carried out to investigate how resveratrol affects the activity of DNA polymerase. The results are shown in Fig. 2.3.

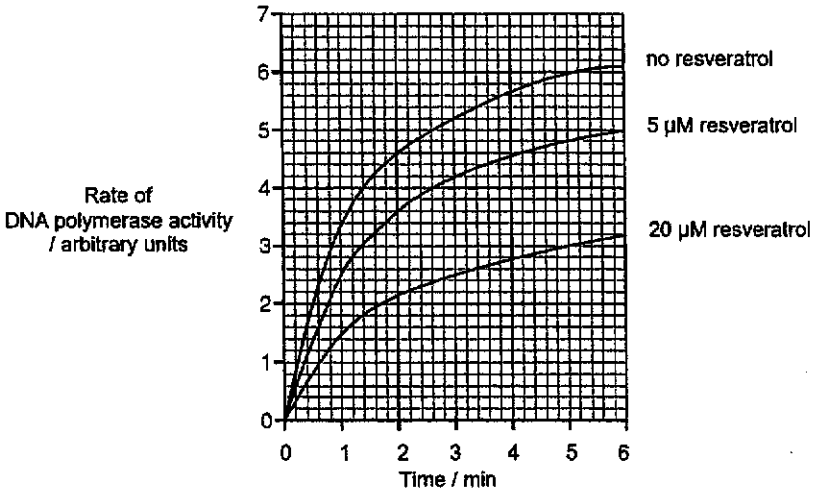

Fig. 2.3

(d) With reference to Fig. 2.3, explain the results of the investigation. [4]

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The structure of resveratrol is shown in Fig. 2.4.

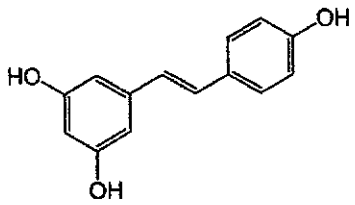

Fig. 2.4

For uptake into cells, resveratrol requires the aid of organic anion-transporting polypeptides (OATPs), a family of transport proteins.

(e) With reference to Fig. 2.4, explain why OATPs are required for resveratrol to be transported across membranes. [3]

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Fig. 2.5 shows two possible graphs that show the relationship between the concentration of resveratrol and the rate of uptake by OATPs.

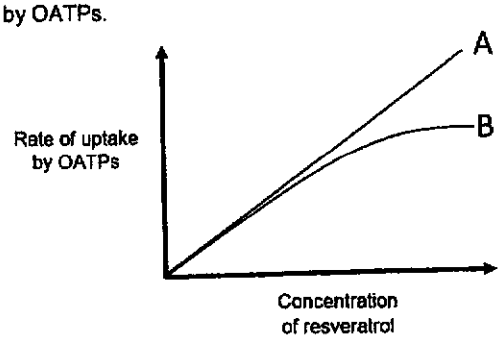

Fig. 2.5

(f) State which graph illustrates the relationship between the variables accurately and explain why. [1]

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[Total: 14]

QUESTION 3

Fig. 3.1 shows two reactions catalysed by Rubisco, an enzyme used in photosynthesis.

$$\text{RuBP} \xrightarrow[\text{Rubisco}]{CO_2} \text{2x Glycerate-3-phosphate}$$

$$\text{RuBP} \xrightarrow[\text{Rubisco}]{O_2} \text{Glycerate-3-phosphate + Phosphoglycolate}$$

Fig. 3.1

(a) Using Fig. 3.1 and your knowledge of the Calvin cycle, explain why starch synthesis in plant cells decreases at high oxygen levels. [3]

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The rate of photosynthesis in the marine seagrass, *Zostera marina*, was investigated under a range of pH conditions (Fig. 3.2). After a period of darkness, the plants were illuminated at a constant light intensity at 15°C and the rate of photosynthesis was measured.

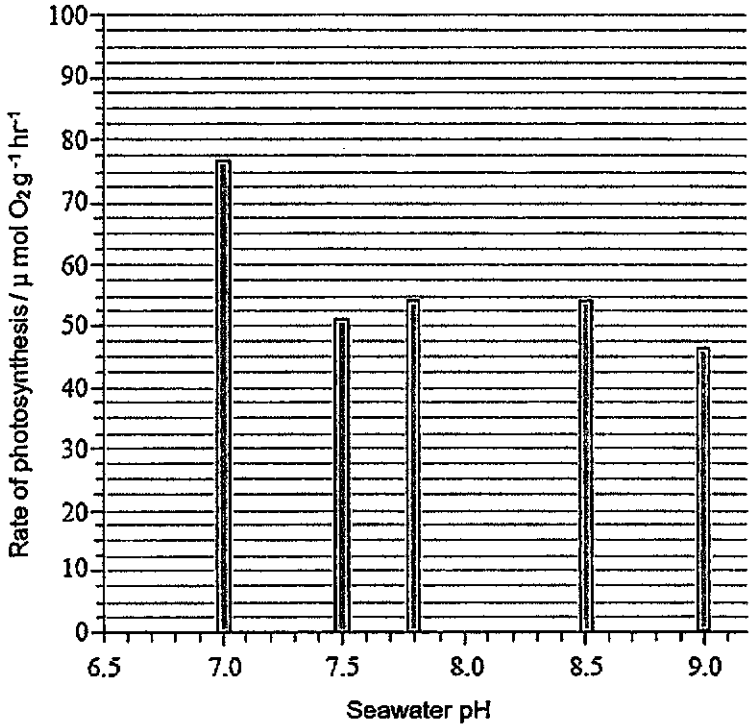

Fig. 3.2

(b) Explain why *Zostera marina* plants were incubated in darkness for a period of time before the start of the experiment. [2]

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(c) With reference to Fig 3.2, explain how the rate of photosynthesis is affected from pH 7 to pH 9. [4]

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(d) Suggest how *Zostera marina* can perform photosynthesis even at very low carbon dioxide concentrations. [1]

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[Total: 10]

QUESTION 4

Fig. 4.1 shows that there is an overexpression of human epidermal growth factor receptor 2 (HER2) protein in breast cancer cells.

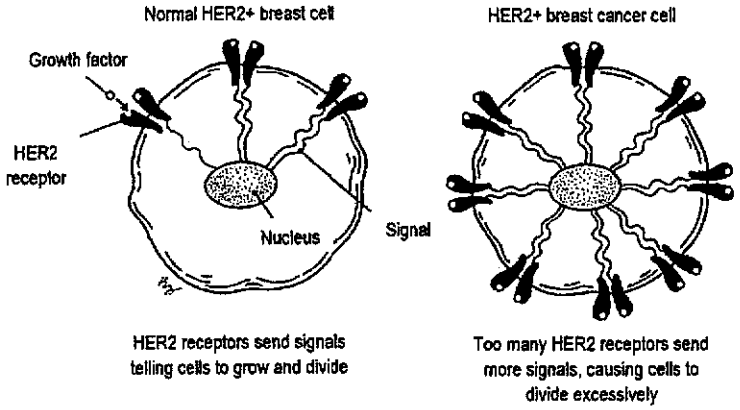

Fig. 4.1

(a) (i) With reference to Fig. 4.1, explain how a chromosomal aberration could lead to an overexpression of HER2 protein. [2]

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(ii) Explain whether HER2 is a proto-oncogene or a tumour suppressor gene. [2]

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Edeine is an antibiotic that inhibits protein synthesis. In an investigation, edeine is added to a cell extract obtained from a developing frog embryo. It was found that edeine stops protein synthesis after a short lag. Analysis of the edeine-inhibited cell extract showed that all the mRNA was found associated with small ribosomal subunit and initiator tRNA.

(b) Explain how edeine inhibits protein synthesis. [2]

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(c) Suggest, with a reason, if edeine can be used as a therapeutic drug to reduce overexpression of HER2 in breast cancer patients. [1]

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[Total: 7]

QUESTION 5

(a) Tuberculosis (TB) is an infectious disease caused by the pathogen *Mycobacterium tuberculosis* that kills about three million people worldwide each year.

Fig. 5.1 is a transmission electron micrograph of the organism that causes tuberculosis.

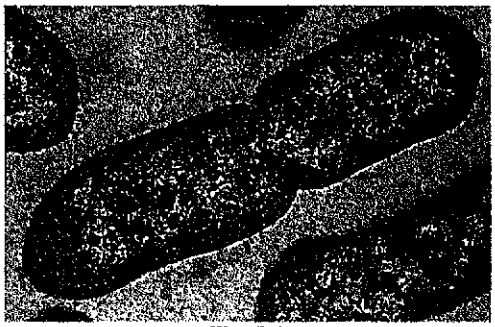

Fig. 5.1

Suggest why the process shown in Fig. 5.1 is more likely to give rise to unequal division of genetic material between daughter cells compared to the equivalent process in eukaryotes. [2]

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In an experiment, a single mutation was induced in the DNA of Organism 1 and the effects of the mutations are recorded in **Table 5.1.**

Table 5.1

Organism 1				
Mutation	**Amount of functional protein A / µg**	**Amount of functional protein B / µg**	**Amount of functional protein C / µg**	**Amount of functional protein D / µg**
Absent	50	44	48	72
Present	0	0	0	73

A similar experiment was conducted on Organism 2 and the result is recorded in **Table 5.2.**

Table 5.2

Organism 2				
Mutation	**Amount of functional protein W / mg**	**Amount of functional protein X / mg**	**Amount of functional protein Y / mg**	**Amount of functional protein Z / mg**
Absent	37	72	29	24
Present	38	71	64	23

(i) State whether Organism 1 and Organism 2 is prokaryotic or eukaryotic. [1]

Organism 1 .....

Organism 2 .....

(ii) With reference to **Table 5.1** and **5.2,** describe and explain how you arrived at this conclusion for:

Organism 1 [2]

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Organism 2 [2]

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(iii) Suggest and explain where the mutation may have occurred in Organism 2. [3]

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[Total: 10]

QUESTION 6

Dengue fever is a disease spread by a particular species of mosquito, *Aedes aegypti*. The incidence of dengue has dramatically increased in recent years. This has heightened the need to understand the vector, as well as the virus. Dengue virus (DENV), an enveloped virus with a single-stranded positive-RNA genome, causes dengue fever. There are four distinct, closely-related DENV, namely DENV-1, DENV-2, DENV-3, and DENV-4.

(a) Describe one structural difference between the genome of the dengue virus and the influenza virus. [1]

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(b) Suggest how the four distinct, closely-related serotypes of the dengue virus may have arisen. [1]

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(c) Fig. 6.1 shows the reproductive cycle of the dengue virus in a human host cell after an individual was bitten by an *Aedes* mosquito carrying the virus.

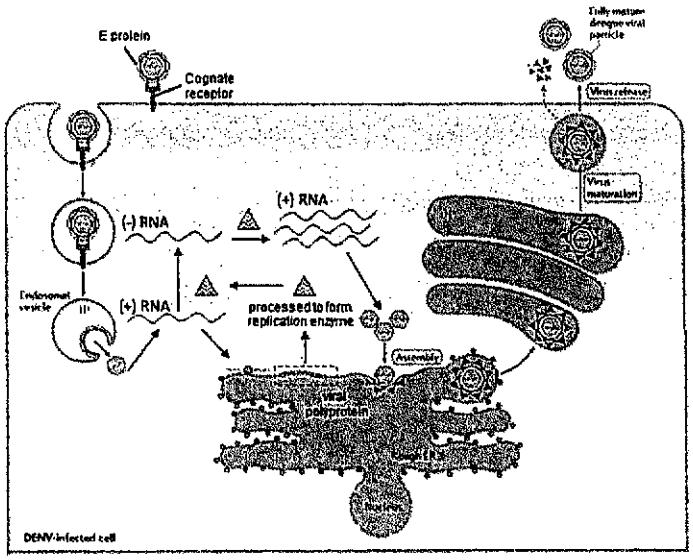

Fig. 6.1

Adapted from Nature Immunology

With reference to Fig. 6.1,

(i) describe how the dengue virus enters its host cell. [3]

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(ii) describe how the dengue virus produces more copies of its genome. [2]

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(iii) suggest two ways how researchers may design a drug to prevent replication of the dengue virus with a human host cell. [2]

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(d) Dengue is the most rapidly spreading mosquito-borne viral disease in the world. In the last 50 years, incidence has increased 30-fold with increasing geographic expansion to new countries and, in the present decade, from urban to rural settings. The shaded areas in Fig. 6.2 are countries at risk of dengue fever.

Fig. 6.2 also shows two contour lines representing the range of January and July isotherm, which indicates the range of *Aedes aegypti* occurrence.

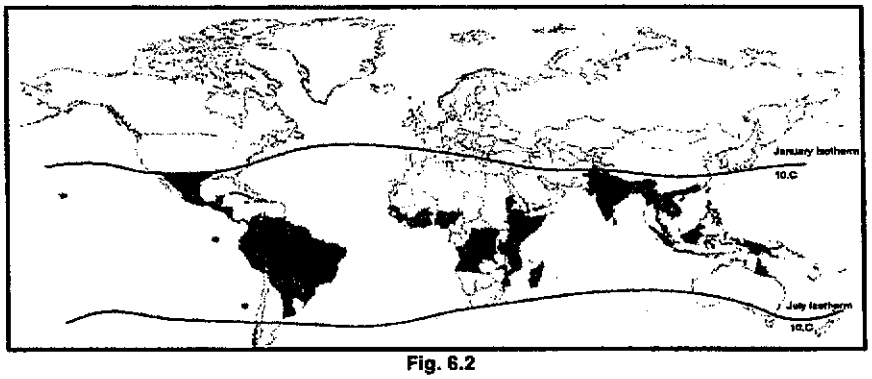

Fig. 6.2

Explain how climate change may affect the spread of dengue beyond the tropics. [3]

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[Total: 12]

QUESTION 7

Nail-patella syndrome is a rare autosomal dominant trait that affects fingernails, toenails, elbows and kneecaps. The locus of the gene for nail-patella syndrome, **N / n**, is 10 map units from the ABO locus on chromosome 9, which will result in a 10% recombination frequency between the two genes.

(a) Explain what is meant by *10% recombination frequency.* [2]

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(b) A man with nail-patella syndrome and blood group AB has a family of five children with his wife who does not have the syndrome and is blood group O.

Three children do not have the nail-patella syndrome and are blood group A.

Two children have nail-patella syndrome and are blood group B.

Illustrate the above cross between the man and his wife with a genetic diagram. [3]

(c) The two children who have nail-patella syndrome and are blood group B are in fact identical twins. They were recruited for a study which investigated the differences expressed by the two individuals. Of the traits studied, they showed differences in only some traits.

Explain what the findings of such a study revealed. [2]

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A group of geneticists researched on another genetic disorder known as hypophosphatemic rickets by studying the inheritance of the disease over four generations in an extended family. Hereditary hypophosphatemic rickets is a genetic disorder that results in low level of phosphate in the blood (hypophosphatemia).

Fig. 7.1 shows the inheritance of this disease over four generations in an extended family.

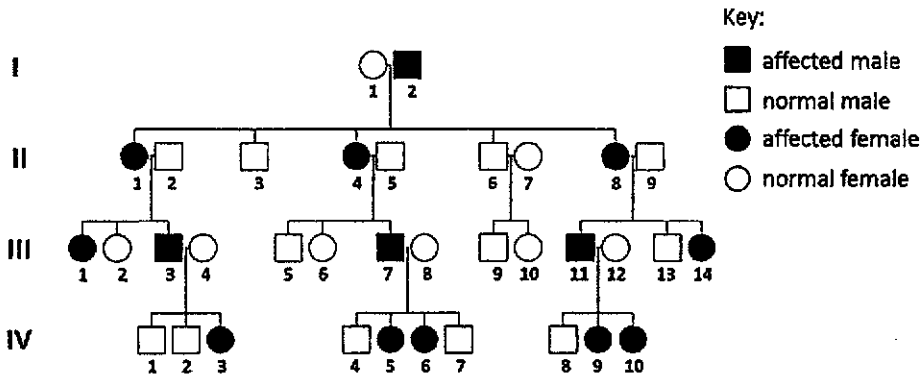

Fig. 7.1

(d) Based on the pedigree chart of the extended family, the geneticists concluded that hypophosphatemic rickets is a recessive trait controlled by a gene located on an autosome.

Comment on the above conclusion. [3]

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[Total: 10]

QUESTION 8

Four species of desert pupfish have evolved from an ancestral population in the Death Valley region of Nevada since the extensive lakes that existed there were reduced to isolated pools 20,000 – 30,000 years ago.

(a) Explain if the formation of the four desert pupfish is an example of microevolution or macroevolution. [2]

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(b) Indicate how environmental factors can act as stabilizing forces of natural selection in an isolated pool after the initial evolution of a new species. [3]

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(c) Suggest what may happen if the water levels rose and the isolated pools once more formed an extensive lake system. [2]

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A scientist attempted to construct the phylogenetic tree of the four pupfish species based on nucleotide sequences, with ages estimated from fossil records.

(d) Explain one advantage of using nucleotide sequences over the use of amino acid sequences in constructing phylogenetic relationships. [1]

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[Total: 8]

QUESTION 9

A vaccine has been available for measles since the 1960s. There are vaccination programmes for many diseases including measles. Babies are born with passive immunity to measles so the vaccine is not given in the first few months after birth.

(a) Explain how active immunity differs from passive immunity. [2]

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(b) Suggest why the vaccine for measles is not given in the first few months of a child's life. [2]

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(c) Explain how vaccines confer an individual protection against viruses such as the measles virus. [4]

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The World Health Organisation (WHO) published data on the vaccination programmes for infectious diseases. The WHO recommends vaccination rate of over 90% of children.

Each health authority in a country reports its success in vaccinating children in their district. The WHO uses these figures to estimate the percentage of districts in each country that vaccinate 90% of children against measles.

The WHO also collects statistics on death rates of children under the age of 5 from all causes including infectious diseases.

Fig. 9.1 shows these statistics for 24 countries for the year 2007.

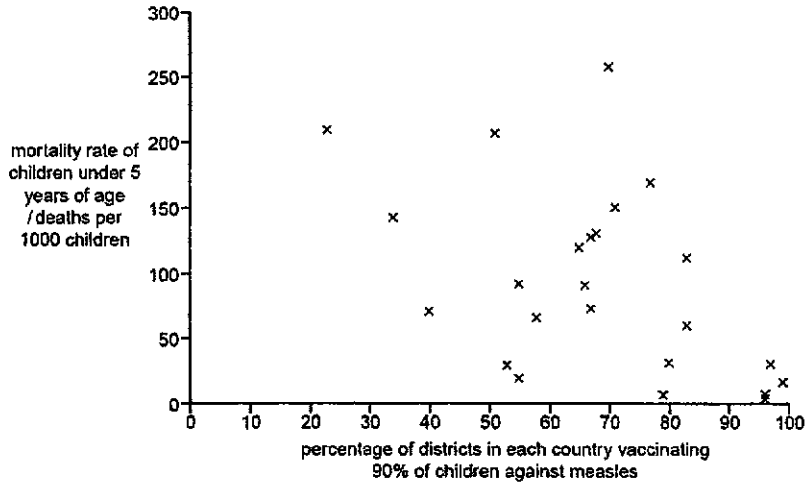

Fig. 9.1

(d) Use the information in Fig. 9.1 to explain why the WHO recommends immunisation of 90% of children. [2]

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[Total: 10]

QUESTION 10

The polar bear, *Urus maritimus*, lives in the Arctic regions of the USA, Canada, Norway and Russia. Polar bears move across the Arctic ice sheet to hunt prey such as seals.

Fig. 10.1 shows a polar bear.

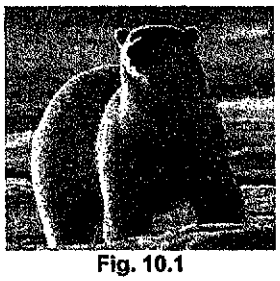

Fig. 10.1

(a) Explain an advantage to scientists in giving polar bears a binomial Latin name, *Urus maritimus*. [1]

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The area over which the Arctic ice sheet extends varies throughout the year.

Fig. 10.2 shows the variation in the extent of the Artic ice sheet for the months of July to November for the years 1979 and 2009.

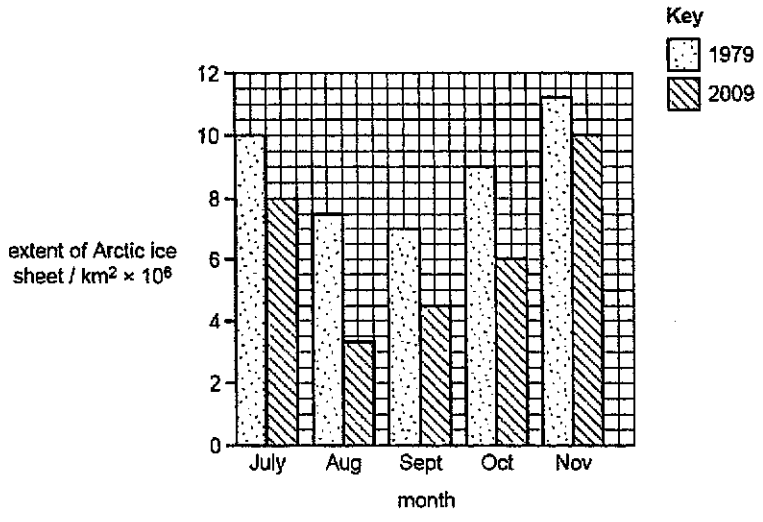

Fig. 10.2

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

Give your answer to the **nearest whole number**. Show your working. [1]

Answer: .....%

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

Using information in Fig. 10.2, suggest what has caused *U. maritimus* to have become endangered. [3]

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[Total: 5]

TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME: _____

CIVICS GROUP: _____ ( )

H2 BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions 24 September 2019

Booklet 1 2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group in the spaces at the **top of this page** and **the cover page of Booklet 2.**
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided within this booklet.
Section B (Booklet 2)
Answer only **one** question in the spaces provided within Booklet 2.

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, **hand in Section A (Booklet 1) and Section B (Booklet 2) separately.**

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

For Examiners' Use	
1	/31
2	/10
3	/9
4 or 5	/25
Total	**/75**

This document consists of 23 printed pages.

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

QUESTION 1
Mitochondria are found in all nucleated eukaryotic cells and are the principal generators of cellular ATP. The mitochondrial genome is a circular DNA comprises 37 genes, which code for 13 essential polypeptides for oxidative phosphorylation and the necessary RNA machinery for their translation within the mitochondria. There are usually more than 100 copies of mitochondrial DNA in one cell, as compared to only two copies of nuclear DNA in one cell.

In recent years, a large and growing number of disorders are known to be due to types of mitochondrial disease (MD).

One form of MD is caused by a mutation of a mitochondrial gene that codes for a tRNA. The mutation involves substitution of guanine for adenine in the DNA base sequence. This changes the anticodon on the aminoacyl-tRNA carrying leucine ($tRNA^{leu}$). This mutant $tRNA^{leu}$ also recognises the phenylalanine codon, resulting in the formation of a non-functional protein in the mitochondrion.

(a) Outline how oxidative phosphorylation produces ATP. [3]

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(b) Explain why there are usually more than 100 copies of mitochondrial DNA in a cell, but only two copies of nuclear DNA. [2]

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(c) Suggest how the change in the anticodon of a tRNA leads to mitochondrial diseases. [3]

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(d) Some MDs are caused by mutations of mitochondrial genes inside the mitochondria. Most MDs are caused by mutations of genes in the cell nucleus that are involved in the functioning of mitochondria. MDs caused by nuclear DNA mutations are autosomal recessive. All of a person's mitochondria are inherited from their mother via the egg cell.

Two couples, couple A and couple B, had one or more children affected by a mitochondrial disease (MD). The type of MD was different for each couple.

None of the parents showed signs or symptoms of MD.

- Couple A had four children who were all affected by an MD.
- Couple B had four children and only one was affected by an MD.

Using the information provided, suggest why all of couple A's children had an MD and only one of couple B's children had an MD. [4]

Couple A

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Couple B

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(e) In women, the first division of meiosis produces one daughter cell that has almost all of the cytoplasm. The other daughter cell, known as a polar body, consists of a nucleus surrounded by a very small amount of cytoplasm and a cell surface membrane.

One proposed treatment of mitochondrial disease is:

- removing the nucleus from an egg cell donated by a woman with healthy mitochondria
- replacing this nucleus with the nucleus of the polar body from a woman whose egg cells are affected by mitochondrial disease.

Suggest the advantages of this treatment for mitochondrial diseases. [2]

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(f) Mitochondrion plays an important role in regulating insulin secretion.

Fig. 1.1 shows the steps involved in the release of insulin from pancreatic islet beta cells, which involves three types of transmembrane proteins.

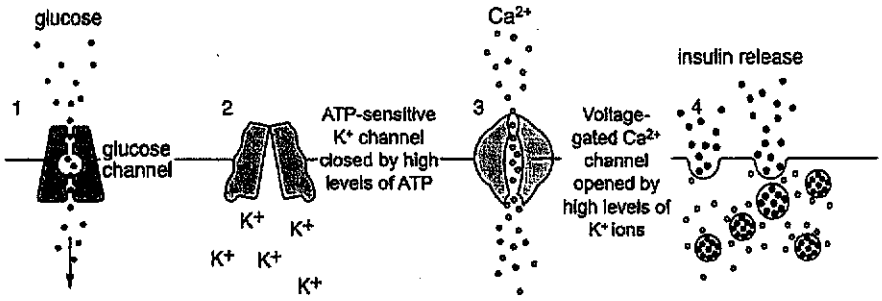

Fig. 1.1

Using the information provided in Fig. 1.1, explain how defective mitochondria affect the release of insulin by pancreatic islet beta cells. [4]

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(g) A research study explored the possibility of using embryonic stem cell as a potential treatment for type 1 diabetes.

In the study, mouse embryonic stem (ES) cells were grown in culture and chemical signals were added to the culture to allow the ES cells to differentiate into ES cell-derived insulin-producing cells. To determine whether the ES cells are producing insulin, the amount of insulin mRNA was measured using the reverse transcription polymerase chain reaction (RT-PCR).

RT-PCR uses a reaction mixture containing:

- the sample for testing
- reverse transcriptase
- DNA nucleotides
- primers
- DNA polymerase
- fluorescent dye.

The principles behind this method is shown in Fig. 1.2.

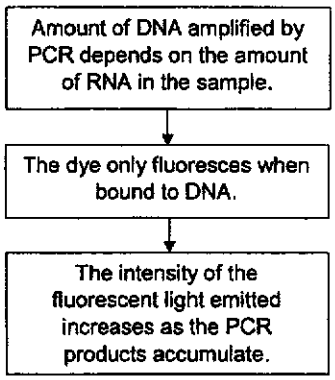

Fig. 1.2

(i) Describe the role of reverse transcriptase in RT-PCR. [1]

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(ii) Outline the process of polymerase chain reaction. [3]

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Fig. 1.3 shows the results of using RT-PCR to detect insulin mRNA in two different samples of ES cell-derived insulin-producing cells, A and B.

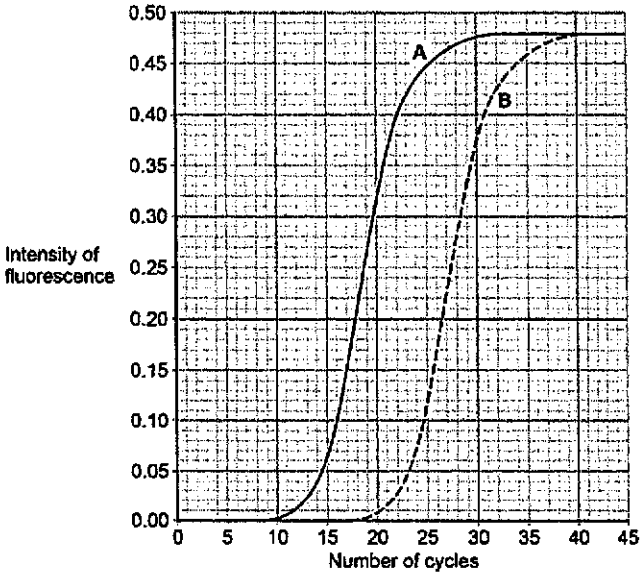


Fig. 1.3

(iii) A quantitative comparison can be made of the amount of RNA in samples **A** and **B**. This involves determining the number of cycles required to reach 50% maximum concentration of DNA (c).

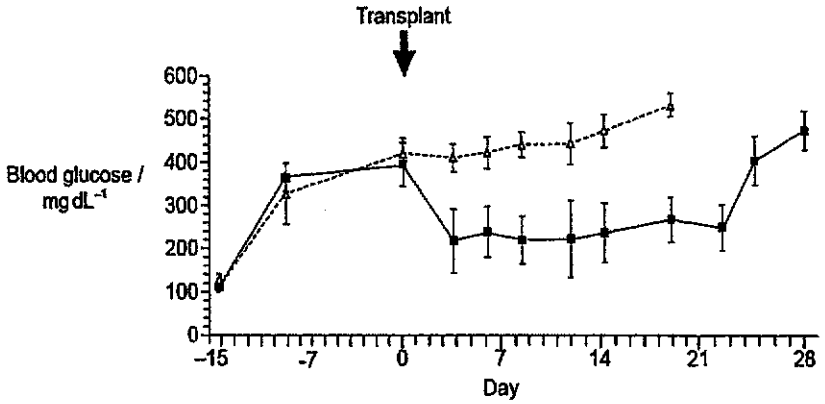
The amount of RNA in a sample can be measured as $\frac{1}{c}$

Using this information, calculate the amount of RNA content in samples **A** and **B**. Show clear working and leave your answers to 2 decimal places. [2]

During the experiment, a drug was injected into two groups of healthy mice in order to simulate type I diabetes 15 days prior to the transplant of the ES cell-derived insulin-producing cells. Type I diabetes is a diabetic state in mice with blood glucose concentrations greater than 350mg/dL.

The mice in the transplant group received the ES cell-derived insulin-producing cells. The control group did not receive the transplant. Control mice exhibited persistent hyperglycemia (blood glucose levels ranging between 350mg/dL and 500mg/dL) and all died by day 19.

Fig. 1.4 shows the blood glucose concentration in both groups.



Key: --▲-- control group —■— transplant group

Fig. 1.4

(iv) Describe the characteristics of embryonic stem cells that enable them to be used for this experiment. [3]

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(v) With reference to Fig. 1.4, compare the concentration of blood glucose resulting from the embryonic stem cell transplant with the control. [2]

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(vi) Discuss whether the embryonic stem cell treatment is effective in controlling blood glucose level. [2]

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[Total: 31]

QUESTION 2

2,4-D is a selective herbicide that kills some species of plants but not others. 2,4-D disrupts cell surface membranes but the extent of disruption differs in different species.

Scientists investigated the effect of 2,4-D on wheat plants (a crop) and on wild oat plants (a weed).

They grew plants of both species in glasshouses. They put plants of each species into one of two groups, W and H, which were treated as follows:

- Group W – leaves sprayed with water
- Group H – leaves sprayed with a solution of 2,4-D.

After spraying, they cut 40 discs from the leaves of plants in each group and placed them in flasks containing 10 cm^3 de-ionised water. After 5 minutes, they calculated the disruption to cell surface membranes by measuring the concentration of ions released into the water from the leaf discs.

Their results are shown in Table 2.1.

Table 2.1

Group	Treatment	Mean concentration of ions in water / arbitrary units	
		Wheat	Wild oats
W	Water	26	45
H	2,4-D	27	70
Probability of difference occurring by chance		P=0.5	P=0.0001

(a) Using the information provided, evaluate the use of 2,4-D as a herbicide on a wheat crop that contains wild oats as a weed. [4]

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(b) Many other herbicides act by inhibiting photosynthesis in weeds. Triazine herbicide acts on the weeds by binding to a specific protein associated with photosystem II, blocking the movement of electrons between electron carriers.

Explain the effect of triazine herbicide on photosynthesis in weeds. [2]

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Wheat and other crops have been genetically modified to be resistant to triazine since 1996.

Fig 2.1 shows the area of triazine-resistant crops grown as a percentage of the total planted hectares (plotted points) and the number of weed species with resistance to triazine (bars).

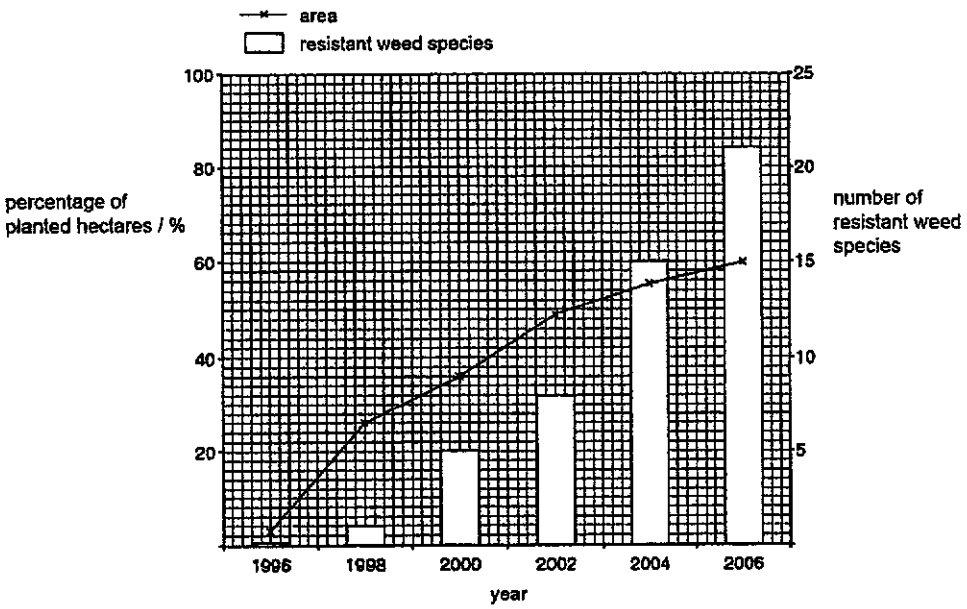

Fig. 2.1

(c) Describe the relationship between the area of triazine-resistant crops grown and the number of resistant weed species from 1996 to 2006. [2]

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(d) Suggest **one** social advantage and **one** environmental advantage of growing triazine-resistant wheat. [2]

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[Total: 10]

QUESTION 3

Coral reefs are among the most spectacular ecosystems on Earth. In Papua New Guinea, the data on the effect of ocean temperature on coral cover were collected as shown in Fig. 3.1. Coral cover is the percentage of the reef surface covered by live hard coral.

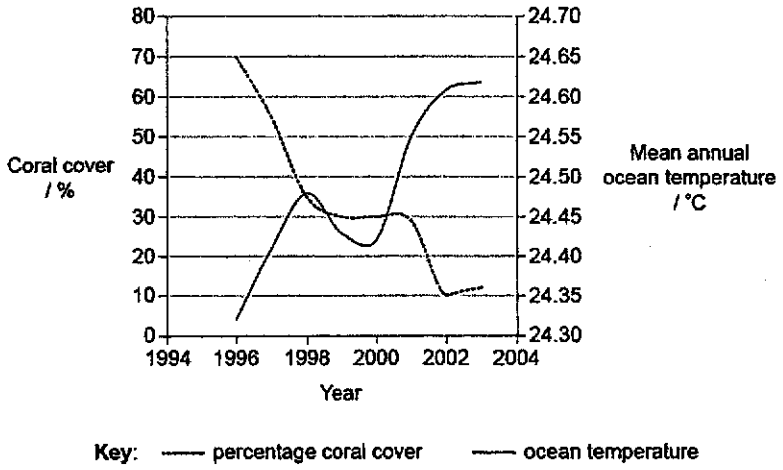

Fig. 3.1

(a) Describe the evidence that the ocean temperature has an effect on coral cover. [2]

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(b) Suggest the causes for the changes in ocean temperature. [3]

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(c) Explain why coral reefs will be affected by an increase in ocean temperature above their optimum. [2]

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In order to test the effect of temperature, live samples of a species of coral, *Pocillopora damicornis*, were placed in an experimental chamber at a constant pH, water depth and low light. All the coral samples were started at 26°C and half of them were rapidly increased to 30°C as shown in Fig. 3.2.

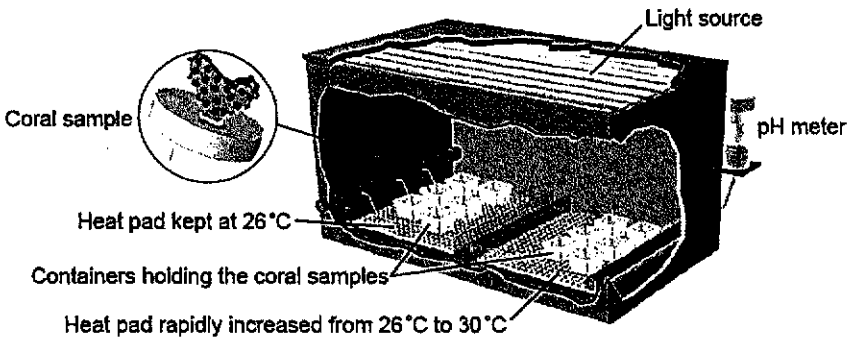

Fig. 3.2

The pie charts in Fig. 3.3 show the percentage of live and dead coral tissues at the end of the experiment.

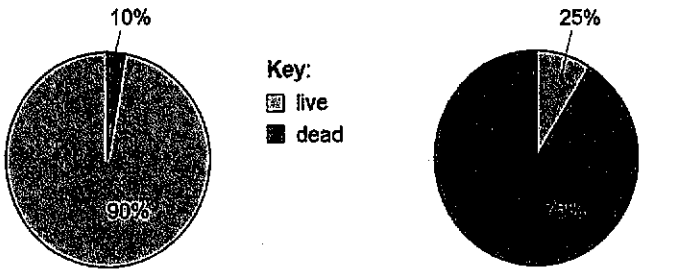

Fig. 3.3

(d) Comment on whether the experimental data in Fig. 3.3 supports the observed data from the ocean in Fig. 3.1. **[2]**

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[Total: 9]

End of Section A
Proceed to Section B (Booklet 2)

Candidate Name	Civics Group	Index Number

Question 4/5
/ 25

TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION 2019

H2 / 9744 Biology

PAPER 3

Section B (Booklet 2)
Free-response Questions

Answer **one** question in this section.

Write your answers on the lined paper provided in this question paper.

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

Your answers must be in continuous prose, where appropriate.

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

QUESTION 4

(a) Pathogens cause disease in humans. Pathogenic bacteria are thought to have emerged when groups of virulent genes are transferred into a previously non-pathogenic bacterium. Antibiotics are used to treat bacterial infections in humans. However, some pathogenic bacteria have evolved to become resistant to antibiotics.

Describe how the virulent genes are transferred from a pathogenic bacterium naturally into a non-pathogenic bacterium and suggest how a population of pathogenic bacteria may have evolved to develop antibiotic resistance. [13]

(b) Many microorganisms live in or on the human body without causing disease. An example of such microorganisms is the *Escherichia coli* (*E. coli*) which colonise the intestine and obtain nutrients from their surroundings.

Describe how *E. coli* respond to the presence of lactose in the intestine and explain how a mutation in the regulatory sequences of the *lac* operon may affect how *E. coli* respond to changes in lactose supply. [12]

[Total: 25]

QUESTION 5

(a) Discuss, with examples, the importance of specific shapes of proteins in organisms. [13]

(b) Comparisons of the patterns of mRNA levels in the cytosol across different human cell types show that the level of expression of almost every active gene is different.

Describe how the level of mRNA of the same gene across the different human cell types is controlled and suggest the advantage of each level of control. [12]

[Total: 25]

End of Paper

TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME: _____

CIVICS GROUP: _____ ( )

H2 BIOLOGY

Paper 4 Practical

9744/04

17 September 2019
2 hours 30 minutes

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on 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 and graphs.
Do not use staples, paper clips, glue or correction fluid/tape.

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	/ 21
2	/ 14
3	/ 20
Total	**/ 55**

This document consists of 17 printed pages and 1 blank page.

QUESTION 1

A grocer has been buying milk from the same supplier for a number of months. Recently, the grocer has found that the milk has been diluted with water. Milk contains macromolecules like proteins which are denser than water thus milk sinks when placed in aqueous solutions.

(a) Predict the behaviour of a milk droplet when placed in water with respect to milk's water content.

.....

..... [1]

The amount of water added to a milk sample can be determined by measuring the density of the milk using aqueous solutions like copper sulfate solution of a standard concentration. When a small drop of milk is placed in copper sulfate, a layer of copper proteinate forms around the milk and this prevents the milk and copper sulfate solution mixing.

Fig. 1.1 shows the movement of a drop of milk through the copper sulfate solution.

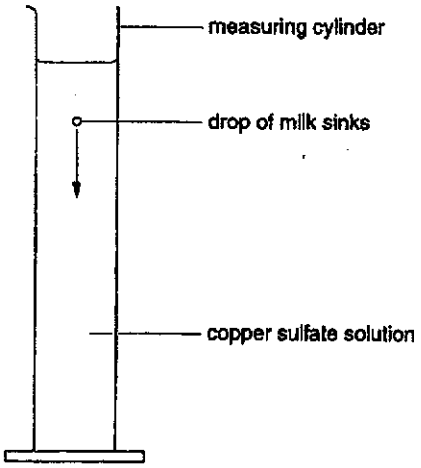

Fig. 1.1

You are required to estimate the percentage of water added to the milk supplied to the grocer.

You are provided with

- 100% milk, labelled **M**
- milk sample supplied to grocer, labelled **B**
- distilled water, labelled **W**
- 0.03 moldm^{-3} copper sulfate, labelled **C**

You are advised to read through the entire procedure before beginning the experiment.

1 Prepare 10.0 cm^3 each of a suitable number of concentrations of milk to help you in your investigation. Record the volume of 100% milk, **M** and distilled water, **W** used in your preparation in a table below.

[3]

2 Using the syringe with attached needle, release one drop of **M** into **C** in a measuring cylinder.

3 Repeat **step 2** for all milk concentrations and milk sample B you have prepared in **step 1**. You may reuse the copper sulfate unless the milk residue obstructs your vision.
Record the time taken by the droplet to sink in an appropriate format in the space provided below. [3]

Note: Needle attached to syringe is sharp. Handle with care. Keep needle capped when not in use.

Observe the largest fragment of **M** should the droplet break up in the copper sulfate solution.

4 Repeat the procedure to obtain a **total of 2 replicates**. Perform appropriate calculations on your readings. [1]

5 Describe how you would carry out **step 2** to increase the accuracy of your observations.

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..... [3]

6 Estimate the percentage of water added to the milk sample supplied to the grocer, **B**. Explain how you derived at your answer.

percentage of water added ..... [1]

Explanation .....

.....

.....

..... [2]

7 Describe **one** way to improve your estimate in terms of

(a) reliability;

.....

..... [1]

(b) accuracy.

.....

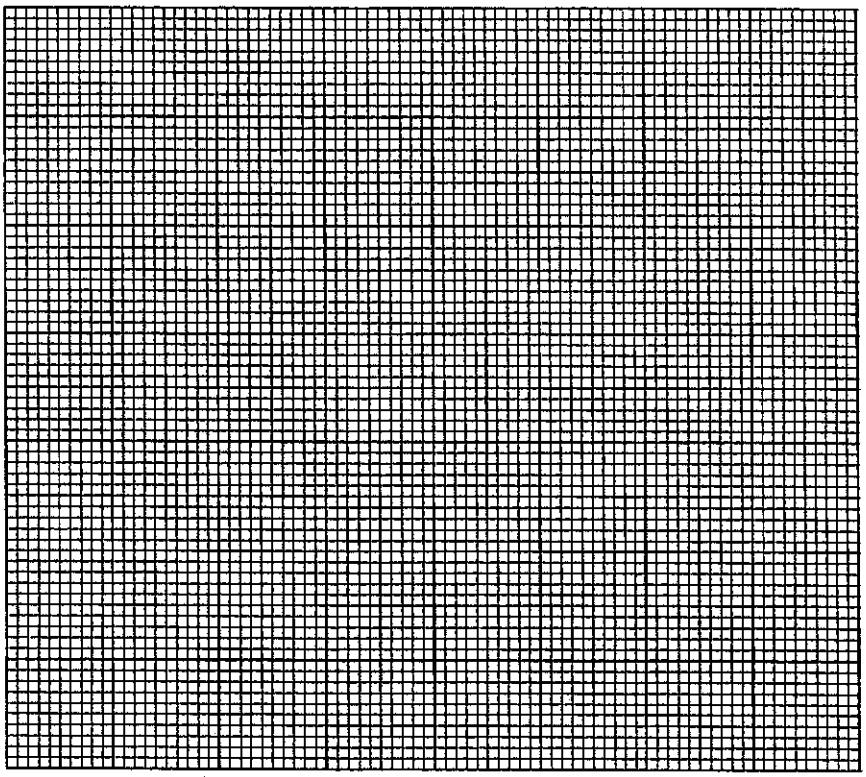
..... [1]

Further investigation was conducted to find the protein concentration in sample **B** using Biuret's test. The absorbance by sample **B** was measured using a colorimeter and compared to a range of protein solutions of known concentrations. Table 1 shows the absorbance by the protein solutions.

Table 1

Protein concentration / %	Absorbance / arbitrary units
100	65
80	55
60	38
40	21
20	10

8 Plot a suitable graph using data provided in Table 1.



[3]

9 The absorbance of the milk sample **B** was recorded to be 26 arbitrary units. Using your graph, deduce the protein concentration in the milk sample **B**. Show on your graph, how you arrived at your answer.

protein concentration of milk sample, **B** ..... [2]

[Total: 21]

QUESTION 2

Urinary tract infection (UTI) is an infection in any part of the urinary system which includes ureter, bladder and urethra. Women are at greater risk of developing UTI. Ciprofloxacin is an antibiotic that is used to treat urinary tract infections by killing the *Escherichia coli* bacteria which is the main cause of infection.

In an investigation, a student was provided with Petri dishes containing nutrient agar. Each Petri dish had already been inoculated with *Escherichia coli* and incubated to produce an evenly distributed growth of the bacteria (a bacterial lawn).

In a trial investigation, the student cut four wells into the agar and added distilled water to one of them and three different concentrations of ciprofloxacin solution to the others.

Fig. 2.1 shows the result after incubating the Petri dish for 24 hours.

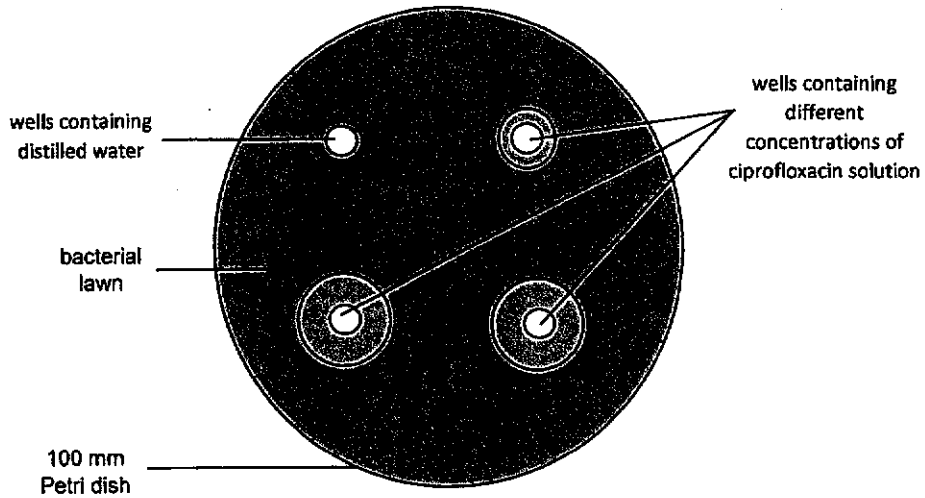


Fig. 2.1

The clear zones around the wells containing ciprofloxacin solution showed that the *Escherichia coli* had been killed, whilst none had been killed by the distilled water. The student noticed that the two highest concentrations of ciprofloxacin tested had clear zones that were of the same size.

The student read that cranberry juice was able to significantly reduce the growth of *Escherichia coli*.

The student wanted to find the most effective concentration of cranberry juice that gives the largest clear zone possible.

Using this information and your own knowledge, design an experiment to find the **lowest** concentration of cranberry juice that gives the largest clear zone possible.

You must use:

- 100 cm^3 20% cranberry juice,
- 200 cm^3 distilled water,
- prepared 100 mm diameter agar plates, with a lawn of *Escherichia coli.*,
- disinfectant (sterilizing) solution and paper towels.

You may select from the following apparatus:

- set of cork borers with diameters from 4 mm to 15 mm
- normal laboratory glassware, e.g. beakers, measuring cylinders, graduated pipettes, glass rods, etc.,
- incubator
- autoclave (a pressurised oven for heating sterilizing apparatus and materials)
- bunsen burner
- sticky tape / parafilm
- mm ruler
- syringes.

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
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible
- show how you will record your results and the proposed layout of results tables and graphs 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: 14]

QUESTION 3

Fig. 3.1 is a photomicrograph of a stained transverse section through part of a plant leaf. This plant species is native to part of Asia.

You are not expected to have studied this leaf.

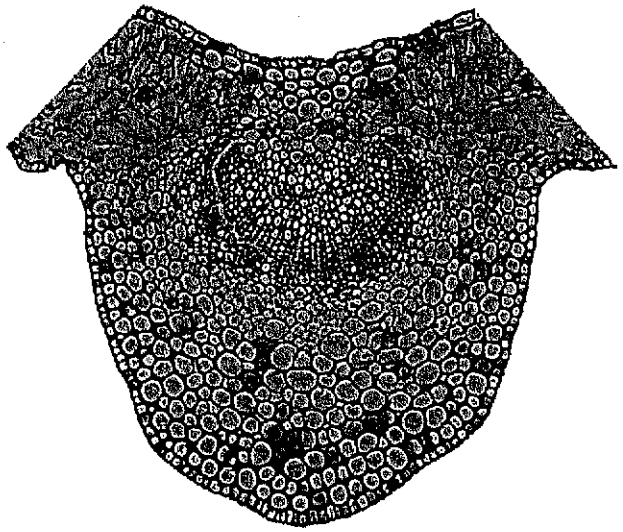


Fig. 3.1

(a) Draw a large plan diagram of the part of the leaf shown in Fig. 3.1.
On your diagram, use a ruled label line and label to show the vascular bundle.

[4]

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.

However, to help draw the correct shape and proportion of tissues, as in **(b)**, it is **not** necessary to calibrate the eyepiece graticule scale.

L1 is a stained, longitudinal section showing the tissues of a young root tip.

(b) Draw a large plan diagram of **L1**.

Use a ruled label line and a label to show the position of the area in which you can see cells showing stages of mitosis.

[5]

Fig. 3.2 is a photomicrograph of root cells.

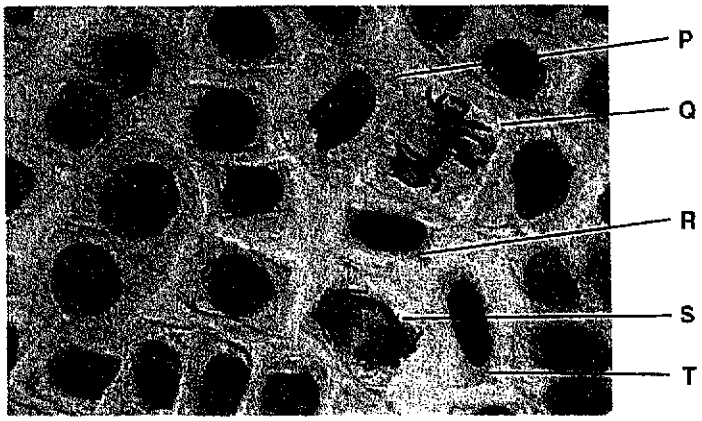


Fig. 3.2

(c) Make a large drawing of each of the **five** cells labelled **P**, **Q**, **R**, **S** and **T** on Fig. 3.2.

On your drawing use ruled label lines and labels to identify two **different** stages of mitosis.

Annotate **one** of the stages to describe **one** observable feature that supports your identification.

[5]

Fig. 3.3 is a photomicrograph of root cells from a different region of the root.

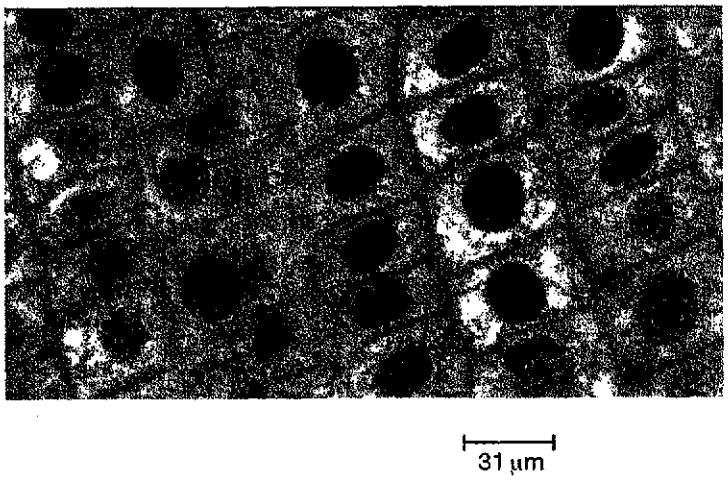


Fig. 3.3

(d) Use the scale bar below Fig. 3.3 to calculate the magnification of Fig. 3.3.
You may lose marks if you do not show your working or if you do not use appropriate units.

Magnification:_____

[2]

Fig. 3.2 is shown again here to help you answer **(e)**.

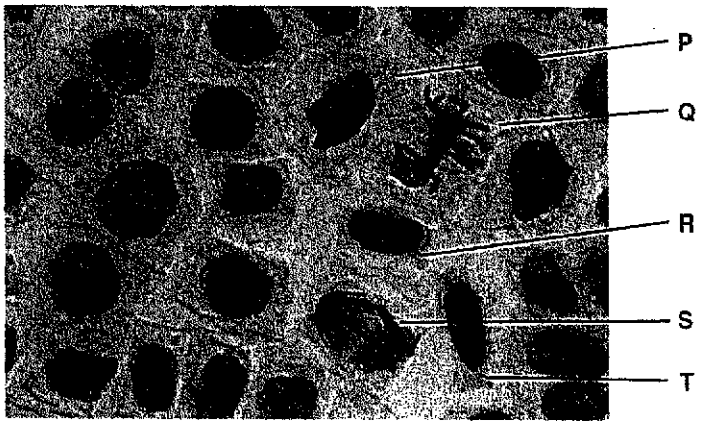


Fig. 3.2

(e) Prepare the space below so that it is suitable for you to record **three** observable differences between the specimens in Fig. 3.2 and in Fig. 3.3.

Record your observations in the space you have prepared.

[4]

[Total: 20]

End of paper

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TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME: _____

CIVICS GROUP: _____ ( )

H2 BIOLOGY

9744/01

Paper 1 Multiple Choice Questions

27 September 2019
1 hour

Answers

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

BP~427

TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

SUGGESTED ANSWERS

CANDIDATE NAME: _____

CIVICS GROUP: _____ ( )

H2 BIOLOGY

Paper 2 Structured Questions

9744/02

20 September 2019

2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, index number and civics group in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid/tape.

Answer all questions in the spaces provided in 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	
1	/ 14
2	/ 14
3	/ 10
4	/ 7
5	/ 10
6	/ 12
7	/ 10
8	/ 8
9	/ 10
10	/ 5
Total	**/ 100**

This document consists of 29 printed pages and 1 blank page.

QUESTION 1

Fig. 1.1 shows a yeast cell.

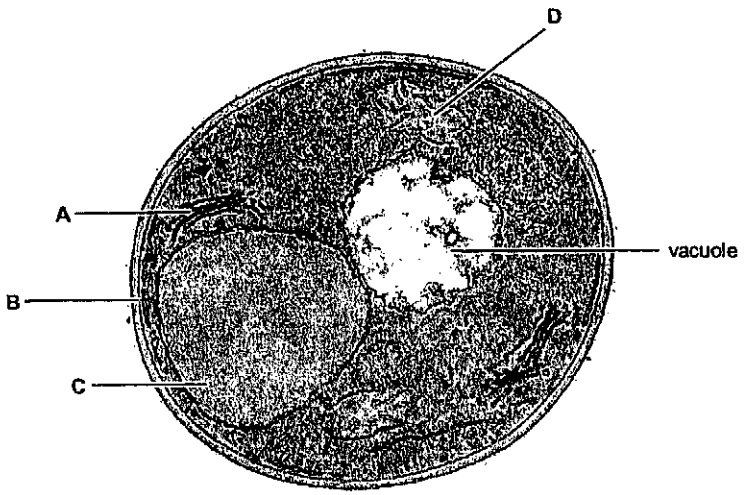


Fig. 1.1

(a) Compare the structures of organelles **C** and **D**. [KU-2] [2]

Similarities [Max 1]:

- Both have a double membrane
- Both contain DNA

Differences [Max 1]:

Feature	C: Nucleus	D: Mitochondrion
Inner membrane	Not folded	Highly folded to form cristae
Shape of DNA present	Linear	Circular

(b) Explain how structures **A**, **B** and **D** are functionally related. [KU-2] [3]

- At the trans-face of the Golgi apparatus (A), modified proteins and lipids are **sorted and packaged** into **Golgi/ secretory vesicles**
- Golgi vesicles **diffuse** to the cell surface membrane via **microtubules**, requiring **ATP produced by mitochondria (D)** via cellular respiration
- Golgi vesicles **fuse with cell surface membrane (B)** and modified proteins and lipids are secreted out of the cell via **exocytosis**
- Golgi vesicles help to **replenish the cell surface membrane (B)** lost through endocytosis

Fungal cells like yeast are bound by a thick cell wall made of chitin, a polysaccharide made of N-acetylglucosamine. Fig. 1.2 shows the structure of chitin.

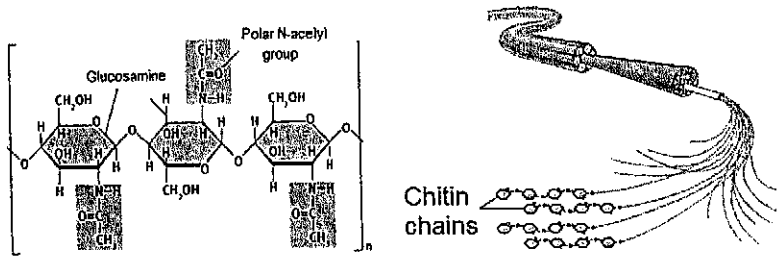


Fig. 1.2

(c) With reference to Fig 1.2, explain why chitin has high tensile strength. [HI-2] [4]

- Chitin is formed with **N-acetylglucosamine** joined together by β-**1,4 glycosidic bonds**
- **β-1,4 glycosidic bonds** are **unreactive** and **not easily degraded**, making chitin stable
- **Alternate N-acetylglucosamine** in chitin chain is **rotated 180°**
- This allows polar **–OH groups and N-acetyl groups** in chitin chains to be **projected outwards** in all directions
- This allows extensive **cross-linking** between chitin chains by formation of **hydrogen bonds** between –OH groups and N-acetyl groups across parallel chains
- Parallel chitin chains associate together to form **microfibrils**, which are arranged in larger bundles to form **fibres**/ Parallel chitin chains associate together to form a **fibrous structure**, giving it high tensile strength

Chitinase is an enzyme found in plants. It degrades chitin in fungal cell walls and exoskeletons of insects, protecting the plants against a range of pathogens.

(d) Describe one way in which chintinase lowers the activation energy and increases the rate of chitin hydrolysis. [KU-1] [1]

- Chintinase holds chitin in a **correct orientation** inside its active site for hydrolysis reaction to occur.
- When chitin is bound to chitinase's active site, **physical stress/ strain** of the **β-1,4 glycosidic bond is induced**, increasing the likelihood that the bond will break to release N-acetylglucosamine
- When R groups of amino acid residues at the active site of chitinase are very close to chitin, they **increase reactivity of chitin** by **altering the distribution of electrons** within the **β-1,4 glycosidic bond** OR **changing the charge on chitin**

(Any 1)

BP~429

A student isolated the chitinase gene from yeast cells and inserted it into *E. coli* cells for protein production. Chitinase from yeast and *E. coli* cells were then extracted and purified separately. The following observations were made by the student during this process:

- The amount of chitinase mRNA transcribed in yeast and *E. coli* cells was similar
- Chitinase produced in *E. coli* had a lower molecular weight than those produced in yeast cells

The student then tested the activity of chitinase produced from both cells. The result obtained is shown in Fig 1.3.

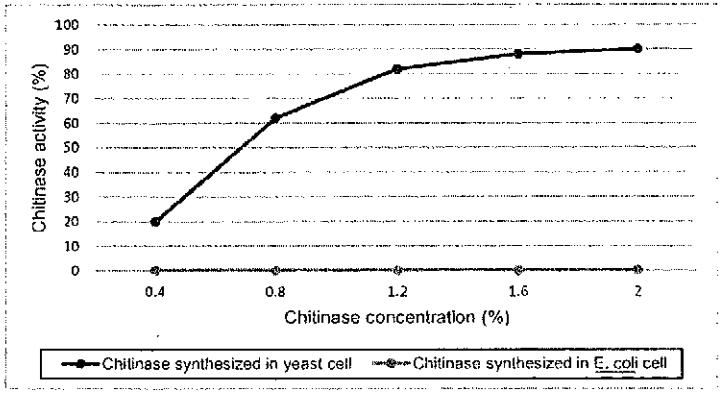


Fig. 1.3

(e) Assuming that no mutations have taken place, account for the results shown in Fig. 1.3. [HI-3]
[4]

[Describe data – compulsory point]

- As **chitinase concentration increased from 0.4% to 2%**, the **activity of chitinase synthesized in yeast cells increased from 20% to 90%**, however, the **activity of chitinase synthesized in *E. coli* cells remained constant at 0%**.

[Explain – max 2m]

- *E. coli* cells are **prokaryotic**, while yeast cells are **eukaryotic**

+

- *(Idea that)* Prokaryotic *E. coli* cells are unable to carry out the specific eukaryotic **post-transcriptional modifications/ RNA splicing** → Translation of introns could result in premature termination of translation, hence chitinase produced in *E. coli* are of lower molecular weight

OR

- *(Idea that) E. coli* contains **70S ribosomes while yeast cells contain 80S ribosomes**, hence **70S ribosomes do not recognise mRNA of eukaryotic origin as efficiently**

- This makes translation process in *E. coli* cells **unstable** with **premature termination**, resulting in chitinase of lower molecular weight

[Extra information: Prokaryotic genes have sequence upstream of start codon that is transcribed onto mRNA (Shine-Dalgarno sequence); this promotes ribosome binding for translation. This is not found in eukaryotic genes.]

OR

- *(Idea that)* Prokaryotic *E. coli* cells are unable to carry out the specific eukaryotic **post-translational modifications/ biochemical modifications** required for chitinase activation, resulting in chitinase of lower molecular weight

[Conclusion – max 1m]

- *(Idea that)* Folding of chitinase is inaccurate/ chitinase changes conformation + **chitinase is rendered non-functional**

- **Active site of chitinase is not complementary to chitin + chitinase is rendered non-functional**

[Note: chitinase rendered non-functional only need to be mentioned once]

[Reject: *E. coli* does not carry out post-transcriptional modification/ RNA splicing does not occur (without further explanation). This would result in chitinase of higher molecular weight as introns are translated.]

[Total: 14]

QUESTION 2

Fig. 2.1 shows DNA replication occurring in a cell.

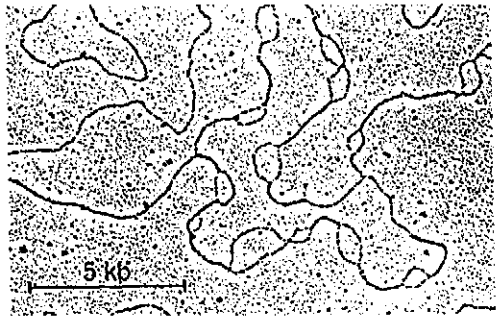


Fig. 2.1

(a) With reference to Fig. 2.1, explain if this cell is prokaryotic or eukaryotic. [HI-1] [1]

- **Eukaryotic; Multiple origins of replication/ Multiple replication bubbles**

Fig. 2.2 illustrates how DNA replication occurs at a replication fork.

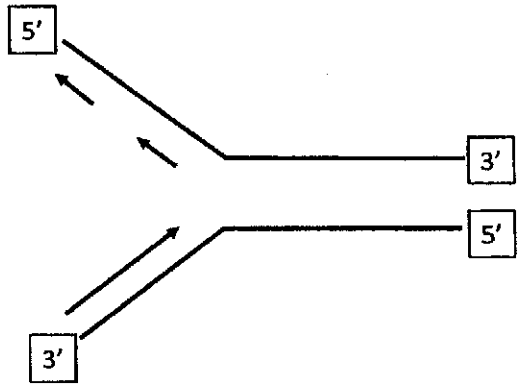


Fig. 2.2

(b) In the four boxes provided in Fig. 2.2, indicate the direction of the DNA template strands. [HI-1] [1]

(c) Fig. 2.2 shows the differences between the synthesis of two daughter strands.

With reference to Fig. 2.2, explain why DNA replication at each replication fork is described as *'asymmetrical'* replication. [KU-2] [4]

[Describe]

- The **leading strand** is **synthesized continuously towards the replication fork**
- The **lagging strand** is synthesized **discontinuously away from the replication fork** as short fragments called **Okazaki fragments**
- **Multiple RNA primers** are needed to synthesize the lagging strand as the DNA continues to unwind, while only **one RNA primer** is needed to synthesize the leading strand

[Accept: contrasting statements for the following features: Synthesis, direction of synthesis with regards to replication fork, number of primers needed: 1m each]

[Explain – max 2m]

- **DNA polymerase III** has an **active site** with a shape that is **complementary to the 3'-OH end** of existing nucleotide strand
- DNA polymerase III only **adds deoxyribonucleotides to free 3'-OH ends**, synthesizing daughter strands in a **5' to 3' direction**
- DNA replication proceeds in opposite directions because parental DNA strands are **anti-parallel**

Resveratrol is a natural compound found in many dietary plants and in red wine. It plays an important role in the prevention of many human pathological processes.

An experiment was carried out to investigate how resveratrol affects the activity of DNA polymerase. The results are shown in Fig. 2.3.

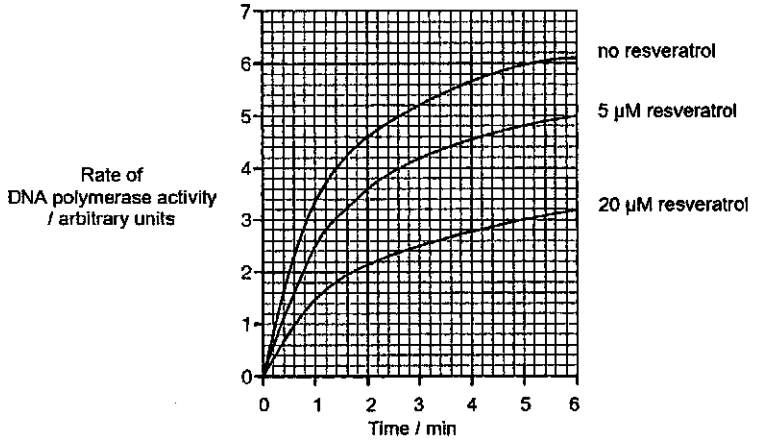


Fig. 2.3

(d) With reference to Fig. 2.3, explain the results of the investigation. **[HI-2]** [4]

[Describe]

- **As resveratrol increases** from **0 μM to 5 μM (or 0 μM to 20 μM, or 5 μM to 20 μM)**, there was an overall **decrease in rate of DNA polymerase activity** from **6.1 AU to 5 AU (or 3.2 AU for 20 μM)**

[accept trend data citation]

- Resveratrol is **not structurally similar to deoxyribonucleotides**, the natural substrate of DNA polymerase.

[Explain]

- Resveratrol is a **non-competitive inhibitor** of DNA polymerase, which **binds at a site away from the active site.**
- The **conformation of the active site changes** upon binding with resveratrol, hence **deoxyribonucleotides are no longer complementary to the active site** of DNA polymerase and cannot bind
- This **decreases the rate of formation of enzyme-substrate complexes**, hence **decreasing the rate** of DNA polymerase activity
- **V_{max} cannot be reached** as effective concentration of DNA polymerase decreases

The structure of resveratrol is shown in Fig. 2.4.

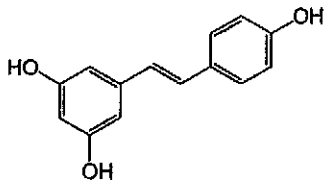


Fig. 2.4

For uptake into cells, resveratrol requires the aid of organic anion-transporting polypeptides (OATPs), a family of transport proteins.

(e) With reference to Fig. 2.4, explain why OATPs are required for resveratrol to be transported across membranes. **[HI-2]** [3]

- Resveratrol is **large**, hence it cannot pass the small temporary gaps created by phospholipids moving laterally within the membrane
- Resveratrol contains three **–OH groups**, which are **polar/ hydrophilic**. Hence these will be **repelled by the non-polar/ hydrophobic fatty acid tails** of the phospholipid bilayer.
- OATPs is a **channel protein** that provides a **hydrophilic passage** for resveratrol to pass through the phospholipid bilayer
  OR
  OATPs is a **carrier protein** that provides **hydrophilic binding sites** for resveratrol to pass through the phospholipid bilayer after the carrier protein changes conformation upon binding with resveratrol

Fig. 2.5 shows two possible graphs that show the relationship between the concentration of resveratrol and the rate of uptake by OATPs.

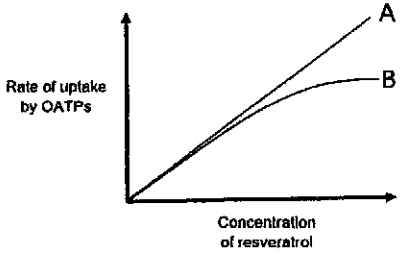


Fig. 2.5

(f) State which graph illustrates the relationship between the variables accurately and explain why. **[HI-2]** [1]

- **B**; Transport proteins/OATPs will be **saturated** at high resveratrol concentration, hence **rate of resveratrol uptake will remain constant**/ graph will **plateau**

[Total: 14]

QUESTION 3

Fig. 3.1 shows two reactions catalysed by Rubisco, an enzyme used in photosynthesis.

$$\text{RuBP} \xrightarrow[\text{Rubisco}]{CO_2} \text{2x Glycerate-3-phosphate}$$

$$\text{RuBP} \xrightarrow[\text{Rubisco}]{O_2} \text{Glycerate-3-phosphate + Phosphoglycolate}$$

Fig. 3.1

(a) Using Fig. 3.1 and your knowledge of the Calvin cycle, explain why starch synthesis in plant cells decreases at high oxygen levels. [KU-2] [3]

- [Compulsory point] Oxygen **competes** with carbon dioxide for the active site of Rubisco/ Oxygen is a competitive **inhibitor** of Rubisco/ Oxygen binds to RuBP with **higher affinity** than carbon dioxide
- **More phosphoglycolate formed**, but **cannot be used for Calvin cycle** → **Less glycerate-3-phosphate formed for Calvin cycle**
- [Compulsory point] **Less glyceraldehyde-3-phosphate (GALP)/ triose phosphate (TP) produced (which then exits Calvin cycle) to be used to synthesize starch**, since glyceraldehyde-3-phosphate (GALP)/ triose phosphate (TP) is the first sugar to be produced in the Calvin cycle

[Reject: Any reference to hydrolysis of starch to release glucose for respiration/ Any reference to rate of respiration]

The rate of photosynthesis in the marine seagrass, *Zostera marina*, was investigated under a range of pH conditions (Fig. 3.2). After a period of darkness, the plants were illuminated at a constant light intensity at 15°C and the rate of photosynthesis was measured.

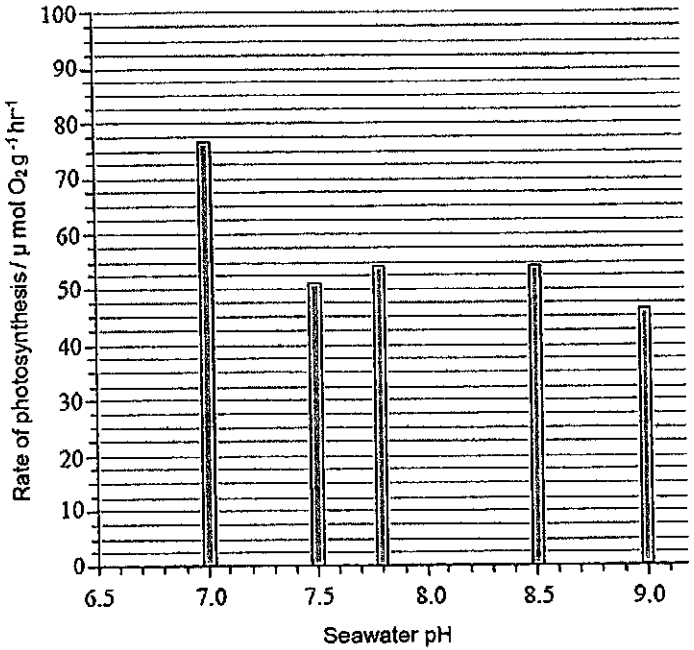


Fig. 3.2

(b) Explain why *Zostera marina* plants were incubated in darkness for a period of time before the start of the experiment. [HI-2] [2]

- The plants were left in darkness to **stop light-dependent reaction from occurring** OR **stop the production of ATP and reduced NADP/ NADPH** OR **ensure all existing ATP and reduced NADP/ NADPH are used up**
- *(Idea that)* This is to ensure that the amount of ATP and reduced NADP/ NADPH is equal for all plants before starting the experiment, so that the changes in rate of photosynthesis measured subsequently could be attributed to the changes in pH

(b) In an experiment, a single mutation was induced in the DNA of Organism 1 and the effects of the mutations are recorded in **Table 5.1**.

Table 5.1

Organism 1				
Mutation	**Amount of functional protein A / µg**	**Amount of functional protein B / µg**	**Amount of functional protein C / µg**	**Amount of functional protein D / µg**
Absent	50	44	48	72
Present	0	0	0	73

A similar experiment was conducted on Organism 2 and the result is recorded in **Table 5.2**.

Table 5.2

Organism 2				
Mutation	**Amount of functional protein W / mg**	**Amount of functional protein X / mg**	**Amount of functional protein Y / mg**	**Amount of functional protein Z / mg**
Absent	37	72	29	24
Present	38	71	64	23

(i) State whether Organism 1 and Organism 2 is prokaryotic or eukaryotic. [HI-1] [1]

Organism 1 prokaryotic

Organism 2 eukaryotic

(ii) With reference to **Table 5.1** and **5.2**, describe and explain how you arrived at this conclusion for: [HI-2]

Organism 1 [2]

- *[Cite data]* The single mutation resulted in a **decrease in the amount of functional proteins A, B, and C,** from **50µg, 44µg, and 48 µg to 0 µg respectively**.
- This suggests that the three **genes** that **code for proteins A, B, and C** are found in the **same operon** / under the control of the **same promoter**, unique of prokaryotes.

Organism 2 [2]

- The mutation **increased** the amount of **functional protein Y** only, from **29 to 64 mg**.
- This suggests that the **genes** coding for the proteins are **transcribed** / **controlled separately**, each having its **own control elements** / **promoter**.

(iii) Suggest and explain where the mutation may have occurred in Organism 2. [HI-2] [3]

- **Loss of function mutation** occurred at the **silencer sequence** controlling the **gene coding for protein Y**.
- **Repressor proteins** are **no longer complementary to** / **unable to recognise and bind** to the silencer sequence,...
- hence **increase rate of transcription** of the gene coding for protein Y, **more mRNA** is produced and translated to form more functional protein Y.

OR

- **Gain of function mutation** at **promoter sequence** controlling the **gene coding for protein Y**.
- **RNA polymerase binds** to the promoter at a **more effectively / OWTTE**,
- hence **increase rate of transcription** of the gene coding for protein Y, **more mRNA** is produced and translated to form more functional protein Y.

OR

- **Gain of function mutation** at **enhancer sequence** controlling the **gene coding for protein Y**.
- **Activator proteins** binds to the enhancer at a **higher efficiency** / OWTTE,
- hence **increase rate of transcription** of the gene coding for protein Y, **more mRNA** is produced and translated to form more functional protein Y.

[Total: 10]

QUESTION 6

Dengue fever is a disease spread by a particular species of mosquito, *Aedes aegypti*. The incidence of dengue has dramatically increased in recent years. This has heightened the need to understand the vector, as well as the virus. Dengue virus (DENV), an enveloped virus with a single-stranded positive-RNA genome, causes dengue fever. There are four distinct, closely-related DENV, namely DENV-1, DENV-2, DENV-3, and DENV-4.

(a) Describe one structural difference between the genome of the dengue virus and the influenza virus. [KU-2] [1]

- **Eight**, **separate** single-stranded RNA in influenza virus, while there is only **one** continuous long RNA strand in dengue virus.
- Influenza virus consist of **negative-RNA** genome while dengue virus consists of **positive-RNA** genome.

[Any 1]

(b) Suggest how the four distinct, closely-related serotypes of the dengue virus may have arisen. [KU-2] [1]

- **Antigenic drift** occurs: **Gene** coding for **glycoprotein / surface antigen** undergoes **mutation**.

(c) Fig. 6.1 shows the reproductive cycle of the dengue virus in a human host cell after an individual was bitten by an *Aedes* mosquito carrying the virus.

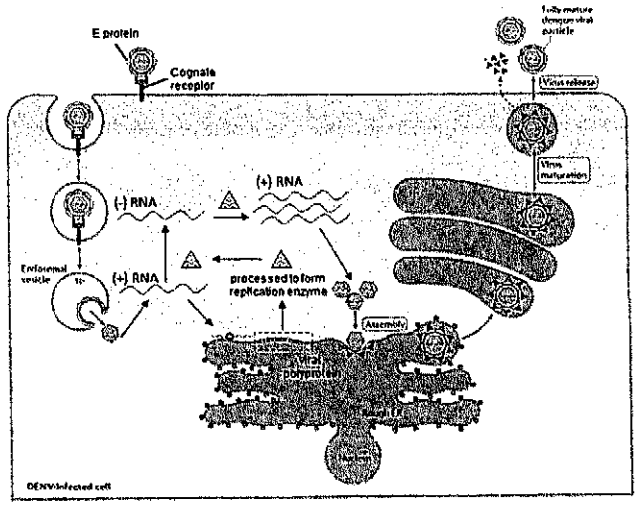


Fig. 6.1

Adapted from Nature Immunology

With reference to Fig. 6.1,

(i) describe how the dengue virus enters its host cell. [HI-2] [3]

- **Glycoprotein / E protein** is **complementary** in shape to **cognate receptor** on the host cell. [Reject if answer is not related to context]
- Virus enters via **receptor-mediated endocytosis,** where the host cell membrane forms an **endosome/endosomal vesicle** around the virus.
- **Acidification of the endosome** led to the **fusion** of the **viral envelope** with the **endosomal membrane**, releasing the nucleocapsid/RNA genome into the cytosol.

(ii) describe how the dengue virus produces more copies of its genome. [HI-2] [2]

- **(+)RNA** acts as a **template** to produce **(-)RNA**, which in turn acts as a **template** to produce many copies of the (+)RNA genome...
- ...by viral **RNA-dependent RNA polymerase**. [reject: replication enzyme]

(iii) suggest two ways how researchers may design a drug to prevent replication of dengue virus with a human host cell. [HI-3] [2]

Drug that

- **binds to E protein** that **prevents virus from binding** to **receptor**.
- **inhibits RNA-dependent RNA polymerase** to **prevent viral replication**.
- **inhibits** viral **protease** and thus **cannot cut/ hydrolyse polyproteins** into **functional proteins**.
  Or
  binds to viral **polyproteins preventing cleavage by viral protease.**
- act as **nucleoside analogs** that **stop RNA synthesis**.
- carries **antisense RNA** that will **bind to viral (+)RNA** to form double-stranded RNA thus **ribosome cannot bind/translation cannot occur/RNA dependent RNA polymerase cannot bind** to replicate viral RNA.

[Any 2]

(d) Dengue is the most rapidly spreading mosquito-borne viral disease in the world. In the last 50 years, incidence has increased 30-fold with increasing geographic expansion to new countries and, in the present decade, from urban to rural settings. The shaded areas in Fig. 6.2 are countries at risk of dengue fever.

Fig. 6.2 also shows two contour lines representing the range of January and July isotherm, which indicates the range of *Aedes aegypti* occurrence.

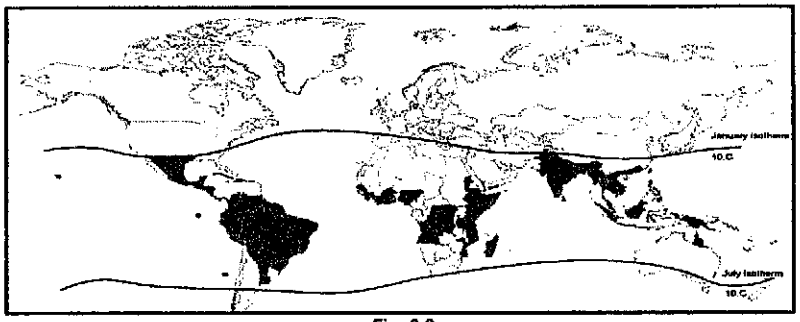


Fig. 6.2

Explain how climate change may affect the spread of dengue beyond the tropics. [3]

- Due to global warming, **countries at the higher latitude / temperate countries** experienced **higher temperature**, encouraging mosquitoes to migrate to higher latitude.
- Higher temperature can lead to **increase in the kinetic energy** of the metabolic **enzymes** in the mosquitoes, hence **increases the rate of enzymatic reactions**.
- Higher temperature **hasten the life cycle of mosquitoes** due to **increased metabolism**, hence producing more offspring
- Higher temperature causes female mosquitoes to **feed more frequently** due to **increased rate of digestion**, this increases transmission intensity
- Climate change leads to **increase in rainfall** may result in **more flooded areas for mosquitoes to breed / more breeding sites** for mosquitoes.

[Total: 12]

QUESTION 7

Nail-patella syndrome is a rare autosomal dominant trait that affects fingernails, toenails, elbows and kneecaps. The locus of the gene for nail-patella syndrome, **N / n**, is 10 map units from the ABO locus on chromosome 9, which will result in a 10% recombination frequency between the two genes.

(a) Explain what is meant by *10% recombination frequency*. [HI-2] [2]

- Recombination frequency refers to the **percentage of recombinants among the total number of offspring**. [Accept if student wrote the formula]
- 10% recombinant frequency implies that the **chance of crossing over between the two genes is 10%** .

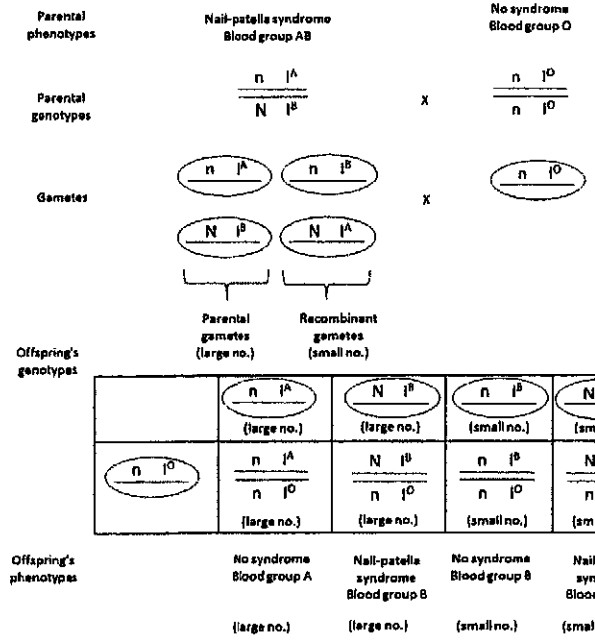
[ans must show that crossing over is occuring **between** the genes]

(b) A man with nail-patella syndrome and blood group AB has a family of five children with his wife who does not have the syndrome and is blood group O.

Three children do not have the nail-patella syndrome and are blood group A.

Two children have nail-patella syndrome and are blood group B.

Illustrate the above cross between the man and his wife with a genetic diagram. [HI-2] [3]



- Correct parental phenotypes & genotypes
- Gametes with labelling of parental (large no) & recombinant (small no).
- Offspring's genotypes and phenotypes (must indicate large / small no)

- Correct parent phenotypes and genotypes
- Gametes with labeling of parental (large no) & recombinant (small no).
- Offspring's genotypes (accept w/o indicating large/small no) and phenotypes (must indicate large / small no)

(*penalize 1m if symbols used is incorrect – for either or both genes)

(c) The two children who have nail-patella syndrome and are blood group B are in fact identical twins. They were recruited for a study which investigated the differences expressed by the two individuals. Of the traits studied, they showed differences in only some traits.

Explain what the findings of such a study revealed. **[HI-2]** [2]

- Twins are **genetically identical** / have **identical alleles**, resulting in identical traits/phenotypes.
- The differences in some traits could be because these traits are **influenced by the environment**.

A group of geneticists researched on another genetic disorder known as hypophosphatemic rickets by studying the inheritance of the disease over four generations in an extended family. Hereditary hypophosphatemic rickets is a genetic disorder that results in low level of phosphate in the blood (hypophosphatemia).

Fig. 7.1 shows the inheritance of this disease over four generations in an extended family.

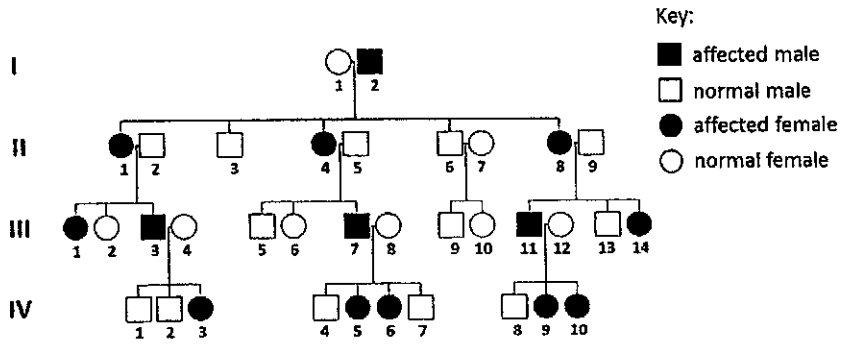


Fig. 7.1

(d) Based on the pedigree chart of the extended family, the geneticists concluded that hypophosphatemic rickets is a recessive trait controlled by a gene located on an autosome.

Comment on the above conclusion. **[HI-2]** [3]

- Hypophosphatemic ricket is a **sex-linked dominant** disease.
- It is not recessive because the disease **does not skip a generation** / **every affected individual has an affected parent / no two unaffected parents gives affected child**, hence is a dominant trait.
- Sex-linked (not autosomal) as an **affected male** passes the disease allele on the X chromosome to **all his daughters** but **not his son**
- + citing any one example
  - I-2 passed the dominant allele to daughters II-1, II-4, II-8 but not to the sons
  - III-7 passed the dominant allele to daughters IV-5 and IV-6 but not to the sons
  - III-3 passed the dominant allele to daughters IV-3 but not to the sons
  - III-11 passed the dominant allele to daughters IV-9 and IV-10 but not to the sons

[Total: 10]

BP~439

QUESTION 8

Four species of desert pupfish have evolved from an ancestral population in the Death Valley region of Nevada since the extensive lakes that existed there were reduced to isolated pools 20,000 – 30,000 years ago.

(a) Explain if the formation of the four desert pupfish is an example of microevolution or macroevolution. [HI-2] [2]

- **Macroevolution** because it involves evolutionary changes **beyond a single species** (ancestral population).
- Not microevolution because microevolution involved only the **change in the allele frequencies within a population** of a **given (pupfish) species**.

(b) Explain how environmental factors can act as stabilizing forces of natural selection in an isolated pool after the initial evolution of a new species. [KU-2] [3]

- **Within each pool**, the environmental **conditions remain the same**. [answer must clearly show condition of EACH POOL]
- Only those **fish well adapted** to the stable **conditions** in each pool **survive** and **reproduce fertile and viable offspring**.
- **Extreme phenotypes** are **selected against** and **do not survive** to **reproduce fertile and viable offspring**.

[penalize once for not stating "reproduce fertile and viable offspring"]

(c) Suggest what may happen if the water levels rose and the isolated pools once more formed an extensive lake system. [KU-2] [2]

- **Competition between species** (e.g. for niche / resources)...
- ...hence **reduction in the number of species** / **not all species will survive**.

- The four species are **restricted to** their preferred **niche**...
- hence **all/most species survive**.

- **One species** likely to be **better adapted** than all other species,...
- hence **increase in proportion** of that species while the rest decrease in numbers.

Note to marker: *accept possible interbreeding / no interbreeding if thorough and logical explanation is given*

A scientist attempted to construct the phylogenetic tree of the four pupfish species based on nucleotide sequences, with ages estimated from fossil records.

(d) Describe one advantage of using nucleotide sequences over the use of amino acid sequences in constructing phylogenetic relationships. [KU-2] [1]

- Comparison of DNA takes into consideration **changes in non-coding sequences**, which are not expressed in proteins/ amino acid sequence / phenotype.
- Comparison of DNA takes into consideration **silent mutation**, where a **different triplets** base can **code for the same amino acid**. Hence difference is not expressed in proteins/ amino acid sequence / phenotype.

[Total: 8]

QUESTION 9

A vaccine has been available for measles since the 1960s. There are vaccination programmes for many diseases including measles. Babies are born with passive immunity to measles so the vaccine is not given in the first few months after birth.

(a) Explain how active immunity differs from passive immunity. [KU-2] [2]

- Active immunity is **long-lasting / long-lived** while passive immunity is **short-lived**.
- In active immunity, **B cells and T cells are activated / clonal selection of B cells** occurs but not in passive immunity.
- Active immunity occurs when the body **produces its own antibodies** while passive immunity is immunity acquired from the introduction of **antibodies from another source/individual**.
- Active immunity involves **production of memory** (T and B) **cells** but not passive immunity.

[Any 2]

(b) Suggest why the vaccine for measles is not given in the first few months of a child's life. [KU-3] [2]

- **Antibodies from mother crosses the placenta / from mother's milk** and...
- *(idea that)*...interact with / neutralise with measles antigen, without activating the child's own active immune response. [Reject: child has passive immunity → need to explain why]

OR

- (Naïve) **T and B cells are not matured/developed / lack of variety of naïve T & B cells**
- *(idea that)* Hence, even in the presence of vaccine/measles antigen, there may not be available T and B cells to trigger active immune response.

(c) Explain how vaccines confer an individual protection against viruses such as the measles virus. [KU-2] [4]

1. [Compulsory] Measles vaccine contains **specific** surface **antigens** (OWTTE) **of measles virus**, hence is able to stimulate an immune response.
2. **Antigen presenting cells (APCs) / macrophages / dendritic cells** take up virus by phagocytosis, and **present antigen on MHC Class II**.
3. **Specific receptor** on **naïve T-helper cells** binds to **complementary** antigen presented on MHC Class II on APC.
4. APC **secretes cytokines** that **activates naïve T-helper cells,** which will undergo **clonal expansion/OWTTE** and **differentiation** to form memory T-cells.
5. **Activated T helper cells** bind to and **secrete cytokines that activate specific naïve B cells** to undergo **clonal expansion/ OWTTE** and **differentiation** to form plasma cells and memory B cells.
6. **Memory B and T cells** when **re-exposed to same measles virus,** will recognize it and mount a **faster** and **stronger secondary immune response**

The World Health Organisation (WHO) published data on the vaccination programmes for infectious diseases. The WHO recommends vaccination rate of over 90% of children.

Each health authority in a country reports its success in vaccinating children in their district. The WHO uses these figures to estimate the percentage of districts in each country that vaccinate 90% of children against measles.

The WHO also collects statistics on death rates of children under the age of 5 from all causes including infectious diseases.

Fig. 9.1 shows these statistics for 24 countries for the year 2007.

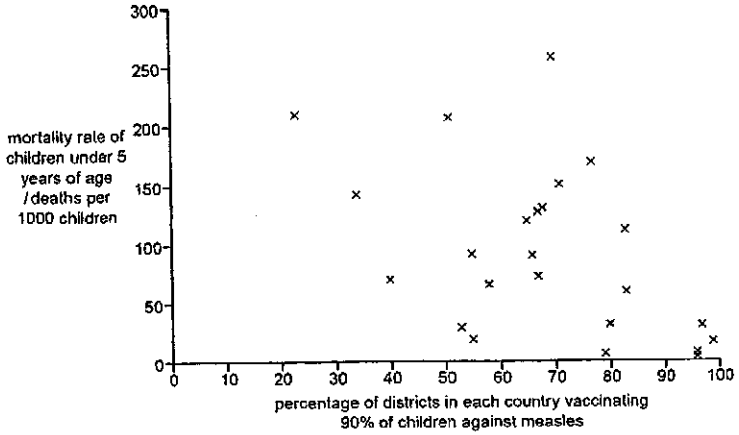


Fig. 9.1

(d) Use the information in Fig. 9.1 to explain why the WHO recommends immunisation of 90% of children. [HI-2] [2]

[Data citation-1]

- Countries with **more than 90%** of districts vaccinating 90% of children against measles have very **low mortality rate** of children under 5 years of age, **between 5 to 40 deaths per 1000 children**.
- Countries with less than 90% of districts vaccinating 90% of children against measles have a wide variation in death rates.

[Explanation-1]

- **Herd immunity decreases transmission**. / By **vaccinating a large proportion** (at least 90% of disctricts) at the same time, **transmission is reduced**.

[Total: 10]

BP ~ 441

QUESTION 10

The polar bear, *Urus maritimus*, lives in the Arctic regions of the USA, Canada, Norway and Russia. Polar bears move across the Arctic ice sheet to hunt prey such as seals.

Fig. 10.1 shows a polar bear.

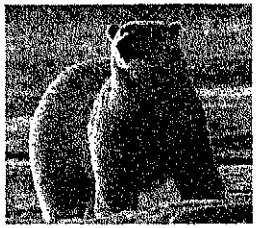


Fig. 10.1

(a) Explain an advantage to scientists in giving polar bears a binomial Latin name, *Urus maritimus*. [KU-2] [1]

1. **Universal name** to **avoid ambiguity** among scientists.
2. Once an organism can be identified, it **can be organised into taxons** according to **shared characteristics**.

The area over which the Arctic ice sheet extends varies throughout the year.

Fig. 10.2 shows the variation in the extent of the Artic ice sheet for the months of July to November for the years 1979 and 2009.

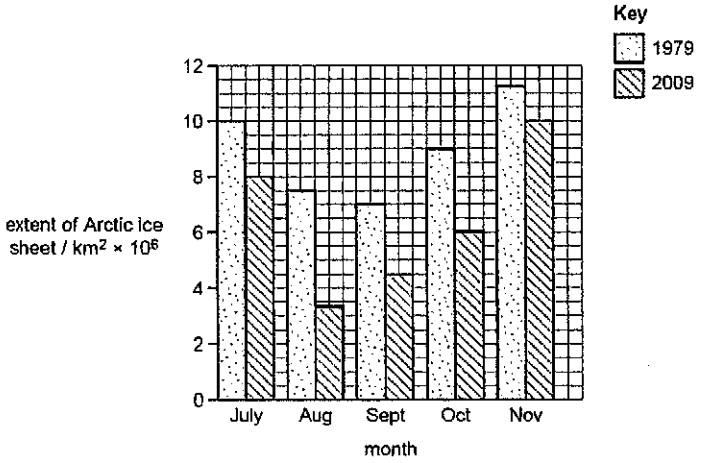


Fig. 10.2

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

Give your answer to the **nearest whole number**. Show your working. [HI-1] [1]

Percentage reduction = |4.5 – 7| / 7 = 35.7% = **36%**

Answer: .....%

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

Using information in Fig. 10.2, suggest what has caused *U. maritimus* to have become endangered. [HI-2] [3]

- **Reduction of the extent of ice sheets between 1979 to 2009** for months from July to November + cite figure for a month / trend over the months.
- Caused by **global warming** due to **enhanced greenhouse effect**.

The reduction in ice sheets will cause the reduction in polar bear population because there is ...

- *(idea that)*...**loss of breeding sites**, hence **less offspring produced** / **reproduce less frequently**.
- *(idea that)*...**reduction of suitable hunting ground** for prey, leading to **starvation**.
- *(idea that)*... **increased distance to travel to find food**, which may lead to **exhaustion / starvation**.
- *(idea that)* **Reduction in number of seals**, hence **less food available**.

[Suggestion given **must** have an implication]

[Total: 5]

BP~443

TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

SUGGESTED ANSWERS

CANDIDATE NAME: _____

CIVICS GROUP: _____ ( )

H2 BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

24 September 2019

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group in the spaces at the top of the page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided in the Question Paper.

Section B
Answer only **one** question in the spaces provided in 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 Examiners' Use	
1	/31
2	/10
3	/9
4 or 5	/25
Total	/75

This document consists of 22 printed pages.

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

QUESTION 1

Mitochondria are found in all nucleated eukaryotic cells and are the principal generators of cellular ATP. The mitochondrial genome is a circular DNA comprises 37 genes, which code for 13 essential polypeptides for oxidative phosphorylation and the necessary RNA machinery for their translation within the mitochondria. There are usually more than 100 copies of mitochondrial DNA in one cell, as compared to only two copies of nuclear DNA in one cell.

In recent years, a large and growing number of disorders are known to be due to types of mitochondrial disease (MD).

One form of MD is caused by a mutation of a mitochondrial gene that codes for a tRNA. The mutation involves substitution of guanine for adenine in the DNA base sequence. This changes the anticodon on the aminoacyl-tRNA carrying leucine ($tRNA^{leu}$). This mutant $tRNA^{leu}$ also recognises the phenylalanine codon, resulting in the formation of a non-functional protein in the mitochondrion.

(a) Outline how oxidative phosphorylation produces ATP. [3]

- **Electrons are transferred from NADH or $FADH_2$** to **electron carriers** in **electron transport chain** of progressively lower energy levels
- The **energy released from the passage of electrons** is used for **active transport of H^+** from the **mitochondrial matrix** into **intermembrane space** via **proton pumps**.
- This creates a **proton gradient** across the inner mitochondrial membrane.
- H^+ ions diffuse back into the matrix through **ATP synthase** via **facilitated diffusion** to **generate ATP** from **ADP & P_i**.

(b) Explain why there are usually more than 100 copies of mitochondrial DNA in a cell, but only two copies of nuclear DNA. [2]

- There are **many mitochondria per cell** but only **one nucleus per cell**
- **Each mitochondrion** contains **many copies of its mitochondrial DNA** but in each **diploid cell**, the nucleus contains only **two copies of each chromosome**

(c) Suggest how the change in the anticodon of a tRNA leads to mitochondrial diseases. [3]

- Change in the anticodon of the tRNA results in the incorporation of **leucine instead of phenylalanine into the polypeptide chain** during translation
- .. the different R-group of amino acid results in different folding of the polypeptide chain, hence, **change in the 3D conformation of the tertiary structure**
- Change in the protein/enzyme required for **oxidative phosphorylation**, hence, **less/ no ATP synthesised**.

Source: https://www.ncbi.nlm.nih.gov/pubmed/10660592

(d) Some MDs are caused by mutations of mitochondrial genes inside the mitochondria. Most MDs are caused by mutations of genes in the cell nucleus that are involved in the functioning of mitochondria. MDs caused by nuclear DNA mutations are autosomal recessive. All of a person's mitochondria are inherited from their mother via the egg cell.

Two couples, couple **A** and couple **B**, had one or more children affected by a mitochondrial disease (MD). The type of MD was different for each couple.

None of the parents showed signs or symptoms of MD.

- Couple **A** had four children who were all affected by an MD.
- Couple **B** had four children and only one was affected by an MD.

Using the information provided, suggest why all of couple **A**'s children had an MD and only one of couple **B**'s children had an MD. [4]

Couple **A**
- mutation occurs in the mitochondrial DNA during the formation of mother's eggs in the ovary
- all children have the affected mitochondria from the mother

Couple **B**
- Mutation occurs in the nuclear DNA of the parents
- Parents are heterozygotes/ heterozygous at the gene locus

Accept: one parent carries the recessive allele and somatic mutation in child's nuclear DNA

(e) In women, the first division of meiosis produces one daughter cell that has almost all of the cytoplasm. The other daughter cell, known as a polar body, consists of a nucleus surrounded by a very small amount of cytoplasm and a cell surface membrane.

One proposed treatment of mitochondrial disease is

- removing the nucleus from an egg cell donated by a woman with healthy mitochondria
- replacing this nucleus with the nucleus of the polar body from a woman whose egg cells are affected by mitochondrial disease.

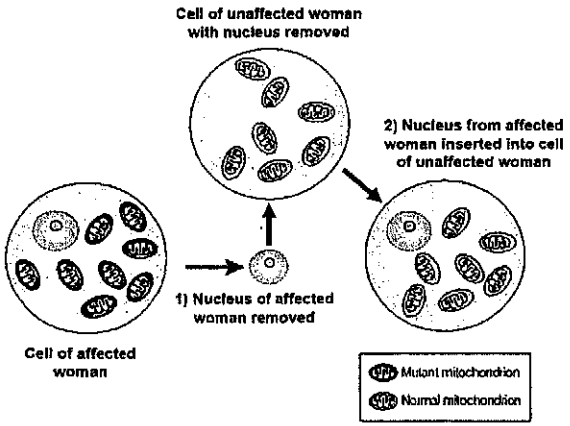
Suggest the advantages of this treatment for mitochondrial diseases. [2]

- The created egg has **nucleus/DNA/ genes of the affected woman** obtained from the polar body, so there is **no alteration of the nuclear DNA sequence of the affected woman's egg**.
- The created egg has many **normal mitochondria obtained from the unaffected woman's egg cell,** so will **prevent the passing on of defective mitochondria to the offspring.**

Reject: Production of healthy mitochondria as a result of the treatment

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1762815/

Diagram to explain (e)



(f) Mitochondrion plays an important role in regulating insulin secretion.

Fig. 1.1 shows the steps involved in the release of insulin from pancreatic islet beta cells, which involves three types of transmembrane proteins.

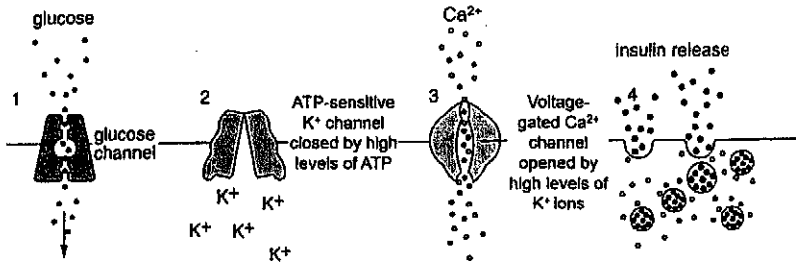


Fig. 1.1

Using the information provided in Fig. 1.1, explain how defective mitochondria affect the release of insulin by pancreatic islet beta cells. [4]

- *[idea of]* defective mitochondria do not produce ATP
- ATP-sensitive K^+ channel remains open due to low level of ATP, hence, no build up of K^+ ions inside beta cells
- Voltage-gated Ca^{2+} channel remains closed, hence, Ca^{2+} ions cannot enter the beta cells
- Vesicles containing insulin cannot fuse with cell surface membrane, hence, insulin cannot be released out of the beta cells via exocytosis

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2824521/

(g) A research study explored the possibility of using embryonic stem cell as a potential treatment for type 1 diabetes.

In the study, mouse embryonic stem (ES) cells were grown in culture and chemical signals were added to the culture to allow the ES cells to differentiate into ES cell-derived insulin-producing cells. To determine whether the ES cells are producing insulin, the amount of insulin mRNA was measured using the reverse transcription polymerase chain reaction (RT-PCR).

RT-PCR uses a reaction mixture containing:

- the sample for testing
- reverse transcriptase
- DNA nucleotides
- primers
- DNA polymerase
- fluorescent dye.

The principles behind this method is shown in Fig. 1.2.

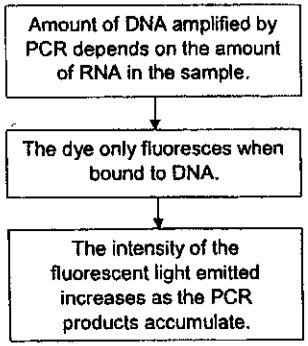


Fig. 1.2

(i) Describe the role of reverse transcriptase in RT-PCR. [1]

- To produce complementary DNA using mRNA as a template

(ii) Outline the process of polymerase chain reaction. [3]

- Temperature is <u>raised to 95°C</u> (A: 92 – 98°C), where double-stranded DNA <u>denatures / hydrogen bonds</u> between complementary base pairs are <u>broken</u> to produce two single strands
- Temperature is <u>cooled to 55°C</u> (A: 50 - 60°C), where the <u>primers</u> bind to the <u>3' region</u> of the <u>single stranded DNA</u> by complementary base pairing.
- Temperature <u>raised to 72°C</u>, where <u>Taq polymerase</u> elongates the primers by <u>adding deoxyribonucleotides to the 3'OH</u> end of the new complementary strand.

Fig. 1.3 shows the results of using RT-PCR to detect insulin mRNA in two different samples of ES cell-derived insulin-producing cells, A and B.

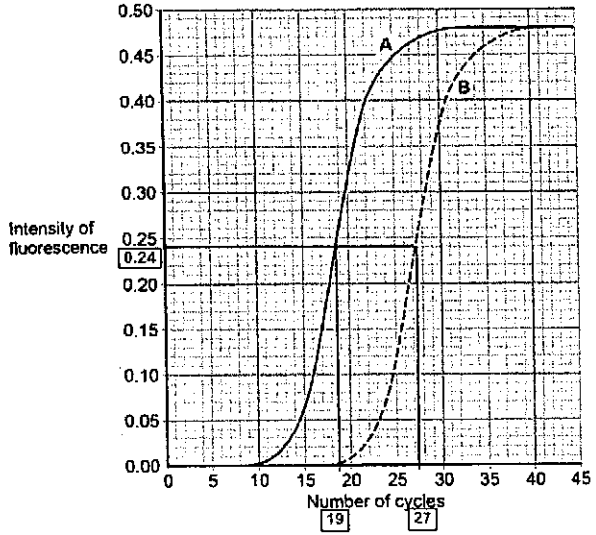


Fig. 1.3

(iii) A quantitative comparison can be made of the amount of RNA in samples A and B. This involves determining the number of cycles required to reach 50% maximum concentration of DNA (c).

The amount of RNA in a sample can be measured as $\frac{1}{c}$.

Using this information, calculate the amount of RNA content in samples A and B. Show clear working and leave your answers to 2 decimal places. [2]

Amount of RNA in sample A = 1/19 = <u>0.05</u> [accept no. of cycles = 18.5]

Amount of RNA in sample B = 1/27 = <u>0.04</u> [accept no. of cycles = 27.5]

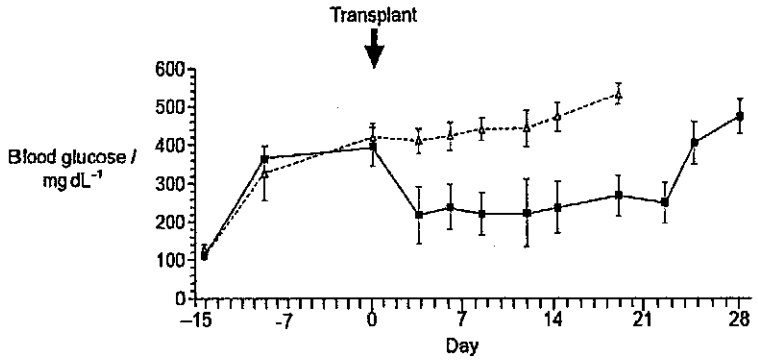
1 mark for working

1 mark for correct decimal places

During the experiment, a drug was injected into two groups of healthy mice in order to simulate type I diabetes 15 days prior to the transplant of the ES cell-derived insulin-producing cells. Type I diabetes is a diabetic state in mice with blood glucose concentrations greater than 350mg/dL.

The mice in the transplant group received the ES cell-derived insulin-producing cells. The control group did not receive the transplant. Control mice exhibited persistent hyperglycemia (blood glucose levels ranging between 350mg/dL and 500mg/dL) and all died by day 19.

Fig. 1.4 shows the blood glucose concentration in both groups.



Key: --▲-- control group —■— transplant group

Fig. 1.4

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2824521/

(iv) Describe the characteristics of embryonic stem cells that enable them to be used for this experiment. [3]

- Embryonic stem cells are <u>pluripotent</u>.
- Capable of <u>differentiating</u> into <u>almost all cell types except cells of extra-embryonic membranes</u> when treated with appropriate signals hence they are able to <u>secrete insulin</u>
- Capable of <u>dividing and renewing themselves for a long period</u> hence the <u>effect</u> of the experiment can be <u>long-lasting.</u>

(v) With reference to Fig. 1.4, compare the concentration of blood glucose resulting from the embryonic stem cell transplant with the control. [2]

[Similarity]
- Both transplant and control groups show a <u>**gradual**</u> **increase** of blood glucose concentration from **Day 4 to Day 19**. In transplant group, blood glucose concentration increases from **220 mg/dL to 260 mg/dL** and in control group, blood glucose concentration increases from **420 mg/dL to 520 mg/dL**.

[Difference- any 1]
- From **Day 0 to Day 4**, in transplant group, the blood glucose concentration **decreases <u>steeply</u> from 400 mg/dL to 220 mg/dL** while in control group, the blood glucose concentration **remained relatively constant at 410 mg/dL / decreases slightly from 420mg/dL to 410mg/dL.**
- From **Day 0 to Day 19**, glucose concentration in transplant group **decreases from 400 mg/dL to 260 mg/dL** while those in control group **increases** from **420 mg/dL to 520 mg/dL.**
- From **Day 0 to Day 19**, in transplant group, glucose concentration remains lower **(400mg/dL to 260mg/dL)** than those from control group **(420mg/dL to 520mg/dL)** [accept a range of days but not comparing point to point]

(vi) Discuss whether the embryonic stem cell treatment is effective in controlling blood glucose level. [2]

<u>Effective</u>
- From Day 0 to Day 19, treatment lowers blood glucose level from 400 mg/dL to 260 mg/dL as compared to control group from 400 mg/dL to 520 mg/dL
- From Day 19 to Day 28, while blood glucose level increases from 260 mg/dL to 470 mg/dL, it is still lower than control group of 520 mg/dL. [any 1]

<u>Not effective</u>
- blood glucose level rises back from Day 19 to Day 28 in the transplant group, from 260 mg/dL to 470 mg/dL, which is greater than 350 mg/dL/ diabetic state.

Note: Answers must address both effective and not effective in order to gain full marks

[Total: 31]

QUESTION 2

2,4-D is a selective herbicide that kills some species of plants but not others. 2,4-D disrupts cell surface membranes but the extent of disruption differs in different species.

Scientists investigated the effect of 2,4-D on wheat plants (a crop) and on wild oat plants (a weed).

They grew plants of both species in glasshouses. They put plants of each species into one of two groups, **W** and **H**, which were treated as follows:

- Group **W** – leaves sprayed with water
- Group **H** – leaves sprayed with a solution of 2,4-D.

After spraying, they cut 40 discs from the leaves of plants in each group and placed them in flasks containing 10 cm^3 de-ionised water. After 5 minutes, they calculated the disruption to cell surface membranes by measuring the concentration of ions released into the water from the leaf discs.

Their results are shown in Table 2.1.

Table 2.1

Group	Treatment	Mean concentration of ions in water / arbitrary units	
		Wheat	Wild oats
W	Water	26	45
H	2,4-D	27	70
Probability of difference occurring by chance		P=0.5	P=0.0001

(a) Using the information provided, evaluate the use of 2,4-D as a herbicide on a wheat crop that contains wild oats as a weed.

[Observation from data]

- 2,4-D causes an **increase in release of ions from wild oat cells** and 2,4-D **does not affect/ has little effect on the release of ions from wheat cells.**

[Cite data to support observation]

- For wheat, the probability of difference between the mean concentration of ions in water is due to chance is P=0.5 where **P>0.05**, so the difference is **not significant**

- For wild oats, the probability of difference between the mean concentration of ions in water is due to chance is P=0.0001 where **P<0.05**, so the difference is **significant**

[Explain the effect of 2,4-D on wheat and weed]

- Loss of ions from cells likely to lead to cell death/ damage of weed but not on wheat
- **OR**
- Disruption of cell membrane likely to lead to cell death/damage of weed but not on wheat

[4]

(b) Many other herbicides act by inhibiting photosynthesis in weeds. Triazine herbicide acts on the weeds by binding to a specific protein associated with photosystem II, blocking the movement of electrons between electron carriers.

Explain the effect of triazine herbicide on photosynthesis in weeds. [2]

- prevent non-cyclic photophosphorylation
- less / no ATP and **no reduced NADP** available for Calvin cycle
- rate of Calvin cycle decreases (reject: affecting Calvin cycle)
- [idea of] ATP production by cyclic photophosphorylation is not prevented

Wheat and other crops have been genetically modified to be resistant to triazine since 1996.

Fig 2.1 shows the area of triazine-resistant crops grown as a percentage of the total planted hectares (plotted points) and the number of weed species with resistance to triazine (bars).

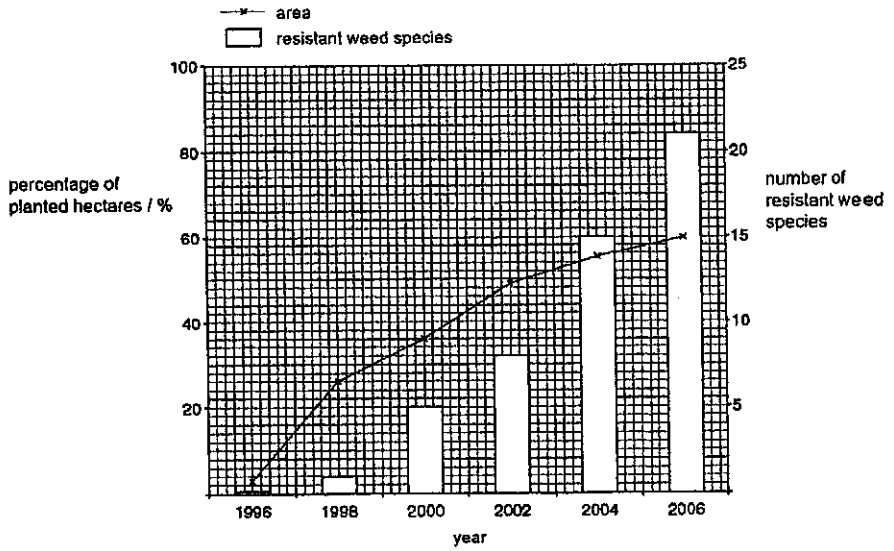


Fig. 2.1

(c) Describe the relationship between the area of triazine-resistant crops grown and the number of resistant weed species from 1996 to 2006. [2]

[Describe]
- As area of triazine-resistant crops **increases [1]** from **3% to 60%** , the number of resistant weed species **increases from 0.2 to 21 [1]**. (reject: almost zero to 21)

(d) Suggest **one** social advantage and **one** environmental advantage of growing triazine-resistant wheat. [2]

social advantage
- <u>increase</u> crop yield / <u>increase</u> food supply

environmental advantage
- less fertilizer used since weed competition is reduced

[Total: 10]

QUESTION 3

Coral reefs are among the most spectacular ecosystems on Earth. In Papua New Guinea, the data on the effect of ocean temperature on coral cover were collected as shown in Fig. 3.1. Coral cover is the percentage of the reef surface covered by live hard coral.

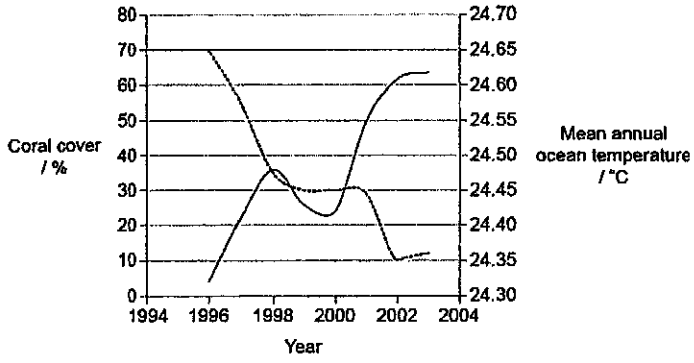


Fig. 3.1

(a) Describe the evidence that the ocean temperature has an effect on coral cover. [2]

- [Evidence] As ocean temperature **rises**, the coral cover **decreases**. [Reject: inversely proportional]
- [Data] From <u>1996 to 1998</u>, as temperature <u>rises from 24.32°C (24.33°C) to 24.47°C (24.48°C)</u>, coral cover <u>decreases from 70% to 34% (35%).</u>

OR
- [Data] From <u>2001 to 2002</u>, as temperature <u>rises from 24.55°C (24.54°C) to 24.61°</u>, coral cover <u>decreases from 30% to 10%</u>

OR
- [Data] From <u>1996 to 2003</u>, as temperature <u>rises from 24.32°C (24.33°C) to 24.62°C</u> , coral cover <u>decreases from 70% to 12% (13%)</u>.

(b) Suggest the causes for the changes in ocean temperature. [3]

- <u>increased</u> carbon dioxide/methane/greenhouse gases in the atmosphere OR <u>increased</u> carbon dioxide emissions from burning of fossil fuels (or other relevant processes).
- <u>increased</u> greenhouse effect OR <u>more</u> heat/ long wave radiation trapped in the atmosphere
- Increase atmospheric temperature → <u>increases melting of ice sheets</u> to <u>expose</u> more <u>ocean</u> which is <u>darker</u>.

- Hence, **ocean absorbs** (more) **heat** from atmosphere / **heat transfer from atmosphere to ocean** [Reject: absorbs light / sun rays / radiation]

Reject: no marks for CO_2 in the oceans, global warming or climate change.

NOTE: The idea of an **increase must be included, not just greenhouse effect or heat trapping

(c) Explain why coral reefs will be affected by an increase in ocean temperature above their optimum. [2]

1. **Enzymes/proteins** found in reef-building corals would **denature** above their optimum temperature.
2. This results in **cessation** of cellular activities such as **photosynthesis (in zooxanthellae) / respiration (in coral reefs / zooxanthellae)** [*must state a specific process]

3. Increase temperature result in **production** of excess **toxic products** by zooxanthellae which caused **corals to expel zooxanthellae**.
4. Hence **no zooxanthellae to photosynthesize to produce food/glucose for corals**, resulting in death of corals.

   [Reject: simply mentioning of no food/nutrient, hence coral die]
   *Must link to photosynthesis / photosynthetic product

5. Temperatures above the optimum can also **damage cell membranes**, leading to the death of corals

*Point 2 and point 4 is awarded only once → same idea

In order to test the effect of temperature, live samples of a species of coral, *Pocillopora damicornis*, were placed in an experimental chamber at a constant pH, water depth and low light. All the coral samples were started at 26°C and half of them were rapidly increased to 30°C as shown in Fig. 3.2.

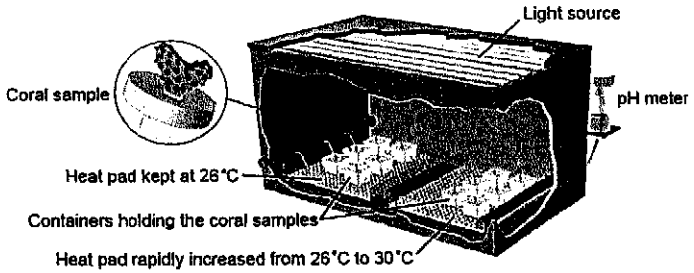


Fig. 3.2

The pie charts in Fig. 3.3 show the percentage of live and dead coral tissues at the end of the experiment.

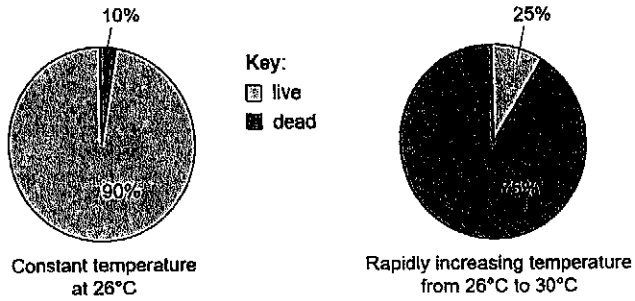


Fig. 3.3

(d) Comment on whether the experimental data in Fig. 3.3 supports the observed data from the ocean in Fig. 3.1. [2]

- Experimental data **supports** observed data because there is **more dead coral at higher temperature**

- [Cite data] There are **75% dead coral at 30°C** whereas there are **only 10% dead coral at 26°C**
  Accept: less % live coral at higher temperature

OR

- Experimental data **does not support** observed data because **experimental temperatures were higher than ocean temperature / rose faster than ocean temperatures**

- [Cite data] Experimental temperatures were between 26 °C to 30 °C while ocean temperature were between 24.32 °C to 24.62 °C / experimental temperatures rose much faster from 26 °C to 30 °C than ocean temperatures from 24.32 °C to 24.62 °C

[Total: 9]

Section B
Free-response Questions

Answer **one** question in this section.

Write your answers on the lined paper provided in this question paper.

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

Your answers must be in continuous prose, where appropriate.

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

QUESTION 4

Pathogens cause disease in humans. Pathogenic bacteria are thought to have emerged when groups of virulent genes are transferred into a previously non-pathogenic bacterium. Antibiotics are used to treat bacterial infections in humans. However, some pathogenic bacteria have evolved to become resistant to antibiotics.

(a) Describe how the virulent genes are transferred from a pathogenic bacterium naturally into a non-pathogenic bacterium and suggest how a population of pathogenic bacteria may have evolved to develop antibiotic resistance. [13]

How virulent genes are transferred into non-pathogenic bacterium [max 8]

Transformation

1. The DNA of the pathogenic bacterium is **fragmented** and **released** into the environment.
2. One of the fragments containing the virulent gene is taken up by a **competent** non-pathogenic bacterium.
3. **Homologous recombination** occurs and the virulent gene is **incorporated into the DNA genome of non-pathogenic bacterium.**

Conjugation

4. The pathogenic bacterium, the **F^+ cell/** contains **F plasmid, forms a sex pilus that attaches to the non-pathogenic bacterium, F^- cell/ without the F plasmid.**
5. F plasmid replicates by the **rolling-circle mechanism** [Details of rolling-circle mechanism - max 2 marks]
6. The F plasmid containing the virulent gene is transferred from the pathogenic bacterium to the non-pathogenic bacterium

Transduction [max 5]

[General Transduction]

7. During the adsorption phase, the **T4/ virulent phage attaches** to and **infects** pathogenic bacterium by **injecting phage DNA** into the host cell.
8. The host **bacterial DNA is hydrolysed / degraded** into pieces by phage enzymes.
9. During encapsidation of viral DNA, a small piece of the **degraded bacterial DNA containing the virulent gene is randomly packaged within a capsid**, forming a **generalized transducing phage particle**
10. When this generalized transducing phage particle **infects the non-pathogenic bacterium**, it **injects the virulent gene from the pathogenic bacterium** into the non-pathogenic bacterium.
11. The virulent gene replaces the homologous region of the non-pathogenic bacterium by **homologous recombination**

[Specialised Transduction]

12. When **temperate/ lambda phage attaches** and **infects** the pathogenic bacterium, the **viral DNA is integrated** into the **bacterial chromosome** to form a **prophage.**
13. Environmental factors (e.g. UV light) can induce a switch in the phage replication mode from **lysogenic to lytic** where the **prophage** is **excised**
14. Occasionally, this **excision** is **imprecise** causing a small region of **adjacent** bacterial DNA carrying the virulent gene to be excised with it.
15. This **prophage with adjacent virulent gene are packaged into a capsid** forming a **specialized transducing phage particle**.
16. When this specialised transducing phage particle **infects the non-pathogenic bacterium**, the **virulent gene** and the phage genome is **injected** into its new bacterial host
17. The virulent gene can subsequently **replace the homologous region** of the **non-pathogenic bacterium by homologous recombination**

How a population of pathogenic bacteria develops antibiotic resistance [max 5]

18. **Genetic variation** exists within the population of pathogenic bacteria due to **random/spontaneous mutation**

19. Spontaneous mutation in bacterial gene that codes for:

- protein pump that transports antibiotics out of the bacterial cell before they can exert effect.
- enzyme that degrades the antibiotics.
- enzyme that alters the antibiotics into a harmless product.
- enzyme that alters that cell wall to prevent entry of the antibiotics.

[1m for any 1 gene product mentioned]

20. *Idea of* Due to **misuse** of antibiotics in treatment

21. Antibiotic acts as the **selection pressure**

22. **Pathogenic bacteria with antibiotic-resistant gene are selected for**

23. **..survived** and are able to undergo binary fission to **pass on the antibiotic-resistant gene to their daughter bacterial cells**

24. **Those without the antibiotic-resistant gene are selected against** and **eliminated** from the bacterial population

25. Over many generations, the **allele frequency of antibiotic-resistant allele increased** within the population of the pathogenic bacteria.

QWC [1]
How antibiotic resistance is developed is communicated accurately and to include at least two different horizontal gene transfer mechanisms.

(b) Many microorganisms live in or on the human body without causing disease. An example of such microorganisms is the *Escherichia coli* (*E. coli*) which colonise the intestine and obtain nutrients from their surroundings.

Describe how *E. coli* respond to the **presence of lactose** in the intestine and explain how a mutation in the **regulatory sequences** of the *lac* operon may affect how *E. coli* respond to changes in lactose supply. [KU-2] [12]

[Describe how *E coli* responds to changes] [4]

lactose is present – *lac* operon switched on

1. When **lactose** is **present** in the cell, the cell **synthesizes the enzymes** needed for hydrolysis of lactose.
2. allolactose acts as an **inducer** which **binds to active repressor** protein to **inactivate** it.
3. This **changes its conformation** such that the inactive repressor cannot **bind to the operator**.
4. This allows **RNA polymerase to bind to the promoter**, hence transcription of the *lac* structural genes.

[Effect of mutation] [at least one mutation in promoter and one mutation in operator]

Gain of function mutation of lac promoter

5. **Gain of function mutation** of the **promoter** results in a **change in the structure/shape** of the promoter.
6. **RNA polymerase** is able to **bind** to the (mutated) **promoter** with **greater affinity** [Reject: permanently/ irreversibly]
7. ... hence **increase the rate** of the transcription of structural genes in the presence of lactose.

Loss of function mutation of lac promoter

8. **Loss of function mutation** of the **promoter** results in a **change in the structure/shape** of the promoter.
9. The shape of the promoter is **no longer complementary** to the (active site) of **RNA polymerase**....
10. ...hence RNA polymerase is **no longer able to bind** to the (mutated) promoter.
11. Transcription of structural genes **cannot occur even in the** presence of lactose.

Gain of function mutation of operator

12. **Gain of function mutation** of the **operator** results in a **change in the structure/shape** of the operator.

13. (Inactive/active) Repressor binds to the operator **permanently/irreversibly**.

14. Hence **RNA polymerase** is **not able to bind** to the **promoter**,

15. **preventing transcription** of structural genes.

Loss of function mutation of operator

16. **Loss of function mutation** of the **operator** results in a **change in the structure/shape** of the operator.

17. Shape of the operator is **no longer complementary** to the (allosteric site) of the (active) **repressor**, hence...

18. ...(active) **repressor can no longer bind to the operator**.

19. **RNA polymerase** is now able to bind to the **promoter**,

20. **allowing transcription** of structural genes **even in the absence of lactose**.

[mark once for change in structure/shape for promoter and operator respectively, pts 5 & 8 ; pts 12 & 16]

QWC [1] Response to lactose in *E.coli* is communicated accurately and to include at least one different mutation in each promoter and operator

QUESTION 5

(a) Discuss, with examples, the importance of specific shapes of proteins in organisms. [13]

[Enzyme-substrate complex formation]
1. Active site of enzyme has specific shape that substrate can fit into
2. Via lock and key mechanism
3. *[Importance]* To form enzyme-substrate complex/ products important for metabolic pathways / increase the rate of reaction
4. *[Example]* any *enzyme and substrate [max 1]*

[DNA-binding proteins for transcription]
5. DNA to fit into binding site of proteins
6. *[Importance]* Ref. to **DNA replication**
7. *[Example]* **single-stranded binding protein bind** to the **unzipped parental strands** to **prevent** them from **reannealing**
8. *[Importance]* Ref. to **transcription**
9. *[Example]* **transcription factor** binding to DNA

[Transport]
10. Binding of substances to transport proteins
11. *[Importance]* Allows for movement of substances across cell membrane
12. *[Example]* transmembrane protein e.g. Na+ channel, Na+K+ pump, glucose transporter etc

13. *[Example]* Haemoglobin is made up of **4 polypeptides** and their **haem groups** to form a specific conformation
14. *[Importance]* allows it to **bind to oxygen molecules** to form oxyhaemoglobin/ transport oxygen to all parts of the body
15. Reference to **cooperative binding**

[Nuclear division]
16. *[Importance]* Ref. to **separation of sister chromatids during anaphase**
17. E.g. kinetochore to bind to centromere via complementary shape

[Amino acid activation]
18. *[Importance]* Ref. to **amino acid activation**
19. E.g. tRNA anticodon bind to the anticodon attachment site of amino-acyl tRNA synthetase

[Cell signalling]
20. *[Importance]* **Ligand/ signalling molecule** binds to the **binding site of receptors**
21. E.g. Insulin binding to tyrosine kinase receptors / glucagon binding to GPLR to activate downstream cell signalling pathways

QWC [1]
Importance of specific shapes communicated accurately and to include at least three different examples

(b) Comparisons of the patterns of mRNA levels in the cytosol across different human cell types show that the level of expression of almost every active gene is different.

Describe how the level of mRNA of the same gene across the different human cell types is controlled and suggest the advantage of each level of control.

[12]

DNA (Chromosomal) Level

Gene expression is switched on by:

1. **Histone acetylation** by **histone acetyltransferase** **loosen the chromatin** structure to allow **general transcription factors and RNA polymerase to access promoter**. (A: reverse argument)

2. **Histone demethylation** by **histone demethylase** **loosen the chromatin** structure to allow for transcription to take place. (A: reverse argument)

Gene expression is switched off by:

3. **DNA methylation** by **DNA methyltransferase** leads to **long term inactivation of genes / alter the shape** of the promoter sequence, **prevent RNA polymerase from accessing the promoter**.

Advantage

4. *Idea of* **longer term switching genes** on and off to restrict active genes to those required (by the cell line), so **more efficient / less wasteful of resources.**

Transcriptional Control

Gene expression is switched on by:

5. **Binding/Assembly** of **general transcription factors and RNA polymerase** to the promoter form **transcriptional initiation complex** for transcription initiation.

6. Binding of specific transcription factor to the proximal control element to increase the rate of transcription.

7. **Activator** binds to **enhancer** to cause the **bending of DNA** so as to **stabilize** the transcription initiation complex at the promoter, thereby **increases rate** of transcription.

Gene expression is switched off by:

8. **Repressor** binds to **silencer** and **recruits histone deacetylase** (A: any other effect), causing **chromatin compaction** and hence **prevent transcription** of the gene.

Advantage

9. *Idea that* Rate of transcription / expression can be regulated (at this level), **to meet short term requirement of the cell**.

Post-Transcriptional Control

10. Addition of 7-methylguanosine cap and 3' Poly(A) tails during post-transcriptional modification/ RNA processing is important to:

    - **protect the mRNA from degradation by exonucleases/hydrolytic enzymes,** hence increases the half-life of mRNA.
    - **facilitate the export** of mature mRNA from **nucleus to cytosol.**
    - act as **site of attachment for translational initiation factors** to promote the binding of ribosomes to promote translation.

11. RNA splicing of pre-mRNA by spliceosome occurs where **all introns are excised** and **exons are spliced** together to produce mature mRNA.

12. Alternative RNA splicing, the **same pre-mRNA** synthesized in **different cell types** have **all introns excised** but **different combinations of exons are spliced together**

Advantages

13. *Idea that* Ensures the **stability of mRNA** and hence the **stability of gene expression.**

14. *Idea that* Allow for production of **different proteins** variants from a **single gene** when alternative splicing occur.

QWC [1]
At least one advantage of regulating mRNA production linked coherently to the correct stage of the process.

BP~455

TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

SUGGESTED ANSWERS

CANDIDATE NAME: _____

CIVICS GROUP: _____ ( )

H2 BIOLOGY

Paper 4 Practical

9744/04

17 September 2019
2 hours 30 minutes

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on 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 and graphs.
Do not use staples, paper clips, glue or correction fluid/tape.

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	/ 21
2	/ 14
3	/ 20
Total	**/ 55**

This document consists of 13 printed pages.

QUESTION 1

A grocer has been buying milk from the same supplier for a number of months. Recently, the grocer has found that the milk has been diluted with water. Milk contains macromolecules like proteins which are denser than water thus milk sinks when placed in aqueous solutions.

(a) Predict the behaviour of a milk droplet when placed in water with respect to milk's water content.

milk droplet with more water will sink slower than a drop with less water [1]

The amount of water added to a milk sample can be determined by measuring the density of the milk using aqueous solutions like copper sulfate solution of a standard concentration. When a small drop of milk is placed in copper sulfate, a layer of copper proteinate forms around the milk and this prevents the milk and copper sulfate solution mixing.

Fig. 1.1 shows the movement of a drop of milk through the copper sulfate solution.

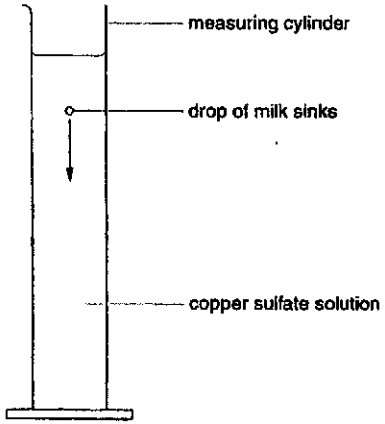


Fig. 1.1

You are required to estimate the percentage of water added to the milk supplied to the grocer.

You are provided with

- 100% milk, labelled **M**
- milk sample supplied to grocer, labelled **B**
- distilled water, labelled **W**
- 0.03 moldm^{-3} copper sulfate, labelled **C**

You are advised to read through the entire procedure before beginning the experiment.

1 Prepare 10.0 cm^3 each of a suitable number of concentrations of milk to help you in your investigation. Record the volume of 100% milk, **M** and distilled water, **W** used in your preparation in a table below.

- ***appropriate layout + headings;***
- ***at least 5 concentrations of wide range, regular interval;***
- ***correct volume of M & W ,total volume of 10 cm^3;***

Concentration of M / %	*Volume of M / cm^3*	*Volume of W / cm^3*	*Total Volume / cm^3*
100	*10.0*	*0.0*	*10.0*
80	*8.0*	*2.0*	*10.0*
60	*6.0*	*4.0*	*10.0*
40	*4.0*	*6.0*	*10.0*
20	*2.0*	*8.0*	*10.0*

[3]

2 Using the syringe with attached needle, release one drop of **M** into **C** in a measuring cylinder. Record the time taken by the droplet to sink in an appropriate format in the space provided below.

Note: Needle attached to syringe is sharp. Handle with care. Keep needle capped when not in use.

Observe the largest fragment of **M** should the droplet break up in the copper sulfate solution.

3 Repeat **step 2** for all milk concentrations and milk sample B you have prepared in **step 1**. You may reuse the copper sulfate unless the milk residue obstructs your vision.
Record the time taken by the droplet to sink in an appropriate format in the space provided below. [3]

4 Repeat the procedure to obtain a **total of 2 replicates**. Perform appropriate calculations on your readings. [1]

- ***2 replicates, average calculated***
- ***correct layout + headings with units;***
- ***readings in seconds to 1 d.p. ;***
- ***correct trend;***

Suggested table format:

Concentration of M / %	*Time taken by droplet of M to sink (e.g. 100cm^3 to 0cm^3 mark = 15.6cm) / s*		
	R1	*R2*	*Average [(R1+R2)/2]*
100			
80			
60			
40			
20			
B			

5 Describe how you would carry out **step 2** to increase the accuracy of your observations.

- *use (equal) volume of copper sulfate of appropriate height*
- *release the milk droplet at the same height / depth (e.g. at the 90 cm^3 mark)*
- *release fixed volume of milk (e.g. 0.1 cm^3)*
- *start stopwatch immediately / simultaneously*
- *record time for droplet to fall to a fixed point (e.g. reach bottom / e.g. 10 cm^3 mark)*

[3]

6 Estimate the percentage of water added to the milk sample supplied to the grocer, B. Explain how you derived at your answer.

Time taken for a droplet of B to sink = 15 s

Based on table in Step 2, 15s corresponds to 20 – 40% of M, hence % of water added is 60 – 80%

percentage of water added *60 – 80%* [1]

Explanation:

- *release a droplet of B into same volume of copper sulfate at same height*
- *find time taken for B to sink same distance as rest of milk droplet;*
- *find (range) milk conc. that corresponds to time taken by B* [2]

7 Describe **one** way to improve your estimate in terms of

(a) reliability;

Repeat step 2 thrice more to obtain 3 replicates / Repeat the entire experiment twice more

to calculate average to eliminate random error OR identify anomaly; [1]

(b) accuracy.

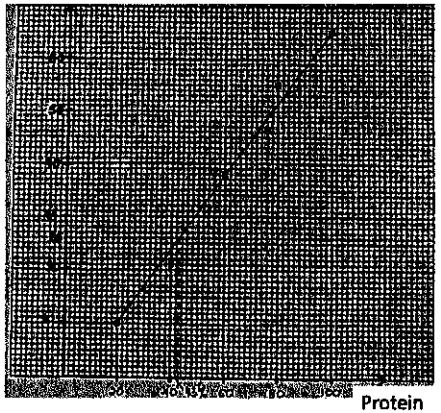
Repeat procedure using milk concentrations of smaller intervals within range identified in step 6; [1]

Further investigation was conducted to find the protein concentration in sample B using Biuret's test. The absorbance by sample B was measured using a colorimeter and compared to a range of protein solutions of known concentrations. Table 1 shows the absorbance by the protein solutions.

Table 1

Protein concentration / %	Absorbance / arbitrary units
100	65
80	55
60	38
40	21
20	10

8 Plot a suitable graph using data provided in Table 1.



[3]

- *correct axes (independent variable on y-axis, dependent variable on x-axis) axes labels with units;*
- *appropriate scale (at least half of grid, able to estimate to half of smallest square) correct data pts;*
- *best fit (straight line with data pts evenly distributed on both sides / point-to-point plot) does not extrapolate graph;*

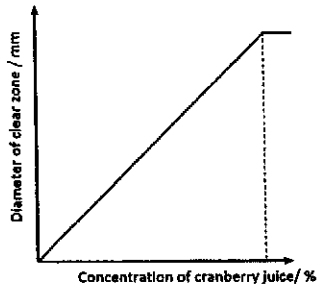
9 The absorbance of the milk sample B was recorded to be 26 arbitrary units. Using your graph, deduce the protein concentration in the milk sample B. Show on your graph, how you arrived at your answer.

value in % (e.g. 43%) show on graph ;

protein concentration of milk sample, B ..... [2]

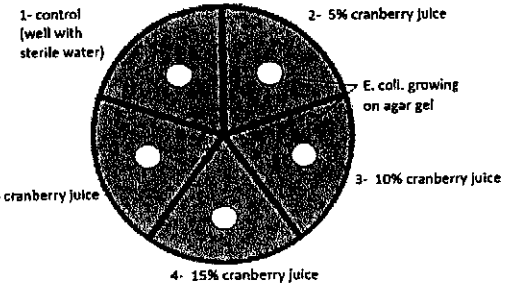
[Total: 21]

QUESTION 2
Planning Answer

Theory	In this experiment, cranberry juice is placed in the wells on the agar gel plated with *E. coli*. The size of the clear zone formed after incubation is a measure of the effectiveness of the cranberry juice. Increasing concentration of cranberry juice will increase the diameter of the clearing and then will level off. At the point of levelling off, will give the lowest concentration of cranberry juice that gives the largest clear zone possible. The expected trend is as such.  The increase in the diameter of the clear zones should be directly proportional to the concentration of cranberry juice.	✓ description of scientific reasoning and theory of the method used to measure effectiveness of cranberry juice ✓ expected relationship between [cranberry] and diameter of clear zone
Variables	Independent variables: 5 concentrations of cranberry juice (0 / 5 / 10 / 15 / 20 %) prepared by simple dilution. Dependent variables: Diameter of clear zone / mm Controlled variables (any 2): • Concentration and volume of bacterial culture • Concentration and volume of agar used • Size of well, use cork borer of fixed size (e.g. 5mm) • Fixed incubation time (30°C in an incubator for 2 days) Control set-up: • Rationale • Brief procedure • Expected outcome	✓ independent, variable & independent variable ✓controlled variables ✓ control

Procedure	1. Using disinfectant (sterilizing) solution and paper towels, wipe the work area. Use autoclave to sterilize all other apparatus. 2. Prepare cranberry juice of 5 different concentrations using simple dilution according to the table below. Label the beakers accordingly.	✓ Aseptic techniques ✓ dilution method

Concentration of cranberry juice / %	Volume of 20% cranberry juice / cm^3	Volume of sterile or distilled water / cm^3	Total volume / cm^3
0	0.0	10.0	10.0
5	2.5	7.5	10.0
10	5.0	5.0	10.0
15	7.5	2.5	10.0
20	10.0	0.0	10.0

3. Draw lines on the base of the prepared 100 mm diameter agar plates using a marker so that the base is split into 6 equal parts. Label the sections 1 to 6.	✓ method- setup
4. Turn on the bunsen burner. Put the agar plate near the flame. Using sterile cork borers with diameter of 5 mm create a well in each section from 1 - 5.	
5. This should be done near the flame. Using a sterile 1ml syringe/ micropipette, add 0.5 cm^3 of cranberry juice into wells 2-5. Add 0.5 cm^3 of sterile distilled water into well 1 (control). The setup of the agar plate in the experiment is as shown below:  	✓ Aseptic techniques ✓relevant diagram
6. Conduct 3 replicates from steps 3-5 and repeat for the entire experiment using freshly prepared stock 20% cranberry juice and prepared agar plates with a lawn of *E.coli*. 7. Seal the petri dish using sticky tape (parafilm) and incubate the petri dish at 30°C in an incubator for 2 days.	✓ 3 replicates, 1 repeat
8. Without opening the lid measure the diameter of the clear zone around each disc using a ruler.	✓ method to calculate growth of bacteria

9. Tabulate the results to show the effect of different cranberry juice concentrations on *E.coli* growth.

Table showing the effect of different concentration of cranberry juice /% on the diameter of clear zone /mm

Conc. of cranberry juice/ %	Diameter of clear zone /mm			
	Reading 1	Reading 2	Reading 3	Average
5				
10				
15				
20				
0 (Control)				

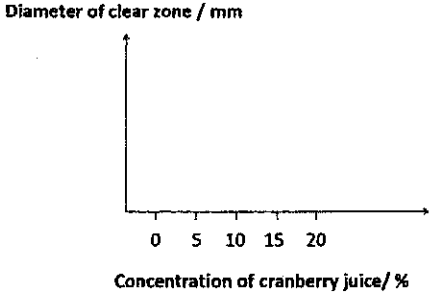
✓ appropriate table

$$\text{Average} = \frac{\text{reading 1 + reading 2 + reading 3}}{3}$$

10. Plot a graph of diameter of clear zone /mm produced against the concentration of cranberry juice /%. Obtain the concentration of the effective concentration of cranberry juice from the graph. **The concentration before the graph plateau off is the effective concentration.**

✓ appropriate graph

Graph of diameter of clear zone /mm produced against the concentration of cranberry juice /%.



Risk and precaution

To prevent infection or growth of harmful microorganisms:

- Cover all cut or broken skin with a waterproof dressing
- Wear tightly fitting disposable gloves and clean laboratory coat
- Clean the bench surface with bactericidal disinfectant and use a bunsen burner to create a sterile environment. Students should work as close as possible to the flame.
- Swap any spillages with bactericidal disinfectant.
- Proper disposal / treatment of contaminated materials or equipment using sterilizer/autoclave

(Students must state both the risk and precaution)

✓ Risks & safety measures (at least two)

[Total: 14]

QUESTION 3

Fig. 3.1 is a photomicrograph of a stained transverse section through part of a plant leaf. This plant species is native to part of Asia.

You are not expected to have studied this leaf.

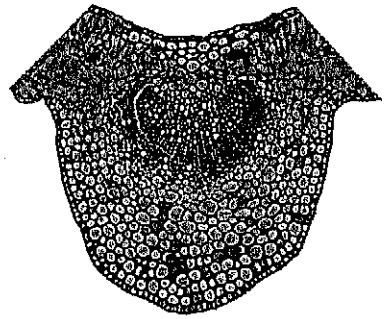
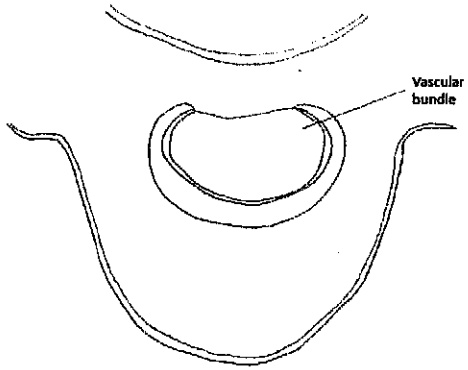


Fig. 3.1

(a) Draw a large plan diagram of the part of the leaf shown in Fig. 3.1.
On your diagram, use a ruled label line and label to show the vascular bundle.



- **at least 2 lines for upper epidermis and lower epidermis + no shading**
- **no cells + one enclosed area (vascular bundle)**
- **correct proportion of vascular bundle in relation to distribution of tissues in midrib**
- **uses label line and label vascular bundle**

[4]

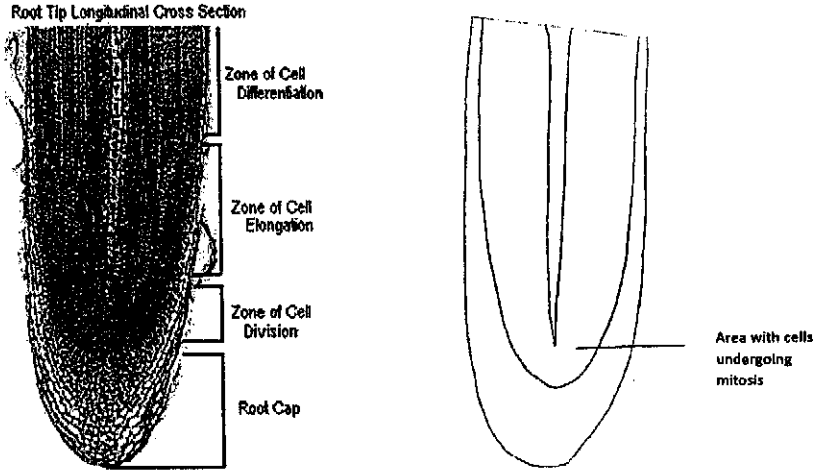
The eyepiece graticule scale in your microscope may be used to measure the actual length of the layers of tissues or cells if the scale has been calibrated against a stage micrometer.

However, to help draw the correct shape and proportion of tissues, as in **(b)**, it is **not** necessary to calibrate the eyepiece graticule scale.

L1 is a stained, longitudinal section showing the tissues of a young root tip.

(b) Draw a large plan diagram of **L1**.

Use a ruled label line and a label to show the position of the area in which you can see cells showing stages of mitosis.



- **at least 3 lines + no shading**
- **no cells + one closed end with one open end**
- **root cap must be shown as a separate area**
- **correct area for cells undergoing mitosis**
- **label (e.g. mitosis) to area with cells undergoing mitosis**

[5]

Fig. 3.2 is a photomicrograph of root cells.

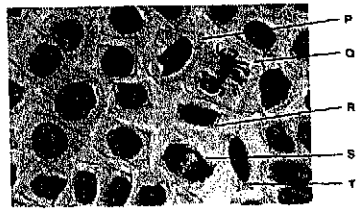
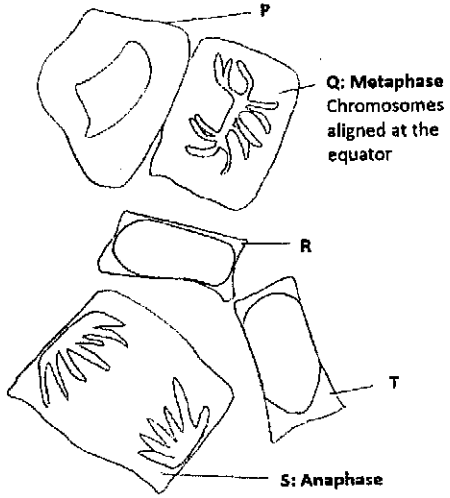


Fig. 3.2

(c) Make a large drawing of each of the **five** cells labelled **P, Q, R, S** and T on Fig. 3.2.
On your drawing use ruled label lines and labels to identify two **different** stages of mitosis.
Annotate **one** of the stages to describe **one** observable feature that supports your identification.



- **only 5 whole cells drawn + no shading**
- **cells P, R and T whole nuclei drawn as different shapes**
- **Q chromosomes drawn in mass**
- **2 labels + 2 lines + 2 different stages of mitosis identified**
- **one correct annotation of a stage**

[5]

Fig. 3.3 is a photomicrograph of root cells from a different region of the root.

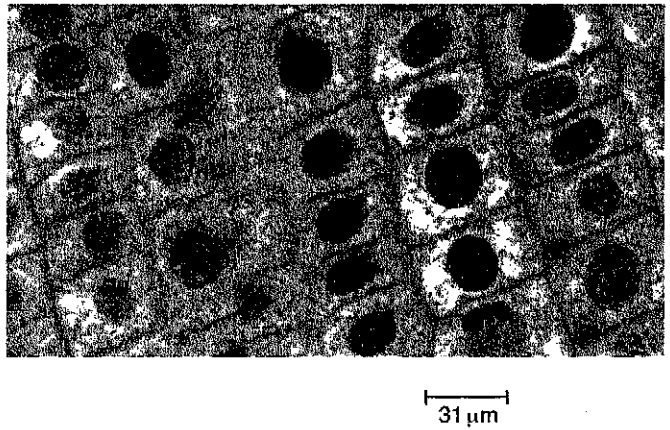


Fig. 3.3

(d) Use the scale bar below Fig. 3.3 to calculate the magnification of Fig. 3.3.
You may lose marks if you do not show your working or if you do not use appropriate units.

- **Measures scale bar within range + mm (15-16mm)**
- **Working:**
  Shows conversion of scale bar in mm to um (x1000) or shows conversion of 31um to mm (31/1000 = 0.031mm)
- **Show measurement of scale bar in um divided by 31um or show mm divided by 0.031mm**
- **Correct answer:**
  If 15mm; magnification= x 483
  OR
  If 16mm; magnification= x 516

[max 2 points]

Magnification:_____

[2]

Fig. 3.2 is shown again here to help you answer **(e)**.

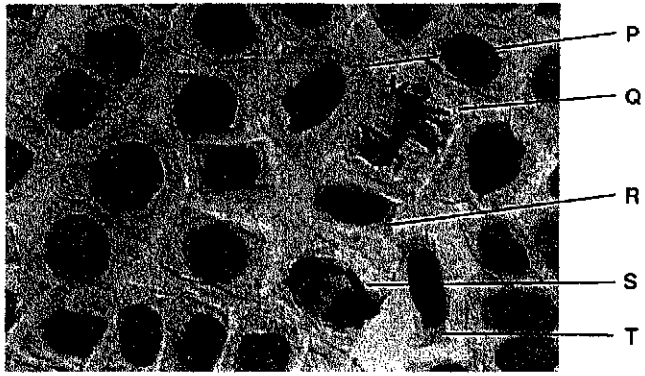


Fig. 3.2

(e) Prepare the space below so that it is suitable for you to record **three** observable differences between the specimens in Fig. 3.2 and in Fig. 3.3.

Record your observations in the space you have prepared. [4]

Features to compare	Fig. 3.2	Fig. 3.3
Cells undergoing mitosis	more	None/fewer
Visibility of chromatids/chromosome	present	absent
Cell wall	Not visible	Prominent/visible
Cell arrangement	Scattered/irregular/random	Aligned/regular
Cell packing	Loosely packed	Closely packed
Air spaces	present	none
nucleus	All cells show nucleus	Not all cells have a nucleus

- **Table with 3 columns and headings**
- **any 3 differences**

[Total: 20]

End of paper