NAME: _____ CLASS: _____ INDEX: _____

CATHOLIC JUNIOR COLLEGE
JC2 PRELIM EXAMINATION
Higher 2

BIOLOGY
Paper 1 Multiple Choice

9744/01
28 AUGUST 2017
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

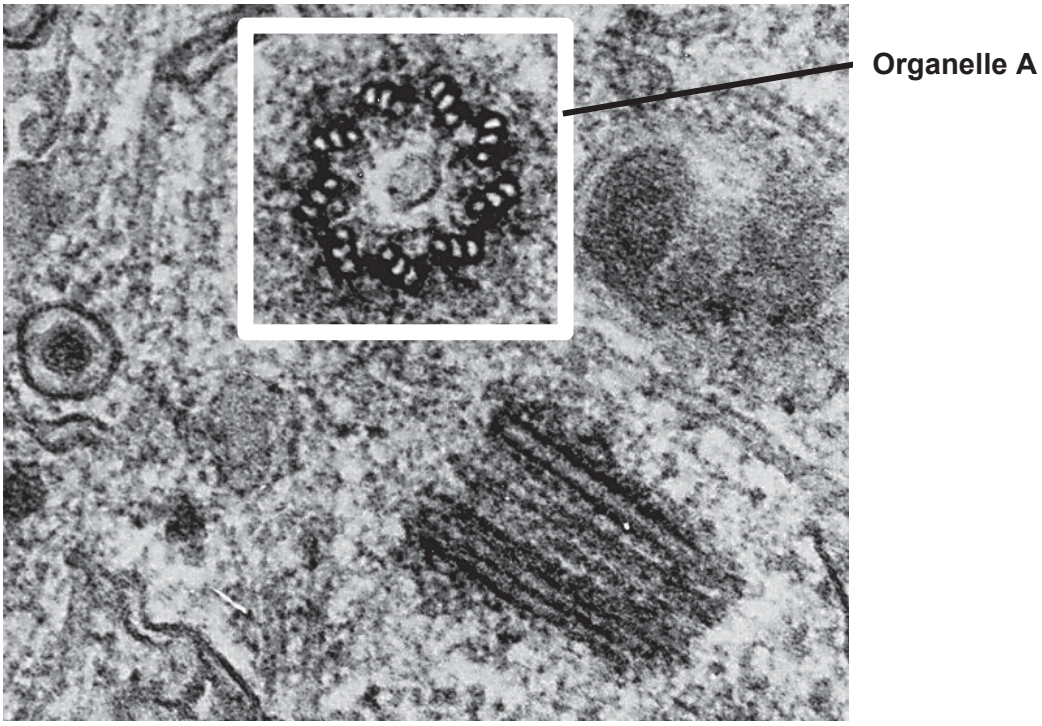
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write and/or shade your name, NRIC / FIN number and HT group on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**.
Choose the **one** you consider correct and record your choice in **soft 2B pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

1 The figure below shows an electron micrograph of a cross-section of an animal (rat) cell.



Which of the following describes organelle A?

i. 9 triplets of microtubules arranged in a ring.

ii. Inner membrane folded into cristae.

iii. Synthesizes spindle fibres during nuclear division.

iv. Involved in aerobic respiration.

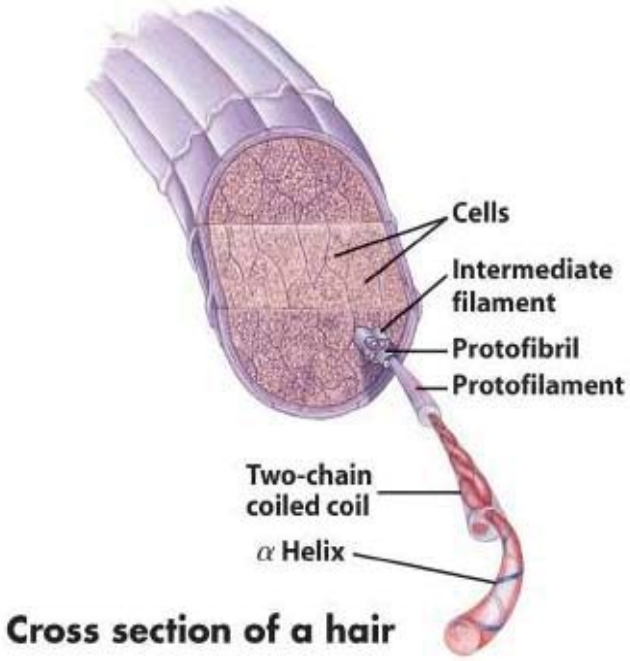
A **i** only

B **i** and **iii** only

C **ii** and **iii** only

D **ii** and **iv** only

2 Keratin is a fibrous protein in skin, hair and nails. The diagram below shows α-keratin molecules in cross section of a hair follicle.



The features of one form of keratin are listed below:

i. The peptide chain has mainly small amino acid residues.

ii. Each peptide chain forms into an α-helix.

iii. Two helices coil together.

iv. Covalent bonds link adjacent helices.

Which features are different from that of collagen molecules?

A **i** and **ii**

B **i** and **iv**

C **ii** and **iii**

D **iii** and **iv**

3 How many different types of oligopeptides, each made up of 8 amino acids, may be synthesized using the 20 common amino acids?

A 144 480

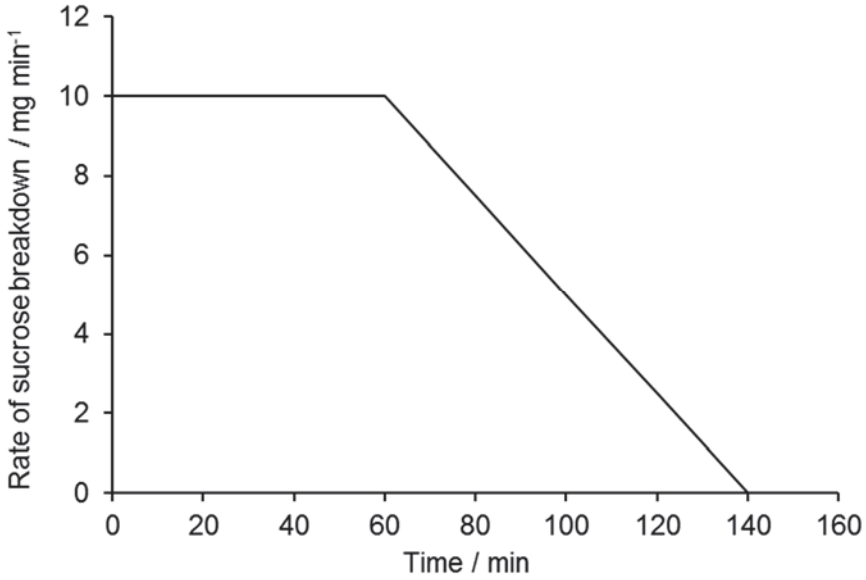
B 20^8

C 8^{20}

D 160

4 The graph shows the results of an investigation using invertase, an enzyme that breaks down sucrose into glucose and fructose.

1 g of sucrose was dissolved in 100 cm^3 of water and 2 cm^3 of a 1% invertase solution was added.



Which conclusion can be drawn from this information?

A Between 0 and 60 min, the concentration of the substrate remains constant.

B After 60 min, the concentration of enzymes becomes the limiting factor.

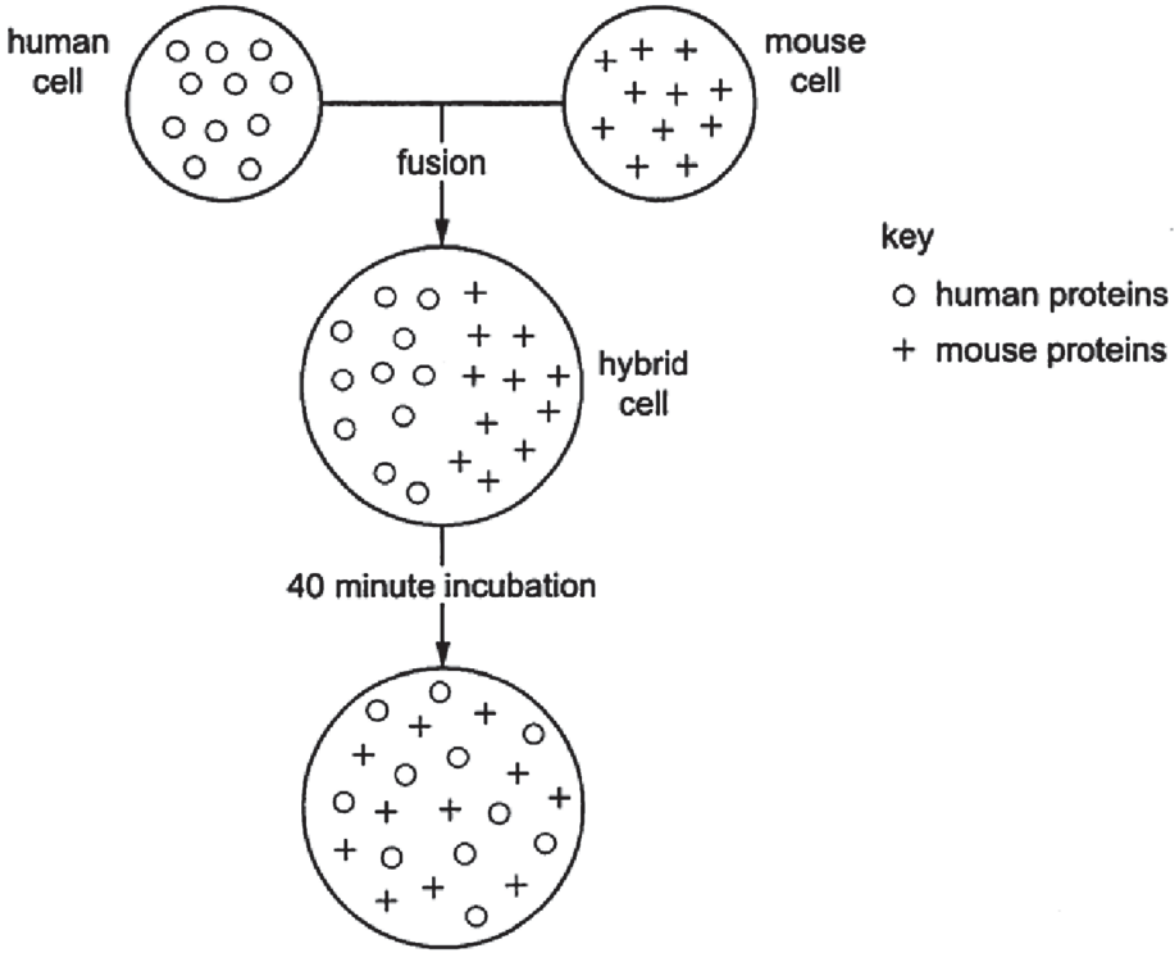
C At 140 min, some of the enzyme molecules are denatured.

D Between 60 and 140 min, the concentration of the substrate is the limiting factor.

5 Human and mouse cells were fused to make hybrid cells. Anti-human and anti-mouse antibodies, carrying different coloured fluorescent dyes, were added. The antibodies bind to the proteins of the cell surface membrane.

The fused cells were incubated for 40 minutes. The locations of the human and mouse membrane proteins were identified at intervals using the fluorescent dyes.

The diagram represents the results of the experiment by showing the positions of the human and mouse proteins on the surface of the cells.



What does this experiment show?

A Movement of the phospholipids pushes the membrane proteins apart.

B Some membrane proteins move through the phospholipids to different places.

C The phospholipids of the human and mouse cell surface membranes do not mix.

D The proteins of human cell surface membranes can move further than those of mouse cells.

6 Which process involves one stem cell giving rise to two distinct daughter cells: one copy of the original stem cell as well as a second daughter cell programmed to differentiate into a non-stem cell?

A asymmetric replication

B differentiation

C potency

D self renewal

7 DNA replication in eukaryotes involves the following processes.

- RNA primer molecules are attached to each strand at points of origin of replication.
- DNA polymerase attaches to primers and synthesises new strands of DNA in a 5' to 3' direction.
- One strand, called the leading strand, is synthesised in continuous long sections.
- The other strand, called the lagging strand, is synthesised in short sections.
- RNA primers are replaced by DNA nucleotides on both strands.

Which statement explains the difference in the way in which the two strands of a DNA molecule are synthesised?

A DNA polymerase enzymes can only synthesise DNA in one direction.

B Fewer RNA primers are needed on the leading strand.

C The lagging strand has more binding points for RNA primers.

D The replication of DNA is semi-conservative. .

8 Which statement is **not** true about the transcription in eukaryotes?

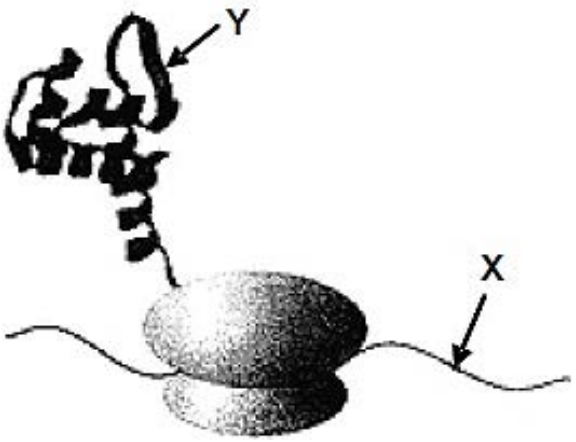
A Transcription occurs in the nucleus.

B There are 3 different types of RNA polymerase for the synthesis of mRNA, rRNA, and tRNA.

C The binding of RNA polymerase to TATA box initiates the transcription process.

D No primers are involved during transcription.

9 The diagram below shows a particular stage of protein synthesis.



Which of the following statements is true of molecules **X** and **Y**?

A The coiling of molecule Y is a direct result of the information on molecule **X**.

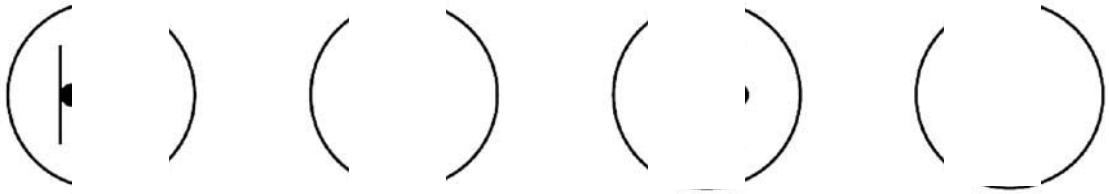
B Molecule **X** is double-stranded whilst molecule **Y** is single-stranded.

C In both molecules **X** and **Y**, the bonds between adjacent monomers of each molecule are phosphodiester bonds.

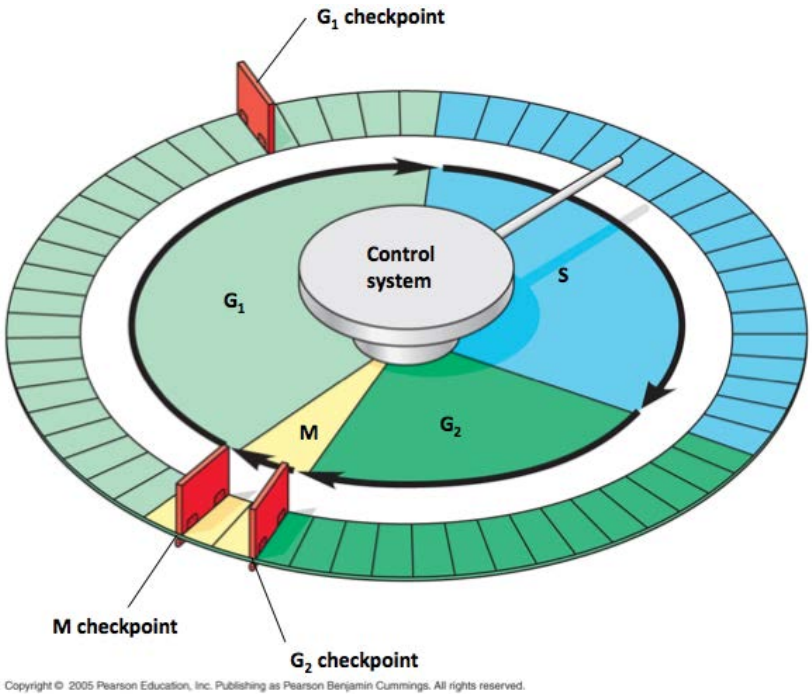
D The monomers of molecule **X** interact with the monomers of molecule **Y** through temporary hydrogen bonds.

10 A cell with one pair of chromosomes (2n = 2) undergoes meiosis. Which nucleus is formed at the end of meiosis I?

A **B** **C** **D**



11 Cell cycle is a highly regulated process. The figure below shows the overview of the different stages and checkpoints in cell cycle.



What happen when G1 checkpoint does not function properly?

A The cell will progress to prophase even when there is mistake during DNA replication.

B The probability of non-disjunction during anaphase increases.

C DNA replication may not occur properly due to the absence of necessary raw materials such as deoxynucleoside triphosphates.

D There will be a decrease in the amount of growth factors secreted.

12 What advantages are there in associating eukaryotic DNA with histones to form chromatin?

A Allows large amount of DNA to be packaged into the small space of the nucleus.

B Allows control of gene expression by modulating degree of packaging.

C Protect DNA from degradation which may lead to mutation or death of the cell.

D All of the above.

13 Proteins that are ubiquitinated will be transported to proteasome for degradation. Which level of control of gene expression is this?

A Translational level

B Transcriptional level

C Post-translational level

D Post-transcriptional level

14 Which of the following statements about bacterial chromosome structure is/are true?

i. Not associated with histone proteins.

ii. Single-stranded chromosome.

iii. Located in the nucleoid region of a nucleus.

iv. Most genes are separated by intergenic DNA sequences.

A **i** only

B **i** and **ii** only

C **ii** and **iii** only

D **ii** and **iv** only

15 When a mutant strain of Escherichia coli that has lost the regulatory gene of its tryptophan operon is placed in a medium that contains all nutrients the cell need to grow except tryptophan, which of the following will occur?

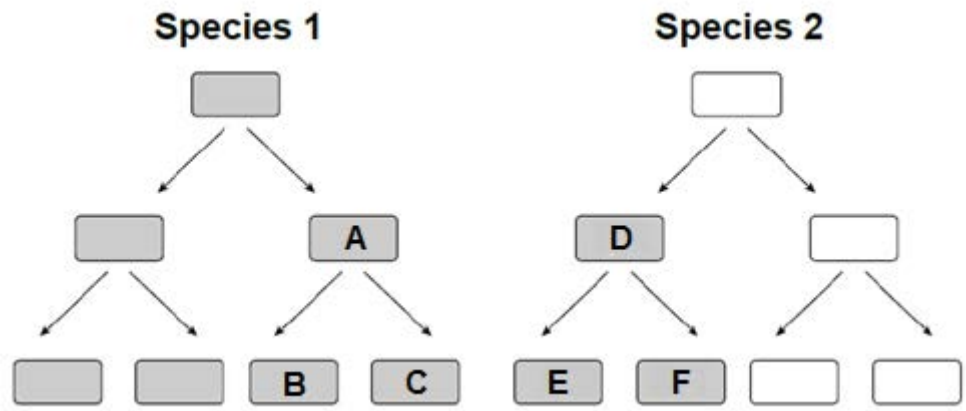
A The cells will grow even though there is no tryptophan in the medium.

B The cells will grow until excessive tryptophan arrests the expression of the operon.

C The cells will not grow until enough tryptophan has been synthesised to make the repressor active.

D The cells will never grow unless tryptophan is added to the medium.

16 The diagram below shows how two species of bacteria reproduce when placed together in a growth medium. The bacteria that are shaded are resistant to the antibiotic penicillin.



Which one of the following statement(s) is/are likely to be true?

i. Bacteria **B** and **C** are resistant to penicillin as a result of binary fission of Bacterium **A**.

ii. Bacteria **C**, **D** and **F** are resistant to penicillin as a result of random mutation.

iii. Bacterium **D** is resistant to penicillin as a result of conjugation process which transfers the F plasmid carrying penicillin resistance gene from Bacterium **A**.

iv. Bacterium **D** is resistant to penicillin through transduction from Bacterium **A** where there is transfer of the complete F plasmid.

A **iii** only

B **i** and **iii**

C **i** and **iv**

D **ii, iii** and **iv**

17 Which of the following is true of influenza and HIV viruses?

A Genetic shift causes variation in influenza but not in HIV.

B Both HIV and influenza are virulent upon budding off from their respective host cell.

C Influenza viruses have DNA genomes that are templates for transcription.

D HIV viruses have genomes that are readily inserted into the host genome.

Please note that Question 18 and 19 are related.

18 Fig 18.1 shows the base sequence of a normal human beta-globin gene and a mutant variant which causes a blood-related disease.

Normal Non-template strand	5’	CAC GTG GAC GGA GGA CTC CTC	3’
Mutant Non-template strand	5’	CAC GTG GAC GGC GGA CAC CTC	3’

Fig. 18.1

Which of the following is correct?

A The blood-related disease is caused by 1 point mutations with more than one amino acid changed.

B The blood-related disease is caused by 1 point mutations with one amino acid changed.

C The blood-related disease is caused by 2 point mutations with more than one amino acid changed.

D The blood-related disease is caused by 2 point mutations with one amino acid changed.

19 Fig. 19.1 shows the southern blot of the co-dominant blood-related disease shown in Fig. 18.1. Only one restriction enzyme *MstII* was used and the blot was hybridized with a probe specific for the beta-globin gene.

Individual	**1**	**2**	**3**	**4**	**5**
Phenotype	**lives**	**lives**	**lives**	**dies**	**lives**

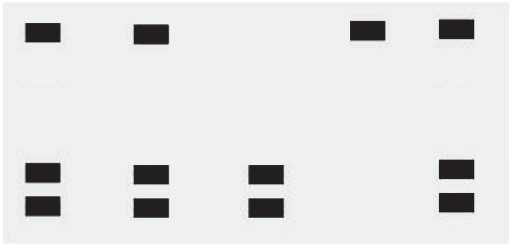


Fig. 19.1

With reference to Fig. 19.1 and Fig. 18.1; which of the following statements is correct?

A Individuals 1, 2 and 5 are normal.

B Individuals 1, 2 and 5 are homozygous at the loci for beta-globin gene.

C Individuals 4 and 5 are homozygous and heterozygous at the loci for beta-globin gene respectively.

D Individuals 3 and 4 are homozygous and heterozygous at the loci for beta-globin gene respectively.

20 A tall green stemmed plant with genotype TTrr was crossed with a short red stemmed plant with genotype ttRR. The F1 plants were allowed to self fertilise. A X^2 test was carried out on the results obtained for the F2 generation. Part of the values for X^2 are shown:

Deg. of freedom	p= 0.5	p= 0.1	p= 0.05	p= 0.01	p= 0.001
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.6	5.99	9.21	13.82
3	2.37	6.25	7.82	11.34	16.27
4	3.36	7.78	9.49	13.28	18.46
5	4.35	9.24	11.07	15.09	20.52

The value of X^2 was 7.6 in this investigation.

What is the probability of this value of X^2 and do the results fit the expected ratio?

	Probability	*Results fit expected ratio*
A	Between 0.01 and 0.05	No
B	Between 0.01 and 0.05	Yes
C	Between 0.05 and 0.1	Yes
D	Between 0.05 and 0.1	no

21 Which of the following is true about gene interactions?

A Gene interactions involve two genes controlling one character.

B Gene interactions involve masking and follow mendelian phenotypic ratios.

C Gene interactions are a form of co-dominance

D Gene interactions restrict the number of phenotypes seen.

22 Sodium azide is a strong inhibitor to the ETC in mitochondria. An experiment was conducted with isolated mitochondria, 2 molecules of glucose, 10 molecules of pyruvic acid along with oxygen, ADP and NAD^+ which was supplied in excess.
What would be the expected production of ATP from the experiment?

A 2

B 4

C 10

D 22

23 Which of the following is not true of photosynthesis.

A The spectra of light in which photosynthesis is most efficient is in the red and violet region.

B Rate of ATP synthesis depends on the differential proton gradient across the thylakoid membrane.

C Photosynthesis starts first with the photolysis of water.

D Oxygen concentration affects the efficiency of the light independent reaction.

24 The Fig. 24.1 represents a G-protein coupled receptor on the cell surface membrane. A peptide hormone ligand is bound to the receptor and initiates the production of a second messenger.

Fig. 24.1

What is the second messenger?

A a peptide hormone.

B ATP

C cyclic AMP

D Kinase

25 Birds, such as cockatoos, have a species of louse (an insect parasite) that lives on their feathers.

White, sulfur-crested cockatoos have pale lice on their wings and bodies while yellow-tailed black cockatoos have dark lice on their wings and bodies. Both of these cockatoos have black lice of this species on their heads. In order to rid themselves of these parasites, cockatoos preen their wings and bodies with their beaks but have to use their feet to preen their heads.

What best explains how this species of louse has diversified into two colour variants on the birds' wings and bodies, but has remained dark on the birds' heads?

A Cockatoo beak preening results in selection pressure on wing and body lice.

B Cockatoos are unable to see the lice while preening their heads.

C Cockatoos notice badly camouflaged lice on their wings and bodies while preening.

D Cockatoos use different preening techniques on different parts of their bodies resulting in natural selection.

26 Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperm, and they selectively kill developing male embryos.

In Samoa in the 1960s, the proportion of male blue moon butterflies fell to less than 1% of the population. However, by 2006, the proportion of males was almost 50 % of the population.

Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

i. *Wolbachia* acts as a selective agent.

ii. The selective killing of male embryos is an example of artificial selection.

iii. When infected with *Wolbachia,* male embryos that are homozygous for the recessive allele of the suppressor gene die.

iv. All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.

v. The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

A **i** and **iv**

B **i**, **iii** and **v**

C **ii** and **iii**

D **ii**, **iv** and **v**

27 Which of the following statements correctly relate to molecular phylogenetics?

i. Lines of descent from a common ancestor to present-day organisms have undergone similar, fixed rates of DNA mutation.

ii. Organisms with similar base sequences in their DNA are closely related to each other.

iii. The number of differences in the base sequences of DNA of different organisms can be used to construct evolutionary trees.

iv. The proportional rate of fixation of mutations in one gene relative to the rate of fixation of mutations in other genes stays the same in any given line of descent.

A **i** and **ii**

B **i** and **iv**

C **ii** and **iii**

D **iii** and **iv**

28 Which statement about vaccination is true?

A Vaccination of a small proportion of the population can break the disease transmission cycle.

B Vaccination can prevent and control disease, but it is unable to eradicate the disease.

C Vaccination stimulates body's innate immune system, thus protecting the individual from future infection by the same pathogen.

D Vaccination stimulates immunity without causing the disease.

29 Fig 29.1 illustrating the effects of elevated CO_2 on growth and development of soybean.

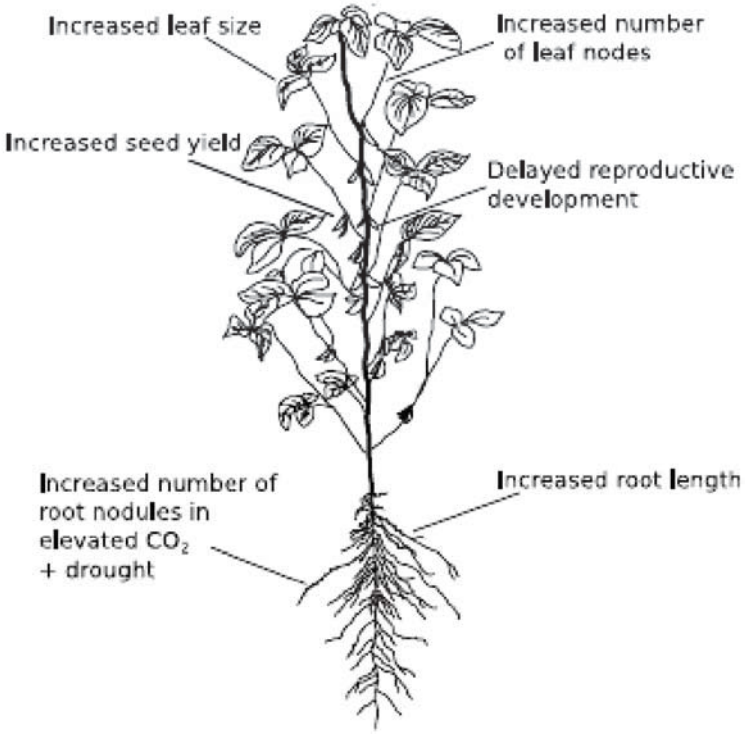


Fig. 29.1

With reference to Fig. 29.1. Which of the following can be inferred from the elevated levels of CO_2.

A Plant photosynthetic rates will increase as CO_2 levels increase.

B Plant biomass increases but dispersal range decreases.

C Plant respiration will outweigh that of photosynthesis.

D Plants are now better able to ensure their own survival and continuation.

30 Which of the following is not true about climate change and biodiversity?

A Climate change results in specific selection pressures that may be disadvantageous to most species causing a decrease in biodiversity.

B Climate change over a short time may result in different selection pressures which may promote speciation and promote biodiversity.

C Climate change may negatively affect keystone species which then affect ecosystems eventually affecting biodiversity.

D Climate change may cause a lowering of temperatures and may push species to physiological limits and eventually lower biodiversity.

END OF PAPER

CATHOLIC JUNIOR COLLEGE
JC2 PRELIM EXAMINATION
Higher 2

CANDIDATE NAME						
CLASS	**2T**	**INDEX NUMBER**				

BIOLOGY
9744/02

Paper 2 STRUCTURED QUESTIONS
21ST AUGUST 2017
2 hours

Candidates answer on the Question Paper.
Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST
Write your index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs. Do not use staples, paper clips, glue or correction fluid. DO NOT WRITE IN ANY BARCODES.

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

For Examiner's Use	
1 [12]	
2 [12]	
3 [13]	
4 [12]	
5 [9]	
6 [13]	
7 [12]	
8 [7]	
9 [10]	
TOTAL P2 [30%]	**100**

This document consists of **19** printed pages and **1** blank page.

[Turn over

Answer **all** questions.

1 Fig. 1.1 is a schematic diagram showing the transport pathways of extracellular and intracellular materials for digestion in a mammalian cell. Depending on the types of digested material, three possible pathways are initiated to deliver these materials for digestion within lysosomes, of which one is labelled as **A**.

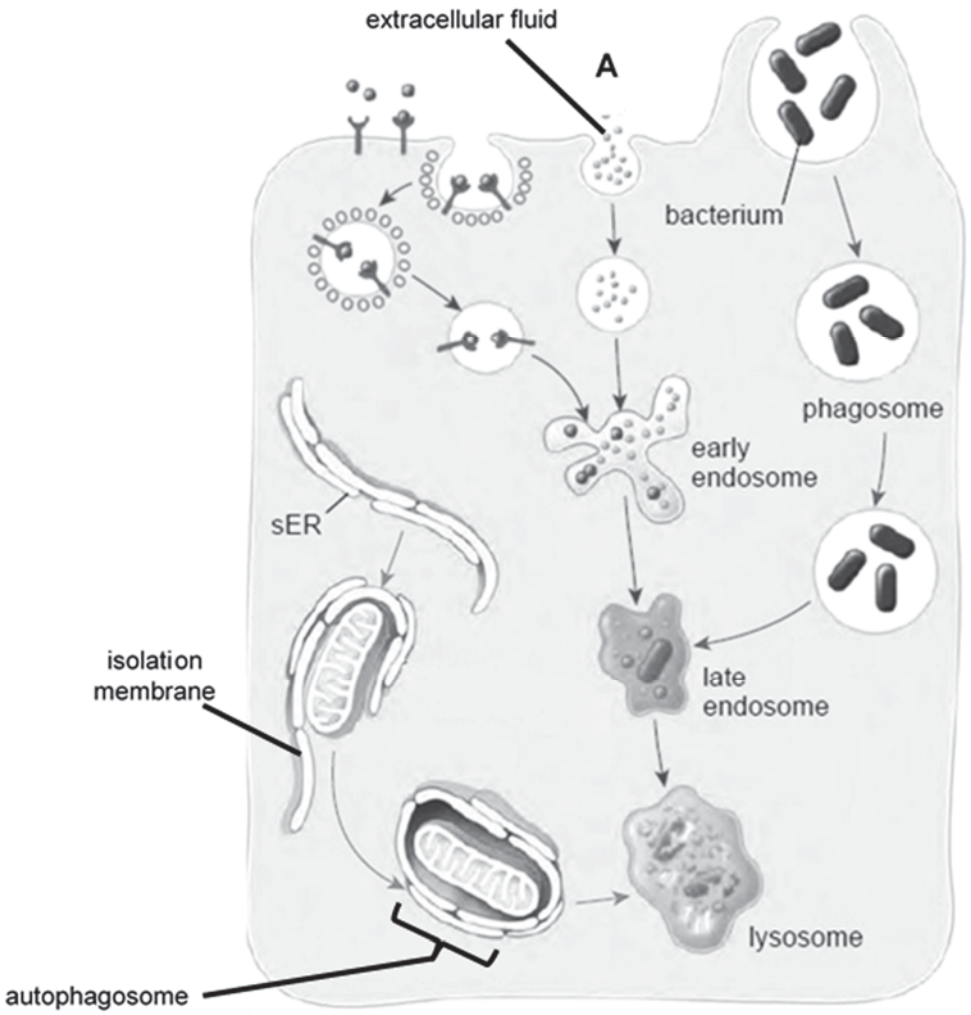


Fig. 1.1

(a) **(i)** Identify precisely process **A**.

…… [1]

(ii) State **one** property of the plasma membrane and explain how it enables process **A** to be carried out by a cell.

……

……

……

…… [2]

(b) Degradation of worn out organelles such as mitochondria occurs inside most cells via autophagy. With reference to Fig.1.1, describe the process of autophagy.

……

……

……

……

……

……[3]

(c) Lysosomes are able to hold a large amount of enzymes. Lysosomal membrane contains a large amount of highly glycosylated integral proteins facing the interior of the lysosome.

Suggest how this high amount of glycosylated protein prevents self-digestion of the lysosome.

…… [1]

Fig.1.2 shows an electron micrograph of parts of the endomembrane system.

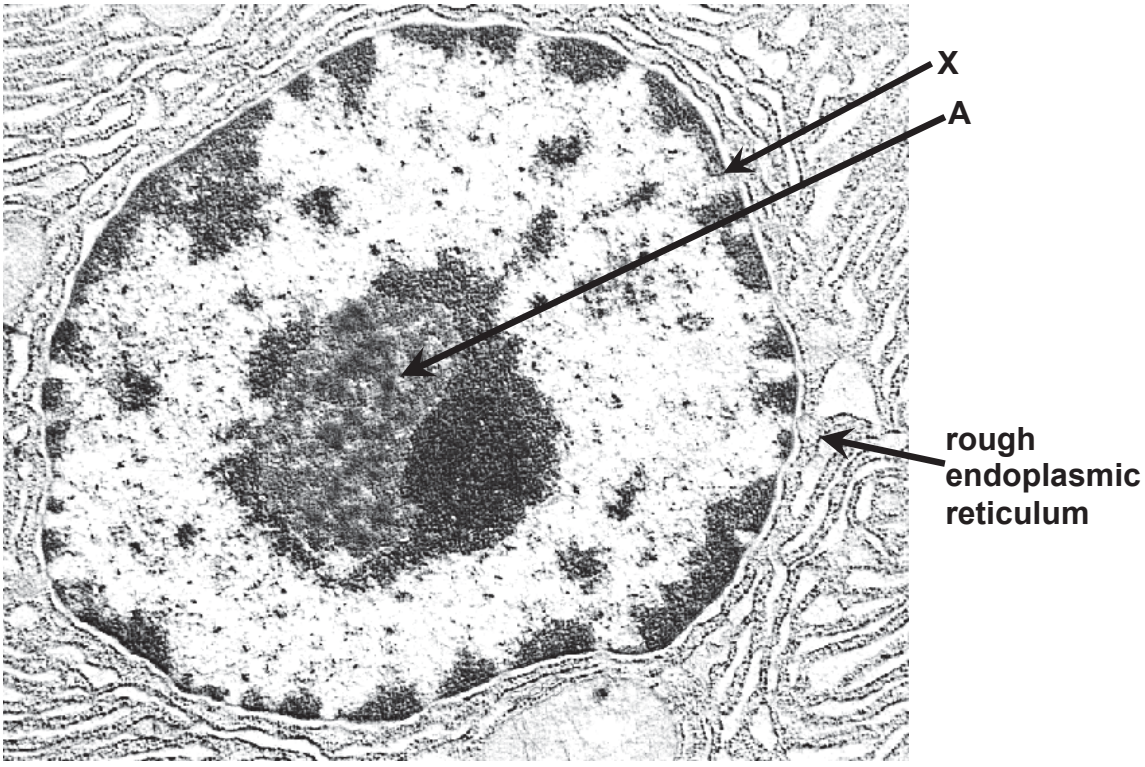


Fig. 1.2

(d) Explain how **X** regulates the movement of materials in protein synthesis.

……

……

……

…… [2]

(e) Explain how the functions of region **A** and rough endoplasmic reticulum are related.

……

……

……

…… [2]

(f) During the early stages of oogenesis (formation of egg) in Xenopus laevis (frog); there are as many as 1000 of region **A** within a single oocyte (egg cell). Suggest the significance of this.

…… [1]

[Total: 12]

2 **(a)** In beer-making, barley is malted with enzymes which hydrolyse starch into sugar, ready for fermentation. The graph below shows the production of sugar during beer-making at three different temperatures over a period of 60 minutes. All other conditions were controlled.

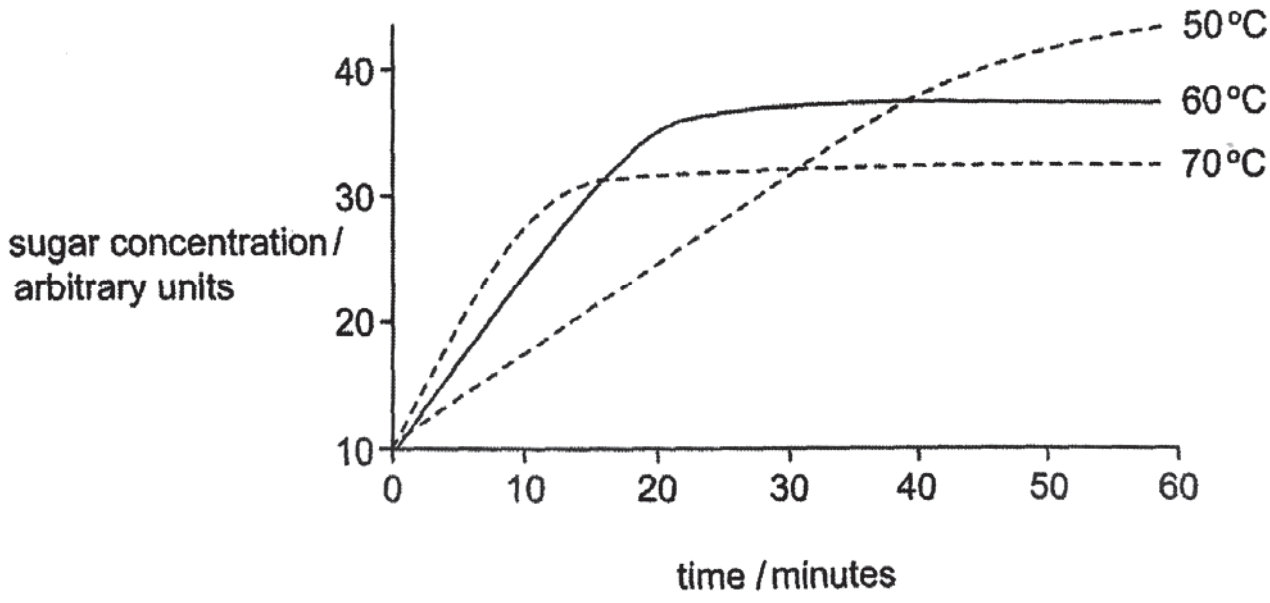


Fig. 2.1

(i) With reference to Fig. 2.1, explain the effect of increasing temperature on enzyme activity for the first 10 minutes of the reaction.

……...

……...

……...

……...

……...

…… [3]

(ii) Explain why the final concentration of sugar produced at 70^{o}C is lower than the reaction incubated at 60^{o}C.

……...

……...

……...

…… [2]

(iii) State the enzyme used in the reaction above.

…… [1]

(iv) Explain how the enzyme stated in **(iii)** plays its role in hydrolysis of starch to glucose.

……...

……...

……...

……...

……...

…… [3]

(b) What structural differences exist between starch and cellulose, and how these are related to their different roles in plants.

……

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……

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……[3]

[Total: 12]

3 Fig. 3.1 below shows DNA replication in an eukaryotic organism.

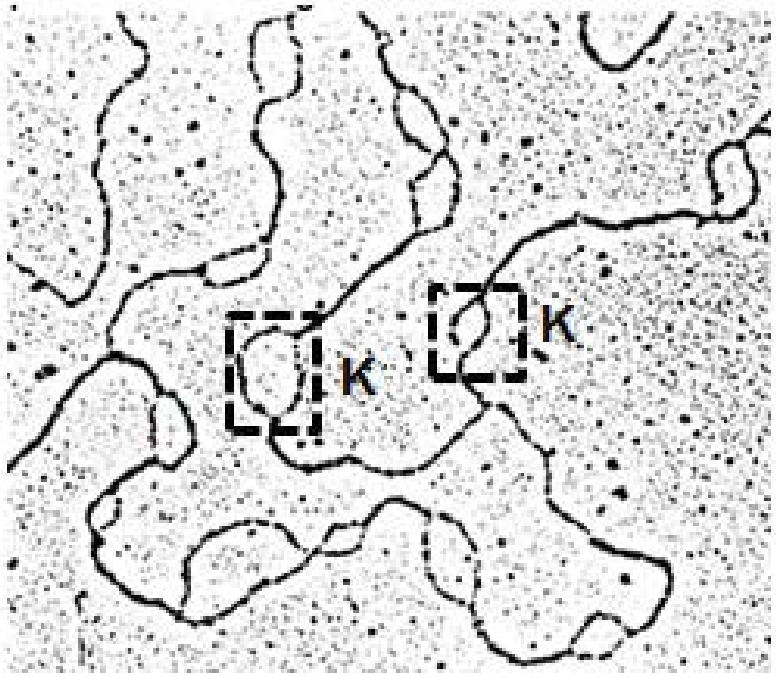


Fig. 3.1

(a) **(i)** What evidence in Fig. 3.1 shows that the process is DNA replication in an eukaryotic cell.

……

…… [1]

(ii) Within structures **K** in Fig. 3.1, there are no occurrences of end-replication problem. Explain why.

……

…… [1]

(b) **(i)** The DNA replication at each replication fork is sometimes described as *'asymmetrical'* replication as there are differences in the way the daughter strands are being synthesized. State **two** such differences.

……

……

……

……

…… [2]

(ii) Suggest **two** reasons for the *'asymmetrical'* replication.

.....

.....

.....

..... [2]

(c) Describe the unique features of hematopoietic stem cells which are common in all stem cells.

.....

.....

.....

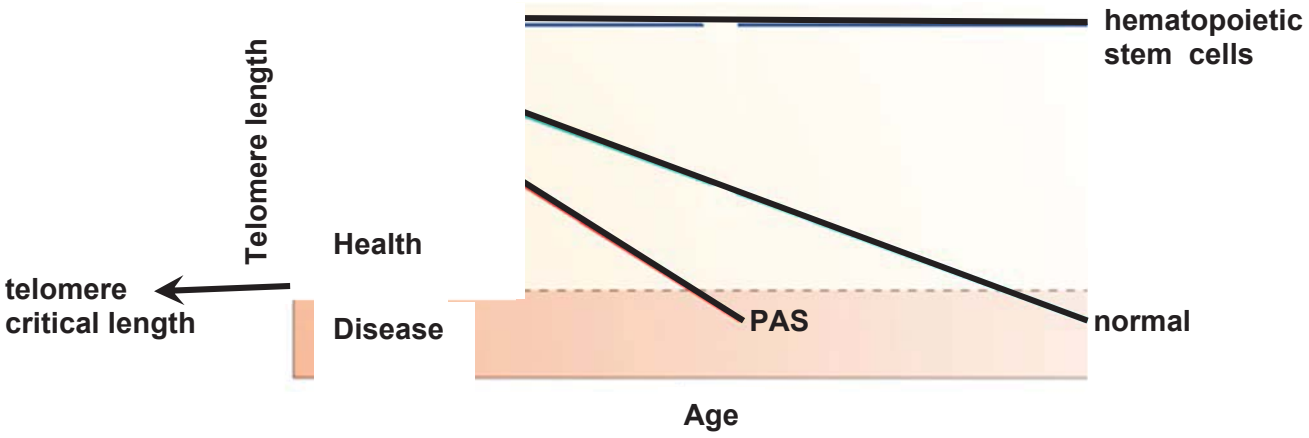
.....

.....

..... [3]

(d) Fig. 3.2 shows a graph showing the relationship between age and the telomere length in 3 different kinds of cell;

- hematopoietic stem cells
- somatic cells from a healthy individual (normal)
- somatic cells from an individual suffering premature aging syndromes (PAS)



Fig

With reference to

(i) account for t e in telomere l hematopoietic stem cells and somatic cells from healthy individual.

.....

.....

……

…… [2]

(ii) suggest the cause of premature aging syndrome

……

……

……

…… [2]

[Total: 13]

4 Root tissue from a barley seedling was prepared and its chromosomes were observed under a microscope. Fig. 4.1 shows a cell from the root tissue at the metaphase stage of mitosis.

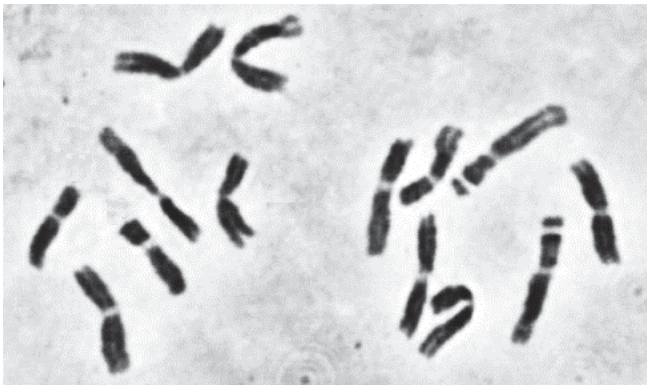


Fig. 4.1

Fig. 4.2 shows the changes in amount of DNA at different stages of the barley life cycle.

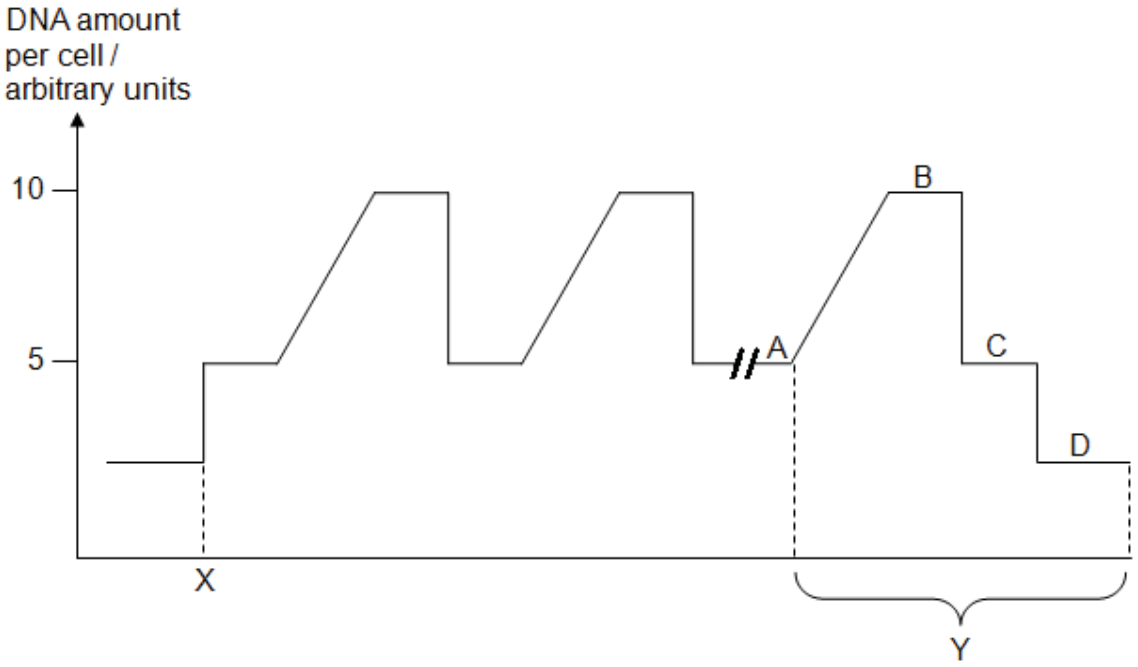


Fig. 4.2

(a) Mark out clearly with an arrow, ↓ , on Fig. 4.2, the part of the graph which corresponds to the stage shown in Fig. 4.1.

[1]

(b) With reference to Fig.4.2,

(i) state which of the stages, from **A** to **D** has/ have the **same** number of chromosomes as shown in Fig.4.1.

…… [1]

(ii) Explain why a mutation which occurs during **Y** is considered as a hereditary mutation.

…… [1]

(c) Explain the significance of the event occurring at **X**.

……

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……

…… [2]

(d) Fig. 4.3 shows the formation of Philadelphia chromosome which is commonly found in chronic myelogenous leukemina (CML) cells.

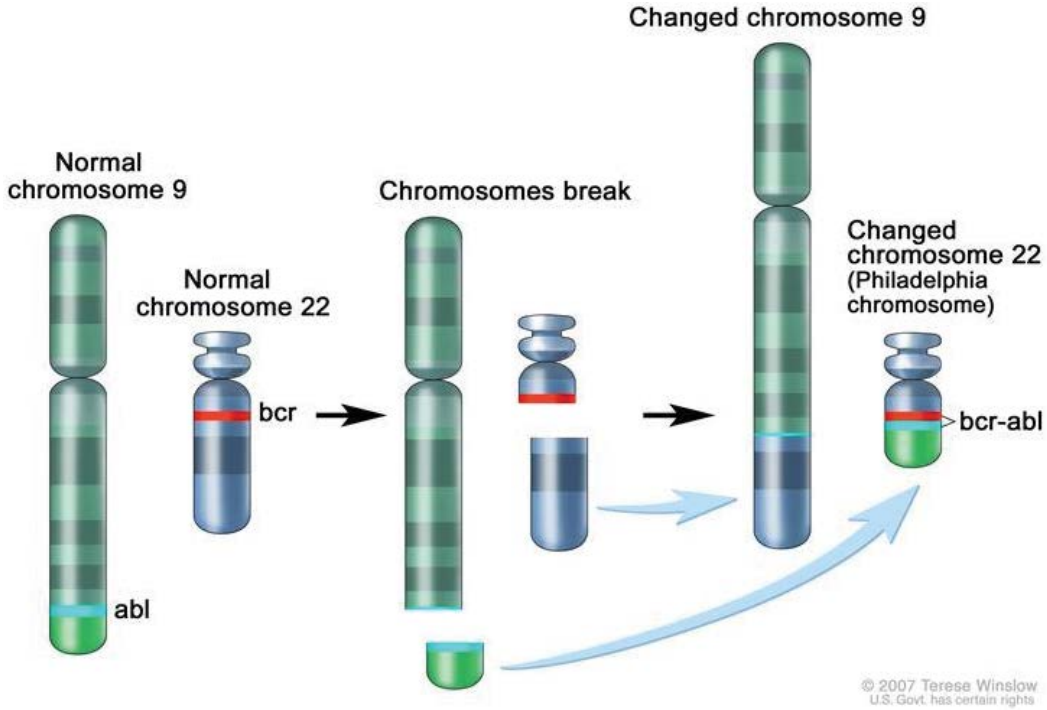

Fig. 4.3

(i) With reference to Fig.4.3, describe the chromosome aberration which results in the formation of Philadelphia chromosome.

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……

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…… [2]

The protein product of *bcr* gene (BCR protein) is a protein involved in signaling pathway and possesses tyrosine kinase activity. In the presence of growth factors, BCR protein is activated and is found to promote cell growth and proliferation.

The results of a study conducted using chronic myelogenous leukemina (CML) cells to show the effect of Philadelphia chromosome on the activity of BCR protein is shown in Table 4.1.

Table 4.1

The variable being studied	normal cells	CML cells
Concentration of BCR protein / mg cm^{-3}	29.8	29.5
Tyrosine kinase activity of BCR protein in the **absence** of growth factor / a.u.	0	40
Tyrosine kinase activity of BCR protein in the **presence** of growth factor/ a.u.	40	40

(ii) With respect to its effect on cell growth and proliferation, name the group of genes which *bcr* gene belongs to.

…… [1]

(iii) With reference to Fig. 4.3 and Table 4.1, explain how Philadelphia chromosome contributes to the onset of chronic myelogenous leukemia (CML).

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……[4]

[Total: 12]

5 In a particular variety of tomato plant, the allele for red fruit colour is dominant to the allele for yellow fruit colour and the allele for hairy stems is codominant with the allele for hairless stems. A true breeding plant with red fruit and hairy stems was crossed with another true breeding plant with yellow fruit and hairless stems. The resulting F1 were selfed to produce one hundred tomato plants with their ratios shown in Table 5.1.

Table 5.1

Frequency and phenotype of offspring	Genotype
37 red fruit and short hairs on stem	
18 red fruit and very hairy stem	
19 red fruit and hairless stem	
13 yellow fruit and short hairs on stem	
7 yellow fruit and very hairy stem	
6 yellow fruit and hairless stem	

(a) Using the letters **R** for red fruit and **r** for yellow fruit, **H** for hairy stem and **L** for hairless stem, fill in the genotypes for each phenotype of the offspring in the Table 5.1 above. [2]

(b) From Table 5.1, explain how codominance brings about the trait “short hairs on stem”.

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……[2]

(c) Draw a genetic diagram to explain this cross.

[5]

[Total 9]

6 Microalgae have been extensively studied for various purposes, such as the production of biomass as a source of valuable chemicals of health foods and for wastewater treatment. Recently, microalgal photosynthesis was considered to be an effective means to reduce the emission of carbon dioxide, a major greenhouse gas, in the atmosphere. Light is the most important factor affecting microalgal photosynthesis kinetics. In general, most microalgal mass culture systems are limited by light, because light is easily absorbed and scattered by the microalgal cells. Therefore, understanding and quantification of light dependence of microalgal activity is of great importance in designing an efficient photobioreactor, in predicting process performance, and in optimizing operating conditions.

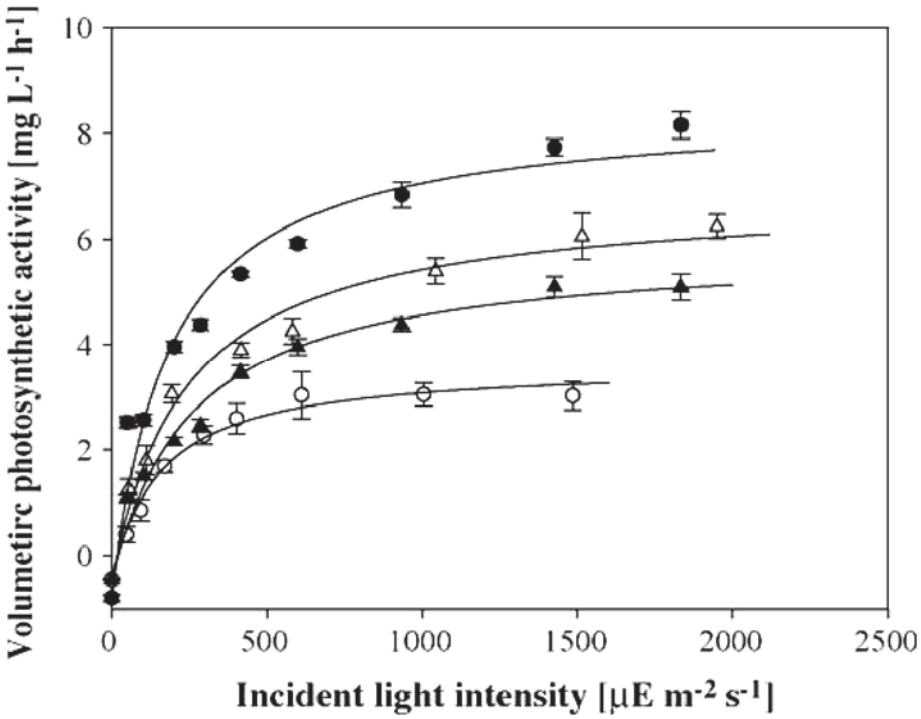

Fig. 6.1
The volumetric photosynthetic activity as a function of incident light intensity at different light types and cell concentrations. Data points and error bars were average values and standard deviations of three replicated experimental results. Solid lines represent the calculated results from the photosynthesis–irradiance model. The light types and cell concentrations were:
(⌀) simulated daylight and 0.215 g L−1;
(▲) simulated daylight and 0.123 g L−1;
(△) red light and 0.123 g L−1; and
(✚) green light and 0.123 g L−1.

Jeon *et al* 2005 Measurement of microalgal photosynthetic activity depending on light intensity and quality. Biochemical Engineering Journal 27 (2005) 127–131

(a) Explain the trends seen when red, green and daylight (at 0.123gL-1) are compared.

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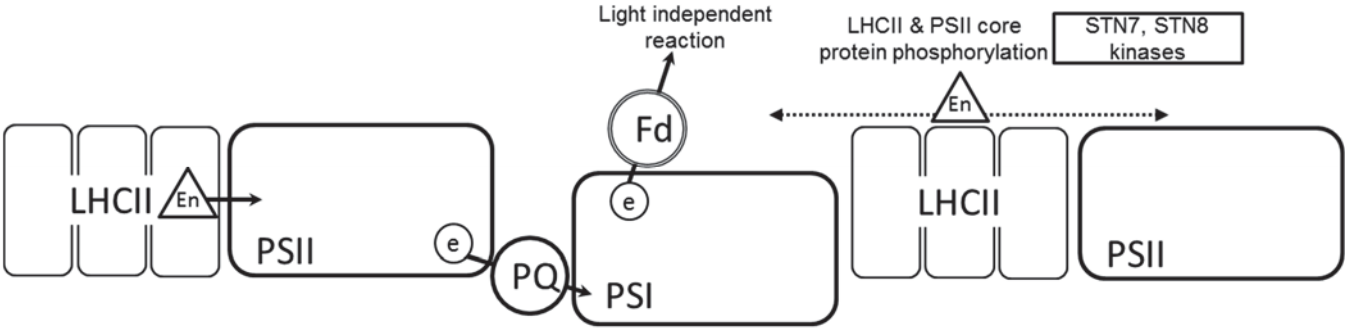
……[5]

Fig. 6.2 shows a schematic showing the functional relationship between light harvesting complexes (LHC) and photosystems II & I. Regulatory complexes are also shown comprising of kinases and the regulation of excess energy between PS II and I.



Gollan et al 2015 Photosynthetic light reactions: integral to chloroplast retrograde signalling. Current Opinion in Plant Biology 27:180-191modified.

Fig. 6.2

(b) Explain what is the LHC and its role in photosynthesis.

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……

……[2]

(c) With reference to Fig. 6.2 explain the role of electrons in the photosynthesis as they move from Photosystem II to Photosystem I.

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……[3]

(d) With reference to Fig. 6.2 suggest the implications of the role of LHC and PSII core protein phosphorylation from Photosystem II to Photosystem I.

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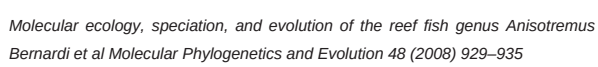
……[3]

[Total: 13]

7 The Isthmus of Panama is the narrow strip of land that lies between the Caribbean Sea and the Pacific Ocean, linking North and South America. It contains the country of Panama and the Panama Canal. The isthmus was formed around 2.8 million years ago. This major geological event separated the Atlantic and Pacific Oceans and caused the creation of the Gulf Stream.

The genus Anisotremus shown in Fig. 7.1b comprises 9 described species which occur predominantly on coral reefs and subtropical rocky reefs in the Neotropics of the Tropical Eastern Pacific the Caribbean and adjacent waters. In this study, the phylogenetic relationships for all described species were examined based on one mitochondrial gene (cytochrome b) and one nuclear marker (the first intron of the ribosomal protein S7).

Fig 7.1a



Molecular ecology, speciation, and evolution of the reef fish genus Anisotremus
Bernardi et al Molecular Phylogenetics and Evolution 48 (2008) 929–935

Fig 7.1b

(a) Name two methods by which evolution can take place.

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……[2]

(b) With reference to Fig. 7.1b explain the type of speciation that would have seen to the derivation of the two fish A. virginicious and A. taeniatus.

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……[2]

(c) With reference to your answer in **(b)** explain the how micro evolution would have taken place.

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……[4]

(d) Suggest how it was determined that A. virginicious and A. taeniatus were phylogenetically descended from A. dovii and A. pacifici.

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……[2]

(e) In this study it was proposed that A. virginicious and A. taeniatus took a shorter time to speciate from one another compared to A. dovii and A. pacifici. Suggest with evidence from Fig. 7.1a how this might be true.

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……

……[2]

[Total: 12]

8 Transpeptidase is a bacterial enzyme that cross-links cell wall peptides during the formation of bacterial cell walls. The antibiotic penicillin inhibits the activity of transpeptidase. Fig. 8.1 shows part of each of the molecular structures of a cell wall peptide and penicillin.

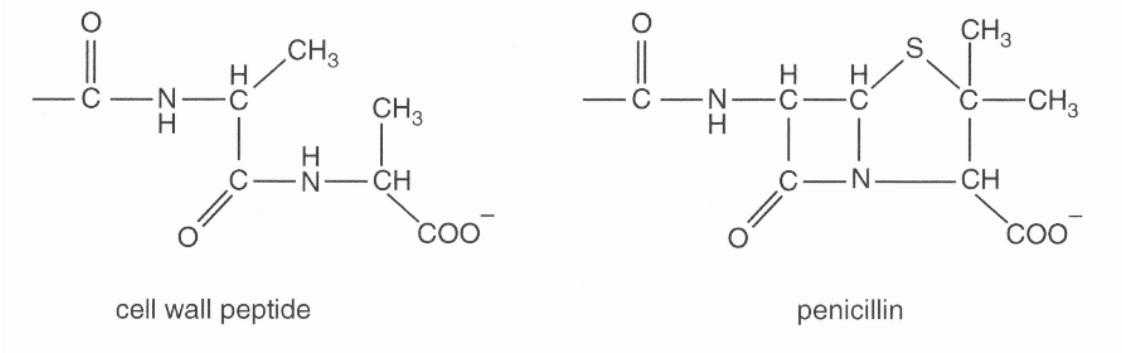

Fig. 8.1

(a) Comment on the structure of cell wall peptides and penicillin.

……[1]

(b) Suggest why the penicillin molecule is an effective inhibitor of transpeptidase.

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……[2]

(c) Fig.8.2 shows an electron micrograph of an alveolar macrophage isolated from a tuberculosis patient.

M. tuberculosis

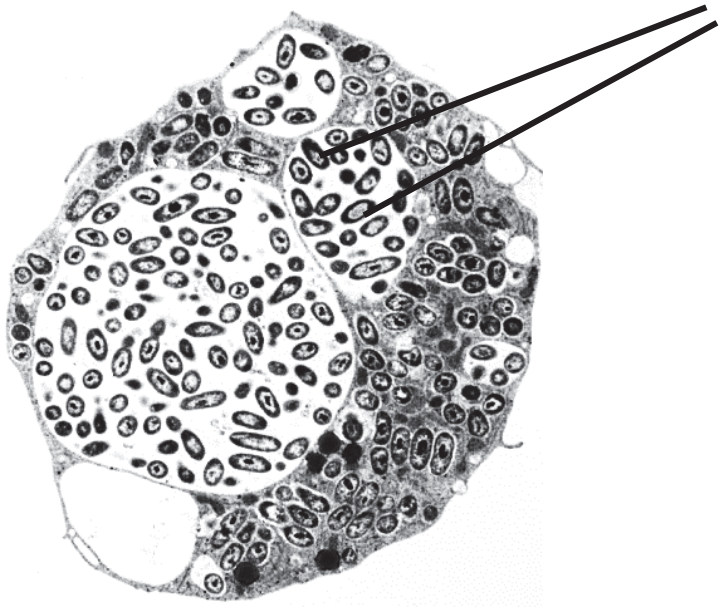

Fig. 8.2

(i) Describe the mode of transmission of Mycobacterium tuberculosis.

……...

…… [1]

(ii) Explain the appearance of the alveolar macrophage in Fig. 8.2.

……

……

……

…….[2]

(d) Tuberculosis patients are commonly treated with antibiotics, isoniazid and rifampicin. Recently, there is an increase in number of multi-drug resistant tuberculosis cases.
State **one** reason why multi-drug resistant tuberculosis continues to emerge.

…….…… [1]
[Total 7]

9 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 (Fig. 9.1). An estimated 50 million dengue infections occur annually and approximately 2.5 billion people live in dengue endemic countries.

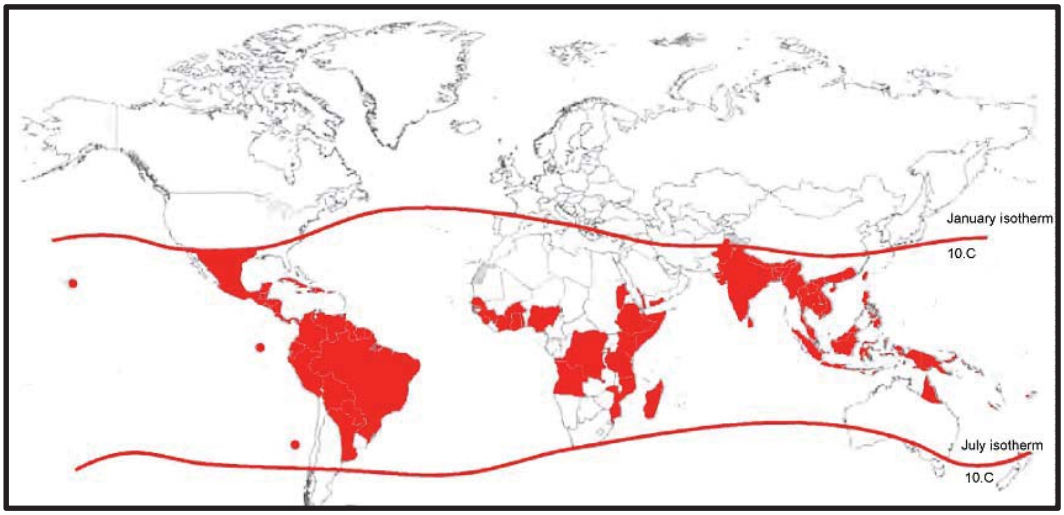

Fig. 9.1 Shaded areas are countries at risk of dengue fever due to presence of Aedes mosquito, as of 2008. The contour lines are range of January/July isotherm indicating the potential range of Aedes aegypti.

(a) Describe the developmental stages (including duration) in the life cycle of the Aedes mosquito.

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.....[4]

(b) Explain why the range of dengue fever is the same as that of the Aedes mosquito.

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.....[2]

(c) To some extent the range of the Aedes mosquito has also followed human expansion, explain how this may be true.

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.....[2]

(d) With reference to Fig. 9.1, explain how climate change may affect the spread of dengue beyond the tropics.

.....

.....

……

……[2]

[Total: 10]

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CATHOLIC JUNIOR COLLEGE
JC2 PRELIM EXAMINATION
Higher 2

CANDIDATE NAME						
CLASS	**2T**	**INDEX NUMBER**				

BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

23RD AUGUST 2017
2 hours

Candidates answer on the Question Paper.
Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

Write your index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs. Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

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

Section B
Answer **one** question in this section on writing papers provided.

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

For Examiner's Use	
SECTION A	
1 [30]	
2 [12]	
3 [8]	
SECTION B	
4 [25]	
OR	
5 [25]	
TOTAL P3 [35%]	**75**

This document consists of **14** printed pages.

[Turn over

Section A

Answer **all** questions in this section.

1 Milk is an important source of diet for most infant. For many adults, milk is an important source of dietary calcium. Milk contains many biological molecules; one of them is lactose. Therefore, it is not surprising that most infant will have a mechanism to digest lactose. While for adults, it is not normal for their body to be able to digest lactose. However, there is an increasing trend of lactose tolerant (also known as lactase persistent) individual in the adult population.

Here, we will discuss 3 types of conditions; namely Congenital Lactase Deficiency (CLD), lactose allergy, and lactose tolerance (lactase persistence).

Silanikove et al The Interrelationships between Lactose Intolerance and the Modern Dairy Industry: Global Perspectives in Evolutional and Historical Backgrounds Nutrients 2015, 7, 7312-7331

(a) Fig. 1.1 shows the structure of lactose.

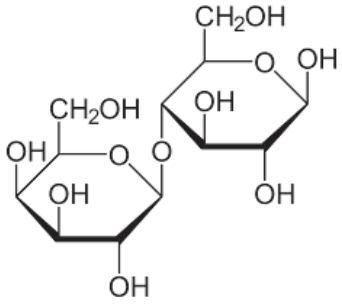


Fig. 1.1

Name the bond joining the 2 monomers in lactose

…… [1]

(b) Fig. 1.2 shows the catalytic residues found in the active site of lactase.

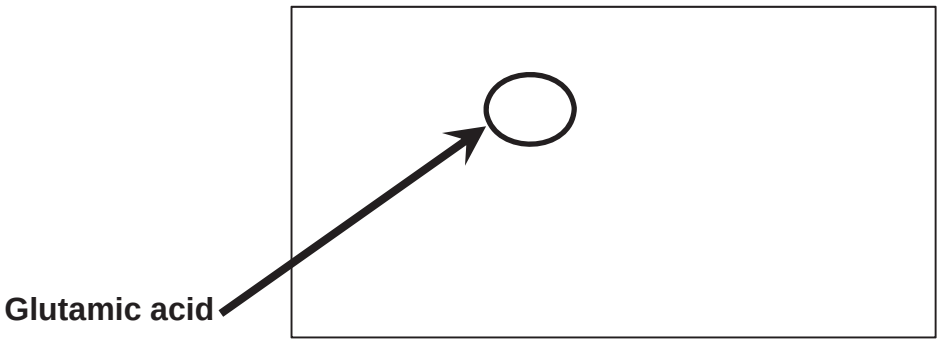


Fig. 1.2

One of the catalytic residues; glutamic acid (circled in Fig. 1.2) is substituted by glycine which is shown in Fig.1.3 below.

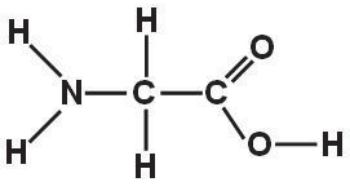


Fig. 1.3

Explain how lactase catalytic activity is affected by the substitution above.

……

……

……

……[2]

(c) Lactose intolerance in infant is also known as Congenital Lactase Deficiency (CLD). It is an autosomal recessive disorder.

Studies have shown that CLD is caused by mutation in *LCT* gene coding for lactase. The most commonly observed mutation is a single nucleotide substitution in *LCT* gene which results in the production of truncated lactase.

Other mutation such as a single nucleotide deletion in *LCT* gene has also been detected in a few patients which also results in the production of truncated lactase.

(c)(i) Explain how two different types of mutations; single nucleotide substitution and single nucleotide deletion in *LCT* gene can lead to the production of truncated lactase.

……

……

……

…… [2]

(c)(ii) A small amount of DNA is isolated from infants suffering CLD resulted from a single nucleotide substitution. The DNA was subjected to process **Y** to ensure enough DNA for the subsequent Southern Blotting process.

Name the process **Y.**

…… [1]

Fig. 1.4 shows wild type *LCT* gene and mutant *LCT* gene. The mutation result in the loss of *NdeI* restriction site (*NdeI* RE) at position 4 kb as shown by the arrow ⇧.

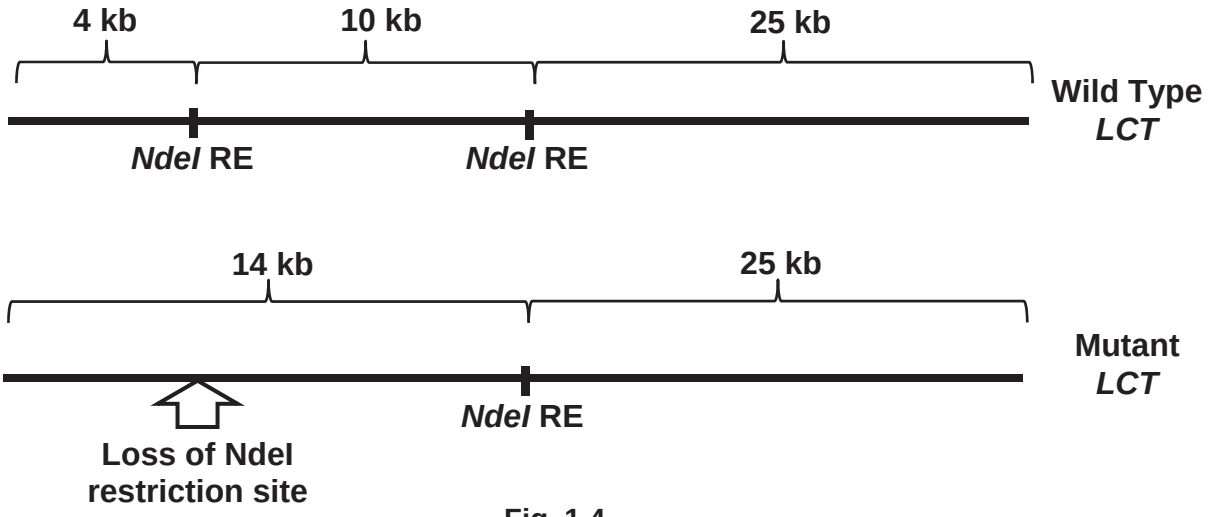


Fig. 1.4

Fig. 1.5 shows the band patterns of the nitrocellulose membrane obtained from the Southern Blotting of DNA sample from 3 infants.

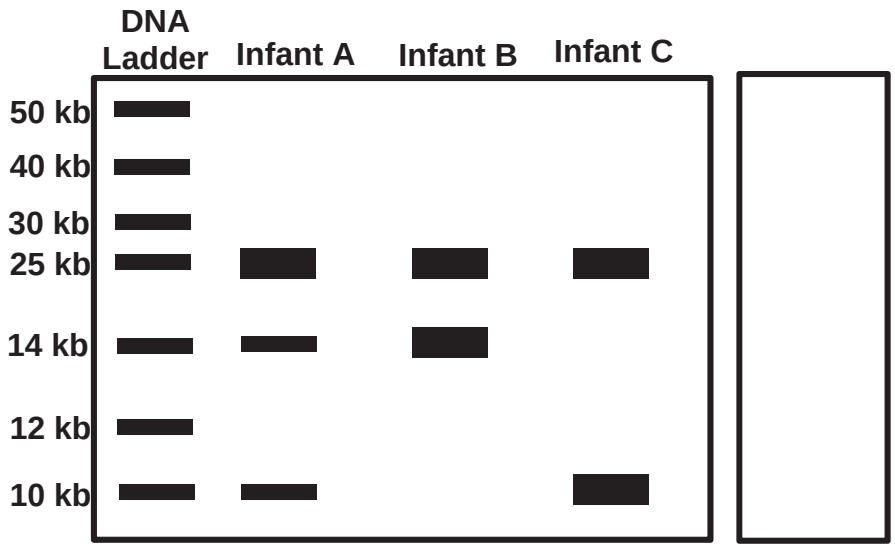
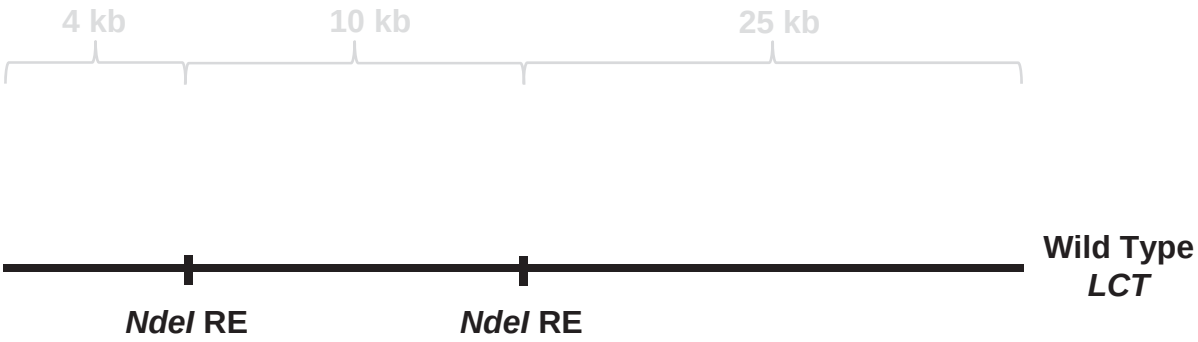


Fig. 1.5

(c)(iii) On the box on the right side of Fig. 1.5, indicate the position of the positive terminal and negative terminal during the gel electrophoresis which results in the band pattern in Fig. 1.5. [1]

(c)(iv) Based on the position of the *NdeI* restriction sites in wild type and mutant *LCT* gene in Fig. 1.4 as well as the band patterns in Fig.1.5, indicate on the wild type *LCT* below where the probe will anneal to (use a ruled line and label). [1]



(c)(v) Based on the information provided in part **(c)** as well as Fig. 1.4 and Fig. 1.5; explain which infant is suffering from CLD.

……

……

……

…… [2]

(d) Another condition known as lactose allergy results in more severe symptoms than lactose intolerance. The symptoms of allergy are due to the action of Immunoglobulin E (IgE) which activates mast cells, which subsequently secrete a chemical signal **X.**

(d)(i) Name **X.**

…… [1]

Fig. 1.6 shows the structure of IgG and IgE.

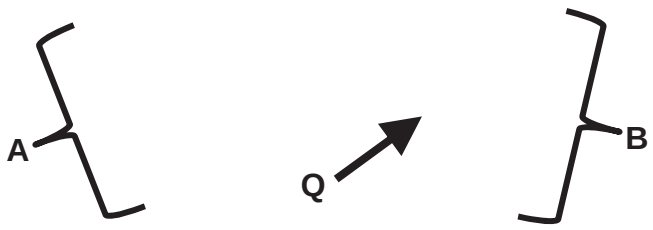


Fig. 1.6

(d)(ii) The number, type, and position of Q on IgG and IgE are different. Name precisely the process which attaches Q on IgG and IgE.

…… [1]

(d)(iii) Describe structures of IgE that allow it to perform its role in eliciting allergy response towards lactose.

……...

……...

……...

…… [2]

(d)(iv) With reference to Fig. 1.6; suggest what will happen to an individual with lactose allergy when part **B** of all his IgE is replaced with part **A** of his IgG

……...

…… [1]

Some human adults continue to produce the lactase enzyme throughout their adulthood (lactase persistent). Therefore, they are able to digest lactose effectively (lactose tolerant) and will not develop symptoms such as bloating, flatulence, or diarrhoea after consuming milk.

However, most adult mammals stop producing the lactase enzyme (lactase non-persistent). Therefore, they are unable to digest lactose effectively (lactose intolerant) and will usually develop symptoms such as bloating, flatulence, or diarrhoea when consuming milk.

Fig. 1.7 shows the pattern of inheritance of lactose intolerance in Family A.

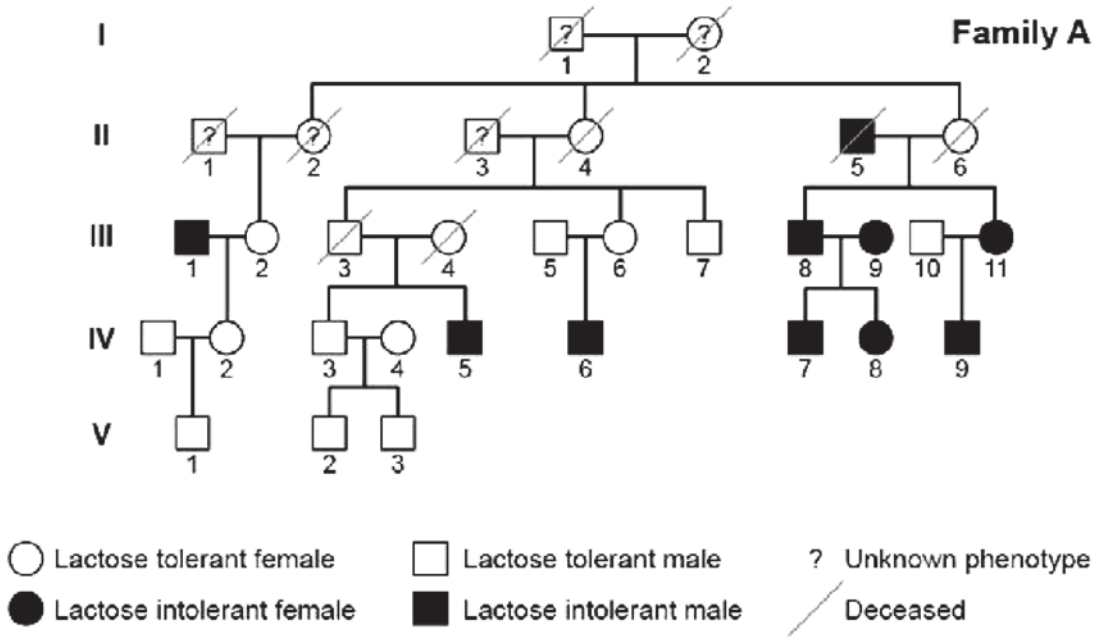


Fig. 1.7

(e)(i) With reference to Fig. 1.7; explain the mode of inheritance of lactose intolerance and where the gene is probably located. Provide evidence to support your claim.

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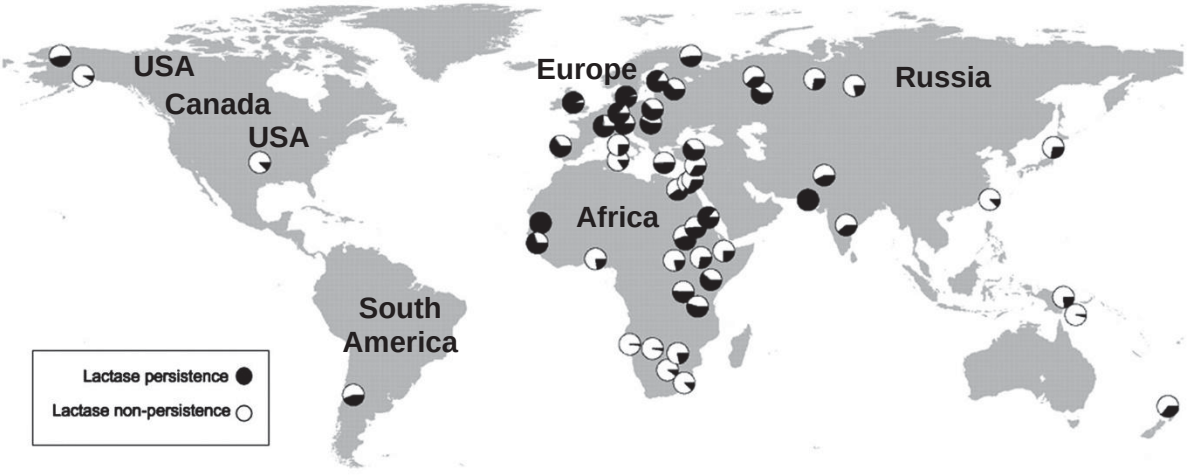
……[4]

Humans learned to exploit ruminants as a source of milk about 10,000 years ago; particularly the European population. Since then, the use of domesticated ruminants as a source of milk and dairy products has expanded until today when the dairy industry has become one of the largest sectors in the modern food industry, including the spread at the present time to countries such as China and Japan.

Widespread lactose intolerance among the adult population is a considerable drawback to dairy-based foods consumption. Over the centuries, three factors allowed humans to overcome limitations imposed by lactose intolerance: (i) mutations, which occurred in particular populations, most notably in the north European Celtic societies and African nomads, in which carriers of the lactose intolerance gene converted from being lactose intolerant to lactose tolerant; (ii) the ability to develop low-lactose products such as cheese and yogurt; and (iii) colon microbiome adaptation, which allow lactose intolerant individuals to overcome its intolerance.

Fig. 1.8 shows the pockets of lactase persistence shown in pie charts.



Pockets of lactase persistence shown in pie charts. Ingram et al, Hum Genet 124:579–591, 2009.

Fig. 1.8

(e)(ii) With reference to Fig. 1.8; apart from the genetic factors, suggest what other factor could have contributed to the spread of lactase persistence.

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……

……

……[2]

(f)(i) Explain how Darwin's principles of evolution may be applied in understanding the type of evolution that would have had to take place in the spread of lactose tolerance.

……

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……[3]

(f)(ii) Suggest how the scenario described in **(f)(i)** is an example of macro or micro evolution.

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……[2]

(g)(i) Define anthropomorphic climate change.

……

……[1]

(g)(ii) Explain how the above scenario of increased lactase persistence may contribute to anthropomorphic climate change.

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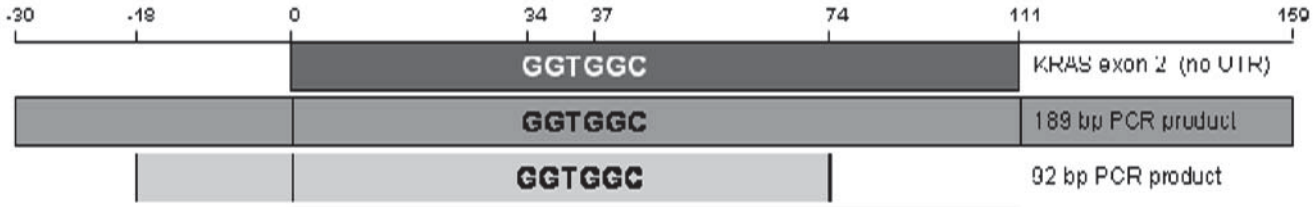
……[3]

[Total: 30]

2 All mammalian cells express three closely related Ras proteins: H-Ras, K-Ras and N-Ras that promote oncogenesis when mutationally activated at codons 12, 13 or 61. Despite a high degree of similarity between the isoforms, K-Ras mutations are far more frequently observed in cancer.



AGTGGC	GLY12 SER
CGTGGC	GLY12 ARG
TGTGGC	GLY12 CYT
GATGGC	GLY12 ASP
GCTGGC	GLY12 ALA
GTTGGC	GLY12 VAL
GGTAGC	GLY13 SER
GGTCGC	GLY13 ARG
GGTTGC	GLY13 CYT
GGTGAC	GLY13 ASP
GGTGCC	GLY13 ALA
GGTGTC	GLY13 VAL

Location of K-RAS codon 12 and 13 mutations and PCR amplicons / products. Exon 2 of K-RAS is shown from the ATG without the untranslated region. The position and size of the PCR amplicons used in the High Resolution Melting HRM assays in relation to exon 2 of K-RAS is indicated. All possible mutations at codon 12 and 13 are listed along with the corresponding amino acid changes from Glycine (GLY) are shown.

Krypup et al. High resolution melting analysis for the rapid and sensitive detection of mutations in clinical samples: KRAS codon 12 and 13 mutations in non-small cell lung cancer BMC Cancer 2006, 6:295

Fig. 2.1

(a) With reference to Fig. 2.1; explain the type of mutation experienced in K-RAS codon 13.

……

……

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……[2]

(b) With reference to Fig. 2.1; suggest why oncogenesis in codon 13 is caused by only 6 possible changes in amino acid and not more.

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.....[4]

Ras proteins are the products of proto-oncogenes that are frequently mutated in human cancers. They are encoded by three ubiquitously expressed genes: *H-Ras*, *K-Ras* and *N-Ras*. These proteins are GTPases that function as molecular switches regulating pathways responsible for proliferation and cell survival.

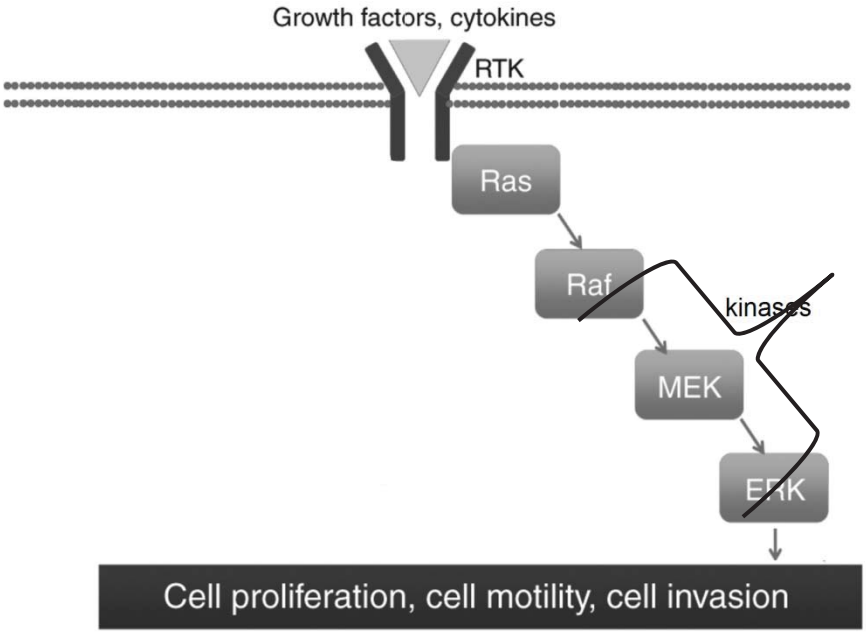

Fig. 2.2

(c) How does Ras protein act as a molecular switch in initiating cell proliferation?

……

……[1]

(d) With reference to Fig. 2.2; explain how Ras protein is normally used to terminate cell proliferation.

……

……

……

……[2]

(e) With reference to Fig. 2.2; suggest how a mutation in *Ras* gene results in uncontrolled cell division.

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……

……[1]

(f) With reference to **(a)** to **(e)**; explain the development of cancer.

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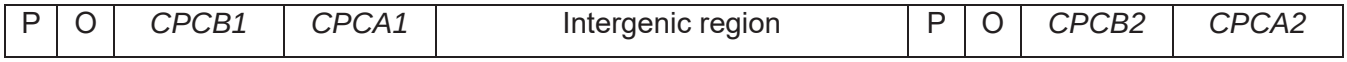
……

……[2]

[Total: 12]

3 Cyanobacteria are a group of bacteria that obtains their energy through photosynthesis. They carry an operon known as *phycocyanin* operon which controls the expression of phycocyanin. Phycocyanin is a protein complex which serves as accessory pigment to chlorophyll in cyanobacteria. Without phycocyanin, light harvesting process is halted. The amount of phycocyanin increases from very low level to high level in the presence of light.

Fig. 3.1 below shows the structure of *phycocyanin* operon in the Cyanobacterium Anacystis nidulans.



Legend:

P	**:**	**promoter**
O	**:**	**operator**
CPCB1* and *CPCA1	**:**	**structural genes coding for β – subunit of phycocyanin**
CPCB2* and *CPCA2	**:**	**structural genes coding for α – subunit of phycocyanin**

Fig. 3.1

(a) Compare the *lac* operon to the *phycocyanin* operon.

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……[3]

(b) Describe how the *CPCA2* gene could be transferred to another bacterium by a prophage.

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……

……[3]

(c) Cyanobacterium Anacystis nidulans has thylakoid which contain the same photosystems as the thylakoid of plant cells. Fig. 3.2 shows a hybrid *phycocyanin* operon.

trp P	O	*CPCB1*	*CPCA1*	Intergenic region	trp P	O	*CPCB2*	*CPCA2*

Legend:
trp P : trp promoter

Fig. 3.2

Explain the rate of production of oxygen in the Cyanobacterium Anacystis nidulans carrying the hybrid operon when light is present and tryptophan is present.

……

……

……

……[2]

[Total: 8]

Section B

Answer **one** question in this section
Write your answers on separate answer paper provided.
Answer each part on a **separate** piece of paper.

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

4 **(a)** Explain the fluid mosaic model and the roles of the constituent biomolecules in functions of membranes at the cell surface and of membranes within the cell. [13]

(b) Explain how genetic variation arises in a natural population and its significance in allowing the population to adapt and evolve. [12]

[Total: 25]

5 **(a)** With reference to named examples, describe the roles of proteins in bringing about cell signalling in living organisms. [13]

(b) Gene expression in eukaryotes is regulated at many different stages of the process.
Explain how gene expression is regulated in eukaryotes and the significance of this at each stage. [12]

[Total: 25]

QUESTION 1

Preparation List

	Apparatus / Reagents / Chemicals	Quantity per candidate
1	In a capped container, labelled **E**, 10% urease solution	at least 15 cm^3
2	In a capped container, labelled **U**, 10% urea solution	at least 15 cm^3
3	In a beaker, labelled **W**, distilled water	At least 100 cm^3
4	Red litmus paper	One length approximately 20 cm or 4 X 5 cm strips from a book
5	Test-tube rack, suitable for holding 6 test-tubes	1
6	Test-tubes	6
7	Small beakers to hold up to 50 cm^3	6
9	10 cm^3 syringes	2
10	5 cm^3 syringes	2
11	White tile or paper or card	1
15	Ruler (mm)	1
16	Container, labelled '**Waste'**	1

Preparation of Solutions

E, 10% urease solution at room temperature. This is prepared by dissolving 10 g of urease active meal or three crushed tablets of urease (according to manufacturer's instructions) in a beaker with 50 cm^3 of distilled water. Make up to 100 cm^3 with distilled water. Mix well. The solution may remain cloudy.

U, 10% urea solution at room temperature. This is prepared by adding 10 g of urea to 80 cm^3 of distilled water in a beaker. Make up to 100 cm^3 with distilled water. Mix well.

Testing the activity of the urease

Before the examination, put a small piece of red litmus paper into a dry test-tube. Add 2 cm^3 of **E** then 2 cm^3 of **U** and start timing. Time how long it takes for the paper to start turning blue.

If this is longer than 5 minutes, increase the concentration of urea to 15%.

It is not necessary to inform the students that the concentration is different from that given in the question paper.

QUESTION 2

Per Student

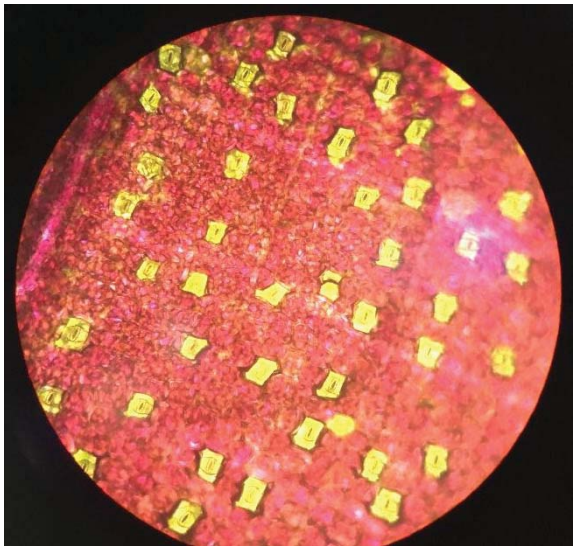
Solution for Each Candidate	Volume / cm^3
0.1 mol dm^{-3} potassium chloride solution, **adjusted to pH 7.0.** Solution should be sufficient to cover one piece of *Tradescantia* (spiderwort) leaf, in a beaker or container labelled **X**.	25
0.1 mol dm^{-3} sodium chloride solution, **adjusted to pH 7.0.** Solution should be sufficient to cover one piece of *Tradescantia* leaf, in a beaker or container labelled as **Y**	25
0.1 mol dm^{-3} potassium chloride solution, **adjusted to pH 4.5.** Solution should be sufficient to cover one piece of *Tradescantia* leaf, in a beaker or container labelled as **Z**	25

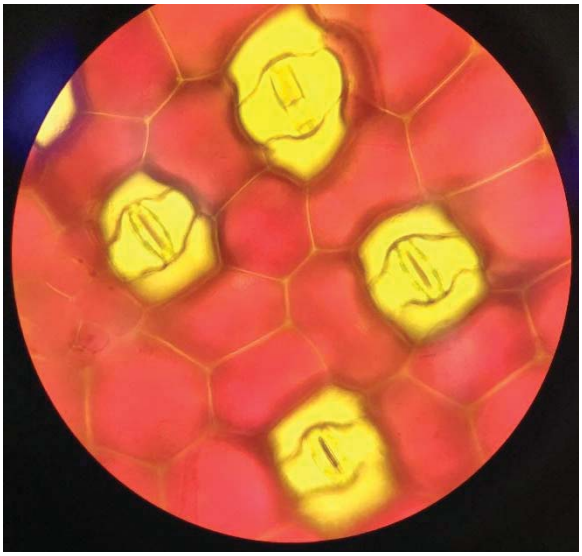
Apparatus for each candidate should be clean. Syringe needles are not required and must not be given to candidates.

Apparatus for each candidate	**Quantity**
Pipette, plastic or glass with teat 1	1
Paper Towel	8
Forceps (blunt)	1
Glass rod	1
Scissors	1
Glass Marker Pen	1
Scalpel or sharp blade	1
Stopwatch	1
Safety Glasses / Goggles	1
Microscope	1
Microscope slides with cover slips	5
Access to a sink and tap water	

Leaf Tissues:
Leaves from *Tradescantia* spp. (common name: Wandering Jew; Spiderwort).

Prepare the leaves by immersing in their different solutions and exposed to light for at least an hour before dispensing out to students. There should be sufficient leaves to provide at least 3 per candidate.





CATHOLIC JUNIOR COLLEGE
JC2 PRELIM EXAMINATION
Higher 2

CANDIDATE NAME		CLASS	2T

INDEX NUMBER				

BIOLOGY
Paper 4 PRACTICAL

9744/04
14th AUGUST 2017
2 hours 30 minutes

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

READ THESE INSTRUCTIONS FIRST

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

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
TOTAL	

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.

1 Investigation into the effect of changing the concentration of an enzyme on enzyme activity.

The biological molecule, U, reacts with water to form aqueous ammonium carbonate. The enzyme urease catalyses this reaction.

Aqueous ammonium carbonate produces ammonium ions. These form an alkaline solution which causes red litmus paper to turn blue. The time taken for red litmus paper to turn blue can be used to monitor the progress of the reaction.

You are required to investigate the effect of enzyme concentration on this reaction.

You are provided with the following:

- 15 cm^3 of 10.0% urease solution, **E**, which is an irritant
- 100 cm^3 of distilled water, **W**
- 25 cm^3 of a solution of the biological molecule, **U**
- Red litmus paper, total length of about 20 cm

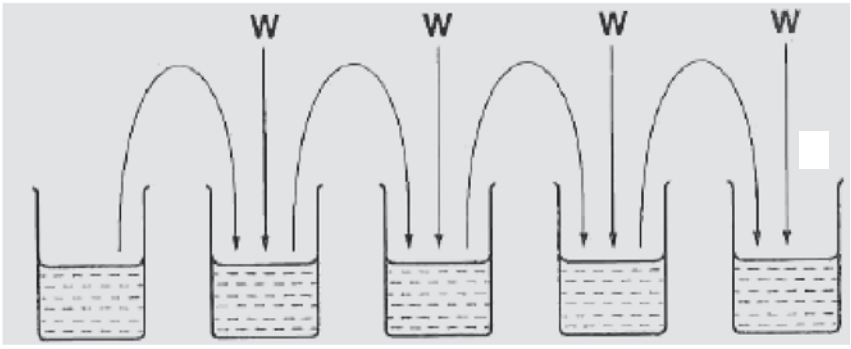
It is recommended that you wear safety goggles / glasses.

1 Carry out a serial solution of the urease solution, **E**, to reduce the concentration of the enzyme by half between each of the four successive dilutions, and set up a control.

Label four small beakers, **D1, D2, D3** and **D4**, for the serial dilutions and label another small beaker, **C**, for the control.

Complete Table 1.1 to show how you will make the different concentrations of urease solution and how you will set up the control, **C**.

Table 1.1



Solution	**E**	**D1**	**D2**	**D3**	**D4**
concentration of urease / %					
volume of urease solution to be diluted / cm^3					
Volume of distilled water, **W** / cm^3					
description of the control, **C:**					

[3]

2 In order to monitor the progress of the reaction, in step **4** red litmus paper will be added to each mixture of enzyme (urease) and substrate, **U**, in a test-tube. To prevent the paper sticking to the wall of the test-tube, you will need to use the glass rod to add it, as follows.

Cut a piece of red litmus paper so that it is a little shorter than the circumference of the glass rod. Moisten the paper and stick it to the end of the glass rod as shown in Fig. 1.1. The glass rod can then be lowered into the mixture of urease enzyme and substrate, **U**. The red litmus paper will slip off into the mixture and the glass rod can be removed.

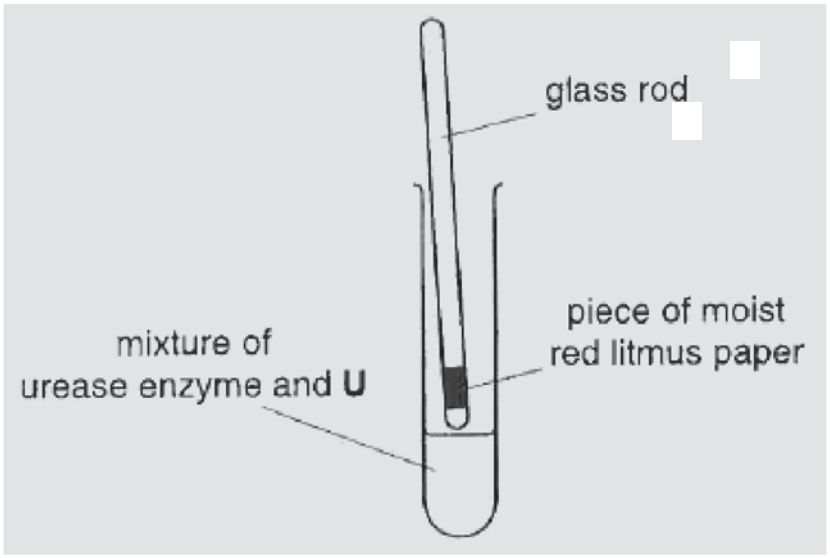


Fig. 1.1

3 Prepare a table in the space on page 4 (step **7**) to record the results of this investigation at various concentrations of urease solutions, including the control.

Proceed as follows:

4 To test the activity of the highest concentration of urease solution, put 2 cm^3 of the substrate, **U**, into a test-tube then add 2 cm^3 of **E** and mix well. The reaction will start as soon as **E** is added.
Immediately, put one piece of red litmus paper into the test0tube as described in step **2** and start timing.

5 Record, in the table that you have prepared on page 4 (step **7**), the time taken for the piece of red litmus paper to turn blue. If the piece of red litmus paper does not turn blue in ten minutes, record ‘more than 600’.

6 Record steps **4** and **5** for the other concentrations of urease solution, **D1, D2, D3** and **D4**, and the control, **C**. The red litmus paper used each time should be of the same size.

7 Use the space below to record your results.

[3]

8 Calculate the rate of reaction, using your result for the 10.0% concentration of the urease solution, **E**.

rate of reaction ..... [1]

9 Lack of repeats is one limitation of this procedure. Describe one significant source of error in this procedure that also acts as a limitation.

.....

..... [1]

10 Suggest how you would make **one** improvement to this procedure to reduce the effect of the significant source of error identified in step **9**.

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..... [1]

The effect of pH on the activity of two proteolytic enzymes, **A** and **B**, was compared. The substrate for the enzyme was coloured jelly, which is made of protein.

The apparatus of each pH was set up as shown in Fig. 1.2.

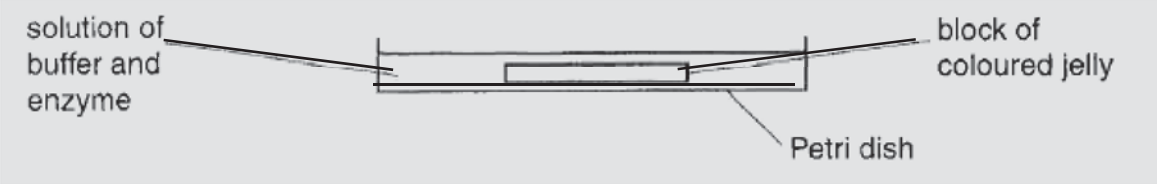

Fig. 1.2

The block of coloured jelly get smaller as it is digested by the enzymes.

11 State two variables which would need to be controlled. Suggest how each variable would be controlled.

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..... [3]

The results of the investigation are shown in Table 1.2.

Table 1.2

pH	area of jelly present after 90 minutes / mm^2	
	enzyme **A**	enzyme **B**
4.0	10	134
6.4	76	124
7.4	128	76
8.0	138	52
9.0	140	6

12 Plot, on the grid opposite, the data shown in Table 1.2. Draw lines of best fit for enzyme **A** and enzyme **B**.
[4]

13 **(a)** Describe the effect of pH on the activity of enzymes **A** and **B**.

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..... [1]

(b) Suggest and explain why changes in pH affect the activity of these two enzymes differently.

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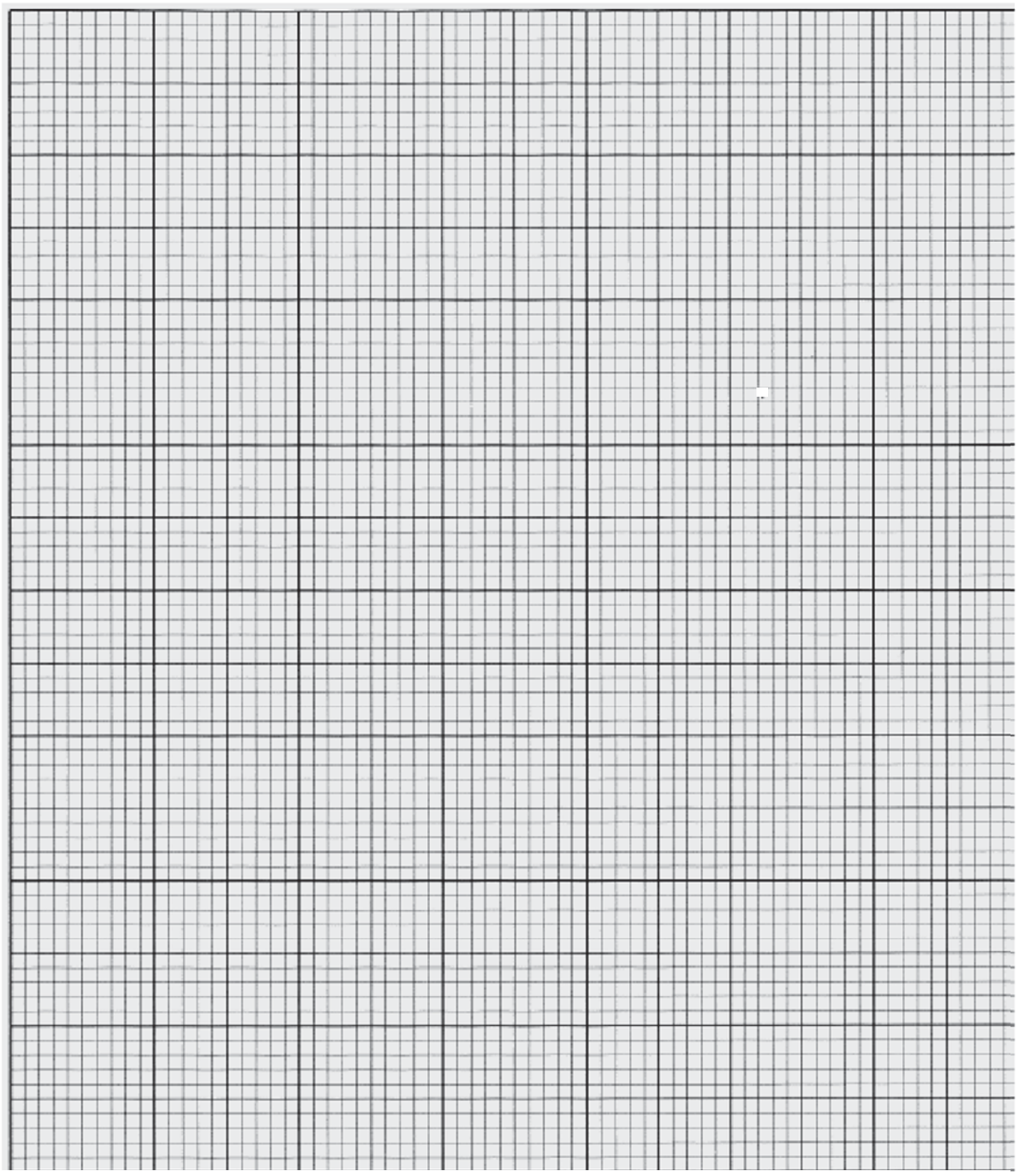
..... [3]

[Total: 20]



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CANDIDATE NAME		CLASS	2T

2 Stomata, in the epidermis of leaves, are responsible for the exchange of gases and the release of water vapour. A pair of guard cells controls the opening and closing of each stoma. In the guard cell membrane there is a transport protein. During the opening of the stomata, this protein uses energy from the hydrolysis of ATP to move protons (H^+) out of guard cells. This has two effects.

- Because protons are positively charged, their removal from the guard cells causes the interior of the cells to become negatively charged relative to the exterior. Because of this, some positive ions such as K^+ move into the interior of the cells lowering the water potential inside the cells.

- The pH inside the cell is increased.

You are provided with leaf samples that are soaking in the following solutions.
solution **X**: 0.1 mol dm^{-3} potassium chloride at pH 7.0
solution **Y**: 0.1 mol dm^{-3} sodium chloride at pH 7.0
solution **Z**: 0.1 mol dm^{-3} potassium chloride at pH 4.5

Proceed as follows:

1 Use a pair of forceps to remove the leaf from solution **X** and use scissors to cut out an area up to 1 cm × 1 cm. Transfer this to a slide ensuring **that the lower epidermis is uppermost**. Use a dropping pipette to add a drop or two of solution **X** to the leaf surface. Lower a cover slip over the leaf being careful to exclude any air bubbles.

2 Use the 10X objective of a microscope to locate the stomata. Count the **total** number of stomata that are visible and the total number that are fully **open** in the same field of view. Ignore any that you are doubtful about. Repeat this for another two areas of the leaf. Calculate the mean percentage of open stomata.

3 Repeat steps **1** and **2** for leaves from solutions **Y** and **Z** using clean slides and cover slips on each occasion. You **must** keep slide **Z** in order to answer **(b)** on page **11.**

(a) **(i)** Record your results in an appropriate format in the space provided below.

[4]

(ii) Explain your results.

X .....
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Y .....
[2]

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[2]

Z .....
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.....
[2]

(iii) Guard cells, unlike other cells in the epidermis, have chloroplasts. These chloroplasts have grana but lack the enzymes necessary for the light-independent stage of photosynthesis (Calvin cycle).

With reference to your results, suggest why guard cells have chloroplasts if they do not carry out the light-independent stage of photosynthesis.

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.....
[2]

(b) Make a **high power** drawing of two guard cells and the epidermal cells on either side of each guard cell from the leaf in solution **Z.**

[3]

(c) Fig. 2.1 shows a diagram of a stage micrometer scale that is being used to calibrate an eyepiece graticule.

One division, on either the stage micrometer scale or the eyepiece graticule, is the distance between two adjacent lines.

The length of one division on this stage micrometer is **0.1 mm**.

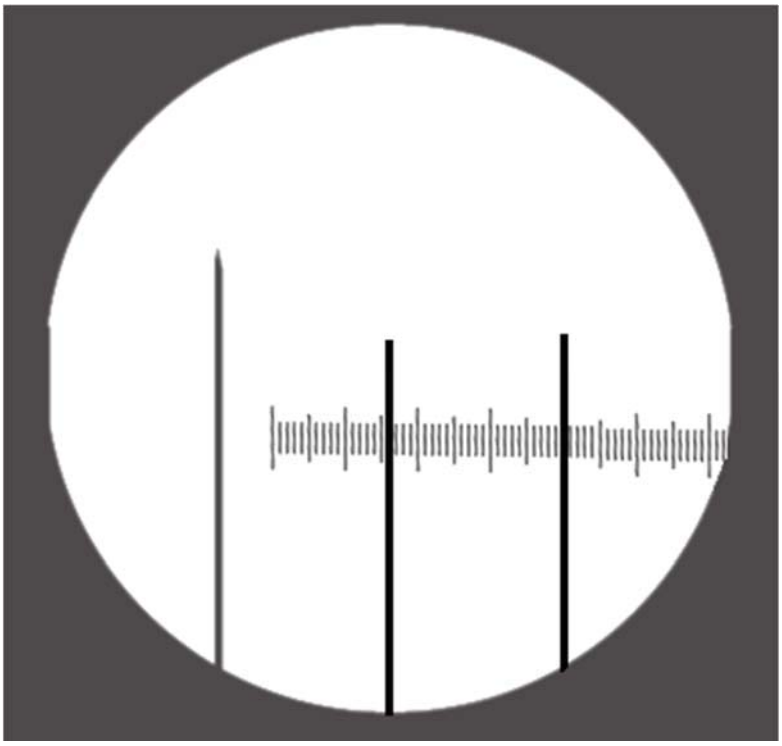

Fig. 2.1

(i) Using this stage micrometer, where one division is 0.1 mm, calculate the actual length of one eyepiece graticule divison, using Fig. 2.1.

Convert your answer to a measurement units most suitable for use in light microscopy. Show the steps and units in your calculation.

[2]

Fig. 2.2 shows a photomicrograph of plant cells some of which have lost water by osmosis.

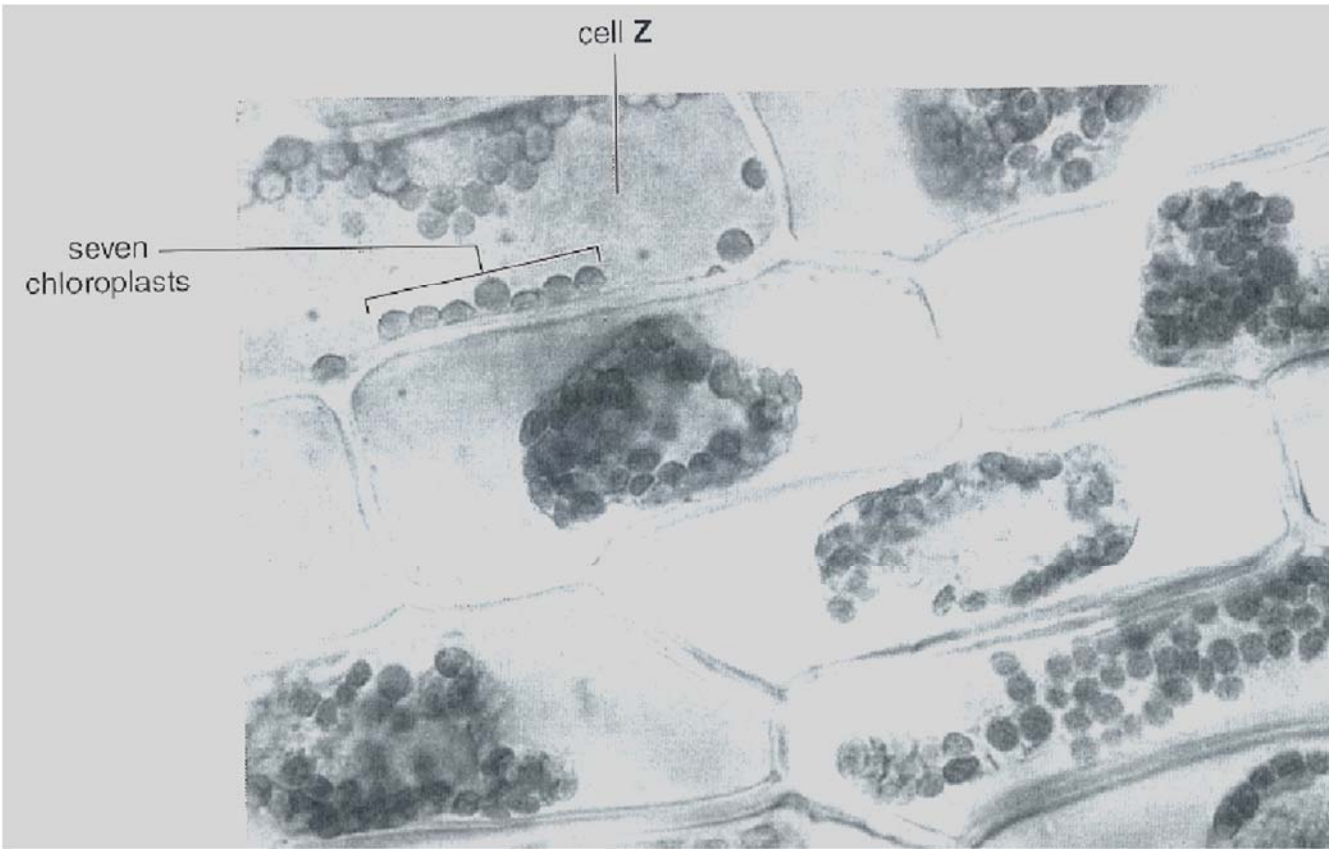

Fig 2.2

A student, using a prepared slide from which this photomicrograph was taken, measured the total length of the seven chloroplasts, labelled in **cell Z** in Fig 2.1.

Fig. 2.3 shows the view that the student saw when using the eyepiece graticule, calibrated in **c(i)** at the high-power of a microscope.

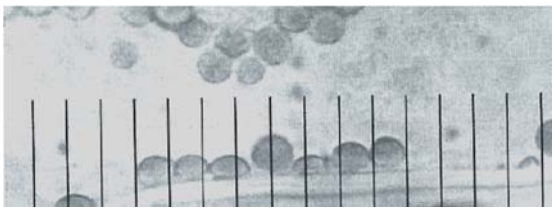

Fig 2.3

(ii) Using this and the information in **c(i),** calculate the actual mean length of one chloroplast as shown in Fig 2.3.

Show the steps and units in your calculation.

actual mean length of one chloroplast ..... [2]

(d) Fig. 2.4 and Fig. 2.5 are photomicrographs of the lower surface of the leaf from two different plants, with the same field of view, using the same objective lens.

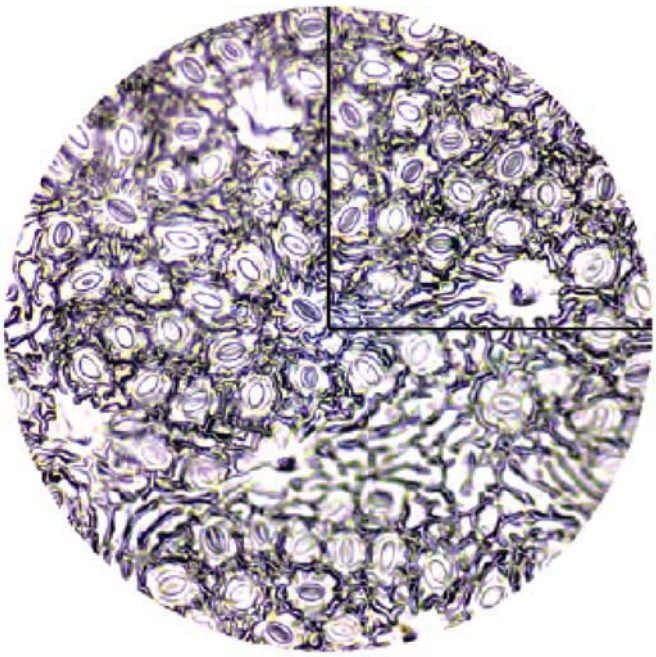

Fig. 2.4

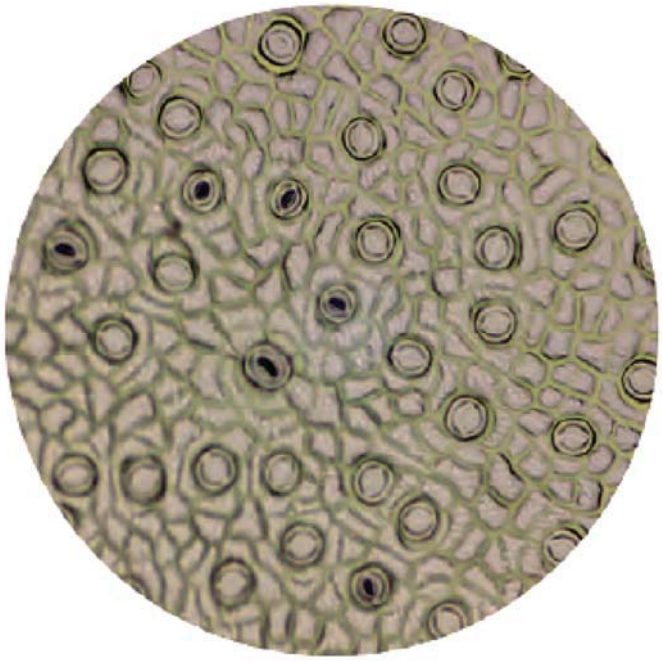

Fig. 2.5

Complete the table below to record 2 observable differences between the surface of each leaf shown in Fig. 2.4 and Fig. 2.5.

Feature	Fig. 2.4	Fig. 2.5

[2]

[Total: 22]

CANDIDATE NAME		CLASS	2T

3 The enzyme urease is a catalyst of the hydrolysis of urea in solution, forming ammonia and carbon dioxide, for example in the breakdown of urea in soils by microorganisms.

You are required to plan an investigation to compare the activity of urease free in solution and urease immobilised in alginate beads.

As the reaction proceeds, the ammonia released dissolves, causing the pH to increase.

You are provided with the following equipment which you may use or not in your plan, as you wish. You may **not** use any additional equipment in your plan.

- an unlimited supply of calcium alginate beads, all of uniform size, prepared with a 50 g dm^{-3} urease solution (you may call this immobilised urease)
- an unlimited volume of 50 g dm^{-3} urease solution (you may call this free urease)
- an unlimited volume of 1.0 mol dm^{-3} urea solution
- an unlimited volume of distilled water
- beakers and flasks of different sizes
- stopwatch
- broad and narrow range of pH papers and liquids with appropriate colour charts, pH probes and meters
- colorimeter and tubes/cuvettes
- thermometer
- thermostatically-controlled water baths
- graduated pipettes and pipette fillers
- filter funnels
- syringes
- glass rods for stirring
- test-tubes and boiling tubes
- test-tube racks

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- include a clear statement of the hypothesis or prediction
- identify the independent and dependent variables
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- describe the method with details and explanations of the procedures that you would adopt to ensure that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment

[Total: 14]

……..……..……..

……

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END OF PAPER

NAME: _____ CLASS: _____ INDEX: _____

CATHOLIC JUNIOR COLLEGE
JC2 PRELIM EXAMINATION
Higher 2

Answers

BIOLOGY

Paper 1 Multiple Choice

9744/01
28 AUGUST 2017
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write and/or shade your name, NRIC / FIN number and HT group on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**.
Choose the **one** you consider correct and record your choice in **soft 2B pencil** on the separate Answer Sheet.

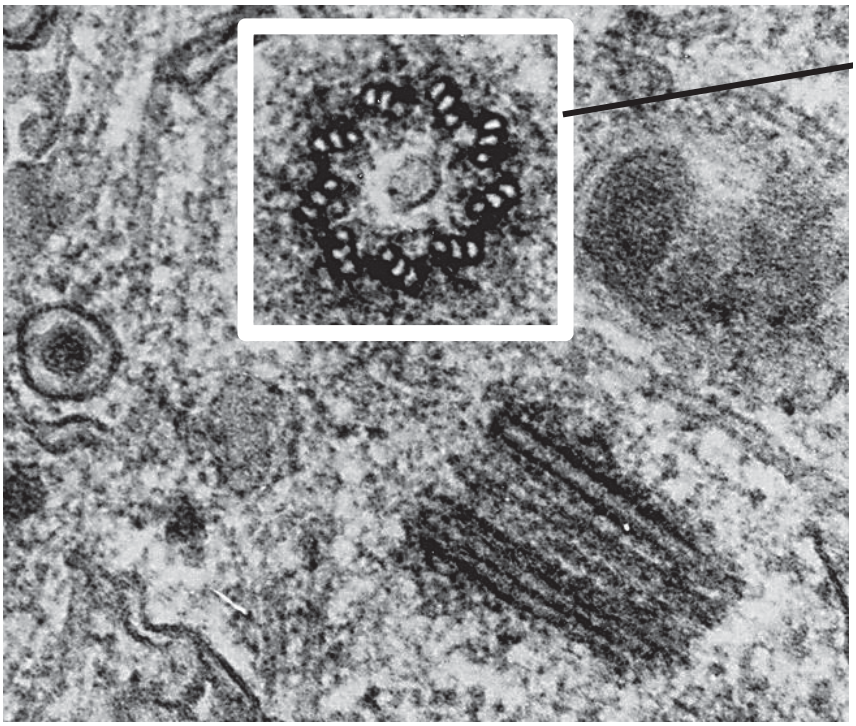
Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

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

[Turn over

1 The figure below shows an electron micrograph of a cross-section of an animal (rat) cell.



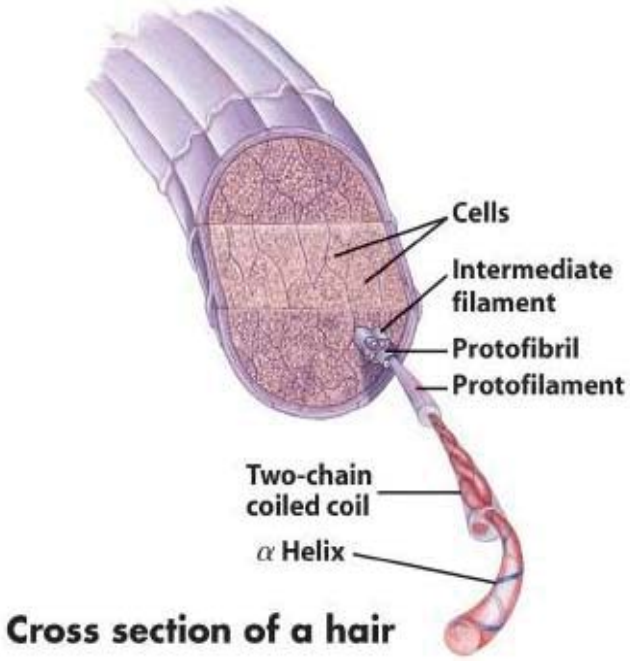
Which of the following describes organelle A?

i. 9 triplets of microtubules arranged in a ring.
ii. Inner membrane folded into cristae.
iii. Synthesizes spindle fibres during nuclear division.
iv. Involved in aerobic respiration.

A **i** only
B **i** and **iii** only
C **ii** and **iii** only
D **ii** and **iv** only

ANS A [L1] (H2 SAJC/2016/P1/Q1) [1]

2 Keratin is a fibrous protein in skin, hair and nails. The diagram below shows α-keratin molecules in cross section of a hair follicle.



The features of one form of keratin are listed below:

i. The peptide chain has mainly small amino acid residues.

ii. Each peptide chain forms into an α-helix.

iii. Two helices coil together.

iv. Covalent bonds link adjacent helices.

Which features are different from that of collagen molecules?

A **i** and **ii**

B **i** and **iv**

C **ii** and **iii**

D **iii** and **iv**

ANS C [L1] (H1 A Levels /2014/P1/Q4 modified) [1]

3 How many different types of oligopeptides, each made up of 8 amino acids, may be synthesized using the 20 common amino acids?

A 144 480

B 20^8

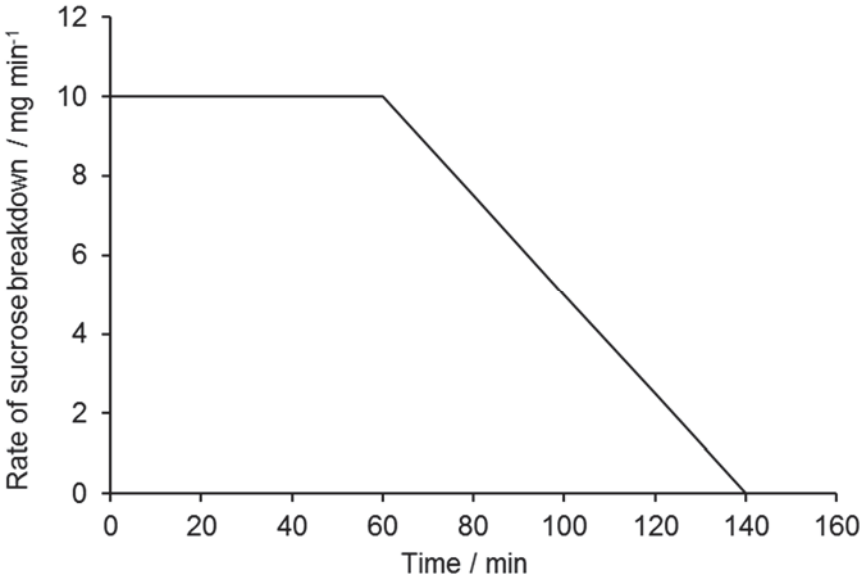
C 8^{20}

D 160

ANS B [L2] (H2 SAJC/2016/P1/Q5 - modified) [1]

4 The graph shows the results of an investigation using invertase, an enzyme that breaks down sucrose into glucose and fructose.

1 g of sucrose was dissolved in 100 cm^3 of water and 2 cm^3 of a 1% invertase solution was added.



Which conclusion can be drawn from this information?

A Between 0 and 60 min, the concentration of the substrate remains constant.

B After 60 min, the concentration of enzymes becomes the limiting factor.

C At 140 min, some of the enzyme molecules are denatured.

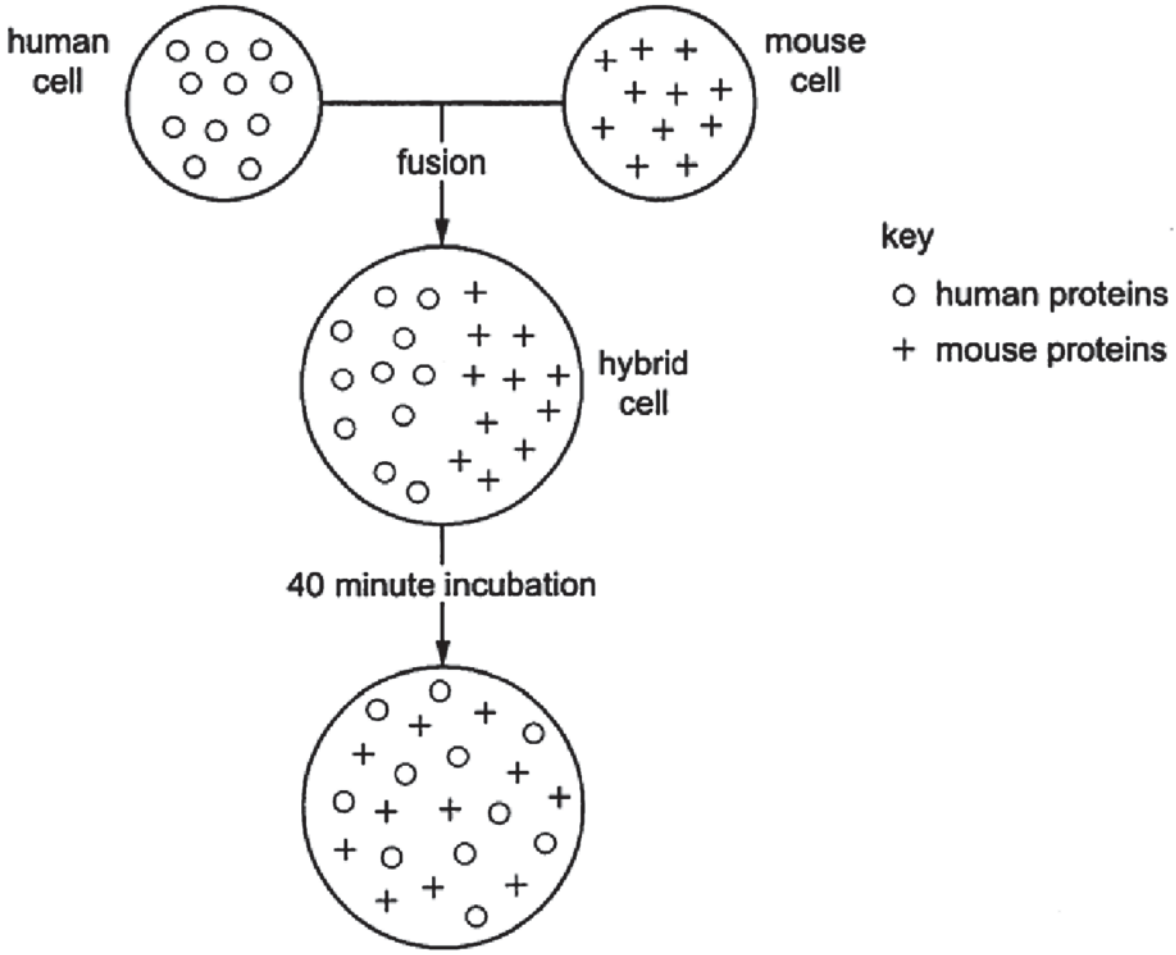
D Between 60 and 140 min, the concentration of the substrate is the limiting factor.

ANS D [L2] (H2 RI/2016/P1/Q6) [1]

5 Human and mouse cells were fused to make hybrid cells. Anti-human and anti-mouse antibodies, carrying different coloured fluorescent dyes, were added. The antibodies bind to the proteins of the cell surface membrane.

The fused cells were incubated for 40 minutes. The locations of the human and mouse membrane proteins were identified at intervals using the fluorescent dyes.

The diagram represents the results of the experiment by showing the positions of the human and mouse proteins on the surface of the cells.



What does this experiment show?

A Movement of the phospholipids pushes the membrane proteins apart.

B Some membrane proteins move through the phospholipids to different places.

C The phospholipids of the human and mouse cell surface membranes do not mix.

D The proteins of human cell surface membranes can move further than those of mouse cells.

ANS B [L2] (H2 A Levels/2015/P1/Q29) [1]

6 Which process involves one stem cell giving rise to two distinct daughter cells: one copy of the original stem cell as well as a second daughter cell programmed to differentiate into a non-stem cell?

A asymmetric replication

B differentiation

C potency

D self renewal

ANS A [L1] (H2 NJC/2016/P1/Q27) [1]

7 DNA replication in eukaryotes involves the following processes.

- RNA primer molecules are attached to each strand at points of origin of replication.
- DNA polymerase attaches to primers and synthesises new strands of DNA in a 5' to 3' direction.
- One strand, called the leading strand, is synthesised in continuous long sections.
- The other strand, called the lagging strand, is synthesised in short sections.
- RNA primers are replaced by DNA nucleotides on both strands.

Which statement explains the difference in the way in which the two strands of a DNA molecule are synthesised?

A DNA polymerase enzymes can only synthesise DNA in one direction.

B Fewer RNA primers are needed on the leading strand.

C The lagging strand has more binding points for RNA primers.

D The replication of DNA is semi-conservative.

ANS A [L3] (H1 A Levels/2016/P1/Q10) [1]

8 Which statement is **not** true about the transcription in eukaryotes?

A Transcription occurs in the nucleus.

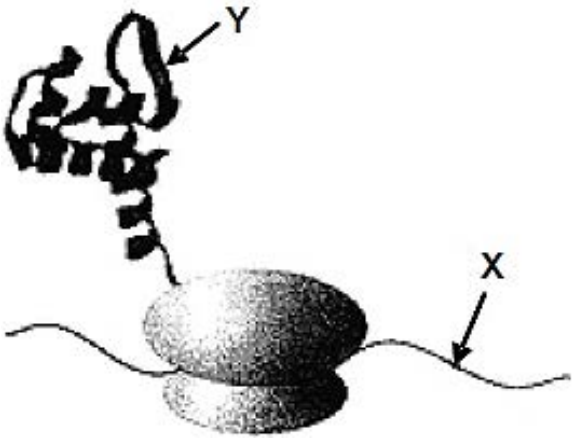
B There are 3 different types of RNA polymerase for the synthesis of mRNA, rRNA, and tRNA.

C The binding of RNA polymerase to TATA box initiates the transcription process.

D No primers are involved during transcription.

ANS C [L1] (Novel) [1]

9 The diagram below shows a particular stage of protein synthesis.



Which of the following statements is true of molecules **X** and **Y**?

A The coiling of molecule Y is a direct result of the information on molecule **X**.

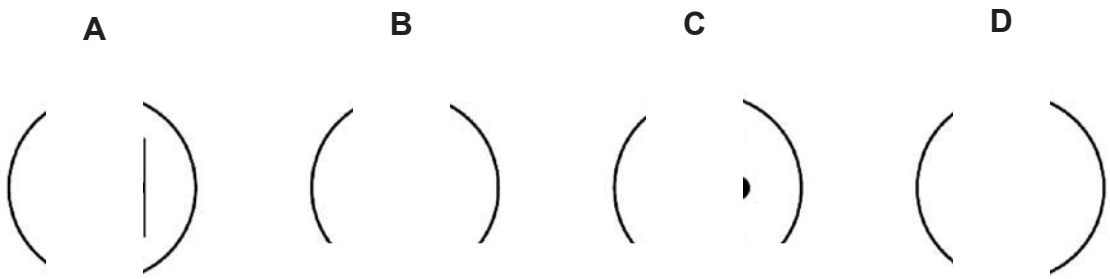
B Molecule **X** is double-stranded whilst molecule **Y** is single-stranded.

C In both molecules **X** and **Y**, the bonds between adjacent monomers of each molecule are phosphodiester bonds.

D The monomers of molecule **X** interact with the monomers of molecule **Y** through temporary hydrogen bonds.

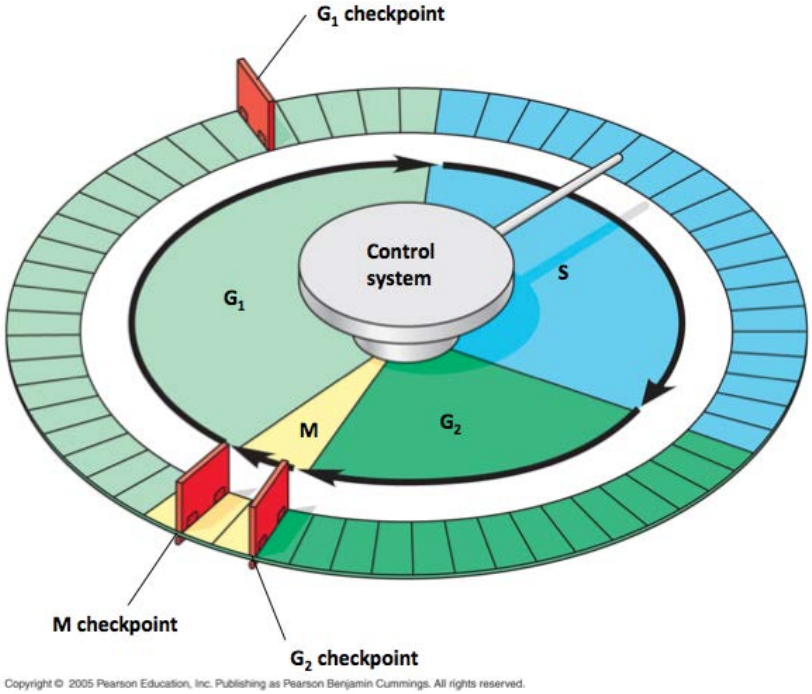
ANS A [L2] (H2 ACJC/2015/P1/Q8) [1]

10 A cell with one pair of chromosomes (2n = 2) undergoes meiosis. Which nucleus is formed at the end of meiosis I?



ANS B [L1] (H2 DHS/2016/P1/Q4) [1]

11 Cell cycle is a highly regulated process. The figure below shows the overview of the different stages and checkpoints in cell cycle.



What happen when G1 checkpoint does not function properly?

A The cell will progress to prophase even when there is mistake during DNA replication.

B The probability of non-disjunction during anaphase increases.

C DNA replication may not occur properly due to the absence of necessary raw materials such as deoxynucleoside triphosphates.

D There will be a decrease in the amount of growth factors secreted.

ANS C [L1] (Novel) [1]

12 What advantages are there in associating eukaryotic DNA with histones to form chromatin?

A Allows large amount of DNA to be packaged into the small space of the nucleus.

B Allows control of gene expression by modulating degree of packaging.

C Protect DNA from degradation which may lead to mutation or death of the cell.

D All of the above.

ANS D [L1] (Novel) [1]

13 Proteins that are ubiquitinated will be transported to proteasome for degradation. Which level of control of gene expression is this?

A Translational level

B Transcriptional level

C Post-translational level

D Post-transcriptional level

ANS C [L1] (Novel) [1]

14 Which of the following statements about bacterial chromosome structure is/are true?

i. Not associated with histone proteins.

ii. Single-stranded chromosome.

iii. Located in the nucleoid region of a nucleus.

iv. Most genes are separated by intergenic DNA sequences.

A **i** only

B **i** and **ii** only

C **ii** and **iii** only

D **ii** and **iv** only

ANS A [L1] (H2 SAJC/2016/P1/Q12) [1]

15 When a mutant strain of Escherichia coli that has lost the regulatory gene of its tryptophan operon is placed in a medium that contains all nutrients the cell need to grow except tryptophan, which of the following will occur?

A The cells will grow even though there is no tryptophan in the medium.

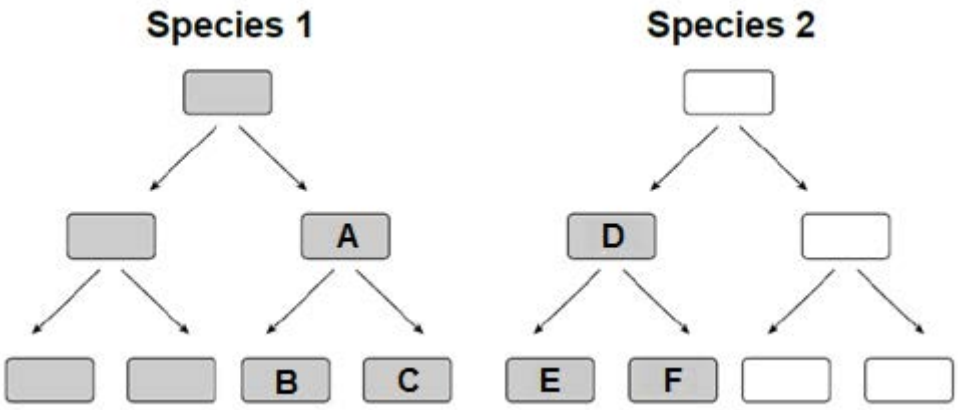
B The cells will grow until excessive tryptophan arrests the expression of the operon.

C The cells will not grow until enough tryptophan has been synthesised to make the repressor active.

D The cells will never grow unless tryptophan is added to the medium.

ANS A [L1] (H2 AJC/2016/P1/Q12) [1]

16 The diagram below shows how two species of bacteria reproduce when placed together in a growth medium. The bacteria that are shaded are resistant to the antibiotic penicillin.



Which one of the following statement(s) is/are likely to be true?

i. Bacteria **B** and **C** are resistant to penicillin as a result of binary fission of Bacterium **A**.

ii. Bacteria **C**, **D** and **F** are resistant to penicillin as a result of random mutation.

iii. Bacterium **D** is resistant to penicillin as a result of conjugation process which transfers the F plasmid carrying penicillin resistance gene from Bacterium **A**.

iv. Bacterium **D** is resistant to penicillin through transduction from Bacterium **A** where there is transfer of the complete F plasmid.

A **iii** only

B **i** and **iii**

C **i** and **iv**

D **ii, iii** and **iv**

ANS B [L2] (H2 AJC/2016/P1/Q11) [1]

17 Which of the following is true of influenza and HIV viruses?

A Genetic shift causes variation in influenza but not in HIV.

B Both HIV and influenza are virulent upon budding off from their respective host cell.

C Influenza viruses have DNA genomes that are templates for transcription.

D HIV viruses have genomes that are readily inserted into the host genome.

ANS A [L2] (Novel) [1]

Please note that Question 18 and 19 are related.

18 Fig 18.1 shows the base sequence of a normal human beta-globin gene and a mutant variant which causes a blood-related disease.

Normal			
Non-template strand	5’	CAC GTG GAC GGA GGA CTC CTC	3’
Mutant			
Non-template strand	5’	CAC GTG GAC GGC GGA CAC CTC	3’

Fig. 18.1

Which of the following is correct?

A The blood-related disease is caused by 1 point mutations with more than one amino acid changed.

B The blood-related disease is caused by 1 point mutations with one amino acid changed.

C The blood-related disease is caused by 2 point mutations with more than one amino acid changed.

D The blood-related disease is caused by 2 point mutations with one amino acid changed.

ANS B [L2] (Novel) [1]

19 Fig. 19.1 shows the southern blot of the co-dominant blood-related disease shown in Fig. 18.1. Only one restriction enzyme *MstII* was used and the blot was hybridized with a probe specific for the beta-globin gene.

Fig. 19.1

With reference to Fig. 19.1 and Fig. 18.1; which of the following statements is correct?

A Individuals 1, 2 and 5 are normal.

B Individuals 1, 2 and 5 are homozygous at the loci for beta-globin gene.

C Individuals 4 and 5 are homozygous and heterozygous at the loci for beta-globin gene respectively.

D Individuals 3 and 4 are homozygous and heterozygous at the loci for beta-globin gene respectively.

ANS C [L2] (Novel) [1]

20 A tall green stemmed plant with genotype TTrr was crossed with a short red stemmed plant with genotype ttRR. The F1 plants were allowed to self fertilise. A X^2 test was carried out on the results obtained for the F2 generation. Part of the values for X^2 are shown:

Deg. of freedom	p= 0.5	p= 0.1	p= 0.05	p= 0.01	p= 0.001
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.6	5.99	9.21	13.82
3	2.37	6.25	7.82	11.34	16.27
4	3.36	7.78	9.49	13.28	18.46
5	4.35	9.24	11.07	15.09	20.52

The value of X^2 was 7.6 in this investigation.

What is the probability of this value of X^2 and do the results fit the expected ratio?

	Probability	*Results fit expected ratio*
A	Between 0.01 and 0.05	No
B	Between 0.01 and 0.05	Yes
C	Between 0.05 and 0.1	Yes
D	Between 0.05 and 0.1	no

ANS C [L1] (N2005/1/22 modified) [1]

21 Which of the following is true about gene interactions?

A Gene interactions involve two genes controlling one character.

B Gene interactions involve masking and follow mendelian phenotypic ratios.

C Gene interactions are a form of co-dominance

D Gene interactions restrict the number of phenotypes seen.

ANS A [L1] (Novel) [1]

22 Sodium azide is a strong inhibitor to the ETC in mitochondria. An experiment was conducted with isolated mitochondria, 2 molecules of glucose, 10 molecules of pyruvic acid along with oxygen, ADP and NAD^+ which was supplied in excess.
What would be the expected production of ATP from the experiment?

A 2

B 4

C 10

D 22

ANS C [L3] (Novel) [1]

23 Which of the following is not true of photosynthesis.

A The spectra of light in which photosynthesis is most efficient is in the red and violet region.

B Rate of ATP synthesis depends on the differential proton gradient across the thylakoid membrane.

C Photosynthesis starts first with the photolysis of water.

D Oxygen concentration affects the efficiency of the light independent reaction.

ANS C [L2] (Novel) [1]

24 The Fig. 24.1 represents a G-protein coupled receptor on the cell surface membrane. A peptide hormone ligand is bound to the receptor and initiates the production of a second messenger.

Fig. 24.1

What is the second messenger?

A a peptide hormone.

B ATP

C cyclic AMP

D Kinase

ANS C [L1] (2007 9744 P1.Q30) [1]

25 Birds, such as cockatoos, have a species of louse (an insect parasite) that lives on their feathers.

White, sulfur-crested cockatoos have pale lice on their wings and bodies while yellow-tailed black cockatoos have dark lice on their wings and bodies. Both of these cockatoos have black lice of this species on their heads. In order to rid themselves of these parasites, cockatoos preen their wings and bodies with their beaks but have to use their feet to preen their heads.

What best explains how this species of louse has diversified into two colour variants on the birds' wings and bodies, but has remained dark on the birds' heads?

A Cockatoo beak preening results in selection pressure on wing and body lice.

B Cockatoos are unable to see the lice while preening their heads.

C Cockatoos notice badly camouflaged lice on their wings and bodies while preening.

D Cockatoos use different preening techniques on different parts of their bodies resulting in natural selection.

ANS D [L2] (H1 A Levels/2015/P1/Q23) [1]

26 Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperm, and they selectively kill developing male embryos.

In Samoa in the 1960s, the proportion of male blue moon butterflies fell to less than 1% of the population. However, by 2006, the proportion of males was almost 50 % of the population.

Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

i. *Wolbachia* acts as a selective agent.

ii. The selective killing of male embryos is an example of artificial selection.

iii. When infected with *Wolbachia,* male embryos that are homozygous for the recessive allele of the suppressor gene die.

iv. All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.

v. The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

A **i** and **iv**

B **i**, **iii** and **v**

C **ii** and **iii**

D **ii**, **iv** and **v**

ANS B [L2] (H1 A Levels/2011/P1/Q23) [1]

27 Which of the following statements correctly relate to molecular phylogenetics?

i. Lines of descent from a common ancestor to present-day organisms have undergone similar, fixed rates of DNA mutation.

ii. Organisms with similar base sequences in their DNA are closely related to each other.

iii. The number of differences in the base sequences of DNA of different organisms can be used to construct evolutionary trees.

iv. The proportional rate of fixation of mutations in one gene relative to the rate of fixation of mutations in other genes stays the same in any given line of descent.

A **i** and **ii**

B **i** and **iv**

C **ii** and **iii**

D **iii** and **iv**

ANS C [L2] (H2 VJC/2015/P1/Q31) [1]

28 Which statement about vaccination is true?

A Vaccination of a small proportion of the population can break the disease transmission cycle.

B Vaccination can prevent and control disease, but it is unable to eradicate the disease.

C Vaccination stimulates body's innate immune system, thus protecting the individual from future infection by the same pathogen.

D Vaccination stimulates immunity without causing the disease.

ANS D [L1] (Novel) [1]

29 Fig 29.1 illustrating the effects of elevated CO_2 on growth and development of soybean.

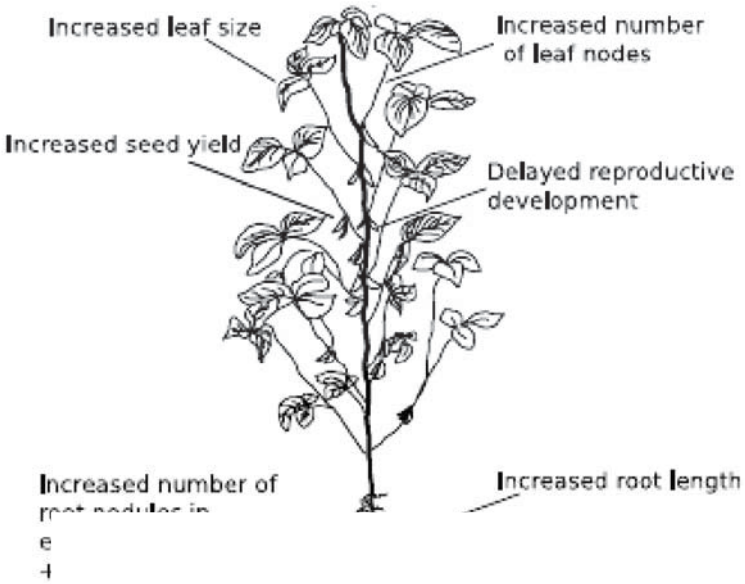


Fig. 29.1

With reference to Fig. 29.1. Which of the following can be inferred from the elevated levels of CO_2.

A Plant photosynthetic rates will increase as CO_2 levels increase.

B Plant biomass increases but dispersal range decreases.

C Plant respiration will outweigh that of photosynthesis.

D Plants are now better able to ensure their own survival and continuation.

ANS B [L2] from L1 (Novel) [1]

30 Which of the following is not true about climate change and biodiversity?

A Climate change results in specific selection pressures that may be disadvantageous to most species causing a decrease in biodiversity.

B Climate change over a short time may result in different selection pressures which may promote speciation and promote biodiversity.

C Climate change may negatively affect keystone species which then affect ecosystems eventually affecting biodiversity.

D Climate change may cause a lowering of temperatures and may push species to physiological limits and eventually lower biodiversity.

ANS B [L2] (Novel) [1]

END OF PAPER

CATHOLIC JUNIOR COLLEGE
JC2 PRELIM EXAMINATION
Higher 2

Answers

CANDIDATE NAME					
CLASS	**2T**	**INDEX NUMBER**			

BIOLOGY

9744/02

Paper 2 STRUCTURED QUESTIONS

21ST AUGUST 2017
2 hours

Candidates answer on the Question Paper.
Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

Write your index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs. Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

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

For Examiner's Use	
1 [12]	
2 [12]	
3 [13]	
4 [12]	
5 [9]	
6 [13]	
7 [12]	
8 [7]	
9 [10]	
TOTAL P2 [30%]	**100**

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

[Turn over

Answer **all** questions.

1 Fig. 1.1 is a schematic diagram showing the transport pathways of extracellular and intracellular materials for digestion in a mammalian cell. Depending on the types of digested material, three possible pathways are initiated to deliver these materials for digestion within lysosomes, of which one is labelled as **A**.

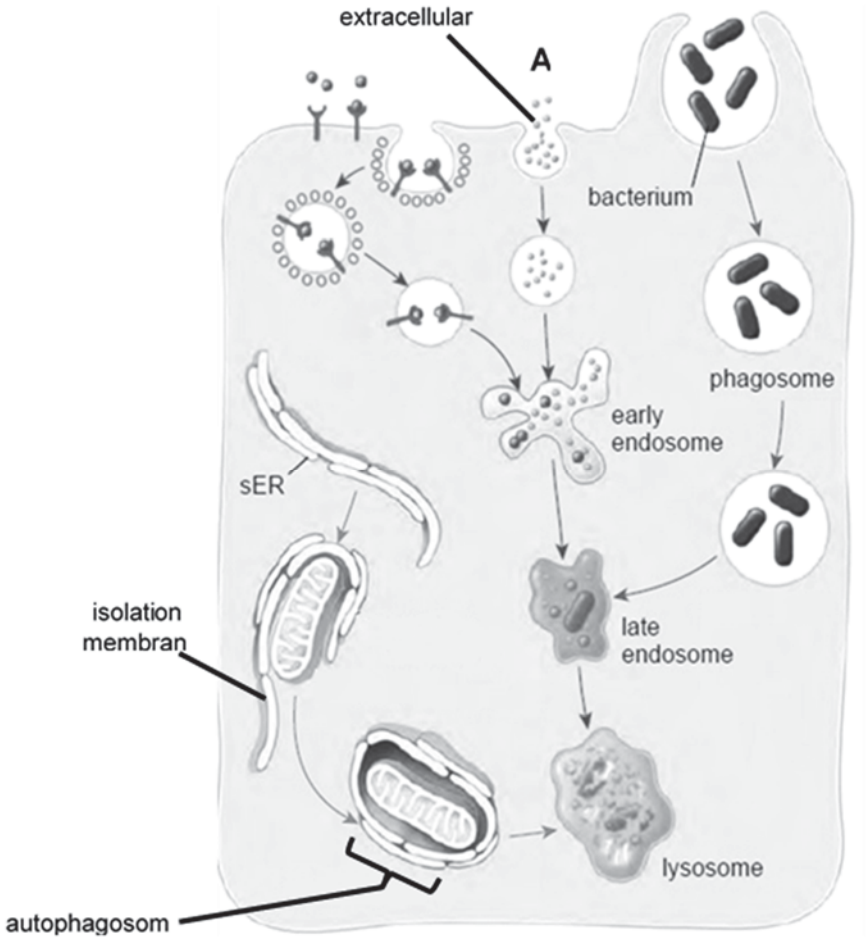


Fig. 1.1

(a) **(i)** Identify precisely process **A**.

ANS [L1] (adapted from H2 ACJC/ 2015/ P2/ Q1) [1]

1. **pinocytosis**

(ii) State **one** property of the plasma membrane and explain how it enables process **A** to be carried out by a cell.

ANS [L2] (adapted from H2 ACJC/ 2015/ P2/ Q1) [2]

1. Membrane is **fluid**;
2. Ref. to **invagination of plasma membrane** / fusion of 2 ends of plasma membrane to form endocytic vesicle.
3. Ref. to phospholipid is amphipathic.
4. OWTTE

(b) Degradation of worn out organelles such as mitochondria occurs inside most cells via autophagy. With reference to Fig.1.1, describe the process of autophagy.

ANS [L2] (adapted from H2 ACJC/ 2015/ P2/ Q1) [3]

1. **Isolation membrane** (derived from SER) encloses **mitochondria** to form a (membrane bound) **autophagosome**;
2. **Fusion** of membrane of **autophagosome** with membrane of **lysosome**;
3. **Digestion** of **mitochondria** by **hydrolytic enzymes** [Reject: digestive enzymes] found in lysosome, (which are activated by low pH within lysosome).

(c) Lysosomes are able to hold a large amount of enzymes. Lysosomal membrane contains a large amount of highly glycosylated integral proteins facing the interior of the lysosome.

Suggest how this high amount of glycosylated protein prevents self-digestion of the lysosome.

ANS [L3] (adapted from H2 ACJC/ 2015/ P2/ Q1) [1]

1. Large amounts of glycoproteins acting as a molecular shield / hindering access of enzymes with substrates (e.g. membrane proteins).

Fig.1.2 shows an electron micrograph of parts of the endomembrane system.

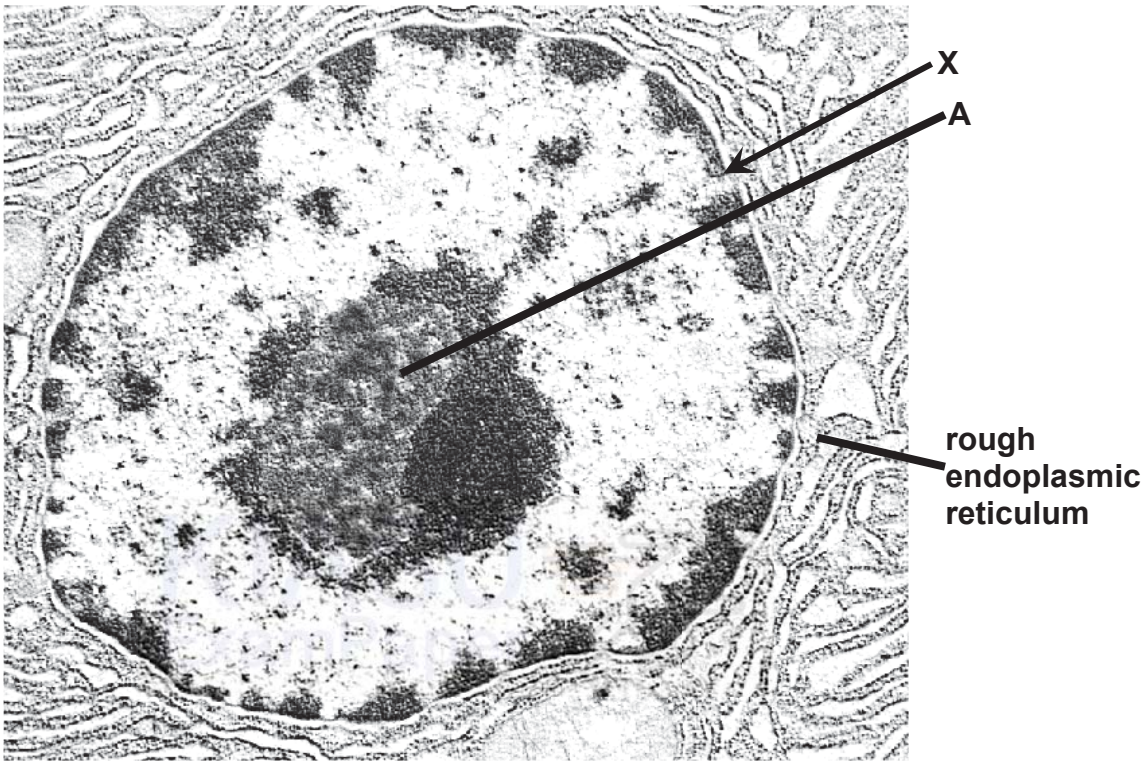


Fig. 1.2

(d) Explain how **X** regulates the movement of materials in protein synthesis.

ANS [L2] (Novel) [2]

1. X is **nuclear envelope** with **nuclear pores**; therefore it allows/ regulates;

Any 1:

2. **mRNA** to **leave the nucleus** to be **translated** to the proteases by **ribosomes on RER**.
3. **tRNA** made to **leave the nucleus** to **attach to amino acid** for the proteases synthesis.
4. **RNA polymerase**, **RNA nucleotide** and **ATP** to **enter the nucleus** for **transcription** of the gene coding for proteases.
5. **AVP**

(e) Explain how the functions of region **A** and rough endoplasmic reticulum are related.

ANS [L2] (Novel) [2]

1. **A** is nucleolus which **contains the gene coding for rRNA.**
2. **rRNA** forms the **structural components** of **ribosome;** which are **found on RER** for **translation process.**
3. **rRNA** contributes to the **tRNA and mRNA binding sites of ribosome;** which are **found on RER** for **translation process.**
4. **rRNA** contributes to **peptidyl transferase** catalytic activity of **ribosome;** which are **found on RER** for **translation process.**

(f) During the early stages of oogenesis (formation of egg) in Xenopus laevis (frog); there are as many as 1000 of region **A** within a single oocyte (egg cell). Suggest the significance of this.

ANS [L3] (Novel) [1]

1. Early stages of oogenesis **requires high amount of protein**; **gene amplification** in region **A** / **nucleolus** increase **the rate of production of rRNA**.

[Total: 12]

2 **(a)** In beer-making, barley is malted with enzymes which hydrolyse starch into sugar, ready for fermentation. The graph below shows the production of sugar during beer-making at three different temperatures over a period of 60 minutes. All other conditions were controlled.

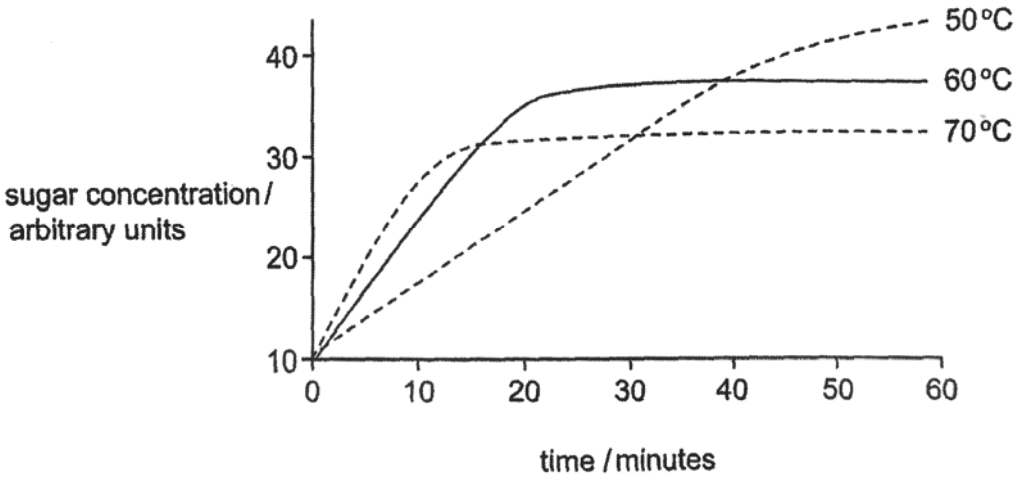


Fig. 2.1

(i) With reference to Fig. 2.1, explain the effect of increasing temperature on enzyme activity for the first 10 minutes of the reaction.

ANS [L2] (adapted from H2 NJC/ 2015/ P2e/ Q1) [3]

1. Reaction at **70°C** had the **highest concentration of glucose formed per unit time** followed by at 60°C, and 50°C respectively. Ref: **Rate of enzyme reaction increases as temperature increases**.
2. **Increase in kinetic energy of enzymes and substrate molecules**; **increase in frequency of effective collisions between enzyme and substrate** / ref: Increase in molecules with **sufficient energy to overcome activation energy**.
3. Ref: **Increase in concentration of enzyme-substrate complexes** produced **per unit time**; increase in **concentration of products formed per unit time**;

(ii) Explain why the final concentration of sugar produced at 70°C is lower than the reaction incubated at 60°C.

ANS [L2] (Novel) [2]

1. At higher temperature, there is higher kinetic energy. The interactions and bonds maintaining the 3-D conformation of the enzyme active site will be disrupted at higher rate.
2. At 70°C, all of the enzymes were denatured earlier (about 12 min) whereas at 60°C, all the enzymes were denatured later (about 18 min).

(iii) State the enzyme used in the reaction above.

ANS [L1] (adapted from H2 NJC/ 2015/ P2/ Q1) [1]

1. Amylase

(iv) Explain how the enzyme stated in **(iii)** plays its role in hydrolysis of starch to glucose.

ANS [L2] (adapted from H2 NJC/ 2015/ P2/ Q1) [3]

1. Amylase **binds to starch** via either:
   a. **Lock and Key hypothesis**: shape of substrate is **complementary** to the shape of the active site of enzyme.
   b. **Induced Fit hypothesis**: **initial binding of substrate** to enzyme causes a **conformation change** in the **shape of the enzyme active site** which leads to **more effective binding**.
2. Formation of **enzyme-substrate complex**, **lower the activation energy** by (any 1 of below):
   a. Serve as template to **position substrate** molecules in **correct orientation** for catalysis.
   b. **Induces stress** in **bonds of substrates**.
   c. **Increases substrate reactivity**.
3. **Release of glucose** from the active site of the amylase as the **shape of glucose is not complementary to the active site**.

(b) What structural differences exist between starch and cellulose, and how these are related to their different roles in plants.

ANS [L2] (adapted from H2 NJC/ 2015/ P2/ Q1) [3]

	Features	Starch	Cellulose
1	The arrangement of hydroxyl groups	Hydroxyl groups of glucose subunits are projected into interior; making starch insoluble. This allows starch to be stored in large amounts without affecting water potential of cells.	Hydroxyl group are projected outwards in all direction. This allows the formation of numerous intermolecular bonding between cellulose. As a result, cellulose has high tensile strength and therefore suitable as the structural support in plant
2	Branching	Present of branching in amylopectin. Allow more a compact structure and therefore, more molecules per cell. Suitable for storage role.	No branching. The straight chain allows the hydrogen that projects in all direction to form numerous hydrogen bonds with the adjacent chains resulting in high tensile strength. Thus, suitable for structural support in plant.
3	Glycosidic bond	Starch comprises many α-glucose joined together by α-1,4 glycosidic bond as well as α-1,6 glycosidic bond. These 2 bonds are relatively easier to be hydrolysed to release large amount of glucose when it is needed. Therefore, good for storage purposes.	Cellulose comprises many β-glucose joined together by β-1,4 glycosidic bond which is relatively harder to be hydrolysed. Therefore, good for structural support in plant.

[Total: 12]

3 Fig. 3.1 below shows DNA replication in an eukaryotic organism.

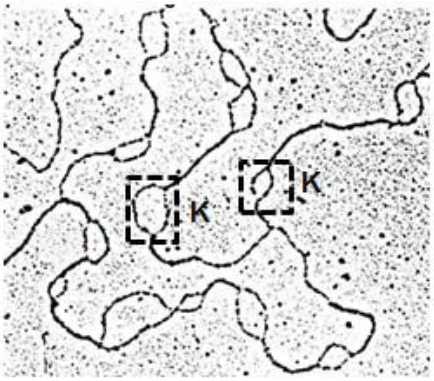


Fig. 3.1

(a) (i) What evidence in Fig. 3.1 shows that the process is DNA replication in an eukaryotic cell.

ANS [L2] (adapted from H2 PJC/ 2015/ P2/ Q2) [1]

1. **Eukaryotic** as there is **more than 1 origins of replication** (**multiple replication bubbles**).

(ii) Within structures **K** in Fig. 3.1, there are no occurrences of end-replication problem. Explain why.

ANS [L2] (adapted from H2 PJC/ 2015/ P2/ Q2) [1]

1. The primers in structure **K** will ultimately be replaced by nucleotides.

(b) (i) The DNA replication at each replication fork is sometimes described as *'asymmetrical'* replication as there are differences in the way the daughter strands are being synthesized. State **two** such differences.

ANS [L2] (adapted from H2 PJC/ 2015/ P2/ Q2) [2]

	Aspect of comparison	Leading strand	Lagging strand
1	Type of synthesis	**continuous**	**Discontinuous**
2	Direction of synthesis of daughter strand with respect to replication fork	**towards the replication fork**	**away from the replication fork**
3	Number of primers involved	**1 primer**	**Many primers involved**
4	Involvement of ligase	**Ligase is not required as** the there is **no nick** at the **sugar phosphate backbone**	**Ligase required as** to seal the **nick** at the **sugar phosphate backbone**

(ii) Suggest **two** reasons for the *'asymmetrical'* replication.

ANS [L3] (adapted from H2 PJC/ 2015/ P2/ Q2) [2]

1. **DNA polymerase** can only add **incoming free deoxynucleoside triphosphate** to the **free 3' OH group** of the **pre-existing chain**.
2. **DNA** is **anti-parallel**.

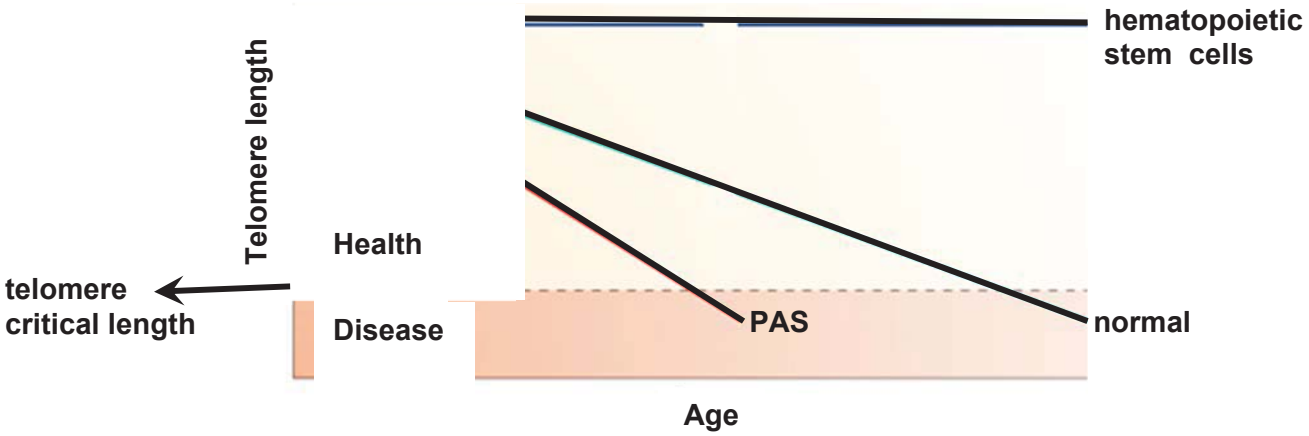
(c) Describe the unique features of hematopoietic stem cells which are common in all stem cells.

ANS [L1] (Novel) [3]

1. Hematopoietic stem cells are **unspecialised cells**. There is an **absence of tissue-specific structures**.
2. Hematopoietic stem cells are able to **proliferate**; capable of **continually self-renewing** and **dividing** through **mitotic** cell division for long periods.
3. Hematopoietic stem cells are capable of **differentiating** into **specialized cells** type **under appropriate conditions.**

(d) Fig. 3.2 shows a graph showing the relationship between age and the telomere length in 3 different kinds of cell;

- hematopoietic stem cells
- somatic cells from a healthy individual (normal)
- somatic cells from an individual suffering premature aging syndromes (PAS)



Fig

With reference to

(i) account for t e in telomere l hematopoietic stem cells and somatic cells from healthy individual.

ANS [L2] (adapted from H2 PJC/ 2015/ P2/ Q2) [2]

1. As the **age increases**, the **telomere length** in **somatic cells from healthy individual decreases linearly** whereas the **telomere length in hematopoietic stem cells remains constant**.
2. **After each round of DNA replication**, there is a **shortening of telomere / end-replication problem** in **all cells**. **Telomerase is active** in **hematopoietic stem cell to maintain the length of the telomere** whereas **telomerase activity is not present in normal somatic cells**.

(ii) suggest the cause of premature aging syndrome

ANS [L2] (Novel) [2]

1. Telomere length **shortens at much faster rate**, resulting in the length of telomere to **reach its critical length at a much early age**.

2. Therefore, **cells undergo senescence / apoptosis** at much **early age**.

[Total: 13]

4 Root tissue from a barley seedling was prepared and its chromosomes were observed under a microscope. Fig. 4.1 shows a cell from the root tissue at the metaphase stage of mitosis.

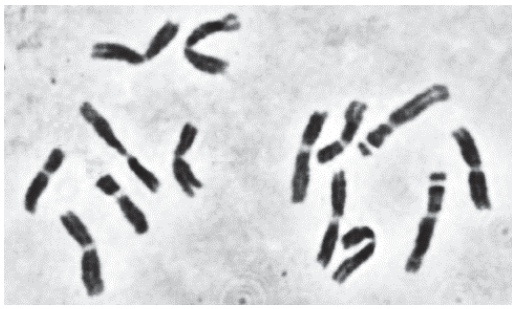


Fig. 4.1

Fig. 4.2 shows the changes in amount of DNA at different stages of the barley life cycle.

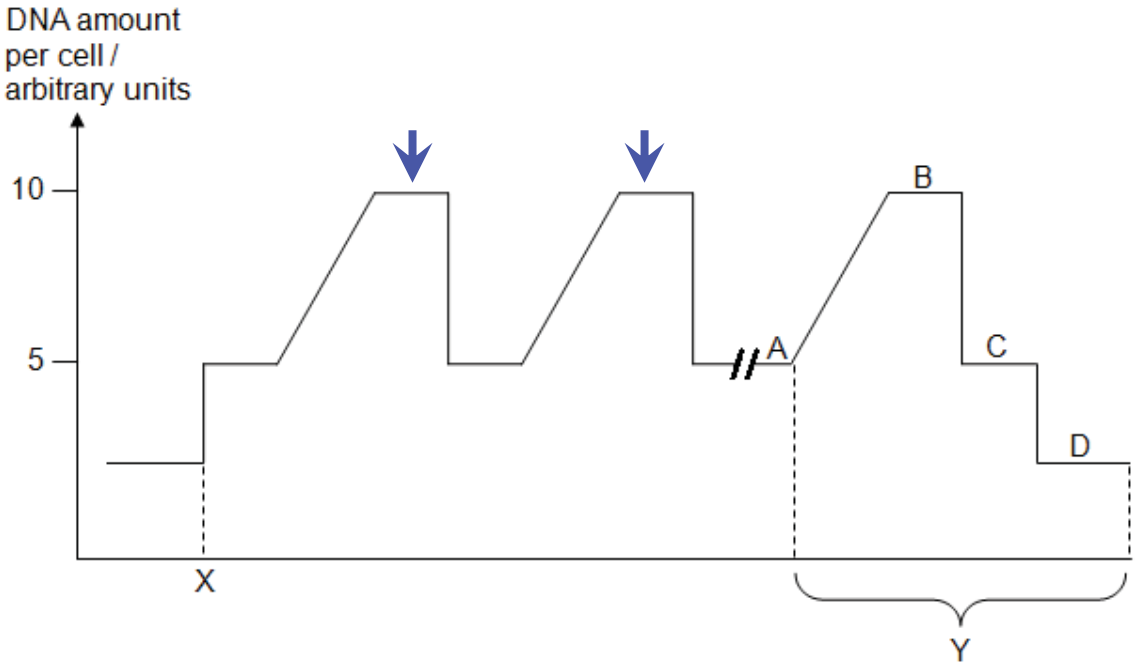


Fig. 4.2

(a) Mark out clearly with an arrow, ↓, on Fig. 4.2, the part of the graph which corresponds to the stage shown in Fig. 4.1. [1]

ANS [L2] (adapted from H2 RI/ 2015/ P2/ Q1) [1]

(b) With reference to Fig.4.2,

(i) state which of the stages, from **A** to **D** has/ have the **same** number of chromosomes as shown in Fig.4.1.

ANS [L2] (adapted from H2 RI/ 2015/ P2/ Q1) [1]

1. **A** and **B**

(ii) Explain why a mutation which occurs during **Y** is considered as a hereditary mutation.

ANS [L2] (Novel) [1]

1. The mutation occurs during **meiosis** / **formation of gametes,** it will be **inherited** to the **next generation.**

(c) Explain the significance of the event occurring at **X**.

ANS [L2] (adapted from H2 RI/ 2015/ P2/ Q1) [2]

1. X refers *to* **fertilisation***;* it allows for the **restoration of the diploid number of chromosomes**;
2. **Random fusion of gametes** results in **greater variation/varied offspring** with **different genotypes and phenotypes**;

(d) Fig. 4.3 shows the formation of Philadelphia chromosome which is commonly found in chronic myelogenous leukemina (CML) cells.

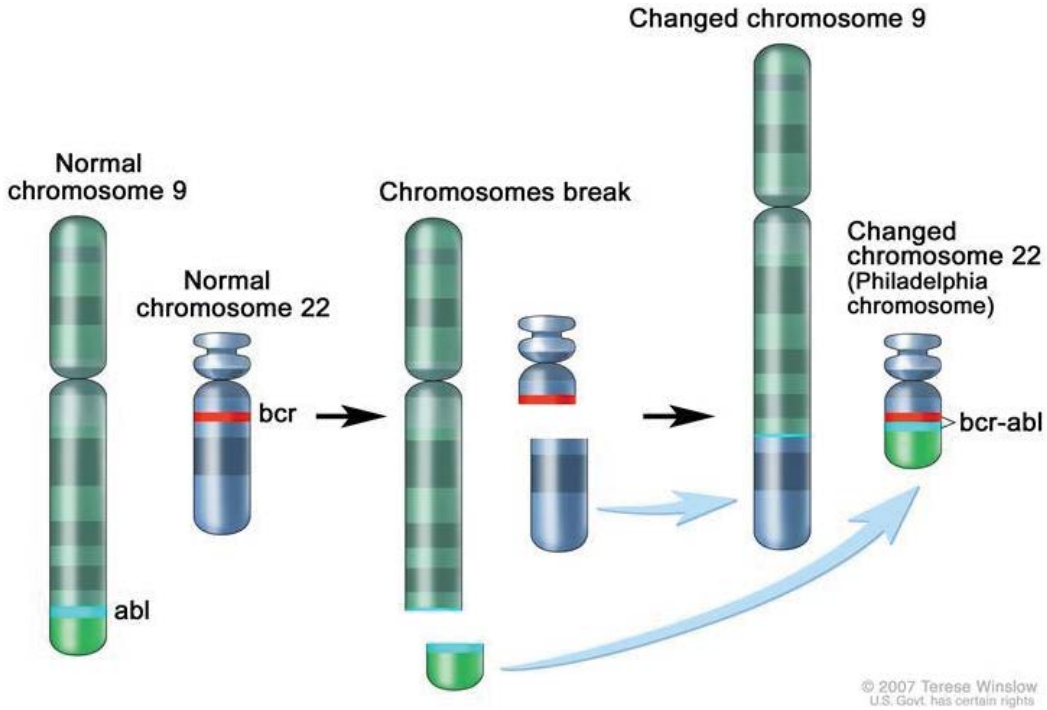


Fig. 4.3

(i) With reference to Fig.4.3, describe the chromosome aberration which results in the formation of Philadelphia chromosome.

ANS [L2] (Novel) [2]

1. The chromosome aberration is **translocation**; where **chromosomes break** occurs at one end of **chromosome 9** and at one end of **chromosome 22**.
2. **Part of the chromosome 9** containing **abl gene** is **translocated / attached** to **chromosome 22** resulting in the ***abl* gene** situated **adjacent to *bcr* gene** on the resulting chromosome 22; known as Philadelphia chromosome.

The protein product of *bcr* gene (BCR protein) is a protein involved in signaling pathway and possesses tyrosine kinase activity. In the presence of growth factors, BCR protein is activated and is found to promote cell growth and proliferation.

The results of a study conducted using chronic myelogenous leukemina (CML) cells to show the effect of Philadelphia chromosome on the activity of BCR protein is shown in Table 4.1.

Table 4.1

The variable being studied	normal cells	CML cells
Concentration of BCR protein / mg cm^{-3}	29.8	29.5
Tyrosine kinase activity of BCR protein in the **absence** of growth factor / a.u.	0	40
Tyrosine kinase activity of BCR protein in the **presence** of growth factor/ a.u.	40	40

(ii) With respect to its effect on cell growth and proliferation, name the group of genes which *bcr* gene belongs to.

ANS [L1] (Novel) [1]

1. **Proto-oncogene**

(iii) With reference to Fig. 4.3 and Table 4.1, explain how Philadelphia chromosome contributes to the onset of chronic myelogenous leukemia (CML).

ANS [L3] (Novel) [4]

1. In Philadelphia chromosome, the ***bcr*** gene is **directly adjacent to *abl*** gene. As a result the gene product of this *bcr-abl* gene is a **hyperactive protein** / **tyrosine kinase** which is **constitutively / continuously activated** even in the **absence of growth factors**.
2. This can be inferred from Table 4.1 which shows the **constant level of tyrosine kinase activity of BCR gene** in CML cells which is **independent of the growth factors**.
3. This lead to an **uncontrolled growth** and **proliferation** of **white blood cells**.
4. The translocation of *abl* adjacent to *bcr* **does not increase the expression** of ***bcr* gene** as shown in Table 4.1 that the **concentrations of BCR protein** in **normal and CML cells are similar at 29.8 mg cm^{-3} and 29.5 mg cm^{-3} respectively.**

[Total: 12]

5 In a particular variety of tomato plant, the allele for red fruit colour is dominant to the allele for yellow fruit colour and the allele for hairy stems is codominant with the allele for hairless stems. A true breeding plant with red fruit and hairy stems was crossed with another true breeding plant with yellow fruit and hairless stems. The resulting F1 were selfed to produce one hundred tomato plants with their ratios shown in Table 5.1.

Table 5.1

Frequency and phenotype of offspring	Genotype
37 red fruit and short hairs on stem	
18 red fruit and very hairy stem	
19 red fruit and hairless stem	

13 yellow fruit and short hairs on stem	
7 yellow fruit and very hairy stem	
6 yellow fruit and hairless stem	

(a) Using the letters **R** for red fruit and **r** for yellow fruit, **H** for hairy stem and **L** for hairless stem, fill in the genotypes for each phenotype of the offspring in the Table 5.1 above.

ANS [L2] (H2 Nov 01, P3.Q4 modified) [2]

Frequency and phenotype of offspring	Genotype	Mark
37 red fruit and short hairs on stem	RRS^HS^L	Any 3 correct 1 mk
18 red fruit and very hairy stem	RRS^HS^H	
19 red fruit and hairless stem	RRS^LS^L	
13 yellow fruit and short hairs on stem	$\underline{rr}S^HS^L$	
7 yellow fruit and very hairy stem	$\underline{rr}S^HS^H$	
6 yellow fruit and hairless stem	$\underline{rr}S^LS^L$	

(b) From Table 5.1, explain how codominance brings about the trait "short hairs on stem".

ANS [L3] (H2 Nov 01, P3.Q4 modified) [2]

1. **Both alleles S^H and S^L** are **fully expressed neither have dominance** over the other
2. **Intermediate condition** because of the **additive effects** of alleles

(c) Draw a genetic diagram to explain this cross.

[1]

Let **R** represent the **allele for red fruit (dominant)**
Let **r** represent the **allele for yellow fruit (recessive)**

Let S^H represent the **allele for hairy stem (co-dominant)**
Let S^L represent the **allele for hairless stem (co-dominant)**

Parent phenotypes ♀ Red fruit, short hair stem X (selfed) ♂ Red fruit, short hair stem

Parent genotypes (2n) RrS^HS^L RrS^HS^L

meiosis

gametes(n) RS^H RS^L rS^H rS^L RS^H RS^L rS^H rS^L [1]

F1 genotypes and phenotypes (listed in each square)

♀ \ ♂	RS^H	RS^L	rS^H	rS^L
RS^H	RRS^HS^H red fruit hairy stem	RRS^HS^L red fruit short hair stem	RrS^HS^H red fruit hairy stem	RrS^HS^L red fruit short hair stem
RS^L	RRS^HS^L red fruit short hair stem	RRS^LS^L red fruit hairless stem	RrS^HS^L red fruit short hair stem	RrS^LS^L red fruit hairless stem
rS^H	RrS^HS^H red fruit hairy stem	RrS^HS^L red fruit short hair stem	rrS^HS^H yellow fruit hairy stem	rrS^HS^L yellow fruit short hair stem
rS^L	RrS^HS^L red fruit short hair stem	RrS^LS^L red fruit hairless stem	rrS^HS^L yellow fruit short hair stem	rrS^LS^L yellow fruit hairless stem

[1] geno
[1] pheno

F1 phenotypic ratio

6 red fruit, short hair stem :
3 red fruit, hairy stem :
3 red fruit, hairless stem :
2 yellow fruit, short hair stem :
1 yellow fruit, hairy stem :
1 yellow fruit, hairless stem

[5]

[Total 9]

6 Microalgae have been extensively studied for various purposes, such as the production of biomass as a source of valuable chemicals of health foods and for wastewater treatment. Recently, microalgal photosynthesis was considered to be an effective means to reduce the emission of carbon dioxide, a major greenhouse gas, in the atmosphere. Light is the most important factor affecting microalgal photosynthesis kinetics. In general, most microalgal mass culture systems are limited by light, because light is easily absorbed and scattered by the microalgal cells. Therefore, understanding and quantification of light dependence of microalgal activity is of great importance in designing an efficient photobioreactor, in predicting process performance, and in optimizing operating conditions.

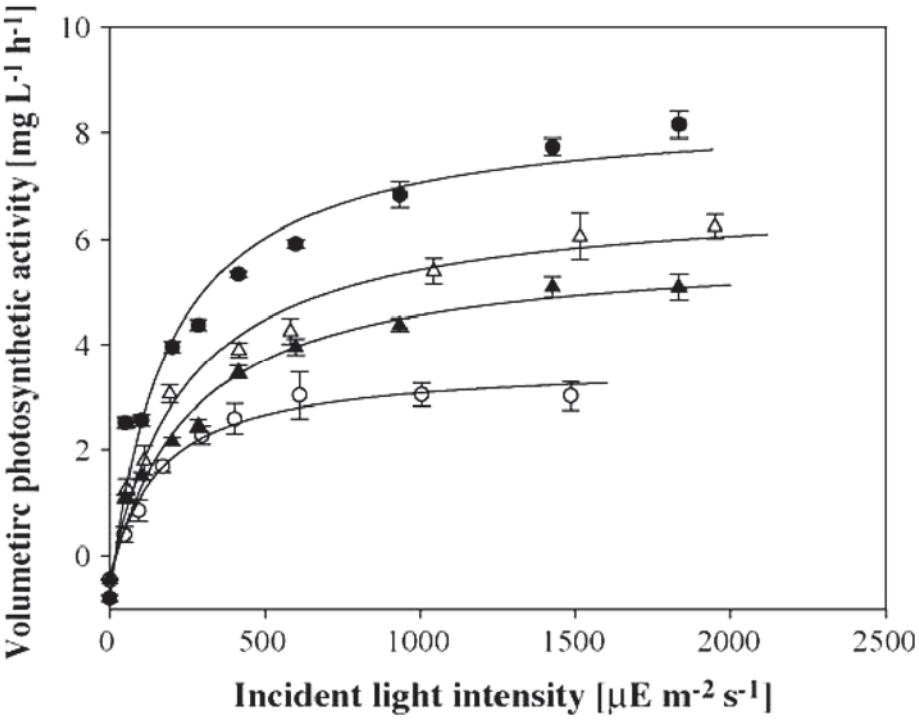


Fig. 6.1
The volumetric photosynthetic activity as a function of incident light intensity at different light types and cell concentrations. Data points and error bars were average values and standard deviations of three replicated experimental results. Solid lines represent the calculated results from the photosynthesis–irradiance model. The light types and cell concentrations were:
(⊘) simulated daylight and 0.215 g L−1;
(▲) simulated daylight and 0.123 g L−1;
(△) red light and 0.123 g L−1; and
(✚) green light and 0.123 g L−1.

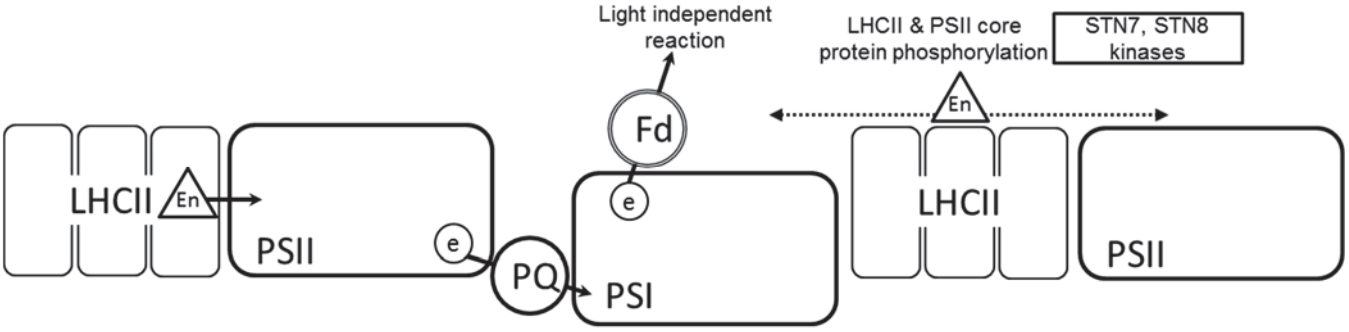
Jeon *et al* 2005 Measurement of microalgal photosynthetic activity depending on light intensity and quality. Biochemical Engineering Journal 27 (2005) 127–131

(a) Explain the trends seen when red, green and daylight (at 0.123gL-1) are compared.

ANS [L2] Novel [5]

1. Comparing at 1500μEm^{-2}s^{-1} **red light yields the highest Photosynthetic rate 5.5 mgL-1h-1** due to the **presence of P680 and P700** absorbing best at those wavelengths.
2. Comparing at 1500μEm^{-2}s^{-1} **Green light yields 3.0 mgL-1h-1 the lowest absorption** as green light is **reflected**.
3. Comparing at 1500μEm^{-2}s^{-1} daylight yields a **moderate Photosynthetic rate 4.5 mgL-1h-1** due to the presence of P680 and P700 but **subject to the efficiency of light capturing**.
4. General trend within graph, at low light intensity, **all three showed that Light was a Limiting Factor**.
5. At **higher intensities** there is a plateau in all three graphs where **light is no longer a limiting factor**.

Fig. 6.2 shows a schematic showing the functional relationship between light harvesting complexes (LHC) and photosystems II & I. Regulatory complexes are also shown comprising of kinases and the regulation of excess energy between PS II and I.



Gollan et al 2015 Photosynthetic light reactions: integral to chloroplast retrograde signalling. Current Opinion in Plant Biology 27:180-191modified.

Fig. 6.2

(b) Explain what is the LHC and its role in photosynthesis.

ANS [L1] Novel [2]

1. LHC is the Light Harvesting Complex comprising mainly of **Carotenoids and special chlorophyll**;
2. Role is to **consolidate / channel energy to the photosystems** in this way helps in the **promotion of electrons within Photosystems**;

(c) With reference to Fig. 6.2 explain the role of electrons in the photosynthesis as they move from Photosystem II to Photosystem I.

ANS [L1] Novel [3]

1. electrons are of a **higher energy state** once promoted, are then **passed down the ETC** where **energy lost in the transfer is used to pump protons** into the **thylakoid space**;
2. **Chemiosmosis of H+ then drives the synthesis of ATP** using **ATP synthase**. ATP will then **be used in the Calvin cycle**.
3. Electrons passed from PSII through the ETC reach and **replenish PSI**.

(d) With reference to Fig. 6.2 suggest the implications of the role of LHC and PSII core protein phosphorylation from Photosystem II to Photosystem I.

ANS [L3] Novel [3]

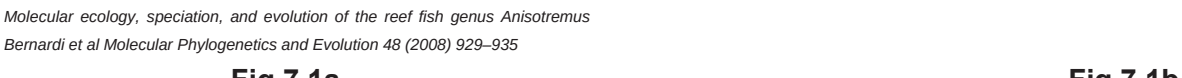
1. LHC and PSII core protein help with the **distribution of energy between PSII and PSI.**
2. At **high light intensity** there is a **redistribution of energy** so that **bleaching does not occur**.
3. At **low light intensities**, there is a **channeling of energy so that photosynthesis will continue**.

[Total: 13]

7 The Isthmus of Panama is the narrow strip of land that lies between the Caribbean Sea and the Pacific Ocean, linking North and South America. It contains the country of Panama and the Panama Canal. The isthmus was formed around 2.8 million years ago. This major geological event separated the Atlantic and Pacific Oceans and caused the creation of the Gulf Stream.

The genus Anisotremus shown in Fig. 7.1b comprise of 9 described species which occur predominantly on coral reefs and subtropical rocky reefs in the Neotropics of the Tropical Eastern Pacific the Caribbean and adjacent waters. In this study, the phylogenetic relationships for all described species were examined based on one mitochondrial gene (cytochrome b) and one nuclear marker (the first intron of the ribosomal protein S7).

Fig 7.1a



Molecular ecology, speciation, and evolution of the reef fish genus Anisotremus
Bernardi et al Molecular Phylogenetics and Evolution 48 (2008) 929–935

Fig 7.1b

(a) Name two methods by which evolution can take place.

ANS [L1] Novel [2]

1. **Divergent evolution**;
2. **Adaptive radiation**;

(b) With reference to Fig. 7.1b explain the type of speciation that would have seen to the derivation of the two fish A. virginicious and A. taeniatus.

ANS [L2] Novel [2]

1. **allopatric speciation**;
2. caused by the formation of a **geographical barrier** the **panama isthmus formed 2.8 mya**
3. each species experienced **different selection pressures** e.g. A virginicious encountering the **newly formed Gulf stream**
4. **advantageous traits** / characteristics were **selected for**, arising from their **advantageous genes** that allowed each species to **survive and reproduce** and over time evolve to become separate species.

(c) With reference to your answer in **(b)** explain the how micro evolution would have taken place.

ANS [L2] Novel [4]

1. Micro evolution comprising of 4 components, **mutation** within the population which contributes to **increased variation** in the gene pool of the population.
2. **selection pressure** which selects for the **advantageous trait / advantageous gene**.
3. **Genetic drift** which **over time**, sees a change in **allele frequency** that favors the population being **more distinct** from other populations of Anisotremus fish.
4. the **lack of gene flow** which allows the population to remain distinct because there is no immigration or emigration of individuals in or out of the population.

(d) Suggest how it was determined that A. virginicious and A. taeniatus were phylogenetically descended from A. dovii and A. pacifici.

ANS [L3] Novel [2]

1. The **use of molecular homology**; using **one mitochondrial gene and the S7 intron as a nuclear marker is an objective one**.
2. Both are regions would be expected to have **higher conservation**
   thus the more differences found compared to **ancestral species Plectorhinchus chaetodonoides** the more further decended these individuals would be. or
   the fewer differences found compared to ancestral species Plectorhinchus chaetodonoides the more closely decended these individuals would be.

(e) In this study it was proposed that A. virginicious and A. taeniatus took a shorter time to speciate from one another compared to A. dovii and A. pacifici. Suggest with evidence from Fig. 7.1a how this might be true.

ANS [L3] Novel [2]

1. A. virginicious and A. taeniatus which both live in the same region in shore and sandy bottoms probably underwent **Sympatric speciation** however due to **gene flow it probably took a long time** before speciation from each other took place.
2. **A. dovii and A. pacifici** which were **separated by the pana ismuth** probably underwent **Allopatric speciation** and with the **geographical barrier preventing gene flow** it probably **took a shorter time before speciation** from one another.

[Total: 12]

8 Transpeptidase is a bacterial enzyme that cross-links cell wall peptides during the formation of bacterial cell walls. The antibiotic penicillin inhibits the activity of transpeptidase. Fig. 8.1 shows part of each of the molecular structures of a cell wall peptide and penicillin.

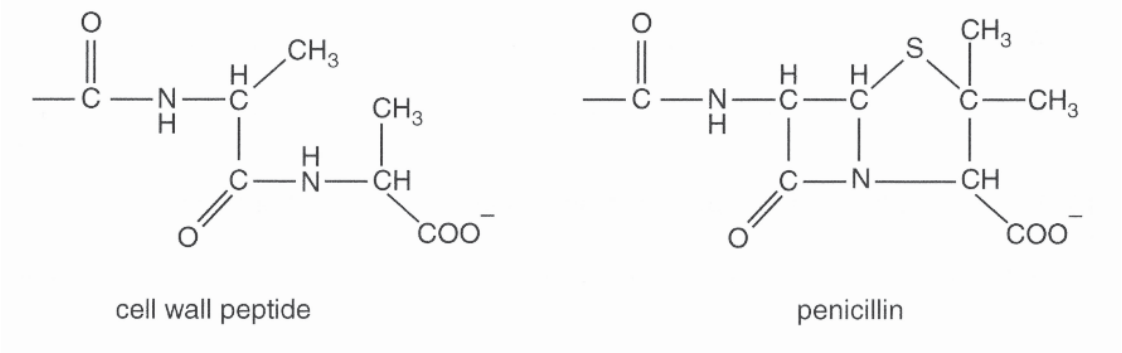


Fig. 8.1

(a) Comment on the structure of cell wall peptides and penicillin.

ANS [L1] (Novel) [1]

2] Shape **similar configuration** **ring structure**

1. Both have **similar functional groups** C=O [Carbonyl] and COOH [carboxylic groups]
2. Both have **similar shape / configuration**

(b) Suggest why the penicillin molecule is an effective inhibitor of transpeptidase.

ANS [L2] (Adapted from H2 JJC/ 2017 MYE/ Q4bii) [2]

1. As the penicillin molecule/competitive inhibitor is **structurally similar** to the **cell wall peptide/actual substrate**, the penicillin molecule can **enter and bind/competes** with the cell wall peptide for binding at the **active site** of the transpeptidase;;
2. When the penicillin molecule is bound at the transpeptidase's active site, it **prevents the cell wall peptide** from **entering the site**, preventing the **formation of E-S complexes** and **formation of products**, hence **decreasing the rate of reaction**.

(c) Fig.8.2 shows an electron micrograph of an alveolar macrophage isolated from a tuberculosis patient.

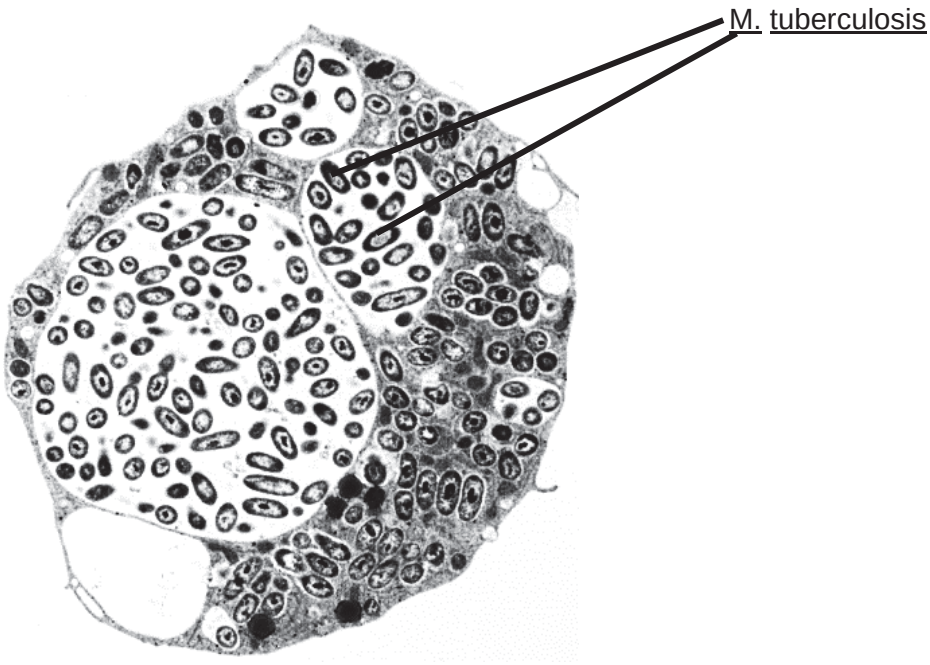


Fig. 8.2

(i) Describe the mode of transmission of Mycobacterium tuberculosis.

ANS [L1] (Novel) [1]

1. Mycobacterium tuberculosis is carried through **air** in the **infectious droplets** produced when **individual with active TB** cough/speak/sneeze/spit.

(ii) Explain the appearance of the alveolar macrophage in Fig. 8.2.

ANS [L2] (Novel) [2]

1. **Many M. tuberculosis in the macrophage**. These bacteria were taken into the macrophage via **phagocytosis**.
2. In the macrophage, M. tuberculosis **prevents fusion** of the **phagosome with lysosome**. The bacteria are able to **survive and divide** within the macrophage.

(d) Tuberculosis patients are commonly treated with antibiotics, isoniazid and rifampicin. Recently, there is an increase in number of multi-drug resistant tuberculosis cases.

State **one** reason why multi-drug resistant tuberculosis continues to emerge.

ANS [L1] (Novel) [1]

1. Inappropriate or incorrect use of antimicrobial drugs.
2. Use of ineffective formulations of drugs.
3. Premature treatment interruption.

[Total 7]

9 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 (Fig. 9.1). An estimated 50 million dengue infections occur annually and approximately 2.5 billion people live in dengue endemic countries.

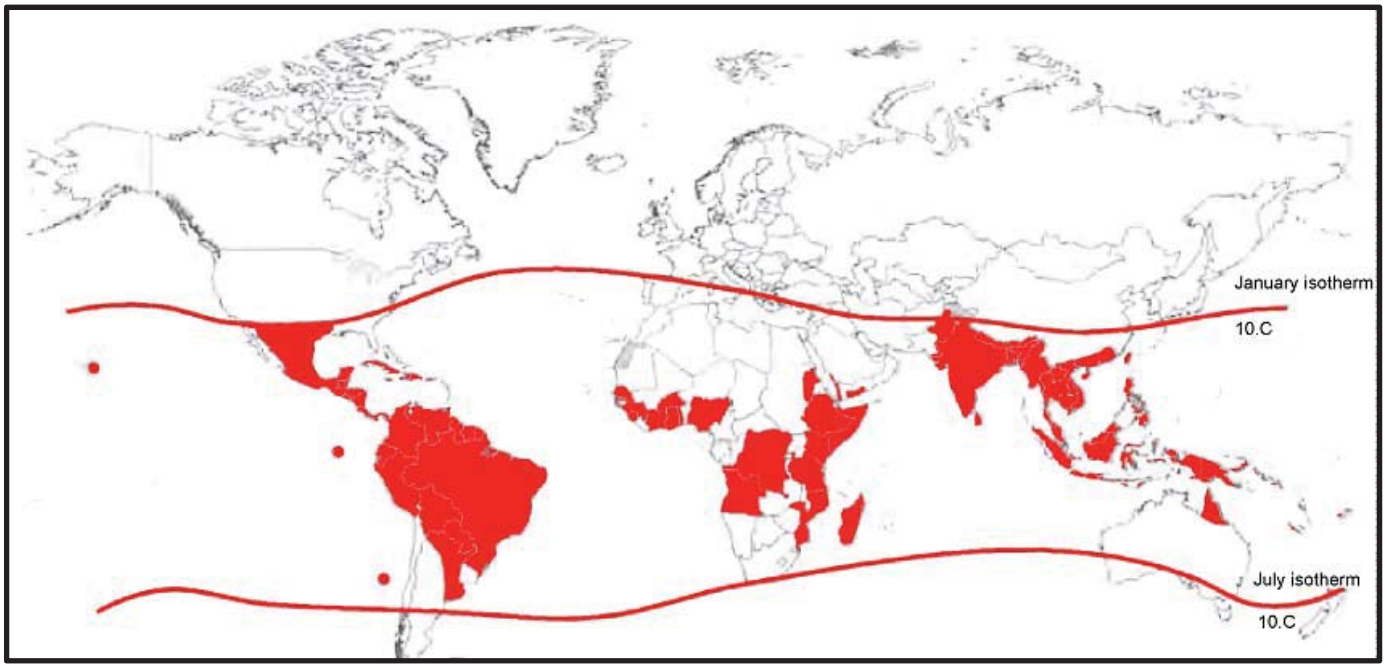


Fig. 9.1 Shaded areas are countries at risk of dengue fever due to presence of Aedes mosquito, as of 2008. The contour lines are range of January/July isotherm indicating the potential range of Aedes aegypti.

(a) Describe the developmental stages (including duration) in the life cycle of the Aedes mosquito.

ANS [L1] Novel [4]

1. **Eggs are laid** on surface of **stagnant water** and subsequently **dry out**.
2. **Larvae hatch** from eggs upon being **submerged in water again**, undergo **3 instars** / moults over **5 days**.
3. **Pupa** stage follows for another **3 days**
4. **emergence** of **adult** which **fed on nectar**, **females take a blood meal** to aid in the **production of eggs**.

(b) Explain why the range of dengue fever is the same as that of the Aedes mosquito.

ANS [L1] Novel [2]

1. **Dengue Virus** has evolved and is **adapted** to its **vector Aedes aegypti**.
2. **insect physiology** is greatly **affected by changes** in **temperature due to its size**. Therefore where the vector thrives so does the dengue virus.

(c) To some extent the range of the Aedes mosquito has also followed human expansion, explain how this may be true.

ANS [L2] Novel [2]

1. Aedes mosquito **adapted to human urban habitats**.
2. where human activity provide **viable habitats** e.g. **stagnant water** for Aedes to thrive.
3. In **colder latitudes or altitudes**, **large cities provide a warmer habitat**.

(d) With reference to Fig. 9.1, explain how climate change may affect the spread of dengue beyond the tropics.

ANS [L2] Novel [2]

1. Current **range limit is restricted by a 10°C temperature barrier**, **anthropomorphic climate change** may speed up **increased global temperatures** as a result of global warming e.g. due to increased green house gases /.
2. increased global temperature see **more favourable physiological conditions** for the **vector Aedes mosquito** and **subsequently for the dengue virus**.

[Total: 10]

CATHOLIC JUNIOR COLLEGE
JC2 PRELIM EXAMINATION
Higher 2

Answers

CANDIDATE NAME					
CLASS	**2T**	**INDEX NUMBER**			

BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

23RD AUGUST 2017
2 hours

Candidates answer on the Question Paper.
Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

Write your index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs. Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

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

Section B
Answer **one** question in this section on writing papers provided.

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

For Examiner's Use	
SECTION A	
1 [30]	
2 [12]	
3 [8]	
SECTION B	
4 [25]	
OR	
5 [25]	
TOTAL P3 [35%]	**75**

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

[Turn over

Section A

Answer **all** questions in this section.

1 Milk is an important source of diet for most infant. For many adults, milk is an important source of dietary calcium. Milk contains many biological molecules; one of them is lactose. Therefore, it is not surprising that most infant will have a mechanism to digest lactose. While for adults, it is not normal for their body to be able to digest lactose. However, there is an increasing trend of lactose tolerant (also known as lactase persistent) individual in the adult population.

Here, we will discuss 3 types of conditions; namely Congenital Lactase Deficiency (CLD), lactose allergy, and lactose tolerance (lactase persistence).

Silanikove et al The Interrelationships between Lactose Intolerance and the Modern Dairy Industry: Global Perspectives in Evolutional and Historical Backgrounds Nutrients 2015, 7, 7312-7331

(a) Fig. 1.1 shows the structure of lactose.

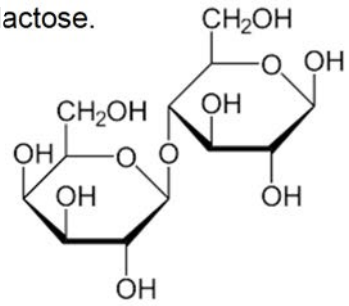


Fig. 1.1

Name the bond joining the 2 monomers in lactose

ANS [L1] (novel) [1]

1. **β-1,4-glycosidic bond**

(b) Fig. 1.2 shows the catalytic residues found in the active site of lactase.

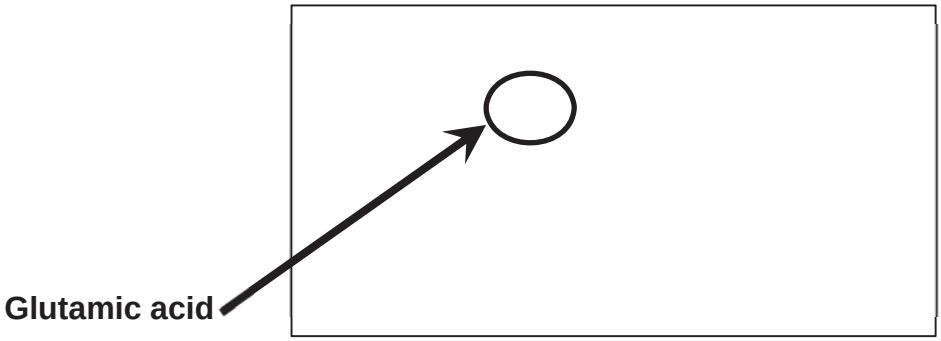


Fig. 1.2

One of the catalytic residues; glutamic acid (circled in Fig. 1.2) is substituted by glycine which is shown in Fig.1.3 below.

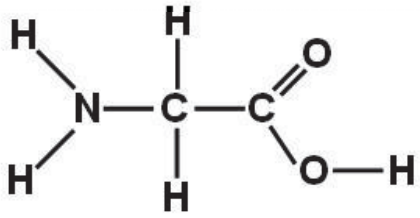


Fig. 1.3

Explain how lactase catalytic activity is affected by the substitution above.

ANS [L3] (novel) [2]

1. **Glutamic acid** has an **R-group** that is **negatively charged** whereas **glycine** has an **R-group** that is **non-polar**.
2. This causes the **change in the interaction** between the **catalytic residues** and the **substrate** at the **active site**; therefore; lactase catalytic activity will be **greatly reduced / lost**.

(c) Lactose intolerance in infant is also known as Congenital Lactase Deficiency (CLD). It is an autosomal recessive disorder.

Studies have shown that CLD is caused by mutation in *LCT* gene coding for lactase. The most commonly observed mutation is a single nucleotide substitution in *LCT* gene which results in the production of truncated lactase.

Other mutation such as a single nucleotide deletion in *LCT* gene has also been detected in a few patients which also results in the production of truncated lactase.

(c)(i) Explain how two different types of mutations; single nucleotide substitution and single nucleotide deletion in *LCT* gene can lead to the production of truncated lactase.

ANS [L3] (novel) [2]

1. **Single nucleotide substitution** may cause the codon to become a **stop codon**, resulting in a **nonsense mutation** which leads to the production of truncated lactase.
2. **Single nucleotide deletion** may cause frameshift mutation, resulting in an early encounter of stop codon downstream the deletion which leads to the production of truncated lactase.

(c)(ii) A small amount of DNA is isolated from infants suffering CLD resulted from a single nucleotide substitution. The DNA was subjected to process **Y** to ensure enough DNA for the subsequent Southern Blotting process.

Name the process **Y.**

ANS [L1] (novel) [1]

1. **Polymerase chain reaction (PCR)**

Fig. 1.4 shows wild type *LCT* gene and mutant *LCT* gene. The mutation result in the loss of *NdeI* restriction site (*NdeI* RE) at position 4 kb as shown by the arrow ⇧.

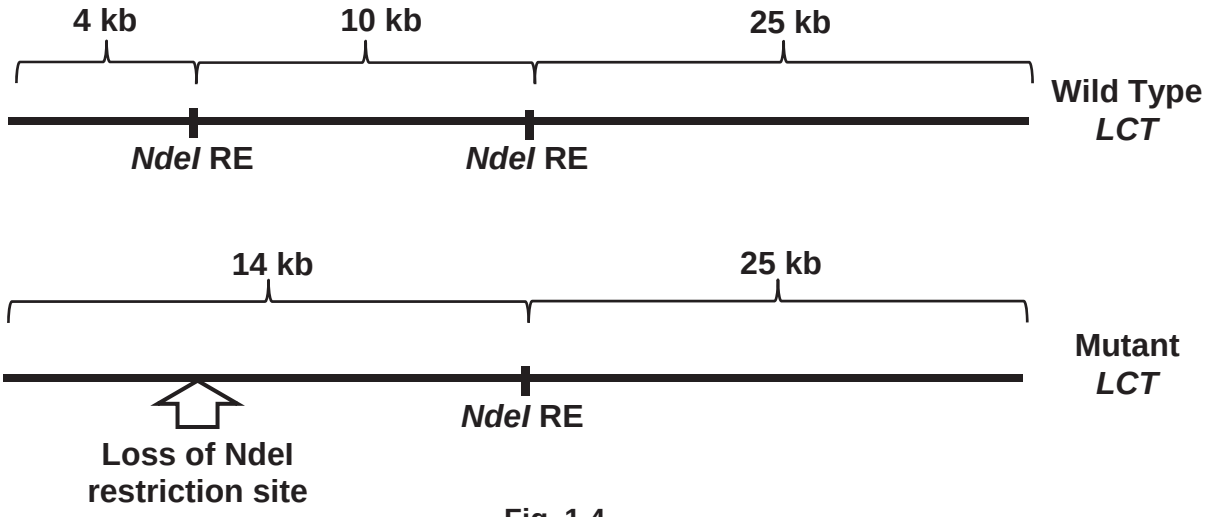


Fig. 1.4

Fig. 1.5 shows the band patterns of the nitrocellulose membrane obtained from the Southern Blotting of DNA sample from 3 infants.

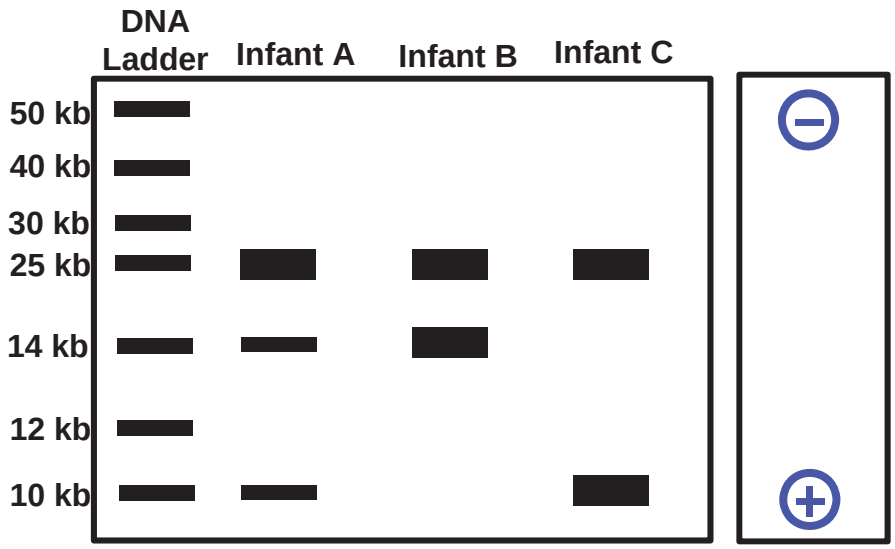
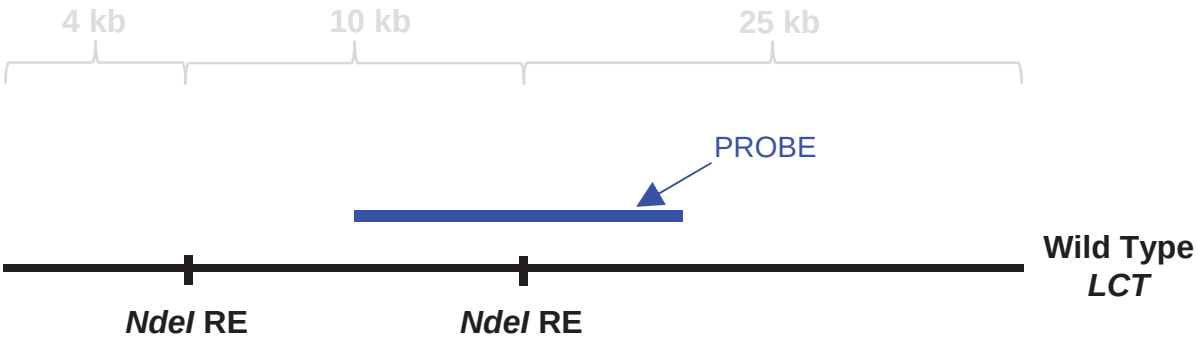


Fig. 1.5

(c)(iii) On the box on the right side of Fig. 1.5, indicate the position of the positive terminal and negative terminal during the gel electrophoresis which results in the band pattern in Fig. 1.5. [1]

ANS [L2] (novel) [1]

(c)(iv) Based on the position of the *NdeI* restriction sites in wild type and mutant *LCT* gene in Fig. 1.4 as well as the band patterns in Fig.1.5, indicate on the wild type *LCT* below where the probe will anneal to (use a ruled line and label). [1]



ANS [L3] (novel) [1]

(c)(v) Based on the information provided in part **(c)** as well as Fig. 1.4 and Fig. 1.5; explain which infant is suffering from CLD.

ANS [L3] (novel) [2]

1. Infant **B** is an infant with CLD as infant B is **homozygous for mutant LCT** / carries **2 copies of mutant LCT**.
2. When digested with *NdeI*, the LCT gene produced **14 kb** and **25 kb** fragments only / **double** band thickness at 14 kb and 25 kb.

(d) Another condition known as lactose allergy results in more severe symptoms than lactose intolerance. The symptoms of allergy are due to the action of Immunoglobulin E (IgE) which activates mast cells, which subsequently secrete a chemical signal **X.**

(d)(i) Name **X.**

ANS [L1] (Novel) [1]

1. histamine

Fig. 1.6 shows the structure of IgG and IgE.

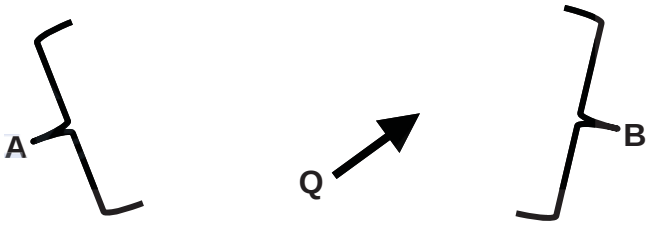


Fig. 1.6

(d)(ii) The number, type, and position of Q on IgG and IgE are different. Name precisely the process which attaches Q on IgG and IgE.

ANS [L1] (Novel) [1]

1. **glycosylation**

(d)(iii) Describe structures of IgE that allow it to perform its role in eliciting allergy response towards lactose.

ANS [L2] (Novel) [2]

1. The **variable region** of IgE is **complementary to lactose** allowing it to **recognise lactose**.
2. The **constant region** of IgE is **able to interact with mast cell** to **activate it** and elicit allergy response towards lactose.

(d)(iv) With reference to Fig. 1.6; suggest what will happen to an individual with lactose allergy when part **B** of all his IgE is replaced with part **A** of his IgG

ANS [L3] (Novel) [1]

1. IgE will still be **able to bind to lactose** to **elicit response** that is usually **elicited by IgG**.

Some human adults continue to produce the lactase enzyme throughout their adulthood (lactase persistent). Therefore, they are able to digest lactose effectively (lactose tolerant) and will not develop symptoms such as bloating, flatulence, or diarrhoea after consuming milk.

However, most adult mammals stop producing the lactase enzyme (lactase non-persistent). Therefore, they are unable to digest lactose effectively (lactose intolerant) and will usually develop symptoms such as bloating, flatulence, or diarrhoea when consuming milk.

Fig. 1.7 shows the pattern of inheritance of lactose intolerance in Family A.

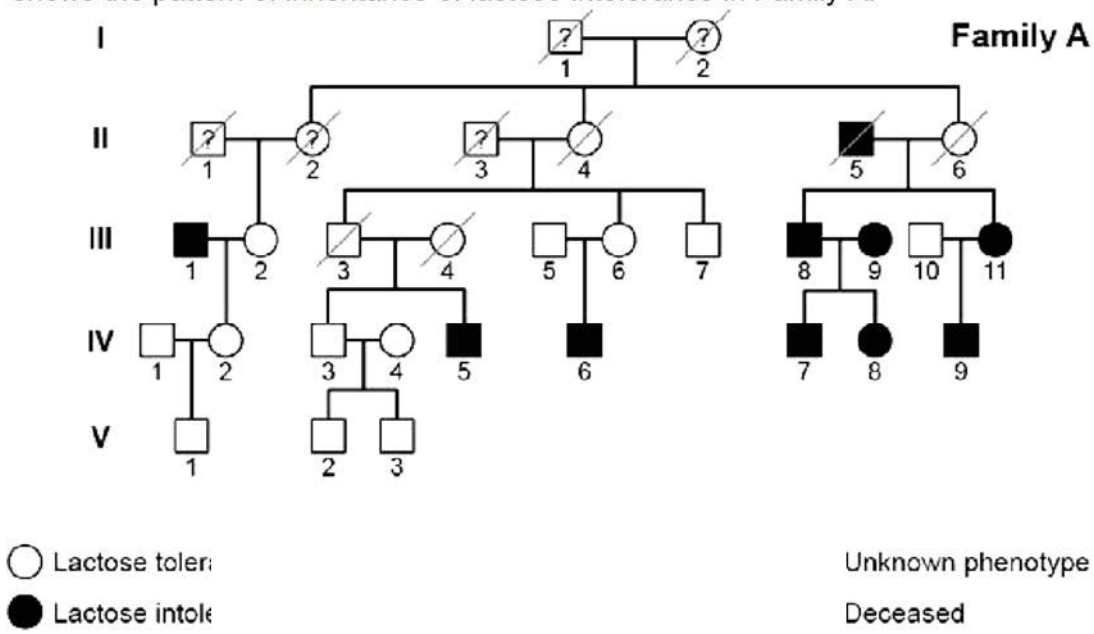


Fig. 1.7

(e)(i) With reference to Fig. 1.7; explain the mode of inheritance of lactose intolerance and where the gene is probably located. Provide evidence to support your claim.

ANS [L2] (novel) [4]

1. Lactose tolerance is recessive
2. **GIII5 x GIII6 [both Lact tolerant] >>GIV6 Lact Intolerant**
3. **Location of gene: Autosomal**

4. Given that **both male** and **females inherit equally.**

Humans learned to exploit ruminants as a source of milk about 10,000 years ago; particularly the European population. Since then, the use of domesticated ruminants as a source of milk and dairy products has expanded until today when the dairy industry has become one of the largest sectors in the modern food industry, including the spread at the present time to countries such as China and Japan.

Widespread lactose intolerance among the adult population is a considerable drawback to dairy-based foods consumption. Over the centuries, three factors allowed humans to overcome limitations imposed by lactose intolerance: (i) mutations, which occurred in particular populations, most notably in the north European Celtic societies and African nomads, in which carriers of the lactose intolerance gene converted from being lactose intolerant to lactose tolerant; (ii) the ability to develop low-lactose products such as cheese and yogurt; and (iii) colon microbiome adaptation, which allow lactose intolerant individuals to overcome its intolerance.

Fig. 1.8 shows the pockets of lactase persistence shown in pie charts.

Pockets of lactase persistence shown in pie charts. Ingram et al, Hum Genet 124:579–591, 2009.

Fig. 1.8

(e)(ii) With reference to Fig. 1.8; apart from the genetic factors, suggest what other factor could have contributed to the spread of lactase persistence.

ANS [L3] (novel) [2]

1. genetic trait influenced by **Cultural factors**
2. There is a relationship between the **frequency of lactase deficiency** in a population and **whether or not the population was involved in intensive dairy farming**. OWOTTE
3. Low levels of lactase deficiency are found in European populations with a long history of dairy farming, and highest levels in populations of Asian /American ancestry who were not dairy farmers.

(f)(i) Explain how Darwin's principles of evolution may be applied in understanding the type of evolution that would have had to take place in the spread of lactose tolerance.

ANS [L2] (Novel) [3]

1. **Natural selection** is the first principle in Darwin's Evolution that would be seen taking place, where the **selection pressure** is the **availability of dairy produce**.
2. **Variation** in the **gene pool** aided through **mutation** that allowed the continuation of the gene lactase ie **lactase persistence**, instead of natural loss of function [lactase non-persistent];

3. Allowing these **advantageous trait [lactase persistence] to be selected for** and allow individuals to **survive** better as they were now able to **exploit the additional resource** to their advantage, and **reproduce** so that the **Advantageous trait is passed** on to the offspring and the next generation ;
4. **divergent evolution** took place and over time allowed the evolution of lactose tolerant individuals ;

(f)(ii) Suggest how the scenario described in **(f)(i)** is an example of macro or micro evolution.

ANS [L3] (Novel) [2]

1. **microevolution**;
2. distinct changes in **allele frequency** within the population making it more **distinct**, allowing lactase persistence the advantage over lactase non-persistance;

(g)(i) Define anthropomorphic climate change.

ANS [L1] (Novel) [1]

1. refers to **the production of greenhouse gases** emitted by **human activity**.

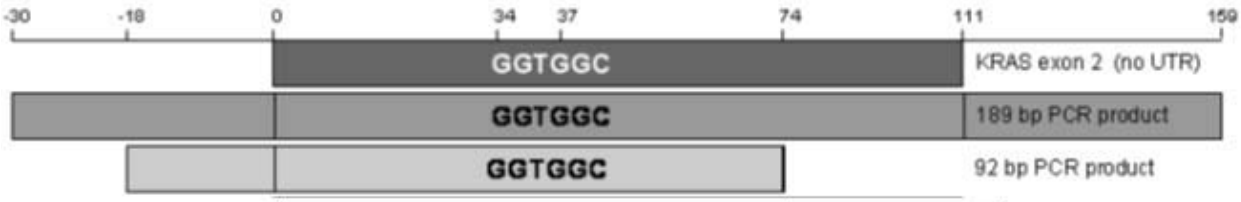
(g)(ii) Explain how the above scenario of increased lactase persistence may contribute to anthropomorphic climate change.

ANS [L2] (Novel) [3]

1. Lactase persistence **confers and evolutionary advantage** in being able to **exploit a wider range of food especially dairy products**. This **indirectly contributes** to anthropomorphic climate change in terms of the **human choice of food**, increased **demand of dairy products**.
2. Impact **[max 1]**
   - 2a] **deforestation** – **arable land** is created for **crop feed and raising of cattle**, there is the **loss of terrestrial carbon sink**
   - 2b] **cattle industry** – increased production of **methane and CO_2**
   - 2c] **Dairy industry** – use of **fossil fuel** in the processing of dairy products e.g. **pasteurization** / and as a result **releasing more CO_2 / carbon foot print larger**.
3. **Green house gas emissions** especially **CO_2 [Green house Warming Potential (GWP):1]** and **Methane GWP 24** contribute to **global warming** and **impact climate change**.

[Total: 30]

2 All mammalian cells express three closely related Ras proteins: H-Ras, K-Ras and N-Ras that promote oncogenesis when mutationally activated at codons 12, 13 or 61. Despite a high degree of similarity between the isoforms, K-Ras mutations are far more frequently observed in cancer.



AGTGGC	GLY12 SER
CGTGGC	GLY12 ARG
TGTGGC	GLY12 CYT
GATGGC	GLY12 ASP
GCTGGC	GLY12 ALA
GTTGGC	GLY12 VAL
GGTAGC	GLY13 SER
GGTCGC	GLY13 ARG
GGTTGC	GLY13 CYT
GGTGAC	GLY13 ASP
GGTGCC	GLY13 ALA
GGTGTC	GLY13 VAL

Location of K-RAS codon 12 and 13 mutations and PCR amplicons / products. Exon 2 of K-RAS is shown from the ATG without the untranslated region. The position and size of the PCR amplicons used in the High Resolution Melting HRM assays in relation to exon 2 of K-RAS is indicated. All possible mutations at codon 12 and 13 are listed along with the corresponding amino acid changes from Glycine (GLY) are shown.

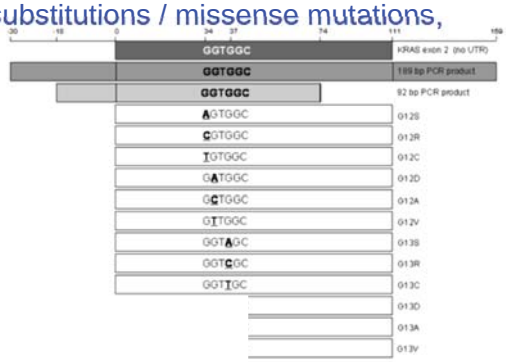
Krypup et al. High resolution melting analysis for the rapid and sensitive detection of mutations in clinical samples: KRAS codon 12 and 13 mutations in non-small cell lung cancer BMC Cancer 2006, 6:295

Fig. 2.1

(a) With reference to Fig. 2.1; explain the type of mutation experienced in K-RAS codon 13.

ANS [L2] (Novel) [2]

1. all mutations found on codon 13 are base pair substitutions / missense mutations, N37 GGC to N37 AGC;
2. resulting in a change of one amino acid, from GLY to SER;
   NB: Minus one mark for no example cited



(b) With reference to Fig.2.1; suggest why oncogenesis in codon 13 is caused by only 6 possible changes in amino acid and not more.

ANS [L3] (Novel) [4]

1. due to base pair substitutions on the **1st and 2nd bases of codon 13,** subsequently causing change in one amino acid;
2. base pair substitution on **3rd base of codon 13** would have a **silent mutation**, i.e. not result in any change in amino acid ;
3. due to the **genetic code** being **degenerate**;
4. **deletion or addition point mutations** result in **frame shift** and subsequent loss of function of RAS which would not result in cancer. / stunted cell division.

Ras proteins are the products of proto-oncogenes that are frequently mutated in human cancers. They are encoded by three ubiquitously expressed genes: *H-Ras*, *K-Ras* and *N-Ras*. These proteins are GTPases that function as molecular switches regulating pathways responsible for proliferation and cell survival.

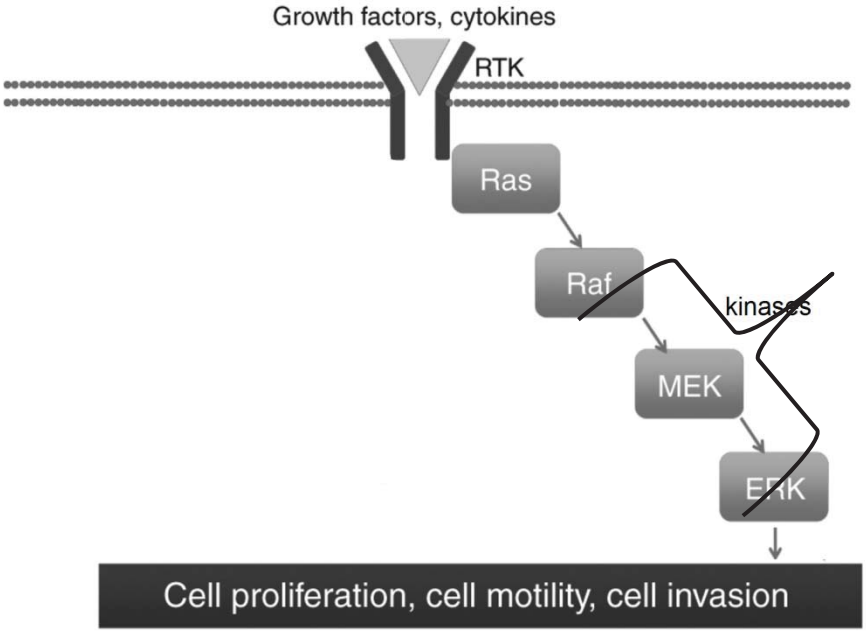


Fig. 2.2

(c) How does Ras protein act as a molecular switch in initiating cell proliferation?

ANS [L2] (Novel) [1]

1. RAS is activated by Tyrosine kinase which includes a GTP within RAS / replacement of GDP with GTP, which turns the switch on activating protein kinases Raf, MEK and ERK.

(d) With reference to Fig. 2.2; explain how Ras protein is normally used to terminate cell proliferation.

ANS [L2] (Novel) [2]

1. When **no growth factors / cytokines is bound to RTK**, Ras acts as a **GTPase** which causes the **hydrolysis of GTP to GDP** therefore inactivating RAS and
2. **Phosphorylation cascade** involving Raf, MEK, and ERK cannot continue and phosphatases are recruited to remove the phosphate; inactivating the protein kinases which terminate cell proliferation.

(e) With reference to Fig. 2.2 suggest how a mutation in *Ras* gene results in uncontrolled cell division.

ANS [L3] (Novel) [1]

1. **Gain of function mutation** in ***Ras* gene** results in **Ras protein** which is **constitutively active / hyperactive**; requiring **no activation by RTK that is bound by growth factors / cytokines**. As a result the signaling pathway involving Raf, MEK, and ERK that lead to cell proliferation is constitutively activated; OR
2. Mutation in RAS would result in a **gain of function** which results in **GTP remaining** within RAS due to a loss of its GTPase function, allowing RAS to **remain turned on** / **active even after the growth factors / cytokines has been removed from RTK**. As a result the signaling pathway involving Raf, MEK, and ERK that lead to cell proliferation is constitutively activated.

(f) With reference to **(a)** to **(e)**; explain the development of cancer.

ANS [L3] (Novel) [2]

1. Development of cancer as a multistep process
2. requiring the mutual activation of codons 12, 13 and 61. OWTTE
3. requiring the accumulation of mutations in these codons
4. acquiring a gain of function such that system is independent of the growth hormone

[Total: 12]

3 Cyanobacteria are a group of bacteria that obtains their energy through photosynthesis. They carry an operon known as *phycocyanin* operon which controls the expression of phycocyanin. Phycocyanin is a protein complex which serves as accessory pigment to chlorophyll in cyanobacteria. Without phycocyanin, light harvesting process is halted. The amount of phycocyanin increases from very low level to high level in the presence of light.

Fig. 3.1 below shows the structure of *phycocyanin* operon in the Cyanobacterium Anacystis nidulans.

P	O	*CPCB1*	*CPCA1*	Intergenic region	P	O	*CPCB2*	*CPCA2*

Legend:
P : promoter
O : operator
***CPCB1* and *CPCA1* : structural genes coding for β – subunit of phycocyanin**
***CPCB2* and *CPCA2* : structural genes coding for α – subunit of phycocyanin**

Fig. 3.1

(a) Compare the *lac* operon to the *phycocyanin* operon.

ANS [L3] (Novel) [3]

Features	***lac* operon**	***phycocyanin* operon**
Similarity:		
Type of operon	**Inducible** operon	**Inducible** operon
Differences:		
Number of promoter	**1 promoter** controlling the **expression of 3 structural genes; *lacZ*, l*acY*, and *lacA***	**2 promoters** controlling the **expression of 2 structural genes** for **β-subunit** of **phycocyanin** and **2 structural genes** for **α-subunit** of **phycocyanin**.
Inducer	Allolactose	Light

(b) Describe how the *CPCA2* gene could be transferred to another bacterium by a prophage.

ANS [L2] (Novel) [3]

1. When the prophage viral DNA is excised from the chromosome, it takes with it ***CPCA2* gene** located **adjacent bacterial DNA** due to **improper excision**. **OWTTE**
2. ***CPCA2* gene** is **injected,** along with the phage's genome, into the next host cell. This DNA remains **double-stranded during transfer**.
3. **Both strands** are **integrated** and may subsequently **replace** the **homologous region** found on the **chromosome** of its **new host**.

(c) Cyanobacterium Anacystis nidulans has thylakoid which contain the same photosystems as the thylakoid of plant cells. Fig. 3.2 shows a hybrid *phycocyanin* operon.

trp P	O	*CPCB1*	*CPCA1*	Intergenic region	trp P	O	*CPCB2*	*CPCA2*

Legend:
trp P : trp promoter

Fig. 3.2

Explain the rate of production of oxygen in the Cyanobacterium Anacystis nidulans carrying the hybrid operon when light is present and tryptophan is present.

ANS [L3] (Novel) [2]

SC:	**Explain**	**rate of production of oxygen**	**hybrid operon**	**light, trp present**
OR:	**Describe with reason**	**very low or negligible**	**controlled by trp P**	**trp co-repressor the operon is off**

1. The rate of production of oxygen is **very low** or **negligible**; the hybrid operon is under the control of **trp promoter** which is **off when tryptophan is present**.
2. **No expression of phycocyanin**; **photoactivation halts**. Therefore, **photolysis cannot occur** to **produce oxygen**.

[Total: 8]

Section B

Answer **one** question in this section

.

Write your answers on separate answer paper provided.
Answer each part on a **separate** piece of paper.

Your answer should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answer must be in continuous prose, where appropriate.

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

4 **(a)** Explain the fluid mosaic model and the roles of the constituent biomolecules in functions of membranes at the cell surface and of membranes within the cell. [13]

(b) Explain how genetic variation arises in a natural population and its significance in allowing the population to adapt and evolve. [12]

[Total: 25]

5 **(a)** With reference to named examples, describe the roles of proteins in bringing about cell signalling in living organisms. [13]

(b) Gene expression in eukaryotes is regulated at many different stages of the process.
Explain how gene expression is regulated in eukaryotes and the significance of this at each stage. [12]

[Total: 25]

4 **(a)** Explain the fluid mosaic model and the roles of the constituent biomolecules in functions of membranes at the cell surface and of membranes within the cell. [13]

ANS [L3] Novel [13]

FLUID MOSAIC MODEL (Max 2)

1. **Fluid** - 'Fluid' refers to the fact that individual phos**pholipid and protein molecule** is able to **diffuse laterally** within the bilayers. It also refers to phospholipids being able to **diffuse transversely** across the bilayers.

2. **Mosaic** - 'Mosaic' describes the **assorted pattern** produced by the **scattered integral and peripheral protein molecules** which differ between each bilayer.

PHOSPHOLIPIDS (Max 4)

3. Arrange themselves in a layer 2 molecules thick ❼ **bilayer**;
   4. 4a] Arrangement confers **stability**;
      4b] where the polar hydrophilic phosphate head interacting with aq. medium in/s and o/s cell;
   4c] non-polar hydrophobic fatty acid tails help enclose a non-polar hydrophobic interior away from the surrounding aqueous medium;
5. 5a] Acts as a **control for movement of substances into and out of cell** as the hydrophobic core restricts movement of ions, large polar molecules;
   5b] forcing these molecules to enter via selective channels conferring selectivity to membrane;
   5c] act as a barrier to separate the content of the cell from the external cell environment.
6. **Regulate membrane fluidity,** hence **permeability** through p**roportion of the saturated fatty acids to unsaturated fatty acids.** Saturated fatty acids are closely packed together, causing the membrane to be rigid; Unsaturated fatty acids have spaces between them due to the double bonds and this increases membrane fluidity.
7. **Also regulate membrane fluidity through length of the fatty acids**. Fluidity increases due to the presence of more short fatty acid chains.

CHOLESTEROL (Max 3)

8. **regulates fluidity** by **regulating** the **movement of phospholipids**. Prevents phospholipid bilayer from becoming too fluid or too rigid and also help **maintain membrane stability**.
9. **decrease fluidity** by **partially immobilising unsaturated fatty acid tails**;
10. **increase fluidity** by **spacing out saturated fatty acid chains**;

11. **low temperatures** ❼ cholesterol disturbs the close packing of phospholipids & keeps them **more fluid** / **increasing permeability**
12. **high temperatures** ❼ cholesterol prevents membranes from breaking up and makes membrane **less fluid** by restraining the movement of phospholipids / **decreasing permeability**

MEMBRANE PROTEINS (Max 4)

13. **Include Peripheral** and **Integral proteins**;
14. **Function in Transport**. **Transmembrane protein that spans the membrane provides a hydrophilic channe**l across the membrane that is selective for a particular solute. E.g. aquaporins (water channels) found on the collecting duct on the kidney nephron.
15. Other **transport proteins** hydrolyze ATP as an energy source to **actively pump** substances across the membrane. E.g. sodium-potassium **pump** on the neurone that utilizes ATP to pump 2 K^+ ions in for every 3 Na^+ ions out.
16. Function as **Enzymes**. A protein built into the membrane may be an enzyme with its active site exposed to the substances in the adjacent solution needed to carry out sequential steps of a metabolic pathway. E.g. mitochondrial ATP synthase.
17. Function in **Cell Singalling**. A membrane protein that has a binding site complementary in shape to the chemical messenger which upon binding causes a conformational change in the protein that relays message to the inside of the cell. E.g. insulin receptors on the hepatocytes of the liver.
18. Function in **Intercellular joining**. Membrane proteins of adjacent cells may be hooked together in various kinds of junctions. E.g. Tight junctions on the proximal convoluted tubule of the nephron.
19. Function in **Cell to cell recognition**. Glycoproteins (proteins with short chains of sugar) that serve as identification tags and are recognized by other cells. E.g. antigens on erythrocytes that confer specificity.
20. Function in **Attachment to the cytoskeleton and the extracellular matrix**. Attachment of microfilaments or other elements of the cytoskeleton to help maintain cell shape and fix the location of certain membrane proteins. These proteins can coordinate extracellular and intracellular changes.

CARBOHYDRATES, GLYCOLIPIDS AND GLYCOPROTEINS (Max 2)

21. Oligosaccharides that are covalently bonded to lipids formed **glycolipids**; Oligosaccharides that are covalently bonded to proteins formed **glycoproteins**.
22. As **recognition sites** for **cell-to-cell recognition** (cell identity markers); **receptor sites for chemical signals**
23. For **cell-to-cell adhesion** ❼ Helps cells maintain structural relationships with neighbouring cells
24. **As Antigens for RBC / MHC or surface Ag for immune response**;

QWC: Scientific argumentation exemplified by:
Two or more examples of constituent biomolecules of membranes linked coherently functions of membranes at the cell surface and of membranes within the cell

4 **(b)** Explain how genetic variation arises in a natural population and its significance in allowing the population to adapt and evolve. [12]

ANS [L2] Novel [12]

Causes of genetic variation in a population. **(Max 8)**

Gene Reshuffling (Max 2)

1. Gene reshuffling is the rearrangement of genes and alleles to produce a **new combination of alleles** within the gene pool of a population.
2. **Independent Assortment** during **Metaphase I** allows for **new combination of alleles** to be formed within a gamete. The possible number of combinations of gametes produced by one human would then be 2^{23} = 8388608 (8 million) combinations.
3. **Crossing over during Prophase I** between **non-sister chromatids of homologous chromosomes** allows for a **recombinant chromatid** to be formed, **forming new combinations of alleles within a gamete.**
4. **Random Fertilization of gametes** allows **for a new combination of alleles within a zygote.**

Gene Mutation (Max 2)

5. Gene mutation is a form of mutation where there is a **change in the nucleotide sequence** or **nucleotide number** of the alleles of a gene. This includes **Substitution**, **Duplication**, **Insertion/addition**, **Deletion** and **Inversion**.
6. Gene mutation **gives rise to new alleles** and **increases the gene pool** of a population.

Chromosomal Structural Aberration (Max 2)

7. Structural aberration includes **Deletion**, **Duplication**, **Inversion** and **Translocation. Structural aberration gives rise to new alleles** and increases the gene pool of a population**.**
8. **Structural aberration** occurs **during crossing over in meiosis**. In crossing over, non-sister chromatids sometimes **exchange unequal-sized segments of DNA**, so that one partner gives up more genes than it receives. The products of such a **nonreciprocal crossover** are one chromosome with a **deletion** and one chromosome with a **duplication**.

Chromosomal Numerical Aberration (Max 2)

9. **Numerical aberration** refers to the change in the **number** of chromosomes, leading to either **aneuploidy** or **polyploidy.**
10. Numerical aberration occurs when there is a **non-disjunction** during meiosis, **where members of a pair of homologous chromosomes do not move apart properly** during meiosis I or **sister chromatids fail to separate** during meiosis II.

Environmental Influence (Max 2)

11. Common environmental factors (Light, Diet and Temperature) may influence the **degree of phenotypic expression** or in some cases, change the phenotype entirely.
12. 1 example of environmental factor influencing phenotype cited

significance in allowing the population to adapt and evolve by natural selection **(Max 6)**

13. **Natural Selection** is the mechanism which **acts on individual organisms in a population** and those with **favourable phenotypes** which are morphologically, physiologically and behaviourally **better adapted** to the **prevailing selection pressure** within the **existing environment** are at a **selective advantage** and hence are more likely to **survive to reproductive age to produce viable offspring** / greater reproductive success and in doing so **pass down their favourable alleles**.

14. Those individuals with **unfavourable phenotypes** that are **not so well adapted** are at a **selective disadvantage** and either **fail to reproduce or die before they can reproduce**. Over **many generations**, the **proportion of the favourable alleles INCREASES** in the population. This then leads to **ADAPTIVE EVOLUTIONARY CHANGE.**

15. Genetic variation within a population **provides the raw material on which natural selection works** (i.e. variation is a **pre-requisite for evolution by natural selection**)

16. When **environmental changes** occur, variations allow some individuals with certain **favourable characteristics to survive better** and **reproduce more successfully** than others, to produce fertile offspring.

17. If there is **no variation** in the population, all will be **equally susceptible** to the effects of environmental change and it is possible that the entire population will be **wiped out**. Variation thus helps to **ensure perpetuation** of species and **safeguard species from extinction**.

18. Citing example to illustrate significance of variation in wild varieties or related organisms being useful in agriculture (e.g. *Teosintes*, evolutionary cousins of corn, carry genes for resistance to diseases affecting domesticated corn and have been used to produce disease-resistant corn varieties.)

QWC: Scientific argumentation exemplified by:
Two or more examples illustrating how genetic variation can from sexual reproduction / meiosis and genetic mutation linked coherently how these variations are important in allowing the population to adapt and evolve by natural selection that to the correct stages of the process

5 **(a)** With reference to named examples, describe the roles of proteins in bringing about cell signalling in living organisms. [13]

ANS [L2] (H2 JC2 CJC MYE/2011/P2/Q8(a) Modified) [13]

Each stage of cell signalling must be clearly stated.

Stage: Ligand-Receptor Interaction (Max 5)

Cell Surface Receptor Proteins

1. Certain **cell surface membrane proteins** function as **specific receptor proteins** with **binding sites complementary in conformation (shape)** *to* particular chemical signal molecules (called **ligands**) - **ligand-receptor interaction** (binding of ligand to receptor) **initiates a signal transduction pathway** INSIDE the cell

G-Protein Linked Receptor (GPLR)

2. Binding of extracellular **ligand (signal) molecule** such as **glucagon**, **adrenaline** to the **binding site** of the **G-Protein Linked Receptor (GPLR)** cause it to undergo **a conformational change.**
3. A**ctivated GPLR** binds to the **G_{α} subunit** of inactive G-protein, inducing a **conformational change** and cause **attached GDP** to be displaced (from the G_{α} subunit) and **replaced by a GTP molecule; G_{α} subunit dissociates from the** $G_{\beta\gamma}$ subunit.
4. Activated **G protein** (or activated G_{α} subunit) then **binds** with and activate other **effector membrane proteins within the cell**.

GTPase Enzyme

5. Present as **part of the G-protein** that is associated with **GPLR (G-protein-linked receptors) or GPCR (G-protein-coupled receptors)**;
6. Once specific cellular responses have been carried out, **GTP** attached to an activated G protein is rapidly **hydrolysed** to **GDP** by the intrinsic **GTPase** enzyme (in the **G_{α} subunit**, causing G_{α} subunit to dissociate from the effector membrane protein and reassociate with the $G_{\beta\gamma}$ subunit). This **inactivates** the **G-protein** and **switches off** the **function of the activated G-protein** / ref. to role of the G-protein in signal transduction;
7. Allows whole **system can be shut down quickly** when the extracellular signal molecule is no longer present.

Adenylyl Cyclase

8. **Found** in the **plasma membrane**; in close association with G-proteins;

9. **Activated by** the binding of **activated G-proteins**; G-proteins are activated as a result of the binding of hormones / ligands (e.g. adrenaline / glucagon) to **G-protein linked receptors**;
10. Upon activation, catalyses **ATP to cAMP** which acts as a second messenger, (diffuses through the cell and) activates protein kinase A (a serine/threonine kinase), which phosphorylates other proteins;

Tyrosine-Kinase Receptors

11. Present as **sections of the 2 TKR (tyrosine-kinase receptor) polypeptides**;
12. Enzymes **activated** by the **binding of ligands** to both of the receptor polypeptides and subsequent **dimerization**;
13. Activated tyrosine kinase on one polypeptide **adds phosphates** to the **tyrosine tails** of the **other polypeptide**;
14. The fully-activated receptor proteins activate a variety of specific relay proteins that bind to specific phosphorylated tyrosine molecules.

Phospholipase C.

15. **Activated** when a **signal molecule binds** to the G-protein linked membrane receptors or tyrosine kinase receptors;
16. Upon activation, **cleaves** a membrane **phospholipid (PIP_2)**, into 2 by-products - **diacylglycerol** (**DAG**) and **inositol trisphosphate** (**IP_3**);
17. the IP_3 acts as a second messenger to activate a gated-calcium channel, releasing Ca^{2+} from the cell's endoplasmic reticulum, thereby increasing the cytosolic Ca^{2+} concentration;

Ion-channel Receptors

18. Transmembranal ligand-gated **ion channel proteins** with **hydrophilic channels** and an **extracellular ligand-binding site.**

19. The hydrophilic channels / pores **open or close** (due conformational change in channel protein) in response to **binding by ligand molecules** such as acetylcholine to **regulate** (i.e.to allow or prevent) the **passage of specific ions**, e.g. Ca^{2+}, **into** or **out** of the cell

Stage: Signal Transduction (incl. phosphorylation and signal amplification) (Max 5)

Protein Kinase A / Protein Kinase

20. **Activated by** second messenger, **cyclic AMP (cAMP)**;
21. Upon activation, brings about **phosphorylation of other inactive protein kinases** (ref. to mostly the serine or threonine amino acids of these protein kinases being affected), activating them;
22. The **subsequent phosphorylation** of other inactive protein kinases by these **activated protein kinases** leads to a '**phosphorylation cascade'** which brings about a widespread cellular mechanism for regulating protein activity;
23. Each protein **phosphorylation changes the shape of the protein kinase** (due to the interaction between the phosphate group and charged or polar amino acids) that typically **converts it from an inactive form to an active form** which in turn activates the subsequent kinase;

Protein Phosphatases

24. Remove **phosphate groups** from **activated protein kinases, inactivating them**;

25. causing the **signaling pathway** and the **subsequent cellular response to shut down**;

26. responsible for **turning off a signal-transduction pathway** in the absence of the extracellular signal molecules;

Stage: Cellular Response (Max 5)

Intracellular Receptors

27. Ref. to intracellular receptors that interact with **ligand molecules** that are **steroidal in nature** (e.g. sex hormones) and able to **dissolve through the cell surface membrane**

28. **Activated protein receptors** (in the form of **hormone-receptor complex**) in turn act as ***transcription factors*** that control which genes are **turned on** and are **transcribed** into messenger RNA (mRNA) in cellular response

29. Ref. to proteins such as transcription factors, RNA polymerase to bring about transcription
30. Ref. to proteins such as ribosomal proteins as part of ribosomes to bring about translation

5 **(b)** Gene expression in eukaryotes is regulated at many different stages of the process.

Explain how gene expression is regulated in eukaryotes and the significance of this at each stage. [12]

ANS [L3] (modified from specimen paper /P3/Q5b) [12]

Regulation *of gene expression / protein synthesis – at various* ***stages***

Any **seven** from below:

1. Chromatin Level / Chromatin modification – by Methylation of DNA
2. Histone modification of DNA
3. Specific Transcription Factors / Repressors & Activators
4. Control Elements, incl. promoters, silencer / enhancer, DNA sequences
5. Post-transcriptional control / pre-mRNA processing
6. RNA / intron splicing / polyadenylation / 5' caping
7. Translational Control
8. Half-life of mRNA / initiation of translation
9. Post-Translational control
10. Biochemical modification to make functional protein, including protein degradation
11. AVP

Advantages *of regulating gene expression*

Any **four** from:

12. Chromatin level
    - idea of longer term switching genes on or off to restrict active genes to cells that required (by the cell line), do more efficient / less waste of resources Reject: inactivation / imprinting
13. Transcriptional Level
    - allows rate of production to be regulated to, match short term requirements / allows flexibility
14. Post-transcriptional level
    - allows for production of different variants / regulates stability of process
15. Translational level
    - idea of affecting how long the process takes to stop
16. Post-translational level
    - allows rapid production of product from stored precursor / product can be activated where it is needed / allowing, safe transport / storage of, inactive form / ref. to phosphorylation for immediate responsiveness to cell conditions / AVP
17. AVP

QWC: Scientific argumentation exemplified by:

Two or more advantages of regulating gene expression / protein synthesis linked coherently to the correct stages of the process

CATHOLIC JUNIOR COLLEGE
JC2 PRELIM EXAMINATION
Higher 2

Answers

CANDIDATE NAME		CLASS	2T

INDEX NUMBER				

BIOLOGY

9744/04
Paper 4 PRACTICAL
14th AUGUST 2017
2 hours 30 minutes

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

READ THESE INSTRUCTIONS FIRST

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

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
TOTAL	

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.

1 Investigation into the effect of changing the concentration of an enzyme on enzyme activity.

The biological molecule, U, reacts with water to form aqueous ammonium carbonate. The enzyme urease catalyses this reaction.

Aqueous ammonium carbonate produces ammonium ions. These form an alkaline solution which causes red litmus paper to turn blue. The time taken for red litmus paper to turn blue can be used to monitor the progress of the reaction.

You are required to investigate the effect of enzyme concentration on this reaction.

You are provided with the following:

- 15 cm^3 of 10.0% urease solution, **E**, which is an irritant
- 100 cm^3 of distilled water, **W**
- 25 cm^3 of a solution of the biological molecule, **U**
- Red litmus paper, total length of about 20 cm

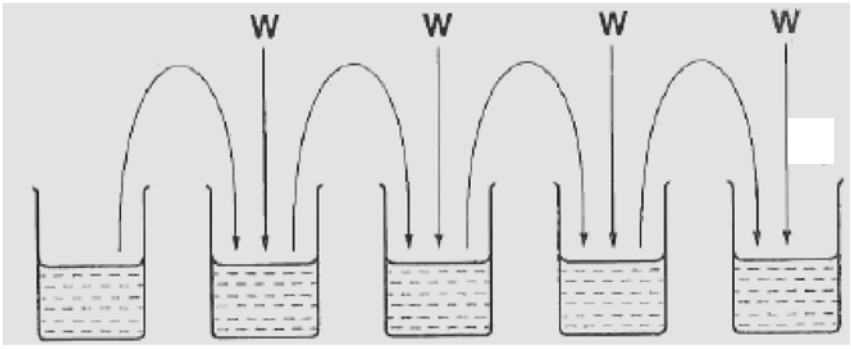
It is recommended that you wear safety goggles / glasses.

1 Carry out a serial solution of the urease solution, **E**, to reduce the concentration of the enzyme by half between each of the four successive dilutions, and set up a control.

Label four small beakers, **D1, D2, D3** and **D4**, for the serial dilutions and label another small beaker, **C**, for the control.

Complete Table 1.1 to show how you will make the different concentrations of urease solution and how you will set up the control, **C**.

Table 1.1



Solution	E	D1	D2	D3	D4
concentration of urease / %	10.00	5.00	2.50	1.25	0.650
volume of urease solution to be diluted / cm^3		5.0	5.0	5.0	5.0
volume of distilled water, **W** / cm^3		5.0	5.0	5.0	5.0
description of the control, **C:**					

[3]

Mark Allocation

[1] – for selecting **10.0, 5.00, 2.50, 1.25 and 0.625** for concentration of urease; expressed consistently in **3 sig. fig**.
[Accept: if all concentrations are expressed consistently in **3 dec. pl.**]

[1] – for **correct volumes** in serial dilution, including
(i) **final volume of each concentration** must be **equal**, i.e. volume of urease and distilled water must add up to give the same final volume
[Accept: any final volume between 6 to 10 cm^3]

(ii) **values** are recorded **consistently** and to **appropriate precision**, i.e. **1 dec. pl**.

[1] – for citing use of distilled water to replace the urease solution for control, **C**; volume of distilled water cited must be consistent with the volume of enzyme / diluted solution.

2 In order to monitor the progress of the reaction, in step **4** red litmus paper will be added to each mixture of enzyme (urease) and substrate, **U**, in a test-tube. To prevent the paper sticking to the wall of the test-tube, you will need to use the glass rod to add it, as follows.

Cut a piece of red litmus paper so that it is a little shorter than the circumference of the glass rod. Moisten the paper and stick it to the end of the glass rod as shown in Fig. 1.1. The glass rod can then be lowered into the mixture of urease enzyme and substrate, **U**. The red litmus paper will slip off into the mixture and the glass rod can be removed.

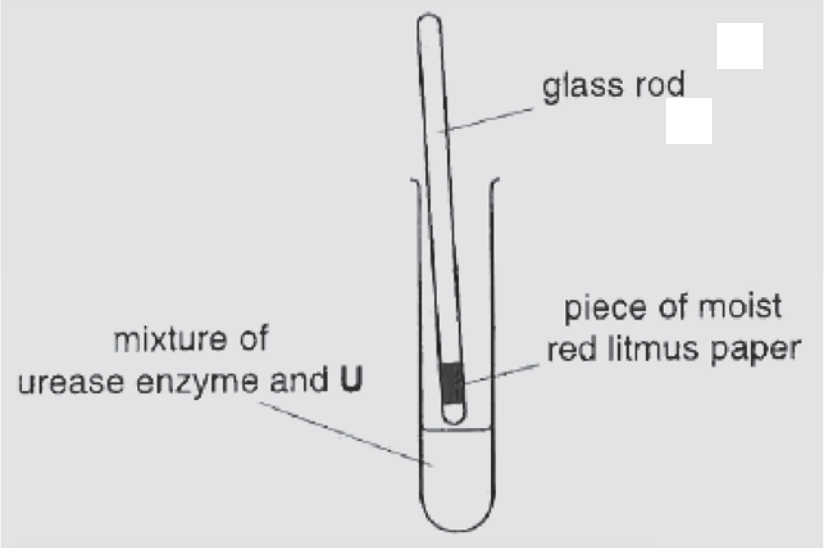


Fig. 1.1

3 Prepare a table in the space on page 4 (step **7**) to record the results of this investigation at various concentrations of urease solutions, including the control.

Proceed as follows:

4 To test the activity of the highest concentration of urease solution, put 2 cm^3 of the substrate, **U**, into a test-tube then add 2 cm^3 of **E** and mix well. The reaction will start as soon as **E** is added.
Immediately, put one piece of red litmus paper into the test0tube as described in step **2** and start timing.

5 Record, in the table that you have prepared on page 4 (step **7**), the time taken for the piece of red litmus paper to turn blue. If the piece of red litmus paper does not turn blue in ten minutes, record 'more than 600'.

6 Record steps **4** and **5** for the other concentrations of urease solution, **D1, D2, D3** and **D4**, and the control, **C**. The red litmus paper used each time should be of the same size.

7 Use the space below to record your results.

Concentration of urease solution / %	Time taken for red litmus to turn blue / s
10.0	71
5.00	141
2.50	313
1.25	More than 600
0.625	More than 600
0.00 (control, **C**)	More than 600

[3]

Mark Allocation

[1] – for results recorded in table format with appropriate column / row heading titles and units
Leftmost column: **Concentration of urease solution / %**
Adjacent column: **Time taken for red litmus paper to turn blue / s**

[1] – for expected trend:
Shortest time for highest concentration of urease solution
Longest time for lowest concentration of urease solution
'More than 600' for Control C

[1] – for values recorded consistently and to appropriate precision, including:
(i) 3 sig. fig. / 3 dec. pl. for urease concentration
(ii) time taken in **whole number**, consistent as per 'more than 600'
[Accept: If time recorded in 2 dec. pl. as per precision of stopwatch used]

8 Calculate the rate of reaction, using your result for the 10.0% concentration of the urease solution, **E**.

For 10.0% concentration of urease solution, E

rate of reaction = 1 / time taken

= 1 / 71

= 0.014 s^{-1}

rate of reaction .....0.014 s^{-1}..... [1]

Mark Allocation
[1] – for correct calculation of rate using 1 / time for E / 10.0% urease concentration and units s^{-1}
[Accept: Answer up to 2 sig. fig. / 3 dec. pl.]

9 Lack of repeats is one limitation of this procedure. Describe one significant source of error in this procedure that also acts as a limitation.

.....

..... [1]

Mark Allocation
For any **ONE** of the following:
- difficulty in starting the stopwatch at the same time as the start of reaction / delay due to difficulty with inserting litmus paper; OWTTE
- difficulty in judging when the red litmus paper changes colour from red to blue; OWTTE
- AVP

[Reject: for size of litmus paper; temperature; pH or evaporation of water that affects urease concentration or any errors which affects all test-tubes equally]

10 Suggest how you would make **one** improvement to this procedure to reduce the effect of the significant source of error identified in step **9**.

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..... [1]

Mark Allocation
For any **ONE** of the following:
- Use second person to start time or to add red litmus paper; OWTTE
- Use pH meter / liquid pH indicator with colorimeter / pH sensor with datalogger, in place of the red litmus paper
- AVP

[Reject: for citing use of colorimeter or liquid pH indicator alone]

The effect of pH on the activity of two proteolytic enzymes, **A** and **B**, was compared. The substrate for the enzyme was coloured jelly, which is made of protein.

The apparatus of each pH was set up as shown in Fig. 1.2.

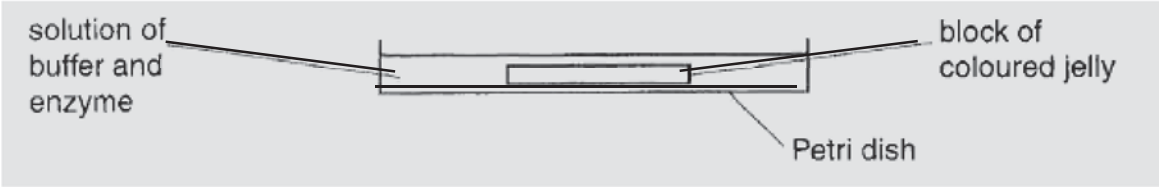

Fig. 1.2

The block of coloured jelly get smaller as it is digested by the enzymes.

11 State two variables which would need to be controlled. Suggest how each variable would be controlled.

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..... [3]

Mark Allocation

[1] – for citing **TWO correct variables** from the following:
- (i) **volume** of buffer solution or **volume** of enzymes A and B
- (ii) **concentration** of enzymes A and B
- (iii) **dimension** / **size** of jelly block
- (iv) **temperature**
- (v) AVP

[2] – for citing **TWO** methods of control that match the 2 identified variables, from the following:
- (i) To use suitable measuring apparatus e.g. syringe, measuring cylinder, graduated pipette - *to transfer / dispense volume*
- (ii) To describe how to make up (e.g. using distilled water to make up to same final volume) – *for enzyme concentration*
- (iii) To measure *jelly block* using ruler or Vernier calipers or grid and cut *to size* using scalpel or knife
- (iv) Use an incubator / thermostatically controlled water-bath, set at a *fixed temperature*
- (v) AVP

The results of the investigation are shown in Table 1.2.

Table 1.2

pH	area of jelly present after 90 minutes / mm^2	
	enzyme **A**	enzyme **B**
4.0	10	134
6.4	76	124
7.4	128	76
8.0	138	52
9.0	140	6

12 Plot, on the grid opposite, the data shown in Table 1.2. Draw lines of best fit for enzyme **A** and enzyme **B**.
[4]

13 **(a)** Describe the effect of pH on the activity of enzymes **A** and **B**.

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..... [1]

Mark Allocation
[1] – for citing / description of the effect of (increasing) pH on activity of both enzyme A (decreases) and enzyme B (increases), e.g. reference to comparison of optimum pH of enzyme A and enzyme B)

(b) Suggest and explain why changes in pH affect the activity of these two enzymes differently.

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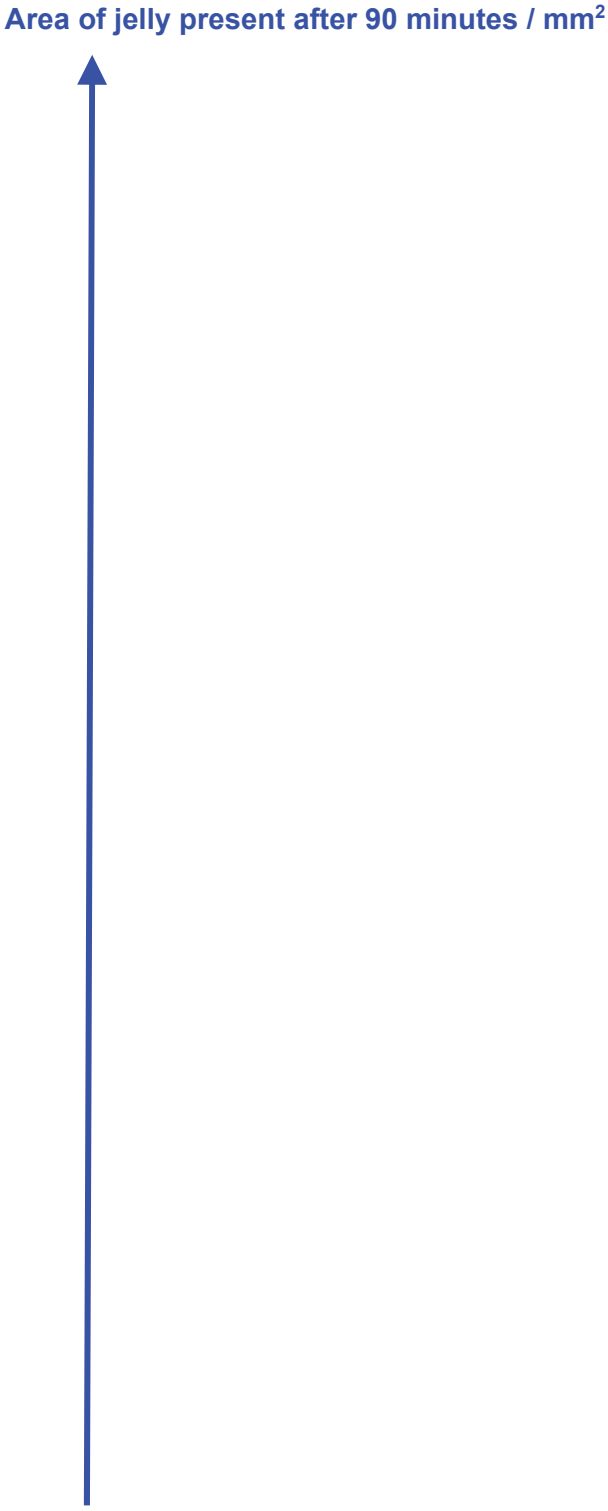
..... [3]

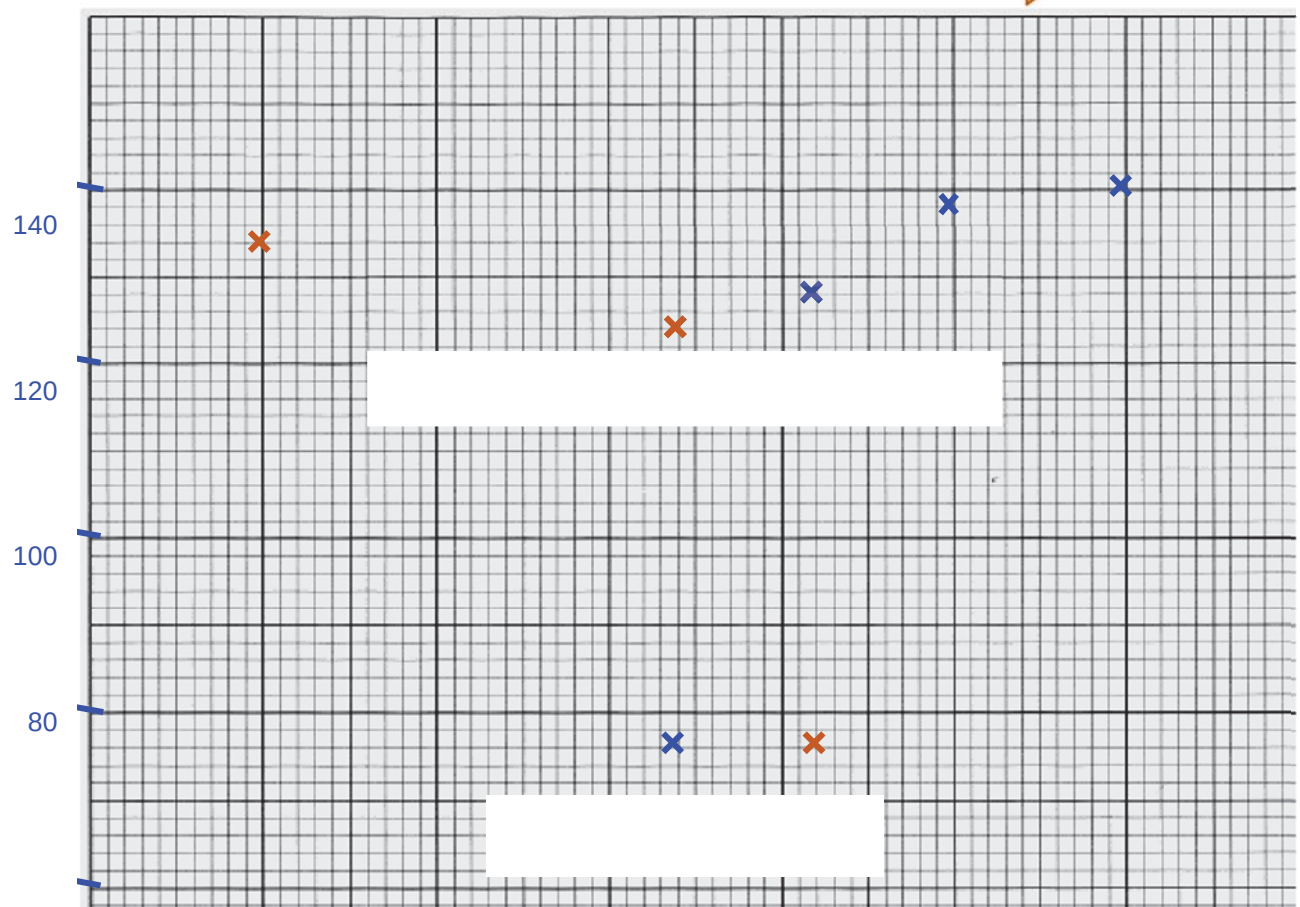
Mark Allocation
[1] - any change in pH / concentration of hydrogen ions, changes / affects ionic bonding / ionisation of (acidic / basic) amino acids
[1] - different amino acids / amino acid side chains, present in enzyme A and B
[1] – **3D structure / shape / conformation of active site** therefore **changes at different pH values** for enzymes A and B

[Total: 20]



Enzyme A

Enzyme B



3.0 4.0 5.0 6.0 7.0 8.0 9.0 **pH**

Mark Allocation

[1] – for **appropriate scale** used for **both axes**, with intervals clearly labelled
X-axis: 2 cm (or 10 squares) to 0.5 units interval; $\log_{10}$ 2.0 at origin
Y-axis: 2 cm to 1.0 units; 5.0 ms^{-1} at origin

[1] – for correct orientation of axes; with appropriate axes titles and units indicated
X-axis: **pH**
Y-axis: **area of jelly present after 90 minutes / mm^2**

[1] – for correct plotting of **all data points** (as small cross or dot in circle) $\pm$ half a square, for enzymes A and B

[1] – for data plots joined by **smooth lines of best fit,** both sets of data **distinguished by appropriate labels / key / legend**

CANDIDATE NAME		CLASS	2T

2 Stomata, in the epidermis of leaves, are responsible for the exchange of gases and the release of water vapour. A pair of guard cells controls the opening and closing of each stoma. In the guard cell membrane there is a transport protein. During the opening of the stomata, this protein uses energy from the hydrolysis of ATP to move protons (H^+) out of guard cells. This has two effects.

- Because protons are positively charged, their removal from the guard cells causes the interior of the cells to become negatively charged relative to the exterior. Because of this, some positive ions such as K^+ move into the interior of the cells lowering the water potential inside the cells.

- The pH inside the cell is increased.

You are provided with leaf samples that are soaking in the following solutions.
solution **X**: 0.1 mol dm^{-3} potassium chloride at pH 7.0
solution **Y**: 0.1 mol dm^{-3} sodium chloride at pH 7.0
solution **Z**: 0.1 mol dm^{-3} potassium chloride at pH 4.5

Proceed as follows:

1 Use a pair of forceps to remove the leaf from solution **X** and use scissors to cut out an area up to 1 cm × 1 cm. Transfer this to a slide ensuring **that the lower epidermis is uppermost**. Use a dropping pipette to add a drop or two of solution **X** to the leaf surface. Lower a cover slip over the leaf being careful to exclude any air bubbles.

2 Use the 10X objective of a microscope to locate the stomata. Count the **total** number of stomata that are visible and the total number that are fully **open** in the same field of view. Ignore any that you are doubtful about. Repeat this for another two areas of the leaf. Calculate the mean percentage of open stomata.

3 Repeat steps 1 and 2 for leaves from solutions **Y** and **Z** using clean slides and cover slips on each occasion. You **must** keep slide **Z** in order to answer **(b)** on page 11.

(a) **(i)** Record your results in an appropriate format in the space provided below.

Solution	Content	Sample / Area	Total Number of Stomata	Total Number of Open stomata	Mean Percentage of open stomata / %
X	0.1 mol dm^{-3} potassium chloride at pH 7.0	1			
		2			
		3			
Y	0.1 mol dm^{-3} sodium chloride at pH 7.0	1			
		2			
		3			
Z	0.1 mol dm^{-3} potassium chloride at pH 4.5	1			
		2			
		3			

[4]

Mark Allocation
[1] – results recorded in suitable table format with appropriate headings
[1] – results recorded for 3 samples / counts (total number and total open stomata) of each of X, Y and Z
[1] – correct calculation of mean % for open stomata
[1] – results show expected trend (more stomata open in X than in Y or Z)

(ii) Explain your results.

X .....
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Y .....
[2]

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[2]

Z .....
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[2]

Mark Allocation [Max 2 for each]

Results with most stomata open (X or Z)

1. (relatively) high concentration of, K^+ / potassium ions, outside cells; K^+ ions moves into guard cells, by facilitated diffusion - reduces water potential

2. water enters by osmosis (down water potential gradient), making (guard) cells turgid - opening stomata

Results in Y (with less opened stomata)

1. (relatively) high concentration of, Na^+ / sodium ions, outside cells but Na^+ enters guard cells slowly / Na^+ does not enter guard cells;

2. Less water enters by osmosis, making (guard) cells less turgid – less opened stomata

3. AVP; e.g. selective channels / channel proteins in guard cell membranes - more for K^+ ions than Na^+ ions; Na^+ ions acts as competitive inhibitor with K^+ for same channel proteins

Result in Z

1. (relatively) high concentration of, H^+ / hydrogen ions, outside cells; - slows down / prevents removal of, H^+ / hydrogen ions, from guard cells;

OR

2. low pH affecting ionic bonds between R groups of amino acids in enzymes - distorts conformation of active site / denaturation of enzyme

3. no $[H^+]$ gradient / respiration reduced; therefore less ATP available for active transport;

(iii) Guard cells, unlike other cells in the epidermis, have chloroplasts. These chloroplasts have grana but lack the enzymes necessary for the light-independent stage of photosynthesis (Calvin cycle).

With results to your results, suggest why guard cells have chloroplasts if they do not carry out the light-independent stage of photosynthesis.

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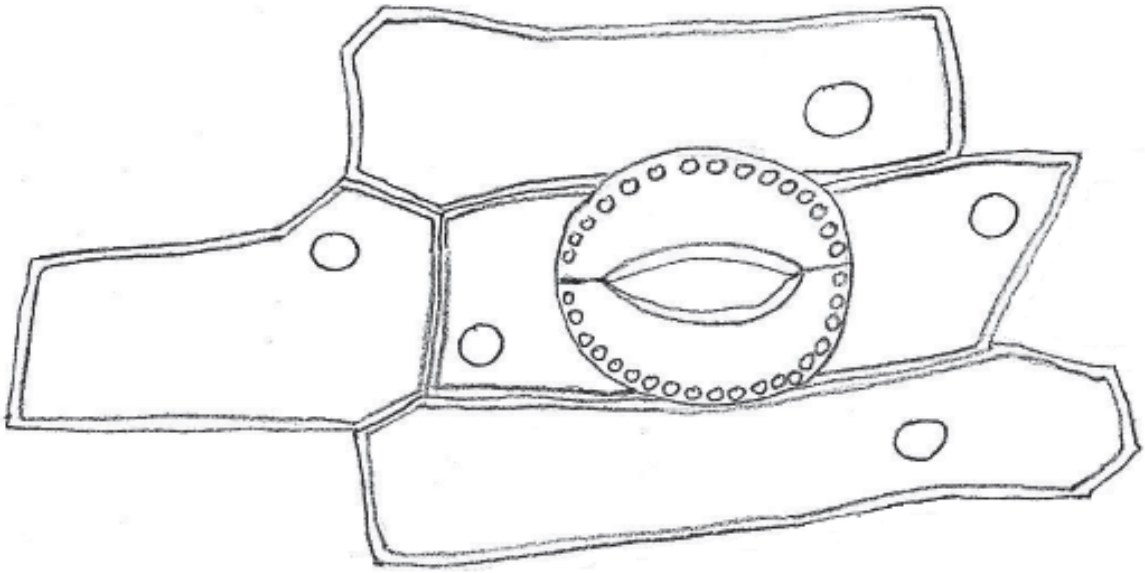
[2]

Mark Allocation

[1] – chloroplasts carry out light-dependent stage, producing ATP (by) photophosphorylation
[Reject: phosphorylation]

[1] – ATP hydrolysed to provides energy for removal of H^+ ions

(b) Make a **high power** drawing of two guard cells and the epidermal cells on either side of each guard cell from the leaf in solution **Z.**



[3]

Mark Allocation

[1] – clear continuous lines, not too faint/bold, not overlapping; cellulose walls as double lines

[1] – correct shape - of guard cells (*e.g. touching with rounded ends*); of epidermal cells (e.g. square or rectangular)

[1] – chloroplasts in guard cells and not in epidermal cells; guard cells have thicker inner wall

(c) Fig. 2.1 shows a diagram of a stage micrometer scale that is being used to calibrate an eyepiece graticule.

One division, on either the stage micrometer scale or the eyepiece graticule, is the distance between two adjacent lines.

The length of one division on this stage micrometer is **0.1 mm**.

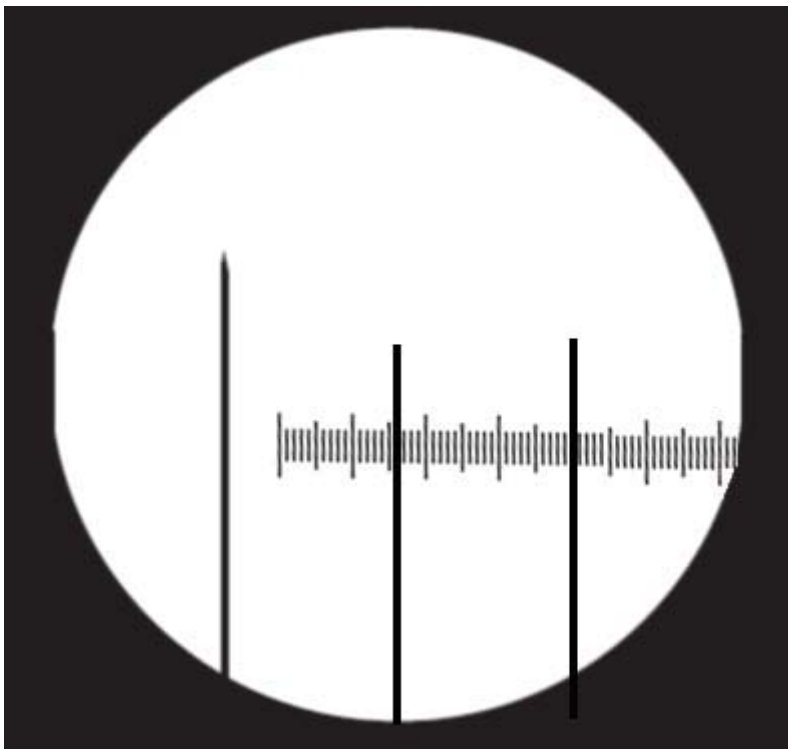


Fig. 2.1

(i) Using this stage micrometer, where one division is 0.1 mm, calculate the actual length of one eyepiece graticule divison, using Fig. 2.1.

Convert your answer to a measurement units most suitable for use in light microscopy. Show the steps and units in your calculation.

Number of eyepiece graticule divisions in 1 stage micrometer division = 24

Length of 1 stage micrometer division = 0.1 mm

Actual length of 1 eyepiece graticule division = 0.1 / 24 mm

= 0.1 / 24 X 10^3 µm

= 4 µm (or 4.1 µm)

[2]

Mark Allocation

[1] – correct calculation for 1 eyepiece graticule division, by dividing 0.1 mm by 24

[1] – correct conversion to µm, by multiplying by 1000, answer expressed to whole number AND with appropriate units

[Accept: Answer up to 1 dec. pl.]

Fig. 2.2 shows a photomicrograph of plant cells some of which have lost water by osmosis.

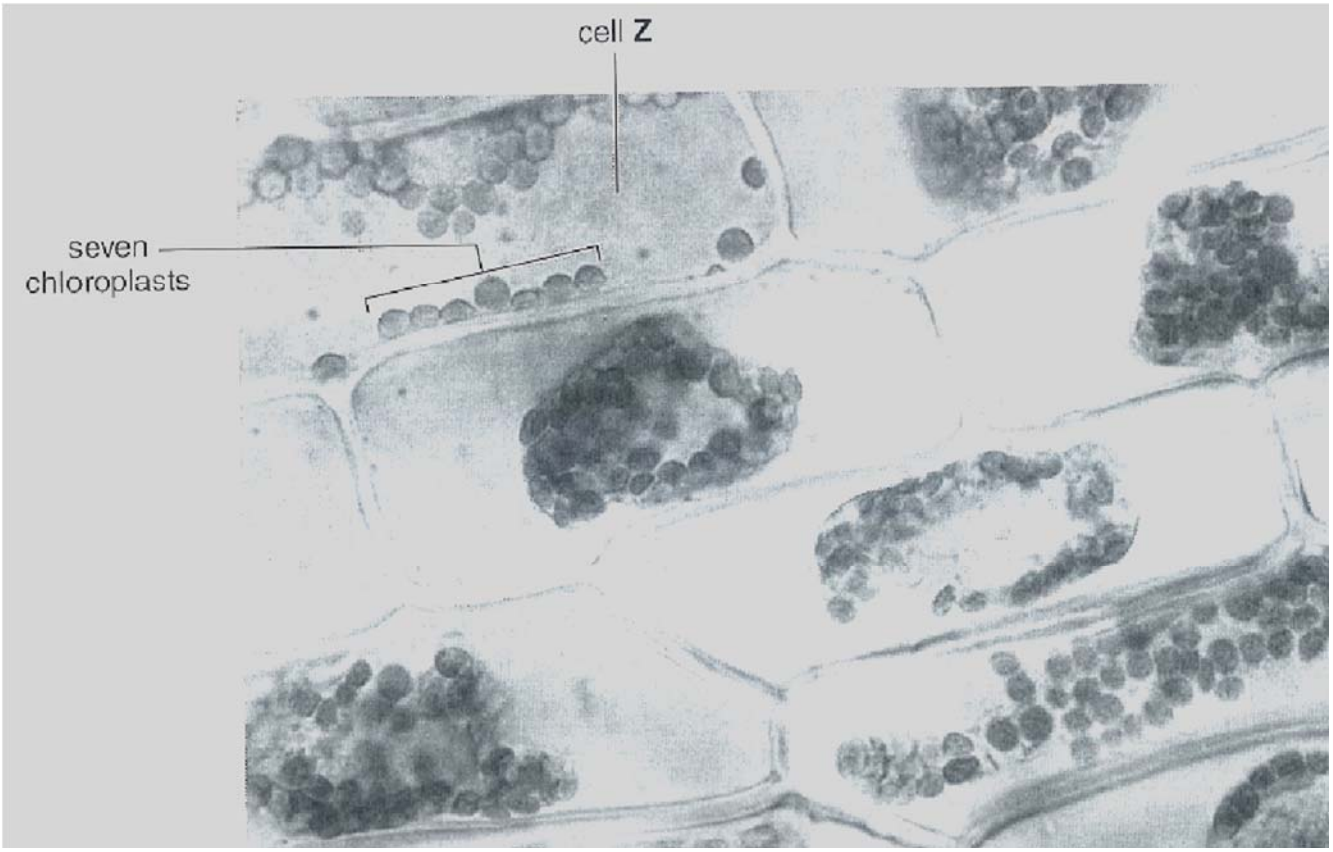


Fig 2.2

A student, using a prepared slide from which this photomicrograph was taken, measured the total length of the seven chloroplasts, labelled in **cell Z** in Fig 2.1.

Fig. 2.3 shows the view that the student saw when using the eyepiece graticule, calibrated in **c(i)** at the high-power of a microscope.

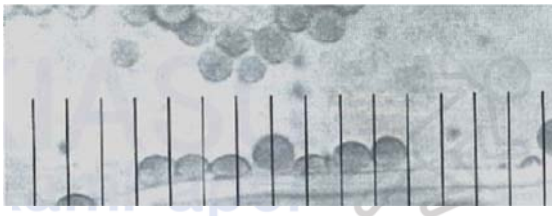


Fig 2.3

(ii) Using this and the information in **c(i),** calculate the actual mean length of one chloroplast as shown in Fig 2.3.

Show the steps and units in your calculation.

Total length of 7 chloroplasts = 8 X 4 µm (or 8 X 4.1 µm)

Actual mean length of 1 chloroplast = (8 X 4) / 7 µm (or (8 X 4.1) / 7 µm)

= 5 µm (or 4.6 µm)

actual mean length of one chloroplast ...**5 µm**....(or **4.6 µm**)..... [2]

Mark Allocation

[1] – expressing the total length of 7 chloroplasts: using answer in **c(i)** multiplied by 8 (eyepiece graticule divisions)

[1] – correct calculation for mean length of one chloroplast, by dividing total length (of 7 chloroplasts) by 7, expressing answer correct to whole number AND with appropriate units
[Accept: Answer up to 1 dec. pl.]

(d) Fig. 2.4 and Fig. 2.5 are photomicrographs of the lower surface of the leaf from two different plants, with the same field of view, using the same objective lens.

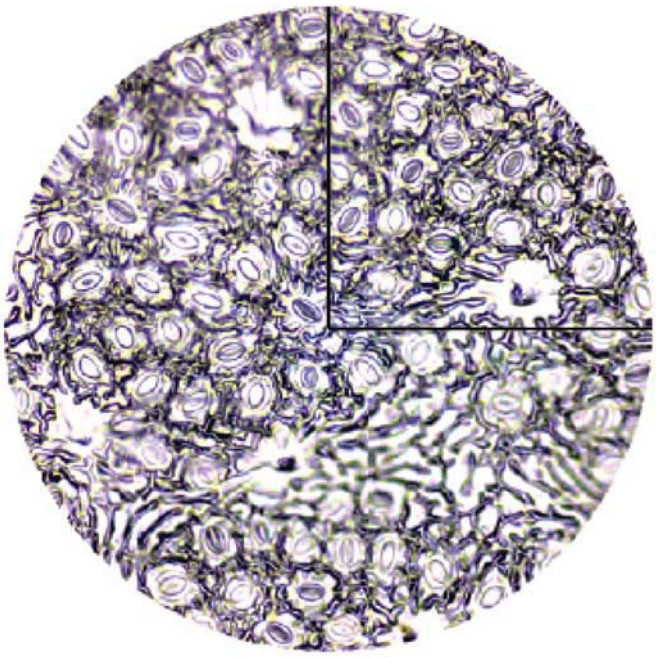


Fig. 2.4

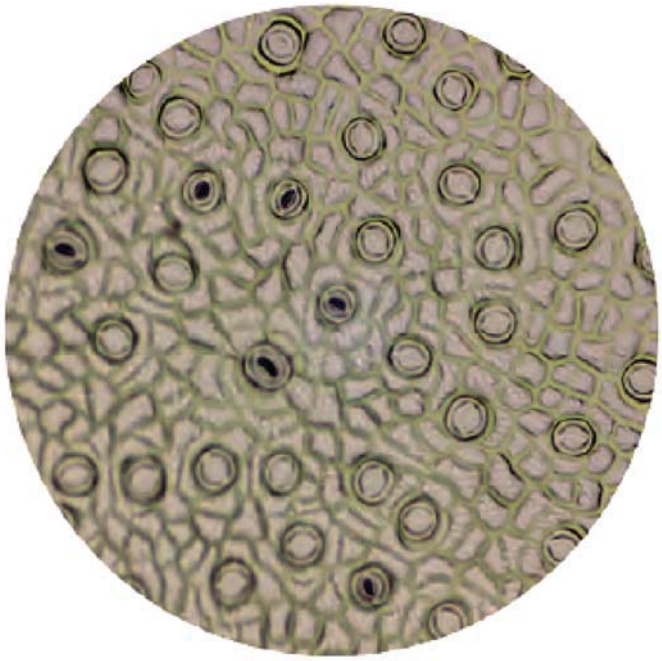


Fig. 2.5

Complete the table below to record 2 observable differences between the surface of each leaf shown in Fig. 2.4 and Fig. 2.5.

Feature	Fig. 2.4	Fig. 2.5

[2]

[Total: 21]

Mark Allocation

Any **TWO** of the following:

Marking Point	**Feature**	**Fig. 2.4**	**Fig. 2.5**
1	Number of stomata	More (or an example of a number) closer packed / nearer each other / gap between stomata narrower / more clustered	Few(er) (or an example of a number)
2	Size of stomata / epidermal cells / guard cells	Small(er)	Large(r)
3	shape of stomata / guard cell	Oval or slit or elongated	Round(er) or circular or more curved
4	Appearance of stomata	More closed or fewer open	Less closed or more open
5	Shape of epidermal cell or pattern of lines	Very irregular or not clear Folded	Clear or anular or corners; Smoother
6	Thickness of epidermal cell walls	Thin(ner)	Thick(er)

CANDIDATE NAME		CLASS	2T

3 The enzyme urease is a catalyst of the hydrolysis of urea in solution, forming ammonia and carbon dioxide, for example in the breakdown of urea in soils by microorganisms.

You are required to plan an investigation to compare the activity of urease free in solution and urease immobilised in alginate beads.

As the reaction proceeds, the ammonia released dissolves, causing the pH to increase.

You are provided with the following equipment which you may use or not in your plan, as you wish. You may **not** use any additional equipment in your plan.

- an unlimited supply of calcium alginate beads, all of uniform size, prepared with a 50 g dm^{-3} urease solution (you may call this immobilised urease)
- an unlimited volume of 50 g dm^{-3} urease solution (you may call this free urease)
- an unlimited volume of 1.0 mol dm^{-3} urea solution
- an unlimited volume of distilled water
- beakers and flasks of different sizes
- stopwatch
- broad and narrow range of pH papers and liquids with appropriate colour charts, pH probes and meters
- colorimeter and tubes/cuvettes
- thermometer
- thermostatically-controlled water baths
- graduated pipettes and pipette fillers
- filter funnels
- syringes
- glass rods for stirring
- test-tubes and boiling tubes
- test-tube racks

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- include a clear statement of the hypothesis or prediction
- identify the independent and dependent variables
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- describe the method with details and explanations of the procedures that you would adopt to ensure that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment

[Total: 14]

ANS [L3]

Step 1: Outline structure and set priority [which to be done first #1….]

Awful	**H.I.V.**			**are**	**probably**	**still**	**residing**	**inside**
[AIM]	[Hypothesis/Introduction/Variables] [Insights/conclusn]			[Apparatus]	[Procedure]	[Safety]	[Results]	
#1	#2	#3	#4	#10	#5 Control #9 Procedure	#8	#6 Graph #7 Table	#11

*The above strategy saves time as ensures all essential parts of Planning are covered.

#1 AIM / HYPOTHESIS [MAX 1][Total 1]

1 1a] Rate of hydrolysis is faster using free enzyme

1b] quantity of urea hydrolysed over time is greater with free enzyme

1c] immobilised urease catalyses reaction over much longer period of time

#2#3 Introduction / Theory to support hypothesis [MAX 1][Total 2]

2 Reference to enzyme active site refs to accessible active sites

diffusion of substrate into alginate beads

stability of enzyme in alginate beads

#4 Variable [MAX 2][Total 4]

3. Independent Variable

3a] Concentration of Urase [Free]

3b] Concentration of Urase [immobilized]/[Alginate]

4. Dependent Variable

4a] pH as a measure of ammonium carbonate [or outline in procedure]

5. At least two control variables : [any 2]

5a] temperature,

5b] concentration of urea solution.

5c] volumes used.

3d] number of beads

#10 Apparatus [nil]

cite apparatus

Procedure Control [Max 1][Total 5]

#5 **6.** Negative control: denatured Urase

#9 Procedure Protocol [Max 3][Total 8]

7. method of following the reaction taking samples at intervals and calculating the initial rate

8. Justification/evaluation. of strategy ; e.g. can only alter concentration of immobilised enzyme by changing number of beads /limitations of colour comparison these could be awarded at the end of the plan

9. Method of determining. pH / (the concentration) of ammonium carbonate, at intervals ; e.g. use of pH indicator, to follow colour change

10. use range of concentrations of urea [Colour standard];

11. use range of concentrations of urease ; to find suitable concentrations to make comparison [at least 5 concentrations]

12. dilution table(s) included ;

13. method to ensure concentration of urease in reaction mixtures is the same for both free and immobilised enzyme ;

14. urea solution mixed with pH indicator ;

15. equilibration in water bath ;

16. mixing. urease/beads. and urea solution at time = 0 ;

17. staggered start ;

18. samples taken at stated intervals ;

19. repeats/replicates (calculate average in table)

#8 Safety [Max 1][Total 9]

20. ref to hazards and precautions [*may be taken from a diagram or a flow or sequence diagram]*

10a] Reagents (irritants) use of Gloves
10b] Glassware fragile handle with care

#6 Results Graph [Max 2][Total 11]

21. Line of best fit : plot results on appropriate graph (bar or line) ;

22. takes gradient to give rate of each Urase [Free / Immobilized];

#7 Results Table [Max 2][Total 13]

23. Headings with Units / no units in table / data present

24. Replicates / repeats

25. Time taken (t) to reach colour standard recorded ;

26. rate = 1/t ; A 1000/t. etc.

27. colour standard set up at known pH ;

28. colour change followed in colorimeter ;

#11 Conclusion [Max 1][Total 14]

29. calculate, standard deviation/standard error ;

30. ref to use of t-test to see if rates are significantly different ;

31. uncertainty/precision. of results ;

[Max 14]