ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2017

BIOLOGY **9744/01**

HIGHER 2 **25 August 2017**

Paper 1 Multiple Choice **1 hour**

Additional Material: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, pencil clips, highlighters, glue or correction fluid.
Write your name, centre number and index number on the Answer Sheet provided.

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

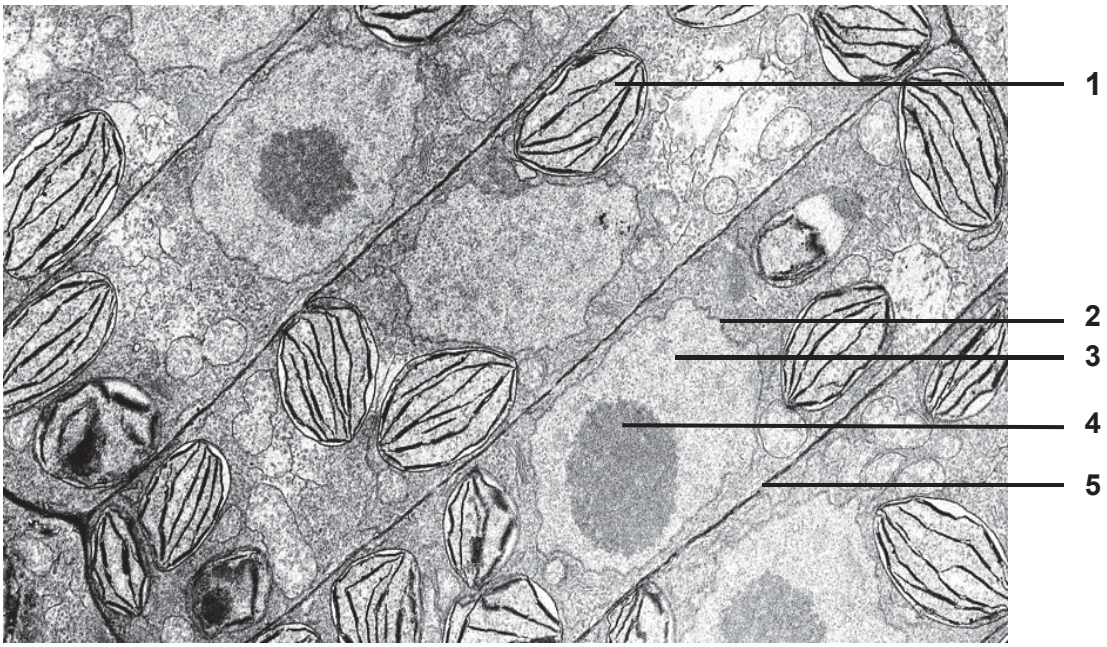
Read the instructions on the Answer Sheet very carefully.

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.

Calculators may be used.

This question paper consists of **23** printed pages.

1 The electron micrograph shows root cells from the duckweed plant.



Which of the following options about structures 1 to 5 is correct?

	Contain ribosomal subunits	Contain tRNA	Contain phospholipids
A	1, 2, 3	3 only	1, 4
B	1, 3, 4	1, 3	2, 5
C	1, 3, 5	1, 2, 4	2, 4, 5
D	2, 4, 5	2, 4, 5	1, 3, 4, 5

2 Plants are able to regulate their thylakoid membrane fluidity at different seasons of the year. In an investigation on thylakoid membrane fluidity in spinach leaves, three variables which influence membrane fluidity were measured at winter and summer.

Variable	Season X	Season Y
Percentage of saturated fatty acids	15.5	13.9
Average number of double carbon bonds per lipid	4.71	4.76
Lipid to chlorophyll ratio	2.9	2.1

Which of the following correctly identifies season X, with the most possible explanation?

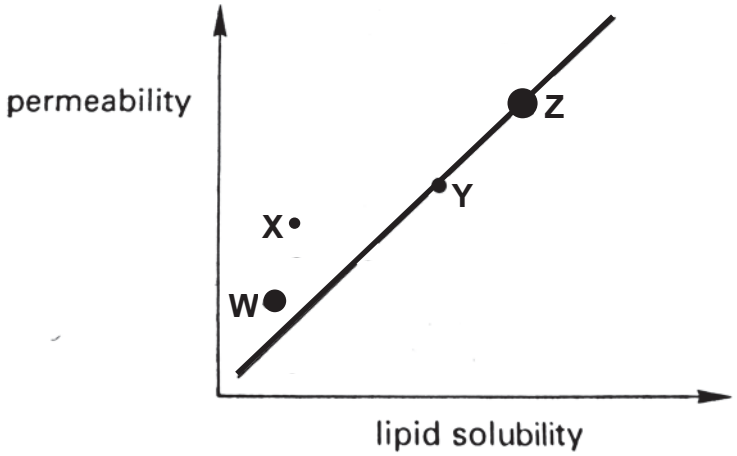
A Winter; a higher lipid to chlorophyll ratio increases proportion of weak hydrophobic interactions resulting in a more fluid membrane at lower temperatures

B Summer; a higher proportion of saturated fatty acids prevents phospholipids from moving too far apart at higher temperatures

C Winter; a higher proportion of saturated fatty acids prevents phospholipids from packing too closely at lower temperatures

D Summer; a higher number of kinks per lipid allows phospholipids to pack closely together at higher temperatures

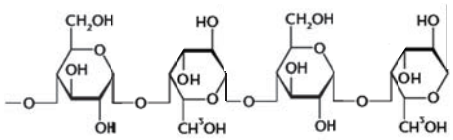
3 The diagram shows the relationship between the size, lipid solubility and ability of molecules to cross the mammalian cell surface membrane. The diameter of the black circles in the diagram is proportional to the size of the molecules.

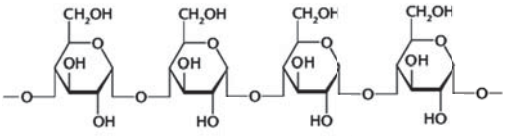


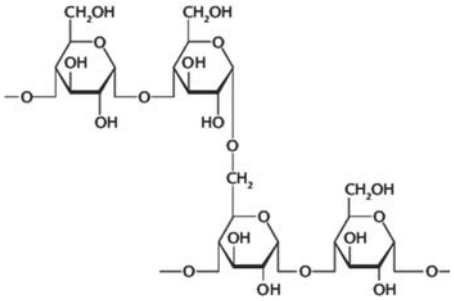
Which of the following could molecules W to Z represent?

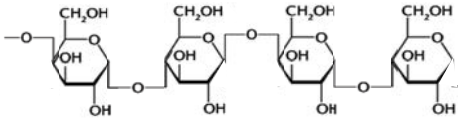
	W	X	Y	Z
A	calcium chloride	methane	cholesterol	glucose
B	glucose	water	carbon dioxide	cholesterol
C	calcium chloride	water	glucose	cholesterol
D	glucose	methane	carbon dioxide	calcium chloride

4 Dextrins are a group of carbohydrates with low molecular weight, and are produced by hydrolysing starch or glycogen. Which of the following is/are **not** likely to be a segment from a dextrin molecule?

1 

2 

3 

4 

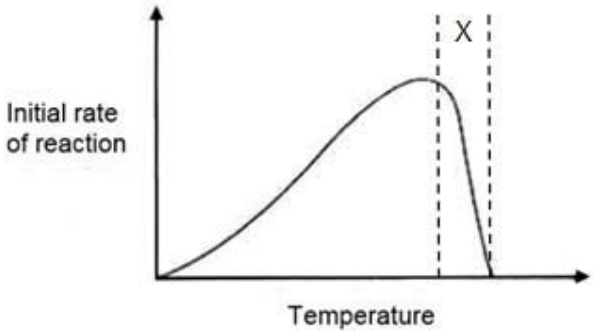
A 1, 3 and 4 only

B 1 and 4 only

C 2 and 3 only

D 4 only

5 The diagram below shows the initial rate of reaction at different temperatures, using constant substrate and enzyme concentrations.



Which of the following is/are possible reason(s) for the decline shown in region X?

1 End product inhibition occurs to inhibit enzyme activity
2 Depletion of substrate at the end of the enzyme catalysed reaction
3 Disruption of intramolecular bonds in the enzyme
4 Change in ionic charges at the active site of the enzyme

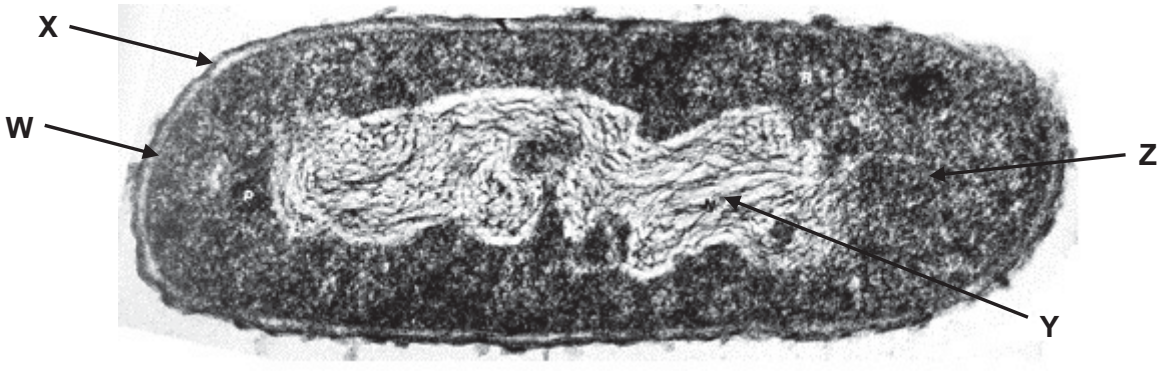
A 1, 2, 3 and 4

B 1 and 2 only

C 3 and 4 only

D 3 only

6 The diagram shows an electron micrograph of a bacterial cell.



Which of the following correctly identifies the functions of structures W, X, Y and Z?

	W	X	Y	Z
A	Maintains shape of bacterial cell	Protects bacterial cell against desiccation	Contains antibiotic resistance genes which may be beneficial to the bacterial cell	Serves as the site of protein synthesis
B	Controls the passage of substances into and out of the cell	Maintains shape of bacterial cell	Contains genetic information which is essential to the survival of bacterial cell	Serves as the site of translation of mRNA
C	Controls the passage of substances into and out of the cell	Maintains shape of bacterial cell	Contains antibiotic resistance genes which may be beneficial to the bacterial cell	Protects bacterial cell against desiccation
D	Protects bacterial cell against desiccation	Protects bacterial cell from the action of phagocytes	Contains genetic information which is essential to the survival of bacterial cell	Maintains shape of bacterial cell

7 The diagram below shows the enterobacteria phage P22 which is a bacteriophage that infects the bacterium *Salmonella typhimurium*. The genetic material and replication cycle of P22 are similar to the lambda phage.

Which of the following statements can be inferred?

A It is a virulent phage which contains double-stranded RNA and undergoes the lytic cycle.

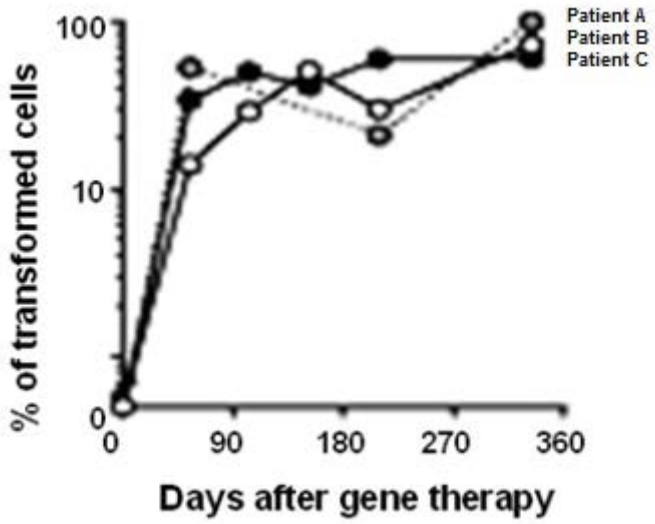
B It has a spherical envelope that is obtained when the phage buds from the host cell.

C It forms a prophage, which is replicated and passed to the daughter bacterial cells during cell division.

D It has tail fibres which allow the phage to attach to various species of host bacteria.

8 Gene therapy is a technique for correcting defective genes responsible for disease development. It involves introducing a copy of a normal functional gene into target cells with non-functional genes. A vector is a vehicle usually required to deliver the functional allele into the patient's target cells.

Gene therapy was conducted on three patients to treat a neurological disease. The percentage of transformed stem cells introduced into their brains was monitored over a period of 360 days after the gene therapy. However, there was no improvement in their neurological condition.



Which of the following would be the most appropriate investigation to carry out in view of the unsuccessful clinical trial?

A Regulation of neurone-specific genes in transformed stem cells

B Effectiveness of vector to deliver the gene into stem cells

C Modification of stem cells to reduce immune reaction to transformed stem cells

D Activation of telomerase gene in transformed stem cells

9 Many of the most effective antibiotics used in modern medicine are compounds made by fungi that inhibit bacterial protein synthesis. Among the most commonly used drugs are Chloramphenicol, Cycloheximide and Rifampicin. The results of the exposure to eukaryotic and prokaryotic cells to the above three drugs are shown.

Anti-microbial drug	Chloramphenicol	Cycloheximide	Rifampicin
Eukaryotic Animal Cell	Truncated polypeptides were found in mitochondria only	Truncated polypeptides were found in cytosol	No protein synthesized
Prokaryotic Cell	Truncated polypeptides were found in the cytosol	Truncated polypeptides were found in the cytosol	No protein synthesized

Which of the following shows the correct combination of the possible drug mechanisms of the above drugs?

	Chloramphenicol	Cycloheximide	Rifampicin
A	Inhibits the peptidyl transferase activity of the 70S ribosomes	Inhibits elongation by binding the E site of the ribosome hence preventing the release of tRNA	Inhibits the transcription of DNA by blocking the movement of RNA polymerase on DNA
B	Inhibits the peptidyl transferase activity of the 80S ribosomes	Inhibits elongation by binding the E site of the ribosome hence preventing the release of tRNA	Inhibits the transcription of DNA by blocking the movement of RNA polymerase on DNA
C	Inhibits elongation by binding the P site of the ribosome hence preventing the formation of peptidyl tRNA	Inhibits elongation by binding the A site of the ribosome hence preventing the release of tRNA	Inhibits translation by binding to the small ribosomal subunit
D	Inhibits elongation by binding to mRNA and preventing ribosomal translocation	Inhibits elongation by binding the P site of the ribosome hence preventing the release of polypeptide	Inhibits translation by binding to the binding site of large ribosomal subunit

10 The list shows the stages in the cellular replication of DNA.

1 Formation of phosphodiester bonds between Okazaki fragments
2 Dissociation of DNA from histone proteins
3 Synthesis of RNA primers
4 Addition of deoxyribonucleotides
5 Separation of DNA double helix

Which is the correct sequence?

A 5 → 4 → 3 → 1 → 2

B 2 → 5 → 4 → 3 → 1

C 5 → 2 → 3 → 1 → 4

D 2 → 5 → 3 → 4 → 1

11 Proteins X and Y play a role in regulating gene expression.

Protein X forms a complex with GTP and mediates the binding of methionyl aminoacyl-tRNA to the small ribosomal subunit which then binds to the 5' end of mRNA and scans for the first AUG codon. When an AUG codon is recognised, protein X hydrolyses bound GTP to GDP and it is released from the small ribosomal subunit. A complete ribosome then forms and protein synthesis begins.

Protein Y is required to cause GDP release from protein X so that it can be reused. The reuse of protein X is inhibited when it is phosphorylated because phosphorylated X binds to protein Y tightly and inactivates protein Y.

Which of the following statements can be concluded?

1 Proteins X and Y control gene expression by regulating translational control.
2 Protein X is a translational initiation factor that has catalytic activity.
3 Inactivation of protein Y will inhibit translation.
4 Active protein kinases will decrease overall protein synthesis.

A 1, 2, 3 and 4

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

12 Which of the following correctly matches the state of the *lac* operon to the presence/absence of the molecule(s)?

	State of *lac* operon	Glucose	Lactose	cAMP
1	On	Present	Present	Absent
2	On	Absent	Present	Absent
3	Off	Present	Absent	Absent
4	On	Absent	Present	Present

A 1, 2, 3 and 4

B 1, 3 and 4 only

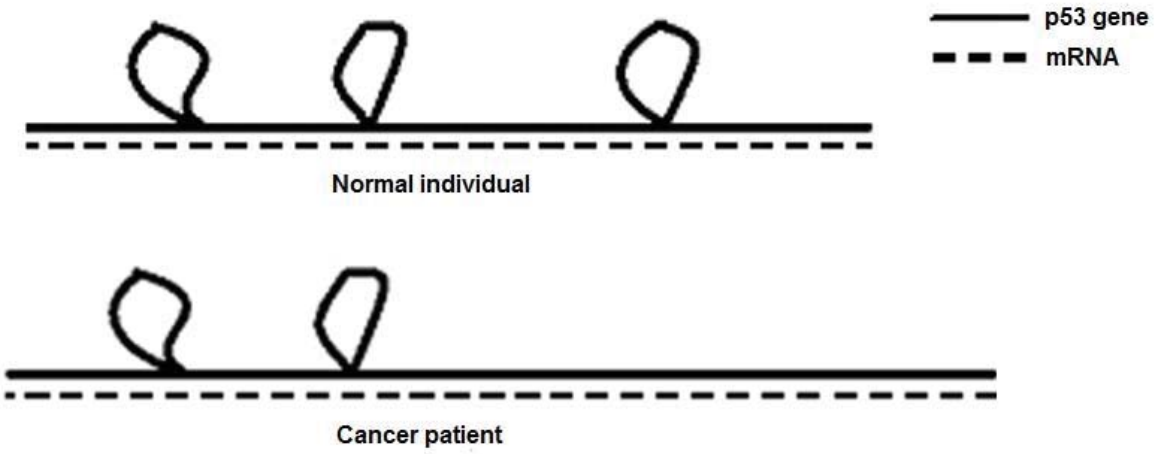
C 1 and 2 only

D 2 and 3 only

13 Which of the following correctly matches the step involved in Southern blotting to its purpose?

	Step	Purpose
A	Transferring DNA fragments from a gel to a nitrocellulose paper with the use of alkaline solution	To permanently attach the DNA fragments to a surface and to separate the two complementary DNA strands
B	Adding a radioactive probe	To bind to all DNA fragments for visualisation of the DNA bands
C	Adding restriction enzymes	To digest each DNA sample into fragments of similar lengths
D	Electrophoresis	To separate DNA fragments based on the amount of negative charges the fragment has

14 mRNA was isolated from a normal individual and a patient suffering from cancer. The mRNA was allowed to hybridise with the *p53* gene. The schematic diagram shows the results of the hybridisation process under the electron microscope.



Which of the following could be a possible explanation why the patient is suffering from cancer?

A A point mutation had occurred in the intron leading to the failure to excise one intron, hence leading to a longer dysfunctional protein being translated.

B A point mutation had occurred in the intron leading to an exon being excised, hence leading to a shorter dysfunctional protein being translated.

C A point mutation had occurred leading to the failure of spliceosome to recognise splice sites leading to the excision of the wrong intron, leading to a dysfunctional protein being translated.

D Gene amplification had occurred leading to the multiple copies of a trinucleotide repeat in an intron, hence causing splice site to be misread due to frameshift mutation, leading to a longer dysfunctional protein being translated.

15 A cell, in the midst of actively dividing cells in a *lilium* root tip, was found to be arrested in its cell cycle with an intact nucleus. Which of the following is/are the likely cause(s)?

1 Damaged DNA or incomplete replication of DNA.
2 Homologous chromosomes are unable to pair up.
3 Incomplete formation of the mitotic spindle resulting in some chromosomes not attached to fibres.
4 Centrioles fail to replicate.

A 2, 3 and 4 only

B 1, 2 and 3 only

C 1 and 2 only

D 1 only

16 Which of the following mutations would increase the probability of getting cancer in an individual?

1 Gain-of-function mutation in a copy of the p53 gene.
2 Somatic mutation in the second copy of the p53 gene.
3 Deletion of a single nucleotide at the third position in a copy of the Ras gene.
4 Gene amplification of the Ras gene, leading to multiple copies of the gene.

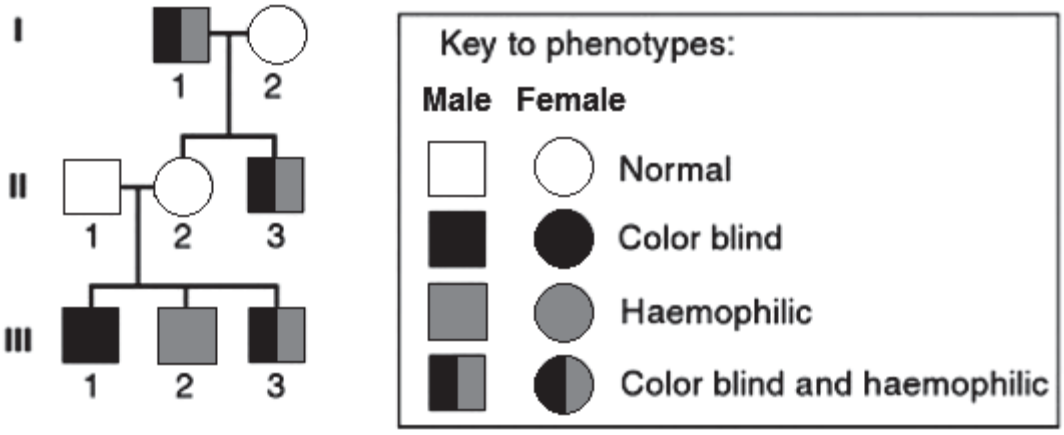
A 1, 2, 3 and 4

B 2, 3 and 4 only

C 1 and 3 only

D 2 and 4 only

17 Haemophilia and red-green colour blindness are both sex-linked genetic disorders caused by recessive alleles. The following pedigree chart shows a family's history of the two disorders.



Assuming that the alleles for haemophilia and colour blindness were found on the same chromosome in generation I, which of the following individuals' phenotype is a result of recombination between the haemophilia and colour blindness genes?

A II-3 and III-1

B II-3 and III-3

C III-1 and III-2

D III-2 and III-3

18 Three different medical therapies have been used for the treatment of influenza infection. Each therapeutic agent targets a different stage of the viral replicative cycle. The effects of each therapy is described as follows.

Therapeutic agent	Effects
Ribavirin	Competitive inhibitor which is structurally similar to a nucleoside
Peramivir	Inhibitor of viral neuraminidase
Seasonal flu vaccine	Artificially induces active immunity

Which of the following correctly arranges the therapies in order of the stages of the replicative cycle they exert their effects, sorted in order of the earlier stages to the later stages?

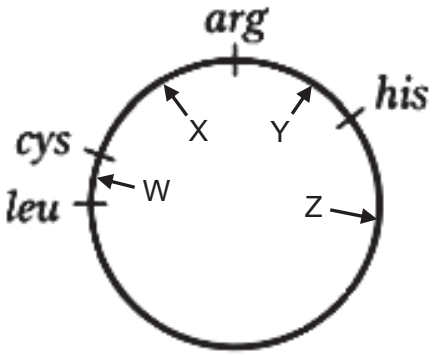
A Peramivir, ribavirin, seasonal flu vaccine

B Ribavirin, peramivir, seasonal flu vaccine

C Ribavirin, seasonal flu vaccine, peramivir

D Seasonal flu vaccine, ribavirin, peramivir

19 *Salmonella typhi* bacteria is known to be a viable host for a newly discovered temperate phage, but the site of prophage integration is unknown. The following gene map shows the loci of four genes on the *S. typhi* chromosome – *arg*, *his*, *leu* and *cys* – responsible for the biosynthesis of four essential amino acids. Four possible prophage integration sites, W, X, Y, Z are indicated.



The phages are allowed to replicate using a strain of *S. typhi* capable of synthesising all four amino acids (arg^+ his^+ leu^+ cys^+), and the replicated phages are then added to a mutant strain of *S. typhi* of genotype arg^- his^- leu^- cys^-.

After a short incubation, samples of these bacteria are plated on four different media supplemented with different amino acids. The following table shows whether colonies were observed on the various media (+ indicates the presence of an amino acid in the medium while – indicates its absence).

Medium	Supplementation of amino acids in medium				Presence of colonies
	Arg	His	Leu	Cys	
1	–	+	+	+	No
2	+	–	+	+	No
3	+	+	–	+	Yes
4	+	+	+	–	Yes

Which of the following is the most likely prophage integration site?

A Site W

B Site X

C Site Y

D Site Z

20 Which of the following statements explains the mechanism for chemiosmosis in the synthesis of ATP?

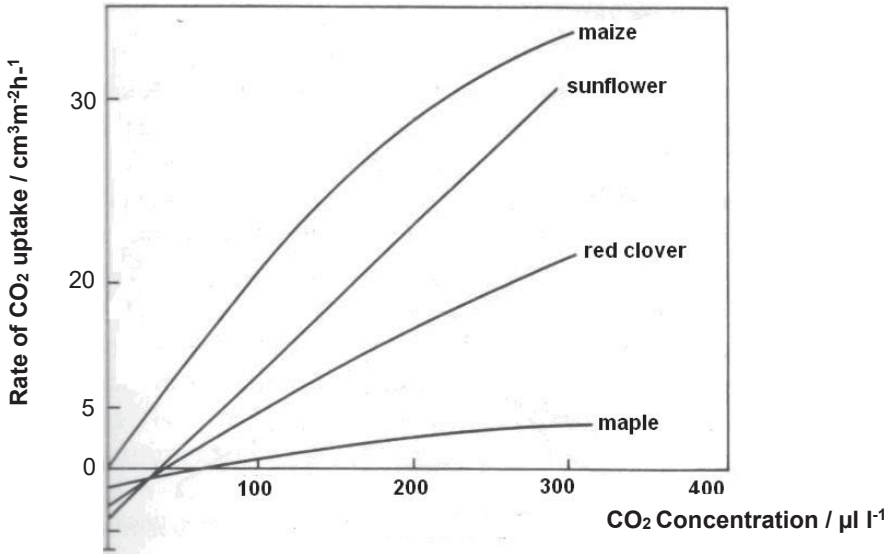
A The energy released by the reduction and subsequent oxidation of components of the electron transport chain is transferred to ATP synthase for the synthesis of ATP.

B Phosphorylation of ADP is linked to the proton gradient established by the electron transport chain.

C The difference in pH between the intermembrane space and the cytosol drives the formation of ATP.

D The flow of H^+ through ATP synthase into the intermembrane space drives the synthesis of ATP.

21 The diagram below shows the rate of photosynthesis of four different plants at different concentrations of carbon dioxide.



Which of the following conclusions can be made?

1 At CO_2 concentrations below 150 µl l^{-1}, CO_2 concentration is the main limiting factor for all the plants.
2 CO_2 compensation point is around 40 µl l^{-1} for sunflower and red clover, and it measures the light intensity when the rate of CO_2 uptake equals to the rate of CO_2 given off.
3 Rate of CO_2 uptake was zero for maize at CO_2 concentration of 0 µl l^{-1} as the amount of CO_2 released from respiration is used for photosynthesis.
4 Of the four plants, maple has the lowest amount of organic compound produced at CO_2 concentration of 200 µl l^{-1}.

A 1, 2 and 3 only

B 1, 3 and 4 only

C 1 and 2 only

D 3 and 4 only

22 Dinitrophenol is a metabolic poison that can lodge within the thylakoid membranes of chloroplasts. It then provides an alternative route for H^+ ions to diffuse across the thylakoid membranes. In what way will the Calvin cycle be affected in chloroplasts poisoned by dinitrophenol?

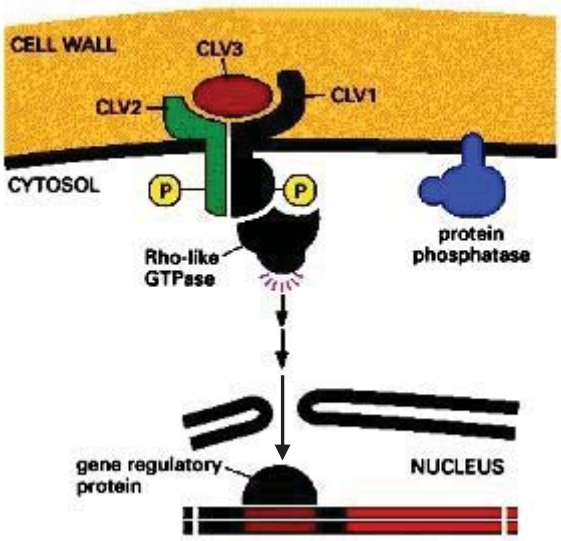
A No change in rate as Calvin cycle occurs in the stroma and not at thylakoid membranes.

B The rate of Calvin cycle will increase as pH in the stroma will decrease towards the optimum for enzymes involved in the cycle.

C The rate of Calvin cycle will decrease with the accumulation of glycerate-3-phosphate.

D The rate of Calvin cycle will decrease with the accumulation of glyceraldehyde-3-phosphate.

23 The diagram below shows a cell signalling pathway involved in plant cells.



Which of the following sequences regarding the activation of the above signaling pathway is correct?

A Dimerization of CLV1 and CLV2 leads to the binding of CLV3 which in turns causes phosphatase to phosphorylate the residues in the cytoplasmic tails, causing the activation of Rho-like GTPase that brings about transcription.

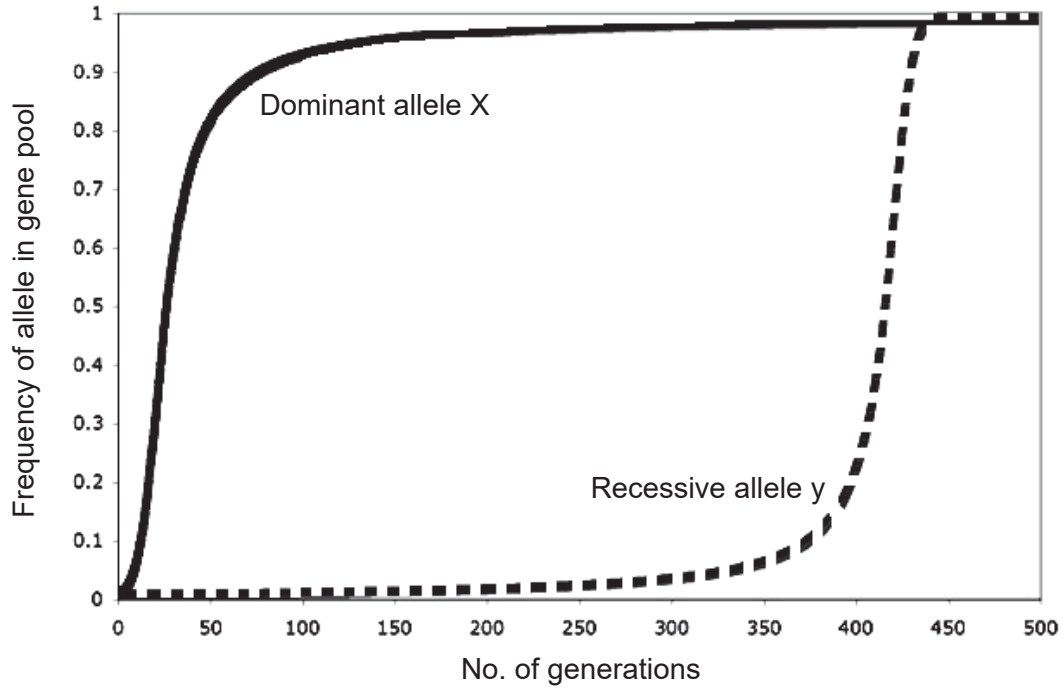
B Dimerization of CLV1 and CLV2 leads to activation of CLV3 that causes autophosphorylation of the residues in the cytoplasmic tails which in turn activate Rho-like GTPase that results in DNA replication.

C Binding of CLV3 to both CLV1 and CLV2 causes dimerization that leads to autophosphorylation of the residues in the cytoplasmic tails resulting in activation of phosphatase enzyme which in turn phosphorylates proteins needed for protein synthesis.

D Binding of CLV3 to both CLV1 and CLV2 causes dimerization that brings about autophosphorylation of the residues in the cytoplasmic tails which in turn activates Rho-like GTPase that results in transcription.

24 The mechanisms of natural selection leads to changes in the frequency of alleles in the gene pool of a population over many generations. When a new allele arises due to mutation, the trait coded for by the new allele may be selected for if it confers a selective advantage. The rate at which this new allele approaches fixation – the condition where the allele is found in all individuals of a population – depends on whether it acts in a dominant or recessive manner.

The following graph shows how a dominant allele of gene X (allele X) approaches fixation over time as compared to a recessive allele of another gene Y (allele y). Both alleles confer advantageous traits to the host organism.



Which of the following explains the differences in rate at which the two types of alleles approach fixation?

A The initial increase in frequency of the recessive allele y is slower as heterozygotes have a selective advantage over homozygotes.

B The initial increase in frequency of the dominant allele X is faster as the effects of the allele is expressed in the phenotype of heterozygotes.

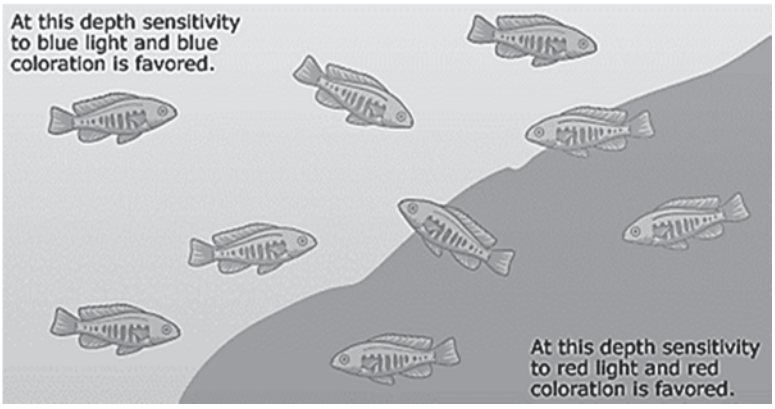
C Fixation of the dominant allele X takes a greater number of generations due to the mechanisms of genetic drift.

D Fixation of the recessive allele y takes a smaller number of generations due to mechanisms which preserve heterozygosity in a population.

25 The cichlid family of fishes living in Africa's Lake Victoria have undergone extensive adaptive radiation. In the cloudy waters of Lake Victoria, the shallow parts of the lake are dominated by blue light. The depths of the lake, however, are dominated by red light due to the absorption by sediment particles. Cichlids with colour vision sensitive to blue light prefer to dwell in shallow waters of the lake, while cichlids with colour vision sensitive to red light dwell in the deeper waters. Light sensitivity is thought to correlate with the cichlid's ability to survive.

Male cichlids also display a wide variation of body coloration. Males with blue body coloration appear brighter in the shallow waters and have greater reproductive success there, while males with red body coloration appear brighter in the deeper waters and experience greater reproductive success at these depths.

The following figure summarises the observations made about these cichlids.



How many of the following statements regarding the speciation process of cichlids is true?

1 Disruptive selection has occurred due to variations in light sensitivity in cichlids.
2 Speciation is driven by preferential mate selection by female cichlids.
3 Allopatric speciation due to geographical isolation has taken place.
4 The mechanisms for reproductive isolation in these cichlids are pre-zygotic.

A 1

B 2

C 3

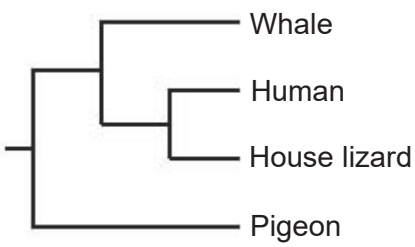
D 4

26 The phylogenetic relationship of four different species – human, whale, pigeon and the house lizard – was investigated. Part of the amino acid sequence for the cytochrome c protein found in the different species was analysed and is shown in the following table (the letters denote different amino acids).

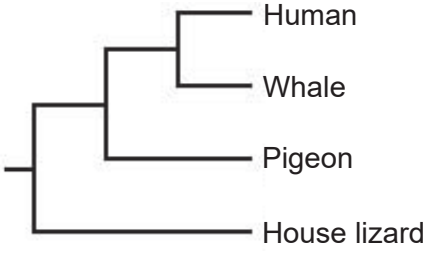
Species	Amino acid sequence of cytochrome c
Human	I F V G I K K K E E R A D L I A Y L K K A T N E
Whale	I F A G I K K K G E R A D L I A Y L K K A T N E
Pigeon	I F A G I K K K A E R A D L I A Y L K Q A T A K
House Lizard	I F A G I K K K A E R A D L I A Y L K D A T S K

Which of the following phylogeny of these four species agrees with the available evidence?

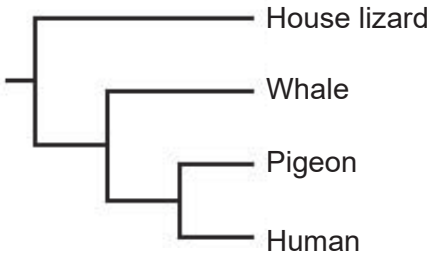
A



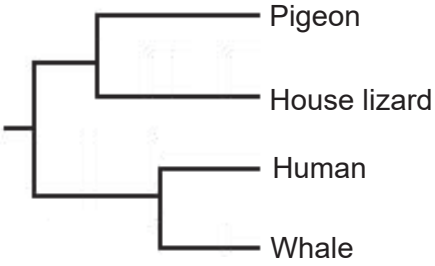
B



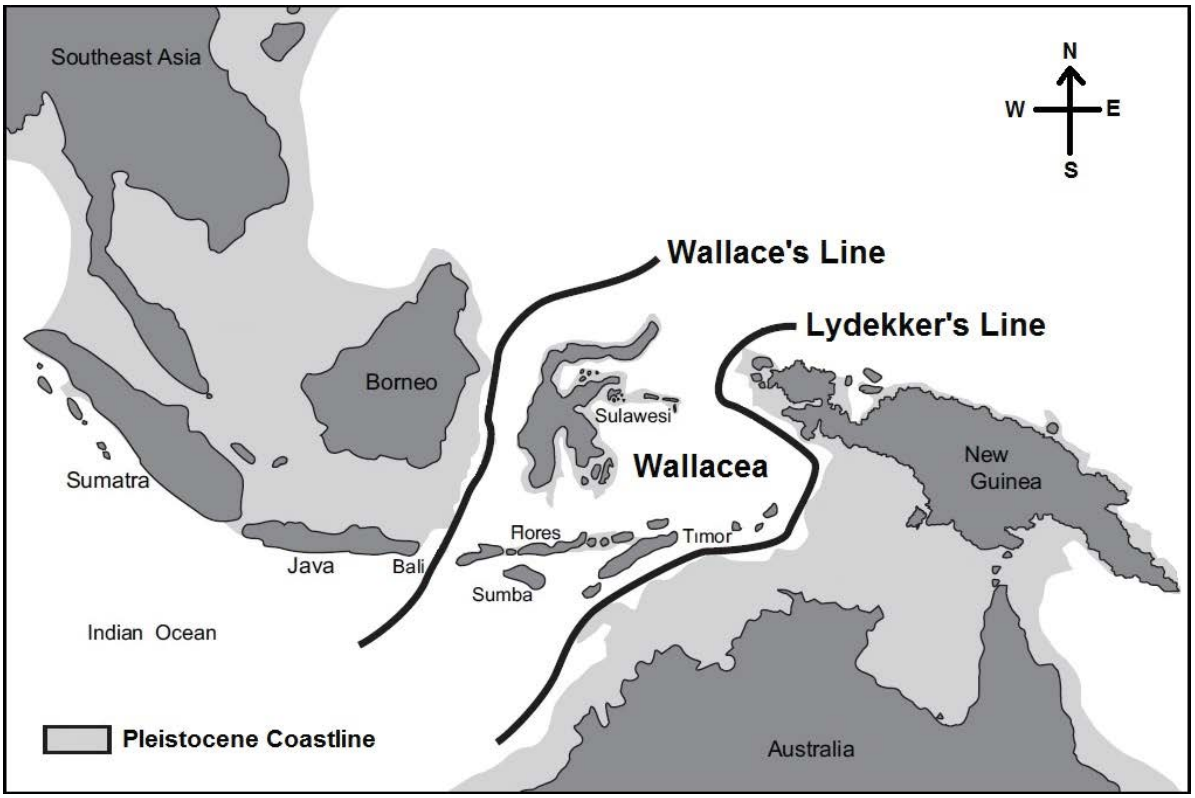
C



D



27 As shown in the following map, in the regions between the islands of Indonesia and Australia, two biogeographical lines were drawn up by European naturalists Alfred Russel Wallace and Richard Lydekker. During the Pleistocene Epoch, lasting from 2 million years till 10,000 years ago, periods of ice ages had lower sea levels. The Pleistocene coastline during ice ages is also indicated in the map.



The islands found west of the Wallace's line are rich in biodiversity, represented by many species common with the Southeast Asian mainland such as tigers, rhinoceros, apes and other placental mammals. To the east of Lydekker's line, many marsupials and birds exclusive to Australia populate these regions.

The islands of Wallacea found between the two lines, including Sulawesi and nearby islands, is relatively species-poor. Only some birds, reptiles and insect species of Asian or Australian origin are found there. Flightless birds and freshwater fishes common to Asia or Australia are not found on these islands.

Which of the following statements does **not** explain the geographical distribution of biological species in this region in the present day?

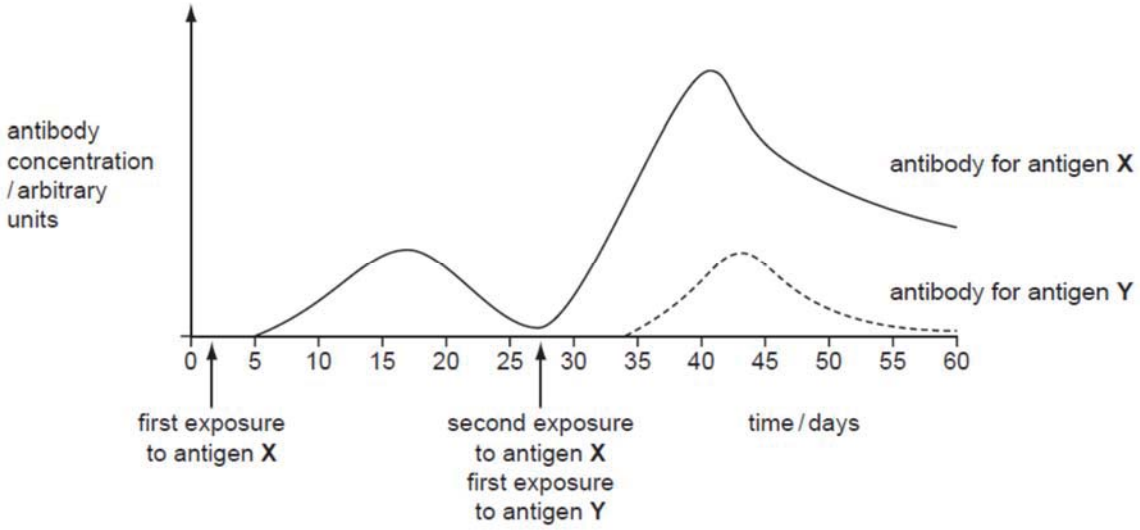
A Placental mammals from the Southeast Asian mainland were able to populate the islands of Borneo, Sumatra and Java during the Pleistocene ice ages.

B The islands of Wallacea were geographically isolated from Southeast Asia and Australia even during Pleistocene ice ages due to the presence of deep water bodies.

C Not all bird species found in this region are able to overcome geographical isolation due to the presence of water bodies.

D Before the Pleistocene Epoch, the land masses of Southeast Asia and Australia were joined together as a single continent.

28 In an investigation into the immune response, a volunteer was exposed to two different antigens, X and Y. The relative antibody concentration in the blood was measured at regular intervals over 60 days. The graph shows the time when the volunteer was exposed to each antigen and the antibody concentration against time for antigens X and Y.



Which of the following is a valid explanation for the results displayed on the graph?

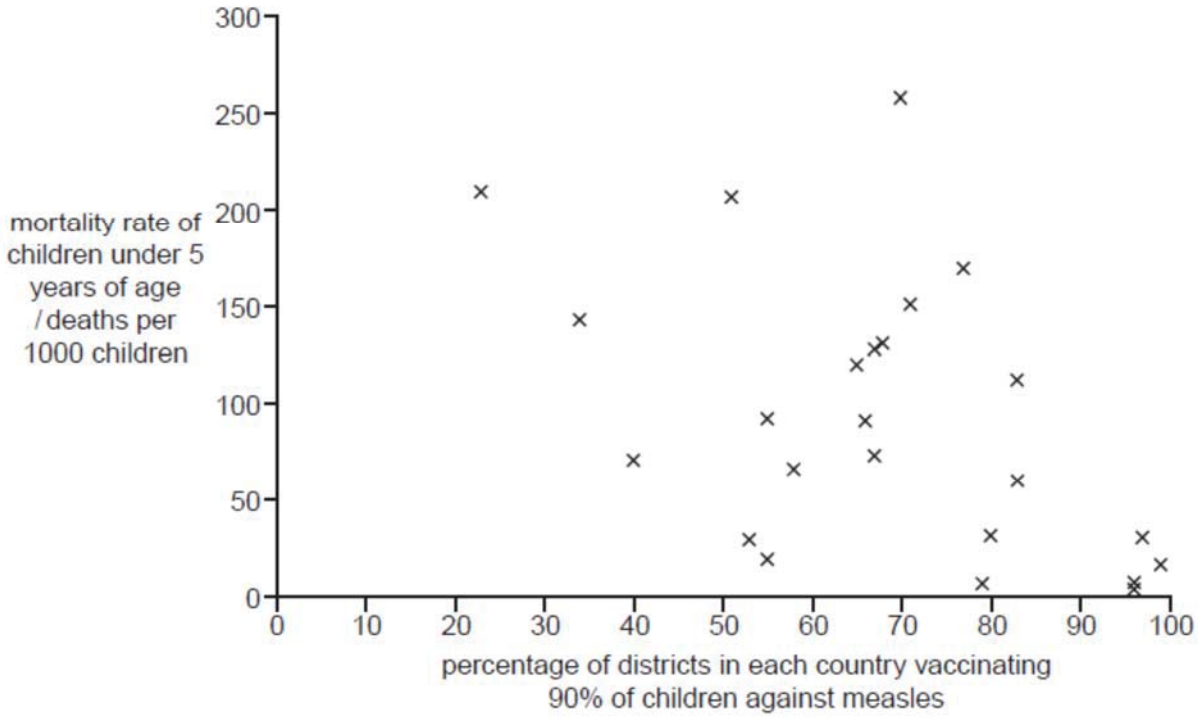
A The innate immune response is activated from day 5, which triggers the activation of the adaptive immunity against antigen X from day 27.

B The adaptive immune response against antigen Y is not activated due to the lack of a second exposure to antigen Y at day 60.

C Memory B cells specific to antigen X produced by the adaptive immune response enabled a secondary immune response to occur between day 27 and 60.

D Memory B cells that remains at the end of day 27 undergo rapid clonal selection to produce antibody against antigen X and Y.

29 The World Health Organization (WHO) publishes data on the vaccination programmes for infectious diseases. Each health authority in a country reports its success in vaccinating children in their district. The WHO collects statistics on mortality rates of children under the age of 5 from all causes, including infectious diseases. The figure shows these statistics for 24 countries for the year 2007.



Which of the following can be concluded from the information provided above?

A Vaccination of 90% of the entire population is recommended as countries with more than 90% of districts reporting 90% of children vaccinated have very low death rates.

B The mortality rate of children is inversely correlated to the percentage of districts in each country vaccinating 90% of children against measles.

C Variation between countries with similar percentage of districts reporting 90% of children vaccinated could be attributed to deaths due to infectious diseases.

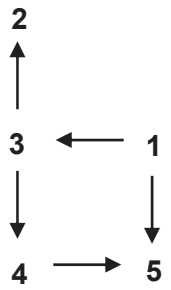
D When 90% of children in a district is vaccinated, mortality rate of the children is reduced.

30 Investigations into the possible current and future impacts of climate change need to be put into the context of the well-documented and on-going impacts of other drivers of change, such as population growth. The statements below are effects of climate change and population growth.

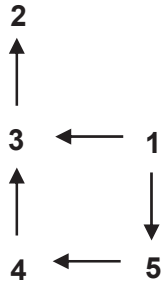
1 More intensive land use results in degradation of soils and more rainfall run-off
2 Food and feed shortages
3 Greater frequency of water deficit in soil for crops and pasture growth
4 More frequent dry years experienced
5 Increase food demand and competition for pastures

Which of the following diagram correctly illustrates the relationship between climate change and population growth?

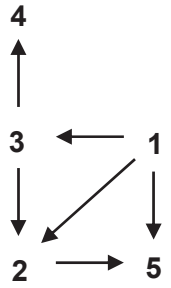
A



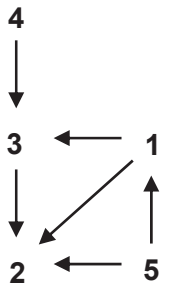
B



C



D



Name	Subject Class	Class	Candidate Number
	2BI		

ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2017

BIOLOGY **9744/02**
17 AUGUST 2017
HIGHER 2 **2 hours**

Paper 2

READ THESE INSTRUCTIONS FIRST
Write your name, index number and class on this answer booklet.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.

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

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total	100

This question paper consists of **22** printed pages.

For examiner's use

1 Fig. 1.1 shows part of a cell.

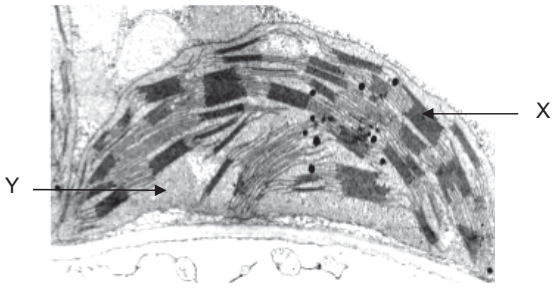


Fig. 1.1

(a) (i) Outline the role of the organelle labelled X.

_____

_____

_____

_____[2]

(ii) Explain the importance of the double membrane enclosing organelle X for the reactions that occur in the region labelled Y.

_____

_____

_____

_____[2]

(b) (i) Plant cells are unable to carry out endocytosis due to the energy needed to overcome the turgor pressure in the plant cell. However, lysosome-like organelles can be found in the plant cells. Suggest reasons for their presence in plant cells.

_____

_____

_____

_____[2]

For examiner's use

(ii) Outline how the lysosome is formed by the endomembrane system in a eukaryotic cell.

[3]

The chloroplast is a member of a larger family of plant organelles called plastids. All plastids, including chloroplasts, develop from proplastids. Fig. 1.2 shows the process of chloroplast development from a proplastid.

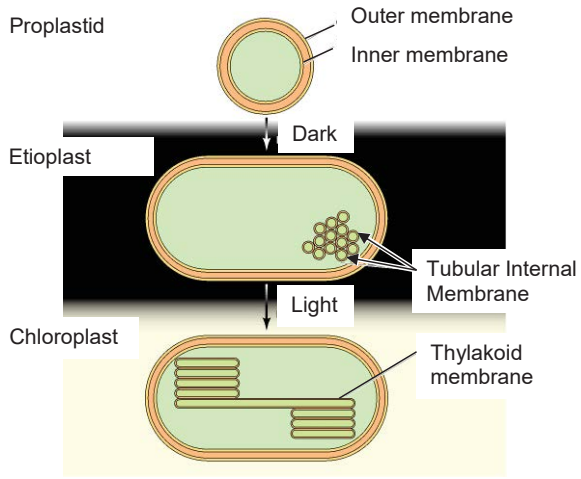


Fig. 1.2

(c) With reference to Fig. 1.2, suggest how thylakoid membranes are formed.

[2]

[Total: 11 m]

For examiner's use

2 Fig. 2.1 shows the formation of a bond in the synthesis of starch.

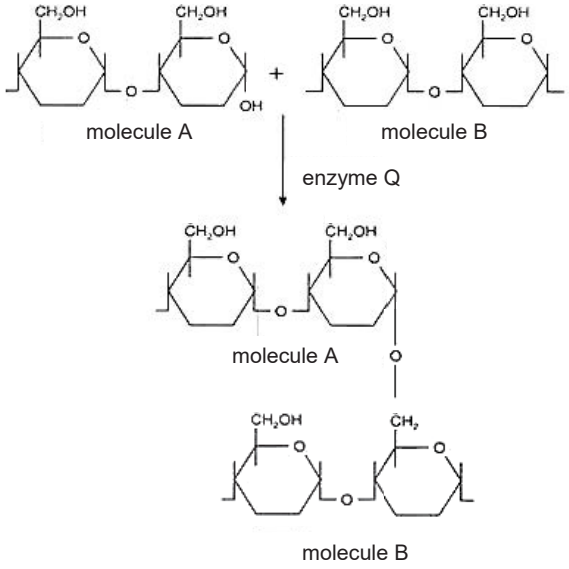


Fig. 2.1

(a) (i) Describe the formation of the bond in Fig. 2.1.

[2]

(ii) Explain how enzyme Q could lower the activation energy of the bond formation.

[3]

For examiner's use

Graph X shows the amount of product formed over time for an enzyme-catalysed reaction (Fig. 2.2).

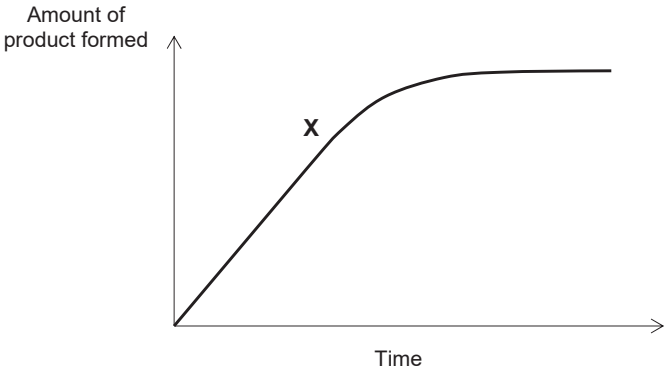


Fig. 2.2

(b) (i) Draw a graph, labelled Y, on Fig. 2.2 to show how a small amount of non-competitive inhibitor affects the amount of product formed over time. [1]

(ii) Explain the difference between graphs X and Y.

_____

_____

_____

_____[2]

[Total: 8 m]

For examiner's use

3 The diagram below shows the structure of a mature tRNA for the amino acid alanine.

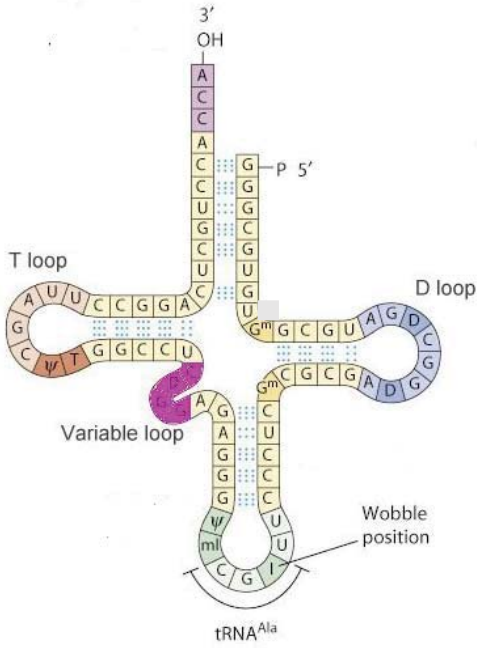


Fig. 3.1

(a) (i) Explain the roles of hydrogen bonds in the proper functioning of tRNA.

[4]

For examiner's use

(ii) The length of the tRNA gene is longer than that of the mature tRNA. Outline how a tRNA molecule is synthesised in eukaryotes.

[3]

An experiment was carried out to investigate the effects of various cytokines on a culture of CD34 cells. CD34 cells are hematopoietic progenitor cells which are produced in the early stage of differentiation to form mature immune cells from stem cells. Three types of cytokines, KF36EG, K36EG and F36EG, were used in the experiment as shown in Fig. 3.2.

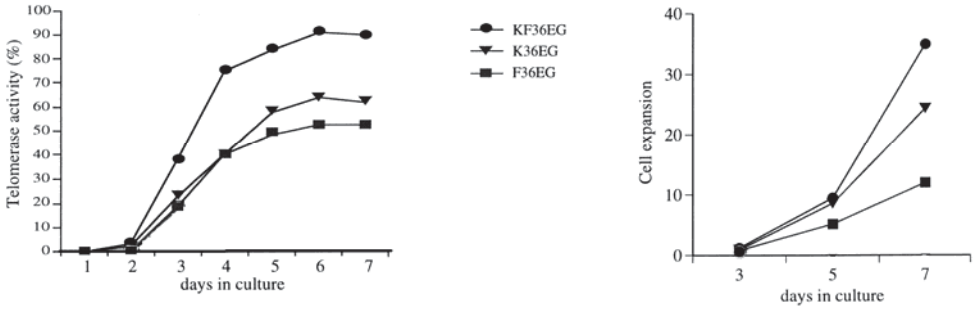


Fig. 3.2

(b) (i) With reference to Fig. 3.2, describe the effects of the types of cytokines on CD34 cells.

[3]

For examiner's use

(ii) With reference to Fig. 3.2, comment on the role of cytokines on the CD34 cells.

[2]

(c) Discuss the accuracy of the following statement:

"Stem cells and cancer cells are able to divide indefinitely as there is no end replication problem due to the presence of active telomerase."

[4]

[Total: 16 m]

For examiner's use

4 The coat colour of Norwegian cattle is mainly determined by the distribution of two pigments: red and black. Both pigments are produced by the action of the enzyme tyrosinase in cells called melanocytes. Low enzyme activity leads to the production of red pigment, while high enzyme activity brings about black pigment production.

The activity of the enzyme is increased when melanocyte stimulating hormone (MSH) combines with a MSH receptor. The receptor is coded for by the gene, **R**, which has three alleles, $\mathbf{R^D}$, $\mathbf{R^A}$ and **r**. $\mathbf{R^D}$ and $\mathbf{R^A}$ each codes for a receptor with a different activity. No receptor is produced by the recessive allele, **r**.

The dominant allele of a second gene, **B**, codes for a protein which binds to and blocks the MSH receptors coded for by $\mathbf{R^A}$, thus preventing stimulation of tyrosinase activity in a melanocyte. The receptors coded for by $\mathbf{R^D}$ is insensitive to the protein coded by **B**. The recessive allele, **b**, does not produce a functional protein.

(a) (i) State the name given to the interaction between the **R** and **B** gene loci.

_____[1]

(ii) Explain why animals with the genotype $\mathbf{R^AR^ABB}$ have red coats.

_____

_____[1]

(iii) A red cow, with genotype $\mathbf{R^AR^ABB}$ is mated with a bull which is homozygous recessive at both gene loci. Draw a genetic diagram in the space below to show the expected genotypes and phenotypes and their ratios in the F_1 and F_2 generations.

[5]

For examiner's use

During a health screening exercise of cattle in a farm, the height of the bulls was measured and the data collected is shown in Table 4.1.

Table 4.1

Height/cm	Number of bulls
131—135	3
136—140	9
141—145	21
146—150	12
151—155	2

(b) Distinguish between the two types of variation as seen in coat colour and height in the Norwegian cattle.

[3]

In the honey bee colony, the queen bee is solely responsible for laying eggs and the drones for fertilizing her. The worker bees have well-developed mouthparts and structural adaptations for collecting nectar and pollen to gather food and to perform other duties in the hive. Male bees are developed from haploid eggs while both queen and worker bees develop from fertilized eggs.

(c) Explain how the phenotypic differences between the queen and the worker bees come about despite both being developed from fertilized eggs.

[2]

[Total: 12 m]

For examiner's use

5 Normal cells rely on oxidative phosphorylation in the mitochondria to generate the energy needed for cellular processes. In contrast, cancer cells undergo a phenomenon termed the "Warburg effect". This is characterised by an increased glucose uptake and reliance on glycolysis for ATP production despite the availability of oxygen for oxidative phosphorylation. Most of the pyruvate is converted to lactate instead of being broken down in the mitochondria (Fig. 5.1).

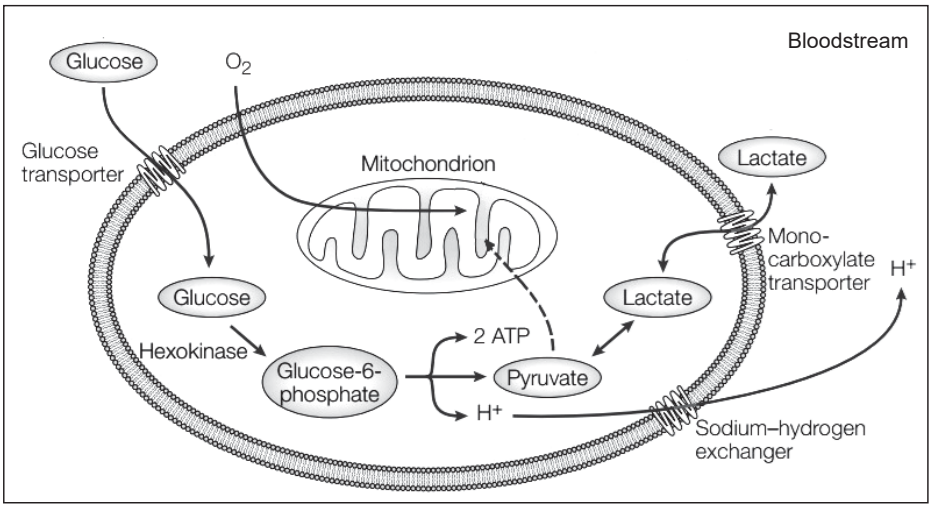


Fig. 5.1

(a) (i) Outline the role of glycolysis in normal cells.

[3]

(ii) With reference to Fig 5.1 and your own knowledge, suggest why the "Warburg effect" may seem disadvantageous to the survival of the cancer cell.

[1]

For examiner's use

In cancer cells, the "Warburg effect" is constitutively upregulated even under normal levels of oxygen. It is thought to be due to the reprogramming of metabolic genes to increase glucose consumption. In a research experiment, the mean glucose consumption rate of MCF-7 breast cancer cells is compared with that of the relatively more aggressive MDA-MB-231 breast cancer cells under normal and low oxygen levels (Fig. 5.2).

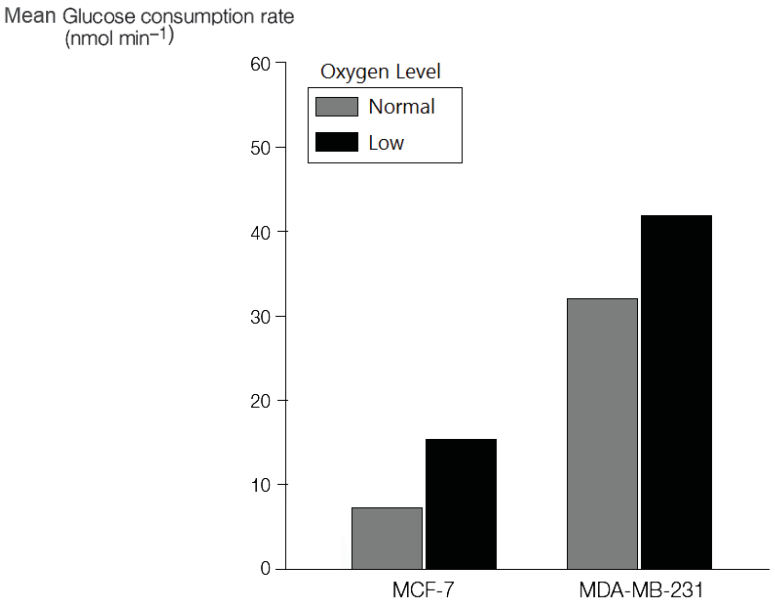


Fig. 5.2

(b) Describe the differences in the mean glucose consumption rate between MCF-7 and MDA-MB-231 cancer cells.

[3]

For examiner's use

The mTOR intracellular signalling pathway is critical for control of cell growth. Fig. 5.3 shows the signalling system that drives cell growth through greatly stimulating glucose uptake and utilisation in a normal cell.

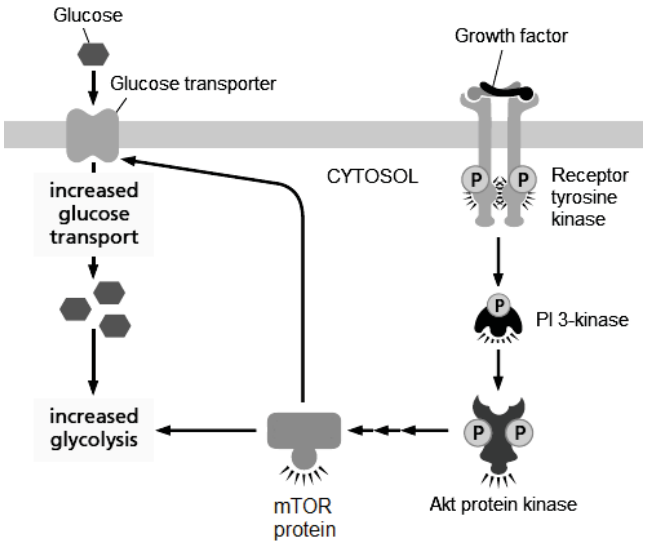


Fig. 5.3

(c) (i) Describe how the binding of the growth factor to the receptor tyrosine kinase leads to the cellular responses in Fig. 5.3.

_____

_____

_____

_____

_____

_____ [3]

(ii) Cancer cells are able to proliferate in the absence of growth factors. Suggest how the ability to do so can lead to the "Warburg effect".

_____

_____ [1]

[Total: 11 m]

For examiner's use

6 Fig. 6.1 shows the different stages of meiosis in a cell.

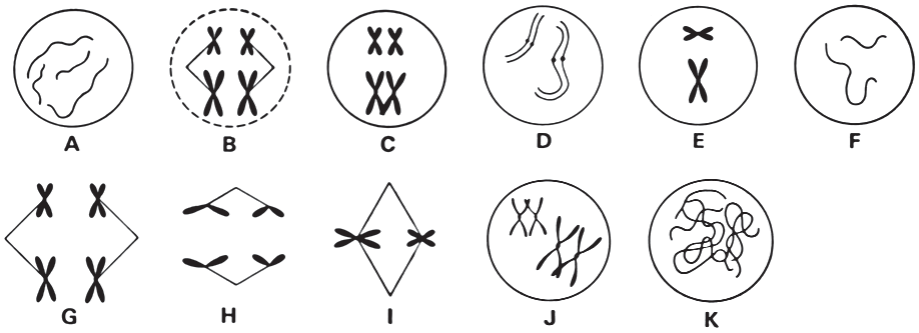


Fig. 6.1

(a) (i) Arrange the stages in chronological order. [1]

		D			B					

(ii) With reference to Fig. 6.1, identify a stage which is critical for a reduction division and explain why.

_____

_____

_____

_____[2]

(iii) Explain how reduction division contributes to variation in diploid organisms.

_____

_____

_____

_____[2]

For examiner's use

Some patients with the Prader-Willi syndrome have both chromosomes 15 from their mother due to an error in meiosis. Fig. 6.2 shows the possible combinations of chromosomes 15 that could be present in the gametes of the mother.

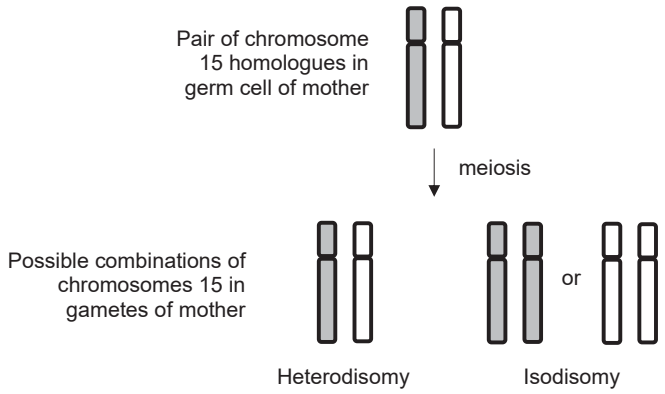


Fig. 6.2

(b) Explain how a gamete with heterodisomy of chromosome 15 could have been formed.

[3]

[Total: 8 m]

For examiner's use

7 The structure of a G-protein-linked receptor (GPLR) is shown from two different views in Fig. 7.1 below. Fig. 7.1a shows a GPLR from a cross section of the plasma membrane while Fig. 7.1b shows the top view of a GPLR.

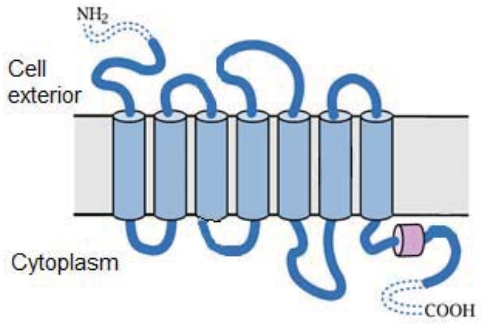


Fig 7.1a

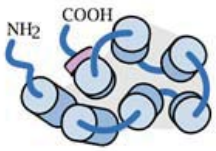


Fig 7.1b

(a) **(i)** State and explain the highest level of organization of the GPLR.

_____

_____

_____

_____[2]

(ii) Identify a hydrophilic domain of the GPLR and describe its corresponding function.

_____

_____

_____

_____[2]

For examiner's use

Recent studies have found that GPLRs have alternative binding sites other than the ligand-binding sites. Allosteric molecules bind to these alternative binding sites to change cellular response levels. One such molecule has been found to bind to the GPLR specific to glucagon.

One of the normal cellular responses of glucagon binding is the inhibition of glycogenesis. The rate of glycogenesis with and without the allosteric molecule is shown in Fig. 7.2.

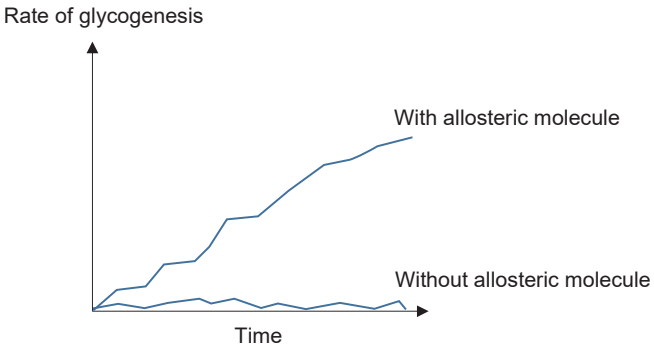


Fig. 7.2

(b) (i) Based on the information above, state if the allosteric molecule is an activator or an inhibitor of GPLR.

_____ [1]

(ii) Explain the effect of the allosteric molecule on the rate of glycogenesis.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ [5]

[Total: 10 m]

For examiner's use

8 Speciation events have been observed to occur very frequently in bacteria. It was suggested that the high rate of speciation is due to the high level of variation in bacteria.

(a) Transformation and conjugation are two processes which increase the level of variation in bacteria.

Distinguish these two processes.

[3]

Bacterial evolution is one of the most dynamic and exciting areas in current biological research.

Over the years, a barrier in this field of research is the difficulty in classifying bacterial species. However, in recent times, new analytical tools in molecular biology have offered new insights into the classification of bacterial species.

(b) **(i)** Suggest why scientists had difficulties in the classification of bacterial species.

[2]

(ii) Explain how analytical molecular tools have helped overcome this barrier in research.

[2]

For examiner's use

(c) The outer layers of the two types of bacteria with peptidoglycan cell walls known as Gram-positive and Gram-negative bacteria are shown in Fig. 8.1 below.

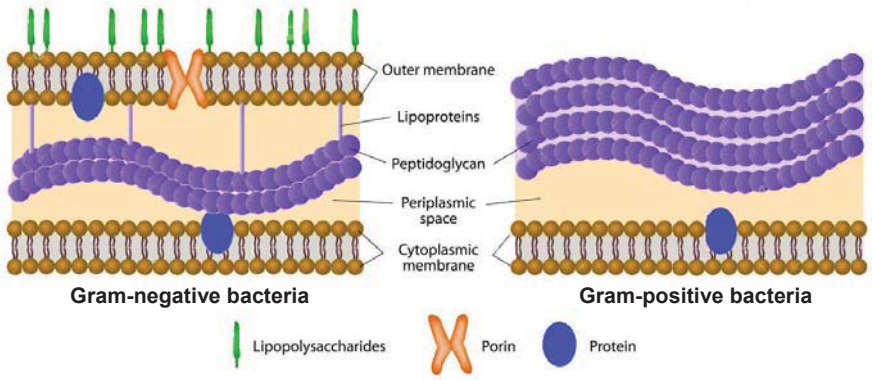


Fig. 8.1

Penicillin is an antibiotic that is known to be effective against only one of the two types of bacteria above.

With reference to the information given and your own knowledge, deduce which type of bacteria is susceptible to the action of penicillin and explain why.

[3]

For examiner's use

(d) Explain how antibiotic-resistant bacteria can become increasingly common in a population of bacteria.

[4]

[Total: 14 m]

For examiner's use

9 Cyanobacteria are aquatic blue-green bacteria which are highly similar to algae as they can obtain their energy through photosynthesis. They are typically found in tropical waters due to their ability to thrive in bright and warm areas. Generally found on the surface of lakes and oceans, they can reproduce exponentially and cause a rapid increase in their population known as blooms. Certain genera of blooming cyanobacteria such as *Microcystis* can produce cyanotoxins which, in high concentrations, can poison and even kill animals and humans.

A study was conducted to find out the effects of temperature on the maximum growth of *Microcystis aeruginosa* as well as three other harmless green algal species (P, Q and R) which are a main source of food for aquatic animals (Fig. 9.1). The global mean sea surface temperature anomalies, which indicate differences in temperature when compared to the baseline temperature in 1880 were also recorded (Fig. 9.2).

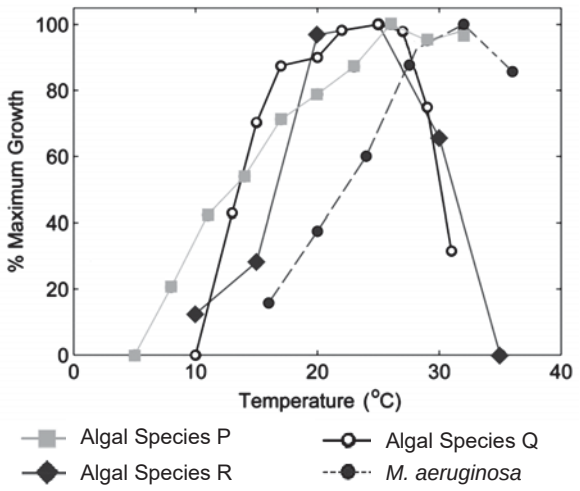


Fig. 9.1

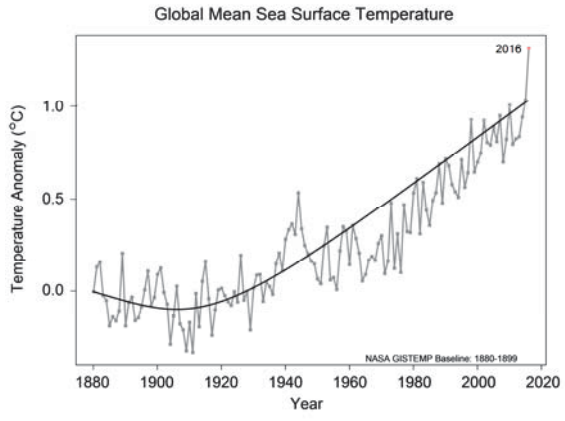


Fig. 9.2

For examiner's use

(a) Describe the effect of temperature on the maximum growth of *M. aeruginosa*.

[2]

Commented [LKM1]: Students must be able to identify different parts of the graph and explain them, while identifying trends (increasing trend)

(b) Explain how human activities could have contributed to an increase in sea surface temperatures.

[3]

Commented [LKM2]: Direct recall from LO – students have to phrase their answers in the context of SST

(c) With reference to the information provided, discuss the impact of *M. aeruginosa* on the global food supply of humans in the future.

[5]

Commented [LKM3]: Similar to CA2 Q phrasing, where student can try to provide evidence where global food supply may be increased or decreased / assess validity of information in making such a claim

[Total: 10 m]

END OF PAPER

Name	Subject Class	Class	Candidate Number
	2BI		

ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2017

BIOLOGY **9744/03**
Long Structured and Free-response Questions **21 Aug 2017**
PAPER 3 **2 hours**

Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

Write your name, subject class, form class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

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

Section B
Answer any **one** question in the spaces provided on the Writing Paper.

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

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

FOR EXAMINER'S USE	
1	
2	
3	
4 / 5	
TOTAL	**75**

This document consists of **17** printed pages.

For Examiner's Use

Section A

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

1 Dengue viruses (DENV) are responsible for millions of infections each year in tropical and subtropical areas of the world. According to the World Health Organization, dengue incidence has increased significantly over the past 50 years, turning this infection into the most important mosquito-borne disease in the world and a global health challenge. Fig. 1.1 shows the general global distribution of dengue fever in the year 2005.

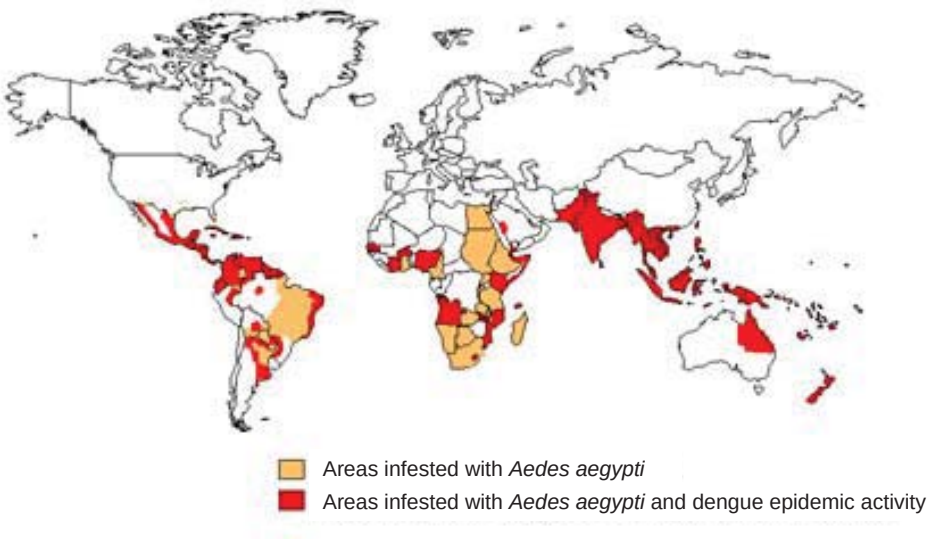


Fig. 1.1

(a) (i) Climate is one of the important factors that affects the distribution of dengue.

Predict and justify the expected distribution of dengue by the end of the 21st century.

_____

_____

_____

_____

_____

_____ [3]

For Examiner's Use

(ii) Symptoms of dengue such as fever usually develop within 4 to 7 days after being bitten by an infected mosquito and is often associated with joint pain.

Explain how DENV may cause these symptoms.

_____

_____

_____

_____

_____

_____ [3]

For Examiner's Use

During an infection, DENV will elicit a primary humoral immune response which involves B cell activation as shown in Fig. 1.2.

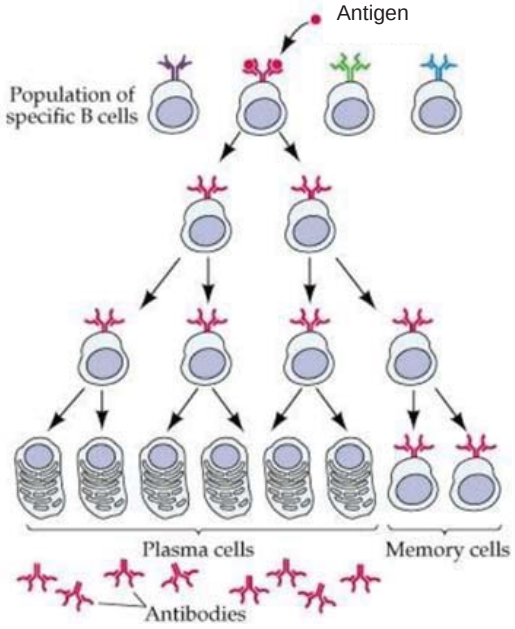


Fig. 1.2

(iii) With reference to Fig. 1.2 and your own knowledge, explain the significance of mitosis in B cell activation.

_____

_____

_____

_____

_____

_____ [3]

(iv) Memory B cells have long life spans because they do not actively undergo cell division. However, upon activation, a memory B cell can undergo many rounds of proliferation.

Suggest why activated memory B cells can undergo multiple rounds of cell division without dying.

_____

_____ [1]

For Examiner's Use

(b) Bacteria has a natural defence system against viral infections involving RNA sequences known as clustered regularly interspaced short palindromic repeats (CRISPR).

When the bacteriophage infects a bacterial cell, the viral genome released into the bacterial cell is cleaved. Subsequently, a cleaved portion of the viral genome is integrated into the bacterial genome. The bacterial cell detects the phage DNA integrated within its genome and produces a type of RNA known as the CRISPR RNA. The CRISPR RNA contains a sequence that is complementary to that of the integrated phage DNA. When the next phage infects the same bacterial cell, the CRISPR RNA will bind to its target sequence in the viral genome and a nuclease is recruited to cut the phage DNA, disabling the invading phage.

The sequence of the CRISPR RNA can be edited and subsequently used to cut any DNA sequence at a precisely chosen site in eukaryotic cells. This gives rise to the possibility of correcting mutations associated with genetic disorders. Fig. 1.3 shows how the sequence of a defective allele can be replaced with the sequence of a normal allele from a donor DNA via homologous recombination using the CRISPR technology.

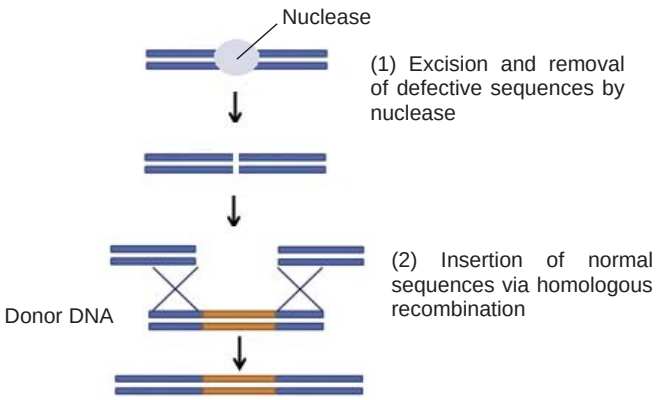


Fig. 1.3

(i) The specificity of CRISPR-mediated immunity in prokaryotes could be applied to eukaryotic cells to make precise changes in the genes of organisms.

Explain why the CRISPR RNA in prokaryotes can also be used in eukaryotic cells.

_____

_____

_____

_____ [2]

For Examiner's Use

(ii) Another technology that can be used to treat genetic disorders is gene therapy. Similar to the CRISPR technology, gene therapy involves the introduction of normal alleles into patients. However, it does not involve the excision and removal of defective alleles. Hence, it can only be used to treat recessive genetic disorder.

With reference to Fig. 1.3, explain the advantages of using CRISPR technology to treat genetic disorders over gene therapy.

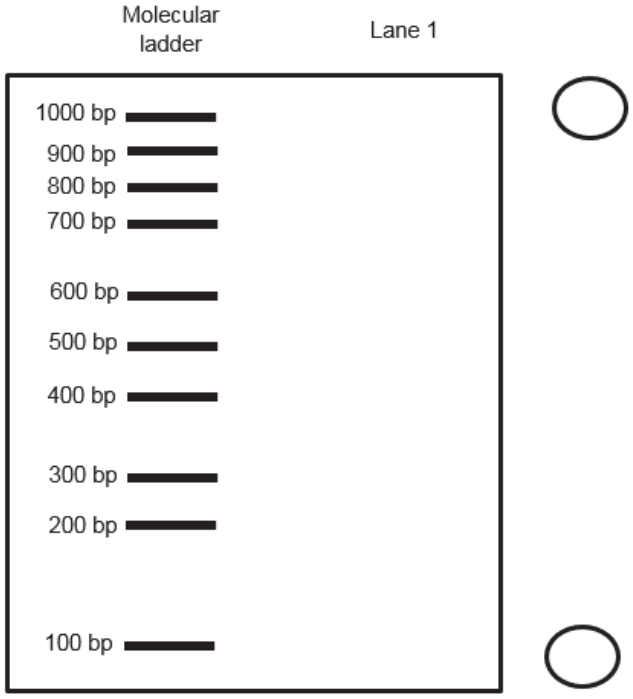
[3]

For Examiner's Use

Polymerase Chain Reaction was used to amplify a gene of 1000 bp. Fig. 1.4 shows the resultant DNA fragment produced. A CRISPR RNA is designed to target a specific sequence found within the gene. The sites of excision by the nuclease are indicated by the arrows. Gel electrophoresis can be used to verify if the target sequence is cut at the precise sites by the nuclease.

Fig. 1.4

(iii) On the electrophoregram below, draw the expected results after the cut fragments are separated if there is specific binding of CRISPR RNA to target sequence in Lane 1. Indicate the charge of the electrodes clearly in the circles on the side of the electrophoregram.



[2]

ori

For Examiner's Use

Fig. 1.5 shows an electrophoregram obtained by a student following excision of the same gene by a nuclease.

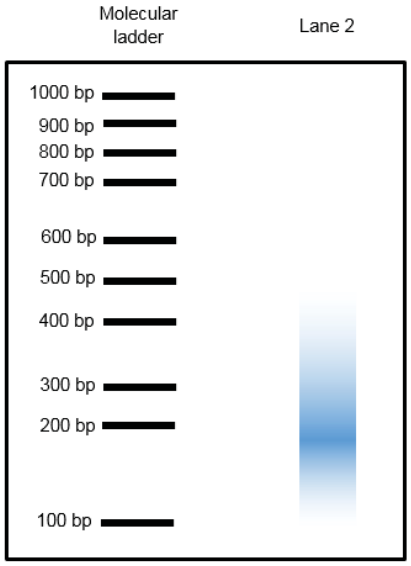


Fig. 1.5

(iv) Suggest how the smear is obtained in Fig. 1.5.

_____

_____ [1]

(v) Geneticists attempted to edit the gene responsible for β-thalassaemia, a potentially fatal blood disorder, in human embryos using the CRISPR technology. However, the experiment was terminated prematurely due to a number of unintended mutations and numerous ethical controversies.

Discuss the ethical implications of the application of CRISPR technology on genes in embryos.

_____

_____

_____

_____ [2]

For Examiner's Use

(c) One of the three tenets of the cell theory states that all living organisms are composed of one or more cells. Non-cellular life forms such as viruses challenge this tenet as they possess both living and non-living characteristics. The recent discovery of giant viruses, known as Mimiviruses, led scientists to rethink the origin of life and viral evolution. The features of the Mimivirus are as described.

1. It contains a double-stranded DNA genome of approximately 1.2 million base pairs which is significantly larger than the genomes of any other known virus and comparable to a cell.
2. It has some genes which show a high degree of homology to those in bacteria, while some show a high degree of homology to those in eukaryotes.
3. It contains a number of protein-coding genes showing high degree of homology to genes coding for products involved in translation, such as aminoacyl-tRNA synthetases and translation initiation factors. It also contains genes associated with metabolic pathways, DNA repair, and protein folding. However, it is still dependent on its host for translation.

Suggest how Mimiviruses evolved and use the above statements to support your hypotheses.

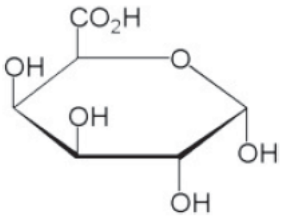
[4]

[Total: 24]

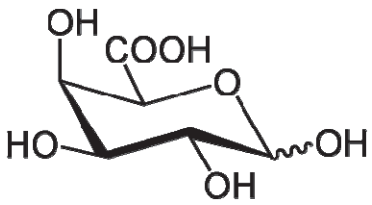
For Examiner's Use

2 Prebiotics is defined as 'an ingredient that results in specific changes in the composition and activity of microbials in the gut thus improving host health'. Prebiotics are non-digestible oligosaccharides that can be selectively fermented by gut bacteria. Currently, most prebiotics are derived from the hydrolysis of simple polysaccharides. Therefore, to develop novel prebiotics, an alternative resource of polysaccharides that supplies oligosaccharides with more diverse and complex structures is required. One of these polysaccharides is pectin.

Fig. 2.1 shows the schematic diagram and natural occurring configuration of D-galacturonic acid, the monomer of pectin. The structure of pectin, a polysaccharide is shown in Fig. 2.2.

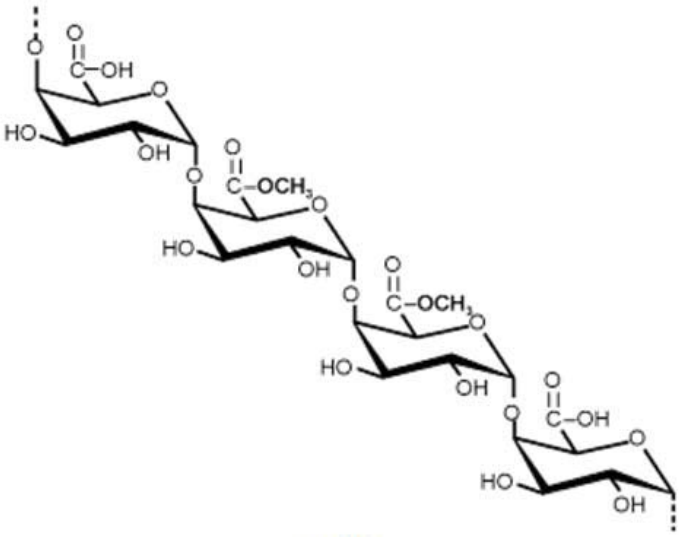


Schematic diagram



Natural occuring configuration

Fig. 2.1



Pectin

Fig. 2.2

For Examiner's Use

(a) With reference to Fig. 2.1 and 2.2, state two structural differences between cellulose and pectin.

[2]

Rhamnogalacturonan I (RG I) is a type of pectin present in the plant cell wall. The schematic diagram of RG I found in plant cell walls is shown in Fig. 2.3. 'Ac' represents acetyl groups added to RG I.

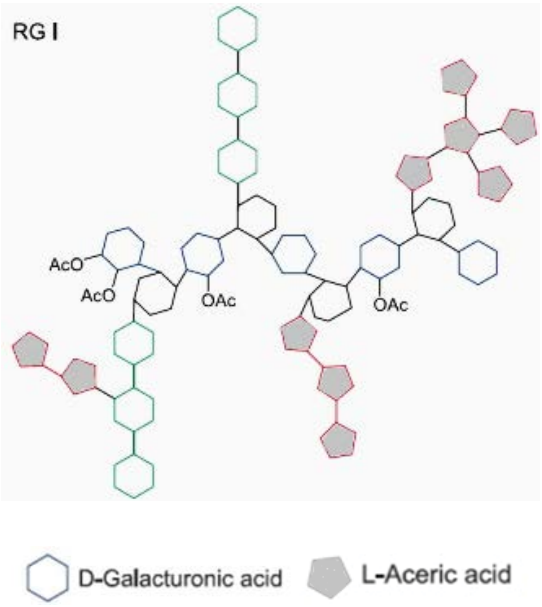


Fig. 2.3

(b) With reference to Fig. 2.3 and your knowledge of carbohydrates, suggest how the structure of monosaccharides allow for complexity in the pectin structure.

[2]

For Examiner's Use

When pectin is consumed by humans, it is digested into oligosaccharides. These oligosaccharides are used by gut bacteria in the process of anaerobic respiration.

(c) Explain why a small yield of ATP can still be achieved with anaerobic respiration.

[3]

In the presence of oxygen, both glucose and triglycerides can be oxidised to yield large amounts of ATP. Fig. 2.4 shows some steps involved in respiration of triglycerides. Respiration of triglycerides involves the hydrolysis of triglycerides into fatty acid chains which are then broken down into acetyl CoA molecules. These acetyl CoA molecules will then enter the Krebs cycle.

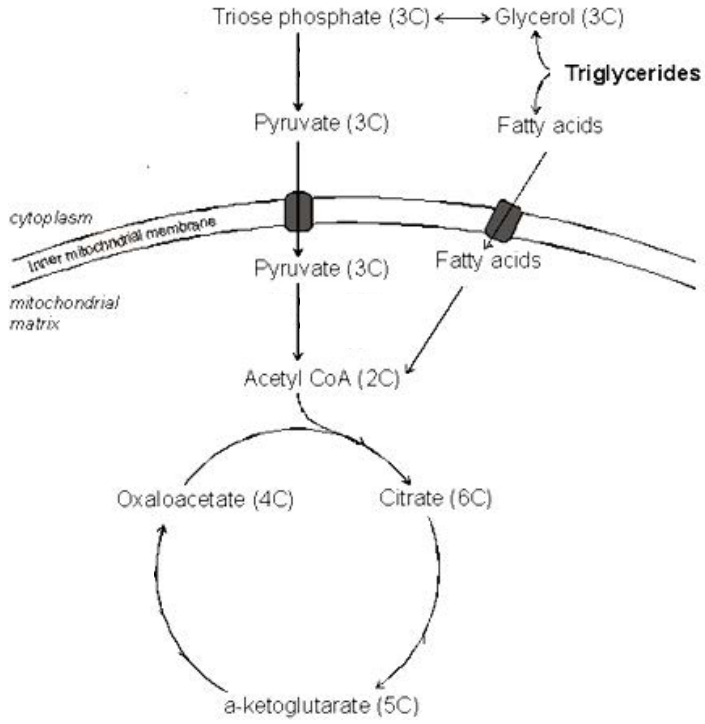


Fig. 2.4

For Examiner's Use

(d) (i) Using the information from Fig. 2.4, calculate the total ATP yield from the complete oxidation of a 14-carbon fatty acid chain. Each NAD yields 2.5 molecules of ATP and each FAD yields 1.5 molecules of ATP. Show your calculation and answer in the space provided.

[3]

(ii) Explain why fatty acid chains can be completely oxidised only under aerobic conditions.

_____

_____

_____

_____

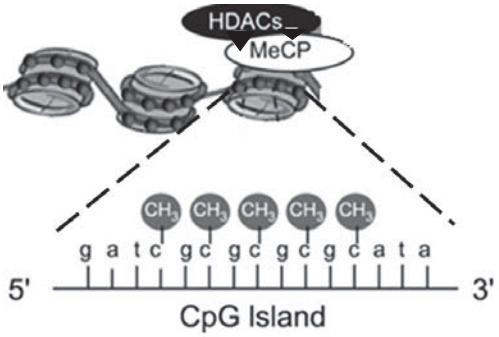
_____

_____[3]

[Total: 13]

For Examiner's Use

3 CpG islands are regions of DNA where a cytosine nucleotide is followed by a guanine nucleotide in the linear 5' to 3' sequence. CpG islands are typically 300 to 3000 base pairs in length. These CpG islands have been found to be in or near approximately 40% of promoters of mammalian genes. Humans have a higher percentage of promoters with high CpG content.



HDAC: Histone Deacetylase
MeCP: Methyl-CpG-binding protein

Fig. 3.1

Commented [WU1]: Make the protein binding more complementary

(a) (i) With reference to the information provided, explain the significance of the presence of CpG islands in many of the genes in the mammalian genome.

[4]

McGhee and Ginder conducted an experiment that examined the effects of inhibiting methylation on gene expression. The experiment was performed using 5-azacytidine in mouse cells. 5-azacytidine is one of many chemical analogs that are structurally similar to the nucleoside cytidine from which cytosine is formed. When these analogs are integrated into growing DNA strands, some, including 5-azacytidine, severely inhibit the action of the DNA methyltransferase enzymes that normally methylate DNA. Interestingly, other analogs, like Ara-C, do not negatively impact methylation.

Scientists hypothesized that if they inhibited methylation by flooding cellular DNA with 5-azacytidine, then they could compare cells before and after treatment to see what impact the loss of methylation had on gene expression. The amount of methylation measured in each treatment is relative to the control. The results are shown in Table 3.1.

Table 3.1

Chemical Added	Number of Differentiated Cells	Amount of Methylation Measured
cytidine (control)	0	100%
Ara-C	0	127%
5-azacytidine	22141	33%

(ii) Explain what the experimental results show about the effects of methylation on gene expression.

[4]

(iii) Explain how confidence in the experimental results could be increased.

[1]

For Examiner's Use

(b) In 2010, a 10 year old boy with a damaged trachea (windpipe) was given a trachea transplant. A donor trachea was obtained and enzymes were used to remove all the cells, leaving only the collagen as shown in Fig. 3.2.

Fig. 3.2

Some bone marrow was removed from the boys' pelvis and about 2.5 million stem cells were isolated from this bone marrow. These stem cells were then treated with chemicals to stimulate proliferation and injected into the collagen.

The collagen, with the injected stem cells, was then immediately used to replace damaged trachea in the boy. Over a period of time, a fully functioning trachea was formed.

Suggest how the properties of the bone marrow stem cells allow for the formation of a fully functioning trachea.

[4]

[Total: 13]

For Examiner's Use

Section B

Answer **one** question in this section.

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

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

Your answers must be in continuous prose, where appropriate.

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

4 **(a)** Using two named examples, explain the importance of bonds to the function' of two different classes of biomolecules. [13]

(b) With reference to named examples, describe the range of roles performed by lipids in living organisms. [12]

[Total: 25]

5 **(a)** Outline the processes that result in genetic variation in nature and explain the significance of such processes. [13]

(b) "The endomembrane system is critical in the synthesis of proteins". Discuss. [12]

[Total: 25]

END OF PAPER

Name	Subject Class	Class	Candidate Number
	2BI		

ANGLO-CHINESE JUNIOR COLLEGE
H2 Biology Preliminary Examinations 2017

H2 BIOLOGY **9744/04**
Practical 02 Aug 2017
2 hours and 30 minutes

READ THESE INSTRUCTIONS FIRST
Write your name, index number, class, shift and laboratory on this Question Paper.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.

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

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

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

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

Shift
Laboratory

For Examiner's Use	
1	/21
2	/20
3	/14
Total	**55**

This question paper consists of 18 printed pages.

1 During anaerobic respiration, yeast cells use glucose and release carbon dioxide and ethanol. Ethanol is known to disrupt enzymes involved in the respiration pathway.

In this experiment, you will investigate the effect of different concentrations of ethanol on the rate of respiration in yeast cells.

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

Explain the shape of your graph. [4]

Methylene blue is a dye which, under certain conditions, is easily reduced to a colourless compound. In the presence of reduced NAD which is produced during glycolysis, methylene turns from blue to colourless.

In your investigation, you are to dilute the given ethanol solution to obtain different concentrations of ethanol solution.

You are provided with:

- 30 cm^3 of 5.0% yeast solution, **Y**
- 20 cm^3 of 100% ethanol, **E**
- 25 cm^3 of glucose, **G**
- 6 cm^3 of methylene blue, **M**

Proceed as follows:

1. Label 5 boiling tubes 1, 2, 3, 4, 5. Place 5 cm^3 of suspension **Y** into each of the boiling tubes. Ensure **Y** is well-suspended. Place all the boiling tubes into a water bath of 60°C for 5 minutes.

2. While waiting, carry out a dilution to make up 5 cm^3 of different concentrations of ethanol solutions using the vials provided. When preparing the solutions, add distilled water first before adding ethanol. This is to ensure better mixing of ethanol and distilled water.

   Complete Table 1.1 to show how you will make the different concentrations of ethanol solution. [2]

Table 1.1

vial	concentration of ethanol / %	volume of distilled water / cm^3	volume of ethanol / cm^3
1	100		
2			
3			
4			
5			

*Read through steps **3** to **10** to prepare a table to record your results in **(b)**, before starting the investigation.*

3. After 5 minutes, lower the temperature of the water bath to 45°C. Leave the boiling tubes in the water bath for 1 minute.

4. Place 2 cm^3 of the ethanol solution from vial 1 into boiling tube 1 then add in 2 cm^3 of **G**.

5. Use a dropper to add 1 cm^3 of **M** into boiling tube 1 immediately.

6. Shake the boiling tube sufficiently to mix the contents well. The mixture should turn pale blue.

7. Carefully place the boiling tube back into the water bath and start the stopwatch. Do not shake or stir the boiling tubes from this point onwards as it may affect the results.

8. Stop the stopwatch when the blue mixture has been decolourised. The surface of the mixture in the boiling tube may remain blue. Record the time taken and hence the rate of respiration in the table prepared in **(b)**. If the mixture does not decolourise within 12 minutes, record 'more than 720' as the time taken and the rate as '0'.

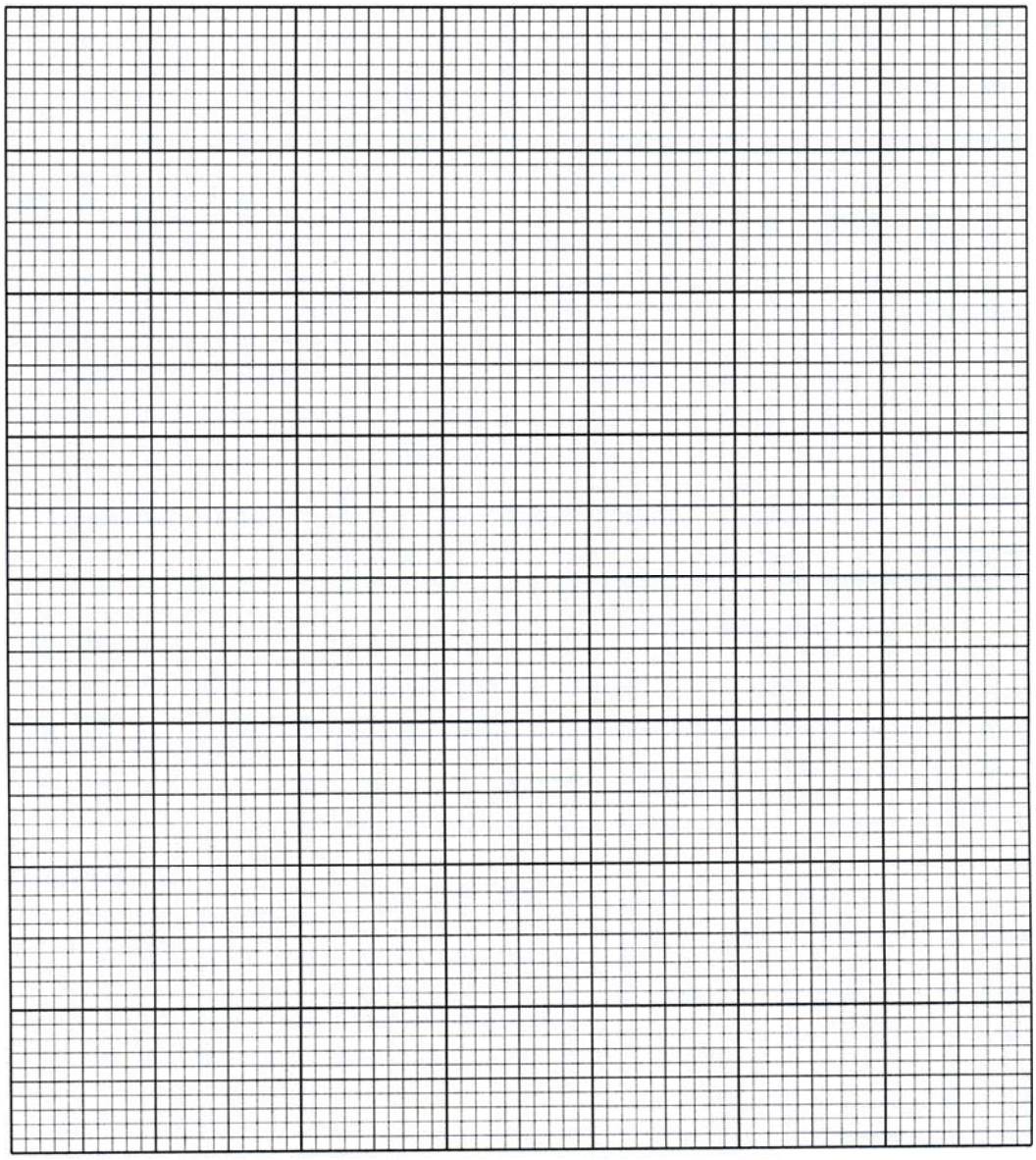
9. Repeat steps 4 to 8 with boiling tubes 2, 3, 4, and 5, in turn.

10. After completing the experiment, shake boiling tube 5 vigorously about 10 times. Record your observations in part **(d)**.

(b) Record your results for each concentration of ethanol in a suitable format in the space below.

[4]

(i) Use the grid below to display your results from **(b)**. [4]



(ii) Discuss what these results suggest about the relationship predicted in part **(a)**. [2]

(c) State and explain your observations from step 10. [1]

(d) Suggest how adding glucose solution to the mixture increases the validity of the results. [2]

(e) One way to increase confidence in the conclusions of this investigation would be to repeat the experiment several times.

Describe two other modifications to the method that would increase confidence in the conclusions, and explain how these modifications would achieve this. [2]

[Total: 21]

2 Section A

You are required to carry out an investigation to estimate the water potential (ψ) of the cells of the plant material with which you have been provided.

You are provided with stems of a plant sample and different concentrations of sucrose solution.

Proceed as follows:

1. Using a sharp scalpel, cut a 5 cm long, straight piece, from near the middle region, of one of the specimens provided. Hold this piece of plant in a vertical position and cut it longitudinally downwards for a distance of approximately 4 cm (Fig. 2.1).

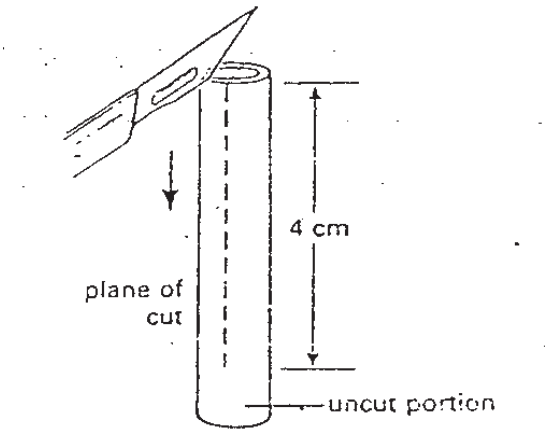


Fig. 2.1

2. You should find that the specimen has curved as shown in Fig. 2.2. Check that the distance A, between the cut pieces is at least 1 cm. If not, repeat the procedure using another specimen. Place the piece of plant tissue horizontally in the base of a clean and dry petri dish. Taking care not to squash the plant material, gently but firmly fix it to the dish using a small roll of plasticine, which you press down at X and Y (Fig. 2.2).

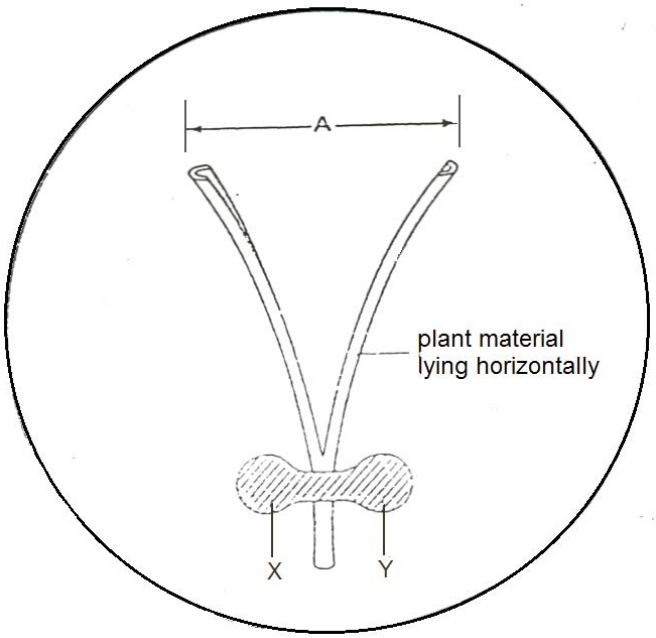


Fig. 2.2

3. Prepare **three** further dishes, using 5 cm long pieces of tissue, cut from roughly corresponding positions of three other stalks. Label your dishes 1, 2, 3 and 4.

4. Place the four dishes on the separate sheet of graph paper provided and measure, to the nearest millimeter, the distance A in each dish. Record these observations in the table below. [2]

	Dish 1 (for S1)	Dish 2 (for S2)	Dish 3 (for S3)	Dish 4 (for S4)
Initial value of A / mm				
Value of A after 10 minutes / mm				
Difference between initial and final value of A / mm				
Change / %				

5. You have been provided with the following sucrose solutions:

S1 is 0.2 mol dm^{-3}

S2 is 0.4 mol dm^{-3}

S3 is 0.6 mol dm^{-3}

S4 is 0.8 mol dm^{-3}

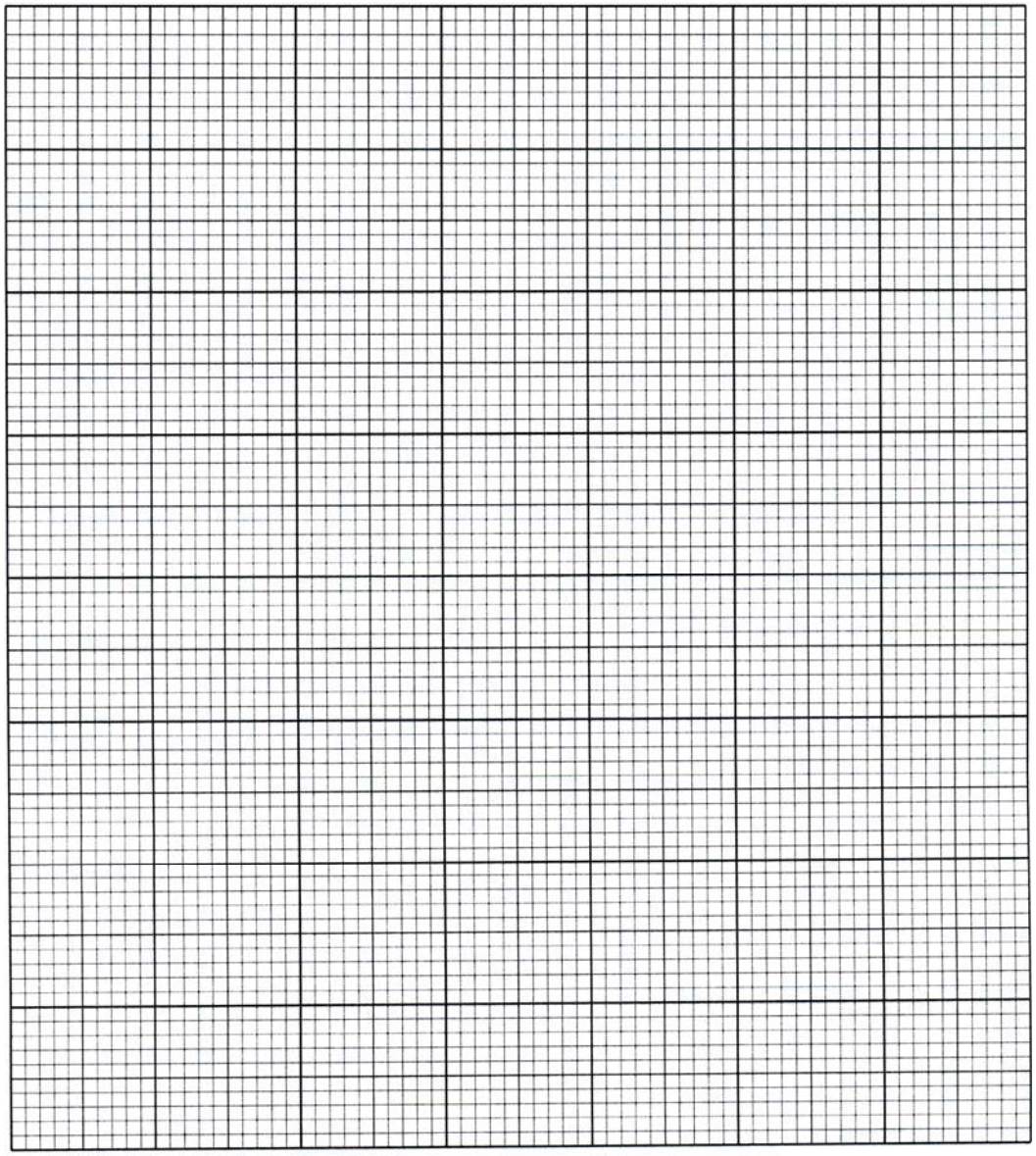
6. Gently, in order to avoid dislodging the plant tissue, pour **S1** into **dish 1**, so that the piece of plant is completely covered by the solution. As quickly as possible, pour the other solutions into their respective dishes.

7. Leave the dishes for 10 minutes. During this time you may begin with Section B.

8. After 10 minutes, measure (to the nearest mm) the distance A in each of the dishes. Record these measurements in the table in Step 4.

9. For each dish, calculate the percentage change in A, and also record this in the table (Step 4). State, in each case, if the value is positive or negative.

10. Plot a graph of the percentage change in A against molarity of sucrose solution. [3]



11. The following table shows the solute potentials (ψ_s) of different concentrations of sucrose solutions, at the approximate temperature at which you have been working.

Concentration / mol dm^{-3}	Solute potential (ψ_s) / kilopascals
0.1	-260
0.2	-540
0.3	-820
0.4	-1120
0.5	-1450
0.6	-1700
0.7	-2170
0.8	-2580

12. Use the graph you have drawn, and the table above, to estimate the solute potential of the cells of this plant material. Explain fully how you arrived at your answer. [3]

Answer: .....

Explanation: .....

.....

.....

.....

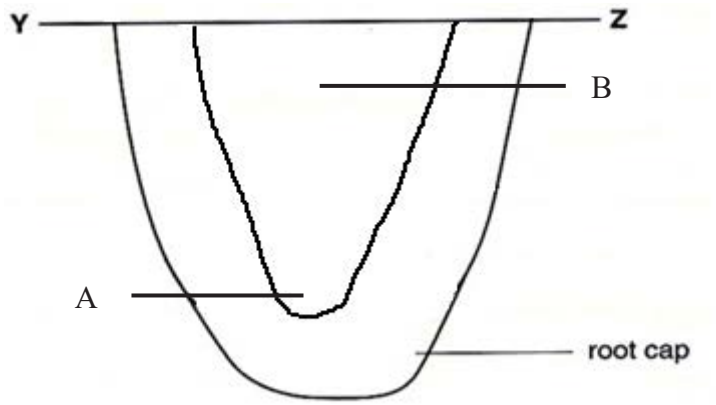
.....

Section B

In this section, you will require access to a microscope and slide **K1**.

K1 is a stained, longitudinal section of a young onion root tip in which some cells are undergoing mitosis. Fig. 2.3 shows a plan diagram of **K1**.

Examine **K1** carefully, in the region labelled **A** in Fig. 2.3, using low- and high- power objectives of your microscope.



.

Fig. 2.3

1. Make a labelled, high−power drawing of a cell in anaphase from region **A**. [4]

2. Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, find the actual length, in μm, of the cell that you have drawn.

   Show the measurements that you made and your working. [3]

Length of cell = _____ μm

3. Measure and calculate the average length of the cells from both regions A and B. Record your results and measurements in a suitable table below. [2]

4. Decide a statistical test that you can use to determine if there is a significant difference between the length of the cells in regions A and B. [1]

5. A student made some measurements of the length of cells of a garlic root tip undergoing mitosis in regions A and B. A summary of the student's results is shown in Table 2.1.

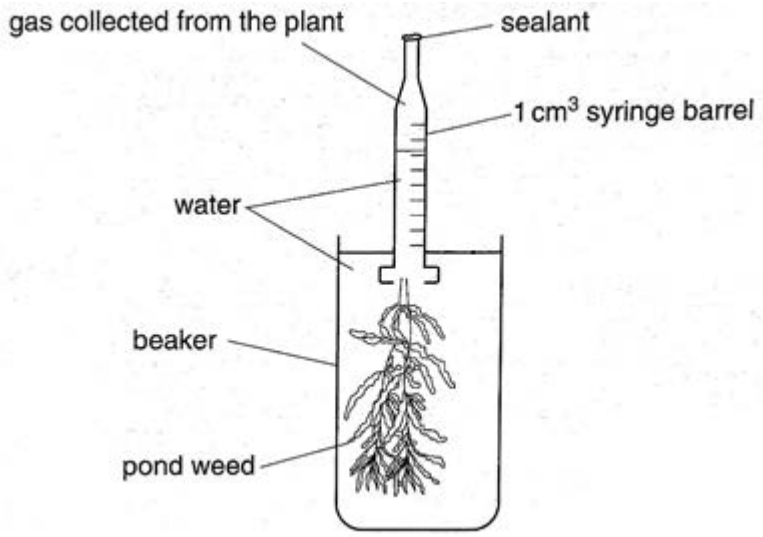
Table 2.1

Length of Cells / μm		Significance of difference
Region A	Region B	
32	58	P<0.05

Comment on what these results show and suggest an explanation for any pattern. [2]

[Total: 20]

3 The rate of photosynthesis can either be measured by the rate at which carbon dioxide is taken in or the amount of oxygen that is given out. Some water plants release bubbles of gas from a freshly cut stem when illuminated. Light intensity is controlled using five filters, F1, F2, F3, F4, F5.



Different water plants are adapted to different light intensities. A sun-loving water plant is adapted to high light intensities while a shade-loving water plant is adapted to low light intensities.

Using this information, the set-up above and your own knowledge, design an experiment to investigate the effect of light intensity on photosynthesis in sun and shade plants.

Your planning must be based on the assumption that you have been provided with the following equipment and materials which you **must** use:

- Sun plant
- Shade plant
- Bench lamp with 60 W bulb
- 5 filters (F1, F2, F3, F4, F5) which can be adjusted to allow different amounts of light to pass through
- 1% sodium hydrogencarbonate solution

You may select from the following apparatus and use appropriate additional apparatus:

- Normal laboratory glassware, e.g. a variety of different sized beakers, measuring cylinders, and syringes for measuring volumes
- Forceps
- Timer, e.g. stopwatch

Your plan should:

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

[Total: 14]

PREPARATION LIST

Question 1

Material	**Per Student**
Prepared yeast (5%) labelled **Y**	30ml
Ethanol labelled **E**	25ml
Glucose (0.2M) labelled **G**	20ml
Methylene blue (0.025%)	6ml
Hot water 80°C (**Point to student: either at the side bench in front or at the back of the lab. Lab staff will inform)**	Per lab

Apparatus/Item	**Per Student**
Boiling tubes	5
Small vials	5
Glass beaker for water bath (500ml)	1
Plastic beaker (100ml)	1
Plastic beaker (500ml)	1
Thermometer	1
Stopwatch	1
Syringe (5 cm^3)	4
Dropper (3ml)	1
Distilled water	1
Boiling tube rack	1
Glass rod	1
Marker	1

Question 2

Material	**Per Student**
Spinach stem	~2 strips
Sucrose solutions: S1 (0.2), S2 (0.4), S3 (0.6), S4(0.8) mol dm^{-3}	Enough for a Petri dish

Apparatus/Item	**Per Student**
Plasticine	Enough to secure 4 stems
Graph paper	1
Knife	1
White tile	1
Petri dish (without cover)	4
Stopwatch (From Qs 1)	1
Ruler	1
Marker (From Qs 1)	1
Tissue paper	1 roll
Microscope	1
Stage micrometer	1
K1 sample slide	**Instr to student: Shared per bench. Odd Seating index no. will use for the first 1hr 15 min followed by the even seating index no. the next 1 hr 15 min**.

Instr to students: Extra Reagent can be found on the teacher's bench. Raise your hands to ask for permission before coming to the front to take the reagent.

ACJC Prelim 2017
H2 Biology Paper 1 (9744/01) Answers

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

Name	Subject Class	Class	Candidate Number
	2BI		

ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2017

BIOLOGY **9744/02**
17 AUGUST 2017
HIGHER 2 **2 hours**

Paper 2

READ THESE INSTRUCTIONS FIRST
Write your name, index number and class on this answer booklet.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.

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

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total	100

This question paper consists of **22** printed pages.

For examiner's use

1 Fig. 1.1 shows part of a cell.

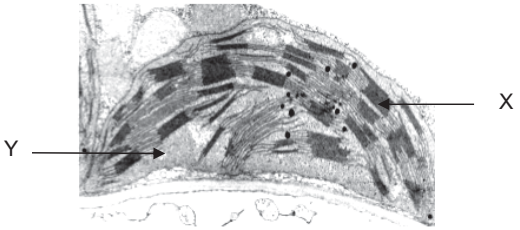


Fig. 1.1

(a) (i) Outline the role of the organelle labelled X.

1. Contain photosystem/ pigments for the synthesis of ATP and reduced NADP via light dependent reaction/ photophosphorylation;

2. For carbon fixation/ synthesis of glucose/ GALP via the Calvin cycle/ light-independent reaction; [2]

(ii) Explain the importance of the double membrane enclosing organelle X for the reactions that occur in the region labelled Y.

1. Increases the concentration of enzyme and/or substrate for higher rate of Calvin cycle;
2. Maintain optimum conditions for the enzymes in Calvin cycle;
3. Separate reactions of the Calvin cycle from incompatible reactions (in the cytoplasm like glycolysis);
R! reference to thylakoid membrane for production of H^+ pool
[2]

(b) (i) Plant cells are unable to carry out endocytosis due to the energy needed to overcome the turgor pressure in the plant cell. However, lysosome-like organelles can be found in the plant cells. Suggest reasons for their presence in plant cells.

1. Digest/ carry out autophagy of old and worn out organelles;

2. Break down macromolecules (by hydrolysis)/ digest ingested particles;

3. Autolysis/ apoptosis of cell; [2]

(ii) Outline how the lysosome is formed by the endomembrane system in a eukaryotic cell.

1. Transcription of genes coding for lysosomal proteins in the nucleus;
2. Synthesis of lysosomal proteins by ribosomes via translation on the RER;
3. Folding/post-translational chemical modification in the RER;
4. Transport of lysosomal proteins via transport vesicles from RER to GA
5. Post-translational chemical modification/modification, sorting and packaging of lysosomal proteins in the GA;
6. Vesicles containing lysosomal proteins pinches off GA to form lysosome;
[3]

For examiner's use

The chloroplast is a member of a larger family of plant organelles called plastids. All plastids, including chloroplasts, develop from proplastids. Fig. 1.2 shows the process of chloroplast development from a proplastid.

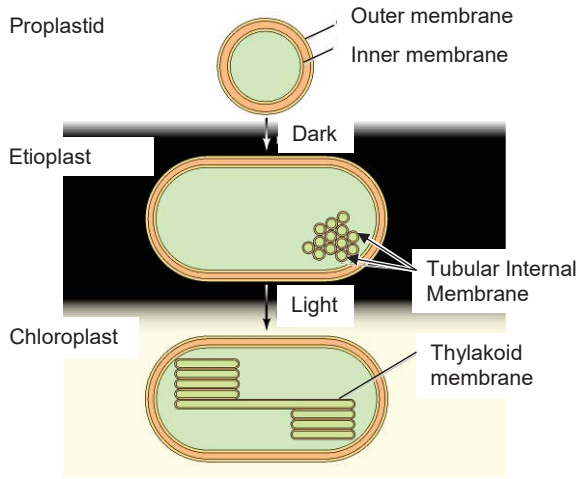


Fig. 1.2

(c) With reference to Fig. 1.2, suggest how thylakoid membranes are formed.

1. * Pinching / invagination + fusion of the inner membrane / budding of the inner membrane of proplastids;
2. Stimulated by transition from light to dark to form a tubular internal membrane / membrane tubules / vesicle;;
3. Light stimulates the tubules to form thylakoid membrane;
4. Elongation of tubules to form thylakoid membranes;
(Max. 1 from pts 1-2)

[2]

[Total: 11 m]

For examiner's use

2 Fig. 2.1 shows the formation of a bond in the synthesis of starch.

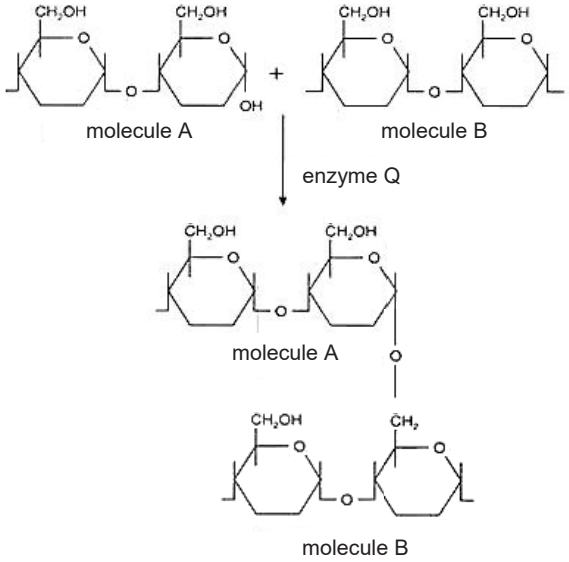


Fig. 2.1

(a) (i) Describe the formation of the bond in Fig. 2.1.

1. **α-1,6-glycosidic bond formed;**
2. **Between -OH groups of C1 of a glucose monomer in molecule A and C6 of a glucose monomer in molecule B;**
3. **Release of a water molecule via condensation reaction;**
4. **Catalysed by an enzyme Q;**

[2]

(ii) Explain how enzyme Q could lower the activation energy of the bond formation.

1. **Enzyme Q has an active site which is complementary/ specific to the substrates molecules A and B;**
2. **Resulting in the formation of an enzyme-substrate complex;**
3. **Orientates molecules A and B accurately for bond formation/ Increases proximity of molecules A and B for bond formation/ Active site provides suitable environment for condensation reaction/ distortion of bonds within molecule A and B;**
4. **Reactants require less energy to reach transition state;**

[3]

For examiner's use

Graph X shows the amount of the product formed over time for an enzyme-catalysed reaction (Fig. 2.2).

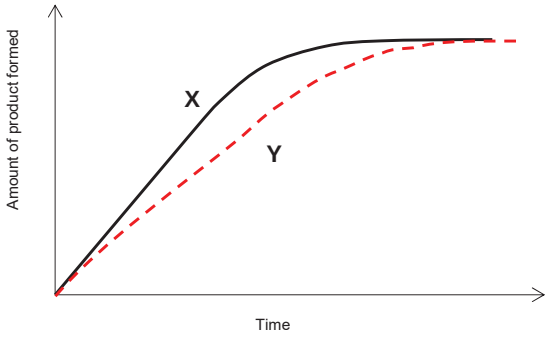


Fig. 2.2

(b) (i) Draw a graph, labelled Y, on Fig. 2.2 to show how a small amount of non-competitive inhibitor affects the amount of product formed over time. [1]

(ii) Explain the difference between graphs X and Y.

1. **Graph Y has a gentler gradient/ Lower rate of product formation / takes longer for final amount of product to be formed**
2. **Less free enzymes available as inhibitor binds to a site other than the active site (R! allosteric site);**
3. **Causing 3D conformation of enzyme to change, and enzyme active site is no longer complementary to the substrate;** [2]

[Total: 8m]

For examiner's use

3 The diagram below shows the structure of a mature tRNA for the amino acid alanine.

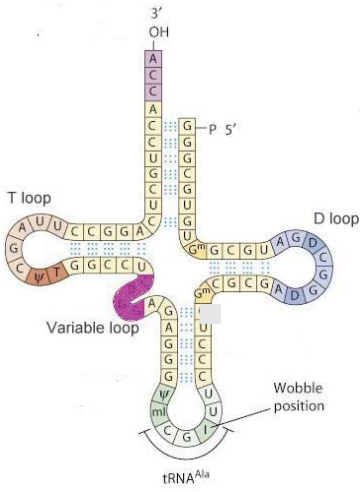


Fig. 3.1

(a) (i) Explain the roles of hydrogen bonds in the proper functioning of tRNA.

1. **Hydrogen bonds are formed between complementary base pairs allows folding of tRNA into (specific) 3D conformation / looped structures / clover-shape;**
2. **For stability (during activation and translation);**
3. **To fit into the complementary binding site of ribosome (P/A site) / active site of aminoacyl-tRNA synthase;**
4. **Hydrogen bonds form between anticodons on tRNA with complementary codons on mRNA;**
5. **To translate codon sequence into amino acid sequence;**

[4]

Note: mark once for concept of complementary base pairing

(ii) The length of the tRNA gene is longer than that of the mature tRNA. Outline how a tRNA molecule is synthesised in eukaryotes.

1. **RNA polymerase binds to promoter of tRNA gene to transcribe tRNA;**
2. **Introns are excised and exons are spliced together;**
3. **Folding of tRNA into clover shape via the formation of H bonds between complementary base pairs;**
4. **Addition of 3'CCA sequence by enzymes / addition and removal of 5' cap; (additional info)**

[3]

For examiner's use

An experiment was carried out to investigate the effects of various cytokines on a culture of CD34 cells. CD34 cells are hematopoietic progenitor cells which are produced in the early stage of differentiation to form mature immune cells from stem cells. Three types of cytokines, KF36EG, K36EG and F36EG, were used in the experiment as shown in Fig. 3.2.

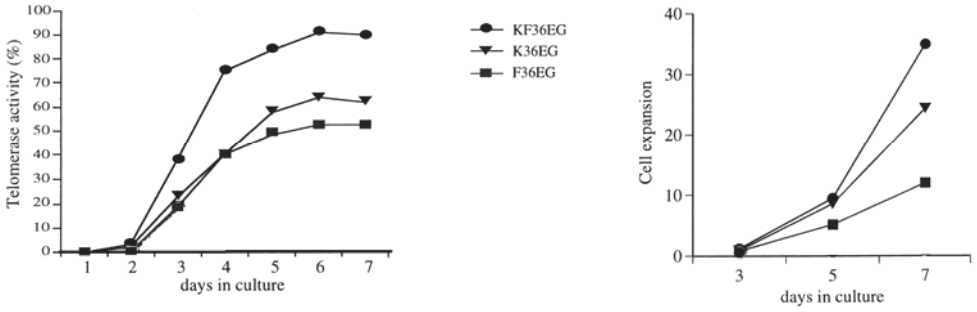


Fig. 3.2

(b) (i) With reference to Fig. 3.2, describe the effects of the types of cytokines on CD34 cells.

1. *** All three cytokines led to an increase in telomerase activities (from day 0 to day 7) + All three cytokines led to an increase in cell expansion from day 3 to day 7;**
2. **KF36EG caused the highest increase in telomerase activities as compared to K36EG and F36EG + KF36EG caused the highest rate of cell expansion at 35 a.u. as compared to K36EG (24 a.u) and F36EG (11 a.u);**
3. **Reference to data with comparison;** Refer to data (max. 1 m)
   Telomerase activity increases from 3% to 90% from day 2 to day 7 for KF36EG + Telomerase activity increases from 3% to 60% from day 2 to day 7 for K36EG / Telomerase activity increases from 3% to 52% from day 2 to day 7 for F36EG;
4. **Rate of increase of telomerase activities decreased from day 4 to day 7;**

[3]

**** Compulsory point***

(ii) With reference to Fig. 3.2, comment on the role of cytokines on the CD34 cells.

1. **Cytokine is a signalling molecule;**
2. **That promotes mitosis/proliferation/cell expansion (and differentiation) of CD34 cells;**
3. **By increasing the rate of transcription / activity of telomerase in CD34 cells;**
4. **Allows CD34 cells to lengthen telomeres for subsequent rounds of DNA replication;**

[2]

For examiner's use

(c) Discuss the accuracy of the following statement:

"Stem cells and cancer cells are able to divide indefinitely as there is no end replication problem due to the presence of active telomerase."

1. **Stem cell and cancer cells are able to divide indefinitely due to the presence of active telomerase is accurate;**
2. **So as to prevent triggering of replicative senescence as length of telomeres is maintained;**
3. **However, there is end replication problem in both cells;**
4. **As DNA polymerase cannot synthesise a complementary DNA strand from scratch / DNA polymerase requires a primer / an free 3' OH end of an existing strand to synthesise a complementary strand;**
5. **Hence the 3' end of the leading strand will not be fully replicated (forming an overhang);**
6. **Active telomerase can only lengthen the 3' end for DNA replication to prevent erosion of genes due to end replication problem;**
7. **Cells would also require other factors such as ATP and nutrients for replication / AVP;** [4]

[Total: 16 m]

For examiner's use

4 The coat colour of Norwegian cattle is mainly determined by the distribution of two pigments: red and black. Both pigments are produced by the action of the enzyme tyrosinase in cells called melanocytes. Low enzyme activity leads to the production of red pigment, while high enzyme activity brings about black pigment production.

The activity of the enzyme is increased when melanocyte stimulating hormone (MSH) combines with a MSH receptor. The receptor is coded for by the gene, **R**, which has three alleles, $\mathbf{R^D}$, $\mathbf{R^A}$ and **r**. $\mathbf{R^D}$ and $\mathbf{R^A}$ each codes for a receptor with a different activity. No receptor is produced by the recessive allele, **r**.

The dominant allele of a second gene, **B**, codes for a protein which binds to and blocks the MSH receptors coded for by $\mathbf{R^A}$, thus preventing stimulation of tyrosinase activity in a melanocyte. The receptors coded for by $\mathbf{R^D}$ is insensitive to the protein coded by **B**. The recessive allele, **b**, does not produce a functional protein.

(a) (i) State the name given to the interaction between the **R** and **B** gene loci.

Epistasis; [1]

(ii) Explain why animals with the genotype $\mathbf{R^AR^ABB}$ have red coats.

Inhibitor / Protein that blocks MSH receptor coded for/produced and hence MSH unable to bind to its receptor to increase/stimulate tyrosinase / enzyme activity; [1]

(iii) A red cow, with genotype $\mathbf{R^AR^ABB}$ is mated with a bull which is homozygous recessive at both gene loci.

Draw a genetic diagram in the space below to show the expected genotypes and phenotypes and their ratios in the F_1 and F_2 generations.

Parent phenotypes	**Red bull**	**x**	**Red cow**
Parent genotypes	**rrbb**		$\mathbf{R^AR^ABB}$
Gametes	**rb**		$\mathbf{R^AB}$
F_1 genotype	$\mathbf{R^ArBb}$		
F_1 phenotype	**All red**		
F_1 cross	$\mathbf{R^ArBb}$	**x**	$\mathbf{R^ArBb}$
F_1 gametes	$\mathbf{R^AB}$ $\mathbf{R^Ab}$		**rB** **rb**

Nucleus

For examiner's use

Punnett Square:

	(R^{A}B)	(R^{A}b)	(rB)	(rb)
(R^{A}B)	R^{A}R^{A}BB Red	R^{A}R^{A}Bb Red	R^{A}rBb Red	R^{A}rBb Red
(R^{A}b)	R^{A}R^{A}Bb Red	R^{A}R^{A}bb Black	R^{A}rBb Red	R^{A}rbb Black
(rB)	R^{A}rBB Red	R^{A}rBb Red	rrBB Red	rrBb Red
(rb)	R^{A}rBb Red	R^{A}rbb Black	rrBb Red	rrbb Red

F_2 phenotypic ratio 13 red coat : 3 black coat

[5]

Mark allocation:
1. **Correct parent gametes;**
2. **Correct F_1 phenotype and genotype;**
3. **Correct F_1 gametes;**
4. **Correct F_2 phenotypes and genotypes in Punnett square;**
5. **Correct F_2 phenotypic ratio;**

During a health screening exercise of cattle in a farm, the height of the bulls was measured and the data collected is shown in Table 4.1.

Table 4.1

Height/cm	Number of bulls
131—135	3
136—140	9
141—145	21
146—150	12
151—155	2

For examiner's use

(b) Distinguish between the two types of variation shown in coat colour and height in the Norwegian cattle.

1. * Coat colour shows discontinuous variation	**While height shows continuous variation;**
2. Discrete phenotypic classes and no intermediates are observed	**A range of phenotypes are observed;**
3. Coat colour is controlled by one or two major genes, which may have two or more allelic forms.	**Height is controlled by a large number of genes (polygenes);**
4. Effect of individual genes can be observed.	**Effect of individual genes cannot be observed;**
5. Effect of genes is not additive.	**Effect of genes is additive;**
6. The environment has a small effect on the phenotype.	**Environment has a large effect on the phenotype;**

**** Compulsory point;***

[3]

In the honey bee colony, the queen bee is solely responsible for laying eggs and the drones for fertilizing her. The worker bees have well-developed mouthparts and structural adaptations for collecting nectar and pollen to gather food and to perform other duties in the hive. Male bees are developed from haploid eggs while both queen and worker bees develop from fertilized eggs.

(c) Explain how the phenotypic differences between the queen and the worker bees come about despite both being developed from fertilized eggs.

1. The different diets brought about differences in gene expression in cells, resulting in the phenotypic differences;

2. Larvae fed on diet of royal jelly throughout development become queen bees while those fed on worker jelly become worker bees; [2]

[Total: 12 m]

For examiner's use

5 Normal cells rely on oxidative phosphorylation in the mitochondria to generate the energy needed for cellular processes. In contrast, cancer cells undergo a phenomenon termed the "Warburg effect". This is characterised by an increased glucose uptake and reliance on glycolysis for ATP production despite the availability of oxygen for oxidative phosphorylation. Most of the pyruvate is converted to lactate instead of being broken down in the mitochondria (Fig. 5.1).

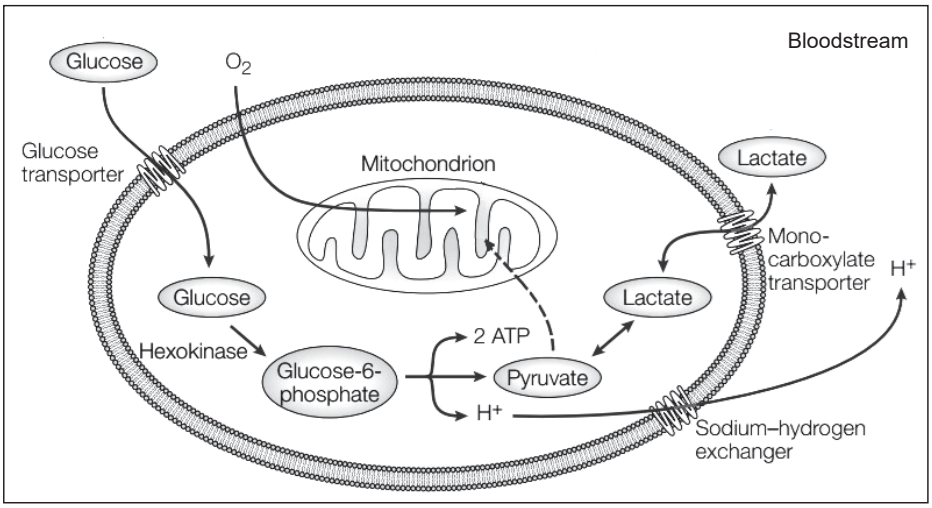


Fig. 5.1

(a) (i) Outline the role of glycolysis in normal cells.

1. **Produces net gain of 2 ATP;**
2. **By substrate-level phosphorylation;**
3. **Reduced NAD for oxidative phosphorylation;**
4. **Breaks down glucose into (two molecules of) pyruvate which can enter the mitochondria and is further broken down in link reaction / Krebs cycle;** [3]

(ii) With reference to Fig 5.1 and your own knowledge, suggest why the "Warburg effect" may seem disadvantageous to the survival of the cancer cell.

1. **Only net gain of 2 ATP produced as compared to 32 / many ATP under complete oxidation of glucose;**
2. **Consistent acidification of bloodstream due to H^+ which might result in cellular toxicity;** [1]

Note: 1 reduced NAD and 1 reduced FAD yields 2.5 and 1.5 ATP respectively.

For examiner's use

In cancer cells, the "Warburg effect" is constitutively upregulated even under normal levels of oxygen. It is thought to be due to the reprogramming of metabolic genes to increase glucose consumption. In a research experiment, the mean glucose consumption rate of MCF-7 breast cancer cells is compared with that of the relatively more aggressive MDA-MB-231 breast cancer cells under normal and low oxygen levels (Fig. 5.2).

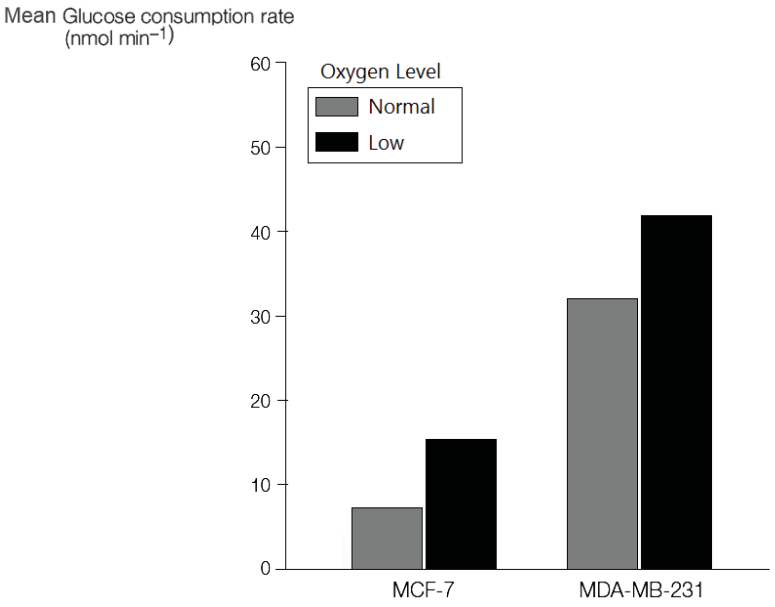


Fig. 5.2

(b) Describe the differences in the mean glucose consumption rate between MCF-7 and MDA-MB-231 cancer cells.

1. **Mean glucose consumption rate of MDA-MB-231 cells is higher than that of MCF-7 cells under both low and normal oxygen levels;**
2. **[Quote data] Under normal O_2 levels, MDA-MB-231 cells consume an average of 32 nmol min^{-1} which is higher than 7 nmol min^{-1} OR 25 nmol min^{-1} higher;**
3. **[Quote data] Under low O_2 levels, MDA-MB-231 consume an average of 42 nmol min^{-1} is higher than 15 nmol min^{-1} OR 27 nmol min^{-1} higher;** [3]

For examiner's use

The mTOR intracellular signalling pathway is critical for control of cell growth. Fig. 5.3 shows the signalling system that drives cell growth through greatly stimulating glucose uptake and utilisation in a normal cell.

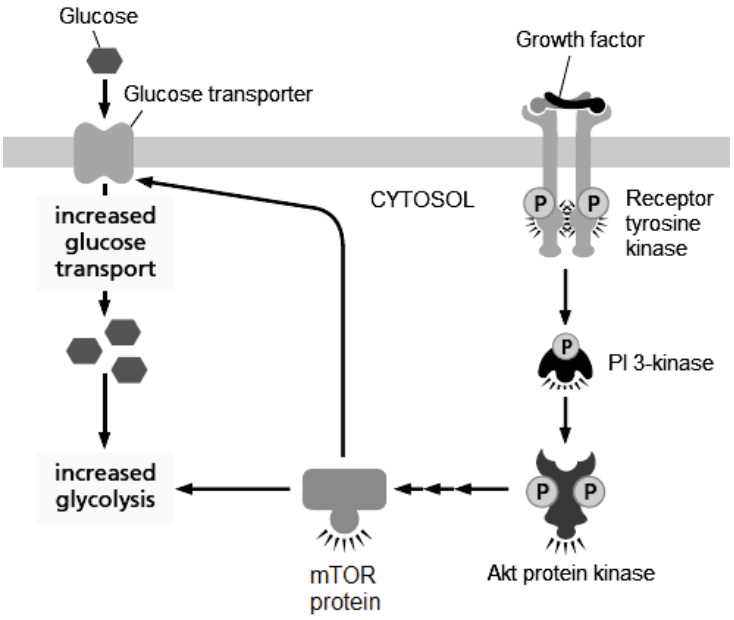


Fig. 5.3

(c) (i) Describe how the binding of the growth factor to the receptor tyrosine kinase leads to the cellular responses in Fig. 5.3.

1. **Receptor tyrosine kinase dimerises and is activated;**
2. **then crossphosphorylates tyrosine residues on cytoplasmic tails;**
3. **Phosphorylates protein kinases such as PI 3-kinase / Akt protein kinase and activating them, and activated Akt protein kinase;**
4. **Which activates other protein kinases via a phosphorylation cascade;**
5. **Last protein kinase in phosphorylation cascade activates mTOR protein, increasing glucose transport / glycolysis;** [3]

(ii) Cancer cells are able to proliferate in the absence of growth factors. Suggest how the ability to do so can lead to the "Warburg effect".

Gene for receptor tyrosine kinase / PI-3 kinase / Akt / mTOR is mutated such that it is constitutively/always activated / AVP; [1]

[Total: 11 m]

For examiner's use

6 Fig. 6.1 shows the different stages of meiosis in a cell.

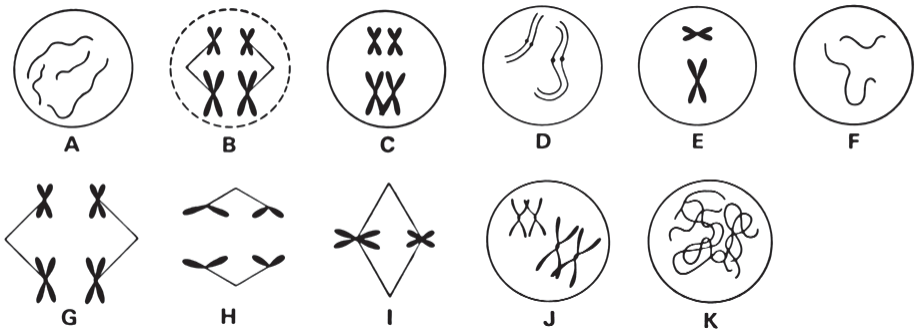


Fig. 6.1

(a) (i) Arrange the stages in chronological order. [1]

K	A	**D**	J	C	**B**	G	E	I	H	F

Need to get all correct to be awarded 1 m

(ii) With reference to Fig. 6.1, identify a stage which is critical for a reduction division and explain why.

1. C – metaphase I;
2. Bivalents/ homologues line up along metaphase plate in 2 rows/ homologous pair line up along metaphase plate, allowing only one homologue to be present in each daughter cell at the end of meiosis I/ chromosome number is halved;
OR
3. B/G – anaphase I;
4. Separation of homologues/ homologous chromosomes results in only one homologue in each daughter cell at the end of meiosis I / chromosome number is halved; [2]

(iii) Explain how reduction division contributes to variation in diploid organisms.

1. Independent assortment results in different combinations of paternal and maternal chromosomes in the gametes;
2. Crossing over results in different combinations of alleles in the gametes;
3. Random fusion of haploid gametes will increase variation;
[2]

@1m, max 2

For examiner's use

Some patients with the Prader-Willi syndrome have both chromosomes 15 from their mother due to an error in meiosis. Fig. 6.2 shows the possible combinations of chromosomes 15 that could be present in the gametes of the mother.

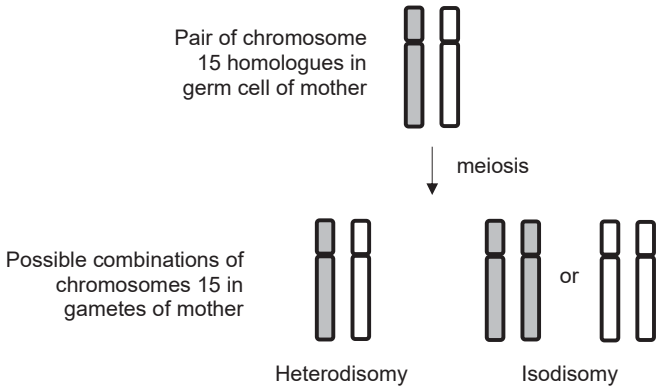


Fig. 6.2

(b) Explain how a gamete with heterodisomy of chromosome 15 could have been formed.

1. **Non-disjunction/ both homologues moved to the same pole;**
2. **In meiosis I / anaphase I of meiosis (where one daughter cell contains both homologues at the end of meiosis I and the other has no chromosome 15);**
3. **In meiosis II / anaphase II, chromatids of each homologue separate (and both daughter cells contain both homologues at the end of meiosis II);** [3]

[Total: 8 m]

For examiner's use

7 The structure of a G-protein-linked receptor (GPLR) is shown from two different views in Fig. 7.1 below. Fig. 7.1a shows a GPLR from a cross section of the plasma membrane while Fig. 7.1b shows the top view of a GPLR.

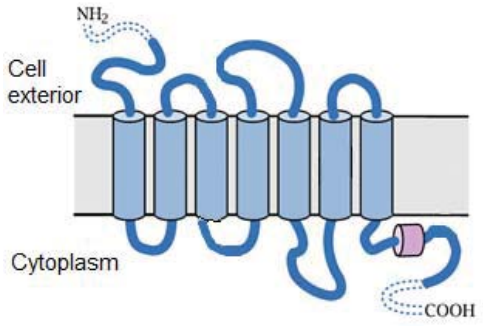


Fig 7.1a

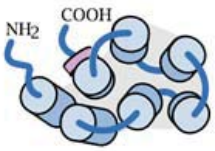


Fig 7.1b

(a) **(i)** State and explain the highest level of organization of the GPLR.

1. Tertiary structure;
2. A single polypeptide chain (shown by one NH_2 COOH group) is folded into a globular structure / 3D conformation. [2]

(ii) Identify a hydrophilic domain of the GPLR and describe its corresponding function.

1. The binding site for signal molecule (facing exterior of the plasma membrane)
2. This allows signal molecule to bind and trigger conformational change in GPLR, activating it.
3. The binding site for G protein (facing cytoplasmic face of the plasma membrane).
4. Activated GPLR binds to G protein and activates G protein when GTP displaces GDP.

**** Points 1 & 2, or points 3 & 4***

[2]

For examiner's use

Recent studies have found that GPLRs have alternative binding sites other than the ligand-binding sites. Allosteric molecules bind to these alternative binding sites to change cellular response levels. One such molecule has been found to bind to the GPLR specific to glucagon.

One of the normal cellular responses of glucagon binding is the inhibition of glycogenesis. The rate of glycogenesis with and without the allosteric molecule is shown in Fig. 7.2.

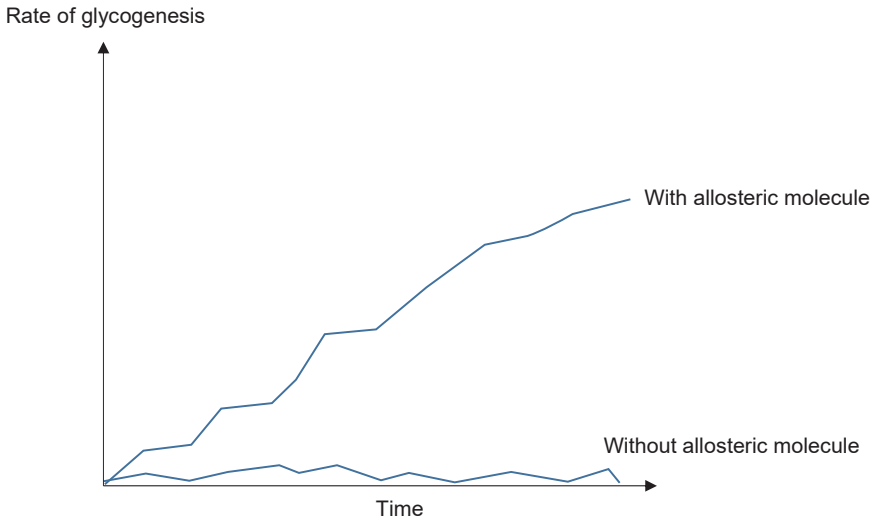


Fig. 7.2

(b) (i) Based on the information above, state if the allosteric molecule is an activator or an inhibitor of GPLR.

Inhibitor; [1]

(ii) Explain the effect of the allosteric molecule on the rate of glycogenesis.

1. **With the binding of the allosteric inhibitor, the rate of glycogenesis steadily increases;**
2. **When the allosteric inhibitor binds, 3D conformation of GPLR changes;**
3. **G protein (is no longer complementary to and) will not be able to bind to and activate adenyl cyclase;**
4. **Adenyl cyclase will not produce cAMP, the second messenger;**
5. **cAMP will not be able to bind and activate Protein Kinase A and the phosphorylation cascade will not occur;**
6. **Glycogen phosphorylase will not be activated, thus glycogenolysis will not occur;** [5]

[Total: 10 m]

For examiner's use

8 Speciation events have been observed to occur very frequently in bacteria. It was suggested that the high rate of speciation is due to the high level of variation in bacteria.

(a) Transformation and conjugation are two processes which increase the level of variation in bacteria.

Distinguish these two processes.

	Conjugation	Transformation
Genetic material being transferred	**1. Transfers the F plasmid or R plasmid**	**1. Transfers fragments of the bacterial chromosome;**
Donor cell	**2. Donor cells are F^+ cells / carries the F plasmid or R plasmid;**	**2. Donor cells may be lysed cells that releases its DNA;**
Recipient cell	**3. Recipient cells are F^- cells / do not carry the F plasmid or R plasmid;**	**3. Recipient cells must be competent / secrete the competence factor;**
Physical contact	**4. Direct physical contact required between two cells through sex pilus;**	**4. No physical contact required between cells / exogenous DNA taken up directly by recipient cell;**

[3]

Bacterial evolution is one of the most dynamic and exciting areas in current biological research.

Over the years, a barrier in this field of research is the difficulty in classifying bacterial species. However, in recent times, new analytical tools in molecular biology have offered new insights into the classification of bacterial species.

(b) (i) Suggest why scientists had difficulties in the classification of bacterial species.

1. Bacteria reproduce asexually / by binary fission;
2. Unable to determine between species according to biological species concept / bacteria are unable to interbreed to produce fertile viable offspring;
3. Horizontal gene transfer/transformation/conjugation between relatively distantly related bacteria / different bacterial species (OWTTE);
4. Results in high rates of recombination, making it difficult to determine a single species;
5. Different species may be morphologically similar;

[2]

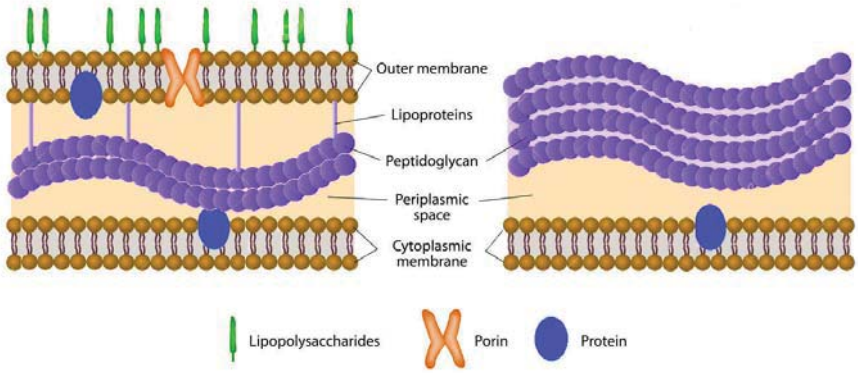
(ii) Explain how analytical molecular tools have helped overcome this barrier in research.

1. Molecular tools have helped determine genetic sequences of bacteria / compare genetic sequences of bacteria;
2. Allowing scientists to classify bacteria according to genetic distance / phylogenetic distance;
3. Provides an objective method (to determine genetic distance);
4. Data obtained is quantitative;
5. Hence more sensitive to differences between species / data could be used for statistical analyses;

[2]

For examiner's use

(c) The outer layers of the two types of bacteria with peptidoglycan cell walls known as Gram-positive and Gram-negative bacteria are shown in Fig. 8.1 below.



Gram-negative bacteria **Gram-positive bacteria**

Fig. 8.1

Penicillin is an antibiotic that is known to be effective against only one of the two types of bacteria above.

With reference to the information given and your own knowledge, deduce which type of bacteria is susceptible to the action of penicillin and explain why.

1. Penicillin is effective only against gram-positive bacteria;
2. Gram-negative bacteria have an outer membrane (and lipoproteins) (that surrounds the peptidoglygan layer of the cell wall) / penicillin can directly access the peptidoglycan cell wall in gram-positive bacteria;
3. Preventing the action of penicillin as penicillin inhibits the crosslinks in peptidoglycan cell wall; [3]

(d) Explain how antibiotic-resistant bacteria can become increasingly common in a population of bacteria.

1. **Horizontal gene transfer (transformation, transduction, conjugation) occurs which increases genetic variation in the bacteria;**
2. **Genetic variation exists in the form of antibiotic sensitivity and antibiotic resistance;**
3. **Antibiotics act as selection pressure;**
4. **Non-resistant bacteria are selected against / bacteria which are resistant to antibiotics are selected for / they have a selective advantage;**
5. **Allele coding for antibiotic resistance passed down to subsequent generations of bacterial cells (during binary fission);**
6. **Over many generations, frequency of allele coding for antibiotic resistance increases in the gene pool;**

[4]

[Total: 14 m]

For examiner's use

9 Cyanobacteria are aquatic blue-green bacteria which are highly similar to algae as they can obtain their energy through photosynthesis. They are typically found in tropical waters due to their ability to thrive in bright and warm areas. Generally found on the surface of lakes and oceans, they can reproduce exponentially and cause a rapid increase in their population known as blooms. Certain genera of blooming cyanobacteria such as *Microcystis* can produce cyanotoxins which, in high concentrations, can poison and even kill animals and humans.

A study was conducted to find out the effects of temperature on the maximum growth of *Microcystis aeruginosa* as well as three other harmless green algal species (P, Q and R) which are a main source of food for aquatic animals (Fig. 9.1). The global mean sea surface temperature anomalies, which indicate differences in temperature when compared to the baseline temperature in 1880 were also recorded (Fig. 9.2).

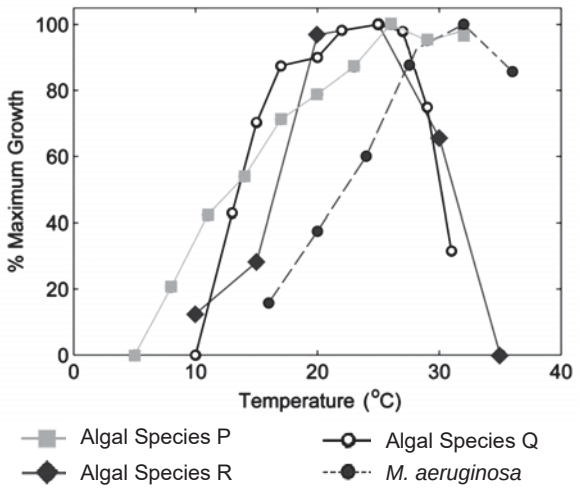


Fig. 9.1

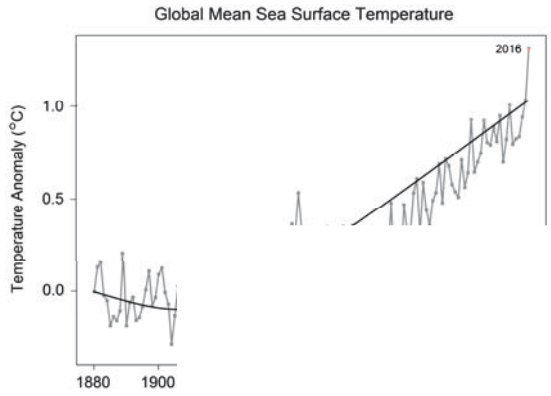


Fig. 9.2

For examiner's

(a) Describe the effect of temperature on the maximum growth of *M. aeruginosa*.

1. **Maximum growth increases from 18% to 100% from 16 to 33ºC;**
2. **And decreases from 100% to 84% from 33 to 37ºC;** [2]

Commented [LKM1]: Students must be able to identify different parts of the graph and explain them, while identifying trends (increasing trend)

(b) Explain how human activities could have contributed to an increase in sea surface temperatures.

1. **Burning of fossil fuels such as coal, natural gas and oil releases greenhouse gases such as CO_2 and CH_4, causing global temperatures to rise;**
2. **Deforestation leads to diminishing carbon sink, and burning of trees and soil disturbance releases CO_2;**
3. **Due to increased meat consumption, more livestock is reared which releases CH_4 due to enteric fermentation;**
4. **Hence increases in global temperatures will lead to increase in sea surface temperatures;** [3]

Commented [LKM2]: Direct recall from LO – students have to phrase their answers in the context of SST

(c) With reference to the information provided, discuss the impact of *M. aeruginosa* on the global food supply of humans in the future.

1. **May adversely affect food supply;**
2. **Fig. 9.1 shows increasing trend of maximum growth of *M. aeruginosa* with increasing temperatures before 33ºC;**
3. **Where SST is increasing as shown in Fig. 9.2 by an increase of 1.4ºC / 1.0ºC from 1880 to 2016;**
4. **Cyanotoxins produced by blooming *M. aeruginosa* harm fishes, hence affecting fisheries and fish supply for humans;**
5. **Cyanobacterial distribution will expand polewards and affect more fisheries in temperate areas as well;**
6. **Blooms of *M. aeruginosa* may also act as competition with other algal species which may be a food source for other fish;**
7. **May not adversely affect food supply;**
8. **Fig. 9.1 shows decreasing maximum growth of *M. aeruginosa* beyond 33ºC;**
9. **Due to denaturation of enzymes and hence metabolic rate;**
10. **As *M. aeruginosa* is unable to survive at higher temperatures;** [5]

Commented [LKM3]: Similar to CA2 Q phrasing, where student can try to provide evidence where global food supply may be increased or decreased / assess validity of information in making such a claim

[Total: 10 m]

Name	Subject Class	Class	Candidate Number
	2BI		

ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2017

BIOLOGY **9744/03**
Long Structured and Free-response Questions **21 Aug 2017**
PAPER 3 **2 hours**

Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

Write your name, subject class, form class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

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

Section B
Answer any **one** question in the spaces provided on the Writing Paper.

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

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

FOR EXAMINER'S USE	
1	
2	
3	
4 / 5	
TOTAL	**75**

This document consists of **17** printed pages.

For Examiner's Use

Section A

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

1 Dengue viruses (DENV) are responsible for millions of infections each year in tropical and subtropical areas of the world. According to the World Health Organization, dengue incidence has increased significantly over the past 50 years, turning this infection into the most important mosquito-borne disease in the world and a global health challenge. Fig. 1.1 shows the general global distribution of dengue fever in the year 2005.

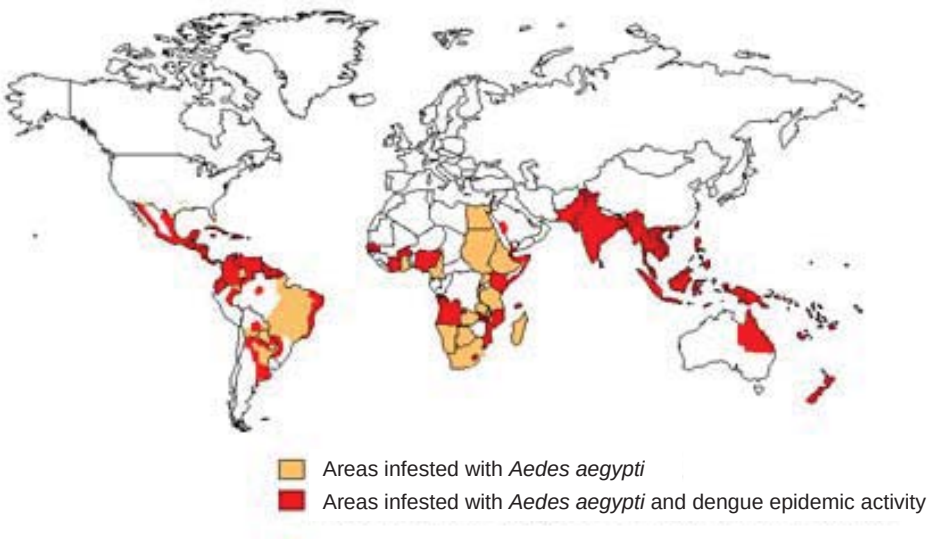


Fig. 1.1

(a) (i) Climate is one of the important factors that affects the distribution of dengue.

Predict and justify the expected distribution of dengue by the end of the 21st century.

1. Geographical range of Aedes mosquito (vector) and dengue will expand towards the two poles/ to areas infested with mosquitoes;

2. As global temperature is predicted to rise (by 4°C)/ global warming/ climate change due to (increase in greenhouse gas emission);

3. resulting in favourable temperatures for mosquito breeding/ suitable breeding places in the temperate regions/ increased viral load/ higher rate of DENV replication;

[3]

For Examiner's Use

(ii) Symptoms of dengue such as fever usually develop within 4 to 7 days after being bitten by an infected mosquito and is often associated with joint pain.

Explain how DENV may cause these symptoms.

1. Virus stimulates/ activates <u>innate/ non-specific</u> immune response/ immune cells (e.g. dendritic cells) in the first four days;

2. Interferons/ cytokines/ histamine released result in inflammation, causing pain;

3. Pyrogen released by activated macrophages leads to rise in systemic body temperature resulting in dengue fever;

***Award mark only when reference is made to respective symptoms**

[3]

For Examiner's Use

During an infection, DENV will elicit a primary humoral immune response which involves B cell activation as shown in Fig. 1.2.

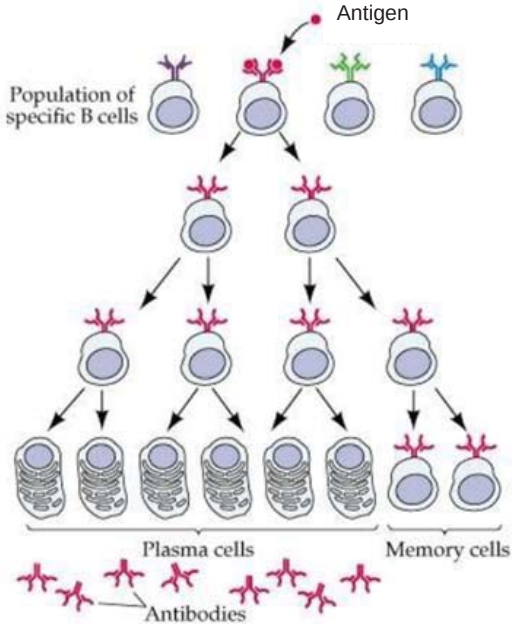


Fig. 1.2

(iii) With reference to Fig. 1.2 and your own knowledge, explain the significance of mitosis in B cell activation.

1.* Clonal expansion occurs via mitosis to produce genetically identical daughter cells;

2. This results in increased/ faster production of antibodies/ memory cells/ plasma cells

3. which can bind to complementary/ specific antigen present;

4. to mediate fast clearance/ destruction of pathogen/ increased rate of phagocytosis/ faster response during secondary infection;

5. Somatic hypermutation during clonal expansion results in antibodies with increased affinity to antigen;

***Compulsory point**

[3]

For Examiner's Use

(iv) Memory B cells have long life spans because they do not actively undergo cell division. However, upon activation, a memory B cell can undergo many rounds of proliferation.

Suggest why activated memory B cells can undergo multiple rounds of cell division without dying.

1. Length of telomeres maintained due to active telomerase/ expression of telomerase upon activation;

R! Length of telomere very long

[1]

For Examiner's Use

(b) Bacteria has a natural defence system against viral infections involving RNA sequences known as clustered regularly interspaced short palindromic repeats (CRISPR).

When the bacteriophage infects a bacterial cell, the viral genome released into the bacterial cell is cleaved. Subsequently, a cleaved portion of the viral genome is integrated into the bacterial genome. The bacterial cell detects the phage DNA integrated within its genome and produces a type of RNA known as the CRISPR RNA. The CRISPR RNA contains a sequence that is complementary to that of the integrated phage DNA. When the next phage infects the same bacterial cell, the CRISPR RNA will bind to its target sequence in the viral genome and a nuclease is recruited to cut the phage DNA, disabling the invading phage.

The sequence of the CRISPR RNA can be edited and subsequently used to cut any DNA sequence at a precisely chosen site in eukaryotic cells. This gives rise to the possibility of correcting mutations associated with genetic disorders. Fig. 1.3 shows how the sequence of a defective allele can be replaced with the sequence of a normal allele from a donor DNA via homologous recombination using the CRISPR technology.

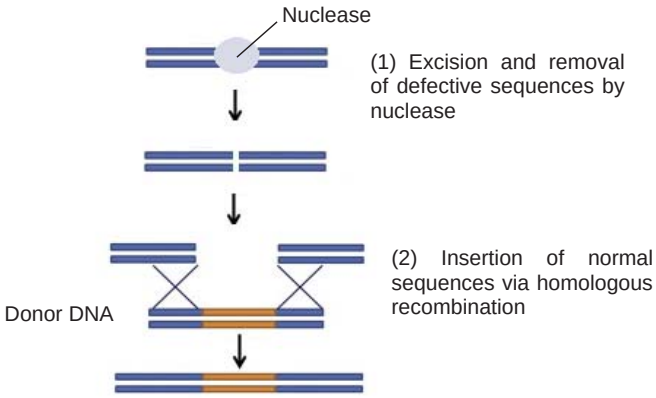


Fig. 1.3

(i) The specificity of CRISPR-mediated immunity in prokaryotes could be applied to eukaryotic cells to make precise changes in the genes of organisms.

Explain why the CRISPR RNA in prokaryotes can also be used in eukaryotic cells.

1. Universal/ similar types of nucleotides (A, U, C, G)/ nucleic acid/ Eukaryotes also contain DNA as its genome; (mark for identify nature of genome)

2. where A is paired with U and C is paired with G via complementary base pairing;

[2]

For Examiner's Use

(ii) Another technology that can be used to treat genetic disorders is gene therapy. Similar to the CRISPR technology, gene therapy involves the introduction of normal alleles into patients. However, it does not involve the excision and removal of defective alleles. Hence, it can only be used to treat recessive genetic disorder.

With reference to Fig. 1.3, explain the advantages of using CRISPR technology to treat genetic disorders over gene therapy.

1. CRISPR technology can be used to treat both <u>dominant</u> and recessive genetic disorders;

2. as nuclease creates a <u>double stranded break</u> in the DNA to remove the dominant <u>alleles</u> (and gene function is restored when normal alleles are inserted via homologous recombination);
R! dominant genes

3. However, insertion of normal alleles in gene therapy is unable to treat dominant genetic disorders as only a copy of dominant allele is required to show its effect in patients;

4. Normal alleles introduced during gene therapy can be degraded overtime/ temporary/ may not be integrated in the genome vs. long lasting treatment/ one treatment required for CRISPR;

5. CRISPR successfully correct the genetic disorder such that subsequent generations of cells are normal while gene therapy can only affect one generation of cells;

6. Gene therapy has a risk of insertional mutagenesis (if retrovirues are used as a vector) while CRISPR does not have this risk;
7. as in gene therapy, insertion is not specific while in CRISPR, insertion is specific/ precise;

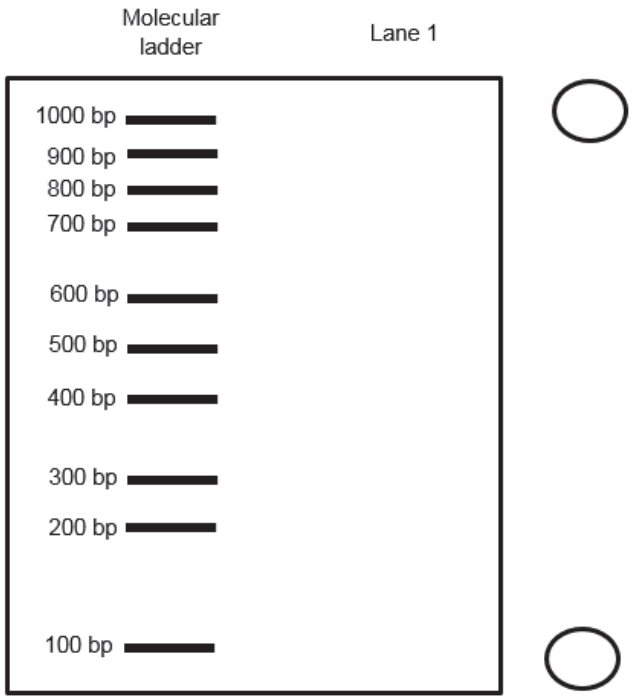
[3]

For Examiner's Use

Polymerase Chain Reaction was used to amplify a gene of 1000 bp. Fig. 1.4 shows the resultant DNA fragment produced. A CRISPR RNA is designed to target a specific sequence found within the gene. The sites of excision by the nuclease are indicated by the arrows. Gel electrophoresis can be used to verify if the target sequence is cut at the precise sites by the nuclease.

Fig. 1.4

(iii) On the electrophoregram below, draw the expected results after the cut fragments are separated if there is specific binding of CRISPR RNA to target sequence in Lane 1. Indicate the charge of the electrodes clearly in the circles on the side of the electrophoregram.



1. A single band at 600, 300, 100 bp position of similar thickness; R! width of band is double
2. Correct labelling of the terminals; [2]

For Examiner's Use

Fig. 1.5 shows an electrophoregram obtained by a student following excision of the same gene by a nuclease.

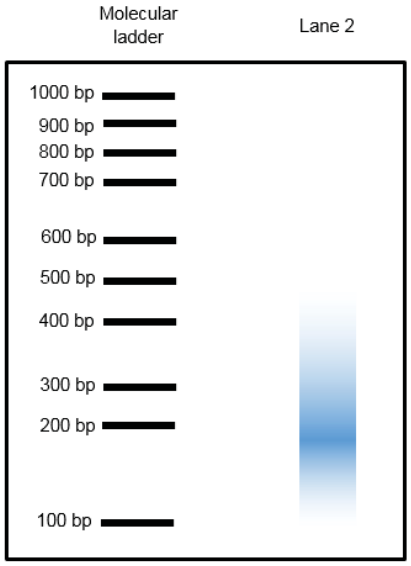


Fig. 1.5

(iv) Suggest how the smear is obtained in Fig. 1.5.

1. Fragments of varied sizes are produced;
2. due to non-specific excision of target sequence;
3. as CRISPR RNA designed is not specific;

[1]

(v) Geneticists attempted to edit the gene responsible for β-thalassaemia, a potentially fatal blood disorder, in human embryos using the CRISPR technology. However, the experiment was terminated prematurely due to a number of unintended mutations and numerous ethical controversies.

Discuss the ethical implications of the application of CRISPR technology on genes in embryos.

1. Permanently changes the genetic makeup of an individual / and future generations;
2. may result in human trait selection/ genetic enhancement/ ref. eugenics by selecting characteristics of offspring;
3. Unintended killing of embryos which is considered a life;
4. Source of embryos may be obtained from donors which did not give their consent;
5. Failure to make informed decisions due to inadequate understanding of the risks associated with technology;
6. Exploitation of women for their oocytes (R! embryos);
7. Experiments using embryos may lead to the killing of embryos and this can desensitize community;

[2]

For Examiner's Use

(c) One of the three tenets of the cell theory states that all living organisms are composed of one or more cells. Non-cellular life forms such as viruses challenge this tenet as they possess both living and non-living characteristics. The recent discovery of giant viruses, known as Mimiviruses, led scientists to rethink the origin of life and viral evolution. The features of the Mimivirus are as described.

1. It contains a double-stranded DNA genome of approximately 1.2 million base pairs which is significantly larger than the genomes of any other known virus and comparable to a cell.
2. It has some genes which show a high degree of homology to those in bacteria, while some show a high degree of homology to those in eukaryotes.
3. It contains a number of protein-coding genes showing high degree of homology to genes coding for products involved in translation, such as aminoacyl-tRNA synthetases and translation initiation factors. It also contains genes associated with metabolic pathways, DNA repair, and protein folding. However, it is still dependent on its host for translation.

Suggest how Mimiviruses evolved and use the above statements to support your hypotheses.

1. From statement 1: The size and nature of mimivirus genome is similar to a cell;
2. suggesting that it may have evolved from cells;
3. From statement 2: Mimivirus have similar genes/ high degree of homology as genes from as bacteria and eukaryotes;
4. suggesting that mimivirus may acquire genes from cells via horizontal gene transfer;
5. that may have preceded eukaryotes and prokaryotes/ share a common ancestor as eukaryotes and prokaryotes;
5. From statement 3: Mimivirus still depends on the host for translation despite having genes that encodes certain components of translation;
6. suggesting that some of the genes coding for previously complete processes may be lost as it becomes more dependent on its host;

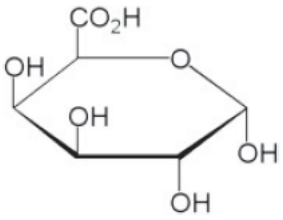
[4]

[Total: 24]

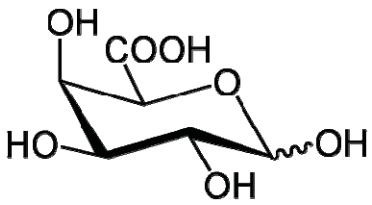
For Examiner's Use

2 Prebiotics is defined as 'an ingredient that results in specific changes in the composition and activity of microbials in the gut thus improving host health'. Prebiotics are non-digestible oligosaccharides that can be selectively fermented by gut bacteria. Currently, most prebiotics are derived from the hydrolysis of simple polysaccharides. Therefore, to develop novel prebiotics, an alternative resource of polysaccharides that supplies oligosaccharides with more diverse and complex structures is required. One of these polysaccharides is pectin.

Fig. 2.1 shows the schematic diagram and natural occurring configuration of D-galacturonic acid, the monomer of pectin. The structure of pectin, a polysaccharide is shown in Fig. 2.2.



Schematic diagram



Natural occuring configuration

Fig. 2.1

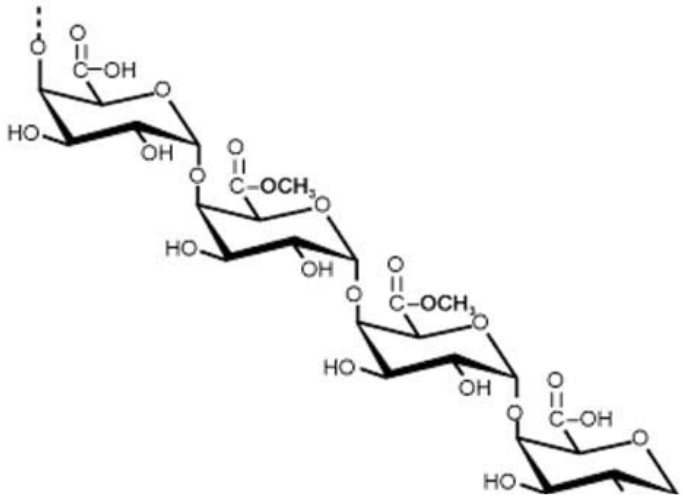


Fig. 2.2

For Examiner's Use

(a) With reference to Fig. 2.1 and 2.2, state two structural differences between cellulose and pectin.

1. **Alternating cellulose monomers inverted but pectin monomers all in same orientation;**
2. **D-galacturonic acid monomer in pectin vs beta glucose in cellulose;**
3. **Beta configuration of glucose monomers in cellulose vs alpha configuration of D-galacturonic acid monomer in pectin/ OH group on C1/anomeric carbon below the plane in pectin but in cellulose it is above the plane;**
4. **β (1→4) glycosidic bonds in cellulose while α (1→4) glycosidic bonds in pectin;**
5. **Monomers in pectin are esterified/modified to carry methyl groups but not in cellulose;**

[2]

Rhamnogalacturonan I (RG I) is a type of pectin present in the plant cell wall. The schematic diagram of RG I found in plant cell walls is shown in Fig. 2.3. 'Ac' represents acetyl groups added to RG I.

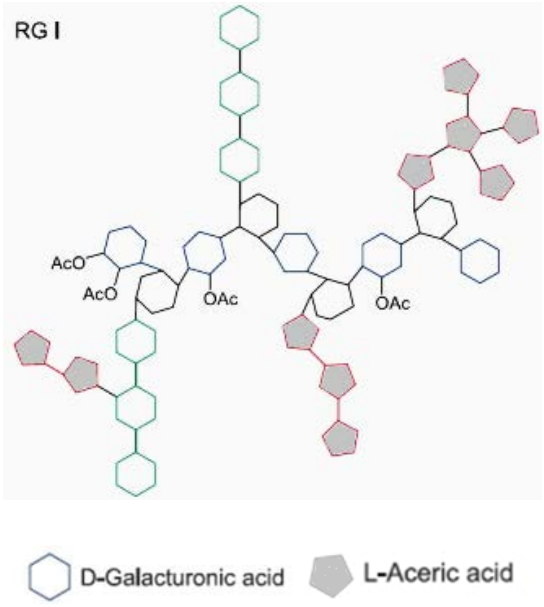


Fig. 2.3

For Examiner's Use

(b) With reference to Fig. 2.3 and your knowledge of carbohydrates, suggest how the structure of monosaccharides allow for complexity in the pectin structure.

1. **There are different number of C in the ring which gives rise to diversity in monomers used in pectin;**
2. **e.g. L- Aceric acid, D-Galacturonic acid;**
3. **Each ring has multiple OH groups at different/ multiple C position enable the formation of multiple bonds;**
4. **for branching in pectin;**
5. **A variety of monomers can be attached to a single monomer, allowing for diversity and complexity;**
6. **The monomers structure also allow for acetylation, allowing for diversity and complexity;**

[2]

When pectin is consumed by humans, it is digested into oligosaccharides. These oligosaccharides are used by gut bacteria in the process of anaerobic respiration.

(c) Explain why a small yield of ATP can still be achieved with anaerobic respiration.

1. **Glycolysis continues for the synthesis of some ATP via substrate-level phosphorylation;**
2. **this is achieved by regenerating NAD^+ from the reduced NAD produced;**
3. **Pyruvate accepts the hydrogen atoms from reduced NAD and is reduced to lactate (which contains a lot of trapped energy);**
4. **1 molecule of glucose is oxidised/ converted to (2 molecules of) pyruvate with the net yield of 2 ATP (and 2 reduced NAD);**

[3]

For Examiner's Use

In the presence of oxygen, both glucose and triglycerides can be oxidised to yield large amounts of ATP. Fig. 2.4 shows some steps involved in respiration of triglycerides. Respiration of triglycerides involves the hydrolysis of triglycerides into fatty acid chains which are then broken down into acetyl CoA molecules. These acetyl CoA molecules will then enter the Krebs cycle.

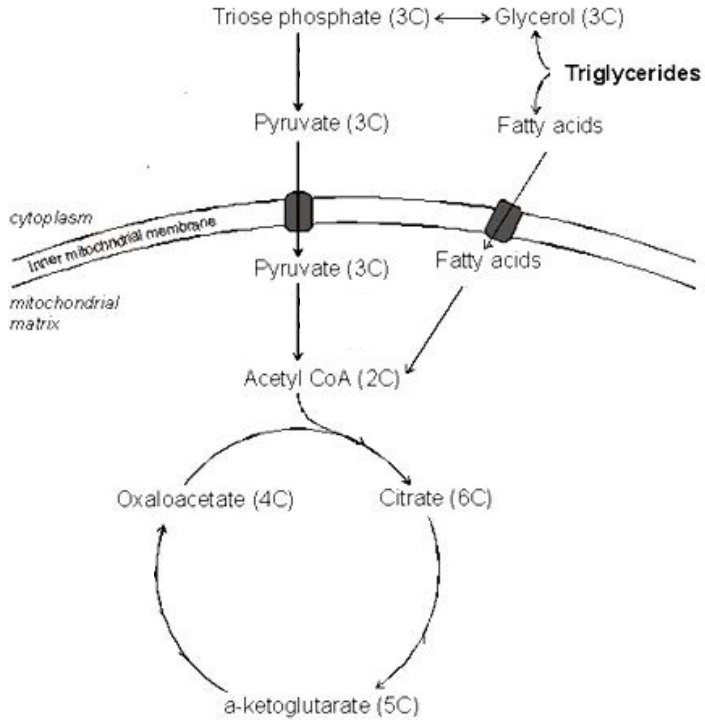


Fig. 2.4

For Examiner's Use

(d) (i) Using the information from Fig. 2.4, calculate the total ATP yield from the complete oxidation of a 14-carbon fatty acid chain. Each NAD yields 2.5 molecules of ATP and each FAD yields 1.5 molecules of ATP. Show your calculation and answer in the space provided.

14-carbon fatty acid chain will yield 7 x 2 carbon chains (7 cycles);
No. of ATP from a 2 carbon-chain = 3 x 2.5 + 1.5 + 1 = 10;
Hence, total ATP yield will produce 7 x 10 ATP molecules = 70 ATP;

[3]

(ii) Explain why fatty acid chains can be completely oxidised only under aerobic conditions.

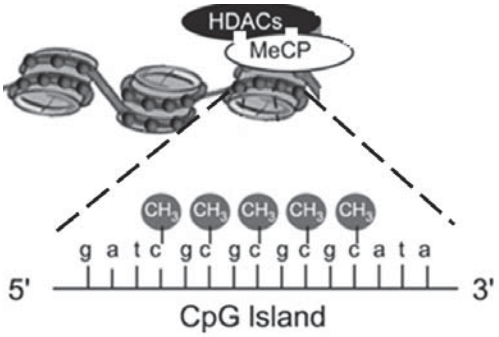
1. **Fatty acids need to be converted first to acetyl CoA;**
2. **that is only oxidised in the Krebs cycle/ bypasses glycolysis and the link reaction;**
3. **In order to be completely oxidised, <u>oxygen</u> is required as the <u>final electron and proton acceptor</u> in the process of oxidative phosphorylation;**

[3]

[Total: 13]

For Examiner's Use

3 CpG islands are regions of DNA where a cytosine nucleotide is followed by a guanine nucleotide in the linear 5' to 3' sequence. CpG islands are typically 300 to 3000 base pairs in length. These CpG islands have been found to be in or near approximately 40% of promoters of mammalian genes. Humans have a higher percentage of promoters with high CpG content.



HDAC: Histone Deacetylase
MeCP: Methyl-CpG-binding protein

Fig. 3.1

Commented [WU1]: Make the protein binding more complementary

(a) (i) With reference to the information provided, explain the significance of the presence of CpG islands in many of the genes in the mammalian genome.

1. **CpG islands are sites of DNA methylation;**
2. **Addition of methyl group changes the 3D configuration of the promoter;**
3. **DNA methylation at/near promoter recruits Methyl-CpG-binding protein which in turn recruits and binds to histone deacetylase;**
4. **Complementary binding of Methyl-CpG-binding protein to Histone Deacetylase;**
5. **Histone Deacetylase removes acetyl group from histone restoring positive charge (on lysine tail);**
6. **causes condensation of chromatin;**
7. **preventing access of RNA pol and <u>general</u> transcription factor to/ formation of TIC at promoters;**
8. ***Allows specific genes to be silenced during regulation/ switched on when needed;**

***Compulsory**

[4]

For Examiner's Use

McGhee and Ginder conducted an experiment that examined the effects of inhibiting methylation on gene expression. The experiment was performed using 5-azacytidine in mouse cells. 5-azacytidine is one of many chemical analogs that are structurally similar to the nucleoside cytidine from which cytosine is formed. When these analogs are integrated into growing DNA strands, some, including 5-azacytidine, severely inhibit the action of the DNA methyltransferase enzymes that normally methylate DNA. Interestingly, other analogs, like Ara-C, do not negatively impact methylation.

Scientists hypothesized that if they inhibited methylation by flooding cellular DNA with 5-azacytidine, then they could compare cells before and after treatment to see what impact the loss of methylation had on gene expression. The amount of methylation measured in each treatment is relative to the control. The results are shown in Table 3.1.

Table 3.1

Chemical Added	Number of Differentiated Cells	Amount of Methylation Measured
cytidine (control)	0	100%
Ara-C	0	127%
5-azacytidine	22141	33%

(ii) Explain what the experimental results show about the effects of methylation on gene expression.

1. The decrease in methylation resulted in an increase in the number of differentiated cells;
2. Inhibition by 5-azacytidine decrease amount of methylation from 100 to 33% leads to increase the number of differentiated cell from 0 to 22141 cells;
3. While the presence/ increase in methylation of 127% due to Ara-C resulted in 0 differentiated cell OR While the presence of 100% methylation in control resulted in 0 differentiated cell;
Max 2

4. Methylation (of CpG region at promoter) causes condensation of chromatin, preventing access of RNA pol (and general TF) to promoter/ Demethylation of genes causes unpacking of chromatin, allowing access of RNA pol to promoter;
5. This allows for gene expression leading to expression of specific proteins in the process of differentiation / shows that specific gene involved in differentiation are methylated;

[4]

(iii) Explain how confidence in the experimental results could be increased.

1. Repeat experiment to increase reliability of results;
2. (Add another chemical which will) induce 0% methylation as a positive control/ to ensure that methylation arises are due to the effect of Ara-C or 5-azacytidine;
3. AVP

[1]

For Examiner's Use

For Examiner's Use

(b) In 2010, a 10 year old boy with a damaged trachea (windpipe) was given a trachea transplant. A donor trachea was obtained and enzymes were used to remove all the cells, leaving only the collagen as shown in Fig. 3.2.

Fig. 3.2

Some bone marrow was removed from the boys' pelvis and about 2.5 million stem cells were isolated from this bone marrow. These stem cells were then treated with chemicals to stimulate proliferation and injected into the collagen.

The collagen, with the injected stem cells, was then immediately used to replace damaged trachea in the boy. Over a period of time, a fully functioning trachea was formed.

Suggest how the properties of the bone marrow stem cells allow for the formation of a fully functioning trachea.

1. Bone marrow stem cells are multipotent stem cells;
2. They are able to undergo indefinite mitosis due to active telomerase;
3. To form/ maintain a constant pool of stem cells for differentiation;
4. Bone marrow stem cell are undifferentiated cells;
5. Which can respond to different environmental factors to change the expression of the bone marrow stem cell into cells in the trachea;

[4]

[Total: 13]

For Examiner's Use

Section B

Answer **one** question in this section.

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

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

Your answers must be in continuous prose, where appropriate.

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

4 **(a)** Using two named examples, explain the importance of bonds to the function of two different classes of biomolecules. [13]

(b) With reference to named examples, describe the range of roles performed by lipids in living organisms. [12]

[Total: 25]

5 **(a)** Outline the processes that result in genetic variation in nature and explain the significance of such processes. [13]

(b) "The endomembrane system is critical in the synthesis of proteins". Discuss. [12]

[Total: 25]

For Examiner's Use

Essay Question 4a

Using two named examples, explain the importance of bonds to the function of two different classes of biomolecules. [13]

Nucleic Acid (e.g. DNA/ RNA)

1. **The role of DNA is to store information;**
2. **and pass it on / transmit information from one generation to the next;**
3. **To ensure that DNA is stable;**
4. ***numerous hydrogen bonds can found between the nitrogenous bases;**
5. ***Strong covalent bonds e.g. phosphodiester bonds between adjacent nucleotides in sugar-phosphate backbone;**
6. ***Hydrophobic interactions between stacked nitrogenous bases;**
7. **Weak hydrogen bonds between nitrogenous bases can be easily broken to allow separation of DNA;**
8. **for DNA replication, transcription and DNA repair (at least 1);**
9. **Complementary base pairing by hydrogen bonds;**
10. **allow for accurate transmission of information;**
11. **The sugar phosphate backbone that is negatively charged allows association with positively charged histone via ionic interactions;**
12. **to allow for condensation;**
13. **Hence, preventing the breakage of DNA/ lost of genetic information during nuclear division;**
14. **Condensation also allows for the DNA to be packaged in the nucleus of the cell;**

Protein – Enzyme/ antibody

15. ***Amino acids join together by (strong covalent bonds known as) peptide bonds;**
16. **The presence of hydrogen bonds formed between the –CO and –NH groups of the polypeptide backbone to form α-helices and B pleated sheets;**
17. **The 3D conformation of the protein is maintained by ionic, hydrogen bonds and hydrophobic interactions and disulfide bonds between R-groups (at least 2 bonds);**
18. **For proteins with quaternary structure, the 3D conformation of the protein is maintained by ionic, hydrogen bonds and hydrophobic interactions and disulfide bonds between R groups of different polypeptide chain (at least 2 bonds);**
19. **This allow formation of active site complementary to substrate;**
20. **for specificity in catalysis;**
21. **This allow formation of binding sites/ sites other than the active sites complementary to activator/ inhibitor/ cofactors;**
22. **For regulation of reactions;**
23. **R groups of binding amino acid residue form transient bonds with substrate;**
24. **Allow formation of enzyme-substrate complex;**

For Examiner's Use

Protein - Collagen

25. ***Amino acids join together by (strong covalent bonds known as) peptide bonds (to form the alpha chain);**
26. **which has a repeating tri-peptide sequence of glycine-X-Y**;
27. **where X is often proline and Y is often hydroxyproline or hydroxylysine;**
28. **Polymerisation allows for the formation of a long molecule that allows collagen to function as a structural protein;**
29. **Collagen is insoluble in water due to absence of hydrogen bonds with water;**
30. **As glycine and proline are hydrophobic;**
31. **Collagen has high tensile strength;**
32. ***Due to covalent cross-links between different tropocollagen molecules;**
33. ***Cross linking by hydrogen bonds between alpha chains/ within triple helix/ tropocollagen (R! within collagen); (award mark if linked to insolubility and tensile strength);**
34. **Bundling for the formation of a fibril and subsequently fibres;**

Protein - Haemoglobin

35. **Amino acids join together by (strong covalent bonds known as) peptide bonds (to form the alpha and beta chains which are 141 amino acid and 146 amino acid long);**
36. **The presence of hydrogen bonds formed between the –CO and –NH groups of the polypeptide backbone to form α-helices;**
37. **The 3D conformation of the protein is maintained by ionic, hydrogen bonds and hydrophobic interactions between R-groups (at least 2 bonds);**
38. **(Relatively weaker) ionic bonds/ and hydrogen bonds occur between dimer pairs (in the deoxygenated state);**
39. **(Relatively stronger) hydrophobic interactions/ and hydrogen bonds between α chain and β chain form (stable) αβ dimers;**
40. **This allows for the arrangement of hydrophobic amino acid residues within the interior of the globular structure;**
41. **allowing for the formation of a haem binding pocket/ hydrophobic environment / deep hydrophobic cleft for the haem group to bind to oxygen;**
42. **Hydrophilic amino acid residues are found at the surface of the globin;**
43. **Allowing hydrogen bonds to be formed between the water and hydrophilic amino acid residues;**
44. **Allows for solubility in a aqueous medium/ allows it to be a good transporter of oxygen in blood;**
45. **The hydrogen bonds between the two dimers allow for cooperativity to occur;**
46. **Increase rate of loading or unloading of oxygen on/ off Hb;**

For Examiner's Use

Protein - G-Protein Linked Couple Receptor

47. ***Amino acids join together by (strong covalent bonds known as) peptide bonds (to form the alpha chain);**
48. ***The presence of hydrogen bonds formed between the –CO and –NH groups of the polypeptide backbone to form 7 α-helices;**
49. ***The 3D conformation of the protein is maintained by ionic, disulfide, hydrogen bonds and hydrophobic interactions between R groups (at least 2 bonds);**
50. ***This allows for the arrangement of hydrophobic/ non-polar R groups of amino acids facing exterior of α helices to interact with hydrophobic/ hydrocarbon tails of the phospholipid bilayer;**
51. **hence allowing for embedment of the protein in the membrane;**
52. **This also allows for the formation of a binding site to allow binding of a signal molecule/ ligand;**
53. **And the formation of a binding site to allow binding of the G protein;**
54. **Hence allowing for the signal molecule to bind and trigger conformation change in GPLR;**
55. **And activated GPLR can bind to the G protein and activate G protein when GTP displaces GDP;**

Mention 3 out of 4 compulsory points

Carbohydrates: Starch and/ or glycogen

56. **Glycosidic bonds (are strong covalent bonds that) join many α-glucose monomers together to form starch / glycogen;**
57. **Which can be released upon hydrolysis as respiratory substrates;**
58. **This also forms a large molecule so that the molecule is insoluble in water;**
59. ***α-1,4-glycosidic bonds forms a helical structure;**
60. **which causes the molecule to be compact for storage;**
61. **Hydroxyl groups of glucose residues that project into the interior of the helices;**
62. **Hence, absence of hydrogen bonds with water causing starch / glycogen to be insoluble in water;**
63. **Hence, they can be stored in large quantities without affecting the osmotic potential of cells;**
64. ***α-1,6-glycosidic bonds allows for amylopectin / glycogen to be highly branched;**
65. **Hence, a greater amount of carbohydrates can be stored per unit volume;**
66. **It also allows for many enzymes to act on it at the same time;**
67. **Allows for quick release of glucose (for an increased rate of respiration);**

For Examiner's Use

Carbohydrates - Cellulose

68. **Glycosidic bonds (are strong covalent bonds) join many β-glucose monomers together to form cellulose;**
69. **This also forms a large molecule so that the molecule is insoluble in water;**
70. ***B 1,4 glycosidic bonds allow the formation of straight chains;**
71. ***Hydrogen bond cross links between hydroxyl groups of adjacent chains**
72. **prevent the hydroxyl groups from forming hydrogen bonds with water hence allowing it to be insoluble in water;**
73. **Also allows for formation of microfibrils and macrofibrils**
74. **which allows cellulose to have tremendous tensile strength;**
75. **Allowing it to perform its function as a structural molecule;**
76. **To help prevent cells from bursting / maintain shape of cell / allows for cell turgidity;**

Lipid - Triglycerides

77. **Ester bonds allow for the joining of three fatty acids and one glycerol group;**
78. **Presence of long hydrocarbon chain results in a hydrophobic molecule that is insoluble in water;**
79. **The presence of multiple energy rich C-H bonds;**
80. **Great amount of energy to be released during oxidisation during respiration to produce ATP;**
81. **Triglycerides contain much more energy per gram than either carbohydrates / proteins i.e. 1 gram of fat respired produces twice as much ATP as 1 gram of carbohydrate or protein;**
82. **Triglycerides can be compacted together for storage;**
83. **via hydrophobic interactions between the hydrophobic hydrocarbon tails;**

Lipid - Phospholipids

84. ***Ester bonds join two fatty acids, one phosphate group and one glycerol together to**
85. ***Phosphate head is negatively charged and hydrocarbon chains are non-polar;**
86. **Hence giving rise to its amphipathic nature;**
87. ***Hydrogen bonds formed between the phosphate head and water/ aqueous medium;**
88. ***and hydrophobic interactions between the hydrophobic hydrocarbon tails;**
89. **Allow for the formation of cell membrane with phospholipid bilayer;**
90. **Prevent polar molecules/ ions to pass through the hydrophobic core/ allows for regulation of specific molecules/ions to move into and out of the cell interior;**
91. **The presence of C=C bonds/ unsaturated hydrocarbon tails causes kink;**
92. **cannot pack so closely together;**
93. **Increase the fluidity of the cell membrane at low temperatures;**
94. **Phospholipids with saturated hydrocarbon tails/tails without C=C bonds;**
95. **can pack together closely;**
96. **so that membrane remains stable at high temperatures;**

Mention 3 out of 4 compulsory points

Lipid derivative – Cholesterol (to be marked under lipids)

97. **Covalent bonds allow the formation of cholesterol which consists of a carbon skeleton with four fused rings and hydroxyl group at one end;**
98. ***Ionic bonds/ hydrogen bonds between the hydroxyl group on cholesterol interacts with the polar phosphate group of membrane phospholipids;**
99. ***Hydrophobic interactions between cholesterol and hydrocarbon chain;**
100. **Allows it to be embedded in the membrane;**
101. **Hence, at relatively warm temperatures, cholesterol makes the membrane less fluid;**
102. **by restraining the movement of phospholipids;**
103. **At low temperatures, cholesterol prevent solidification;**
104. **by disrupting the regular packing of phospholipids;**

QWC: Candidates should discuss points from two different categories of biomolecules with an example each with a coherent and logical flow;

Max 7m per category

Mark first 2 named examples if more than 2 named examples are given

To include antibodies, general proteins

For Examiner's Use

Essay Question 4b

With reference to named examples, describe the range of roles performed by lipids in living organisms. [12]

Triglycerides

1. **Serve as long term energy store;**
2. **As there are many energy rich C-H bonds which can be oxidized;**
3. **during respiration to produce ATP;**
4. **They contain much more energy per gram than carbohydrates or proteins/ higher calorific value;**
5. **They are only oxidised after carbohydrates are depleted;**
6. **Especially important for hibernating animals;**

Max 2m for pt 1 - 6

7. **Serve as excellent heat insulator underneath the skin;**
8. **prevent excessive loss of heat;**
9. **important for aquatic mammals and mammals living in cold climates;**
10. **Provide buoyancy;**
11. **because they are less dense compared to water;**
12. **this is important for aquatic animals.;**
13. **Provide mechanical protection because they are found around vital organs;**
14. **and helps to cushion them against physical trauma and impact;**
15. **Serve as a source of metabolic water;**
16. **During respiration, the same mass of triglycerides releases twice as much water as carbohydrates;**
17. **this is important for desert mammals;**
18. **Solvent for fat-soluble vitamins;**
19. **For absorption and storage of vitamins A, D, E and K in the body;**

Max 4m for pt 7 - 19

Phospholipids

20. **Amphipathic nature allows them to form a phospholipid bilayer;**
21. **which is the main component of the cell membranes/ named example of membrane e.g. cell surface membrane, thylakoid, nuclear membrane;**
22. **This allows for regulation of specific molecules/ions to move into and out of the cell interior;**
23. **The degree of saturation in fatty acid chains regulates fluidity of cell membrane;**
24. **Phospholipids with saturated hydrocarbon tails;**
25. **ensure that membrane does not become too fluid at high temperatures;**
26. **Phospholipids with unsaturated hydrocarbon tails/ C=C bonds in the tails form kinks;**
27. **to ensure that membrane remains fluid even at low temperatures;**
28. **Fluid nature of phospholipid membrane also allows for embedding of membrane proteins/ named example of membrane protein and roles e.g. ATP synthase for ATP synthesis;**
29. **Sphingomyelin, a type of phospholipid is found abundantly in the myelin sheath of neurons;**
30. **facilitates rapid conduction of nerve impulses;**
31. **Oligosaccharides can associate with phospholipids to form glycolipids;**
32. **Which in turn are involved in cell-cell recognition;**

<u>Cholesterol</u>

33. **Cholesterol helps to maintain the fluidity of cell membranes;**
34. **At warm temperatures, it makes the membrane less fluid by restraining the movement of phospholipids**
35. **At low temperatures, it hinders solidification by disrupting the regular packing of phospholipids;**
36. **It is a precursor for the synthesis of other steroids e.g. sex hormones such as testosterone and oestrogen;**
37. **It is a precursor for the synthesis of bile salts which aids in the digestion of fats;**

QWC: Candidates should discuss points from at least 2 examples of lipids to cover a range of functions in a coherent flow;

Max 6m for each categories

For Examiner's Use

Essay Question 5a
Outline the processes that results in genetic variation in nature and explain the significance of such processes. [13]

Mutation

1. **Mutation results in genetic variation;**
2. **Mutation can be brought about by errors in DNA replication due to DNA polymerase;**
3. **Mutation can be brought about by environmental factors / chemical agents;**

Sexual Reproduction

4. **Crossing over between non sister chromatids of homologous chromosomes;**
5. **Where homologous chromosomes pairs up to form a bivalent;**
6. **during prophase I;**
7. **Results in different combination of alleles in gametes;**
8. **Independent assortment of homologous chromosomes during metaphase;**
9. **Results in different combination of paternal and maternal chromosomes;**
10. **Random fusion of haploid gametes during fertilization;**

Significance (for mutation and sexual reproduction)

11. **These increases genetic variation in the gene pool of subsequent generation;**
12. **for natural selection to take place;**
13. **where individuals with advantageous traits to be selected for;**

Immune system

14. **Somatic/ VDJ recombination occurs on the B cell (and T cell) receptors genes/ antibody genes/ in undifferentiated B (and T cells);**
15. **Random selection and joining of 1 V, (1 D,) 1 J segments in the light/ heavy chain;**
16. **result in a variety of different variable regions/ antigen binding site;**

Significance

17. **Brings about a large variation/ vast repertoire of B (and T cell) receptors/ antibodies;**
18. **Allows immune cells to recognise a vast repertoire of antigens found on pathogens;**
19. **for adaptive immune response/ destruction and clearance of pathogen;**

20. **Somatic hypermutation occurs in antibody gene coding for V region of activated B cells;**

Significance

21. **Allows for the production antibodies / antigen receptors with higher affinity to antigen;**

22. **Class switching occurs in antibody gene coding for c region/ heavy chain in activated B cell;**

Significance (for immune system)

23. **Allow it to activate different effector cell for immune response;**

For Examiner's Use

Horizontal gene transfer

24. **Genetic variation also arises due to <u>horizontal gene transfer</u> in bacteria;**
25. **<u>Transformation</u> occurs where competent bacteria takes up foreign naked DNA from the environment;**
26. ***Homologous regions undergo genetic recombination via crossing over/ homologous recombination;**
27. **Bacteriophage transfer DNA fragment from host to recipient bacteria via <u>specialised</u> due to error in packing of bacteria DNA;**
28. **or <u>generalised transduction</u> due to excision of bacteria DNA;**
29. ***Homologous regions undergo genetic recombination via crossing over/ homologous recombination;**
30. **In <u>conjugation</u>, plasmid DNA is transferred;**
31. **from F^+ cell to F^- cell through a <u>mating bridge/ conjugation tube</u> (R! sex pilus);**

Significance (for horizontal gene transfer)

32. **These allows bacteria to gain new genes for metabolism / synthesis amino acid;**
33. **Allows for evolution into different strains via natural selection;**

Mutation and recombination in viruses

34. **In viruses, mutation can result in <u>antigenic drift</u>;**
35. **In viruses, recombination occurs when two or more strains infected the same host cell result in <u>antigenic shift</u>;**

Significance (mutation and recombination in viruses)

36. **Allows viruses to evade the host immune response;**
37. **For antigenic shift: and infect new host cells;**

QWC: At least 2 categories, processes linked coherently to the appropriate significance;

***Mark once for pt 26 and 29**
Max 7m for each categories (min 1 significance in each category)

For Examiner's Use

Essay Question 5b
"The endomembrane system is critical in the synthesis of proteins" Discuss. [12]

1. **The endomembrane system is confers several benefits in the synthesis of protein;**
2. **In the eukaryotes, endomembrane systems such as the nucleus, rough endoplasmic reticulum, Golgi apparatus (at least 2) are present;**
3. **The nucleus is an organelle where the genetic material in the form of DNA are surrounded by the nuclear envelope;**
4. **This nuclear envelope protects the genetic material from degradation by nuclease present in the cytoplasm;**
5. **Hence maintaining the integrity of the DNA / prevent mutation caused by oxidative agents;**
6. **Nuclear envelope also allows for regulation of protein synthesis at the post transcriptional level;**
7. **via the export of the mRNA to the cytoplasm;**
8. **Rough endomembrane reticulum provides a large surface area for the attachment of ribosomes for the translation of mRNA to polypeptide;**
9. **RER provides an optimal condition for the folding of the polypeptide/ post translational chemical modification by enzymes;**
10. **GA lumen provides an optimal condition for post translational chemical modification by enzymes;**
11. **It also provides an optimal conditions for the enzymatic reactions in post translational chemical modification;**
12. **Increasing the rate of reaction due to compartmentalization which increases the local concentration of enzyme and substrate:**
13. **Hence the RER and the GA allows for the synthesis of proteins that are complexed with carbohydrates / lipids/ producing glycolipids and glycoproteins;**
14. **It also allow the synthesis of lysosomes, membrane bound organelles that contains hydrolytic enzymes;**
15. **involved in autophagy/ intra-cellular digestion/ apoptosis;**
16. **It also allow synthesis of membrane bound proteins;**

17. **However the endomembrane system is not necessary in the synthesis of intracellular proteins;**
18. **mRNA of intracellular proteins are translated by free ribosomes in the cytoplasm;**
19. **which are in turned folded in the cytoplasm into their native conformation (by with the help of chaperone proteins);**
20. **The endomembrane system is also not necessary in the synthesis of protein in the bacteria;**
21. **Membrane bound proteins/ lactose permease in bacteria can be synthesized despite the absence of endomembrane system;**
22. **Bacteria do not have membrane bound organelles;**
23. **(As the genetic material of the bacteria are not bounded by the nuclear envelope,) transcription of the gene and translation of the mRNA can occur simultaneously;**

24. **However, in the absence of nuclear envelope, genes in the bacteria are also subjected to a higher rate of mutation;**
25. **Regulation of protein synthesis occurs predominantly at the transcriptional level;**

QWC: Good spread of knowledge communicated from both sides;

Pt 1 to 16, 24 and 25: max 7
Pt 17 to 23: max 5

Name	Subject Class	Class	Candidate Number
	2BI		

ANGLO-CHINESE JUNIOR COLLEGE
H2 Biology Preliminary Examinations 2017

H2 BIOLOGY **9744/04**
Practical 02 Aug 2017
2 hours and 30 minutes

READ THESE INSTRUCTIONS FIRST
Write your name, index number, class, shift and laboratory on this Question Paper.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.

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

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

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

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

Shift
Laboratory

For Examiner's Use	
1	/21
2	/20
3	/14
Total	**55**

This question paper consists of 18 printed pages.

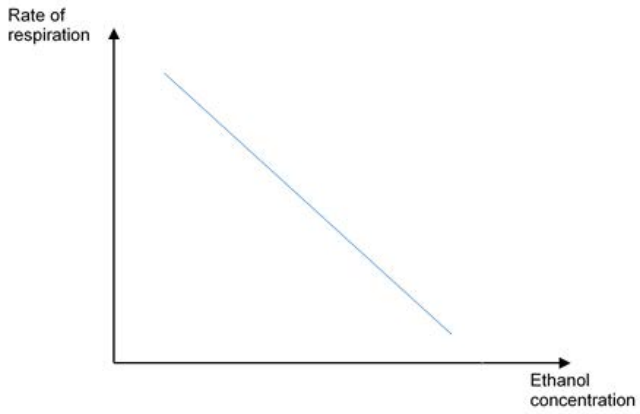
For Examiner's Use

1 During anaerobic respiration, yeast cells use glucose and release carbon dioxide and ethanol. Ethanol is known to disrupt enzymes involved in the respiration pathway.

In this experiment, you will investigate the effect of different concentrations of ethanol on the rate of respiration in yeast cells.

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

Explain the shape of your graph. [4]



1. **Y-axis labelled rate of respiration and x-axis labelled ethanol concentration;**
2. **Line / Curve with negative gradient;**

3. **As ethanol concentration increases, rate of respiration decreases;**

4. **Active site of enzyme is lost/disrupted with one possible reason, e.g. competitive/non-competitive inhibitor, 3D conformation of enzyme is changed;**

5. **Enzymes in glycolysis/respiration cannot form enzyme-substrate complexes;** **Max. 2**

For Examiner's Use

Methylene blue is a dye which, under certain conditions, is easily reduced to a colourless compound. In the presence of reduced NAD which is produced during glycolysis, methylene turns from blue to colourless.

In your investigation, you are to dilute the given ethanol solution to obtain different concentrations of ethanol solution.

You are provided with:

- 30 cm^3 of 5.0% yeast solution, **Y**
- 20 cm^3 of 100% ethanol, **E**
- 25 cm^3 of glucose, **G**
- 6 cm^3 of methylene blue, **M**

Proceed as follows:

1. Label 5 boiling tubes 1, 2, 3, 4, 5. Place 5 cm^3 of suspension **Y** into each of the boiling tubes. Ensure **Y** is well-suspended. Place all the boiling tubes into a water bath of 60°C for 5 minutes.

2. While waiting, carry out a dilution to make up 5 cm^3 of different concentrations of ethanol solutions using the vials provided. When preparing the solutions, add distilled water first before adding ethanol. This is to ensure better mixing of ethanol and distilled water.

   Complete Table 1.1 to show how you will make the different concentrations of ethanol solution. [2]

Table 1.1

vial	concentration of ethanol / %	volume of distilled water / cm^3	volume of ethanol / cm^3
1	100	**0.0**	**5.0**
2	**80**	**1.0**	**4.0**
3	**60**	**2.0**	**3.0**
4	**40**	**3.0**	**2.0**
5	**20**	**4.0**	**1.0**

1. **Correct concentration (Equal intervals across an appropriate range – max lowest concentration = 40%, R! 0%);**
2. **Correct volumes and precision (1dp);**

R! total volume less or more than 5.0 cm^3

For Examiner's Use

*Read through steps **3** to **10** to prepare a table to record your results in **(b)**, before starting the investigation.*

3. After 5 minutes, lower the temperature of the water bath to 45°C. Leave the boiling tubes in the water bath for 1 minute.

4. Place 2 cm^3 of the ethanol solution from vial 1 into boiling tube 1 then add in 2 cm^3 of **G**.

5. Use a dropper to add 1 cm^3 of **M** into boiling tube 1 immediately.

6. Shake the boiling tube sufficiently to mix the contents well. The mixture should turn pale blue.

7. Carefully place the boiling tube back into the water bath and start the stopwatch. Do not shake or stir the boiling tubes from this point onwards as it may affect the results.

8. Stop the stopwatch when the blue mixture has been decolourised. The surface of the mixture in the boiling tube may remain blue. Record the time taken and hence the rate of respiration in the table prepared in **(b)**. If the mixture does not decolourise within 12 minutes, record 'more than 720' as the time taken and the rate as '0'.

9. Repeat steps 4 to 8 with boiling tubes 2, 3, 4, and 5, in turn.

10. After completing the experiment, shake boiling tube 5 vigorously about 10 times. Record your observations in part **(d)**.

(b) Record your results for each concentration of ethanol in a suitable format in the space below. [4]

Table showing effects of ethanol concentration (%) on the rate of respiration of yeast (%)

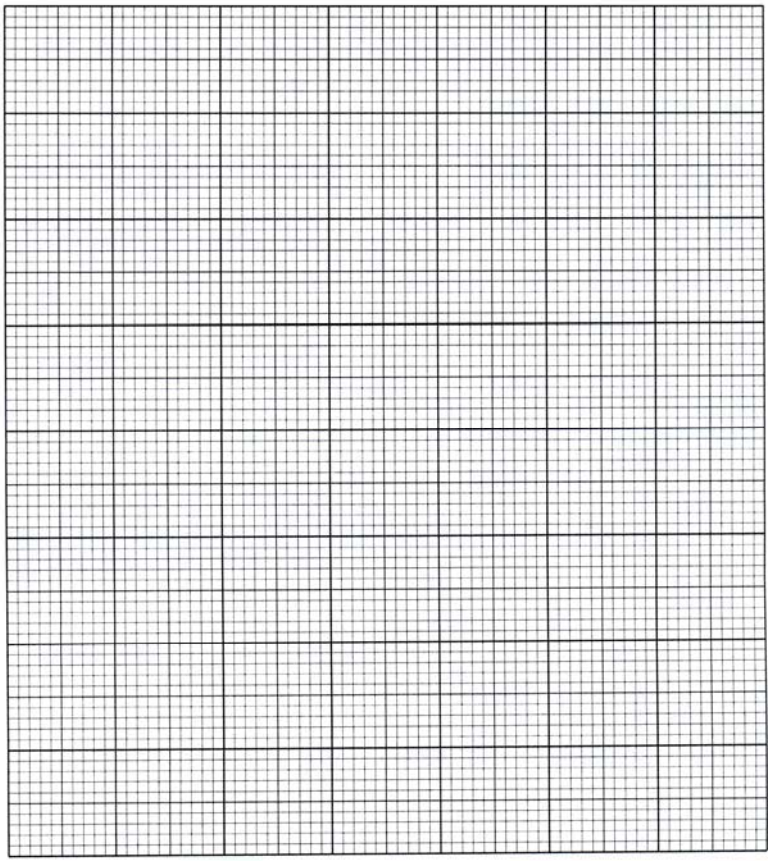
Boiling tube	Ethanol concentration / %	Time taken / s	Rate of respiration / s^{-1}
1	100		
2	80		
3	60		
4	40		
5	20		

1. **Table layout: Independent variable to occupy leftmost column;**
2. **Appropriate column headings + Units;**
3. **Precision of data: Raw data: to the nearest second, rate of respiration: 3sf if time taken is in hundreds (consistency);**
4. **Complete set of data (including rate – increasing rate as ethanol concentration decrease) + Correct calculation + correct trend (accept more than 720 for 100% and 80%);**

For tubes with 'more than 720', since rate is $1/\infty$, hence rate is 0.
Reject '-'

For Examiner's Use

(i) Use the grid below to display your results from **(b)**. [4]



1. **Independent variable (concentration of ethanol) on x-axis (no need to mark for units);**
2. **Both axes correctly labelled with units (concentration of ethanol/% on the rate of respiration/s^{-1});**
3. **Sensible scale with graph occupying at least ½ the grid on both x- and y- axes + equidistant divisions on axes + accurate plotting of points to nearest half a small square;**
4. **Line of best fit drawn, without extrapolation beyond plotted points (appropriate where data gives confidence in underling relationship) / dot-to-dot plot joined by a straight line;**

For Examiner's Use

(ii) Discuss what these results suggest about the relationship predicted in part **(a)**. [2]

1. No clear pattern in the results/results do not match at high ethanol concentrations

2. Decreases confidence in the predicted relationship / further results will need to be collected in order to further evaluate the relationship

OR (if experiment was conducted and matches predicted results)
1. Pattern of results shows same pattern as predicted in (a);

2. Which increases the confidence in the hypothesis / proposed relationship;

OR (if pattern of results initially matches predicted pattern if plateau is present)
1. Pattern of results shows same pattern as predicted in (a) initially, but no plateau is reached;
2. Decreases confidence in the predicted relationship / further results will need to be collected in order to further evaluate the relationship;

R! confirming results… / concluded that results are… / results are true/valid

(c) State and explain your observations from step 10. [1]

1. Mixture turns blue again as oxygen was reintroduced into the mixture, reoxidising methylene blue;

(d) Suggest how adding glucose solution to the mixture increases the validity of the results. [2]

1. Glucose is required (as the raw material / substrate) for respiration / glycolysis;

2.So substrate / glucose is not / less likely to be limiting;

3.The concentration of ethanol would thus be the only variable in the experiment / Changes in rate of respiration will be due to changes in concentration of ethanol;

(e) One way to increase confidence in the conclusions of this investigation would be to repeat the experiment several times.

Describe two other modifications to the method that would increase confidence in the conclusions, and explain how these modifications would achieve this. [2]

1. **Repeat with a control using boiled and cooled yeast to check if the results are due to (anaerobic) respiration of yeast;**
2. **Repeat with a control using 0% of ethanol solution / 2 cm^3 of distilled water to check if the results are due to presence of ethanol;**
3. **Add methylene blue before adding glucose to prevent problem of yeast using glucose for respiration before time taken for decolourisation is recorded;**
4. **Use a thermostatically-controlled water bath to ensure the temperature is kept constant;**
5. **Use a colourimeter to determine end-point (to measure absorbance of solutions at regular intervals);**

For Examiner's Use

6. **Use a lid/parafilm to minimize changes in concentration of ethanol solutions due to evaporation of water;**
   (Note: rate of evaporation is affected to a similar extent for most experiments involving solutions; however, for this experiment, the range of ethanol concentration is large and discrepancies in evaporation might be magnified)

7. **Repeat experiment with smaller intervals of ethanol concentration, e.g. 10% difference between each solution;**

[Total: 21]

For Examiner's Use

2 Section A

You are required to carry out an investigation to estimate the water potential (ψ) of the cells of the plant material with which you have been provided.

You are provided with stems of a plant sample and different concentrations of sucrose solution.

Proceed as follows:

1. Using a sharp scalpel, cut a 5 cm long, straight piece, from near the middle region, of one of the specimens provided. Hold this piece of plant in a vertical position and cut it longitudinally downwards for a distance of approximately 4 cm (Fig. 2.1).

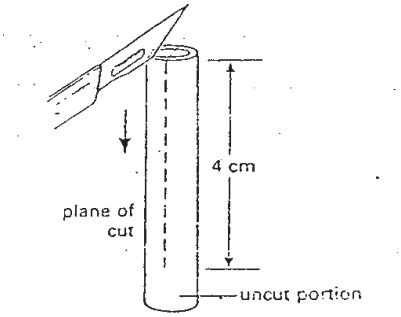


Fig. 2.1

2. You should find that the specimen has curved as shown in Fig. 2.2. Check that the distance A, between the cut pieces is at least 1 cm. If not, repeat the procedure using another specimen. Place the piece of plant tissue horizontally in the base of a clean and dry petri dish. Taking care not to squash the plant material, gently but firmly fix it to the dish using a small roll of plasticine, which you press down at X and Y (Fig. 2.2).

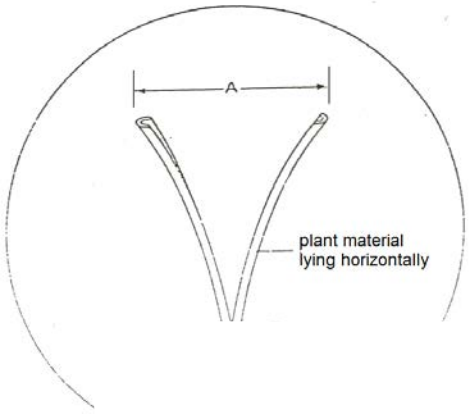


Fig. 2.2

3. Prepare **three** further dishes, using 5 cm long pieces of tissue, cut from roughly corresponding positions of three other stalks. Label your dishes 1, 2, 3 and 4.

For Examiner's Use

4. Place the four dishes on the separate sheet of graph paper provided and measure, to the nearest millimeter, the distance A in each dish. Record these observations in the table below. [2]

	Dish 1 (for S1)	Dish 2 (for S2)	Dish 3 (for S3)	Dish 4 (for S4)
Initial value of A / mm				
Value of A after 10 minutes / mm				
Difference between initial and final value of A / mm				
Change / %				

1. **Correct precision for A: whole number + Correct precision for percentage change: 1/2 sf;**
2. **Complete set of data + Correct trend: more negative percentage change (negative gradient);**

5. You have been provided with the following sucrose solutions:

   S1 is 0.2 mol dm^{-3}
   S2 is 0.4 mol dm^{-3}
   S3 is 0.6 mol dm^{-3}
   S4 is 0.8 mol dm^{-3}

6. Gently, in order to avoid dislodging the plant tissue, pour **S1** into **dish 1**, so that the piece of plant is completely covered by the solution. As quickly as possible, pour the other solutions into their respective dishes.

7. Leave the dishes for 10 minutes. During this time you may begin with Section B.

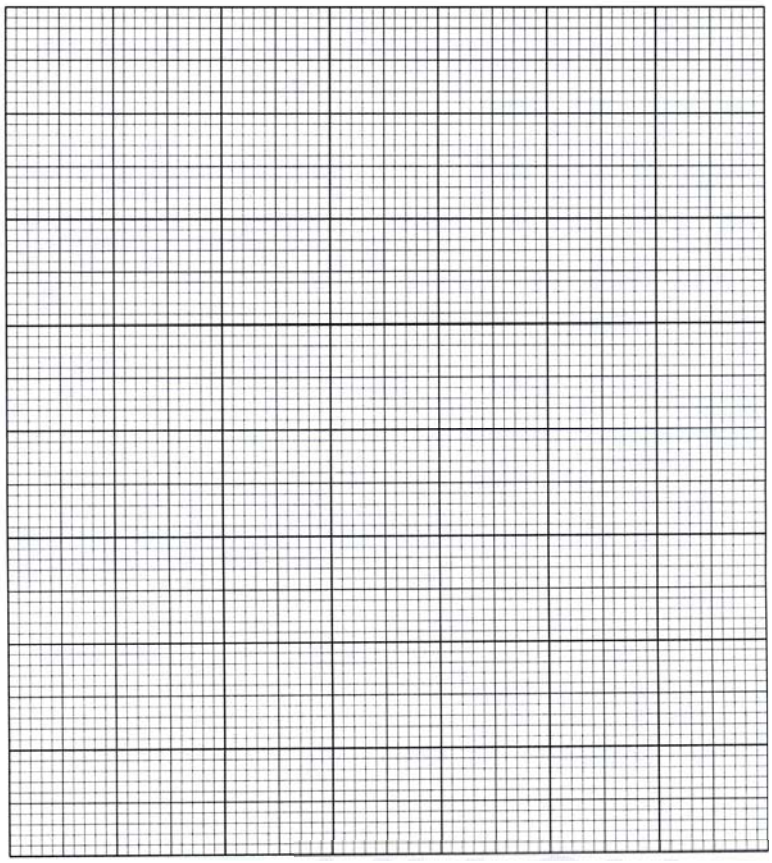
8. After 10 minutes, measure (to the nearest mm) the distance A in each of the dishes. Record these measurements in the table in Step 4.

9. For each dish, calculate the percentage change in A, and also record this in the table (Step 4). State, in each case, if the value is positive or negative.

For Examiner's Use

10. Plot a graph of the percentage change in A against molarity of sucrose solution. [3]

1. **Independent variable (sucrose concentration) on x-axis (no need to mark for units) + Both axes correctly labelled with units (percentage change in A (%) against sucrose concentration (mol dm^{-3});**
2. **Sensible scale with graph occupying at least ½ the grid on both x- and y- axes + equidistant divisions on axes;**
3. **Line of best fit drawn, without extrapolation beyond plotted points (appropriate where data gives confidence in underling relationship) / dot-to-dot plot;**



For Examiner's Use

11. The following table shows the solute potentials (ψ_s) of different concentrations of sucrose solutions, at the approximate temperature at which you have been working.

Concentration / mol dm^{-3}	Solute potential (ψ_s) / kilopascals
0.1	-260
0.2	-540
0.3	-820
0.4	-1120
0.5	-1450
0.6	-1700
0.7	-2170
0.8	-2580

12. Use the graph you have drawn, and the table above, to estimate the solute potential of the cells of this plant material. Explain fully how you arrived at your answer. [3]

Answer: **1. Accept solute potential from -260 to -820 ψ_s;**

R! water potential

Explanation: **2. There is no change when [sucrose] = ____mol dm^{-3}; (refer to Q10 graph);**

3. It is the point at which there is no <u>net</u> movement of H_2O via osmosis;

(4. Given that $\psi_W = \psi_S + \psi_P$, the cells here are at incipient plasmolysis, where ψ_P of the cell = 0 kPa;)

(Point 4 is not in the syllabus) @ 1m

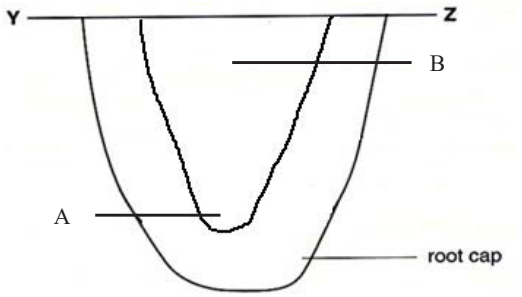
For Examiner's Use

Section B

In this section, you will require access to a microscope and slide **K1**.

K1 is a stained, longitudinal section of a young onion root tip in which some cells are undergoing mitosis. Fig. 2.3 shows a plan diagram of **K1**.

Examine **K1** carefully, in the region labelled **A** in Fig. 2.3, using low- and high- power objectives of your microscope.



.

Fig. 2.3

1. Make a labelled, high−power drawing of a cell in anaphase from region **A**. [4]

Accuracy of drawing;	**1. Show all the structures (chromosomes, plasma membrane, cytoplasm, cell wall) that can be seen in the defined part of a specimen;** **R! double-arm structure of chromosomes** **2. Direction of chromosome separation: to opposite poles;**
Clarity of drawing;	**1. Use of sharp HB pencil** **2. Clear single neat lines**
Scale of drawing;	**1. Use at least 2/3 of space provided** **2. Correct proportion (Chromosomes and cell is drawn to the same scale - same magnification)**
Label of drawing;	**1. Clear straight lines** **2. Correct labels (chromosomes*, plasma membrane, cytoplasm, cell wall)** **** Compulsory point***

For Examiner's Use

2. Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, find the actual length, in μm, of the cell that you have drawn.

   Show the measurements that you made and your working. [3]

   1. PDO: Shows division of stage micrometer measurement by number of eyepiece graticular divisions (+ what power is used);
   2. MMO: Shows measurement of cells from slide in eyepiece graticular division (5 to 23);
   3. ACE: Conversion of measurement from graticular division to answer in μm;

   Length of cell = _____ μm

3. Measure and calculate the average length of the cells from both regions A and B. Record your results and measurements in a suitable table below. [2]

   1. At least 3 counts for each region in whole numbers + Average in whole number/1 dp;
   2. Length of A is between 12.5-57.5 um, length of B is between 37.5-75 um;

4. Decide a statistical test that you can use to determine if there is a significant difference between the length of the cells in regions A and B. [1]

   T test;

   @ 1m

For Examiner's Use

5. A student made some measurements of the length of cells of a garlic root tip undergoing mitosis in regions A and B. A summary of the student's results is shown in Table 2.1.

Table 2.1

Length of Cells / μm		Significance of difference
Region A	Region B	
32	58	P<0.05

Comment on what these results show and suggest an explanation for any pattern. [2]

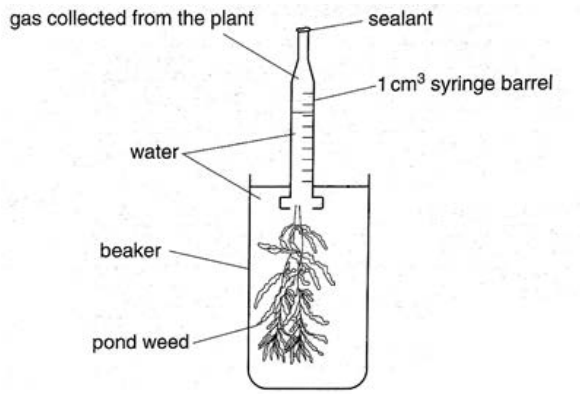
1. *** Results shows that there is a <u>significant</u> difference between the length of cell B and A where B is <u>longer</u> in length that A;**
2. **Cells in region A are the resultant daughter cell after mitosis / Cells in region B have not yet undergone mitosis;**
3. **Mitosis in plant cell involved the formation of a cell plate via vesicles from the Golgi apparatus (instead of cell elongation followed by cleavage furrow in cytokinesis of animal cells);**
4. **Hence cells in region A is about half the length of cells in region B;**

**** Compulsory point***

[Total: 20]

For Examiner's Use

3 The rate of photosynthesis can either be measured by the rate at which carbon dioxide is taken in or the amount of oxygen that is given out. Some water plants release bubbles of gas from a freshly cut stem when illuminated. Light intensity is controlled using five filters, F1, F2, F3, F4, F5.



Different water plants are adapted to different light intensities. A sun-loving water plant is adapted to high light intensities while a shade-loving water plant is adapted to low light intensities.

Using this information, the set-up above and your own knowledge, design an experiment to investigate the effect of light intensity on photosynthesis in sun and shade plants.

Your planning must be based on the assumption that you have been provided with the following equipment and materials which you **must** use:

- Sun plant
- Shade plant
- Bench lamp with 60 W bulb
- 5 filters (F1, F2, F3, F4, F5) which can be adjusted to allow different amounts of light to pass through
- 1% sodium hydrogencarbonate solution

You may select from the following apparatus and use appropriate additional apparatus:

- Normal laboratory glassware, e.g. a variety of different sized beakers, measuring cylinders, and syringes for measuring volumes
- Forceps
- Timer, e.g. stopwatch

Your plan should:

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

[Total: 14]

For Examiner's Use

Marking scheme

Compulsory

1	Broad outline C 1m	**General idea** *How would you measure the dependent variable?* (Oxygen is given off during light dependent stage via photolysis.) The experiment involves measuring oxygen evolved in response to different light intensities over a set period of time. OR Mark will be awarded if the broad outline of experiment is reflected in the procedure.
2	Independent variable C 1m	**State what the independent variable is, use at least five different values with regular intervals, good range, units** Independent variable: Light intensity (20%, 40%, 60%, 80%, 100% transmission) A! Highest low limit: 30% Lowest high limit: 90% A! Lux R! Au
3	Method (How to Vary IV) C 1m	**Plan suitable method to vary the independent variable.** Place filters with the different light transmissions in front of the lamp.
4	Table C 1m	**Shows how results are to be presented in the form of a table with independent and dependent variables in appropriate columns / rows. Units must be correct.**

Type of plant	Light intensity / %	Distance moved / Volume of oxygen evolved in 10 min/cm^3				Average rate of photosynthesis/ Average rate of oxygen evolved / $cm^3 s^{-1}$
		Try 1	Try 2	Try 3	Average	
Sun plant	20					
	40					
	60					
	80					
	100					
Shade plant	20					
	40					
	60					
	80					
	100					

A! Separate table for sun and shade plant
No need control
Units: To follow raw data collected

Commented [THA1]: To teach students considerations when deciding range

For Examiner's Use

5	Risk/ safety C 1m	**Risk / safety** What are the hazard **and** precaution? 1. Take care when cutting plants. Use forceps to hold plants so as to prevent cutting fingers; 2. Sodium hydrogen carbonate is an irritant. Wear gloves when handling; 3. Avoid touching the electrical socket with wet hands as there may be a risk of electrocution; 4. Bulb of lamp will be hot, do not touch when lamp is in use; 5. *(Low priority)* Take care when handling glassware to prevent breakage which may cause injury;

Max 9m from any of the below points

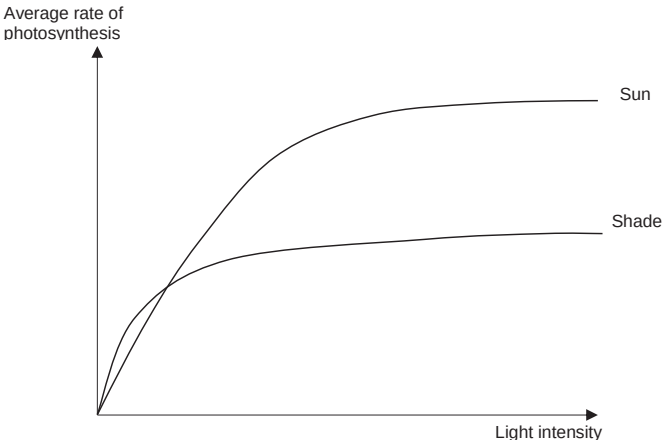
6	Method + Scientific reasoning (Overall) 1m	**Plan a suitable method that involves monitoring/measuring the DV in response to the varied ID over a period of time/ set interval** *If experiment is fundamentally wrong, do not award for this mark.* **Theory (1m)** *How would the independent variable affect the dependent variable?* An increase light intensity will increase the rate of photophosphorylation as more electrons are excited. In order to fill the electron gap, the rate of photolysis of water increases, where water is broken down to form of H^+ and oxygen, which is given off. The higher the light intensity, the higher the rate of oxygen formation. (The sun plant would have higher rate of photosynthesis at high light intensities while shade plants would have a higher rate of photosynthesis at low light intensities.)
7	Dependent variable (1m)	**State what is the dependent variable.** Dependent variable: (Rate of photosynthesis measured by) volume of oxygen evolved / distance of meniscus moved;
8	Method (1m) How to measure / monitor DV	**Specifies method of measuring / monitoring DV** Record the change in liquid level / volume of gas over a period of (10 min);
9	Controlled variables to improve accuracy or reliability (1m)	**Identifies at least two variables to control**; (Mark if specified in diagram) Controlled variable 1. Distance of lamp from plant; 2. Distance of filter from lamp; 3. Length of plant / number of leaves / number of plants / size of leaves; 4. Duration of exposure to light; 5. Volume of sodium hydrogen carbonate added to the water; 6. Temperature; R! Concentration of sodium hydrogen carbonate (Given in question)

Commented [THA2]: To teach in class: Write controlled variable

Commented [THA3]: Accept "amount" but circle and highlight

For Examiner's Use

10/11	Controlled variables (2m)	**Describes how two identified variables are controlled. (Must specify appropriate value)** 1. Place a lamp of 60 W bulb at a distance of 15 cm away from the beaker of water; 2. Cut a branch of plant 2 cm long and place it in a glass filter funnel; 3. Turn on the lamp for a period of 10 min; 4. Add 2 cm^3 of sodium hydrogencarbonate added; 5. Use a thermostatically-controlled water bath;
12	Control (1m)	Conduct a control or * experiment using boiled and cooled sun and shade plant / no plant / plant without leaves (*with the same set up / experimental conditions.) (This is to ensure that the changes in volume of oxygen is due to the change of rate of photosynthesis.) R! Zero light intensity is not a good control because gas will still be produced. (Specific to photosynthesis)
13/14	Method (2m)	**Steps to take that would ensure the validity of the experimental results. (Not the same as controlled variable)** 1. Adding excess sodium hydrogen carbonate into the water (to ensure sufficient concentration of CO_2). 2. Use a fresh solution of sodium hydrogencarbonate for each replicate (to ensure sufficient concentration of CO_2); 3. Conduct experiment in a dark room / eliminate all other light sources / ensure all other light sources are constant (to prevent heating effect); 4. Use a cool light source / water screen in front of the lamp / use thermostatically-controlled water bath (to prevent heating effect of lamp)**unless about thermostatically controlled water bath*; 5. Ensure the water level of thermostatically-controlled water bath is above the water level in the beaker (to ensure homogenous temperature of liquid); 6. Pick actively bubbling plants (for observable displacement of water) 7. Ensure sufficient number of leaves (for observable displacement of water); 8. AVP;
15	Method (1m)	**Plan a method for equilibration** Immerse the plant in the sodium hydrogen carbonate solution and illuminate it for fixed time (10) minutes for equilibration before starting to collect oxygen;
16	Reliability (1m)	Reference to repeating at least two more time with different experimental subjects. Perform experiment for another 2 times using another branch / plant;

17	Accuracy (1m)	**Repeating experiment with smaller intervals** Repeating the experiment with filters of smaller interval of light transmission at 10% intervals / any suitable interval;
18	Graph (1m)	Axes drawn must be correct, two graphs on the same axes  Look out for • Shape: Shade > Sun at low light intensities, Sun > Shade at high light intensities, Plateau on both graphs • A! Rate of photosynthesis and light intensity