H2

ANDERSON JUNIOR COLLEGE
HIGHER 2

BIOLOGY 9744/01

Paper 1 Multiple Choice

19 September 2017
Tuesday

1 hour

Additional Materials: Multiple Choice Answer Paper

READ THESE INSTRUCTIONS FIRST

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

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

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

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

1 A scientist viewing β-cells in the islets of Langerhans with a light microscope found that many of these cells contained very large nucleoli.

Which of these organelles would be found in large quantities in the cytoplasm if these cells were viewed with an electron microscope?

1. Mitochondria
2. Rough endoplasmic reticulum
3. Vesicles

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

2 Which of the following regarding embryonic stem cells and blood stem cells is true?

A As embryonic stem cells develop, they turned into blood stem cells as they lose their ability to differentiate into all types of cells.

B Embryonic stem cells have more genes than blood stem cells and thus are able to form more types of cells.

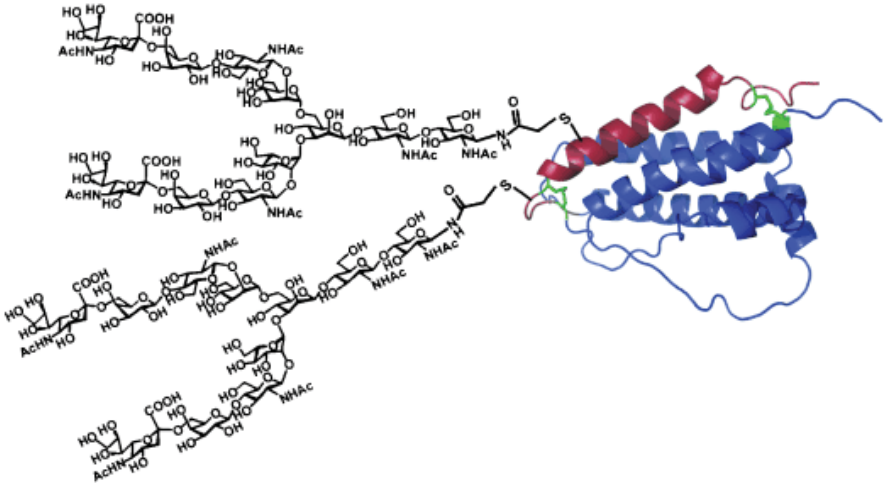
C Under normal conditions, embryonic stem cells express more of their genes compared to the blood stem cells.

D Both stem cells are derived from the zygotic stem cells with the blood stem cells having a lowered telomerase activity compared to the embryonic stem cells.

3 Which of the following options correctly matches the functional and structural features of cellulose, collagen, glycogen and triglycerides?

		Function	Structure		
			Fibrous	Molecule held together by hydrogen bonds	Branched chains
A	Cellulose	Support	✓	×	✓
	Collagen	Strengthening	✓	✓	×
B	Cellulose	Support	✓	✓	×
	Triglyceride	Energy source	×	×	×
C	Collagen	Strengthening	✓	✓	✓
	Glycogen	Storage	×	×	✓
D	Glycogen	Storage	×	✓	✓
	Triglyceride	Energy source	×	✓	×

4 The figure below shows the structure of a biomolecule extracted from a cell.



Below are some statements regarding the structure, property and function of biomolecules with structures similar to that shown above. Which of the following statements are true?

1 This biomolecule has both hydrophilic and hydrophobic properties.

2 This kind of biomolecule plays a role in blood group determination.

3 This biomolecule is contained within the secretory vesicle.

4 When completely hydrolysed, all the monomers of this biomolecule are soluble in water.

A 1 and 3 only

B 2 and 4 only

C 1, 2 and 4 only

D 2, 3 and 4 only

5 A peptide section of an insulin molecule was hydrolysed by two proteases, trypsin and chymotrypsin.

- Trypsin breaks the peptide bonds at the carboxyl terminals of lysine (lys) and arginine (arg).
- Chymotrypsin breaks the peptide bonds at the carboxyl terminals of phenylalanine (phe), tryptophan (trp) and tyrosine (tyr).

The hydrolysis was performed separately using:

(i) Both enzymes, or
(ii) Trypsin only, or
(iii) Chymotrypsin only.

The sequence of amino acid residues in the peptide is shown below:

amino terminal	tyr-leu-val-cys-gly-glu-arg-gly-phe-phe-tyr-thr-pro-lys-ala	carboxyl terminal

Which statement concerning the products of hydrolysis is correct?

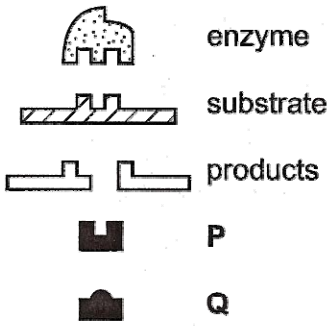
A Fewer than half of the fragments from hydrolysis (i) are single amino acids.

B Hydrolysis (ii) yields one few fragment than hydrolysis (iii)

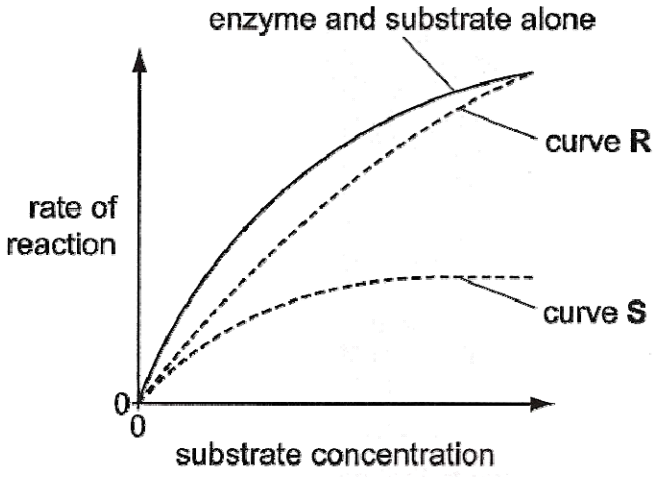
C Hydrolysis (ii) yields one more dipepetide than hydrolysis (iii)

D With hydrolysis (i), all fragments formed are seven or fewer amino acid residues long.

6 The diagram shows an enzyme molecule with its normal substrate and products. P and Q are other molecules that can bind to the enzyme.



The graph shows the effect of P and Q on the rate of reaction of the enzyme at different substrate concentrations.



Which statement correctly describes the activity of the enzyme?

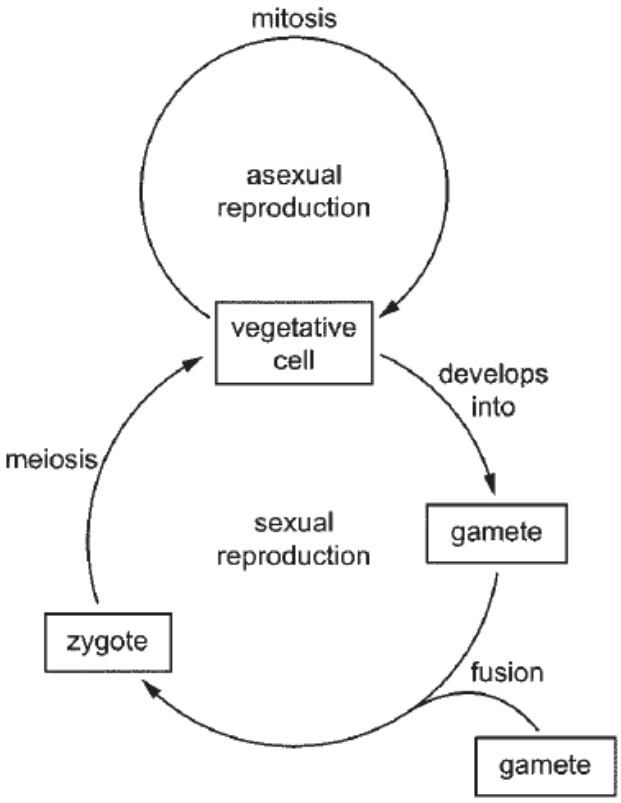
A P is a competitive inhibitor that binds to the active site, resulting in curve R.

B P is a non-competitive inhibitor that distorts the shape of the enzyme, resulting in curve S.

C Q is a competitive inhibitor that distorts the shape of the enzyme, resulting in curve R.

D Q is a non-competitive inhibitor that binds to the active site, resulting in curve S.

7 *Chlamydomonas* is a small, unicellular, green alga that undergoes asexual and sexual reproduction as part of its life cycle, as shown in the diagram.



What can be deduced from this information?

A Fusion of gametes restores the diploid number of the vegetative cell.

B Gametes for sexual reproduction are always formed as the products of meiosis.

C Vegetative cells from haploid daughter cells in asexual reproduction.

D Vegetative cells undergo meiosis to form gametes for sexual reproduction.

8 The mechanism of action of four drugs that inhibit DNA replication is stated below.

- Aphidicholine inhibits DNA polymerase
- Cytarabine is converted into a molecule that can substitute for a DNA nucleotide and also inhibits DNA repair mechanisms
- Epirubicin inhibits an enzyme involved in the unwinding of DNA and separation of strands
- Hydroxycarbamide inhibits an enzyme involved in the production of deoxyribonucleotides

Which row correctly matches a drug to an explanation of the mechanism of action?

	explanation of mechanism of action			
	decreased pool of available nucleotides inhibits chain elongation	DNA strands not available as templates for transcription	DNA damaged during replication and cell death occurs	exposed DNA template strands unable to be copied
A	aphidicholine	epirubicin	cytarabine	hydroxycarbamide
B	epirubicin	cytarabine	hydroxycarbamide	aphidicholine
C	hydroxycarbamide	aphidicholine	epirubicin	cytarabine
D	hydroxycarbamide	epirubicin	cytarabine	aphidicholine

9 A bacterium produces a normal protein with the following amino acid sequence:

Met – Val – His – Lys – Arg – Thr – Leu - Val

After irradiation, a mutant strain is produced that synthesises a mutant protein from the same coding region on DNA with the following sequence:

Met – Val – His – Lys – Glu – Pro

The mRNA codons for some amino acids are shown as follows:

Arg	Glu	Leu	Pro	Thr	Val
AGA	GAA GAG	UUA	CCU CCC	ACC ACG ACA	GUU GUA GUG

Which of the following mutations have occurred in the template DNA strand encoding the protein?

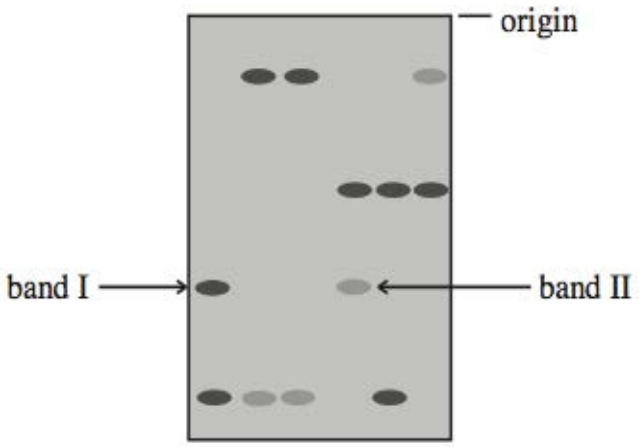
A Substitution of T by A at the 13th nucleotide position.

B Deletion of T at the 13th nucleotide position.

C Insertion of C at the 13th nucleotide position.

D Substitution of A by T at the 20th nucleotide position.

10 The diagram shows the results of DNA profiling using gel electrophoresis.



What conclusion can be drawn about the DNA in bands I and II?

A The DNA in the two bands had the same base sequence.

B The DNA in the two bands had the same ratio of bases.

C The DNA in the two bands came from the same source.

D The DNA in the two bands have the same charge to mass ratio.

11 Which of the following statement comparing the human immunodeficiency virus (HIV) and lambda phage is **incorrect**?

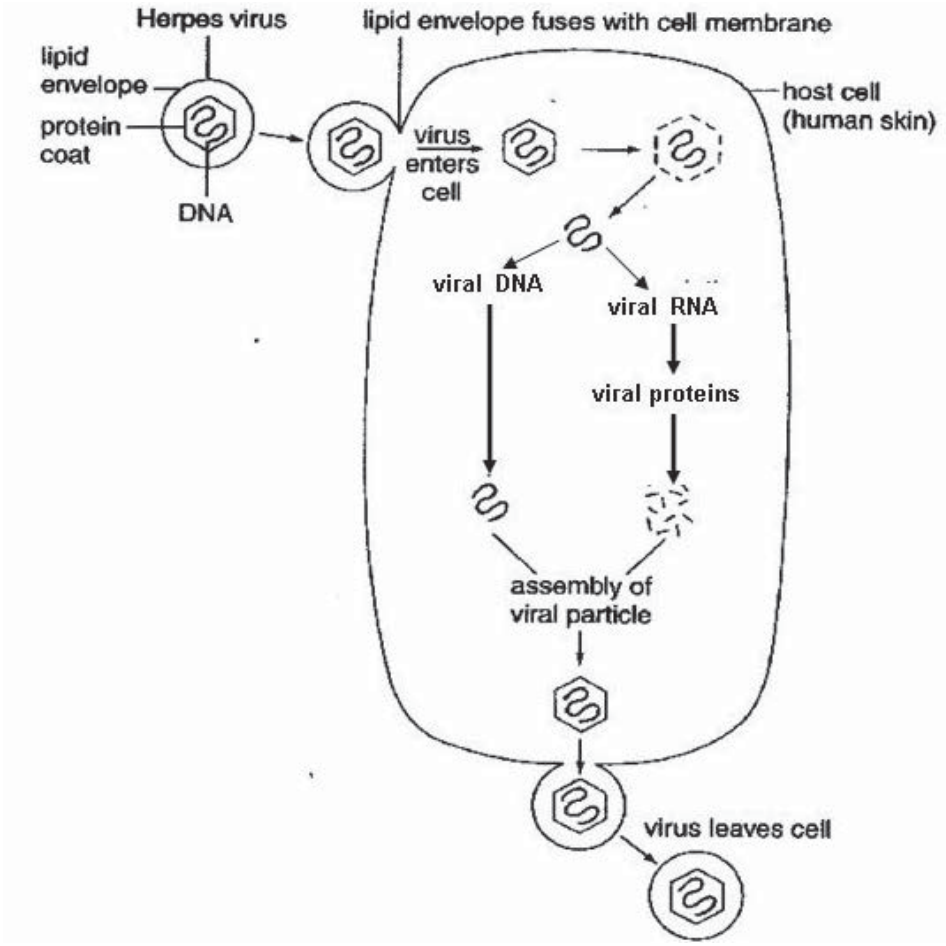
A The HIV enters by receptor-mediated endocytosis, but the lambda phage infects bacterial cells by injecting its DNA.

B The capsid of the HIV enters the host cell, but the capsid of the lambda virus does not.

C The genome of the HIV must be processed before it is integrated into the host chromosome, but the genome of the lambda virus can be directly integrated.

D New HIV are released from the host cell via budding, but new lambda virus are released via cell lysis.

12 The diagram below shows the reproductive cycle of the herpes virus which causes cold sores on the mouth. With reference to the diagram below, which of the following statements best describes the herpes virus?



A It is not a retrovirus as it does not contain RNA as its genetic material

B Its mode of replication is similar to that of influenza virus.

C Its replication cycle includes a lysogenic phase.

D It carries its own enzymes and ribosomes to make viral proteins.

13 What are the correct characteristics for a prokaryotic genome?

	Promoters	DNA always bound to histone proteins	Plasmids often present	Repeat sequences absent or uncommon
A	✓	×	×	×
B	×	✓	✓	✓
C	×	✓	×	×
D	✓	×	✓	✓

14 A mutant strain of *E. coli* has been isolated in which the *lac* operon is not expressed in the presence of lactose. This mutant strain was mated so that it now contains an F plasmid containing a normal *lac* operon. The mutant and mated strain with regard to their β-galactosidase activities in the presence and absence of lactose was compared. The following results were obtained:

Strain	Addition of lactose	Amount of β-galactosidase (percentage of parent strain)
Parent	No	0
Parent	Yes	0
Mated	No	0
Mated	Yes	100

With respect to the results shown in table, which part of the bacterial DNA most likely is mutated?

A *lac A*

B *lac I*

C Promoter of lac operon

D Operator of lac operon

15 Which comparative statements about prokaryotic and eukaryotic gene expression are correct?

1 DNA methylation is a feature of prokaryotes but not eukaryotes.
2 Eukaryotes and prokaryotes both use ribosomes to translate mRNA.
3 Eukaryotes have introns, most prokaryotes do not.
4 Prokaryotes have genes organized into operons, most eukaryotes do not.

A 1, 2 and 3

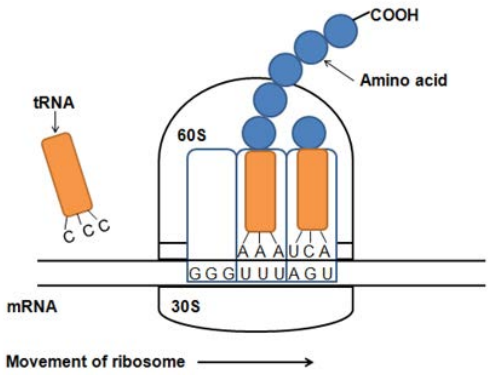
B 1, 2 and 4

C 1, 3 and 4

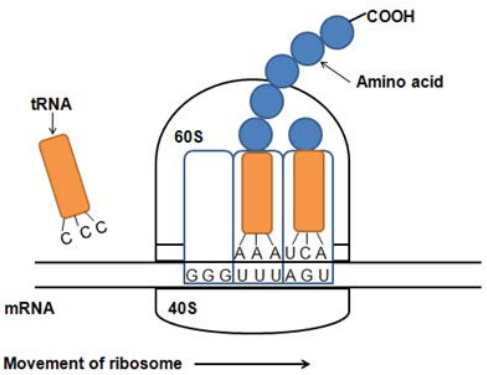
D 2, 3 and 4

16 Which of the following diagrams shows the correct process of eukaryotic translation?

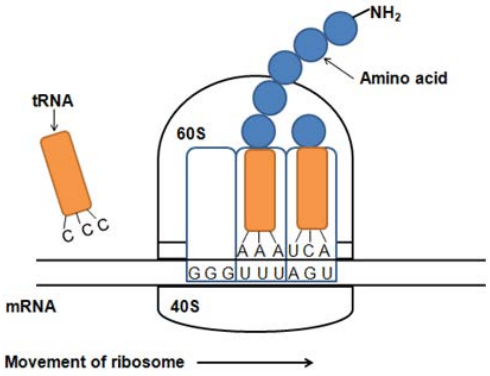
A



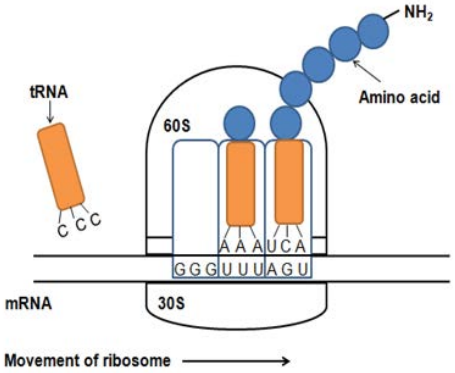
B



C

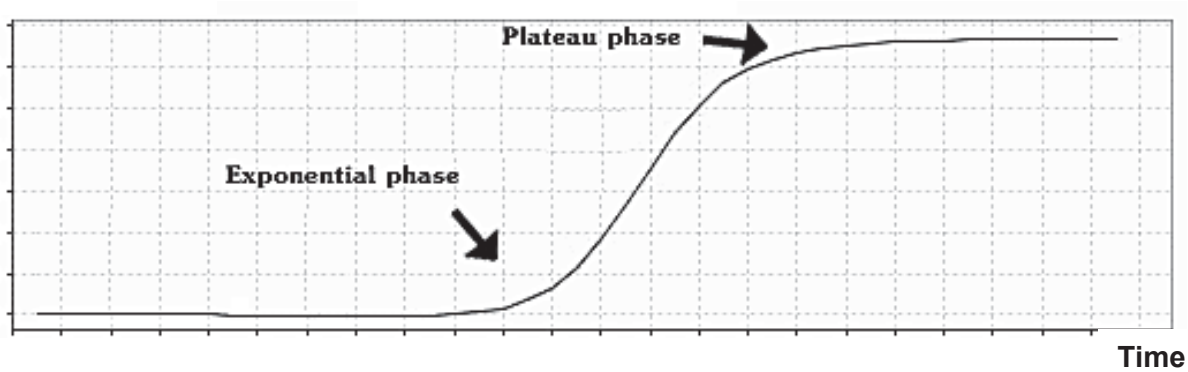


D



17 During PCR, the amount of DNA synthesised can be traced using fluorescent primers and the measurements are shown in the following plot. The process initially goes through an exponential phase, followed by a plateau phase eventually.

Amount of DNA



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

A During the exponential phase, the number of DNA molecules synthesized after 15 cycles is 15^2.

B During the exponential phase, the temperature is always maintained at the optimum temperature of 72°C hence there is rapid amplification.

C During the plateau phase, the reaction mixture is being depleted of ribonucleotides.

D During the plateau phase, *Taq* polymerase may be denatured.

18 Which of the following is true about both cyclic and non-cyclic photophosphorylation?

1 Establishes an electrochemical gradient across the thylakoid membrane
2 Involve photosystem II
3 Require oxygen as the final electron acceptor
4 Photolysis of water occurs

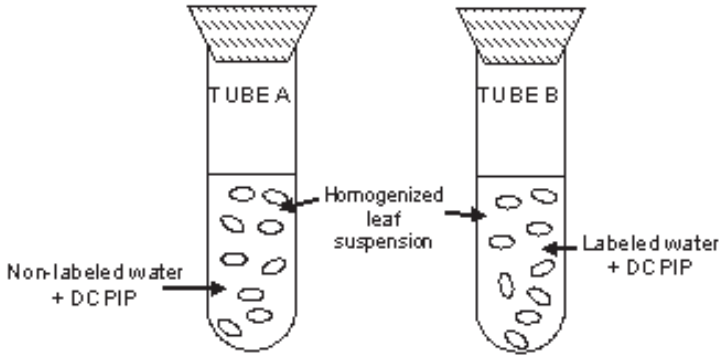
A 1 only

B 1 and 2 only

C 2 and 4 only

D 1, 3 and 4 only

19 The experimental setup below was created by homogenizing leaf cells to break their cell walls. The leaf suspensions containing the cytoplasm and organelles were then placed in test-tubes containing non-labeled water ($H_2{}^{16}O$) and ^{18}O-labeled water ($H_2{}^{18}O$) respectively. A few drops of DCPIP, a hydrogen acceptor, were added to each test-tube. DCPIP will turn from blue to colourless when it is reduced and this colourless DCPIP can be reoxidized to blue.



The test-tubes were then exposed to blue light for 30 minutes. Which of the following shows the results of the two test-tubes after 30 minutes?

	Tube A		Tube B	
	Gas evolved	**DCPIP colour**	**Gas evolved**	**DCPIP colour**
A	$C^{16}O_2$	Blue	$C^{18}O_2$	Blue
B	$^{16}O_2$	Blue	$^{16}O_2$	Blue
C	$C^{16}O_2$	Colourless	$C^{18}O_2$	Colourless
D	$^{16}O_2$	Colourless	$^{18}O_2$	Colourless

20 From which substrate is the first carbon dioxide molecule released during cellular respiration?

A Glucose

B Pyruvate

C Acetyl-coA

D Citrate

21 Four tubes containing preparations from animal tissue were set up as shown in the table.

Tube	Contents
1	Glucose + homogenized cells
2	Glucose + cytoplasm lacking organelles
3	Pyruvic acid + homogenized cells
4	Pyruvic acid + mitochondria

After incubation, in which tube/ tubes would at least 36 ATP be produced?

A 1 only

B 1 and 3 only

C 1, 2 and 4 only

D 1, 3 and 4 only

22 A plant is known to be heterozygous at two gene loci, X and Y. The pollen grains from this plant are used to fertilise another plant of the same genotype. What is the probability that an embryo will be homozygous dominant at one locus.

A 1 in 4

B 3 in 8

C 5 in 8

D 1 in 16

23 Barring in chickens is due to a sex-linked dominant gene. The sex of chicks at hatching is difficult to determine but barred chicks can be distinguished from nonbarred at that time. What cross would you make such that all chicks of one sex are barred?
In chicken, the male is the homogametic sex.

A Barred males x barred females

B Barred males x nonbarred females.

C Nonbarred males x barred females

D Nonbarred males x nonbarred females

24 Birds, such as cockatoos, have a species of louse (an insect parasite) that lives on their feathers. White sulfur-crested coackatoos have pale lice on their wings and bodies while yellow-tailed black cockatoos have dark lice on their wings and bodies. Both of these cockatoos have black lice of this species on their heads. In order to rid themselves of these parasites, cockatoos preen their wings and bodies with their beaks but have to use their feet to preen their heads.

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

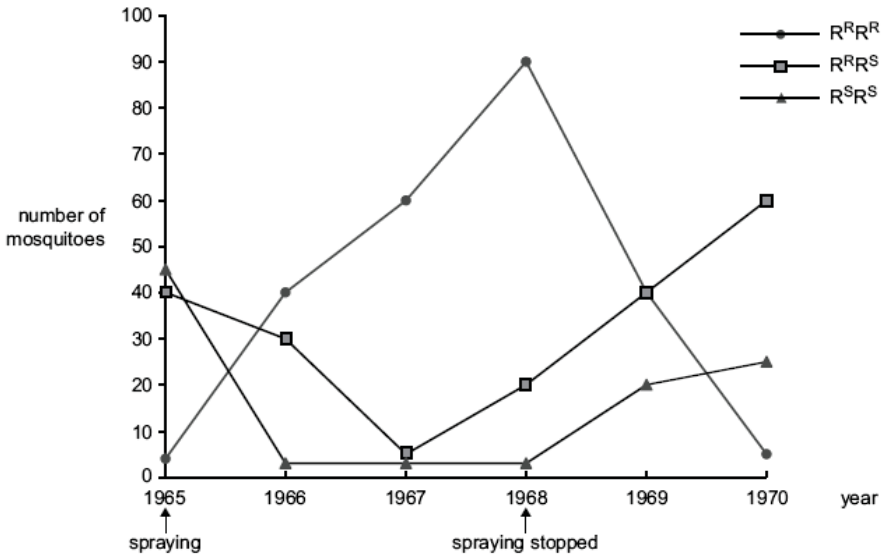
A Cockatoo beak preening results in selection pressure on wing and body lice.

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

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

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

25 In the mosquito, there is a gene locus which has two alleles, R^R and R^S, involved in resistance to the insecticide DDT. R^R represents the allele for DDT resistance and R^S represents the allele for DDT sensitivity. The graph shows the number of mosquitoes of three genotypes collected from 1965, when DDT was first used, through to 1970, two years after the spraying of DDT stopped.



From the data, it is possible to conclude that

A the frequency of the R^S allele is greater than the frequency of the R^R allele in 1968.

B many generations after the removal of DDT, the R^R allele would disappear from the population.

C after removal of DDT from the environment in 1968, having the R^RR^R genotype reduces the chance of survival.

D in the presence of DDT in the environment between 1967 and 1968, mosquitoes with the R^RR^S genotype are most likely to survive.

26 Which of the following shows the correct sequence of events?

1	adaptation of a population	➔	competition and predation leading to natural selection	➔	behavioural isolation	➔	allopatric speciation
2	adaptation of a population	➔	competition and predation leading to natural selection	➔	physiological isolation	➔	allopatric speciation
3	competition and predation leading to natural selection	➔	physiological isolation	➔	adaptation of isolated populations	➔	sympatric speciation
4	competition and predation leading to natural selection	➔	geographical isolation	➔	adaptation of isolated populations	➔	allopatric speciation

A 3 only

B 1 and 2 only

C 3 and 4 only

D 1, 3 and 4 only

27 Which of the following statements regarding a B cell expressing both IgM and IgD on its membrane is incorrect?

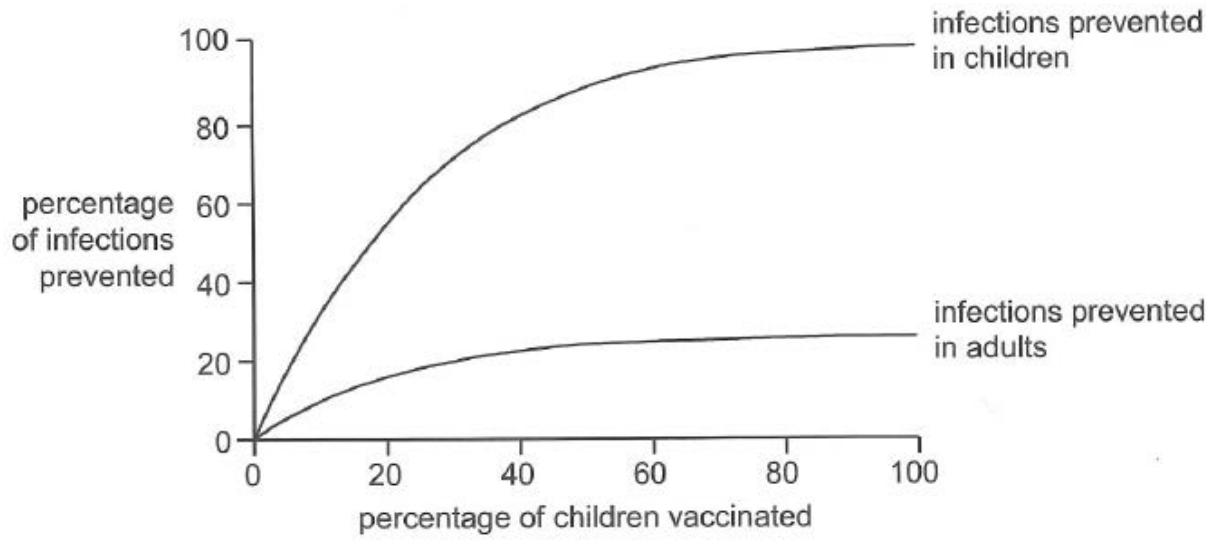
A The L chains of the IgM and IgD have identical amino acid sequences.

B The constant parts of the H chains of the IgM and IgD have different amino acid sequences.

C The IgM and IgD have different antigenic specificities.

D If it is triggered by antigen and T-cell signals to proliferate and differentiate, it may differentiate into a plasma cell that may secrete IgG, IgE, or IgA antibodies.

28 The diagram shows the effect of vaccination of children on the prevention of infection.



What can be concluded about the effect of vaccination of children from this data?

1. When approximately 80% of children are vaccinated, the cycle of disease transmission in children is broken.
2. Vaccination of children reduces the percentage of infections in both adults and children.
3. The effect on adult infection is less than that on infection in children, because adults will have been vaccinated as children
4. The effect on children infection is less than that on infection in adults, because more children are not suitable candidates for vaccination.

A 1 and 2 only

B 1 and 4 only

C 2 and 3 only

D 1, 2 and 4

29 What contributes to the enhanced greenhouse effect?

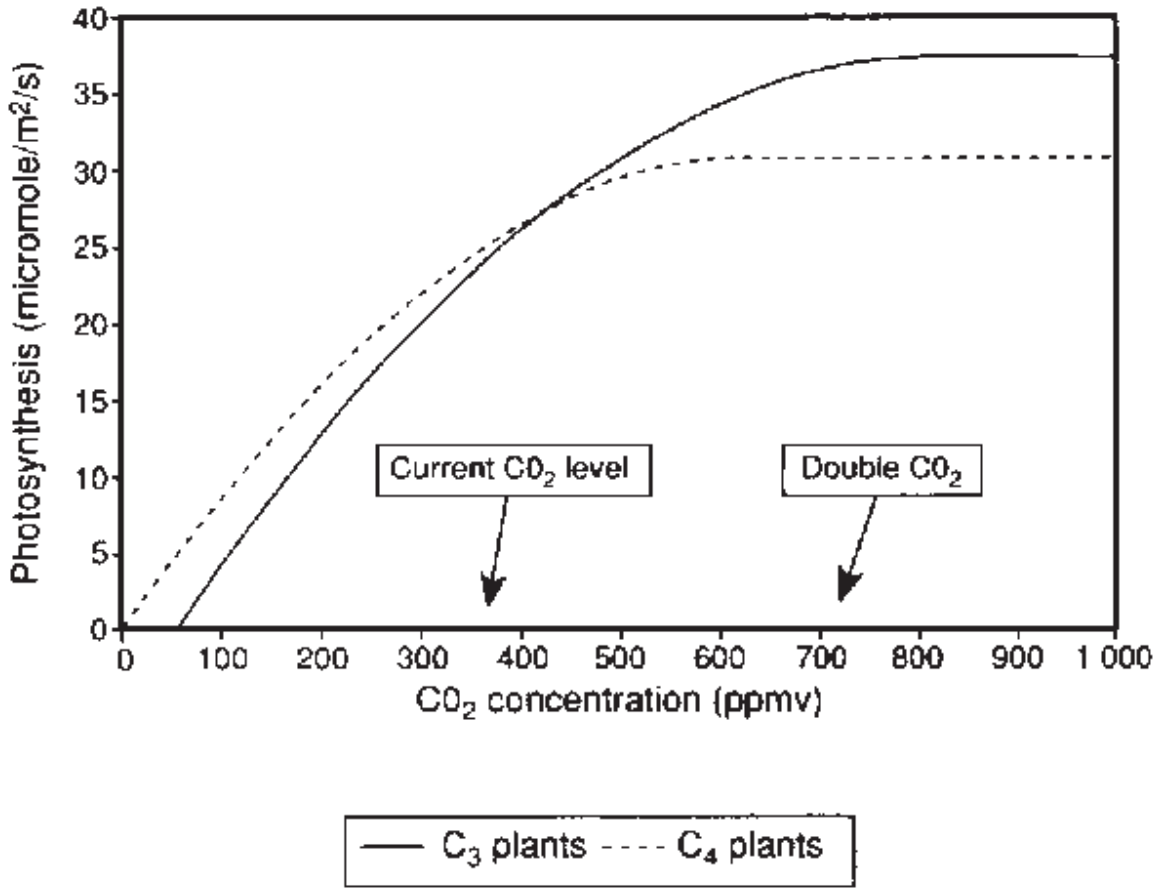
A Ozone from violent thunderstorms

B Carbon particles in diesel engine exhaust

C Methane from agricultural sources

D Carbon dioxide from active volcanoes around the world

30 The graph shows the impact of climate change on C3 and C4 plants. C3 and C4 are the different types of photosynthetic methods used by different plants.



Which of the following statement is supported by the graph?

A Both C3 and C4 plants photosynthetic rate are only limited by carbon dioxide concentration currently.

B C3 and C4 plants react to environmental stress caused by an increase in carbon dioxide differently.

C Farmers may want to consider growing more C3 crop plants in future

D Global warming increases the yield of crop plants for both cattle and human.

H2 ANDERSON JUNIOR COLLEGE
HIGHER 2

CANDIDATE NAME

PDG

PDG INDEX NUMBER

BIOLOGY
9744/02

Paper 2 Structured Questions

12 September 2017
Tuesday

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

All working for numerical answers must be shown.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Calculators may be used

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

This document consists of **22** printed pages.

Answer **all** the questions.

1 Lactose intolerance in humans is the inability to hydrolyse lactose due to the lack of the enzyme lactase in the alimentary canal. As a result, bacteria in the large intestines feed on the lactose and produces fatty acids and methane which lead to diarrhoea and flatulence.

Bacteria have been used to produce lactase (Fig. 1.1) on an industrial scale as a dietary supplement for people who are lactose intolerant. Human lactase consists of a single 160 kDa polypeptide chain that localizes to the brush border membrane of intestinal epithelial cells.

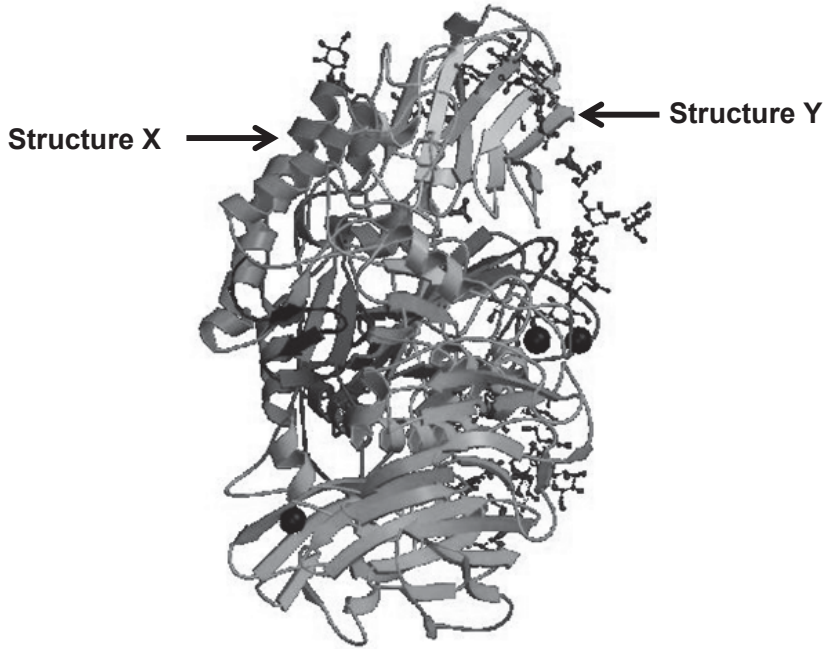


Fig. 1.1

(a) With reference to the **Fig. 1.1**,

(i) state the levels of organization seen in the structure of lactase.

[1]

(ii) Describe structures **X** and **Y.**

[2]

(b) **Fig. 1.2** shows the hydrolysis of lactose.

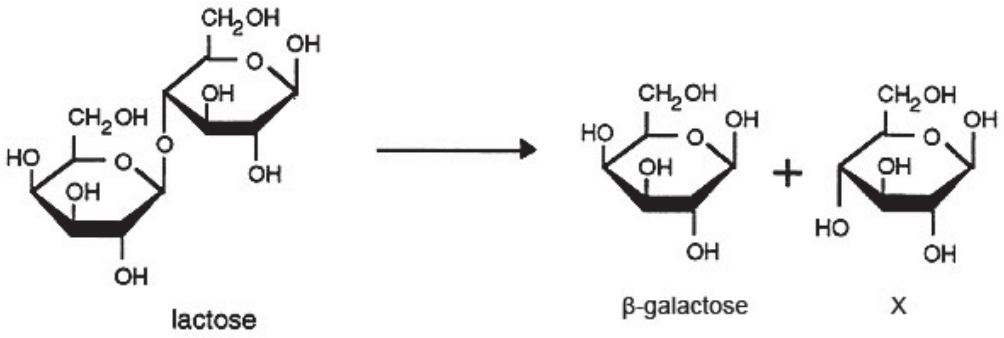


Fig. 1.2

Describe the hydrolysis of lactose, naming the bond that is broken and product **X**.

.....

..... [2]

(c) Lactase and lactose are protein and carbohydrates respectively.
Explain why there are fewer types of carbohydrate polymers compared to protein polymers.

.....

.....

.....

.....

..... [3]

Cell organelles can be separated by centrifuging a cell extract in a sucrose density gradient. The organelles settle at the level in the sucrose solution which has the same density as their own.

The cells used to synthesized lactase were lysed and the cell extract centrifuged in a sucrose density gradient. Three distinct fractions of nuclei, mitochondria and ribosomes (in no particular order) were obtained. The three fractions **A, B** and **C** are shown in the **Fig. 1.3**.

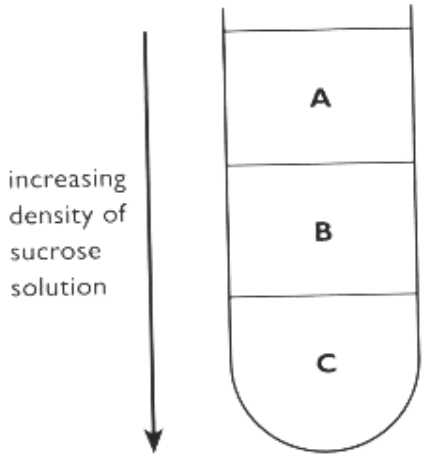


Fig. 1.3.

(d) Identify the organelle in each fraction and describe its role in the synthesis of lactase.

[4]

[Total: 12 marks]

2 Recently, scientists discovered the presence of a population of bone-marrow derived stem cells that have the ability to form heart muscles cells when transferred to the heart. The stem cells were removed from the bone marrow and cultured so that they divided by mitosis. It was proposed that these stem cells resembled embryonic stem cells.

(a) (i) Describe **two** similarities between these bone-marrow derived stem cells and embryonic stem cells.

[2]

(ii) Describe how the rate of mitosis is controlled.

[4]

(iii) State an advantage of using bone marrow derived stem cells rather than heart stem cells for the treatment of heart diseases.

[1]

(c) Troponin is a protein that is integral to muscle contraction in heart muscles. **Fig. 2.1** shows part of its DNA sequence. The entire sequence is 63 base pairs.

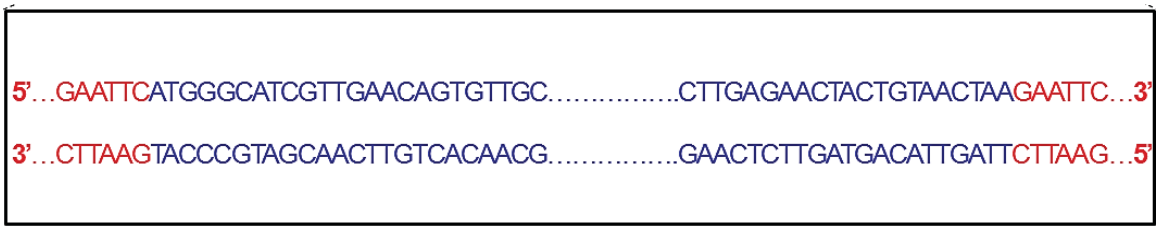


Fig. 2.1

PCR can be used to confirm presence of troponin DNA sequence. The following pair of primers are used.

Primer	Primer sequence
1	5' AATTCATGGGCATCG 3'
2	5' GAATTCTTAGTTACA 3'

(i) In the boxed area in Fig. 2.1, circle and label the DNA sequences where Primers 1 and 2 will anneal. [1]

(ii) Explain how results of gel electrophoresis of the PCR products are able to show that troponin DNA has been successfully amplified.

[1]

(iii) Besides the use of PCR, nucleic acid hybridisation can also be used to determine presence of troponin DNA.

Outline how nucleic acid hybridisation can be used to identify troponin DNA.

[4]

[Total: 13 marks]

3 The pie chart in Fig. 3.1 shows the relative length of time of each of the stages that occur during a particular eukaryotic cell cycle. This complete cycle takes 15 hours.

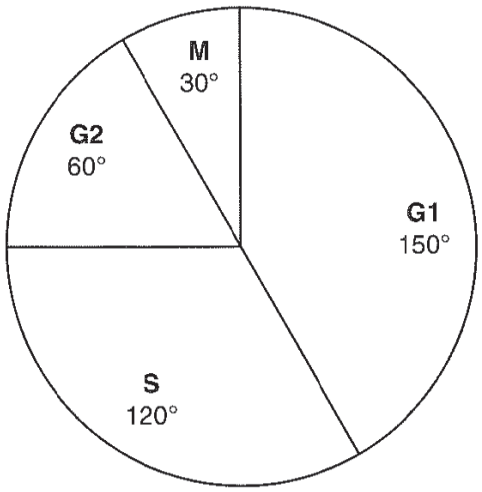


Fig. 3.1

(a) Using the information provided above, calculate how long interphase lasts.

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

[2]

(b) During the cell cycle there are a number of checkpoints.

State one function of these checkpoints and explain what might occur as a result of dysregulation of these checkpoints.

[3]

(c) Colorectal cancer is one of the most common cancers in Singapore. Cancer of the colon and rectum – colorectal cancer – begin as polyps (also known as adenoma) that grow on the inner lining of the large intestine.

Most sporadic cases of colorectal cancer are believed to develop from benign adenomas (polyps) to carcinoma by the accumulation of genetic abnormalities as shown in Fig. 3.2.

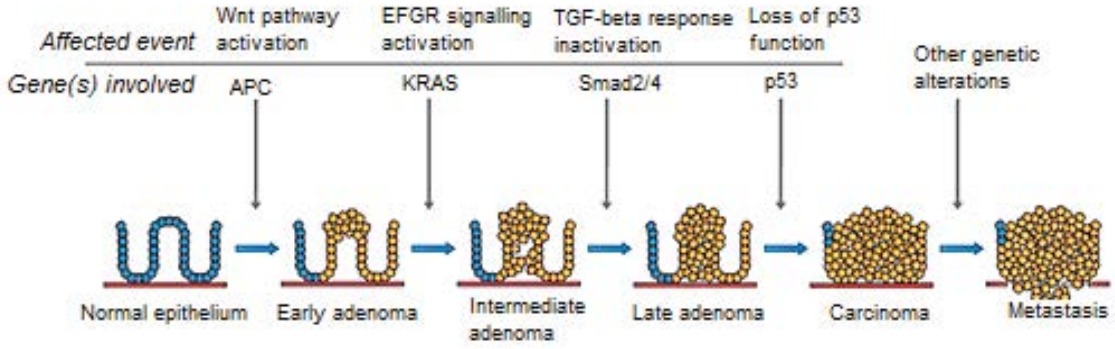


Fig 3.2

(i) Using the Fig. 3.2, explain why the development of cancer is a multi-step process.

[5]

(ii) The majority of all colorectal cancers occur sporadically without any known cause, but certain groups of people have a predisposition to the development of cancer of the large intestine. These people may carry specific genetic mutations or have relatives with the condition.

Approximately 15% of all colorectal cancer cases are familial, with the most common inherited conditions being familial adenomatous polyposis (FAP). Patients with FAP have a lifetime risk of the development of colon cancer that approaches 100%. Patients with FAP have a germline inactivation of one APC allele. Adenoma formation is faster, ~~but~~ progression from adenoma to carcinoma has the same rate as sporadic colorectal cancer as shown in Fig. 3.3.

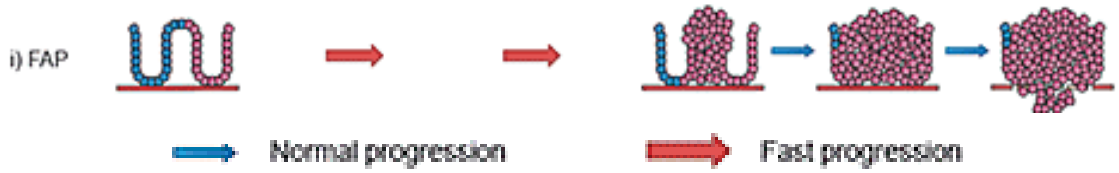


Fig. 3.3

Using the information above and your own understanding of the development of cancer, suggest why patients with FAP form adenoma faster.

.....

.....

.....

..... [2]

[Total: 12 marks]

4 Genome editing is the process in which a DNA target sequence is replaced by a desired sequence. **Fig. 4.1** shows how the process is being done by Cas9 enzyme which makes use of a guide RNA to achieve the editing effect. This can be done in embryos so that those children who are born from parents with the genetic disease alleles would not suffer from the genetic disease.

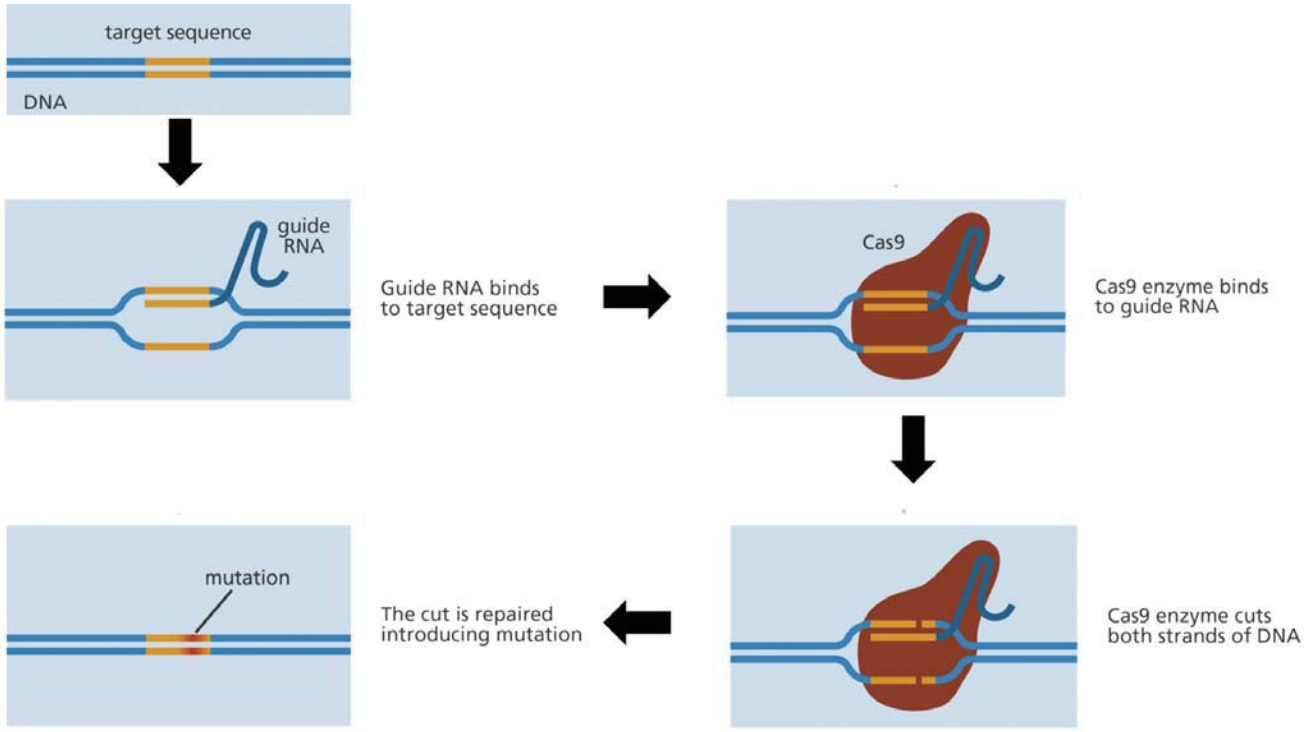


Fig. 4.1

(a) With reference to Fig. 4.1, describe how the guide RNA and Cas9 enzyme are used to cut both strands of DNA.

[3]

(b) **(i)** Explain why gene editing done on embryos help to prevent children born from suffering from the genetic disease.

[2]

(ii) Suggest and explain if the mutation introduced by gene editing as shown in Fig. 4.1 should be dominant or recessive.

[2]

(c) Describe how mutations in DNA arise in nature.

[2]

RNA plays a very important role in many biological processes. One of them is transfer RNA (tRNA) which has extensive intramolecular hydrogen bonds.

(d) **(i)** State **two** importance of having such bonds.

[2]

(ii) Relate the structure of tRNA to its functions.

[2]

[Total: 13 marks]

5 Fig. 5.1 represents a bacteria DNA and a eukaryotic chromosome in metaphase of mitosis, not drawn to scale.

Fig. 5.1

(a) State **two** ways in which the organization of genes found in these two structures differ and suggest **one** advantage of this to the bacterium.

.....

.....

.....

.....

..... [3]

(b) In 1946, Joshua Lederberg and Edward Tatum proposed that bacterial cells undergo genetic recombination. To test their hypothesis, they conducted experiments using two bacteria strains of *Escherichia coli (E.coli*), A and B, with different nutritional requirements.

Strain A, B and a mixture of both strains were grown on culture plates containing minimal medium that does not contain essential amino acids. The results are shown in Fig. 5.2.

Mutant genes (–) do not code for enzymes that synthesize amino acids. Note that all five amino acids are required for bacterial growth.

Bacterial strains	Genes for biosynthesis of amino acids	Mutant genes for biosynthesis of amino acids
A	thr^+ leu^+ thi^+	met^- bio^-
B	met^+ bio^+	thr^- leu^- thi^-

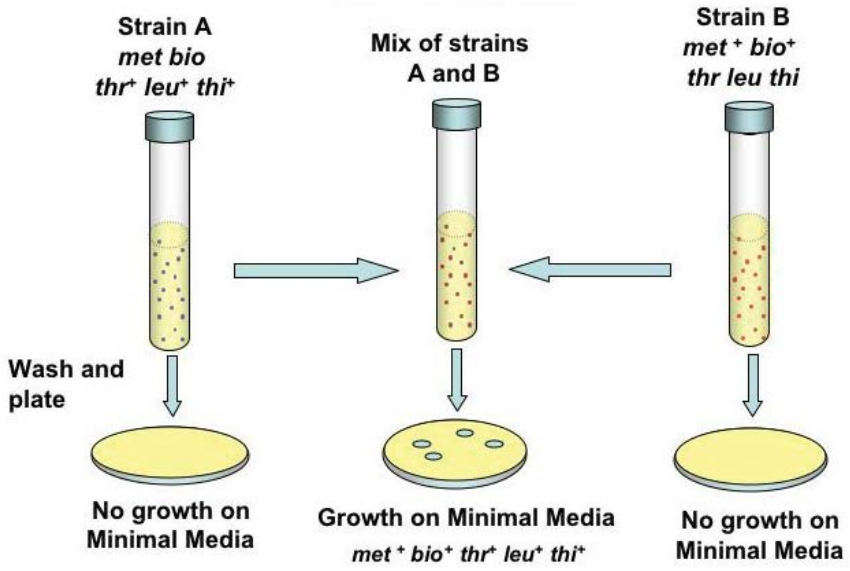


Fig. 5.2

Another researcher, Bernard Davis also worked with the same hypothesis. In his experiment he constructed a U-tube in which the two arms were separated by a fine filter. The pores of the filter were too small to allow bacteria to pass through but large enough to allow easy passage of the fluid medium, any dissolved substances and free DNA. The results are shown in Fig. 5.3.

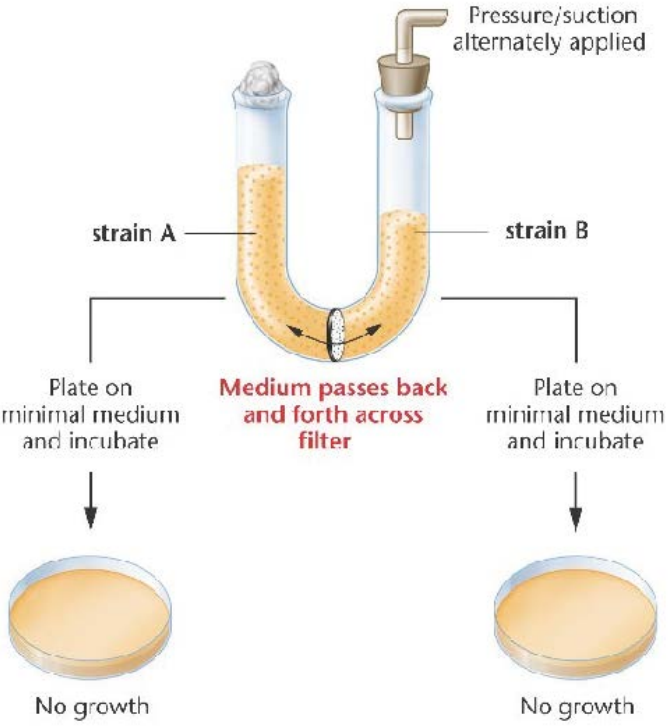


Fig. 5.3

(i) Using the results of the two experiments shown in Fig. 5.2 and Fig. 5.3 and your understanding of genetic recombination in bacteria, state the genetic recombination that has taken place between Strain A and B. Explain your answer.

[6]

(c) In 2016, a pathogenic strain of *E.coli* found on unwashed salad caused food poisoning in 151 people in Britain, leaving two of them dead.

Describe how such pathogens are usually treated using a named example.

[3]

[Total: 12 m]

6 In anaerobic respiration in yeast, the pyruvate molecules are broken down to produce ethanol and carbon dioxide. The release of carbon dioxide can be used to investigate the rate of anaerobic respiration.

Fig. 6.1 shows an experiment which was set up to find the rate of anaerobic respiration.

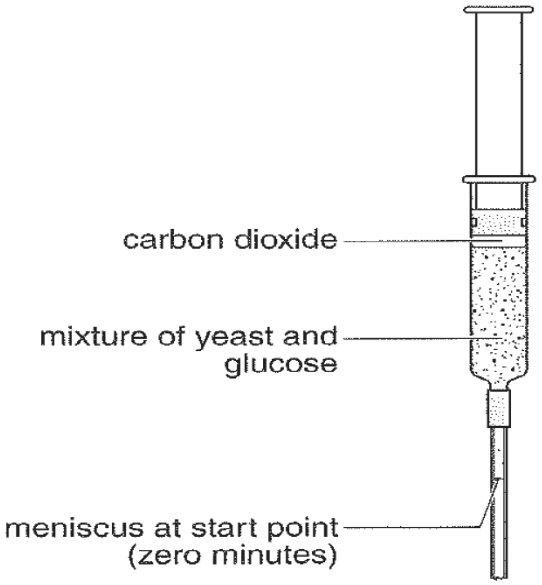


Fig. 6.1

The meniscus moves down the tube as carbon dioxide is released.

Table 6.1 shows the distance moved by the meniscus from the start point. This was recorded every 10 minutes.

Table 6.1

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	1	2	5	9	14	21	45	73	98

(a) The rate of anaerobic respiration can be calculated by using the rate of movement of the meniscus.

Calculate the rate of anaerobic respiration between 70 and 80 minutes.

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

[2]

(b) This experiment was repeated three more times. Each time, the glucose (a monosaccharide) was replaced with a different disaccharide sugar:

- Maltose – a disaccharide of glucose and glucose
- Sucrose – a disaccharide of glucose and fructose
- Lactose – a disaccharide of glucose and galactose.

Tables 6.2 (a), (b) and (c) show the results of these experiments.

Table 6.2 (a): Using maltose

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	0	0	0	0	2	3	6	9	12

Table 6.2 (b): Using sucrose

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	0	0	1	3	11	22	37	48	61

Table 6.2 (c): Using lactose

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	0	0	0	0	0	0	0	0	0

With reference to the information provided in Tables 6.2 (a), (b) and (c) and your biological knowledge:

(i) Describe the difference in the results for maltose and sucrose, and suggest one explanation for this difference,

.....

.....

.....

.....

..... [2]

(ii) Suggest two explanations for the results for lactose.

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..... [2]

(c) An electron micrograph of yeast, *Candida albicans*, is shown in Fig. 6.2.

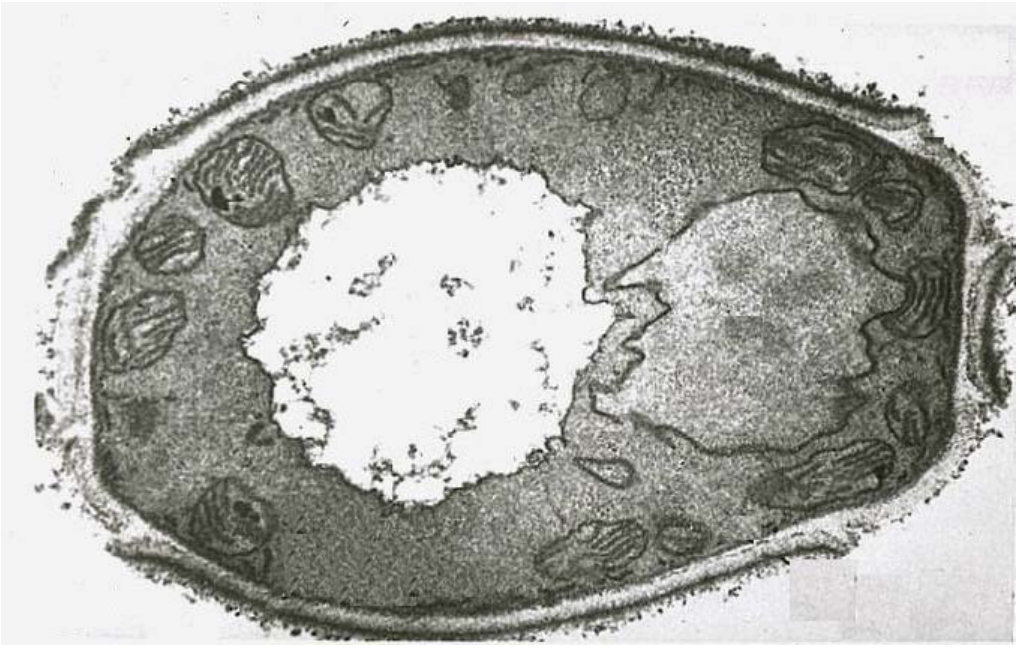

Fig. 6.2

(i) On Fig. 6.2, label site of
- i. Glycolysis
- ii. Oxidative phosphorylation [2]

(ii) State one visible structure of mitochondria from Fig. 6.2 and describe how it supports mitochondria's function.

.....

.....

..... [1]

(ii) Besides location, compare between oxidative phosphorylation and photophosphorylation.

[4]

[Total: 13 marks]

7 Pigment production in onions is controlled by two enzymes resulting in three different coloured bulbs - red, yellow and white.

A pure-white strain crossed with a pure-red strain produces an all-white offspring (F_1). Two F_1 onions with white bulbs were crossed. The F_2 generation was found to consist of 2170 white, 530 red and 180 yellow-bulbs.

The alleles are represented by the following symbols:

I: no production of pigment
i: production of pigment
R: red pigment
r: yellow pigment

(a) State the mode of inheritance in the onion bulb colour.

.....[1]

(b) Explain the results of the cross by drawing a genetic diagram in the space below. [5]

(c) Explain how different genotypes give rise to different phenotypes.

[4]

(e) Suggest how a farmer may determine if a red onion is homozygous in both loci.

[2]

[Total: 12 marks]

8 Antibodies against tuberculosis are produced by plasma cells during an immune response.

Fig. 8.1 shows a diagram of an antibody molecule.

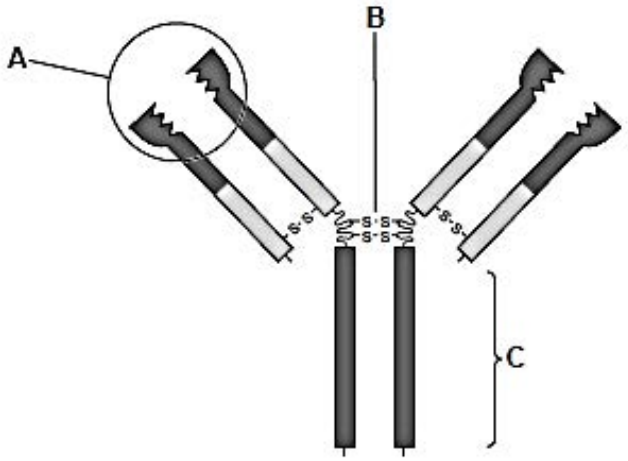

Fig. 8.1

(a) Explain the functions of the parts labelled A, B and C.

(i) A

.....

.....

..... [2]

(ii) B

.....

..... [1]

(iii) C

.....

..... [1]

(b) Explain why tuberculosis (TB) is known as an infectious disease.

[3]

(c) Outline the roles of antibiotics in the treatment of infectious diseases, such as TB.

[3]

(d) While TB is a bacterial infectious disease, HIV is a viral infectious disease.

Explain how HIV cause diseases in humans through the disruption of host tissue and functions.

[3]

[Total: 13 marks]

H2 ANDERSON JUNIOR COLLEGE
HIGHER 2

CANDIDATE NAME

PDG

PDG INDEX NUMBER

BIOLOGY 9744/03

Long Structured and Free response Question Paper 3

14 September 2017 Thursday

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

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staplers, 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 Question Paper.

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

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

For Examiner's Use	
1	
2	
3	
4 OR	
5	
Total	55

This document consists of **18** printed pages and **0** blank page.

Section A

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

1 Cyanobacteria are a group of photosynthetic, nitrogen-fixing bacteria that live in a wide variety of moist soils and water either freely or in a symbiotic relationship with plants. Some cyanobacteria float in water by forming gas vesicles that are bounded by a protein sheath.

Fig. 1.1 below shows a generalized drawing of a cyanobacterium. The plasma membrane of cyanobacterium consists of an outer and inner membrane which is not represented in Fig. 1.1.

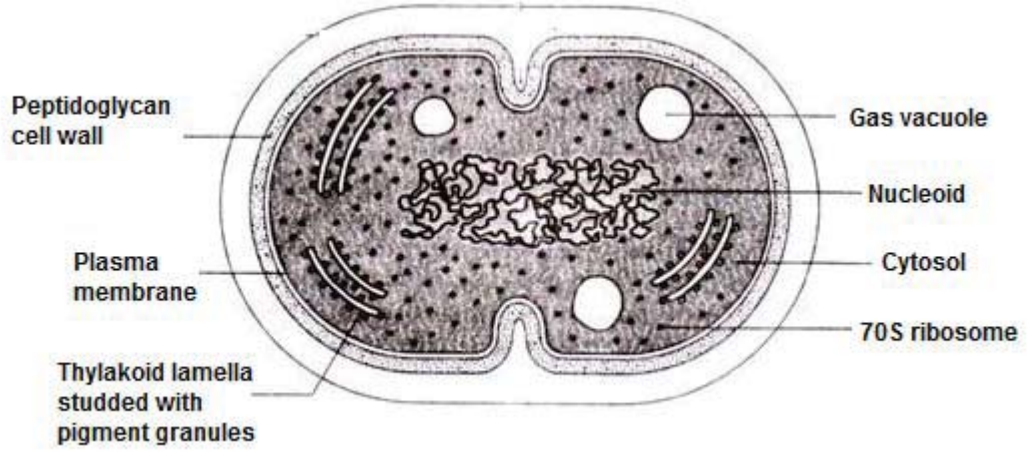

Fig. 1.1

(a) From Fig. 1.1, state two structural features that are expected in a typical prokaryote and two structural features that are not expected in a typical prokaryote.

Expected:

.....

.....

Not expected:

.....

..... [2]

(b) Process of photosynthesis that occurs in cyanobacterium is largely similar to photosynthesis in chloroplast. Fig. 1.2 shows the effect of carbon dioxide concentration on the light-independent stage of photosynthesis in *Synechococcus* genus of cyanobacterium. The following steps were carried out in a study:

- a cell suspension of *Synechococcus* was illuminated using a bench lamp.
- the suspension was supplied with carbon dioxide at a concentration of 1% for 200 seconds.
- the concentration of carbon dioxide was then reduced to 0.03% for a further 200 seconds.
- the concentration of RuBP and glycerate-3-phosphate (GP) were measured at regular intervals.
- the temperature of the suspension was maintained at 25 °C throughout the investigation.

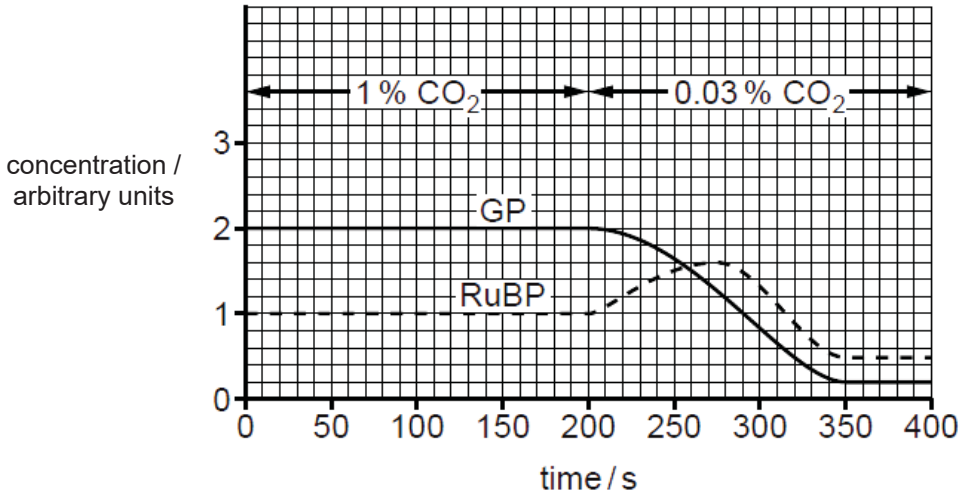

Fig. 1.2

(i) With reference to Fig. 1.2, explain why the concentration of RuBP changed between 200 and 275 seconds.

[2]

(ii) Suggest how the decrease in the concentration of GP leads to an increase in the generation time (time it takes for the population to double) of *Synechococcus.*

[3]

(iii) Scientists have suggested that chloroplast may have originated as cyanobacterium that continued to function after becoming engulfed by primitive eukaryotic cells, in a process similar to endocytosis.

Describe two features of chloroplast that provide support for this hypothesis.

[2]

(c) In the study of evolution of Man, the theory of natural selection is widely used to understand how speciation of humans has occurred. The study of fossils and genetic sequences are now commonly used to help us understand more about human evolution. It is widely believed that humans are closely related to the Great Apes – chimpanzees, gorillas and orang utan, and share a common ancestor millions of years go.

Fig. 1.3 below shows some comparisons of skull structure between the Great Apes and modern Man (*Homo sapiens)*.

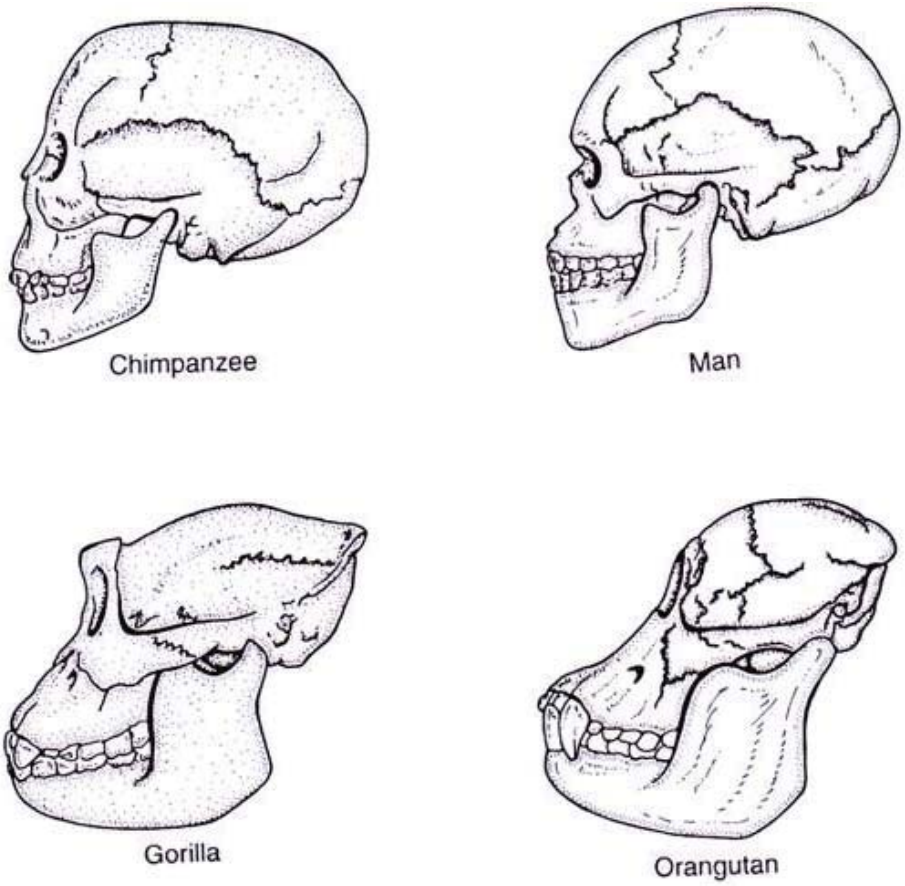

Fig. 1.3

(i) Using Fig. 1.3, state two features that support the hypothesis that modern Man shares a common ancestor with the Great Apes.

.....

.....

.....

.....

..... [2]

Neanderthals (*Homo neanderthalensis*), another primate similar to modern humans is our closest human relative. Fig. 1.4 below shows a comparison between the fossilized skull of a Neanderthal and modern Man.

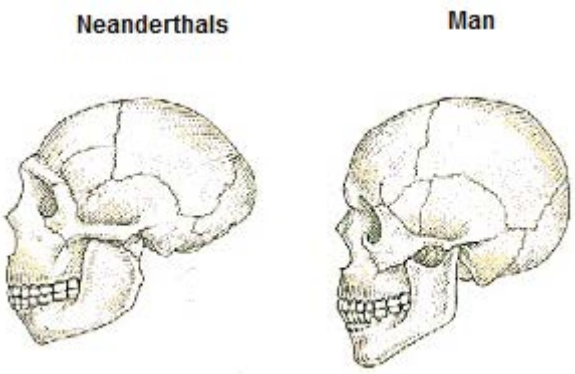

Fig. 1.4

(ii) Disagreement exists as to whether the scientific name for Neanderthals should be *Homo sapiens* or *Homo neanderthalensis*.

With reference to **four** different species concepts, explain why it is difficult to assign a scientific name to Neanderthals.

[4]

(iii) Discuss one advantage of using genetic sequences to study evolution of Man.

[2]

[Total: 17]

2 B-lymphocytes respond to the presence of a non-self antigen by dividing as shown in Fig. 2.1.

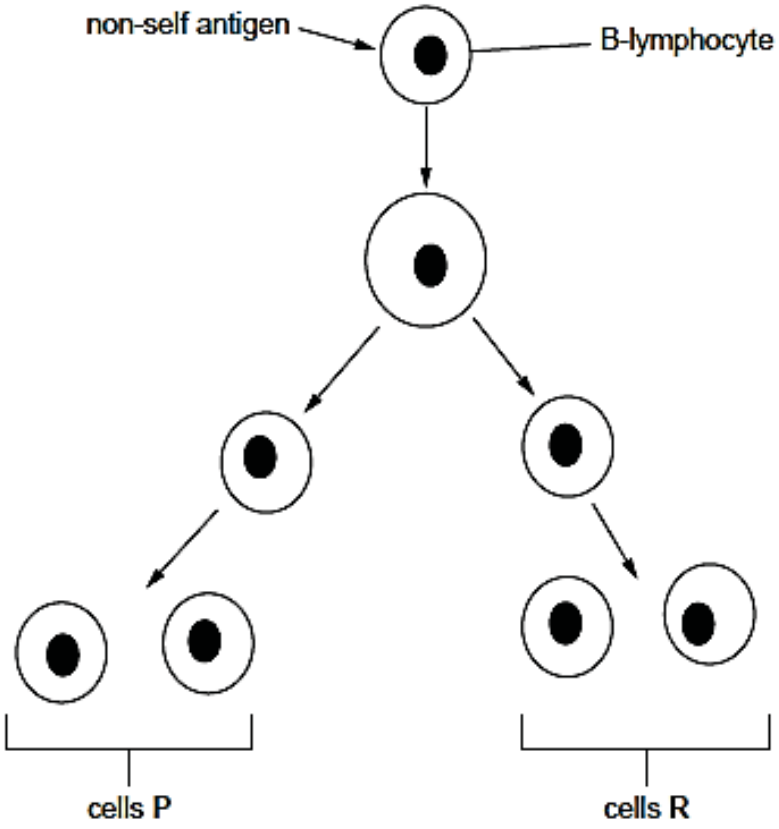

Fig. 2.1

(a) During an immune response, cells divide by mitosis. Describe how mitosis is involved in an immune response.

.....

.....

.....

..... [3]

(b) The cells labelled P on Fig. 2.1 continue to divide to give rise to many cells that differentiate into short-lived plasma cells. The plasma cells release antibody molecules.

(i) Outline how plasma cells produce antibody molecules.

[4]

(ii) Describe how antibody molecules are released from the plasma cell.

[2]

(c) Both B and T lymphocytes are part of adaptive immunity. Describe the mode of action of T-lymphocytes during an immune response.

[4]

(d) Immune response is mounted against pathogen such as bacteria. Explain why phagocytes act only against the bacteria and not against human cells.

[4]

[Total: 17]

3 The olive tree, *Olea europaea*, is a small tree native to the Mediterranean area of Europe, Africa and parts of Asia, where it has been cultivated for several thousand years. In 1993, Beerling and Chaloner carried out estimates of stomatal density on preserved olive leaves. The oldest of these were obtained from the tomb of the Egyptian King Tutankhamun who died over 3000 years ago. The results of the study are summarised in Fig. 3.1.

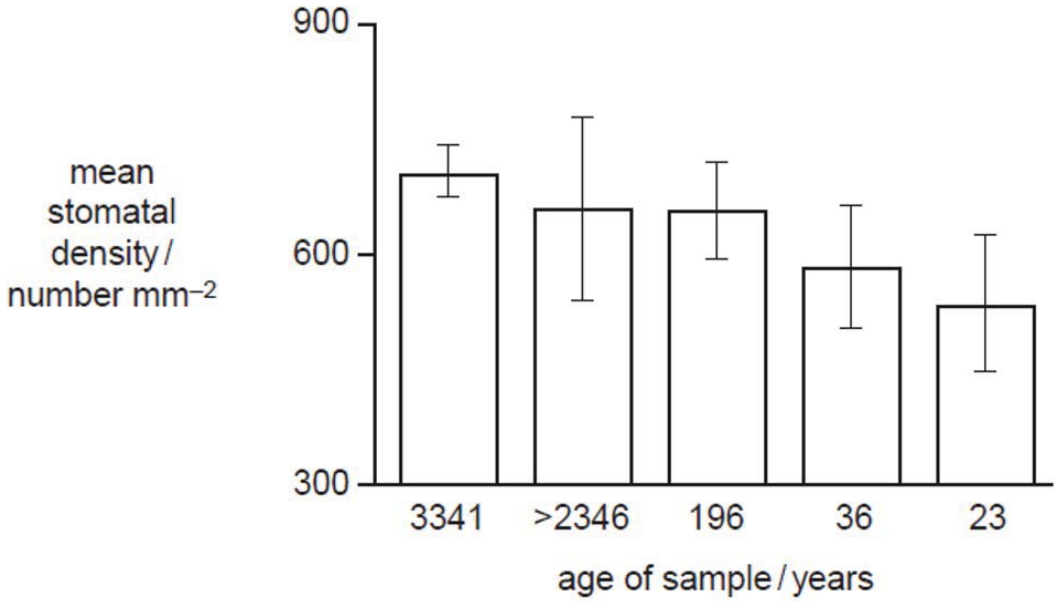

Fig. 3.1

(a) (i) Describe the results shown by the data in Fig. 3.1.

[2]

(ii) Explain why it is difficult to reach a valid conclusion about changes in stomatal density over time

[4]

Over the last 10 years, Kenya has made progress in malarial control. However, the country is still far from defeating the disease.

Fig. 3.2 shows how prevalence of malaria is across the country.

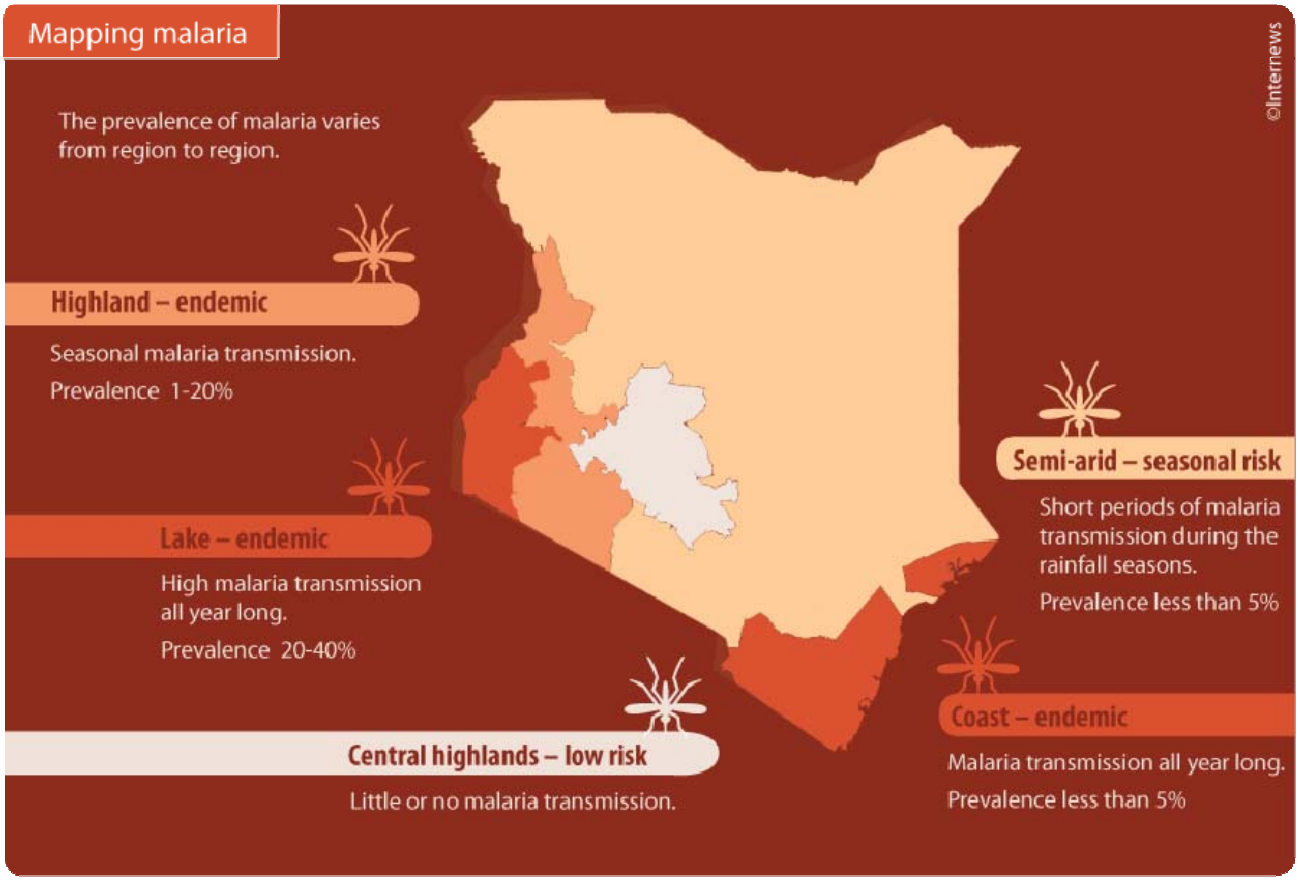

Fig. 3.2

(b) (i) With reference to Fig. 3.2, explain the two determining factors that lead to uneven prevalence of malaria across the country.

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.....

.....

.....[4]

(ii) Suggest why it is difficult to control malaria worldwide, apart from reasons associated with global warming.

[2]

(c) Besides mosquito-borne diseases, describe **two** other problems caused by a change in insect population as a result of climate change.

[4]

[Total: 16]

Section B

Answer **one** question in this section

Write your answers on the lined paper provided at the end of this Question Paper.

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

Your answer must be in continuous prose, where appropriate;

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

4 **(a)** Describe the production and folding of a functional enzymatic protein that is used within a cell. [12]

(b) Discuss the importance of anaerobic respiration, and why it produces few ATP. [13]

[Total: 25]

OR

5 **(a)** Discuss the importance of membranes in the reproductive cycle of the influenza virus. [12]

(b) Distinguish the differences in transcriptional control between *E. coli* and yeast cell, and explain the significance of post-translational control in yeast cell. [13]

[Total: 25]

H2 ANDERSON JUNIOR COLLEGE
HIGHER 2

CANDIDATE NAME

PDG

PDG INDEX NUMBER

BIOLOGY 9744/04

Paper 4 Practical **24 August 2017 Thursday**

Candidates answer on the Question Paper. **2 hours 30 minutes**

READ THESE INSTRUCTIONS FIRST

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

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

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

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

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
Total	55

This document consists of **15** printed pages.

Answer **all** the questions.

1 The enzyme lipase catalyses the hydrolysis of triglycerides into fatty acids and glycerol.

You are required to investigate the effect on the lipase-catalysed reaction of the independent variables:

- enzyme concentration
- presence of calcium ions

The substrate for lipase will be the triglycerides present in milk.

The progress of this hydrolysis can be monitored by using an indicator, **T**, which changes colour due to the production of fatty acids.

You are provided with the following solutions;

25cm^3 of milk containing calcium ions, labelled **M+C**,
25cm^3 of milk without calcium ions, labelled **M**,
25cm^3 of indicator solution, labelled **T**,
30cm^3 of sodium carbonate solution, labelled **A**,
20cm^3 of 10% lipase solution, labelled **E10**,
20cm^3 of 5% lipase solution, labelled **E5**,

Lipase is an irritant. You are advised to wear the eye protection provided. Contact of the solution with your skin should be avoided. If it touches your skin, wash it off with tap water.

Proceed as follows.

(a) Stage 1

Use the beaker or container provided to make a water-bath with warm water, between 38^{0}C and 42^{0}C.

Stage 2

Label four boiling tubes, **B1, B2, B3** and **B4**.

Using the syringes, put:

- 2cm^3 of solution **M+C** into each of the boiling tubes labelled **B1** and **B2**,
- 2cm^3 of solution **M** into each of the boiling tubes labelled **B3** and **B4**,
- 2cm^3 of solution **T** into each of the boiling tubes labelled **B1**, **B2**, **B3** and **B4** and gently shake,
- 3cm^3 of solution **A** into each of the boiling tubes labelled **B1, B2, B3** and **B4** and gently shake so that all the mixture turns blue. Minor variations in colour between the tubes can be ignored as long as the contents are blue.

Put the four boiling tubes into the water-bath for at least three minutes, before progressing to **Stage 3**.

Stage 3

After the boiling tubes have been in the water-bath for three minutes, start a stopwatch, which will be left running continuously throughout the investigation. Start and end times will be taken from this stopwatch.

Stage 4
Remove the boiling tubes labelled **B1** and **B3** from the water-bath and put them in a boiling tube rack. Use a syringe to put 2cm^3 of solution **E10** into each of these two boiling tubes and mix well. Record the start times in Table 1.1, below.

Stage 5

Observe the boiling tubes **B1** and **B3** and record the times at which the colour changes (end times) in Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

Stage 6
Remove the boiling tubes labelled **B2** and **B4** from the water-bath and put them in a boiling tube rack. Use a syringe to put 2cm^3 of solution **E5** into each of these two boiling tubes and mix well. Record the start times in Table 1.1.

Stage 7
Observe the boiling tubes **B2** and **B4** and record the times at which the colour changes (end times) In Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

Stage 8
Calculate the time taken for the colour to change for each of the boiling tubes **B1-B4**, and record this in Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

Table 1.1

	B1	**B2**	**B3**	**B4**
Start time/s				
Time at which colour changes (end time)/s				
Time taken for colour to change/s				

[3]

(b) Prepare a table in the space below to show the effect of enzyme concentration and presence of calcium ions on the hydrolysis of triglycerides in milk. [6]

(c) Describe how you could set up a control for the effect of lipase on triglycerides.

[1]

(d) Identify **one** significant source of error in measuring the dependent variable in this investigation.

[1]

(e) State **two** ways in which the experimental procedure could be improved.

[2]

(f) Explain why the method used in this investigation is not suitable for investigating the effect of pH on the activity of lipase.

[2]

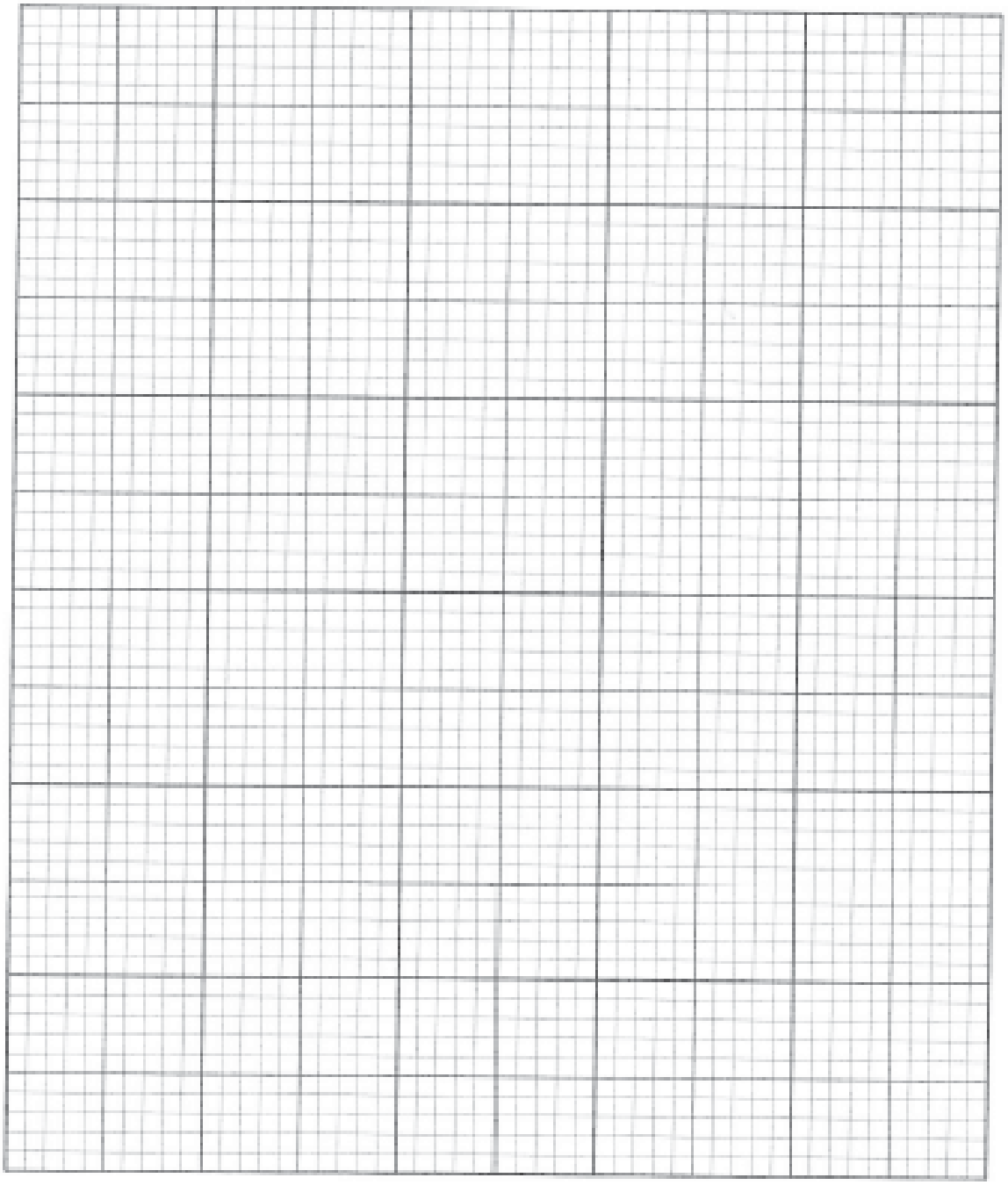
Some students carried out an investigation using lipase and found that its activity was affected by the concentration of copper sulfate solution. All other variables were kept constant.

The results of their investigation are shown in Table 1.2.

Table 1.2

Copper sulfate concentration/ $x10^{-3}$ $moldm^{-3}$	Lipase activity/arbitrary units
1.0	26.0
2.0	12.0
3.0	5.0
4.0	2.5
5.0	1.5

(g) Plot a graph of the data shown in Table 1.2, on the grid on the next page.



[4]

(h) Describe and explain these results.

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[2]

[Total: 21]

2 **K1** and **K2** are stained, transverse sections of leaves from two different species of plant.

(a) **(i)** Make a large, labelled, plan drawing of **K1** to show the distribution of tissues in the leaf lamina (avoiding the midrib). Details of individual cells are **not** required.

[3]

(ii) Make a labelled, high-power drawing to show the detailed structure of **three** adjacent cells from the palisade mesophyll layer.

[3]

(iii) Use the stage micrometer to determine the area of the field of view under high power. Calculate the **average** density of palisade mesophyll cells. **State the magnification used and show your working.**

Magnification used: _____

Average density of palisade mesophyll cells: _____ [3]

(iv) Calibrate the eyepiece graticule using the stage micrometer so that you can use it to measure the length along one palisade mesophyll cell under a suitable magnification. Repeat until you have three measurements. **State the magnification used and show your working in calculating the average length.**

Magnification used: _____

Average length of palisade mesophyll cell: _____ [3]

(b) The plant species from which **K2** was taken grows in a dry habitat.
Examine **K2**, using your microscope.
State **four** observable features that distinguish **K2** from **K1** and present the differences in a suitable format.

[4]

(c) You are required to investigate some aspects of the water.

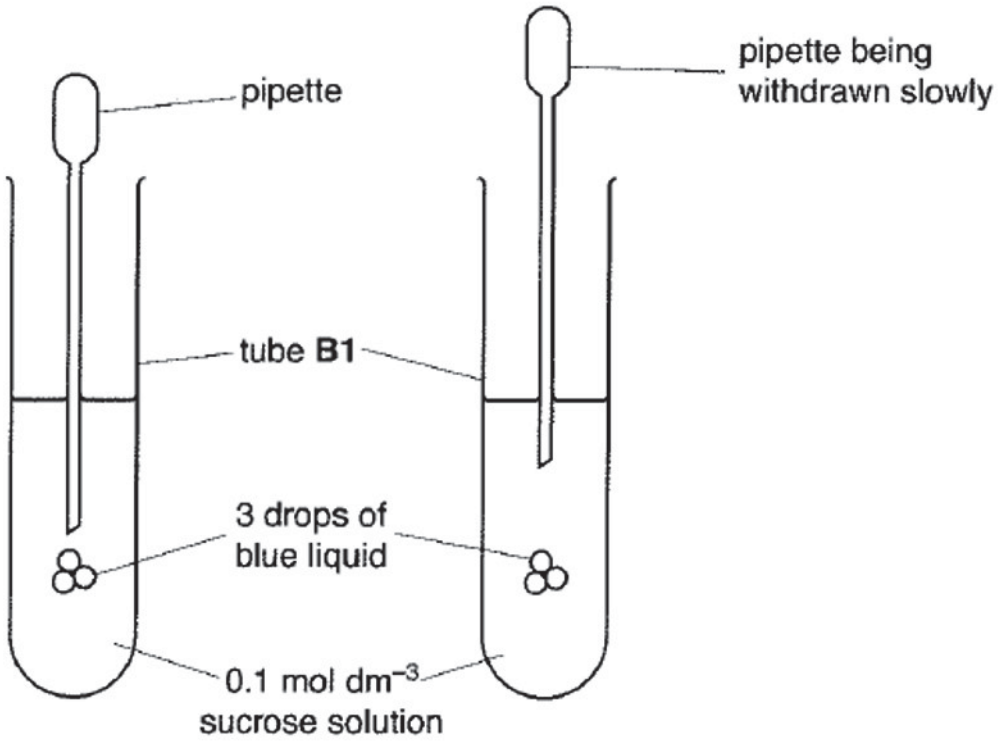
(i) Label four test tubes **B1, B5**, **B10 and C5** respectively.

Using a syringe or pipette, prepare the three concentrations of sucrose using the water and 1.0 mol dm^{-3} sucrose solution provided. Record the volume of water and 1.0 mol dm^{-3} sucrose solution used in the table below. The total volume of different concentrations of sucrose should be 10cm^3. Then place 10 cm^3 of sucrose solution into each of these tubes.

Tube	**B1**	**B5**	**B10**
Concentration of sucrose solution/ moldm^{-3}	0.1	0.5	1.0
volume of water/ cm^3			
volume of 1.0 mol dm^{-3} sucrose solution/ cm^3			

[2]

Transfer all 10 cm^3 0.5 mol dm^{-3} sucrose solution from **B5** into a test tube labelled **C5** and add three drops of the dye, methylene blue (labelled **MB**) to it. Shake tube **C5** to make the colour uniform. Suck up a little of this blue 0.5 mol dm^{-3} sucrose solution into a pipette and then, with the tip of this pipette held stationary, half way down the solution in tube **B1** (see diagram below), **very gently** release three drops from the pipette. **Do not squirt these drops into the solution. Withdraw the pipette slowly.**



Carefully observe the movement of the blue liquid. Repeat the procedure for **B10**.

(i) Record your observations in a suitable format for **B1** and **B10.**

[2]

[Total: 20]

3 Planning question

Yeast undergoes aerobic respiration, breaking down glucose into carbon dioxide and water. This process is catalyzed by enzymes.

Methylene blue is an artificial **hydrogen acceptor** which is blue in the oxidised form and colourless when reduced.

coloured methylene blue $\xrightarrow{\text{reduction}}$ colourless methylene blue

A colorimeter can be used to measure the absorbance of light at 550 nm by methylene blue solution. When methylene blue is reduced and becomes colourless, its absorbance reading will become 0 arbitrary units. Yeast suspension has an absorbance value of 15 arbitrary units. The colorimeter is shown in **Fig. 4.1** below.

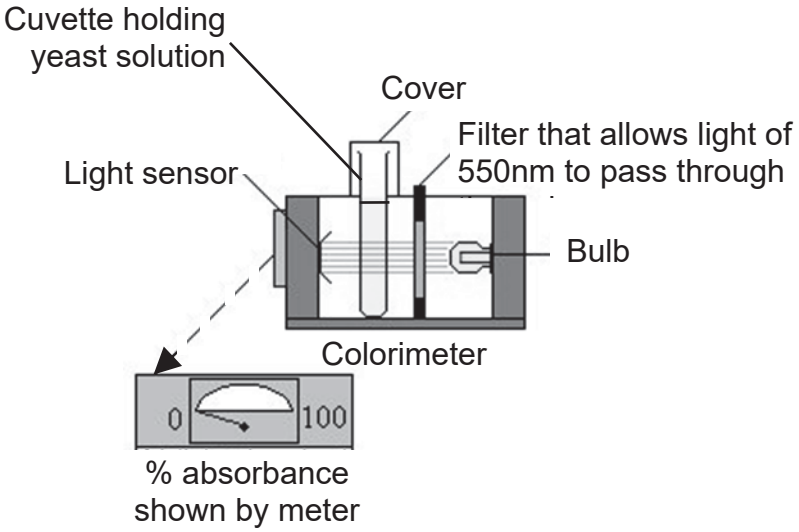


Fig. 4.1

Using this information and your own knowledge, design an experiment to test the hypothesis that:

"The rate of respiration in yeast cells is dependent on the concentration of glucose solution."

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- identify independent and dependent variables,
- describe the method with scientific reasoning used to decide the method so that the results are as accurate and reliable 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.

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

- active yeast suspension
- 1.0 mol dm^{-3} glucose solution
- methylene blue
- test tubes
- stopwatch
- colorimeter
- 2 cuvettes
- beakers
- a variety of different sized measuring cylinders, syringes and pipettes for measuring volumes

[14]

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THE END

Question 1

Each candidate must be provided with the following apparatus and materials:

1 25 cm^3 of reconstituted milk solution with calcium, labelled **M + C**
This is prepared by adding 10 g of Coffee-mate® Original (do not use fat-free Coffee-mate®), to 100 cm^3 hot, distilled water (approximately 80°C) and stirring. To this solution, add 0.05 g calcium chloride ($CaCl_2.2H_2O$ – not anhydrous) and stir. This is sufficient for four candidates.

The milk solution must be prepared on the day of the examination and provided to the candidates at room temperature.

The solution should be provided to candidates in 100 cm^3 beakers, labelled **M + C**.

2 25 cm^3 of reconstituted milk solution without calcium, labelled **M**
This is prepared by adding 10 g of Coffee-mate® Original (do not use fat-free Coffee-mate®), to 100 cm^3 hot, distilled water (approximately 80°C) and stirring. This is sufficient for four candidates.

The milk solution must be prepared on the day of the examination and provided to the candidates at room temperature.

The solution should be provided to candidates in 100 cm^3 beakers, labelled **M**.

[H] 3 20 cm^3 of 1.5% lipase solution, labelled **E10**
This is prepared by adding 1.5 g of lipase powder to 70 cm^3 of distilled water in a beaker while stirring. Make up to 100 cm^3 with distilled water. This is sufficient for five candidates.

This must be prepared within **one hour** of the start of **Question 1** and be at room temperature for use by candidates.

The solution should be provided to candidates in 100 cm^3 beakers, labelled **E10**. Candidates will be informed that **E10** is a 10% lipase solution.

[H] 4 20 cm^3 of 1.2% lipase solution, labelled **E5**
This is prepared by adding 1.2 g of lipase powder to 70 cm^3 of distilled water in a beaker while stirring. Make up to 100 cm^3 with distilled water. This is sufficient for five candidates.

This must be prepared within **one hour** of the start of **Question 1** and be at room temperature for use by candidates.

The solution should be provided to candidates in 100 cm^3 beakers, labelled **E5**. Candidates will be informed that **E5** is a 5% lipase solution.

Before the examination, the activity of the lipase solution should be tested at about 40°C. Mix 2 cm^3 of solution **M + C** with 2 cm^3 of solution **T** and 3 cm^3 of solution **A**. Add 2 cm^3 of solution **E5**. The indicator should change colour from blue to yellow within 5 minutes. If there is no colour change within 5 minutes then use 2% lipase for solution **E5** and 2.5% lipase for solution **E10**. Do not inform candidates of the change in concentration or change the labelling of the solutions.

5 30 cm^3 of sodium carbonate solution, labelled **A**
This is prepared by dissolving 0.30 g of anhydrous sodium carbonate in 80 cm^3 of distilled water in a beaker and stirring to dissolve. Make up to 100 cm^3 with distilled water. This is sufficient for three candidates.

The solution should be provided to candidates in 100 cm^3 beakers, labelled **A**.

6 25 cm^3 of Thymol blue solution, labelled **T**
This is prepared by dissolving 0.1 g of Thymol blue powder in 50 cm^3 of 70% ethanol and making up to 250 cm^3 with distilled water. This is sufficient for ten candidates.

The solution should be provided to candidates in 100 cm^3 beakers, labelled **T**.

7 four boiling tubes

8 two boiling tube racks to hold four boiling tubes

9 1 x 5 cm^3 syringe and 3 x 3 cm^3 syringes

If there is a shortage of syringes, candidates can be instructed to re-use them as long as the syringes are thoroughly washed with distilled water before re-use.

10 stopwatch

11 glass marker pen

12 thermometer (-10°C to 110°C)

13 500 cm^3 beaker labelled **water bath**, to act as a water-bath to contain four boiling tubes at a time

14 500 cm^3 glass beaker, with water between 40°C and 45°C, labelled **hot water**

The supervisor may use a thermostatically-controlled water-bath to provide additional hot water if requested by candidates.

15 access to a tap and sink

16 paper towels

17 a pair of goggles or eye protection

18 a pair of disposable gloves

Question 2

Each candidate must be provided with the following apparatus and materials:

(i) Microscope with low and high power objectives e.g. X4 and X 40

(ii) Slices (2mm thick) of potato sufficient for the student to cut at least 12 strips 80 mm long – Approximately 5 slices in a sealed Ziploc bag (they must not dry up).
The potato slicer is to be used to slice the potato.

(iii) Part of a red fleshy scale leaf from an onion (at least 2 cm width). The material must be provided fresh in a sealed Ziploc bag.

(iv) 50 cm^3 of each of **0.1 M, 0.5 M** and **1.0 M** sucrose solutions, labelled as such.

[O] (v) 5 cm^3 of 1mol cm^{-3} potassium nitrate solution in a container labelled **X**.

[H] (vi) Dropper(3ml) for solution **X**

(vii) 5 cm^3 of **methylene blue** labelled as such. Prepared by dissolving 2 g in 100 cm^3 of water. Skin irritant/ Harmful.

(viii) Filter paper (to substitute tissue paper for Q2 (a))

(ix) Three 10 cm^3 syringes

(x) Marker for marking glassware

(xi) Three very fine teat droppers to be used for Q2 (b)

(xii) Ruler mm

(xiii) Scalpel

(xiv) Fine forceps

(xv) Microscope slides and cover slips

(xvi) Mounted needle

(xvii) Three tiles

(xviii) Seven test tubes (15 x 125 mm approx); test tube rack.

(xix) Beaker (250 cm^3) containing 100 cm^3 distilled water, marked **Water for washing**

(xx) Paper towels

(xxi) Petri dish.

Answers

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

H2 ANDERSON JUNIOR COLLEGE
HIGHER 2

CANDIDATE NAME	

PDG					PDG INDEX NUMBER		

BIOLOGY
9744/02

Paper 2 Structured Questions

12 September 2017
Tuesday

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

All working for numerical answers must be shown.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Calculators may be used

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

This document consists of **22** printed pages.

Answer **all** the questions.

1 Lactose intolerance in humans is the inability to hydrolyse lactose due to the lack of the enzyme lactase in the alimentary canal. As a result, bacteria in the large intestines feed on the lactose and produces fatty acids and methane which lead to diarrhoea and flatulence.

Bacteria have been used to produce lactase on an industrial scale as a dietary supplement for people who are lactose intolerant. Human lactase consists of a single 160 kDa polypeptide chain that localizes to the brush border membrane of intestinal epithelial cells.

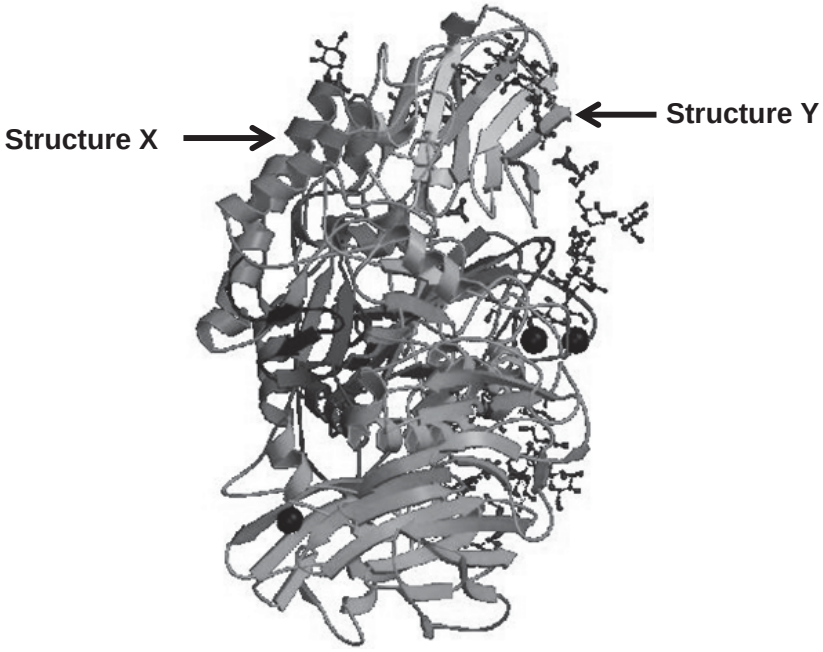


Fig. 1.1

(a) With reference to the **Fig. 1.1**,

(i) state the levels of organization seen in the structure of lactase.

primary, secondary, tertiary structure; [1]

(ii) Describe structures **X** and **Y**

- structure X- alpha helix, Structure Y- beta pleated sheets
- **repeated coiling/ folding** of polypeptide chain, intrachain hydrogen bond between N-H group of a peptide bond on one fold and C=O of a peptide bond on four amino acids away (alpha helix)/ another fold (beta pleated sheets); [2]

(b) **Fig. 1.2** shows the hydrolysis of lactose.

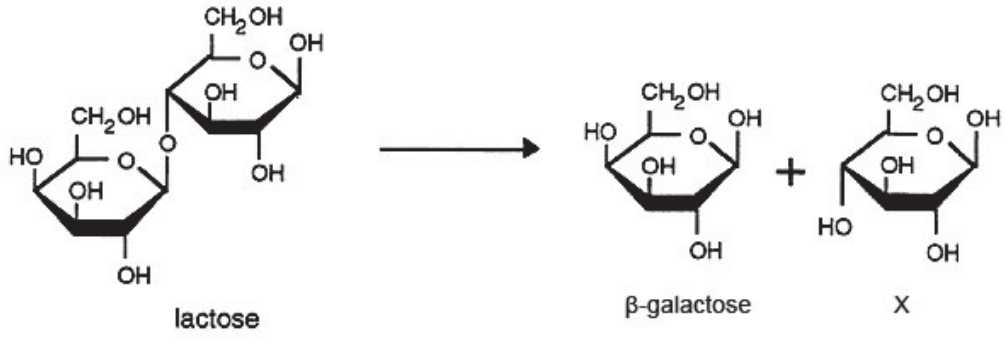


Fig. 1.2

Describe the hydrolysis of lactose, naming the bond that is broken and product **X**.

Use of **water** to break **β-1,4-glycosidic** bond;
to form (either) galactose and **β-glucose**; [2]

(c) Lactase and lactose are protein and carbohydrates respectively.
Explain why there are fewer types of carbohydrate polymers compared to protein polymers.

1. lactose (carbohydrate) is made up of **two** monomers, glucose and galactose but lactase (proteins) are made up of many different types/ 20 types of monomers, amino acids;
2. amino acids differ by their R groups;
3. the different sequences and number of amino acids making up proteins give rise to the large number of different types of proteins / ref to various types of amino acids in a single polypeptide chain vs in a carbohydrate polymer, the same monomer makes up the polymer; [3]

Cell organelles can be separated by centrifuging a cell extract in a sucrose density gradient. The organelles settle at the level in the sucrose solution which has the same density as their own.

The cells used to synthesized lactase were lysed and the cell extract centrifuged in a sucrose density gradient. Three distinct fractions of nuclei, mitochondria and ribosomes (in no particular order) were obtained. The three fractions **A, B** and **C** are shown in the **Fig. 1.3**.

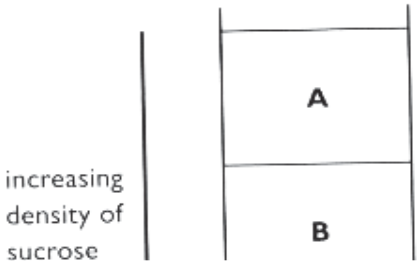


Fig. 1.3.

(d) Identify the organelles in each fraction and describe its role in the synthesis of lactase.

A: Ribosomes – translate genetic message carried by messenger RNA into a polypeptide chain;

B: Mitochondria – sites of cellular respiration, producing energy in the form of ATP which can then

be used for peptide bond formation / amino acids activation / exocytosis;

C: Nucleus – contains nucleolus which is responsible for synthesis of ribosomal ribonucleic acids (rRNA) which is a component of ribosomes; OR contains genetic materials (DNA) and the genes found on DNA contains information on how lactase is synthesized;

[1 mark for correct identification of **all** fractions and 1 mark each for each correct function] [4]

[Total: 12 marks]

2 Recently, scientists discovered the presence of a population of bone-marrow derived stem cells that have the ability to form heart muscles cells when transferred to the heart. The stem cells were removed from the bone marrow and cultured so that they divided by mitosis. It was proposed that these stem cells resembled embryonic stem cells.

(a) (i) Describe **two** similarities between these bone-marrow derived stem cells and embryonic stem cells.

- **Unspecialised** cell with **no specific structure and function**;
- Ability to **self-renew** via **mitosis**
- Ability to **differentiate** into **specialised** cell types under suitable conditions
- Exhibit **pluripotency**: ability to differentiate into **almost any** cell types except cell of extra-embryonic membranal cells

[2]

(ii) Describe how the rate of mitosis is controlled.

- External growth factors serve as ligands that bind to receptors of cell surface membrane;
- fully- activated receptor activates relay protein which activates a series protein kinases in the phosphorylation cascade;
- Cellular response is the switching on genes that code for transcription factors which will bind to promoter of cyclin genes/ genes that promote or slow down cell cycle;
- Increase transcription and translation of proteins that promote or slow down cell division/ M,S, G1 cyclins/CDKs which control checkpoints in cell cycle;
- **G_1 checkpoint** checks that cell size is adequate/ There is sufficient nutrients are available to support daughter cells/ Growth factors (Extracellular signal proteins that stimulate a cell to grow or divide) are present.
- **G_2 checkpoint** checks that cell size is adequate/ DNA replication is complete and successful/ there is no DNA damage.
- **Metaphase (M) checkpoint** checks that chromosomes are under bipolar tension (in other words, properly attached to kinetochore microtubules originating from the two different poles of the cell)/ chromosomes are aligned at the metaphase plate.
- **Cell cycle checkpoints prevent premature progression of the cell cycle**/ E.g. prevent the segregation of chromosomes before DNA replication is completed.
- **Provides time for cell machinery to be repaired should there be any damage/** E.g. To repair incorrectly replicated DNA sequence.
- Tumour suppressor genes code for proteins that preventing the stimulating activity of cellular proto-oncogenes or oncogenes/ activating DNA repairing genes /activating apoptosis (programmed cell death), preventing uncontrolled cell division.

[4]

(iii) State an advantage of using bone marrow derived stem cells rather than heart stem cells for the treatment of heart diseases.

- Idea of bone marrow stem cells are **easier to isolate / extract** by direct aspiration from the bone marrow in the spinal cord

OR

- Idea of isolation/ extraction of bone marrow stem cells are **less less risky**/ may puncture major blood vessels in removing heart stem cells.

[1]

(c) Troponin is a protein that is integral to muscle contraction in heart muscles. **Fig. 2.1** shows part of its DNA sequence. The entire sequence is 63 base pairs.

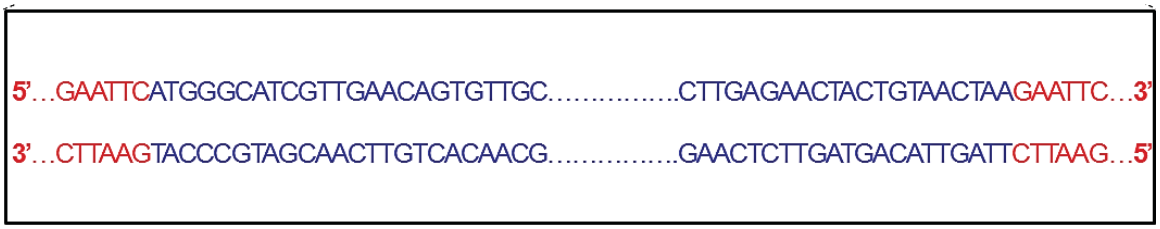


Fig. 2.1

PCR can be used to confirm presence of troponin DNA sequence. The following pair of primers are used.

Primer	Primer sequence
1	5' AATTCATGGGCATCG 3'
2	5' GAATTCTTAGTTACA 3'

(i) In the boxed area in Fig. 2.1, circle and label the DNA sequences where Primers 1 and 2 will anneal. [1]

(ii) Explain how results of gel electrophoresis of the PCR products are able to show that troponin DNA has been successfully amplified.

- If cloning is successful, a band corresponding to a DNA fragment of 63 bp would be observed;

[1]

(iii) Besides the use of PCR, nucleic acid hybridisation can also be used to determine presence of troponin DNA.

Outline how nucleic acid hybridisation can be used to identify troponin DNA.

- Extract DNA from heart cells, add restriction enzyme and perform gel electrophoresis to separate DNA fragments by size and charge/ Heart cells pressed against a special filter paper;
- which is treated with chemical (NaOH) to burst/lyse the cells and denature the **double-stranded** DNA to obtain **single-stranded** DNA on the filter;
- (Solution containing) chromogenic / labelled / radioactive **single-stranded** nucleic acid/DNA probe complementary to (part of) the troponin DNA is added, probe will hybridise/ bind/anneal to troponin DNA sequence if it is present at areas on the filter paper;
- Carry out/perform autoradiography by placing filter paper on a photographic film; [4]

[Total: 13 marks]

3 The pie chart in Fig. 3.1 shows the relative length of time of each of the stages that ovvur during a particular eukaryotic cell cycle. This complete cycle takes 15 hours.

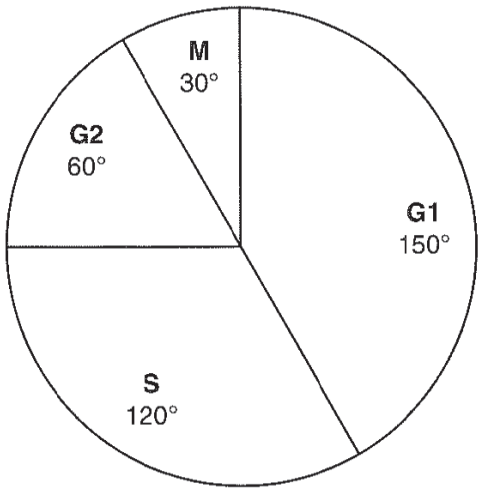


Fig. 3.1

(a) Using the information provided above, calculate how long interphase lasts.

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

- **Total interphase = 150 + 120 + 60/ 360 – 30 = 330 °**
- **Time in interphase= 330/360 x 15 = 14 hr (to 2 sf)**

[2]

(b) During the cell cycle there are a number of checkpoints.

State one function of these checkpoints and explain what might occur as a result of dysregulation of these checkpoints.

Function:

- Ensure that environmental signals (e.g. growth factors) are present for cell division + enough nutrients to support cell division;
- Check that DNA has been replicated without mistakes + DNA repair enzymes to ensure no mutation in cell;
- Ensure there is bipolar tension for every chromosomes so that sister chromatids can separate to opposite pole/ maintain chromosome number;

(any 1)

Dysregulation:

- Cell divides even without growth factor/ mutation during DNA not detected or repaired and passed on to daughter cells/ sister chromatids not separated to opposite poles leading to changes in chromosome number or gain of function mutation of protooncogene to oncogene;
- Uncontrolled cell division;

[3]

(c) Colorectal cancer is one of the most common cancers in Singapore. Cancer of the colon and rectum – colorectal cancer – begin as polyps (also known as adenoma) that grow on the inner lining of the large intestine.

Most sporadic cases of colorectal cancer are believed to develop from benign adenomas (polyps) to carcinoma by the accumulation of genetic abnormalities as shown in Fig. 3.2.

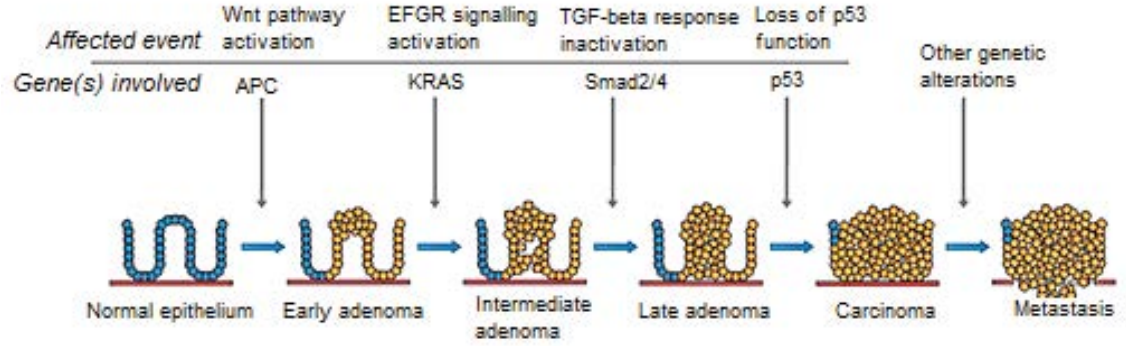


Fig 3.2

(i) Using the Figure 3.2, explain why the development of cancer as a multi-step process.

- Requires accumulation of mutation in a single cell/ same lineage;
- Mutation of APC activates Wnt signaling pathway that leads to uncontrolled cell division, forming early adenoma;
- Accumulation of mutation in KRAS activates EGFR signaling pathway induces cell to divide even without growth factor/ Smad2/4 inactivates TGFβ response which causes increase cell proliferation/ cell division is uncontrolled and excessive;
- Loss of function mutation of tumor suppressor gene p53 results in formation of a carcinoma;
- Further genetic mutations causes metastasis; [5]

(ii) The majority of all colorectal cancers occur sporadically without any known cause, but certain groups of people have a predisposition to the development of cancer of the large intestine. These people may carry specific genetic mutations or have relatives with the condition.

Approximately 15% of all colorectal cancer cases are familial, with the most common inherited conditions being familial adenomatous polyposis (FAP). Patients with FAP have a lifetime risk of the development of colon cancer that approaches 100%. Patients with FAP have a germline inactivation of one APC allele. Adenoma formation is faster, but progression from adenoma to carcinoma has the same rate as sporadic colorectal cancer as shown in Fig. 3.3.

Fig. 3.3

Using the information above and your own understanding of the development of cancer, suggest why patients with FAP form adenoma faster.

- FAP patients only need to have one more copy of their APC allele to undergo a loss-of-function mutation;
- Ref. to APC as tumor suppressor gene;
- Need to accumulate less mutations for adenoma formation and therefore formation is faster;

[2]

4 Genome editing is the process in which a DNA target sequence is replaced by a desired sequence. **Fig. 4.1** shows how the process is being done by Cas9 enzyme which makes use of a guide RNA to achieve the editing effect. This can be done in embryos so that those children who are born of parents with the genetic disease alleles would not suffer from the genetic dsease.

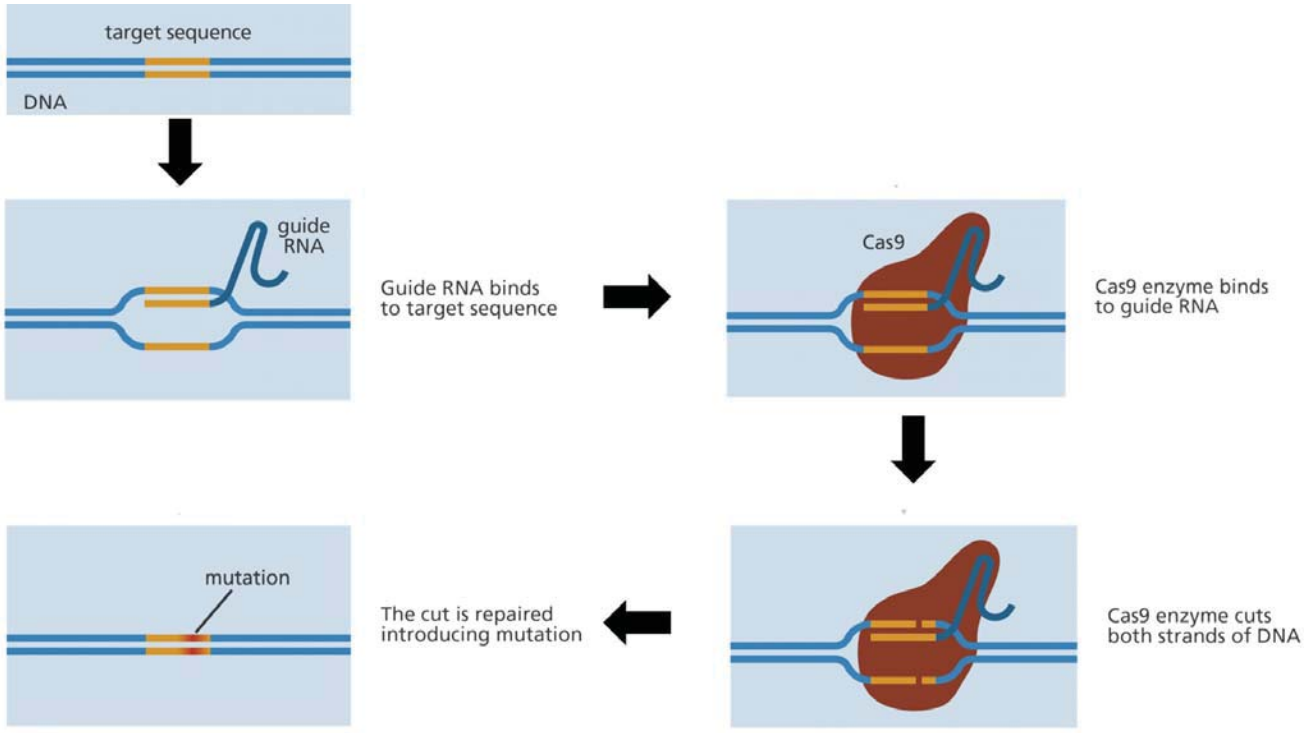


Fig. 4.1

(a) With reference to Fig. 4.1, describe how the guide RNA and Cas9 enzyme are used to cut both strands of DNA. [3]

- Hydrogen bonds form between single-stranded guide RNA with complementary bases to 1 target DNA strand;
- Cas9 has active site which binds to guide RNA;
- Cleaves both strands of DNA by breaking phosphodiester bonds;
- **Additional marking point:** Active site of Cas9 is complementary in shape to target base sequence;

(b) **(i)** Explain why gene editing done on embryos help to prevent children born from suffering from the genetic disease. [2]

- All organs and tissues are derived from the embryos by mitosis and differentiation;
- All daughter cells are genetically identical to the edited embryos;
- **Additional marking point:** Embryonic stem cells are pluripotent;

(ii) Suggest and explain if the mutation introduced by gene editing as shown in Fig. 4.1 should be dominant or recessive. [2]

- Dominant mutation;
- Codes for a functional protein to mask the effect of recessive allele;

(c) Describe how mutations in DNA arise in nature. [2]

- A named factor (e.g.UV light, ionizing radiation, tar in cigarette smoke) as cause;
- Proof-reading by DNA polymerase or DNA repair mechanisms did not correct mutation;
- Any valid point

RNA plays a very important role in many biological processes. One of them is transfer RNA (tRNA) which has extensive intramolecular hydrogen bonds.

(d) **(i)** State **two** importance of having such bonds. [2]

- Confers stability;
- Confers a 3D shape;

(ii) Relate the structure of tRNA to its functions. [2]

- Has 3' CCA end to form covalent bond with amino acid;
- Its 3D shape allows it to fit into the active site of amino-acyl tRNA synthetase;
- Has anticodon which forms complementary base pair with mRNA codon;

(Any 2)

[Total: 13 marks]

5 Figure 5.1 represents a bacteria DNA and a eukaryotic chromosome in metaphase of mitosis, not drawn to scale.

Fig. 5.1

(a) State **two** ways in which the organization of genes found in these two structures differ and suggest **one** advantage of this to the bacterium.

Feature	Eukaryotic	Prokaryotic
Gene organization	Monocistronic genes	Polycistronic genes / **operons**
Advantage to bacteria	Simultaneous expression of closely-related genes organised in an operon	
Association between DNA and histones	Association with **histones** / scaffolding	No association with histones

	Proteins - allows for increased structural complexity/folding to higher degree of condensation e.g. between euchromatin and heterochromatin states	- does not achieve same level of condensation complexity as eukaryote

[3]

(b) In 1946, Joshua Lederberg and Edward Tatum proposed that bacterial cells undergo genetic recombination. To test their hypothesis, they experiments using two bacteria strains of *Escherichia coli (E.Coli*) with different nutritional requirements.

Strain A, B and a mixture of both strains were grown on culture plates containing minimal medium that does not contain essential amino acids. The results are shown in Fig. 5.2.

Mutant genes (–) do not code for enzymes that synthesize amino acids. Note that all five amino acids are required for bacterial growth.

Bacterial strains	Genes for biosynthesis of amino acids	Mutant genes for biosynthesis of amino acids
A	thr^+ leu^+ thi^+	met^- bio^-
B	met^+ bio^+	thr^- leu^- thi^-

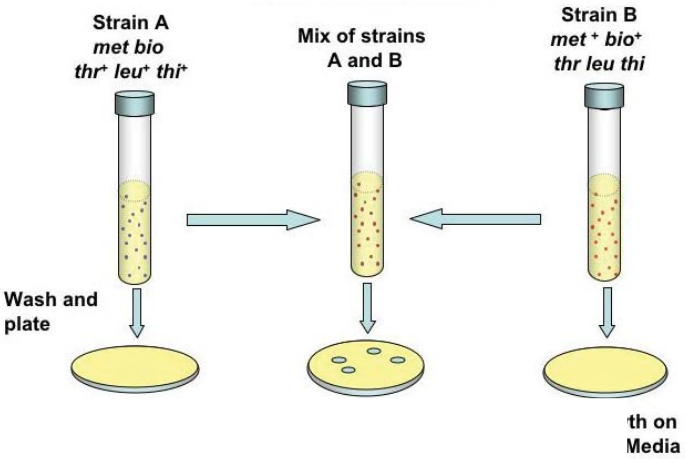


Fig. 5.2

Another researcher, Bernard Davis also worked with the same hypothesis. In his experiment he constructed a U-tube in which the two arms were separated by a fine filter. The pores of the filter were too small to allow bacteria to pass through but large enough to allow easy passage of the fluid medium, any dissolved substances and free DNA. The results are shown in Fig. 5.3.

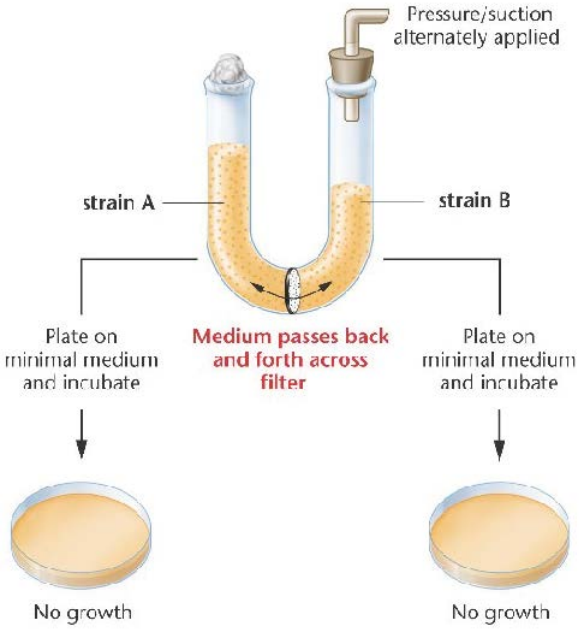


Fig. 5.3

(i) Using the results of the two experiments and your understanding of genetic recombination in bacteria, state the genetic recombination that has taken place between Strain A and B. Explain your answer.

- Conjugation;
- Second experiment shows transduction and transformation did not take place;
- Because no colonies grew on minimal medium agar;
- genetic recombination occurs only when physical contact is possible between 2 strains;
- In first experiment, bacteria that grew on minimal medium has DNA that encodes for all essential amino acids/ ref. recombinant bacteria has grown on minimal medium
- Showing the genes from Strain A have transferred to Strain B / converse through formation of conjugation tube/ ref. to conjugation tube [6]

(c) In 2016, a pathogenic strain of *E.Coli* found on unwashed salad caused food poisoning in 151 people in Britain, leaving two of them dead.

Using a named example, describe how such pathogens are usually treated. [3]

- Antibiotics
- Penicillin
- Competitive inhibitor to transpeptidases, prevent cell wall synthesis;
- Resulting in bacterial cell lysis;

[Total: 12 m]

6 In anaerobic respiration in yeast, the pyruvate molecules are broken down to produce ethanol and carbon dioxide. The release of carbon dioxide can be used to investigate the rate of anaerobic respiration.

Fig. 6.1 shows and experiment which was set up to find the rate of anaerobic respiration.

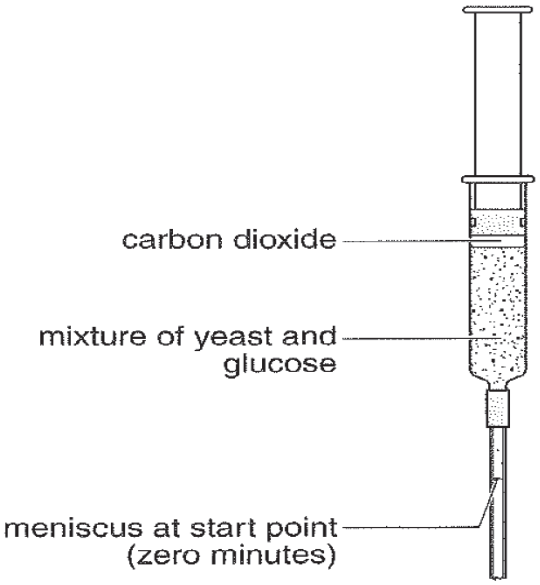


Fig. 6.1

The meniscus moves down the tube as carbon dioxide is released.

Table 6.1 shows the distance moved by the meniscus from the start point. This was recorded every 10 minutes.

Table 6.1

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	1	2	5	9	14	21	45	73	98

(a) The rate of anaerobic respiration can be calculated by using the rate of movement of the meniscus.

Calculate the rate of anaerobic respiration between 70 and 80 minutes.

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

Rate of Anaerobic Respiration = (73-45) mm / (80-70) min
= 28 mm / 10 min
= **2.8** mm min^{-1}

[2]

(b) This experiment was repeated three more times. Each time, the glucose (a monosaccharide) was replaced with a different disaccharide sugar:

- Maltose – a disaccharide of glucose and glucose
- Sucrose – a disaccharide of glucose and fructose
- Lactose – a disaccharide of glucose and galactose.

Tables 6.2 (a), (b) and (c) show the results of these experiments.

Table 6.2 (a): Using maltose

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	0	0	0	0	2	3	6	9	12

Table 6.2 (b): Using sucrose

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	0	0	1	3	11	22	37	48	61

Table 6.2 (c): Using lactose

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	0	0	0	0	0	0	0	0	0

With reference to the information provided in Tables 6.2 (a), (b) and (c) and your biological knowledge:

(i) Describe the difference in the results for maltose and sucrose, and suggest one explanation for this difference,

- **Glucose** is the respiratory substrate for **glycolysis**;
- Maltose: meniscus only starts moving at 50 min vs sucrose at 30 min/ movement of sucrose more than maltose + data;
- Enzyme to break down sucrose is more readily available/at higher concentration than enzymes to break down maltose; [2]

(ii) Suggest two explanations for the results for lactose.

- Yeast does not have proteins channels that allows uptake of lacotse;
- Yeast does not encode for lactase that breaks down lactose to glucose and galactose;
- AVP; [2]

(c) An electron micrograph of yeast, *Candida albicans*, is shown in Fig. 6.2.

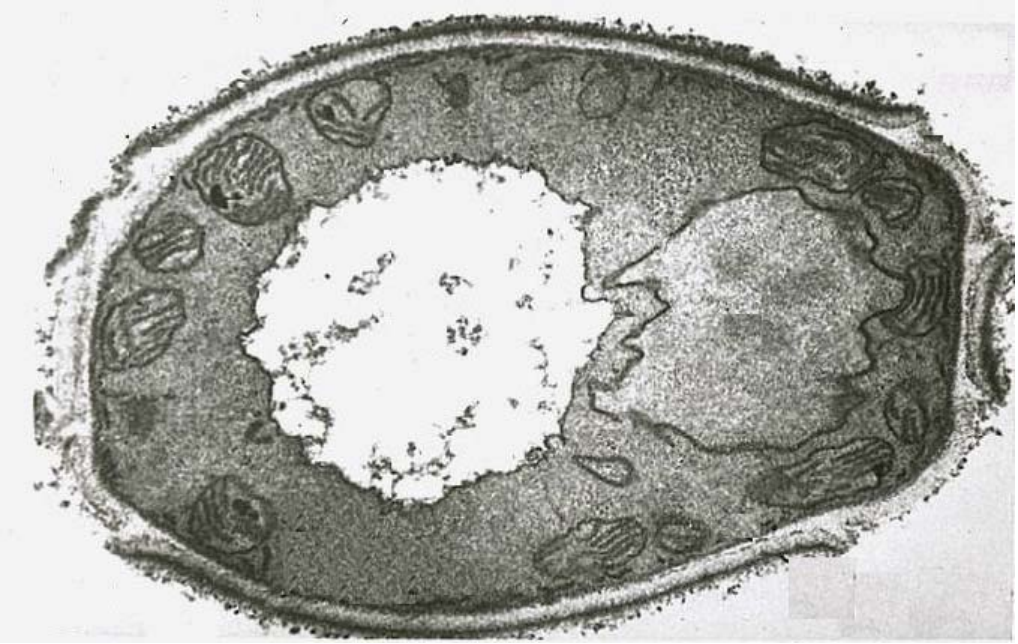


Fig. 6.2

(i) On Fig. 6.2, label site of
- i. Glycolysis
- ii. Oxidative phosphorylation [2]

(ii) State one visible structure of mitochondria from Fig. 6.2 and describe how it supports mitochondria's function.
- Highly folded inner membrane + Increase surface area for embedment of more ETC/ ATP synthase to increase rate of ATP production
- Membrane bound/ double membrane + Enclose matrix that contains enzymes for link reaction and Kreb's cycle/ compartmentalizes matrix for optimum conditions for enzymes to work; [1]

(ii) Besides location, compare between oxidative phosphorylation and photophosphorylation. [4]

Features	Oxidative phosphorylation	Photophosphorylation
Functions in the presence of..	oxygen	light
Source of energy	NADH and FADH2	light
No. of electron transport chain	1	2
Electron flow	linear – one-way	linear or cyclic
Final electron acceptor	oxygen	NADP (non-cyclic) PSI reaction center (cyclic)
Involvement of water	water produced	photolysis of water
Establishment of proton gradient	protons pumped outwards from matrix across inner mitochondrial membrane into intermembrane space	protons pumped inwards from stroma across thylakoid membrane into thylakoid space
Products	ATP, water	ATP, NADPH, oxygen

[Total: 13 marks]

7 Pigment production in onions is controlled by two enzymes resulting in three different coloured bulbs - red, yellow and white.

A pure-white strain crossed with a pure-red strain produces an all-white F_1. Two F_1 onions with white bulbs were crossed. The F_2 generation was found to consist of 2170 white, 530 red and 180 yellow-bulbs.

The alleles are represented by the following symbols:

I: no production of pigment **i**: production of pigment
R: red pigment **r**: yellow pigment

(a) State the mode of inheritance in the onion bulb colour. [1]

- (Dominant) epistasis

(b) Explain the results of the cross by drawing a genetic diagram in the space below. [5]

Parental phenotypes: **White bulb** X **Red bulb**
Parental genotypes: **IIrr** X **iiRR**
Gametes: **(Ir)** X **(iR)** **[1]**

F_1 phenotypes: **White bulb** X **White bulb**
F_1 genotypes: **IiRr** X **IiRr** **[1]**
Gametes: **(IR)** **(Ir)** **(iR)** **(ir)** **[1]**

Punnett Square:

	(IR)	(Ir)	(iR)	(ir)
IR	**IIRR**	**IIRr**	**IiRR**	**IiRr**
Ir	**IIRr**	**IIrr**	**IiRr**	**Iirr**
iR	**IiRR**	**IiRr**	**iiRR**	**iiRr**
ir	**IiRr**	**Iirr**	**iiRr**	**iirr**

F_2 genotype ratio: **12 I_ _ _ : 3 iiR_ : 1iirr** **[1]**

F_2 phenotype ratio: **12 White : 3 Red : 1 Yellow** **[1]**

(c) Explain how the different phenotypes results. [4]

- Allele I is dominant over the R/r locus;
- I codes for an inhibitor as a first step;
- In absence of inhibitor allows R allele codes for an enzyme that results in red pigment;
- In absence of inhibitor allows rr genotype results in a different enzyme that results in yellow intermediate;

(e) Suggest how a farmer may determine if a red onion is homozygous in both loci. [2]

- Cross a red onion with a yellow onion (iirr);
- If it is homozygous in both loci, only red onion offsprings will result;

[Total: 12 marks]

8 Antibodies against tuberculosis are produced by plasma cells during an immune response.

Fig. 8.1 shows a diagram of an antibody molecule.

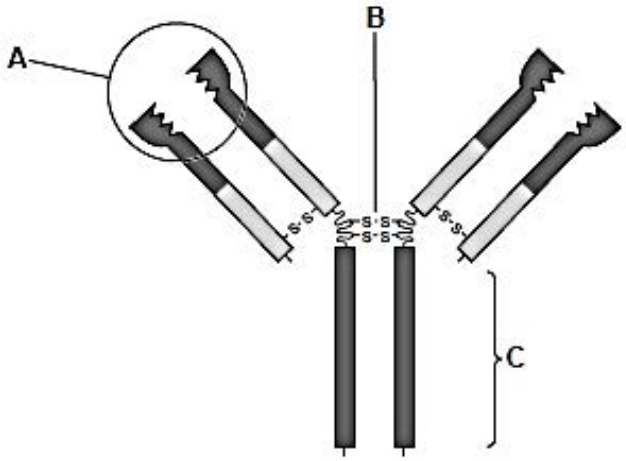


Fig. 2.1

(a) Explain the functions of the parts labelled A, B and C.

(i) A

Variable region forms the antigen-binding sites;
Binds/attaches/combines, to antigen;
Each antigen-binding sites (has a specific 3D shape) is specific to the shape of one antigen. [2]

(ii) B

Disulphide bond holds polypeptides/heavy chains together;
Maintains tertiary/quarternary/3D shape/structure;
The 'hinge' region gives the flexibility for the antibody molecule to bind around the antigen; [1]

(iii) C

Constant region binds to receptors/ cell surface membrane on phagocytes/ macrophages;
Antigen marking/tagging for phagocytosis/macrophage action;
Opsonisation - Many phagocytic cells bear receptors for the Fc portion of the antibody and adhere to the antibody-coated bacteria, leading to engulfing and destruction of the microorganism. [1]
Agglutination/ precipitation of antigen - Insoluble antigen-antibody complexes are easily phagocytized and destroyed by phagocytic cells

(b) Explain why tuberculosis (TB) is known as an infectious disease. [3]

1. Caused by a pathogen, bacterium, mycobacterium tuberculosis;
2. Transmits easily from infected individual to other uninfected individual via various mode of transmission - aerosol/airborne droplet from infected person exhaling/coughing/sneezing/shout/sing;
3. **Depending on the environment**, these tiny particles can remain **suspended in the air for several hours**;
4. Transmission occur when a person **inhales** and the droplet nuclei transverse the mouth or nasal passages, upper respiratory tract, and bronchi to reach the alveoli of the lungs.
5. Person drinks unpasteurized milk/ eats meat from infected cattle;

(c) Outline the role of antibiotics in the treatment of infectious diseases, such as TB.

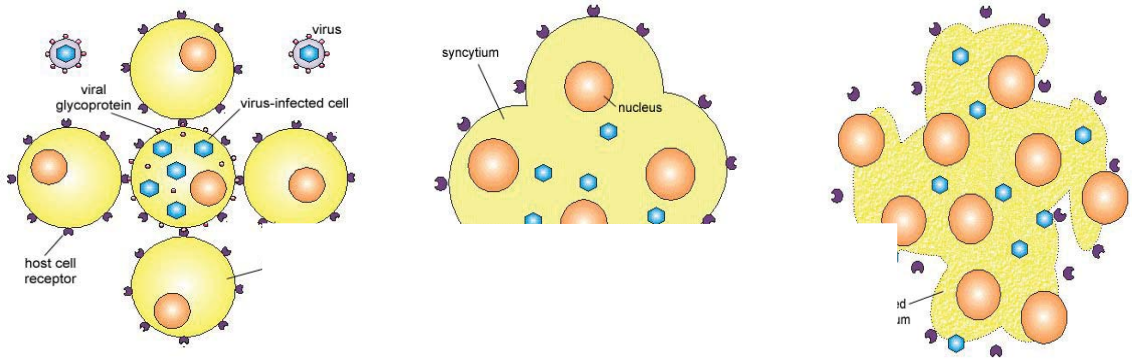
1. Kill bacteria/bactericidal/ cause bacteria to lyse/ swell and burst; [3]
2. (or) bacteriostatic/prevents bacterial growth/prevents bacterial replication;
3. Antibiotics interferes with the modulation of chromosomal supercoiling through topoisomerase-catalyzes strand breakage and rejoining reactions is required for DNA synthesis, mRNA transcription and cell division.
4. Prevents protein synthesis (Initiation and elongation)/ inhibit RNA polymerase;
5. Antibodies may also result in protein mistranslation by promoting tRNA mismatch with mRNA codon.
6. Antibiotics may also Inhibit cell membrane function which result in leakage of important solutes essential for the cell's survival.
7. Prevent spread of bacteria within body/ prevents formation of pathogen reservoir for re-infection;
8. Do not affect human cells/ tissues/ not toxic to humans;
9. Prevents death/ consequences may be fatal if no antibiotic treatment/ alleviate symptoms/ faster recovery;
10. Prevent transmission/ spread of disease (do not confuse with mp 4);

(d) While TB is a bacterial infectious disease, HIV is a viral infectious disease.

Explain how HIV cause diseases in humans through the disruption of host tissue and functions.

HIV infection causes destruction of T helper cells by the following mechanisms: [3]

1. Hijacking of cellular machinery and resources towards producing new virus disrupts normal activities needed for cell survival, eventually causing **cell death**.
2. Budding of a large amount of viruses from the cell surface might also disrupt the cell membrane sufficiently for host cell to die.
3. HIV may induce adjacent T helper cells to fuse together forming giant multinucleated cells or **syncytia**.
4. Shortly after syncytia formation occurs, the fused cells lose immune function and die.
5. functional T helper cell levels decline to a critical point



Uninfected cells bind to a virus infected cell.

The uninfected and infected cells fuse forming a multinucleated giant cell or syncytium.

The syncytium eventually becomes too large and ruptures.

***Fig 36: Formation of a syncytium** (singular).*

[Total: 13 marks]

H2 ANDERSON JUNIOR COLLEGE
HIGHER 2

CANDIDATE NAME

PDG

PDG INDEX NUMBER

BIOLOGY 9744/03

Long Structured and Free response Question Paper 3

14 September 2017 Thursday

Additional Materials: Answer Paper

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

All working for numerical answers must be shown.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Calculators may be used

For Examiner's Use	
1	
2	
3	
4 OR	
5	
Total	55

This document consists of 13 printed pages and 1 blank page.

Answer **all** the questions.

1 Cyanobacteria are a group of photosynthetic, nitrogen-fixing bacteria that live in a wide variety of moist soils and water either freely or in a symbiotic relationship with plants. Some cyanobacteria float in water by forming gas vesicles that are bounded by a protein sheath.

Fig. 1.1 below shows a generalized drawing of a cyanobacterium. The plasma membrane of cyanobacterium consists of an outer and inner membrane which is not represented in Fig. 1.1.

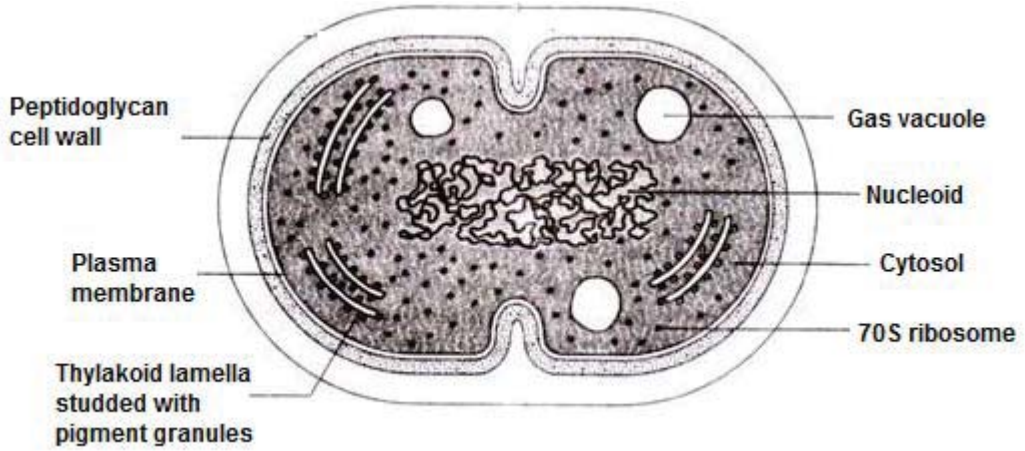


Fig. 1.1

(a) From Fig. 1.1, state two structural features that are expected in a typical prokaryote and two structural features that are not expected in a typical prokaryote.

Expected:

.....

.....

Not expected:

.....

..... [2]

Expected: 70S ribosome, nucleoid/ DNA not bound by envelope, peptidoglycan cell wall (any 2)
Not expected: presence of membrane bound thylakoid lamella, gas vacuole
[1 mark for each]

(b) Process of photosynthesis that occurs in cyanobacterium is largely similar to photosynthesis in chloroplast. Fig. 1.2 shows the effect of carbon dioxide concentration on the light-independent stage of photosynthesis in *Synechococcus* genus of cyanobacterium. The following steps were carried out in a study:

- a cell suspension of *Synechococcus* was illuminated using a bench lamp.
- the suspension was supplied with carbon dioxide at a concentration of 1% for 200 seconds.
- the concentration of carbon dioxide was then reduced to 0.03% for a further 200 seconds.
- the concentration of RuBP and glycerate-3-phosphate (GP) were measured at regular intervals.
- the temperature of the suspension was maintained at 25 °C throughout the investigation.

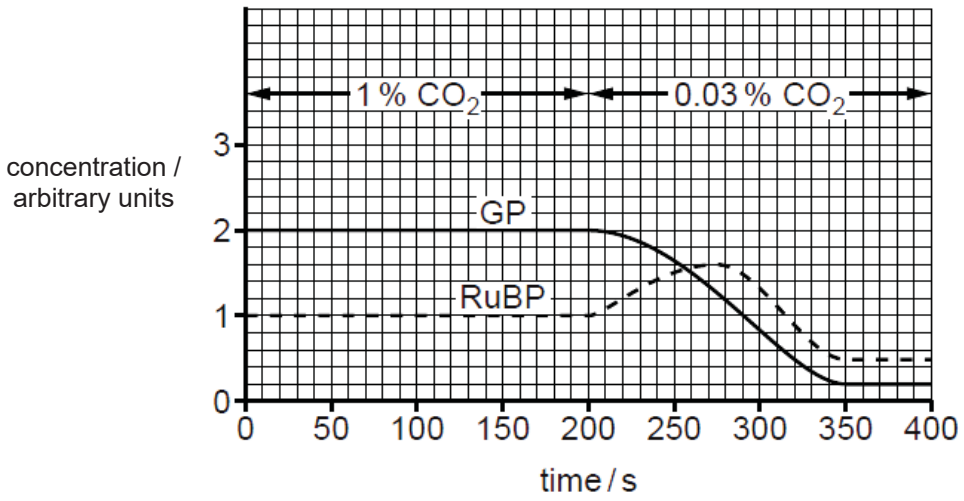


Fig. 1.2

(i) With reference to Fig. 1.2, explain why the concentration of RuBP changed between 200 and 275 seconds.

- concentration of RuBP increases from 1 a.u to 1.6 au when CO_2 concentration is lowered to 0.03%;
- decrease in frequency of effective collision between CO2, RuBP and rubisco;
- rate of carbon fixation decreased, less RuBP is used/ RuBP accumulates; [2]

(ii) Suggest how the decrease in the concentration of GP leads to an increase in the generation time (time it takes for the population to double) of *Synechococcus.*

- less glyceraldehyde-3-phosphate will be produced;
- so less conversion to carbohydrates / amino acids / proteins;
- less glucose for respiration to produce ATP for binary fission/ less amino acids to produce proteins for binary fission/ less raw materials for DNA binary fission; [3]

(iii) Scientists have suggested that chloroplast may have originated as cyanobacterium that continued to function after becoming engulfed by primitive eukaryotic cells, in a process similar to endocytosis.

Describe two features of chloroplast that provide support for this hypothesis.

- presence of DNA/ ribosomes OR ability to synthesize proteins starting with DNA;
- DNA is circular;
- Idea of cyanobacterium is also double membrane like chloroplast/ idea of double membrane linked to endocytosis/ vesicle;
- Presence of 70S ribosomes;
- Multiply by binary fission;
- AVP [2]

(c) The acquisition of photosynthetic bacterium would have provided the plants with nutritional independence, afforded by the ability to photosynthesize. It is hypothesized that these endosymbiotic associations were highly advantageous and thus naturally selected for in the course of evolution.

In the study of evolution of Man, the theory of natural selection is widely used to understand how speciation of humans has occurred. The study of fossils and genetic sequences are now commonly used to help us understand more about human evolution. It is widely believed that

humans are closely related to the Great Apes – chimpanzees, gorillas and orang utan, and share a common ancestor millions of years go.

Fig. 1.3 below shows some a comparison of skull structure between the Great Apes and modern Man (*Homo sapiens)*.

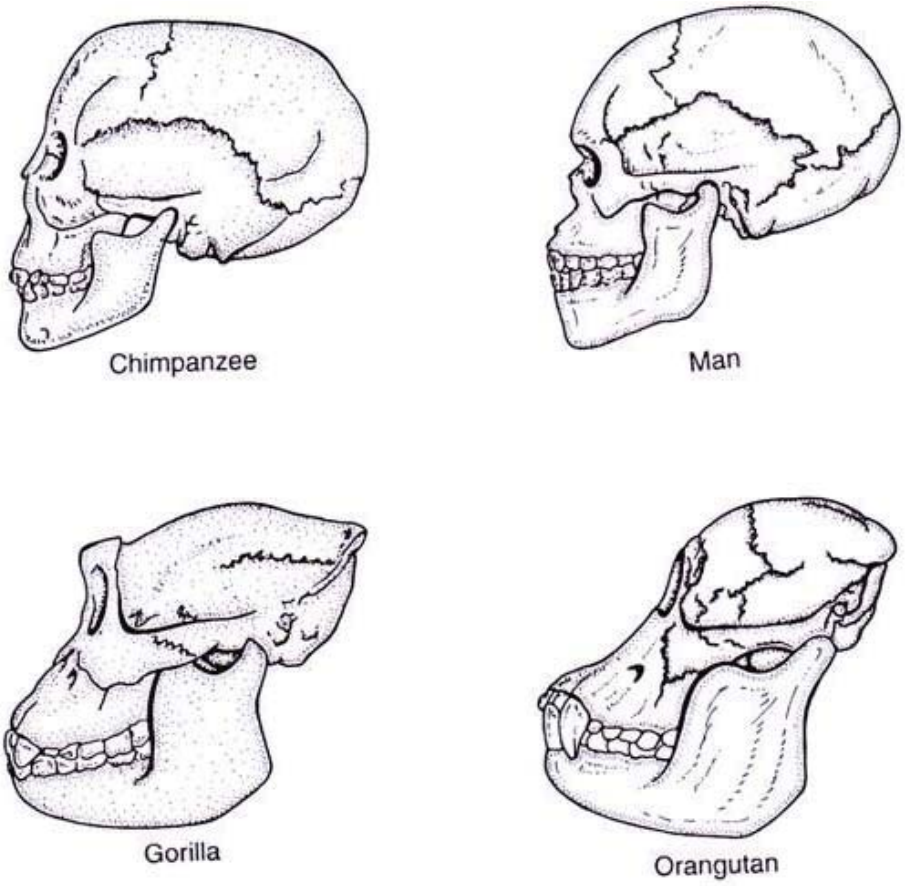


Fig. 1.3

(i) Using Fig. 1.3, state 2 features that support the hypothesis that modern Man shares a common ancestor with the Great Apes.

- Moveable lower jaw;
- Upper and lower sets of teeth;
- Position of cranial space/ brain same/ behind the eyes/ any other suitable description;
- Presence of eye sockets;
- AVP

[2]

Neanderthals (*Homo neanderthalensis*), another primate similar to modern humans is our closest human relative. Fig. 1.4 below shows a comparison between the fossilized skull of a Neanderthal and modern Man.

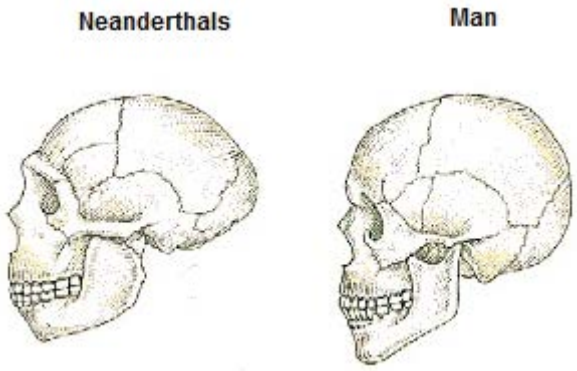


Fig. 1.4

(ii) Disagreement exists as to whether the scientific name for Neanderthals should be *Homo sapiens* or *Homo neanderthalensis*.

With reference to **four** different species concepts, explain why it is difficult to assign a scientific name to Neanderthals.

Any three from:

- Biological species concept: cannot directly test whether humans and Neanderthals could interbreed to produce viable and fertile offsprings;
- Ecological species concept: cannot determine if they share same niche/ idea that humans outcompeted Neanderthals therefore did share same niche;
- Morphological species concept: incomplete knowledge of Neanderthal morphology from fossilized bones/ no easy way to quantify how much morphological changes defines a different species;
- Genetic species concept: hard to quantify how much genetic difference defines a different species/ hard to get complete sequence data from Neanderthal;
- Phylogenetic species concept: limited data to determine phylogeny/ hard to decide if split in phylogeny is at species level; [4]

(iii) Discuss one advantage of using genetic sequences to study evolution of Man.

- Analysis of molecular data is **objective** since differences in DNA/RNA/ amino acid sequences can be **quantified** and **compared** by analyzing nucleotide and amino acid sequences.
- So that able to **differentiate two fossils/ earlier species of man with similar morphologies based on molecular differences**.
- So that Scientists are able to **use both living and dead specimen material** in classification of organisms.

[2]

[Total: 17]

2 B-lymphocytes respond to the presence of a non-self antigen by dividing as shown in Fig. 2.1.

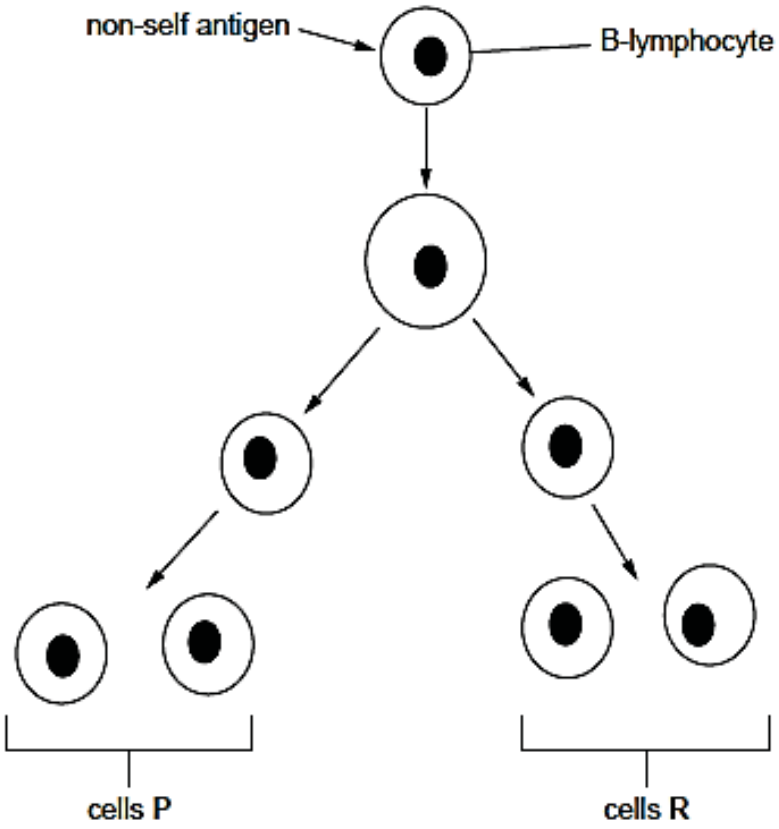


Fig. 2.1

(a) During an immune response, cells divide by mitosis. Describe how mitosis is involved in an immune response.

1. Occurs in both primary and secondary immune response;
2. Clonal selection and expansion - Selected B and T lymphocytes divide by mitosis;
3. Mitosis in memory cells for rapid secondary response; [3]

(b) The cells labelled P on Fig. 2.1 continue to divide to give rise to many cells that differentiate into short-lived plasma cells. The plasma cells release antibody molecules.

(i) Outline how plasma cells produce antibody molecules.

1. Using DNA as a template, gene is transcribed to mRNA;
2. Small ribosomal subunit binds to ribosome binding site at 5' end of mRNA, followed by attachment of large ribosomal subunit;
3. tRNA with complementary anticodon to mRNA codon carries specific amino acid to the ribosome;
4. formation of peptide bonds between adjacent amino acids;
5. synthesized polypeptide enters RER to fold into secondary and tertiary structure;
6. vesicle containing polypeptide buds off from RER and fuse with Golgi body;
7. undergoes further modification such as glycosylation/ formation of quaternary structure and disulphide bonds in Golgi apparatus; [4]

(ii) Describe how antibody molecules are released from the plasma cell.

Vesicles migrate/move and fuse with to cell surface membrane;
Release antibodies via exocytosis;
Movement of vesicle/exocytosis requires ATP; [2]

(c) Both B and T lymphocytes are part of adaptive immunity. Describe the mode of action of T-

		lymphocytes during an immune response.	
		T cells are activated when they encounter antigen in association with MHC II on another APC eg.macrophage; Those T cells that have receptors complementary to the antigen respond by **dividing by mitosis** and undergo **clonal selection** and **clonal expansion** to produce clones of T cells; T helper secrete cytokines to activate B- lymphocytes to divide and differentiate into plasma cells which will secrete antibody; Increase antibody levels for agglutination, neutralisation, opsonisation, ADCC, complement activation, immobilization of bacteria (any 2) Some T helper cells secrete cytokines that stimulate macrophages to carry out phagocytosis more vigorously; Some helper T cells secrete cytokines that stimulate killer T cells to divide by mitosis and to differentiate by producing vacuoles full of toxins; Cytotoxic T cells attach to kill infected cells by release of cytotoxic substances; Or by releasing perforin which will induce pores in the infected cell surface membrane for cell lysis/ granzymes which will trigger cell apoptosis; Memory helper T cells and memory killer T cells are produced, which remain in the body and become active very quickly during the secondary response to antigens; Natural killer (NK) cells - The F_{ab} portion of IgG binds with the target cell (microorganism or tumour cell) and the F_c portion binds with specific F_c receptors (*structure*) that are found on natural killer (NK) cells. NK cells destroy the target by releasing **toxic** substances contained in its cytoplasm granules and not by phagocytosis	[4]
	(d)	Immune response is mounted against pathogen such as bacteria. Explain why phagocytes act only against the bacteria and not against human cells.	
		1. bacterial's antigens are non-self/foreign and human cells have self antigens; 2. non-self and self antigens are proteins of different amino acid sequence/ self antigens are encoded by genes in the body; 3. non-self antigen will trigger phagocytosis by APCs (macrophages and dendritic cells); 4. phagocytes bind to antibodies complexed with non-self antigens/ human cells will not have bound antibody;	[4]
			[Total: 17]

3 The olive tree, *Olea europaea*, is a small tree native to the Mediterranean area of Europe, Africa and parts of Asia, where it has been cultivated for several thousand years. In 1993, Beerling and Chaloner carried out estimates of stomatal density on preserved olive leaves. The oldest of these were obtained from the tomb of the Egyptian King Tutankhamun who died over 3000 years ago. The results of the study are summarised in Fig. 3.1.

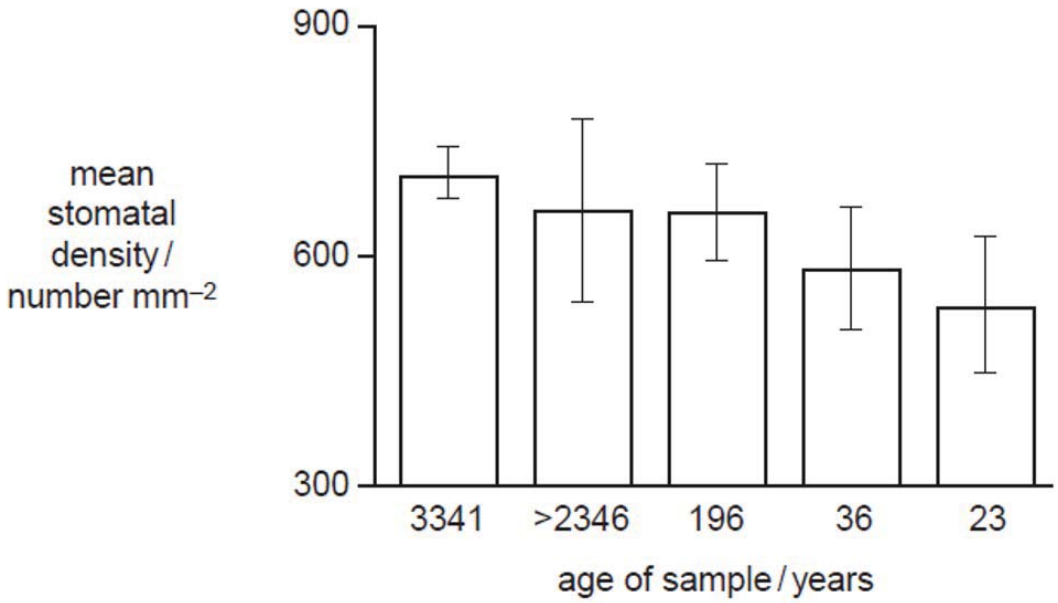


Fig. 3.1

(a) (i) Describe the results shown by the data in Fig. 3.1. [2]

- mean stomatal density decreases (cite data);
- stomatal density has decreased steeply since 196 BP ;
- no change between >2346 BP and 196 BP ;
  (any 2)

(ii) Explain why it is difficult to reach a valid conclusion about changes in stomatal density over time [4]

- error bars show variation within samples / large variation within samples ;
- overlapping errors bars indicates no significant difference between (most) means / samples ;
- error bars for 3341 BP and 23 BP do not overlap ;
- there is a significant difference over, 3318 years / period of study ;
- a very long period / approximately 3500 years, represented by only five means ;
- second sample, could be any age from 2346 BP / might be older than the first sample ;
- large periods of time between samples / changes could have taken place between sampling dates ;
- historical samples, are / likely to be, very small / non-representative ;
- Any valid point;
  (Any 4)

Over the last 10 years, Kenya has made progress in malaria control. However, the country is still far from defeating the disease.

Fig. 3.2 shows how prevalence of malaria is across the country.

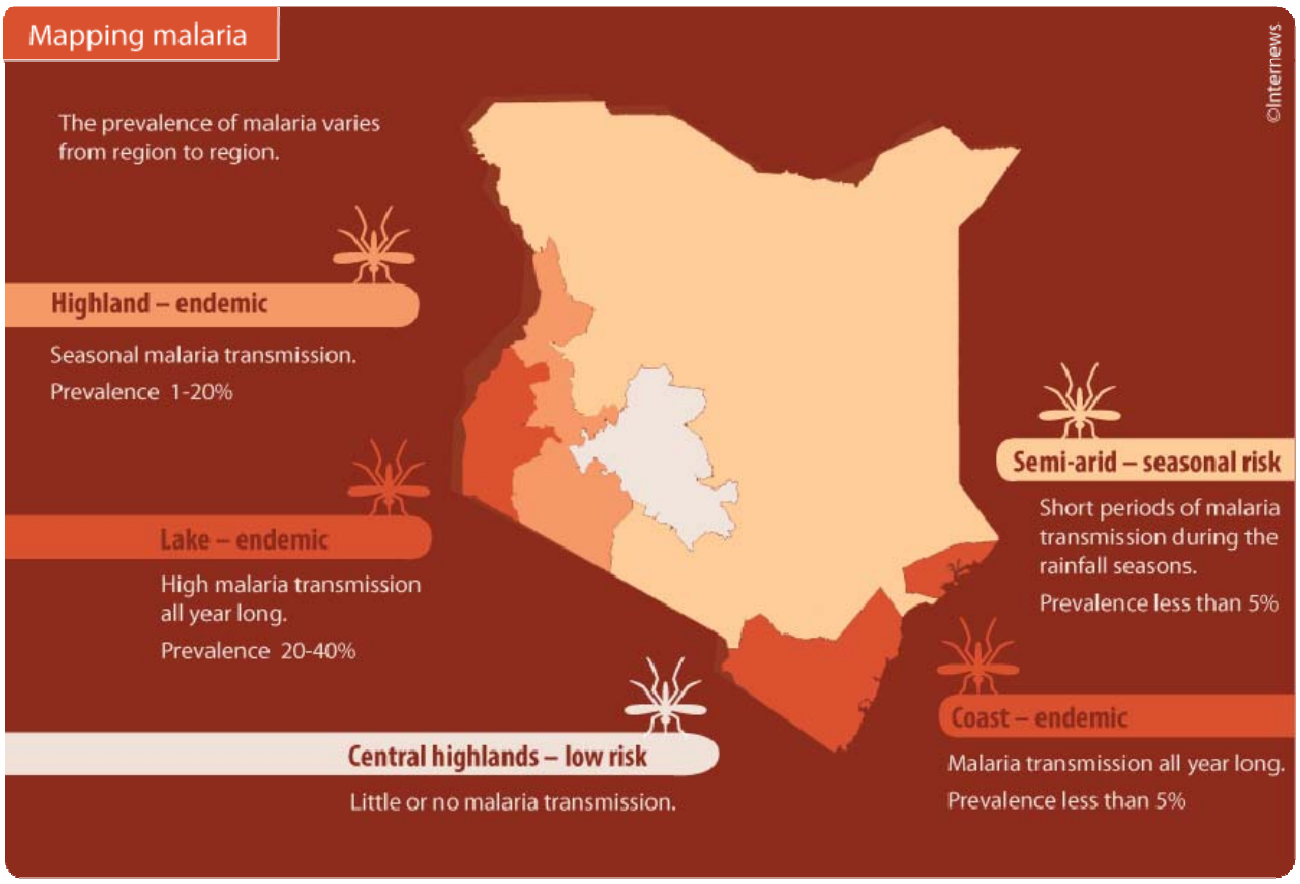


Fig. 3.2

	(b)	**(i)**	With reference to Fig. 3.2, explain the two determining factors that lead to uneven prevalence of malaria across the country.	[4]
			Water • Higher prevalence near lake area (20-40%)/ Semi-arid areas only have seasonal risk during the rainfall seasons. Hence prevalence is less than 5% • Due to breeding area for mosquitos; **Temperature** • Highland or central highland has less % prevalence than coast (all year long) • Due to warm temperature needed to complete the mosquito life cycle – state 1 e.g. egg laying; or metabolism	
		(ii)	Suggest why it is difficult to control malaria worldwide, apart from reasons associated with global warming.	[2]
			• Poor awareness of how mosquito spreads/ how to prevent being bitten/ effective government programme; • Resistance of mosquito to insecticide; • Resistance of plasmodium parasite to antibiotics; • Any valid reasons (Any 2)	
	(c)	Besides mosquito-borne diseases, describe **two** other problems caused by a change in insect population as a result of climate change.		[4]
			• Increase in **named** insect attacks on **named crop**; • affects crop yield which affects food security/ cattle feed; • **Migration** of insects to higher altitude; • Affects food chains/ food webs of ecosystem;	
				[Total: 16]

Free-response question

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

Your answer:

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

4	**(a)**	Describe the production and folding of a functional enzymatic protein that is used within a cell.	[12]

Describe transcription: (max 5m)

- Ref. to transcription of gene on **template strand**
- Ref. to **RNA polymerase** binding to **promoter** region
- Ref. to RNA polymerase adding free ribonucleotide triphosphates and are joined together by **phosphodiester bonds**
- Ref. to elongation of mRNA in a **5' to 3' direction**
- Ref. to transcription stops after RNA polymerase reads the **termination signal** (in prokaryotes) / p**olyadenylation signal** (in eukaryotes)
- Ref. to pre-mRNA undergoes post-transcriptional processing of 5'capping, splicing and poly-A tailing (any 1 e.g.) to form mature mRNA;

Describe translation: (max 5m)

- mature mRNA translocates from nucleus to cytoplasm through nuclear pores;
- Ref. to initiation of translation at 5' end of mRNA by assembling small and large ribosome and initiator tRNA;
- Ref. to tRNA with complementary anticodon forms complementary base pairs with codon sequences, bringing specific amino acids to ribosome;
- Ref. to formation of peptide bonds catalysed by peptidyltransferase in large ribosomal subunit;
- Ref to stop codon and addition of release factor to A site;
- Ref. to hydrolysis of ester bond between amino acid and tRNA, releasing polypeptide chain from ribosome;

Describe protein folding: (max 5 m)

- Enzymes are globular proteins with unique three-dimensional conformation / tertiary / quaternary structure;
- Ref to primary structure being the unique sequence and number of amino acids in a polypeptide linked by peptide bonds;
- Ref to secondary structure being the regular coiling and folding/pleating of the polypeptide held by *hydrogen bonds* between CO and NH groups of the peptide bonds / polypeptide backbone;
- In *alpha helix*, *hydrogen bonds* form between CO and NH groups 4 a.a. apart, forming a 3D helical structure
- In *beta pleated sheet*, *hydrogen bonds* form between CO (or NH) group of one region/segment and NH (or CO) group of an adjacent region/segment of a single polypeptide chain, forming a flat/pleated sheet;
- Tertiary structure refers to the folding of polypeptide into a specific conformation, held by bonds between *R-groups** of structural amino acids within same polypeptide, maintained by *hydrophobic interaction, hydrogen bonds, ionic bonds, disulfide bridges;*
- Ref to quaternary structure: more than 1 polypeptide chain to form functional protein held by *hydrophobic interaction, hydrogen bonds, ionic bonds, disulfide bridges* between R groups between polypeptide chains;
- Folding gives rise to a specific cleft / groove - *active site* that is *complementary in shape and charge* to its *substrate*.

		• Folding brings catalytic amino acids and binding amino acids far apart in the primary structure / polypeptide close together in the active site Overall max 12m.	
	(b)	Discuss the importance of anaerobic respiration, and why it produces few ATP.	[13]
		Importance of anaerobic respiration (max 4) • Produces ATP even though no oxygen is available; • Ref to heart pumping at maximum rate, and not delivering enough oxygen to mammalian muscle • Importance to human: Yeast produce alcohol for use. • Reference to death/ ATP used for cellular processes/ allow ATP to be made, so few ATP is better than none. • AVP; **Why it produces few ATP (max 10)** • No oxygen as final electron acceptor; • No oxidative phosphorylation, no Krebs cycle and no link reaction; • Only glycolysis takes place; • Produces 2 ATP per glucose; • By Substrate level phosphorylation; • 19 times lesser compared to aerobic respiration/ aerobic respiration makes 38 ATP per glucose; • Due to NAD and FAD not regenerated by Oxidative phosphorylation; • Aerobic respiration produces a lot of ATP because 1 NADH and 1 $FADH_2$ give 3 ATP and 2 ATP respectively per glucose. • However, NAD is regenerated by fermentation/ NADH made in glycolysis is regenerated to NAD in fermentation; • Energy is still trapped in ethanol and lactate;	
			[Total: 25]
5	**(a)**	Discuss the importance of membranes in the reproductive cycle of the influenza virus.	[12]
		1. Envelope/ cell membrane of viruses contains haemagglutinin (HA/H); which mediates the binding of the virus to specific receptor sites containing sialic acid sugars on the cell surface membrane of epithelial cells;; (especially in the nose, throat and lungs of mammals and intestines of birds); 2. Importance: allows the virus to recognize and attach to specific host cells; 3. The virus enters by endocytosis as the host cell membrane invaginates, forming a endocytic vesicle / endosome; 4. Importance of membrane: fluid nature of the membrane allows formation of vesicles; 5. Within the endosome, the acidic pH causes the hemagglutinin protein to undergo a conformational change; 6. Importance of membrane: allow the setting up of an acidic medium within the endosome (with the help of proton pumps on endosome membrane); 7. Resulting in the fusion of the viral envelope with the endosome membrane; 8. releasing the nucleocapsid into the cytoplasm; 9. (During synthesis of the new viruses) glycoproteins(HA and NA) are first synthesized in the rER; and then chemically modified in the Golgi apparatus (both are single membrane bound organelles in the host cells);; 10. The glycoproteins are then transported to the cell membrane via (secretory) vesicles (pinched off the Golgi apparatus); 11. These vesicles then **fuse** with the host cell membrane, thereby incorporating/**embedding** the glycoproteins into the (host) cell surface membrane; 12. These sites then serve as exit point for viral release;	

13. New viruses leave the host cells through **budding**; thereby **acquiring the host cell membrane (=envelope)**;
14. Neuraminidase (NA/N), present on cell membrane helps in the release of new viruses by infected cells by cleaving off the sialic acids present on the host cells;

(b) Distinguish the differences in transcriptional control between *E. coli* and yeast cell, and explain the significance of post-translational control in yeast cell. [13]

Point of comparison	*E. coli*	Yeast cell
Operon	Allows bacteria to coordinately regulate a group of genes that encode gene products with related functions.	Group of genes that encode gene products with related functions are located on different chromosomes.
Regulatory gene – repressor and binding site	Codes for a repressor which binds to operator	repressor protein binds to silencer (distal control element)
activator and binding site	Catabolite Activator Protein (CAP) binds to CAP binding site on promoter.	Activator protein binds to enhancer (distal control element)
Promoter	One promoter controlling a group of structural genes coding for enzymes involved in the same metabolic pathway	One promoter for each gene
mRNA	Polycistronic mRNA one mRNA code for more than 1 protein Presence of several start and stop codons	Monocistronic mRNA one mRNA code for 1 protein 1 start codon 1 stop codon
Accessibility of RNA polymerase to promoter	Inducible – inducer binds to active repressor allosterically to change its conformation such that it becomes inactive as its binding site is no longer complementary to operator sequence, therefore RNA polymerase is able to bind to promoter/ repressible operon – co-repressor (trp) binds allosterically to inactive repressor to change its conformation such that it becomes active as its binding site is now complementary to operator sequence, therefore RNA polymerase is no longer able to bind to promoter.	State at least two: Histone Acetylation / Histone methylation/ DNA methylation
Number of chromosomes involved	Operon is within the bacterial chromosome	More than one chromosome involved resulting in a coordinated response.

(8 maximum from above)

Importance of post-translational control:

a) **Cleavage and/or covalent modification**
Give 1 suitable example - glycosylation, disulfide bond formation, attachment of prosthetic groups etc. is required.

b) **Form functional protein - newly synthesized proteins need to be modified for proper assembly / functioning**

c) **Regulate - control cellular activity / influence biological activity**

d) **Eg: phosphorylation/dephosphorylation may activate/inactivate proteins (e.g. kinases in phosphorylation cascade)**

e) **Degrade proteins allows control of protein activities OR prevent aberrant activities so that proteins will not stay too long in cytoplasm and still be active**

f) **E.g. Proteins are linked to ubiquitin that will target a protein for degradation.**

g) **(Save/recycle resources) - proteins not needed can be hydrolysed to amino acids, to be used for synthesis of new proteins**

h) **(Heterogeneity) - many different proteins modified from one polypeptide serve different function so smaller no of proteins/ small genome needed**

i) **(Localisation) – direct proteins to particular locations inside and outside cell**

j) **Eg: modifications at terminus of amino acid chain help target proteins for transporting to final destination in the cell / move across membranes/ tag proteins to be incorporated in various cellular and organelle membranes**

(7 maximum from above)

[Total: 25]

H2 ANDERSON JUNIOR COLLEGE
HIGHER 2

ANDIDATE NAME

PDG

PDG INDEX NUMBER

BIOLOGY 9744/04

Paper 4 Practical **24 August 2017 Thursday**

Candidates answer on the Question Paper. **2 hours 30 minutes**

READ THESE INSTRUCTIONS FIRST

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

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

Shift
Laboratory

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

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

For Examiner's Use	
1	
2	
3	
Total	55

This document consists of **16** printed pages and **1** blank page.

Answer **all** the questions.

1 The enzyme lipase catalyses the hydrolysis of triglycerides into fatty acids and glycerol.

You are required to investigate the effect on the lipase-catalysed reaction of the independent variables:

- enzyme concentration
- presence of calcium ions

The substrate for lipase will be the triglycerides present in milk.

The progress of this hydrolysis can be monitored by using an indicator, **T**, which changes colour due to the production of fatty acids.

You are provided with the following solutions;

25cm^3 of milk containing calcium ions, labelled **M+C**,
25cm^3 of milk without calcium ions, labelled **M**,
25cm^3 of indicator solution, labelled **T**,
30cm^3 of sodium carbonate solution, labelled **A**,
20cm^3 of 10% lipase solution, labelled **E10**,
20cm^3 of 5% lipase solution, labelled **E5**,

Lipase is an irritant. You are advised to wear the eye protection provided. Contact of the solution with your skin should be avoided. If it touches your skin, wash it off with tap water.

Proceed as follows.

(a) **Stage 1**

Use the beaker or container provided to make a water-bath with warm water, between 38^{0}C and 42^{0}C.

Stage 2

Label four boiling tubes, **B1, B2, B3** and **B4**.

Using the syringes, put:

- 2cm^3 of solution **M+C** into each of the boiling tubes labelled **B1** and **B2**,
- 2cm^3 of solution **M** into each of the boiling tubes labelled **B3** and **B4**,
- 2cm^3 of solution **T** into each of the boiling tubes labelled **B1**, **B2**, **B3** and **B4** and gently shake,
- 3cm^3 of solution **A** into each of the boiling tubes labelled **B1, B2, B3** and **B4** and gently shake so that all the mixture turns blue. Minor variations in colour between the tubes can be ignored as long as the contents are blue.

Put the four boiling tubes into the water-bath for at least three minutes, before progressing to **Stage 3**.

Stage 3

After the boiling tubes have been in the water-bath for three minutes, start a stopwatch, which will be left running continuously throughout the investigation. Start and end times will be taken from this stopwatch.

Stage 4 [3]

Remove the boiling tubes labelled **B1** and **B3** from the water-bath and put them in a boiling tube rack. Use a syringe to put 2cm^3 of solution **E10** into each of these two boiling tubes and mix well. Record the start times in Table 1.1, below.

Stage 5

Observe the boiling tubes **B1** and **B3** and record the times at which the colour changes (end times) in Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

Stage 6

Remove the boiling tubes labelled **B2** and **B4** from the water-bath and put them in a boiling tube rack. Use a syringe to put 2cm^3 of solution **E5** into each of these two boiling tubes and mix well. Record the start times in Table 1.1.

Stage 7

Observe the boiling tubes **B2** and **B4** and record the times at which the colour changes (end times) In Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

Stage 8

Calculate the time taken for the colour to change for each of the boiling tubes **B1-B4**, and record this in Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

Table 1.1

	B1	**B2**	**B3**	**B4**
Start time/s				
Time at which colour changes (end time)/s				
Time taken for colour to change/s				

[3]

- Time recorded to nearest second;
- Time recorded to whole numbers;
- B1 and B2 takes shorter time than B3 and B4, reject if B3 records as no change;

(b) Prepare a table in the space below to show the effect of enzyme concentration and presence of calcium ions on the hydrolysis of triglycerides in milk.

Lipase concentration/ %	Presence of calcium ions	Time taken for colour to change/ s	Rate of hydrolysis / s^{-1}
5	Present		
5	Absent		
10	Present		
10	Absent		

T1 - Well presented - fully ruled table;
T2 - Heading with lipase concentration and correct units;
T3 - Heading with presence of calcium ions, no units;
T4 - Time taken or rate of hydrolysis recorded with appropriate units;
T5 - Values brought over and filled in correctly + correct calculation of rate;
T6 - Consistent number of dp: time and lipase concentration in whole numbers, rate to 3 sf; [6]

(c) Describe how you could set up a control for the effect of lipase.

Replace lipase with equal volume/ 2 cm^3 of distilled water, subject the tube to same experimental

conditions. This shows that a shorter time taken/ no colour change is due to enzymatic action of lipase in breaking down triglycerides.

Also accept: **boiled and cooled** lipase

(d) Identify **one** significant source of error in measuring the dependent variable in this investigation. [1]

Determination of extent of green colour as end point is **subjective** via **visual inspection**.

(e) State **two** ways in which the experimental procedure could be improved.

- Use a colorimeter/ spectrophotometer/ pH probe to determine a **fixed absorbance value/ wavelength of light/ fixed pH vale** as end point;
- Use an electrostatically controlled water bath and **monitor temperature using a thermometer**;
- Equilibrate temperature of enzymes E5 and E10 **separately** first before mixing with M and M+C;
- Use a white tile as background for clearer observation of colour change;
- Use a colour chart with end point colour to compare for clearer observation of end point;
- Prepare a negative control boiling tube to compare the colour change against experimental tubes for clearer observation of end point;

Reject:

- Do replicates/ repeats

(f) Explain why the method used in this investigation is not suitable for investigating the effect of pH on the activity of lipase.

- Triglycerides will yield fatty acids and glycerol as products upon hydrolysis/ Fatty acids will reduce the pH of the solution;
- The variable being manipulated (pH) and that being measured (amount of fatty acids to indicate lipase rate of reaction) is the same/ fatty acids will change the pH of the boiling tubes and therefore not possible to keep a constant pH to investigate its effects;

Some students carried out an investigation using lipase and found that its activity was affected by the concentration of copper sulfate solution. All other variables were kept constant.

The results of their investigation are shown in Table 1.2.

Table 1.2

Copper sulfate concentration/ $X10^{-3}$ $moldm^{-3}$	Lipase activity/arbitrary units
1.0	26.0
2.0	12.0
3.0	5.0
4.0	2.5
5.0	1.5

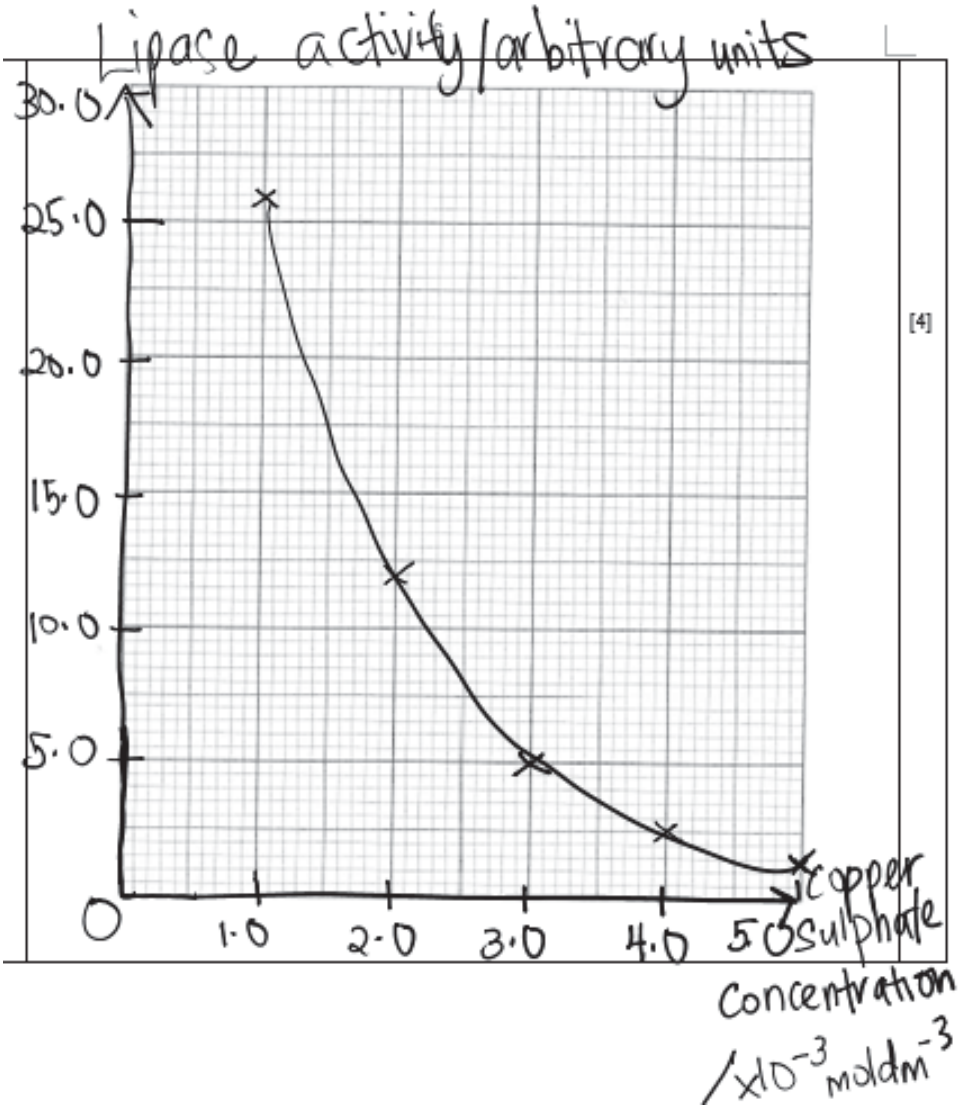
(g) Plot a graph of the data shown in Table 1.2, on the grid below.

G1 – appropriate scale + graph occupies at least half of graph paper in both x and y axis direction + origin labeled + last y-axis label beyond last plotted point;
G2 - Correctly labelled X and Y axis + correct units + x and y axis values labeled to one dp;
G3 - Plot individual points precisely using a cross
G4 - Line of best fit, Sharp, clear line through/close to the plotted points.

Reject:

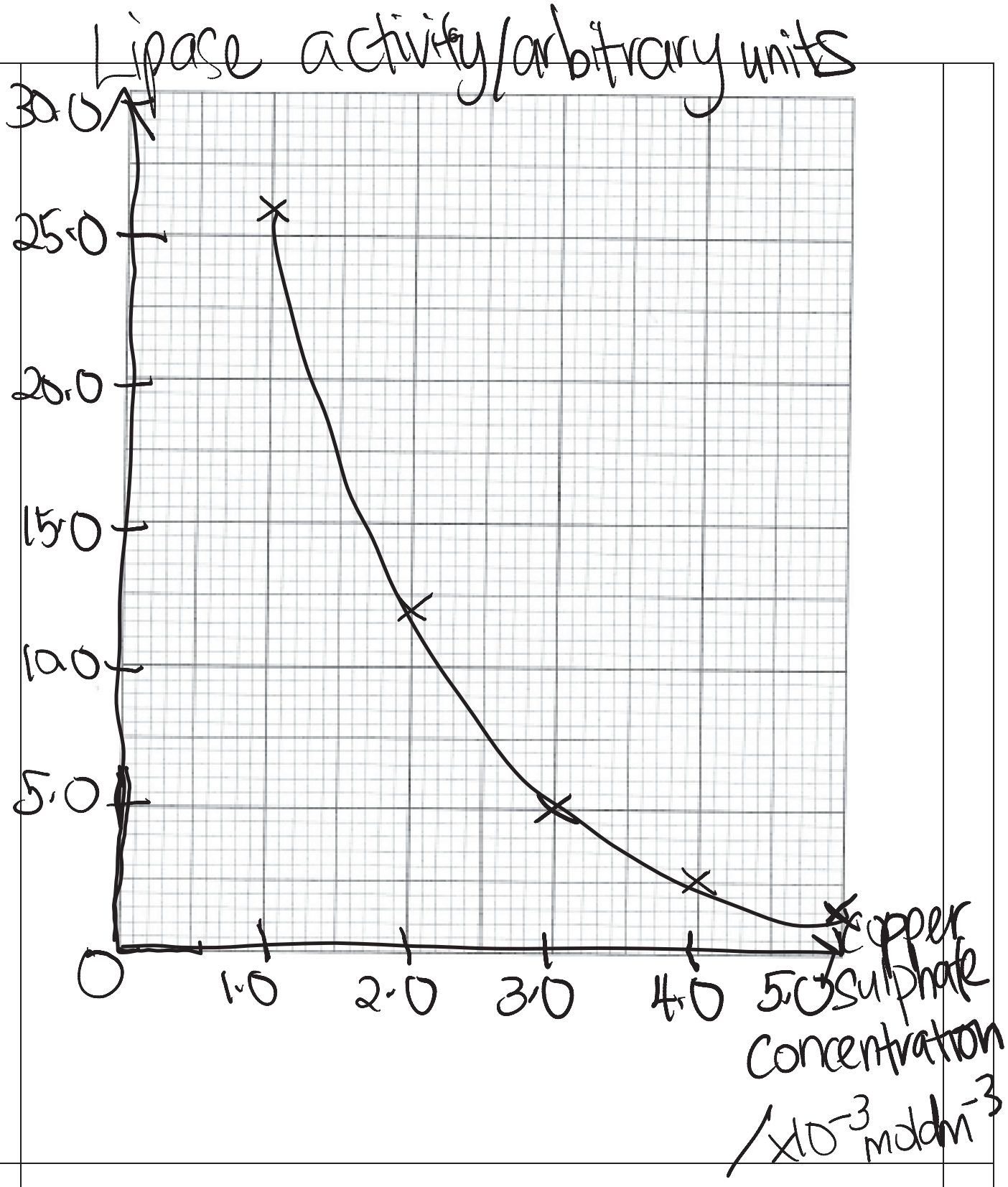
- Extrapolated beyond the data
- Unsuitable scale on x and y axis

- Lacked precision in plotting data.



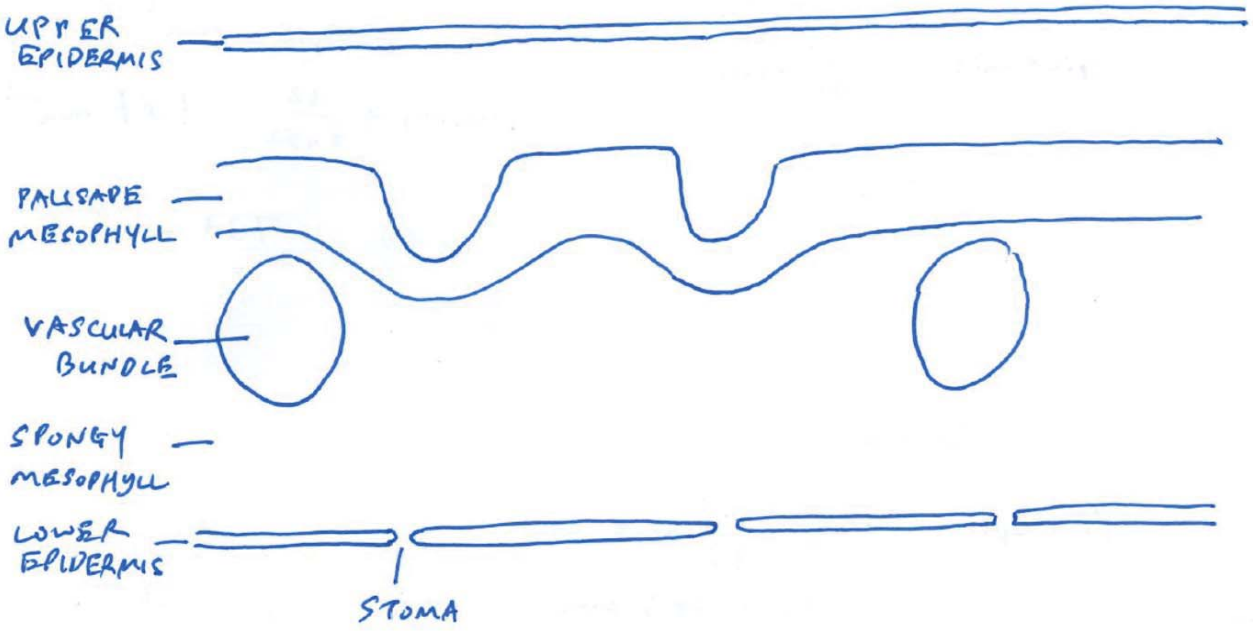
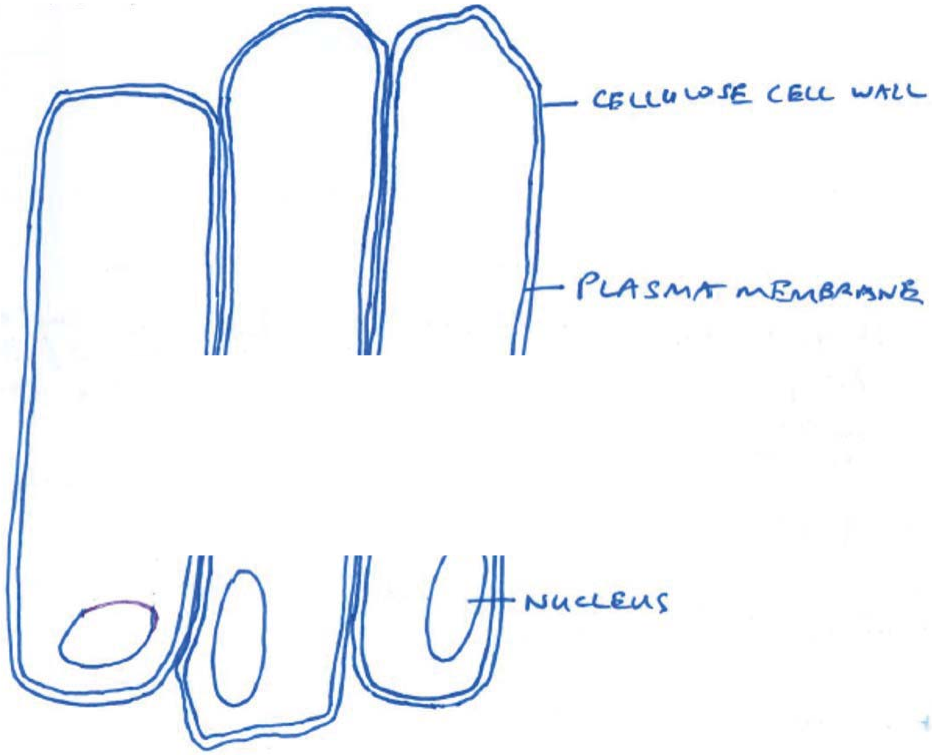
[4]

[4]



(h) Describe and explain these results.

[Total: 21]

2	**K1** and **K2** are stained, transverse sections of leaves from two different species of plant.		
(a)	**(i)**	Make a large, **labelled**, **plan drawing** of **K1** to show the **distribution of tissues** in the leaf lamina (avoiding the midrib). Details of individual cells are **not** required.	
			[3]
	(ii)	Make a **labelled**, high-power drawing to show the **detailed structure** of **three adjacent cells** from the palisade mesophyll layer.	
			[3]

	(iii)	Use the stage micrometer to determine the area of the field of view **under high power**. Calculate the **average** density of palisade mesophyll cells. **State the magnification used and show your working.**	
		Density = Average number of cells/ Area of field of view (NOT mass/volume!!) To calculate the area of the field of view **under high power** (i.e. x400 or x600 only), Use the stage micrometer divisions. At **x400**, you can see there are 44 or 45 of stage micrometer divisions in diagram below. Each division is 0.01 mm. Hence the **diameter** of the field of view is **0.44 mm**. Radius = **0.22 mm** at x400 Area = $\pi r^2 = \pi (0.22)^2 = 0.152$ mm^2 (1 mark) Count the number of palisade mesophyll at least twice. Then get **average number of cells**. Say you got 112 cells. (1 mark) **So density** **= Average number of cells/ Area of field of view** **= 112/ 0.152 = 737 mm^{-2}.** (1 mark) At x600 magnification, diameter = 30 stage micrometer divisions = 30 x 0.01 = 0.3 mm Hence radius = 0.15 mm.	[3]
	(iii)	Calibrate the eyepiece graticule using the stage micrometer so that you can use it to measure the length along one palisade mesophyll under a suitable magnification. Repeat until you have three measurements. **State the magnification used and show your working in calculating the average length.**	
		X400 **Calibration (1 mark)** 40 eyepiece graticule units = 10 divisions on stage micrometer 1 division on stage micrometer = 0.01 mm Hence 40 eyepiece graticule units = 10 x 0.01 = 0.1 mm **1 eyepiece graticule = 0.1/40 = 0.0025 mm = 2.5 µm (1 mark)** (1 mm = 1000 µm) **Measurement of average palisade mesophyll cell length** Readings | Eyepiece graticule units 1 | 19 2 | 18 Average | 18.5 (1 mark) 18.5 x 2.5 µm = **46.25 µm** (1 mark for accuracy) **Note: At x 600,** **Calibration (1 mark)** 1 eyepiece graticule = 1.6 µm or 1.6 µm (1 mark) (1 mm = 1000 µm)	
(b)	The plant species from which **K2** was taken grows in a dry habitat.		

Examine **K2**, using your microscope.

State four observable features that distinguish **K2** from **K1** and **present the differences in a suitable format**.

Any 4 below:

Features	K1 (*Ficus*)	K2 (Marram grass)
Shape of leaf	Leaf is flat	Leaf is curled/ rolled
Hair-like structures	Absent	Present
Protrusions	Absent	Present
Stomata number	More	Fewer
Location of stomata	More exposed to air/ lower epidermis	Not exposed/ sunken/ within grooves
Air spaces between cells	More	Little
Mesophyll cells	Elongated (palisade) or round (spongy)	Round
Cuticle layer	2 layers/ on both sides of leaf	1 layer on one side

[4]

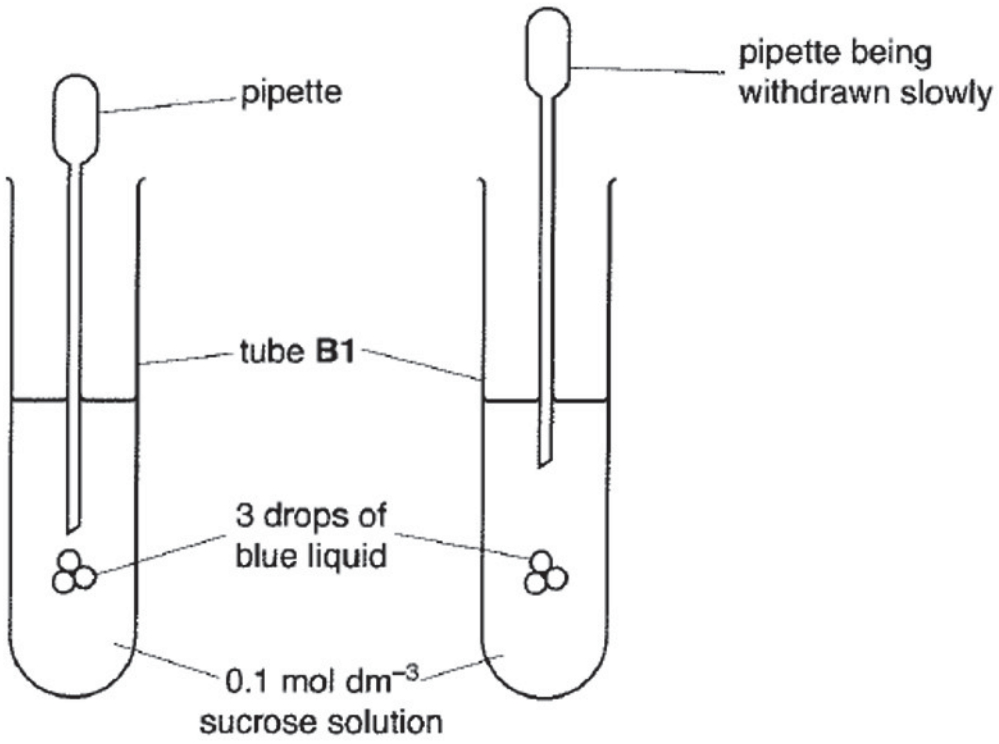
(c) You are required to investigate some aspects of the water relation of living plant cells.

(i) Label three test tubes **B1, B5**, **B10 and C5** respectively.
Using a syringe or pipette, prepare the three concentrations of sucrose using the water and 1.0 mol dm^{-3} sucrose solution provided. Record the volume of water and 1.0 mol dm^{-3} sucrose solution used in the table below. The total volume of different concentrations of sucrose should be 10 cm^3. Then place 10 cm^3 of sucrose into each of these tubes.

Tube	B1	B5	B10
Concentration of sucrose solution (10 cm^3)	0.1 mol dm^{-3}	0.5 mol dm^{-3}	1.0 mol dm^{-3}
volume of water	9.0	5.0	0.0
volume of 1.0 mol dm^{-3} sucrose solution	1.0	5.0	10.0

[2]

Transfer all 10 cm^3 0.5 mol dm^{-3} sucrose solution from **B5** into a test tube labelled **C5** and add three drops of the dye, methylene blue (labelled **MB**) to it. Shake tube **C5** to make the colour uniform. Suck up a little of this blue 0.5 mol dm^{-3} sucrose solution into a pipette and then, with the tip of this pipette held stationary, half way down the solution in tube **B1** (see diagram below), **very gently** release three drops from the pipette. **Do not squirt these drops into the solution. Withdraw the pipette slowly.**



Carefully observe the movement of the blue liquid. Repeat the procedure of **B10**.

(i) Record your observations in a suitable format for **B1** and **B10.**

	B1	**B10**
Observations	Blue liquid disperses and sinks/ remain suspended	Blue liquid disperses and sinks to the bottom/ float.

[2]

[Total: 20]

3	**Planning question**	

Yeast undergoes aerobic respiration, breaking down glucose into carbon dioxide and water. This process is catalyzed by enzymes.

Methylene blue is an artificial **hydrogen acceptor** which is blue in the oxidised form and colourless when reduced.

coloured methylene blue $\xrightarrow{\text{reduction}}$ colourless methylene blue

A colorimeter can be used to measure the absorbance of light of 550 nm by methylene blue solution. When methylene blue is reduced and becomes colourless, its absorbance reading will become 0 arbitrary units. Yeast suspension has an absorbance value of 15 arbitrary units. The colorimeter is shown in **Fig. 4.1** below.

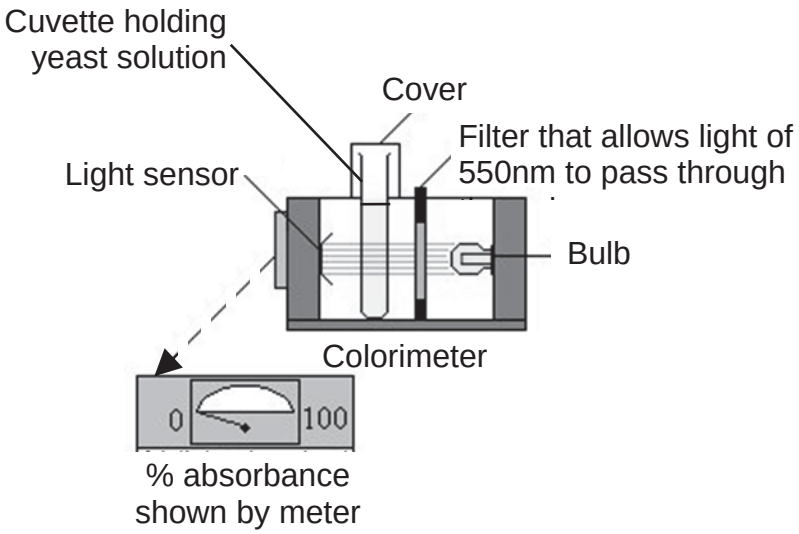


Fig. 4.1

Using this information and your own knowledge, design an experiment to test the hypothesis that:

"The rate of respiration in yeast cells is dependent on the concentration of sucrose solution."

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- identify independent and dependent variables,
- describe the method with scientific reasoning used to decide the method so that the results are as accurate and reliable 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.

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

- active yeast suspension
- 1.0 mol dm^{-3} glucose solution
- methylene blue
- test tubes
- stopwatch
- colorimeter
- 2 cuvettes
- beakers
- a variety of different sized measuring cylinders, syringes and pipettes for measuring volumes
-

Theoretical considerations (max 1m):

- During respiration, NAD^+ and FAD are reduced to form NADH and $FADH_2$ during glycolysis, link reaction and Krebs cycle;
- Methylene blue replace NAD^+ and FAD, it changes colour from blue to colourless when it is reduced;

Measurable Quantity (1m):

- The time taken for methylene blue to reach absorbance value of 15 a.u can be used to measure the rate of respiration;

Predicted Trend (1m):

- As concentration of glucose increases, time taken for methylene blue to decolorise and reach absorbance value of 15 a.u. decreases;
- Increase in frequency of effective enzyme-substrate collision between glucose and enzyme, increasing the rate of reaction;

Dependent variable (1m):

- Concentration of glucose solution/ $moldm^{-3}$.

Independent variable (1m):

- Time taken for methylene blue to decolorise and reach 15 a.u of absorbance value/s.

Control (1m):

- Replace glucose solution with **same volume** of distilled water, subject to **same experimental conditions** to see that **decolorisation** is due to respiration when glucose is available;

Procedure:

- Carry out simple/ serial dilution of 1.0 mol dm^{-3} glucose solution with at least **5** different glucose concentration;
- Shows dilution table with correct calculation + correct headings + total volume same in all tubes + **vol recorded to 1 dp**;

Concentration of glucose/ mol dm^{-3}	Vol. of glucose solution/ cm^3	Vol. of distilled water/ cm^3
1.0	10.0	0.0
0.8	8.0	2.0

0.6	6.0	4.0
0.4	4.0	6.0
0.2	2.0	8.0

- Add stated volume (not exceeding 3 cm^3) of methylene blue solution to stated volume (equal or more) of glucose solution;
- Ensure yeast suspension is stirred before adding to glucose solution to (scientific reasoning) ensure that yeast is well suspended/ not at the bottom of beaker;
- Add stated volume of yeast (equal volume/ more than glucose) to mixture;

Total volume should not exceed 15 cm3.

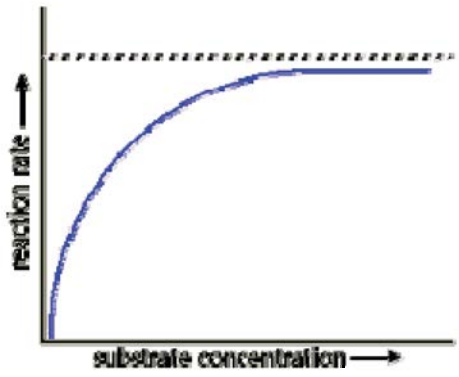
- Stir with a glass rod to (scientific reasoning) mix well;
- Pour mixture into cuvette provided and place cuvette into colorimeter (set to 550 nm);
- Start the stopwatch immediately and stop when absorbance reading on meter reaches 15 a.u.
- Record the time taken in a suitable table;
- Repeat experiment for the rest of the glucose solution;
- Rinse cuvette with distilled water and dry in between each measurement;
- Perform **2 replicates** for each glucose solution to ensure **accuracy**;
- **Repeat** the experiment **twice** to ensure **reproducibility**;

Results and Graph (2 m: 1m table; 1 m graph)

Concentration of glucose/ mol dm^{-3}	Time taken for methylene blue to decolorize/ s				Rate of respiration/ s^{-1}
	Time 1	Time 2	Time 3	Average	
1.0					
0.8					
0.6					
0.4					
0.2					

- Table with appropriate headings and units;

Graph



- Graph with appropriate axes:

X-axis: concentration of glucose/ mold m-3
Y-axis: rate of respiration/ s-1

- Correct shape of graph sketched

Safety considerations:

- (*Precaution*) Dry your hands before switching the colorimeter on or off to (*risk*) avoid

	being electrocuted. • (*risk*) Methylene blue solution can be harmful / a skin irritant. (*Precaution*) Wear glove and goggles;	