



# RIVER VALLEY HIGH SCHOOL

## YEAR 6

### PRELIMINARY EXAMINATION

CANDIDATE  
NAME

CENTRE  
NUMBER

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CLASS

INDEX  
NUMBER

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**H2 BIOLOGY**

**9744/01**

Paper 1 Multiple Choice

**19 Sep 2018**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

#### READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

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

Write your name, Centre number, index number on the Answer Sheet in the spaces provided unless this has been done for you.

**DO NOT WRITE IN ANY BARCODES.**

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.

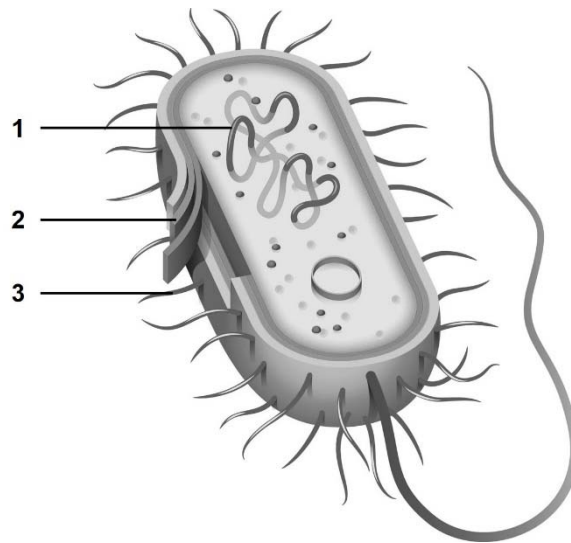
**Read the instructions on the Answer Sheet very carefully.**

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

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

This Question Paper consists of **23** printed pages and **1** blank page.

- 1 The diagram shows a typical unicellular prokaryote.

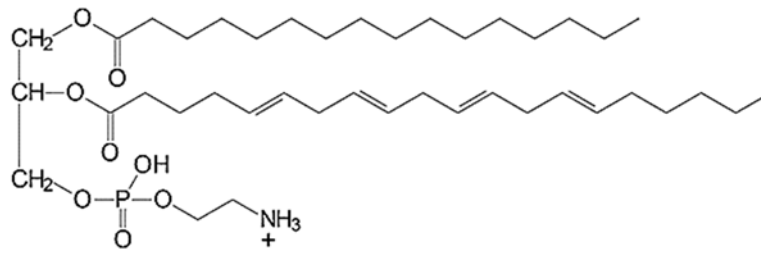


Which row correctly describes the labelled structures?

	1	2	3
<b>A</b>	chromatin	cell surface membrane	pilus
<b>B</b>	chromosome	cell wall	flagellum
<b>C</b>	chromosome	cell wall	pilus
<b>D</b>	plasmid	cell surface membrane	flagellum

- 2 Which of the following correctly describes the process of exocytosis?
- 1 The secretory vesicle diffuses from the *trans* face of the Golgi apparatus towards the cell surface membrane.
  - 2 Secretory vesicles tend to contain small molecules that cannot pass through the hydrophobic core of the membrane.
  - 3 The membrane of the secretory vesicle fuses with the cell surface membrane, releasing the molecules into the extracellular fluid.
- A** 3 only
- B** 1 and 3 only
- C** 1 and 2 only
- D** All of the above

- 3 The structure of phosphatidylcholine, a common membrane phospholipid, is shown.



Which combination correctly describes the synthesis, structure and property of one molecule of phosphatidylcholine?

	number of water molecules eliminated during synthesis	number of ester bonds	property
<b>A</b>	3	3	amphipathic
<b>B</b>	2	2	amphipathic
<b>C</b>	2	2	amphoteric
<b>D</b>	3	3	amphoteric

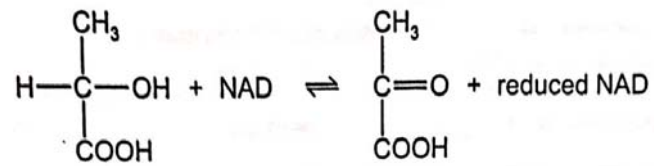
- 4 The following statements describe the four levels of organisation of the structure of haemoglobin.

How many of the following statement(s) is true?

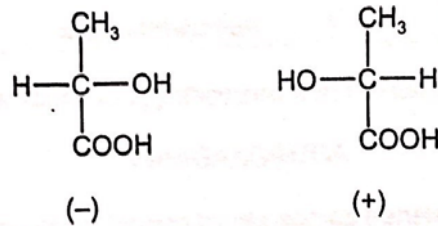
- 1 In primary structure,  $\alpha$  and  $\beta$  subunits consist of any number of amino acids joined in a specific sequence by peptide bonds.
- 2 In secondary structure, the  $\alpha$ -helices in each subunit are a result of hydrogen bonding between C=O and N-H groups of regions of the polypeptide backbone that are far apart.
- 3 In tertiary structure, R group interactions between amino acids allow hydrophilic amino acids to be clustered in the interior of the protein.
- 4 In quaternary structure, R group interactions between amino acids of different subunits allow for the molecule to exhibit cooperative binding.

- A** 1  
**B** 2  
**C** 3  
**D** 4

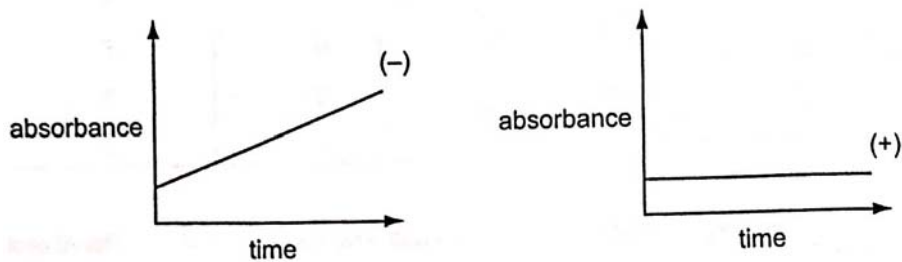
- 5 Lactic dehydrogenase catalyses the conversion of lactic acid to pyruvic acid as shown in the following equation.



Two isomers of lactic acid, (-) and (+), are shown below.



Reduced NAD absorbs ultraviolet light but NAD does not. The activity of bacterial lactic dehydrogenases on the two different isomers of lactic acid was compared. The absorbance of ultraviolet light was measured using an ultraviolet spectrophotometer. The graphs show the results.



What can be concluded about bacterial lactic acid dehydrogenases?

- A The enzyme is specific to the (-) isomer.
- B The enzyme is specific to the (+) isomer.
- C Both isomers fit the active site.
- D Neither isomer fit the active site.

- 6 Both bacterium *Streptococcus salivarius* and fungus *Aspergillus niger* produce enzymes which digest complex sugars. The enzyme produced by *A. niger* has a higher molecular weight and is encoded by a different gene.

How can these enzymes digest the same complex sugars in the same way?

- A Both enzymes have the same primary structures.
  - B Both enzymes have the same tertiary structures.
  - C The enzyme-substrate complexes formed by both enzymes are identical.
  - D The amino acids forming the active site are the same in both enzymes.
- 7 Blood transfusion laboratories around the world are hoping to produce large numbers of red blood cells (RBCs) from 'spare' human embryos produced during *in vitro* fertilisation procedures.

Embryonic stem cells are removed from an embryo and cultured in a growth medium that stimulates their differentiation into RBCs.

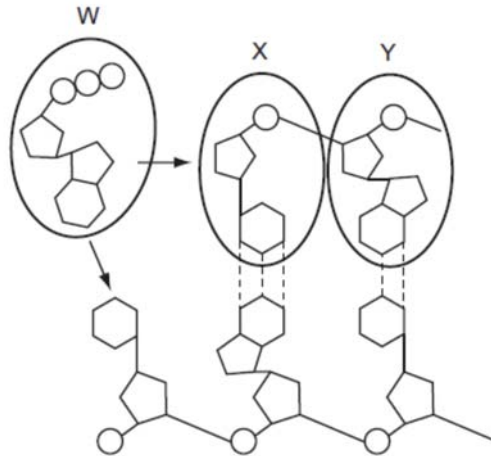
Which statement correctly describes this differentiation?

- A Multipotent embryonic stem cells differentiate into pluripotent blood stem cells and then into RBCs.
  - B Pluripotent embryonic stem cells differentiate into multipotent blood stem cells and then into RBCs.
  - C Totipotent embryonic stem cells differentiate into multipotent blood stem cells and then into RBCs.
  - D Totipotent embryonic stem cells differentiate into pluripotent blood stem cells and then into RBCs.
- 8 An unknown organism has a linear double-stranded DNA genome like that in a eukaryote. When its DNA replication was examined, it was revealed that although the process is semi-conservative, no Okazaki fragments were observed in the multiple replication forks. In addition, the end-replication problem of shortened daughter strands was not observed.

Which statement correctly explains this phenomenon?

- A The organism's DNA is antiparallel.
- B DNA replication only starts at the 3' end of each template strand.
- C DNA polymerases synthesise DNA in both 5' to 3' and 3' to 5' direction.
- D DNA ligases are not involved in the DNA replication process.

- 9 The diagram shows the synthesis of a polynucleotide. **W** is a nucleoside triphosphate and the arrows indicate the location where **W** form bonds with the polynucleotide.



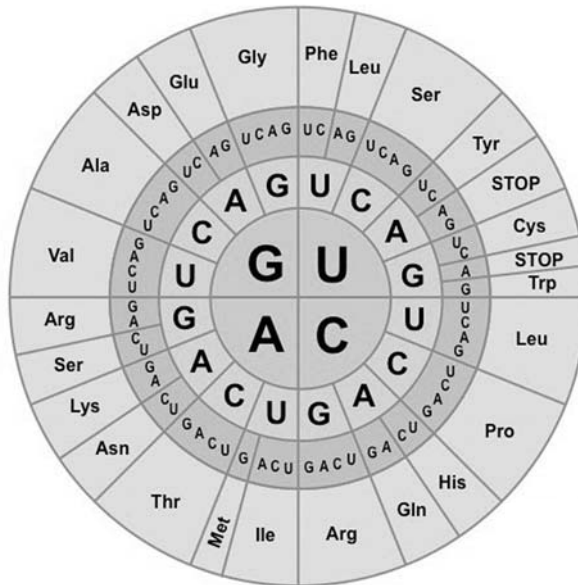
Which statements are correct?

- 1 The base in **W** could be the purine, adenine.
  - 2 The base in **Y** is the purine guanine.
  - 3 The base in **X** is the pyrimidine, cytosine
  - 4 The base in **X** could be the pyrimidine, uracil
- A** 1 and 3  
**B** 2 and 3  
**C** 2 and 4  
**D** All of the above

- 10 A segment of a polypeptide chain, Arg – Gly – Leu – Phe – Val – Leu – Arg, is encoded by the following segment of DNA:

strand 1 3' G G C A T T C T G C T T A T C T G G G G A 5'  
 | | | | | | | | | | | | | | | | | | | | | |  
 strand 2 5' C C G T A A G A C G A A T A G A C C C C T 3'

The genetic code (read from inside out) is given below.

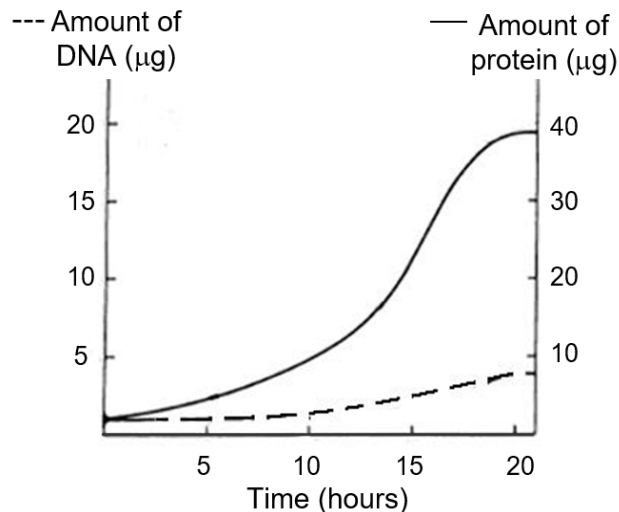


Which of the following correctly identifies the template strand and mRNA codon?

	template strand	mRNA codon coding for amino acid Leu
<b>A</b>	strand 1	UUA
<b>B</b>	strand 1	AUU
<b>C</b>	strand 2	AUC
<b>D</b>	strand 2	CUA

- 11 Which of the following are features of a eukaryotic genome?
- 1 multiple genes are under the control of the same regulatory sequence
  - 2 many genes are interrupted by non-coding sequences
  - 3 presence of multiple control elements for controlling gene expression
  - 4 supercoiling in most regions to further compact the DNA molecule
- A 1 and 4  
 B 1 and 3  
 C 2 and 3  
 D 2 and 4

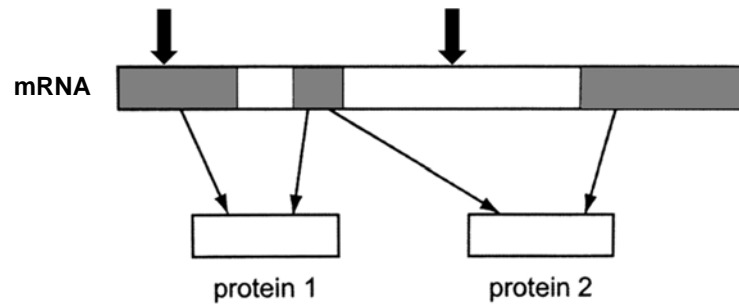
- 12 The following graph shows the average amount of DNA and eggshell proteins present in germ cells of *Drosophila* flies that are actively producing eggs.



Which of the following could explain the graph?

- A The activity of eukaryotic initiation factor has increased, increasing the rate of transcription.
- B Gene amplification has occurred, increasing the number of genes coding for eggshell proteins.
- C DNA replication has occurred during meiosis, increasing the DNA templates available for transcription.
- D Crossing over has occurred, translocating the genes coding for eggshell proteins to be under the control of an active promoter.

- 13 The diagram shows alternative splicing, in which the same mRNA can be translated to give two different proteins.



If a base-pair addition occurred at the DNA corresponding to the two sites indicated by arrows, what is the likely result on proteins 1 and 2?

	protein 1	protein 2
<b>A</b>	functional	functional
<b>B</b>	functional	non-functional
<b>C</b>	non-functional	functional
<b>D</b>	non-functional	non-functional

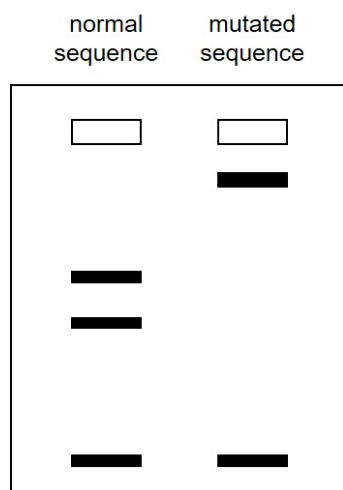
- 14 The following shows a target sequence of interest.

5' CGA GCT TTT ATA GAT TAT AGG CCT AAC AGA CTA 3'  
 3' GCT CGA AAA TAT CTA ATA TCC GGA TTG TCT GAT 5'

The sequence can be digested by two different restriction enzymes. The sequences recognised by the restriction enzymes and points of action (indicated by \*) are shown.

<i>AluI</i>	5' ... A G * C T ... 3'
	3' ... T C * G A ... 5'
<i>HaeIII</i>	5' ... G G * C C ... 3'
	3' ... C C * G G ... 5'

A sample of the target sequence was digested with both restriction enzymes. The restriction fragments were then subject to gel electrophoresis. The same procedure was performed for a mutated target sequence.



Which of the following shows the mutation in the mutated target sequence?

	restriction site	type of mutation
<b>A</b>	<i>AluI</i>	base-pair substitution
<b>B</b>	<i>AluI</i>	inversion of restriction sequence
<b>C</b>	<i>HaeIII</i>	base-pair substitution
<b>D</b>	<i>HaeIII</i>	inversion of restriction sequence

- 15** Yeast cells without a *cdc25* gene cannot divide. This gene is active throughout the cell cycle, steadily building up the concentration of a protein, p80cdc25. This protein activates a kinase which regulates other proteins involved in cell division, but does not seem to affect other cell processes. When the p80cdc25 protein reaches a critical concentration, mitosis starts.

Which changes will be seen if p80cdc25 is produced at a faster rate than usual?

- 1 faster cell cycle
- 2 slower cell cycle
- 3 smaller cells
- 4 larger cells

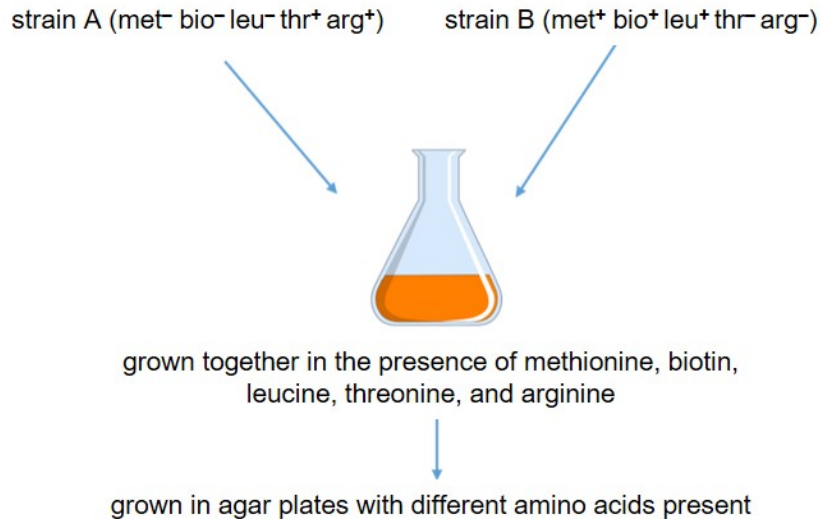
- A** 1 and 3  
**B** 1 and 4  
**C** 2 and 3  
**D** 2 and 4

- 16** In 2009, the H1N1 influenza outbreak caused nearly 15 000 deaths worldwide. The highly virulent virus was formed by antigenic shift.

Which of the following is most likely to have resulted in antigenic shift?

- A** Chance mutations occurring in a strain of influenza, giving rise to novel haemagglutinin proteins.  
**B** Recombination of viral genes within a host cell during infection.  
**C** Simultaneous infection of a cell by two or more strains of influenza.  
**D** High error rate in influenza RNA-dependent RNA polymerase resulting in new strains upon viral reproduction.

- 17 In order for bacteria to survive and replicate, they need essential amino acids including methionine (met), biotin (bio), leucine (leu), threonine (thr) and arginine (arg). Bacteria either have the genes required for the synthesis of the amino acid (indicated by “+”) or do not have the genes (indicated by “-”), thus have to take up the amino acids from the culture medium. The figure below shows an investigation to study gene transfer between two strains of bacteria.



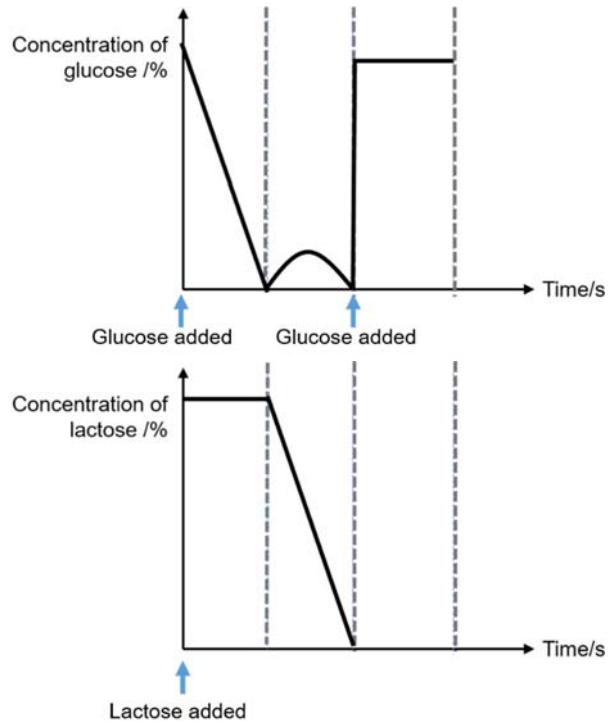
The results of the investigation are summarised in the table below.

amino acid present in agar plate					presence of bacteria colonies
methionine	biotin	leucine	threonine	arginine	
X	✓	✓	✓	✓	yes
X	X	✓	✓	✓	yes
X	✓	X	X	✓	yes
X	X	X	✓	✓	yes
X	✓	✓	✓	X	yes
X	X	X	X	X	yes

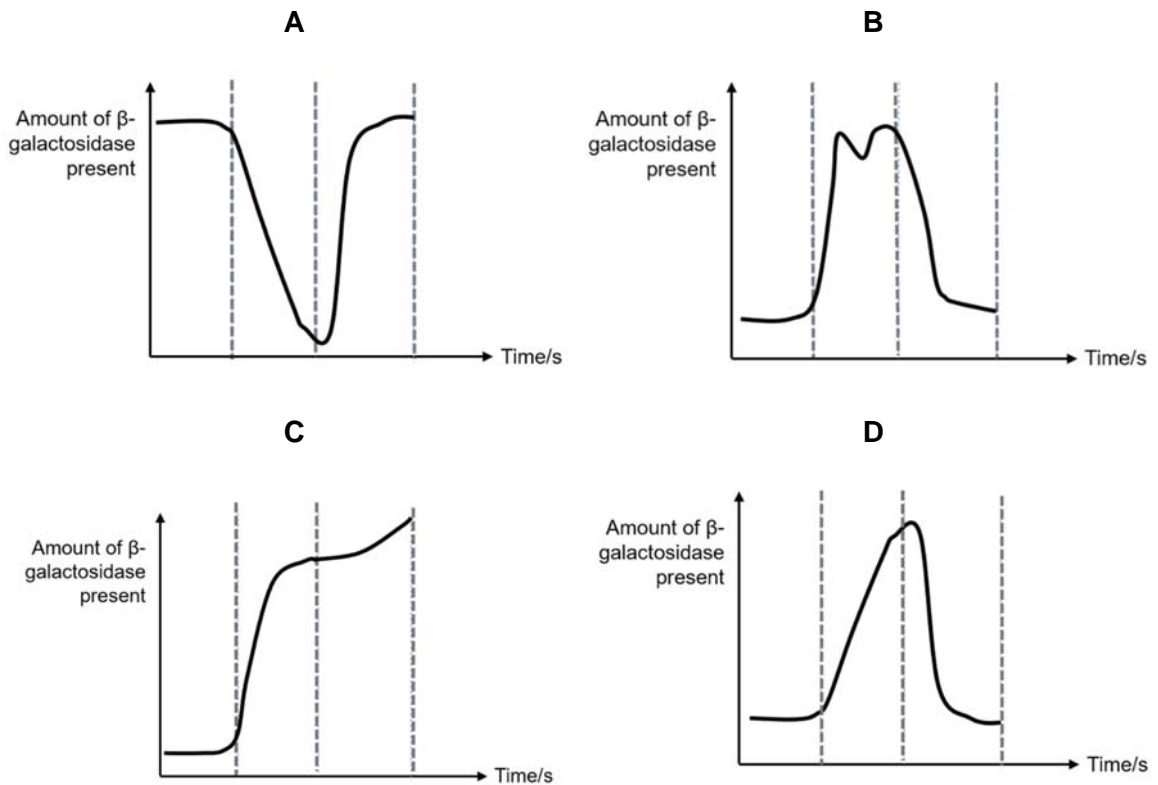
Which of the following process(es) could explain the above results?

- 1 Conjugation
  - 2 Transduction
  - 3 Transformation
- A** 3 only
- B** 1 and 2
- C** 1 and 3
- D** 1, 2 and 3

- 18 *Escherichia coli* are able to metabolise both glucose and lactose for their energy requirement. In an experiment, researchers added glucose and lactose into the *E. coli* culture at different time points and measured the  $\beta$ -galactosidase, glucose and lactose levels at regular time intervals. The arrows in the diagram indicate the addition of the respective metabolite into the culture.



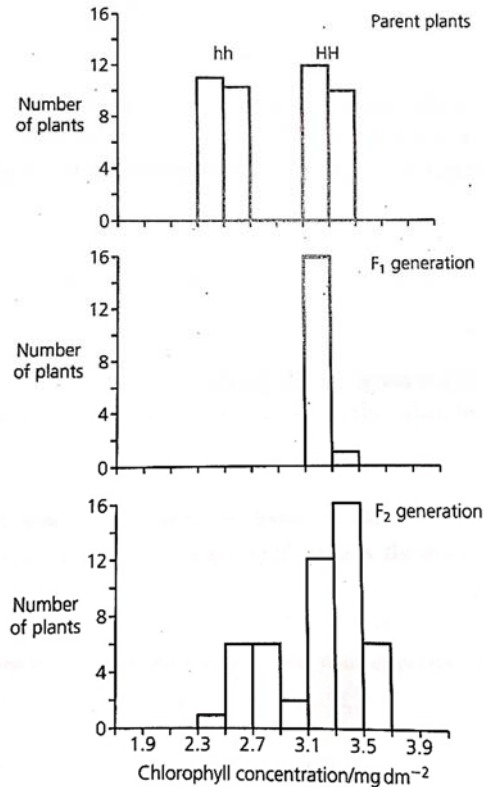
Which graph correctly shows the corresponding amount of  $\beta$ -galactosidase present in the culture?



- 19 In wheat, the flag-leaf is the last leaf to be produced. The concentration of chlorophyll in the flag-leaf is controlled by a single gene. The allele for high chlorophyll concentration, **H**, is dominant to that for low chlorophyll concentration, **h**.

Pure breeding wheat with genotypes **HH** and **hh** were crossed to produce an F<sub>1</sub> generation. The plants were then interbred to produce an F<sub>2</sub> generation.

The chlorophyll concentration of flag-leaves in each generation were analysed and the results are shown below.



A student made four deductions based on information presented above.

- 1 Chlorophyll concentration in plants exhibits discontinuous variation as it is controlled by a single pair of alleles.
- 2 The large number of plants with high chlorophyll concentration in the F<sub>1</sub> generation shows that the allele **H** is the dominant allele.
- 3 The genotype for the 16 F<sub>1</sub> plants is all **HH** as they have the same chlorophyll concentration as parent plants with **HH** genotype.
- 4 The chlorophyll concentration in plants is affected by sunlight availability.

How many of the above statements are supported by the results?

- A** 0  
**B** 1  
**C** 2  
**D** 3

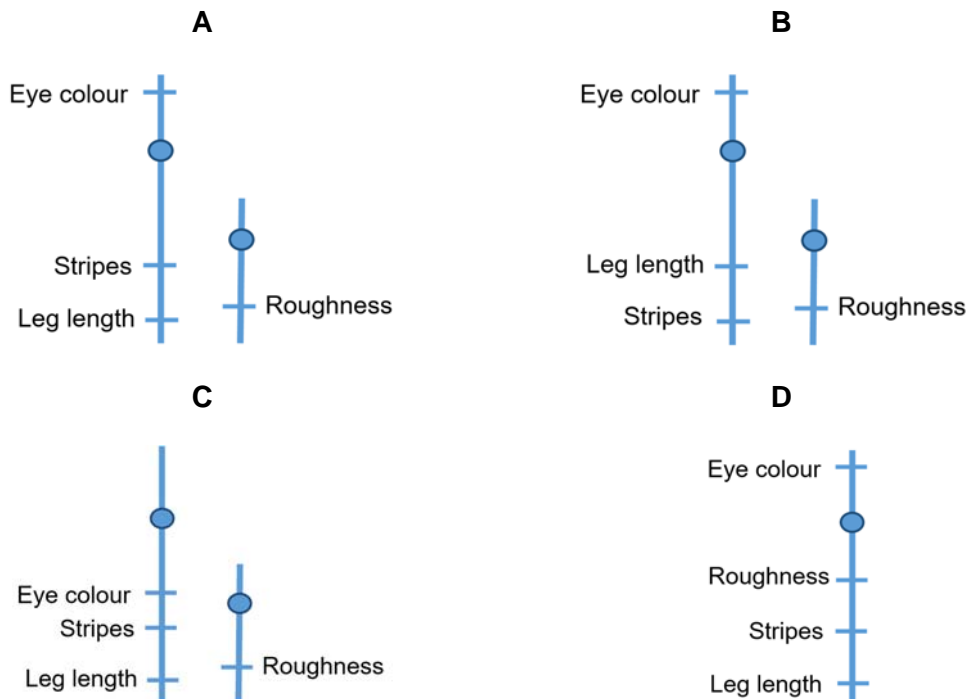
20 Length of legs, stripes on body, eye colour and roughness of body of *Drosophila* were investigated to determine the linkage of genes controlling these characteristics.

Pure-breeding parents were crossed to produce heterozygous F1. Subsequently, a test cross was conducted on the F1 *Drosophila* to determine the relative distance between different pairs of genes.

The results of the test crosses are summarised in the table below.

parent		offspring			
F1 individual	test cross individual				
long legs, striped body	short leg, plain body	130 long legs, striped body	122 short legs, plain body	24 short legs, striped body	24 long legs, plain body
long legs, red eye	short legs, white eye	79 long legs, red eye	82 short legs, white eye	55 long legs, white eye	50 short legs, red eye
striped, rough body	plain, smooth body	77 striped, rough body	71 plain, smooth body	75 striped, smooth body	71 plain, rough body
striped body, red eye	plain body, white eye	113 plain body, white eye	112 striped body, red eye	31 striped body, white eye	36 plain body, red eye

Which of the following correctly shows the relative position of the four genes controlling the investigated characteristics?



- 21 In a species of mammal, the inheritance of skin colour is controlled by three pairs of alleles, **A/a**, **B/b** and **C/c**, which are inherited independently.

Alleles **A**, **B** and **C** code for the production of roughly the same degree of pigmentation. If skin colour is proportional to the sum of the dominant alleles present, how many classes of skin colour would be expected from a mating between two individuals that are heterozygous at all three loci?

- A 3
- B 6
- C 7
- D 9
- 22 A yellow seed, green-stemmed plant with the genotype **YYrr** was crossed with a white seed, red-stemmed plant with the genotype **yyRR**. The F1 plants were allowed to self-fertilise. A chi-squared test was carried out on the results obtained for the F2 generation.

Part of the table of chi-squared values is shown.

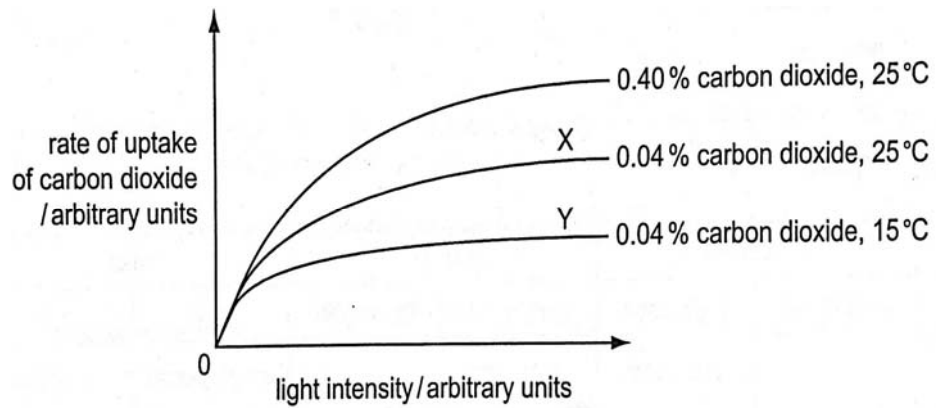
degrees of freedom	p = 0.5	p = 0.1	p = 0.05	p = 0.01	p = 0.001
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.6	5.99	9.21	13.82
3	2.37	6.25	7.82	11.34	16.27
4	3.37	7.78	9.49	13.28	18.46
5	4.35	9.24	11.07	15.09	20.52

The chi-squared value in this investigation is 10.6.

What is the p-value and does the results fit the expected ratio?

	p-value	results fit expected ratio
<b>A</b>	between 0.01 and 0.05	no
<b>B</b>	between 0.01 and 0.05	yes
<b>C</b>	between 0.05 and 0.1	yes
<b>D</b>	between 0.1 and 0.5	no

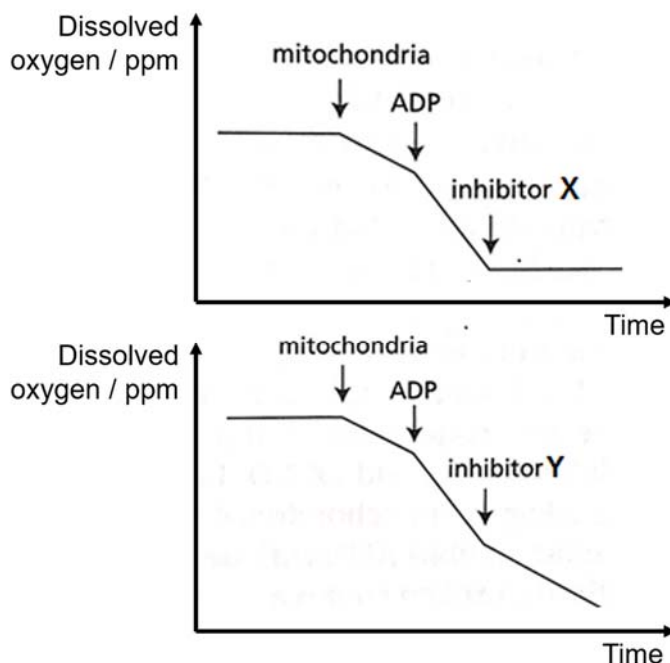
- 23 The graph shows the rate of uptake of carbon dioxide by a photosynthetic plant in different conditions.



Based on the graph, which processes limit the rate of uptake of carbon dioxide?

	X	Y
<b>A</b>	light dependent reaction	light dependent reaction
<b>B</b>	light dependent reaction	light independent reaction
<b>C</b>	light independent reaction	light dependent reaction
<b>D</b>	light independent reaction	light independent reaction

- 24 In an investigation analysing mitochondria function, different inhibitors were introduced and the change in dissolved oxygen levels were recorded. In all the experiments, mitochondria was added to a buffer solution containing respiratory substrates. After a short interval, ADP was added, followed by inhibitor X or Y.

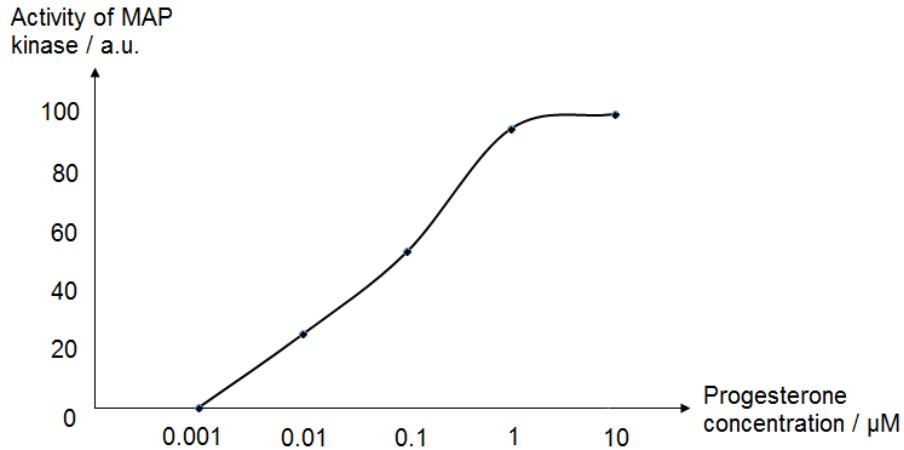


Which of the following correctly explains how the addition of ADP, inhibitor X and inhibitor Y affect the levels of dissolved oxygen?

	ADP	inhibitor X	inhibitor Y
<b>A</b>	Increase substrate concentration of ATP synthase	Increase inner mitochondria membrane permeability	End product inhibition of ATP synthase
<b>B</b>	Increase substrate concentration of ATP synthase	Increase inner mitochondria membrane permeability	Inhibits cytochrome complex of electron transport chain
<b>C</b>	Increase substrate concentration of ATP synthase	Inhibits cytochrome complex of electron transport chain	Inhibits ATP synthase
<b>D</b>	End product inhibition of ATP synthase	Inhibits ATP synthase	Inhibits cytochrome complex of electron transport chain

- 25** Maturation of frog oocytes (fertilised eggs) results from a series of cell signalling events triggered by the hormone progesterone. Progesterone directly stimulates the translation of mRNA encoding Mos, a protein that sets off a downstream signalling cascade. This cascade leads to the activation of an enzyme called MAP kinase. MAP kinase directly stimulates oocyte maturation.

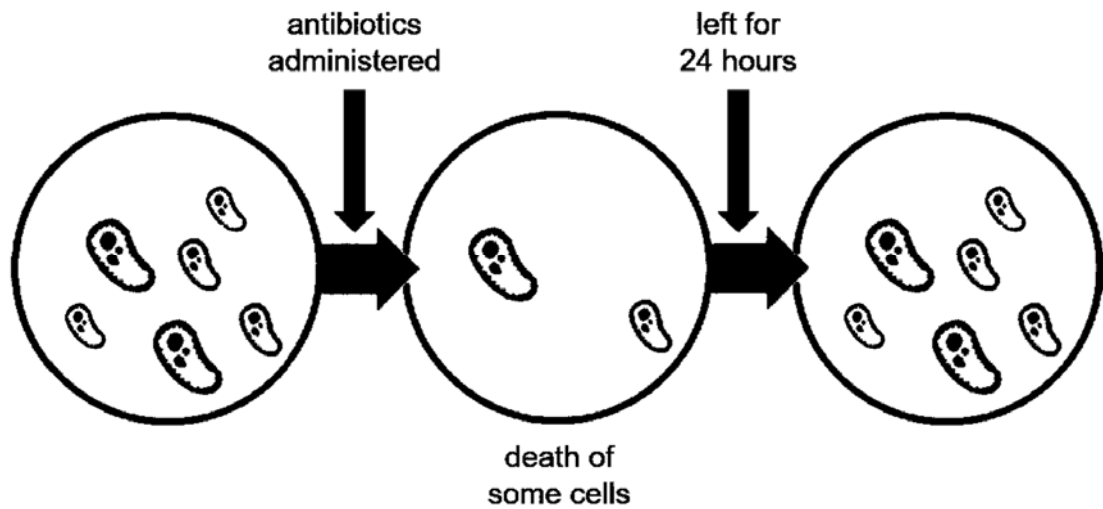
In an investigation, 16 frog oocytes were treated with six different concentrations of progesterone. The activity of MAP kinase was measured by the proportion of oocytes that have matured. The results are shown in the graph.



Which of the following cannot be concluded from the information above?

- 1 Progesterone is a lipid-soluble hormone.
  - 2 55 oocytes would have matured in the set-up with 0.1  $\mu\text{M}$  progesterone.
  - 3 The maturation of frog oocytes is activated by phosphorylation.
  - 4 The rate of oocyte maturation is highest at 0.5  $\mu\text{M}$  progesterone.
  - 5 Mos is a second messenger.
  - 6 Signal transduction for maturation of frog oocyte is multistep.
- A** 2 and 4 only
- B** 1, 3 and 6 only
- C** 2, 4 and 5 only
- D** 3, 5 and 6 only

26 The diagram shows the administration of antibiotics to a culture of different bacteria strains.



Which of the following can be observed?

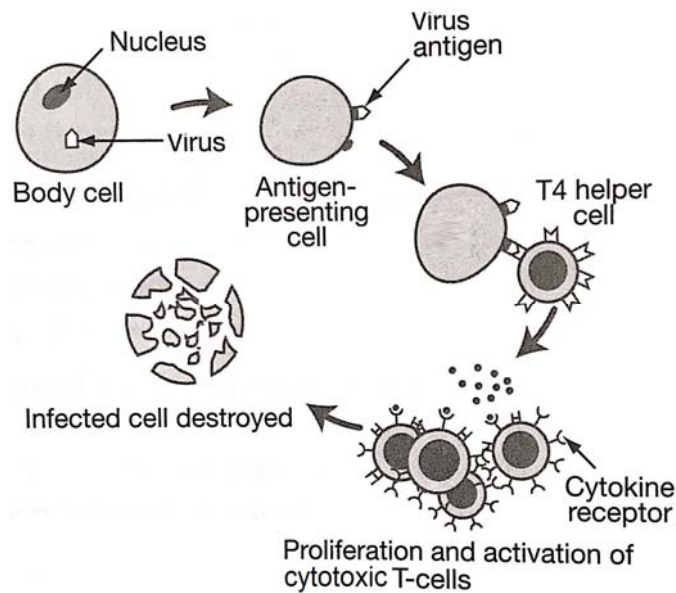
- 1 sympatric speciation
  - 2 antibiotics resulting in a bottleneck event
  - 3 convergent evolution as the strain develops antibiotic resistance
  - 4 variation as the raw material for natural selection
- A** 1 only
- B** 2 only
- C** 1 and 3 only
- D** 2 and 4 only

- 27** Recent DNA studies have examined the skeletal remains of Europeans buried during the plagues of the Roman Empire, the Middle Ages, the seventeenth and eighteenth centuries and in modern times. These plague outbreaks varied in their symptoms and severity. Despite these differences, the studies suggest that these plagues were all caused by the bacterium *Yersinia pestis*.

Which statement does **not** describe a feature that could contribute to the evolution of *Y. pestis* through natural selection?

- A** Bacteria from the various strains of *Y. pestis* have different genotypes which could account for the changes in the symptoms and severity of the disease over the centuries.
- B** Bacteria within each strain of *Y. pestis* have the same DNA sequence but, depending on their interaction with the human host, can cause different symptoms with a variety of consequences.
- C** Changes in the genome of *Y. pestis* over the centuries may be associated with changes in its environment, including the changing genetic characteristics of human hosts.
- D** Two DNA sequences that significantly increase the severity of the disease have been found in plasmids that replicate independently of the rest of the bacterial DNA.

- 28 The following diagram shows cell-mediated immunity.



Which of the following correctly describes the events in this cell-mediated immunity?

- 1 Foreign antigen is displayed on the surface of the body cell via major histocompatibility complex II.
  - 2 Displayed virus antigens are targets for cytotoxic T cells.
  - 3 T4 helper cells have a receptor to identify presented antigen.
  - 4 The antigen stimulates the cytotoxic T cells to produce antibodies.
- A** 1 and 2 only
- B** 2 and 3 only
- C** 1, 2 and 3 only
- D** All of the above
- 29 The first step in producing anti-venoms for snake bites is to inject a horse with a small amount of the particular snake venom. The anti-venom is then isolated from the blood of the horse.
- Why are anti-venoms effective against snake poison?
- A** They contain molecules that will bind with the poison.
  - B** They cause specific T cells to bind with infected cells.
  - C** They cause specific B cells to bind with infected cells.
  - D** They give immunological memory so that there will be faster future response.

- 30** In the Indian state of Odisha, the incidence of dengue in the first half of 2018 has tripled compared to the whole of 2017. Officials have attributed the severe spike in cases to the prolonged monsoon season leading to intermittent heavy rainfall in the first half of the year. The dengue virus is transmitted by the *Aedes aegypti* mosquito.

Which of the following are possible explanations for the spike in dengue cases?

- 1 Persistent rainfall resulted in increased number of breeding habitats for the mosquito.
  - 2 Persistent rainfall led to dried out mosquito eggs being rehydrated and hatching.
  - 3 Decrease in temperature in Odisha results in shorter life cycle of mosquitoes.
  - 4 Insufficient proportion of citizens are vaccinated against the dengue virus, resulting in a lack of herd immunity.
- A** 1 and 2 only
- B** 3 and 4 only
- C** 1, 2 and 3 only
- D** All of the above

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**Y6 2018 Prelim P1 Solution**

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



# RIVER VALLEY HIGH SCHOOL

## YEAR 6

### PRELIMINARY EXAMINATION

CANDIDATE  
NAME

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CLASS

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NUMBER

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**H2 BIOLOGY**

**9744/02**

Paper 2 Structured Questions

**10 Sep 2018**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

#### READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

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

DO **NOT** WRITE IN ANY BARCODES.

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

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

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

At the end of the examination, fasten all your work together.

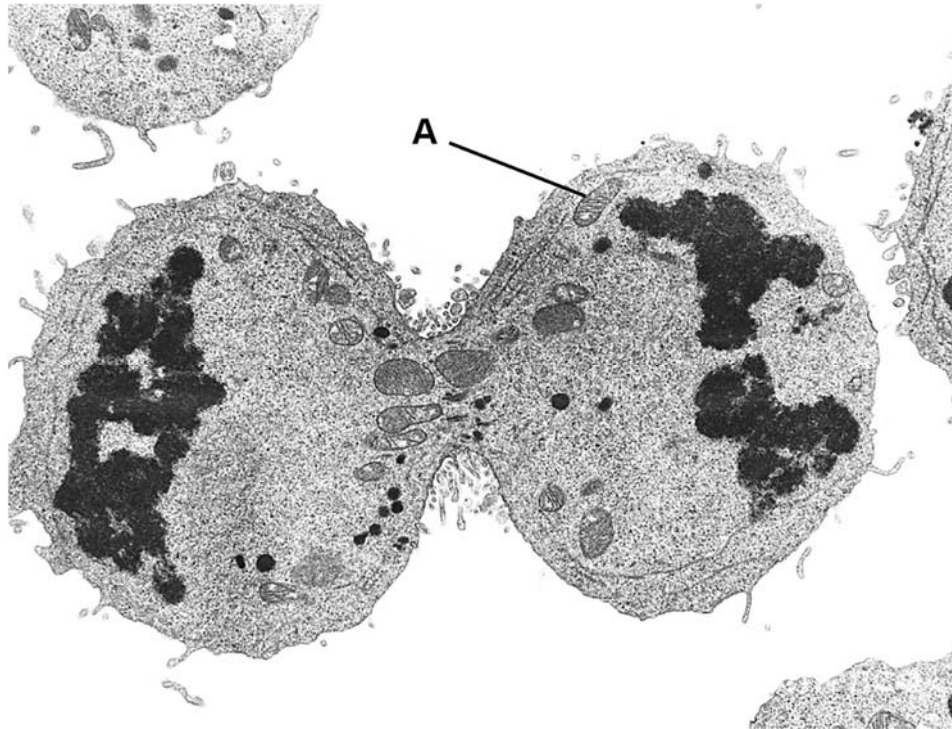
The number of marks is given in brackets [ ] at the end of each question or part question.

<b>For Examiner's Use</b>	
<b>1</b>	<b>/ 6</b>
<b>2</b>	<b>/ 11</b>
<b>3</b>	<b>/ 12</b>
<b>4</b>	<b>/ 8</b>
<b>5</b>	<b>/ 12</b>
<b>6</b>	<b>/ 10</b>
<b>7</b>	<b>/ 10</b>
<b>8</b>	<b>/ 11</b>
<b>9</b>	<b>/ 10</b>
<b>10</b>	<b>/ 5</b>
<b>11</b>	<b>/ 5</b>
<b>Total</b>	<b>/ 100</b>

This document consists of **24** printed pages.

Answer **all** questions.

- 1 Fig.1.1 shows a cell undergoing telophase and process **X** simultaneously.



**Fig. 1.1**

*Source: David M. Phillips, 2014*

- (a) Name structure **A**.

[1]

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- (b) Name process **X** and explain how it supports the cell theory.

[2]

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(c) Outline the role of **A** and explain its significance to process **X**. [3]

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[Total: 6]

- 2 (a) Explain how the structure of fatty acids allow triglycerides to be a good store of energy. [2]

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Fig. 2.1 shows the structure of a lipoprotein. Lipoproteins transport fats from the liver to other tissues via the bloodstream. The proteins of lipoproteins play an important role in the deposition of fats to the correct tissue.

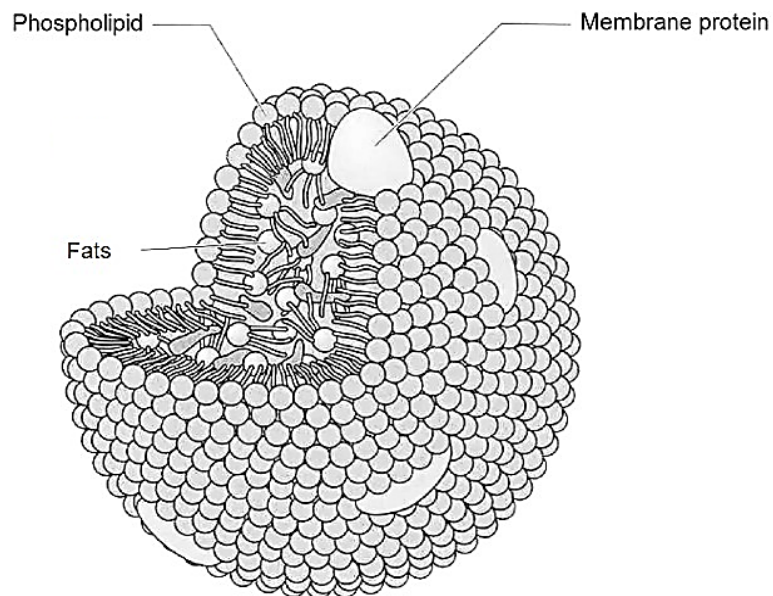


Fig. 2.1

- (b) Describe how lipoproteins allow for the transport of fats from the liver to a specific tissue via blood. [4]

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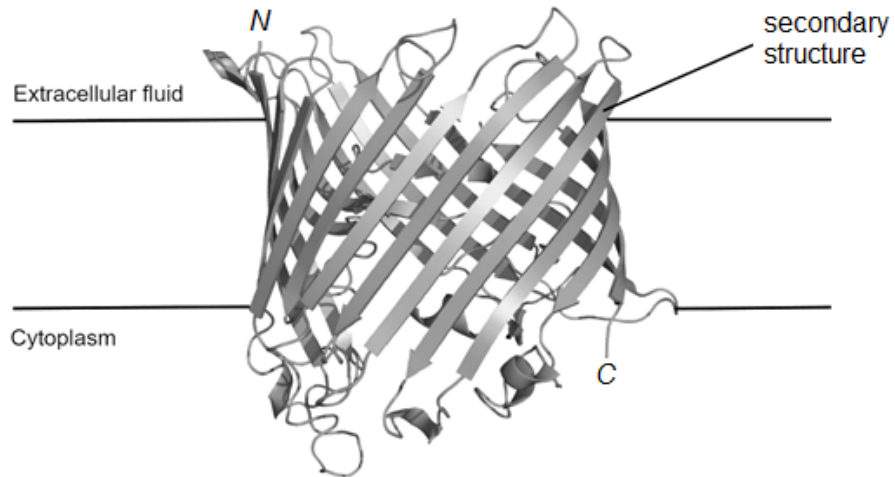


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Fig. 2.2 shows a protein embedded in a phospholipid bilayer.



**Fig. 2.2**

Source: Adapted from RCSB Protein Data Bank

(c) With reference to Fig. 2.2,

(i) name the secondary structure and describe the bonding involved, and [3]

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(ii) describe how the structure of haemoglobin differs from that of the protein in Fig. 2.2. [2]

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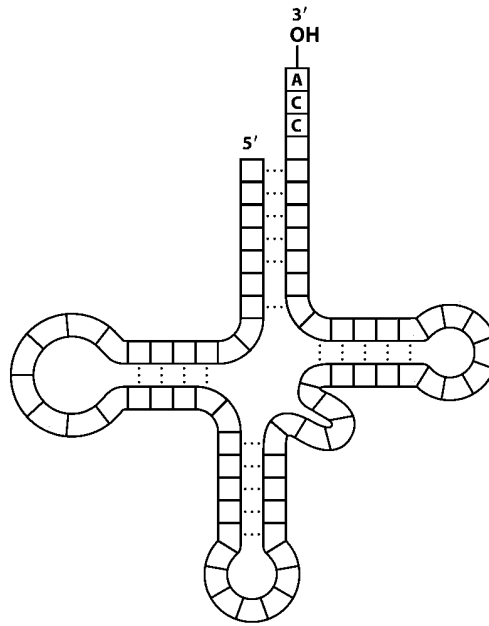
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[Total: 11]

- 3 Fig. 3.1 shows the structure of a tRNA.



Source: *Biochem, Seventh edition, 2012*

**Fig. 3.1**

- (a) Describe how the structure of tRNA allows for its role in translation. [4]

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Synthetic RNA, which binds to bacterial mRNA, could interfere with translation. Fig. 3.2 shows the sequences of a bacterial mRNA and two different synthetic RNA.

Bacterial mRNA

5'- GUCAACCAUGCCAAUUAUCACGGACAUUCAUGGUAGGCCUUAGUAGACAACUG-3'

Synthetic RNA 1

5'- CAGUUGUCUA-3'

Synthetic RNA 2

5'- CUAGGUUGAC-3'

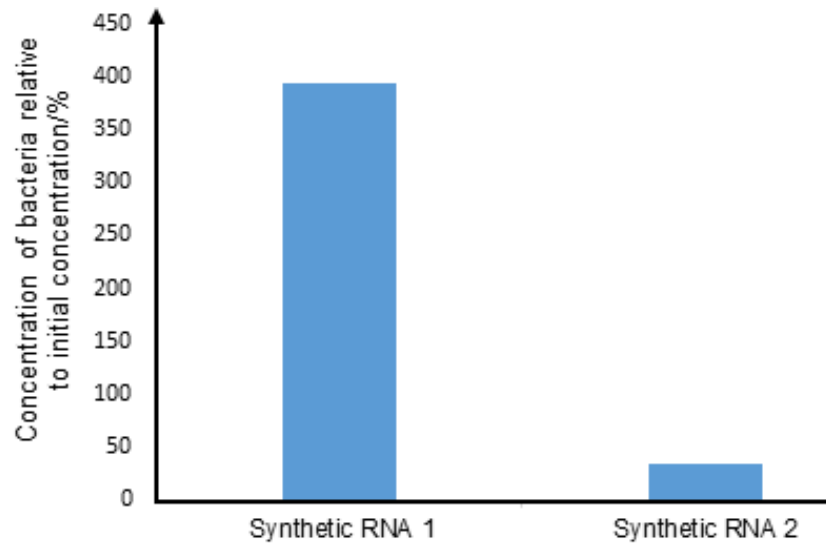
**Fig. 3.2**

**(b)** With reference to Fig. 3.2, suggest how synthetic RNA binds to mRNA. [1]

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The effectiveness of synthetic RNA 1 and 2 are investigated by introducing them to separate bacterial cultures and incubating for 24 hours. The results of the investigation is shown in Fig. 3.3.



**Fig. 3.3**

- (c) With reference to Fig. 3.2 and Fig. 3.3, explain the results of the investigation. [6]

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- (d) Suggest a limitation of using synthetic RNA as an oral antibiotic for bacterial infections in humans. [1]

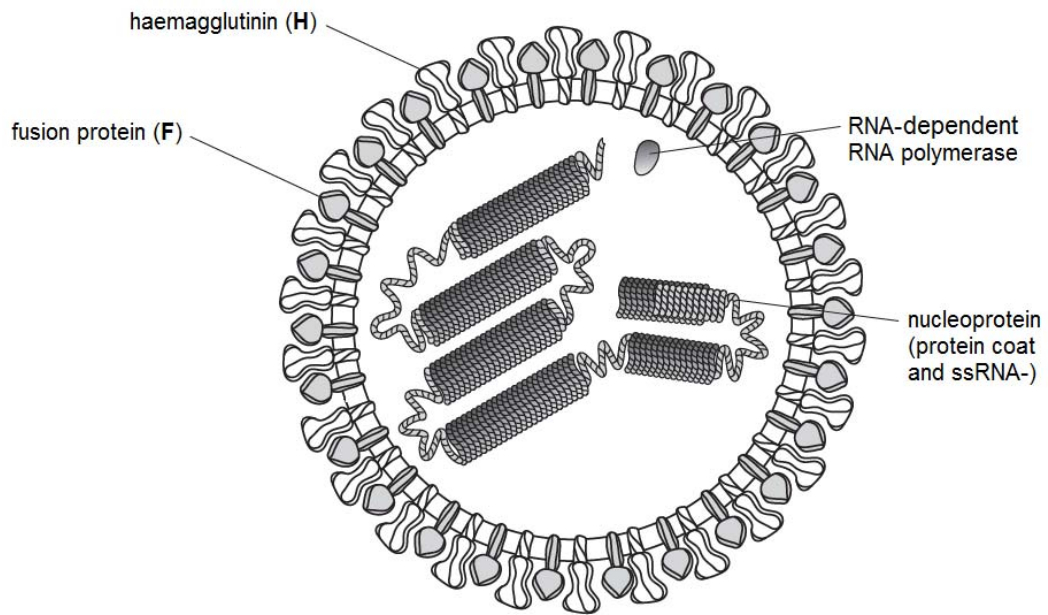
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[Total: 12]

- 4 *Morbillivirus*, which causes measles, has a structure as shown in Fig. 4.1.



**Fig. 4.1**

Source: UCLES, 2016

*Morbillivirus* only infects cells that have a membrane glycoprotein known as signaling lymphocyte activation protein (SLAM). When *Morbillivirus* infects a cell, **H** acts before **F**.

- (a) State how the structure of *Morbillivirus* envelope is similar to that of human immunodeficiency virus (HIV). [2]

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**(b)** *Morbillivirus* and HIV utilise a similar mechanism to enter host cells.

Describe how *Morbillivirus* enters a host cell.

[3]

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**(c)** Describe how the *Morbillivirus* genome enables the *Morbillivirus* reproductive cycle.

[3]

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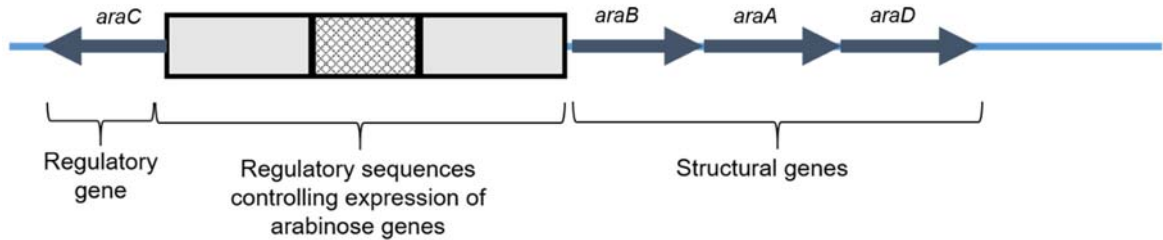
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[Total: 8]

- 5 The *ara* operon is an inducible operon involved in the breakdown of a pentose sugar, arabinose. The organisation of the *ara* operon differs from that of a *lac* operon. Fig. 5.1 shows the organisation of the *ara* operon in a bacterium.

The *ara* operon encodes three structural genes (*araB*, *araA* and *araD*) and is regulated by the regulatory gene *araC*. The arrows in Fig 5.1 represent the directions of transcription of the respective genes.



**Fig. 5.1**

- (a) Using the *ara* operon, explain what is meant by the term operon. [2]

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- (b) Suggest why the transcription of the structural genes (*araB*, *araA* and *araD*) proceeds in a different direction from the regulatory gene (*araC*). [2]

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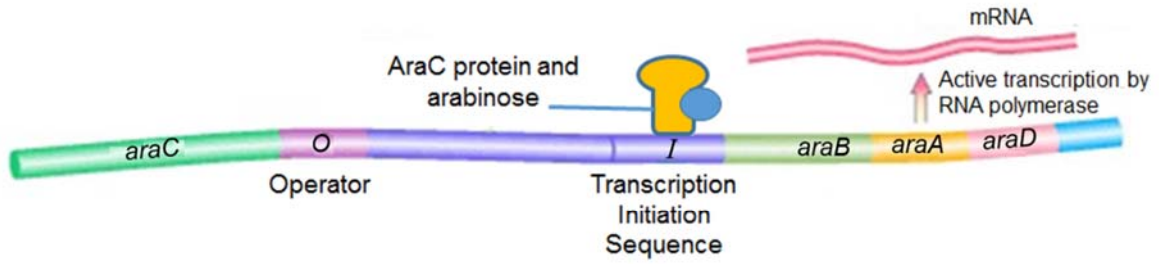
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Fig. 5.2 shows how araC protein interact with arabinose and the regulatory sequences to regulate the expression of the structural genes of the *ara* operon.

In the presence of arabinose:



In the absence of arabinose:



**Fig. 5.2**

- (c) With reference to Fig. 5.2, describe how transcription of the *ara* operon is inhibited. [3]

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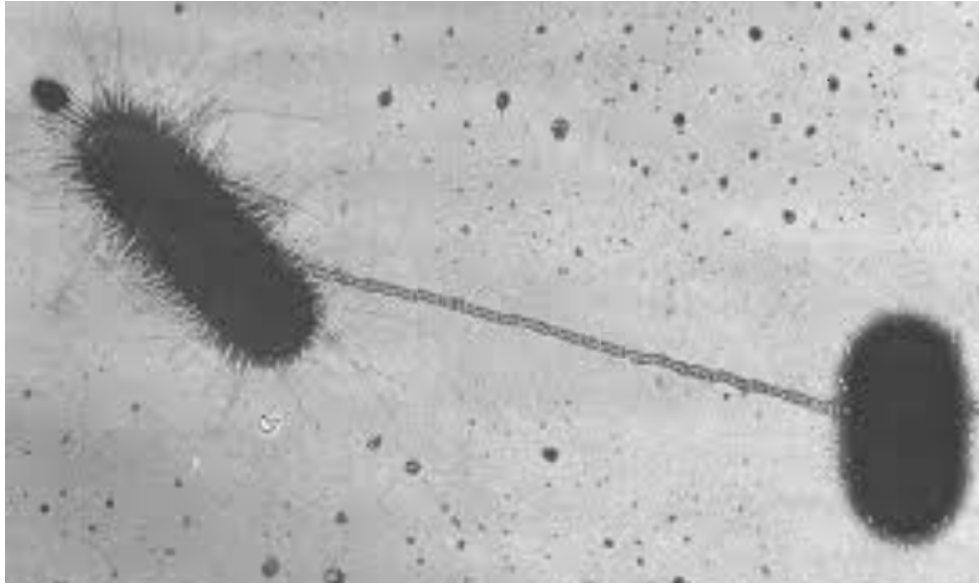


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Plasmids can be transferred from one bacterium to another via the process shown in Fig. 5.3.



**Fig. 5.3**

*Source: Appl. Environ. Microbiol. October 2016 vol. 82 no. 19 5940-5950*

**(d)** With reference to Fig. 5.3,

**(i)** state the process, and

[1]

**(ii)** describe the main features of the process.

[4]

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[Total: 12]

- 6 A germline cell is undergoing meiosis to produce gametes. Fig. 6.1 shows a stage in this process.

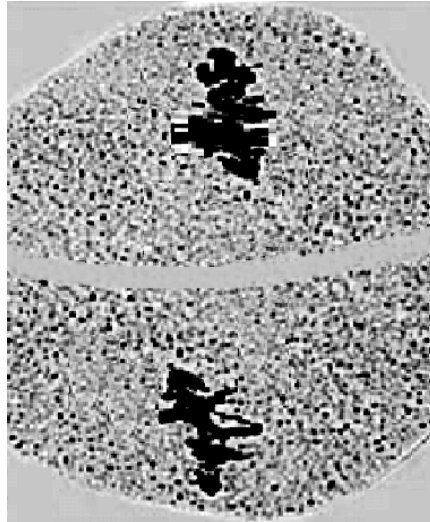


Fig. 6.1

- (a) (i) Identify the stage of meiosis shown in Fig. 6.1 [1]

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- (ii) Explain your answer in (a)(i). [2]

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- (b) Describe the role of centrioles in the next stage of meiosis. [3]

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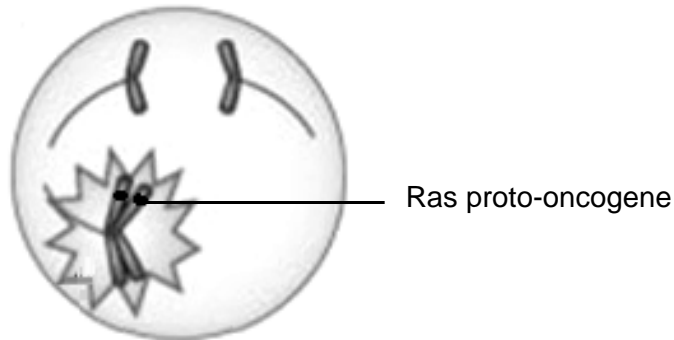


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Fig. 6.2 shows an error in anaphase II.



**Fig. 6.2**

- (c)** Explain why this error may increase the risk of cancer in a newborn. [3]

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- (d)** Kinase inhibitors are often used to target such cancers associated with Ras proto-oncogenes by interrupting their downstream signalling. Suggest how kinase inhibitors can interrupt Ras signalling pathway. [1]

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[Total: 10]

7 (a) Distinguish between polygenic inheritance and multiple allele inheritance. [3]

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In humans, an individual's blood group is a combination of the ABO system and the Rhesus (Rh) system. The ABO system divides blood into four types: A, B, AB and O. The Rh system divides blood type into negative (–) or positive (+). The genes for ABO blood type and Rh blood type are inherited independently.

As part of family planning, Claudia, with blood group O<sup>–</sup> consulted a genetic counsellor who charted the inheritance of Rh blood type in the family, shown in Fig. 7.1.

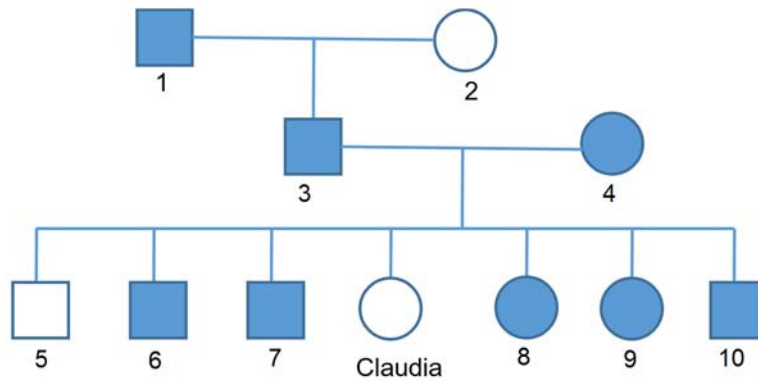


Fig. 7.1

(b) With reference to Fig. 7.1, explain why the two claims below are correct.

Claim 1: The Rh<sup>+</sup> phenotype is expressed in heterozygotes.

Claim 2: The Rh gene is not found on sex chromosomes. [3]

Claim 1:

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Claim 2:

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Claudia is married to a man whose blood group is AB<sup>+</sup>. Their first child has blood group A<sup>-</sup>. She is expecting a second child.

- (c) Using the symbols I<sup>A</sup>, I<sup>B</sup> and I<sup>O</sup> to represent the alleles of the ABO blood type and the symbols Rh<sup>+</sup> and Rh<sup>-</sup> to represent the alleles of the Rh blood type, draw a genetic diagram to show all the possible phenotypes of her second child.

[4]

[Total: 10]

- 8 Fig. 8.1 shows the absorption spectrum ( — ) of a photosynthetic pigment from a plant, and the rate of photosynthesis ( - - - ) of the same plant in different colours of light.

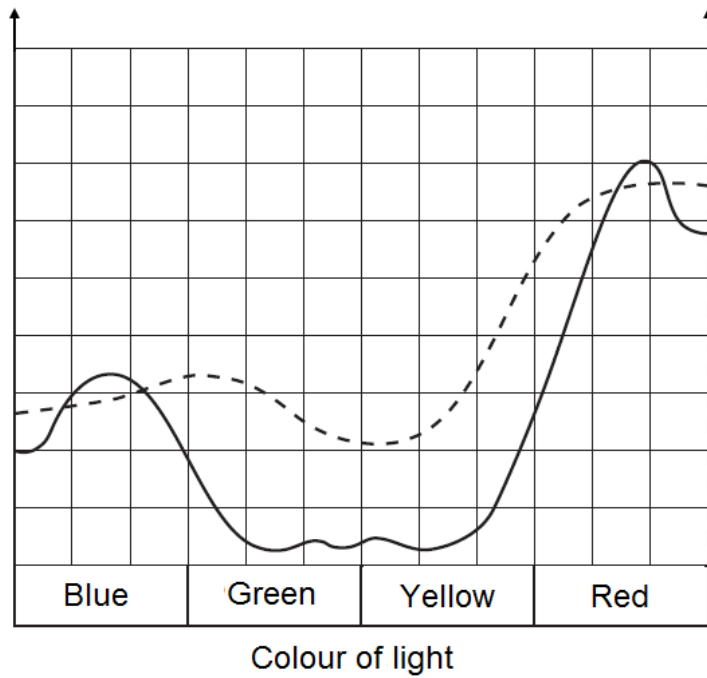


Fig. 8.1

- (a) Explain what is meant by an absorption spectrum. [2]

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- (b) State whether this plant contains more than one type of photosynthetic pigment. Explain your answer. [2]

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- (c) Plants typically have several photosynthetic pigments, some of which function as accessory pigments.

Suggest the role of accessory pigments in photophosphorylation.

[1]

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In a separate experiment to study photophosphorylation in plants, chloroplasts are isolated, and the pH levels in various compartments are monitored.

The table below shows the results of this experiment.

**Table 8.1**

environmental condition	pH	
	stroma	thylakoid lumen
dark	7.2	6.8
light	8.8	5.2

- (d) Describe and explain the changes in pH as environmental conditions change from dark to light.

[6]

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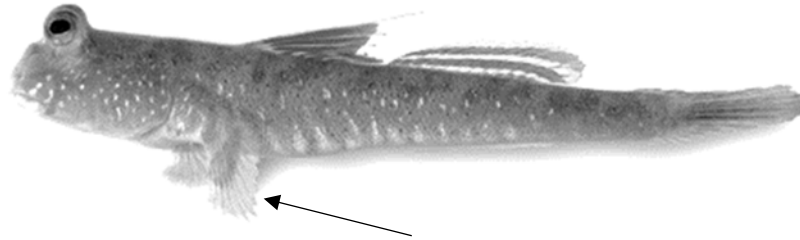


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[Total: 11]

- 9 Mudskippers are fish which have evolved to use their modified pectoral fins to move onto land to avoid being eaten by larger oceanic fish.

Fig. 9.1 shows a mudskipper. The arrow indicates the modified pectoral fin.



**Fig. 9.1**

*Adapted from: <http://www.mudskipper.it/ita/SpeciesPages/noveIT.html>*

- (a) Explain how mudskippers evolved from their fully aquatic ancestors to have modified pectoral fins. [4]

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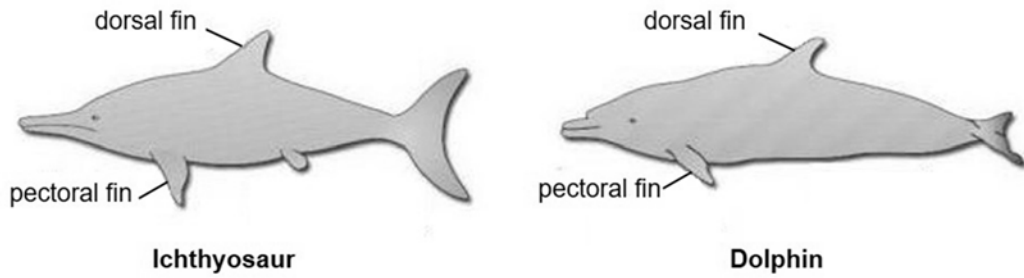
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Fig. 9.2 shows the body plan of Ichthyosaurs, which are extinct marine reptiles, and dolphins, which are mammals. Both types of animals can swim quickly to catch prey.



**Fig. 9.2**

**(b) (i)** State the type of evolution shown by Ichthyosaurs and dolphins. [1]

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**(ii)** Explain your answer in **(b)(i)**. [2]

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There are more than 40 species of dolphins known to scientists. To determine the evolutionary relationships between the different species, scientists are gathering genomic data to construct a phylogenetic tree.

**(c)** Describe the advantages of using molecular methods in constructing a phylogenetic tree. [3]

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[Total: 10]

- 10 (a) Describe how *Mycobacterium tuberculosis* is transmitted. [2]

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- (b) (i) Penicillin is often used to treat bacterial infections due to its ability to interfere with bacterial cell wall synthesis.  
Describe the mode of action of penicillin. [2]

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- (ii) Suggest why penicillin is ineffective against *M. tuberculosis*. [1]

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[Total: 5]

- 11 Arctic foxes in Iceland hunt for prey such as lemmings, which are rodent-like animals. Due to global warming, there were milder and shorter winters from 2000 to 2006. This led to the melting of and collapse of snow burrows inhabited by the lemmings.

Fig. 11.1 shows the populations of arctic foxes and lemmings between 2000 and 2008.

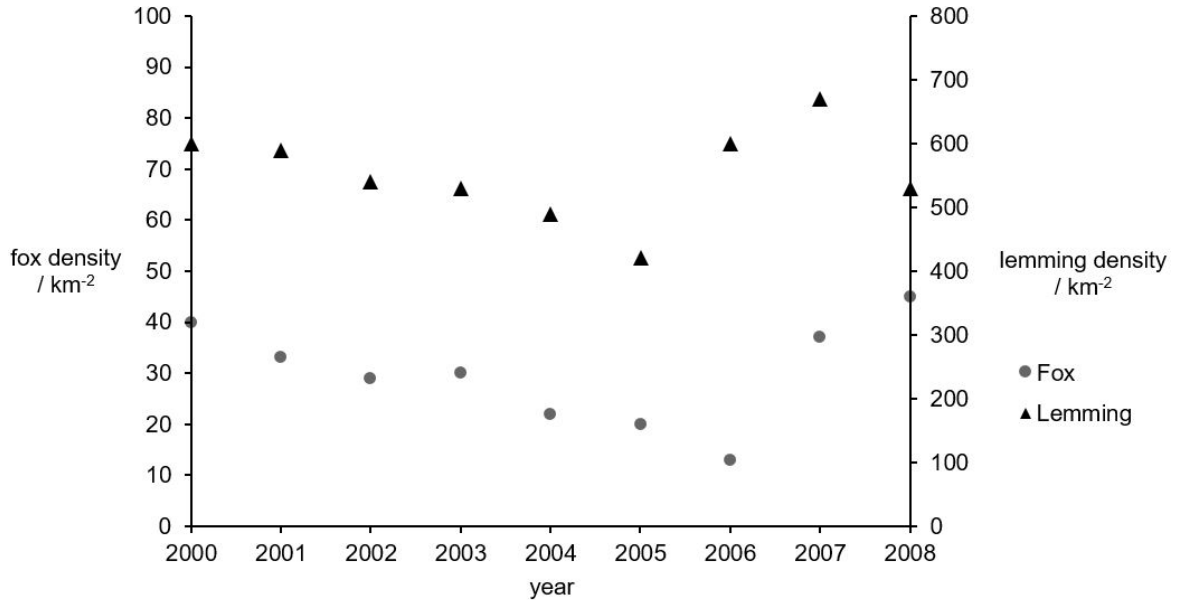


Fig. 11.1

- (a) Explain how the melting of snow may lead to further warming of the island. [1]

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- (b) With reference to Fig. 11.1,

- (i) describe the change in fox density, [2]

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- (ii) explain why the density of lemmings increased from 2005 to 2006, and [1]

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- (iii) suggest why arctic fox population density would not increase indefinitely beyond 2008. [1]

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[Total: 5]



# RIVER VALLEY HIGH SCHOOL

## YEAR 6

### PRELIMINARY EXAMINATION

CANDIDATE  
NAME

CENTRE  
NUMBER

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CLASS

INDEX  
NUMBER

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**H2 BIOLOGY**

**9744/02**

Paper 2 Structured Questions

**10 Sep 2018**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

#### READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

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

DO **NOT** WRITE IN ANY BARCODES.

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

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

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

At the end of the examination, fasten all your work together.

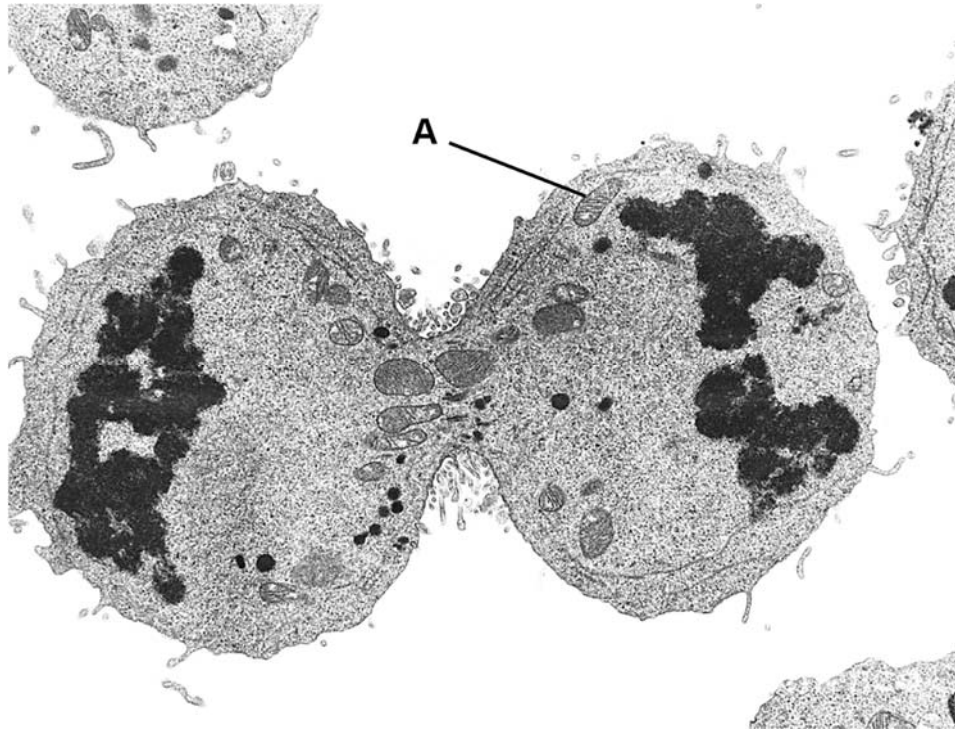
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 6
2	/ 11
3	/ 12
4	/ 8
5	/ 12
6	/ 10
7	/ 10
8	/ 11
9	/ 10
10	/ 5
11	/ 5
<b>Total</b>	<b>/ 100</b>

This document consists of **24** printed pages.

Answer **all** questions.

- 1 Fig.1.1 shows a cell undergoing telophase and process **X** simultaneously.



**Fig. 1.1**

*Source: David M. Phillips, 2014*

- (a) Name structure **A**. [1]  
**mitochondrion**
- (b) Name process **X** and explain how it supports the cell theory. [2]  
**1. Cytokinesis**  
**2. The process shows that all cells come from pre-existing cells**

(c) Outline the role of **A** and explain its significance to process **X**. [3]

1. (Site of) ATP synthesis;
2. during aerobic respiration
3. Provide energy
4. to form contractile ring of filaments
5. to form cleavage furrow
6. so as to separate the cell (into two)

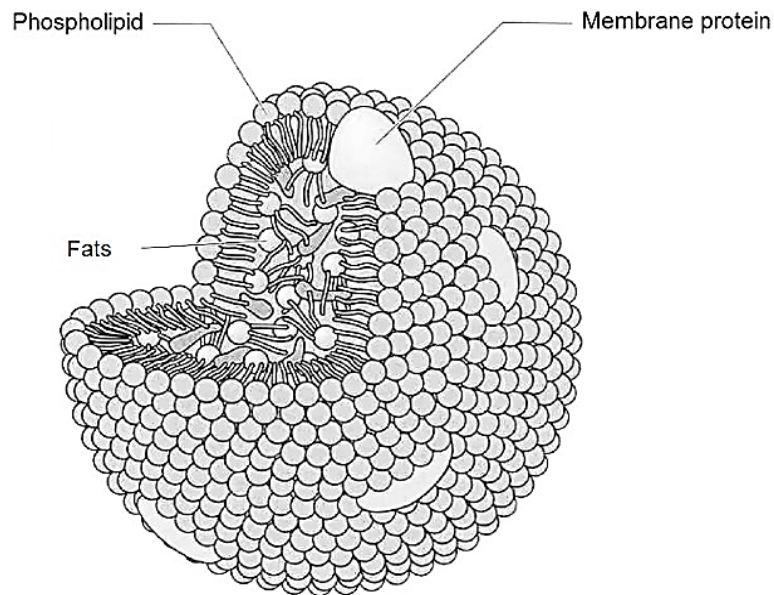
[Total: 6]

- 2 (a) Explain how the structure of fatty acids allow triglycerides to be a good store of energy. [2]

**Fatty acids makes triglycerides**

1. (S) non-polar/uncharged/large/long hydrocarbon chain
2. (F) can be stored (in large amounts) without having any significant effect on the water potential of a cell
3. (S) have large number of hydrogen atoms
4. (F) store large amounts of energy

Fig. 2.1 shows the structure of a lipoprotein. Lipoproteins transport fats from the liver to other tissues via the bloodstream. The proteins of lipoproteins play an important role in the deposition of fats to the correct tissue.

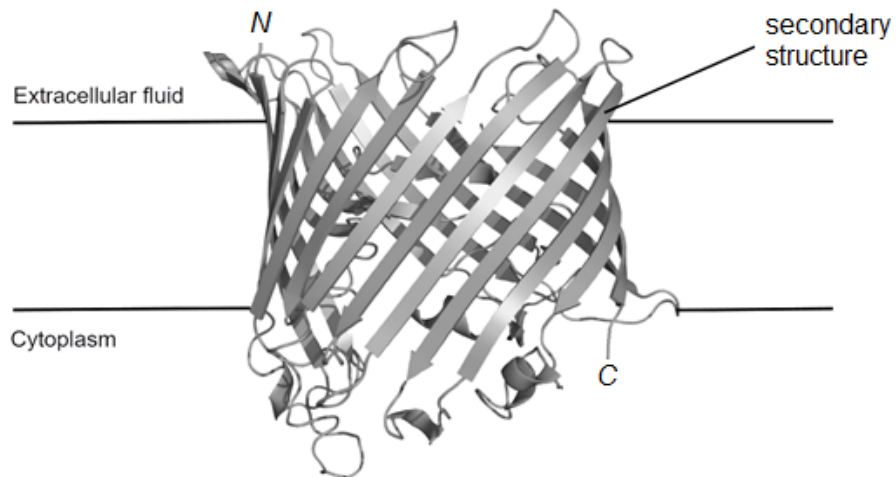


**Fig. 2.1**

**(b)** Describe how lipoproteins allow for the transport of fats from the liver to a specific tissue via blood. [4]

1. **Phospholipid molecules form a single layer**
2. **Non polar / hydrophobic hydrocarbon tail interact with (non polar / hydrophobic) fats**
3. **Polar / hydrophilic phosphate head interact with the (aqueous) blood**
4. **Membrane protein binds to cell of target tissue**
5. **via complementary shape**

Fig. 2.2 shows a protein embedded in a phospholipid bilayer.



**Fig. 2.2**

*Source: Adapted from RCSB Protein Data Bank*

(c) With reference to Fig. 2.2,

(i) name the secondary structure and describe the bonding involved, and [3]

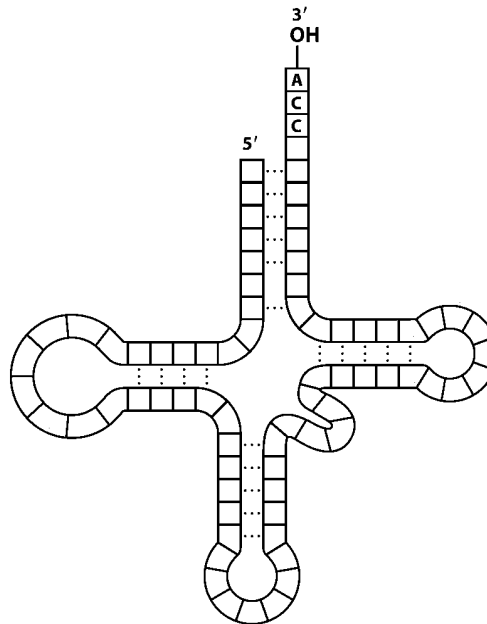
1.  **$\beta$ -pleated sheet**
2. **held in place by hydrogen bonds**
3. **between (O atom of) C=O and (H atom of) N-H groups**
4. **at regular intervals**
5. **of polypeptide chain parallel to each other**

- (ii) describe how the structure of haemoglobin differs from that of the protein in Fig. 2.2. [2]

	Haemoglobin	Protein in Fig 2.2
Level of protein structure	Quaternary	Tertiary
Secondary structure	Largely $\alpha$ -helices	Largely $\beta$ -pleated
Amino acids arrangement	Hydrophilic amino acids on the surface of protein.	Both hydrophobic and hydrophilic amino acids on the surface of protein
Haem group	Presence of haem group	No haem group

[Total: 11]

- 3 Fig. 3.1 shows the structure of a tRNA.



Source: *Biochem, Seventh edition, 2012*

**Fig. 3.1**

(a) Describe how the structure of tRNA allows for its role in translation. [4]

1. 3' CCA end of tRNA
2. Serve as attachment site of a specific amino acid
3. Contains anticodon at one end
4. Specifies the identity of amino acid attached to (the 3' CCA end of the) tRNA
5. (Sequence of bases of) anticodon able to complementary base pair
6. With the corresponding mRNA codon
7. (T) loop
8. binds to rRNA of ribosome (via base-pairing)
9. (D) loop
10. for binding to amino-acyl tRNA synthetase (that attaches tRNA with its specific amino acid)
11. tRNA folds into a clover-leaf shape (2-D structure)/L-shape (3-D structure)
12. to reduce steric hindrance

Synthetic RNA, which binds to bacterial mRNA, could interfere with translation. Fig. 3.2 shows the sequences of a bacterial mRNA and two different synthetic RNA.

Bacterial mRNA

5'- GUCAACCAUGCCAAUUAUCACGGACAUAUCAUGGUAGGCCUAGUAGACAACUG-3'



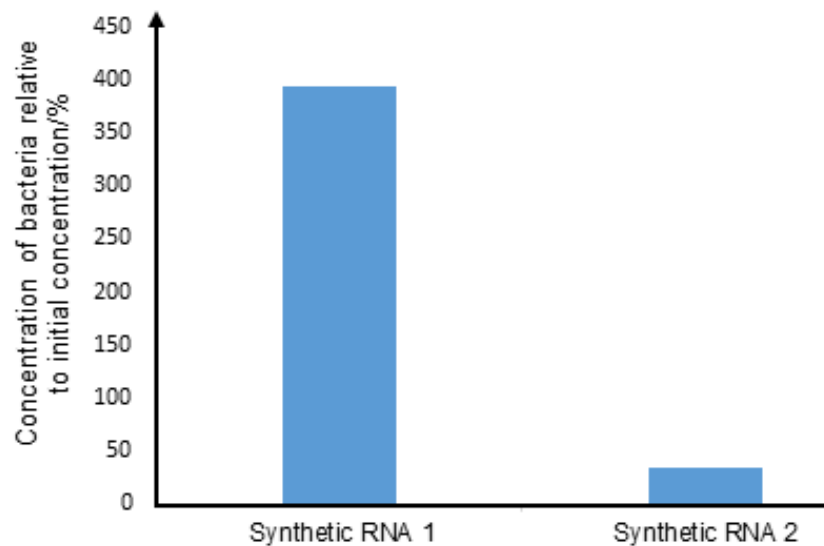
**Fig. 3.2**

(b) With reference to Fig. 3.2, suggest how synthetic RNA binds to mRNA. [1]

**Synthetic RNA and mRNA**

1. forms hydrogen bonds
2. between complementary base-pair

The effectiveness of synthetic RNA 1 and 2 are investigated by introducing them to separate bacterial cultures and incubating for 24 hours. The results of the investigation is shown in Fig. 3.3.



**Fig. 3.3**

(c) With reference to Fig. 3.2 and Fig. 3.3, explain the results of the investigation. [6]

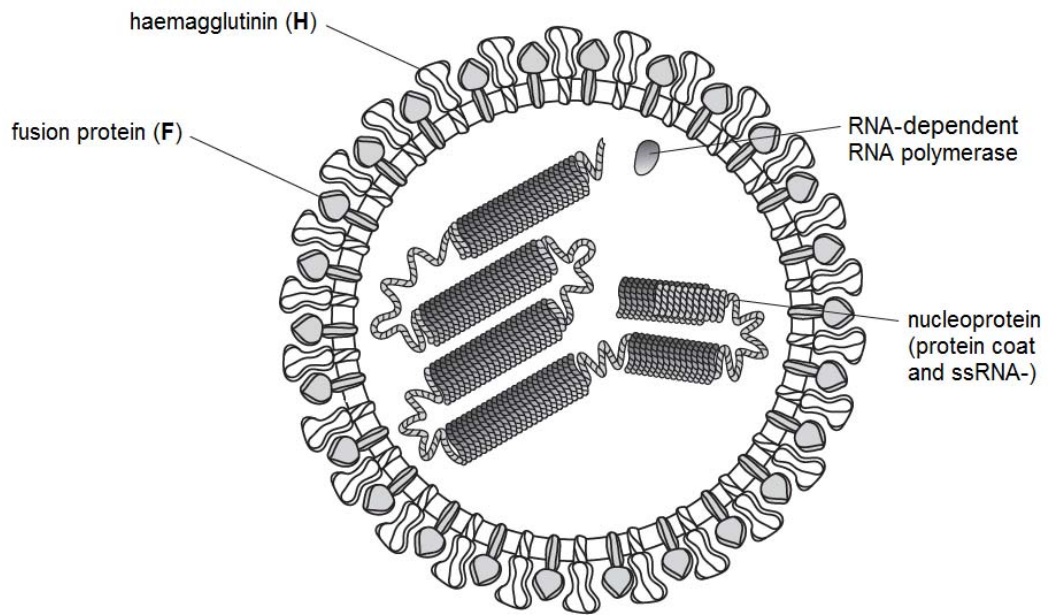
1. Synthetic RNA 1 will bind to 3' end of bacterial mRNA
2. Ribosome can still bind to 5' end of mRNA
3. Stabilises mRNA
4. Polypeptide for growth synthesised
5. for cell to divide / undergo binary fission
6. Synthetic RNA 2 will bind to 5' end of bacterial mRNA
7. to form double stranded RNA
8. Block binding of ribosome to (5' end) mRNA (for translation)/block AUG
9. Proteins for normal cellular functions not produced
10. killing bacteria

(d) Suggest a limitation of using synthetic RNA as an oral antibiotic for bacterial infections in humans. [1]

1. Synthetic RNA broken down during digestion
2. Kills good bacteria in gut
3. Enters human cells and inhibit translation

[Total: 12]

- 4 *Morbillivirus*, which causes measles, has a structure as shown in Fig. 4.1.



**Fig. 4.1**

Source: UCLES, 2016

*Morbillivirus* only infects cells that have a membrane glycoprotein known as signaling lymphocyte activation protein (SLAM). When *Morbillivirus* infects a cell, **H** acts before **F**.

- (a) State how the structure of *Morbillivirus* envelope is similar to that of human immunodeficiency virus (HIV). [2]

1. Both have glycoproteins embedded in viral envelope
2. Both viral envelopes are made up of phospholipid bilayer

- (b) *Morbillivirus* and HIV utilise a similar mechanism to enter host cells.

Describe how *Morbillivirus* enters a host cell.

[3]

1. H binds to SLAM on host cell (surface membrane)
2. causing H to change its three-dimensional conformation
3. F triggers fusion
4. of viral envelope with host cell surface membrane
5. releasing nucleoprotein and viral polymerase
6. into host cell's cytoplasm

- (c) Describe how the *Morbillivirus* genome enables the *Morbillivirus* reproductive cycle.

[3]

1. Serves as a template
2. for viral RNA polymerase
3. to synthesise (complementary) ssRNA+
4. for synthesis of F / H / protein coat / viral polymerase
5. via translation / by host ribosomes
6. for synthesis of viral genome
7. via transcription / by viral RNA polymerase

[Total: 8]

- 5 The *ara* operon is an inducible operon involved in the breakdown of a pentose sugar, arabinose. The organisation of the *ara* operon differs from that of a *lac* operon. Fig. 5.1 shows the organisation of the *ara* operon in a bacterium.

The *ara* operon encodes three structural genes (*araB*, *araA* and *araD*) and is regulated by the regulatory gene *araC*. The arrows in Fig 5.1 represent the directions of transcription of the respective genes.

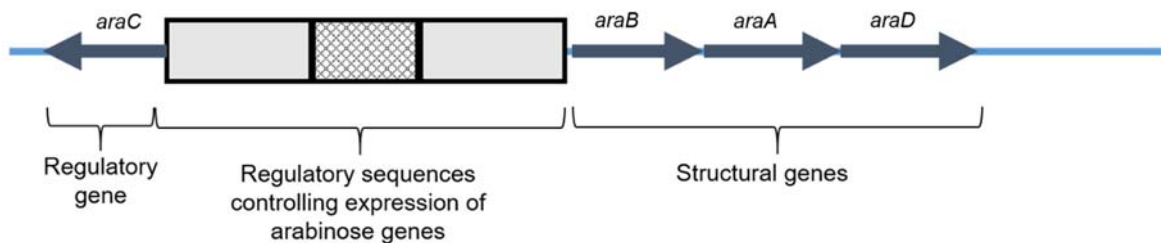


Fig. 5.1

- (a) Using the *ara* operon, explain what is meant by the term operon. [2]

1. Gene involved in the metabolism of arabinose (*araB*, *araA* and *araD*)
2. Clustered/grouped together
3. Under the control of the same promoter
4. and operator

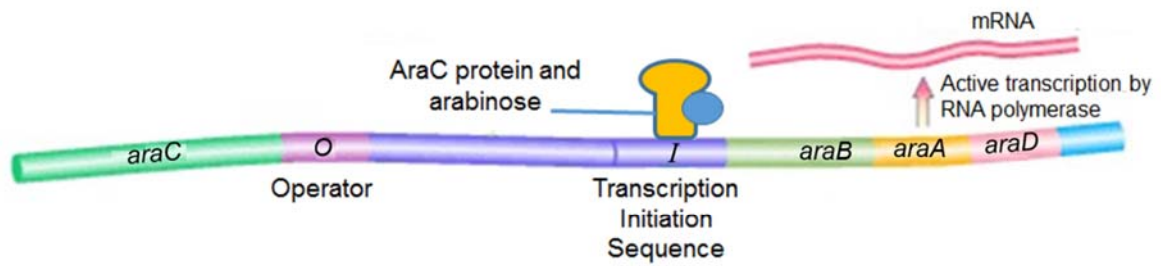
- (b) Suggest why the transcription of the structural genes (*araB*, *araA* and *araD*) proceeds in a different direction from the regulatory gene (*araC*). [2]

Templates of structural genes and regulatory gene are

1. found on different strands
2. antiparallel
3. read from 3' to 5' direction

Fig. 5.2 shows how araC protein interact with arabinose and the regulatory sequences to regulate the expression of the structural genes of the *ara* operon.

In the presence of arabinose:



In the absence of arabinose:

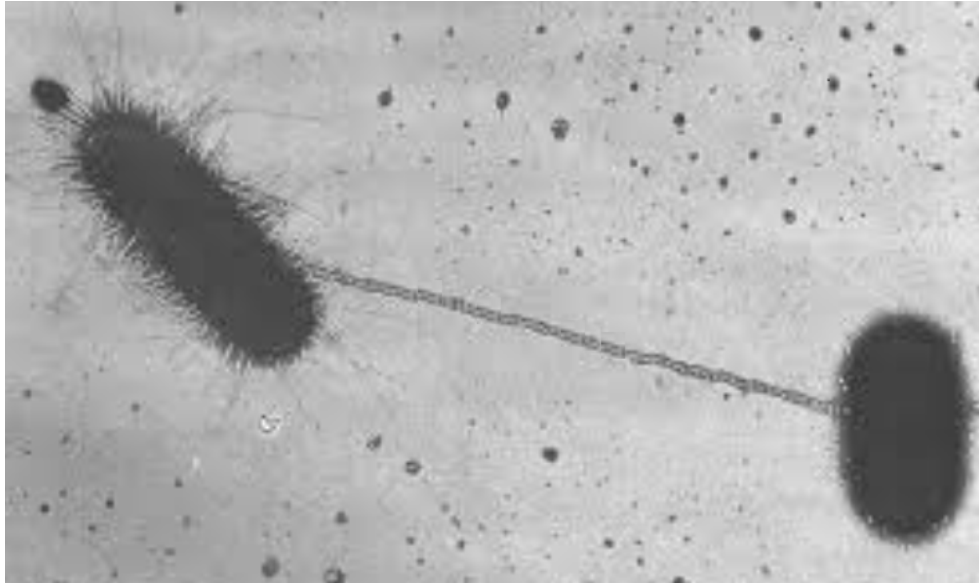


**Fig. 5.2**

(c) With reference to Fig. 5.2, describe how transcription of the *ara* operon is inhibited. [3]

1. No arabinose bound to araC protein
2. araC is in active conformation
3. araC protein binds to transcription initiation sequence
4. DNA bends
5. resulting in araC protein binding to the operator
6. RNA polymerase cannot bind
7. to promoter
8. ara operon is turned off

Plasmids can be transferred from one bacterium to another via the process shown in Fig. 5.3.



**Fig. 5.3**

*Source: Appl. Environ. Microbiol. October 2016 vol. 82 no. 19 5940-5950*

(d) With reference to Fig. 5.3,

(i) state the process, and

[1]

**Conjugation**

(ii) describe the main features of the process.

[4]

1. donor F<sup>+</sup> cell synthesises a sex pilus
2. and makes direct contact with a recipient cell
3. forming a temporary mating bridge between the two cells
4. single stranded nick on Fertility plasmid
5. followed by transfer of a single strand (of F plasmid from donor cell to recipient cell)
6. DNA replication occur in both cells
7. F plasmid circularise in both cells
8. Both cells are now F<sup>+</sup> cell

[Total: 12]

- 6 A germline cell is undergoing meiosis to produce gametes. Fig. 6.1 shows a stage in this process.

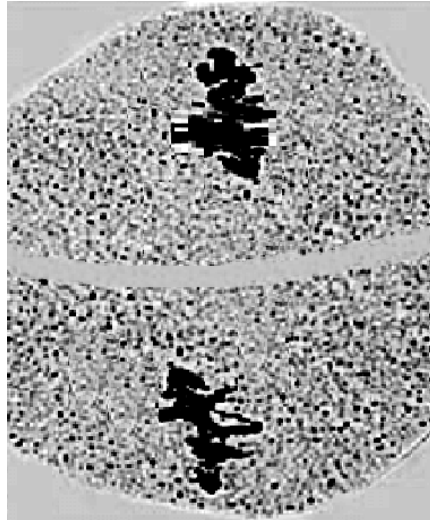


Fig. 6.1

- (a) (i) Identify the stage of meiosis shown in Fig. 6.1 [1]

**Metaphase II**

- (ii) Explain your answer in (a)(i). [2]

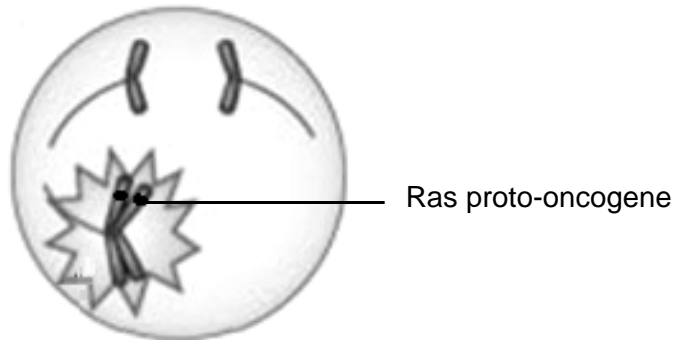
- 1. Cytoplasm / chromosomes has separated into two**
- 2. Chromosomes are gathered at the centre of each cell**

(b) Describe the role of centrioles in the next stage of meiosis.

[3]

1. Centrioles organise spindle fibres
2. that shortens
3. to separate sister chromatids
4. to opposite poles of the cell
5. Centrioles move apart
6. as (interpolar) microtubules lengthen
7. to elongate cell

Fig. 6.2 shows an error in anaphase II.



**Fig. 6.2**

(c) Explain why this error may increase the risk of cancer in a newborn. [3]

1. **Non-disjunction (in meiosis II)**
2. **results in two copies of (Ras) proto-oncogene in gamete**
3. **and three copies of (Ras) proto-oncogene in zygote (after fertilisation)**
4. **resulting in excessive Ras proteins**
5. **This causes overstimulation of cell cycle**
6. **resulting in uncontrolled cell proliferation**

(d) Kinase inhibitors are often used to target such cancers associated with Ras proto-oncogenes by interrupting their downstream signalling.

Suggest how kinase inhibitors can interrupt Ras signalling pathway. [1]

**Prevent activation of phosphorylation cascade, thus prevent signal transduction**

[Total: 10]

- 7 (a) Distinguish between polygenic inheritance and multiple allele inheritance. [3]

	Polygenic inheritance	Multiple alleles
Number of genes/gene loci	Involves two or more gene loci	Involves only one gene locus
Number of alleles present at each gene locus in a population	May not have more than two alleles present	More than two alleles present
Variation	Results in continuous variation	Results in discontinuous variation
Additive effect of <u>genes</u>	Additive effect of <u>multiple genes</u> at involved gene loci.	No additive effect of <u>genes</u> only one gene locus is involved

In humans, an individual's blood group is a combination of the ABO system and the Rhesus (Rh) system. The ABO system divides blood into four types: A, B, AB and O. The Rh system divides blood type into negative (-) or positive (+). The genes for ABO blood type and Rh blood type are inherited independently.

As part of family planning, Claudia, with blood group O<sup>-</sup> consulted a genetic counsellor who charted the inheritance of Rh blood type in the family, shown in Fig. 7.1.

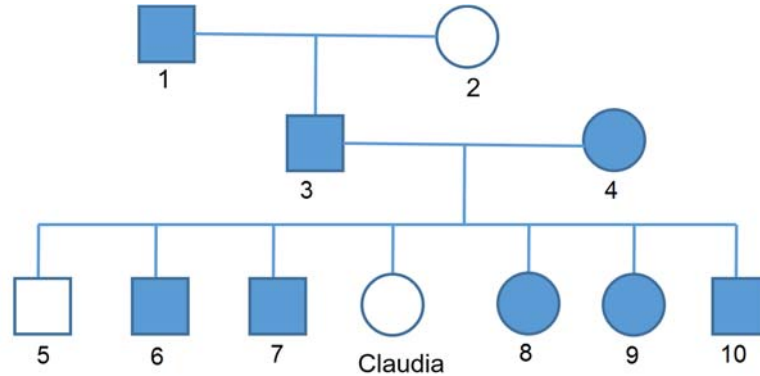


Fig. 7.1

- (b) With reference to Fig. 7.1, explain why the two claims below are correct.

Claim 1: The Rh<sup>+</sup> phenotype is expressed in heterozygotes.

Claim 2: The Rh gene is not found on sex chromosomes.

[3]

**Rh blood type is expressed in heterozygotes as**

1. Individual II-1 and II-2 are Rh<sup>+</sup> but have children who are Rh<sup>-</sup>
2. Indicating that II-1 and II-2 are heterozygotes
3. II-1 and II-2 are Rh<sup>+</sup>

**Rh blood type is found on the autosome as**

**Not found on X chromosome**

4. II-1 is a Rh<sup>+</sup> father but Claudia is Rh<sup>-</sup>
5. II-1 is a Rh<sup>+</sup> male with Rh<sup>+</sup> father and Rh mother, II-1 inherited Rh<sup>+</sup> allele from father

**Not found on Y chromosome**

6. There are Rh<sup>+</sup> female (II-2 / III-5 / III-6)
7. II-1 is Rh<sup>+</sup> but has a Rh<sup>-</sup> son (III-1)

Claudia is married to a man whose blood group is AB<sup>+</sup>. Their first child has blood group A<sup>-</sup>. She is expecting a second child.

- (c) Using the symbols I<sup>A</sup>, I<sup>B</sup> and I<sup>O</sup> to represent the alleles of the ABO blood type and the symbols Rh<sup>+</sup> and Rh<sup>-</sup> to represent the alleles of the Rh blood type, draw a genetic diagram to show all the possible phenotypes of her second child.

[4]

1. Parents genotype (I<sup>O</sup> I<sup>O</sup> Rh<sup>-</sup> Rh<sup>-</sup> x I<sup>A</sup> I<sup>B</sup> Rh<sup>+</sup> Rh<sup>-</sup>)
2. Parents gametes [(I<sup>O</sup> Rh<sup>-</sup>) x (I<sup>A</sup> Rh<sup>-</sup>) (I<sup>A</sup> Rh<sup>+</sup>) (I<sup>B</sup> Rh<sup>-</sup>) (I<sup>B</sup> Rh<sup>+</sup>)
3. All possible genotype I<sup>A</sup> I<sup>O</sup> Rh<sup>-</sup> Rh<sup>-</sup>, I<sup>B</sup> I<sup>O</sup> Rh<sup>-</sup> Rh<sup>-</sup>, I<sup>A</sup> I<sup>O</sup> Rh<sup>+</sup> Rh<sup>-</sup>, I<sup>B</sup> I<sup>O</sup> Rh<sup>+</sup> Rh<sup>-</sup>
4. and correctly matched phenotype (A<sup>-</sup>, B<sup>-</sup>, A<sup>+</sup>, B<sup>+</sup>)

[Total: 10]

- 8 Fig. 8.1 shows the absorption spectrum ( — ) of a photosynthetic pigment from a plant, and the rate of photosynthesis ( - - - ) of the same plant in different colours of light.

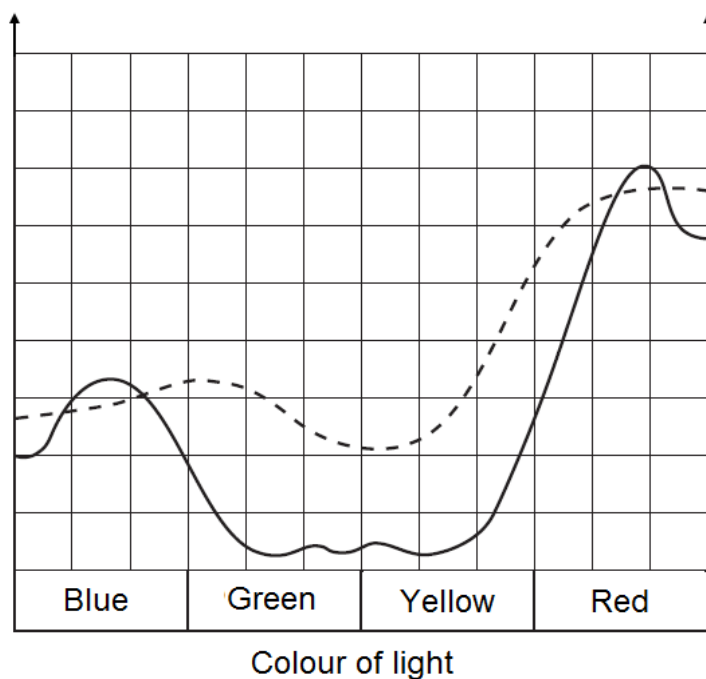


Fig. 8.1

- (a) Explain what is meant by an absorption spectrum. [2]

**An absorption spectrum**

1. Shows the amount of light absorbed
2. at each wavelength of light
3. by a particular pigment

- (b) State whether this plant contains more than one type of photosynthetic pigment. Explain your answer. [2]

1. Yes
2. Relatively higher rate of photosynthesis despite low absorption in green and yellow light

- (c) Plants typically have several photosynthetic pigments, some of which function as accessory pigments.

Suggest the role of accessory pigments in photophosphorylation.

[1]

Increase the range of wavelength / light in which plants can absorb photons

Facilitate transfer of energy from main photosynthetic pigment via resonance to special pair of chlorophyll a

In a separate experiment to study photophosphorylation in plants, chloroplasts are isolated, and the pH levels in various compartments are monitored.

The table below shows the results of this experiment.

**Table 8.1**

environmental condition	pH	
	stroma	thylakoid lumen
dark	7.2	6.8
light	8.8	5.2

- (d) Describe and explain the changes in pH as environmental conditions change from dark to light. [6]

**As environment condition change from dark to light**

1. pH in stroma increases from 7.2 to 8.8, while that in thylakoid lumen decreases from 6.8 to 5.2

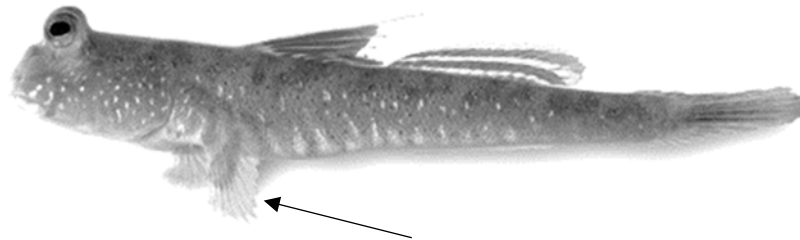
**In the presence of light,**

2. photon excites a photosynthetic pigment
3. This causes electron displacement
4. from a special pair of chlorophyll a
5. Electron is then transferred down electron transport chain
6. Energy released
7. during sequential reduction and oxidation (of electron carriers)
8. is used to pump  $H^+$
9. from stroma to thylakoid lumen
10. decrease  $H^+$  concentration in stroma / increase  $H^+$  concentration in thylakoid lumen
11. Photolysis of water contributes  $H^+$  to thylakoid lumen

[Total: 11]

- 9 Mudskippers are fish which have evolved to use their modified pectoral fins to move onto land to avoid being eaten by larger oceanic fish.

Fig. 9.1 shows a mudskipper. The arrow indicates the modified pectoral fin.



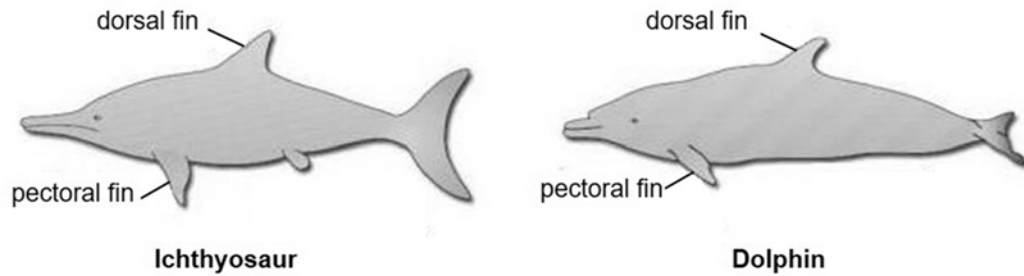
**Fig. 9.1**

*Adapted from: <http://www.mudskipper.it/ita/SpeciesPages/noveIT.html>*

- (a) Explain how mudskippers evolved from their fully aquatic ancestors to have modified pectoral fins. [4]

1. **Mutation**
2. **leads to phenotypic variation in pectoral fins**
3. **Predation acts as a selection pressure**
4. **Natural selection takes place**
5. **individuals with modified pectoral fins survive and reproduce**
6. **pass down alleles coding for modified pectoral fins to offspring**
7. **over generations, there is an increase in allele frequency (coding for modified pectoral fins)**
8. **lack of gene flow (between populations of mudskippers and oceanic ancestor)**
9. **due to habitat/behavioural isolation**

Fig. 9.2 shows the body plan of Ichthyosaurs, which are extinct marine reptiles, and dolphins, which are mammals. Both types of animals can swim quickly to catch prey.



**Fig. 9.2**

- (b) (i)** State the type of evolution shown by Ichthyosaurs and dolphins. [1]

**Convergent evolution**

- (ii)** Explain your answer in **(b)(i)**. [2]

- 1. Animals from different evolutionary branches / with no recent common ancestor**
- 2. face similar selection pressures**
- 3. lead to formation of analogous structures**
- 4. such as fins / streamlined body**

There are more than 40 species of dolphins known to scientists. To determine the evolutionary relationships between the different species, scientists are gathering genomic data to construct a phylogenetic tree.

(c) Describe the advantages of using molecular methods in constructing a phylogenetic tree. [3]

1. To assess phylogenetic relationships that cannot be measured by comparative anatomy
2. To compare species too closely related to display much divergence in morphology
3. To trace evolutionary relationships of species that are so different that there is little morphological homology
4. Each nucleotide/ amino acid position along a stretch of DNA/ polypeptide represents a point of comparison → multiple points of comparison
5. Each nucleotide/ amino acid are unambiguous/ objective
6. provides a quantitative tool for constructing cladograms
7. Molecular data are easily converted to quantitative data/ numerical form (amenable to mathematical and statistical analysis)

[Total: 10]

- 10 (a) Describe how *Mycobacterium tuberculosis* is transmitted. [2]
1. Inhalation of
  2. airborne particles / droplet nuclei
  3. that traverse nasal passage / respiratory tract to reach alveoli (of the lungs)
  4. when infected person cough / sneeze / shout
- (b) (i) Penicillin is often used to treat bacterial infections due to its ability to interfere with bacterial cell wall synthesis. [2]  
Describe the mode of action of penicillin.
1.  $\beta$ -lactams ring of penicillin
  2. binds to active sites
  3. of penicillin binding proteins (in bacteria)
  4. preventing cross-linking of bacterial cell wall
- (ii) Suggest why penicillin is ineffective against *M. tuberculosis*. [1]  
**Penicillin unable to reach *M. tuberculosis* in pulmonary cavities / due to granuloma barrier**

[Total: 5]

- 11 Arctic foxes in Iceland hunt for prey such as lemmings, which are rodent-like animals. Due to global warming, there were milder and shorter winters from 2000 to 2006. This led to the melting of and collapse of snow burrows inhabited by the lemmings.

Fig. 11.1 shows the populations of arctic foxes and lemmings between 2000 and 2008.

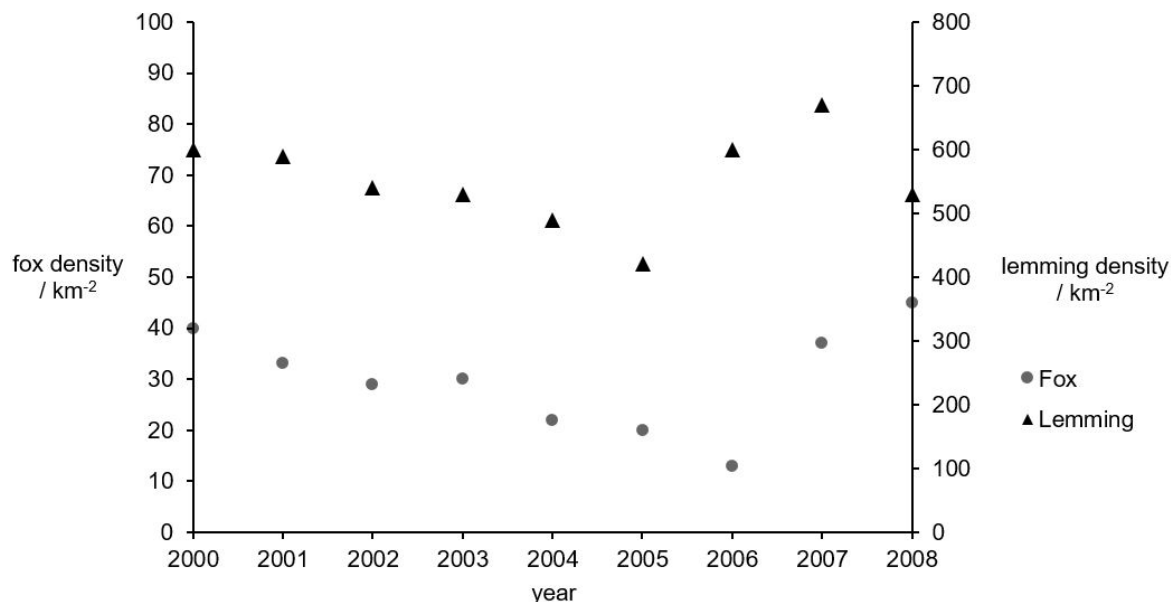


Fig. 11.1

- (a) Explain how the melting of snow may lead to further warming of the island. [1]

1. Due to the albedo effect / albedo of ground lower than snow
2. More solar radiation is absorbed by the ground / reflected into the atmosphere

- (b) With reference to Fig. 11.1,

- (i) describe the change in fox density, [2]

1. From 2000 to 2006, fox density decreased gradually from 40 km<sup>2</sup> to 13 km<sup>2</sup>
2. From 2006 to 2008, fox density increased sharply from 13 km<sup>2</sup> to 45 km<sup>2</sup>

(ii) explain why the density of lemmings increased from 2005 to 2006, and [1]

1. Fox density decreased
2. fewer predators

(iii) suggest why arctic fox population density would not increase indefinitely beyond 2008. [1]

1. decreased food availability as lemming population density decreases further

[Total: 5]



# RIVER VALLEY HIGH SCHOOL

## YEAR 6

### PRELIMINARY EXAMINATION

CANDIDATE  
NAME

CENTRE  
NUMBER

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CLASS

INDEX  
NUMBER

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**BIOLOGY**

**9744/03**

Paper 3 Long Structured and Free-response Questions

**14 Sep 2018**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

#### READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

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

**DO NOT WRITE IN ANY BARCODES.**

#### Section A

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

#### Section B

Answer any **one** question in the spaces provided on the Question Paper.

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

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

For Examiner's Use	
<b>Section A</b>	
<b>1</b>	<b>/ 25</b>
<b>2</b>	<b>/ 25</b>
<b>Section B</b>	<b>/ 25</b>
<b>Total</b>	<b>/ 75</b>

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

**Section A**

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

**1** Plant tissue culture is a technique to produce an entire plant using undifferentiated meristem cells. A cluster of meristem cells can be extracted and stimulated with growth hormones to differentiate to form different types of cells that give rise to an entire plant.

**(a)** Suggest why meristem cells from any part of a plant can be used to produce the entire plant in plant tissue culture. [2]

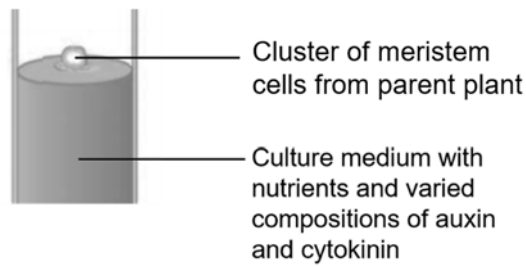
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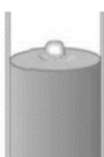



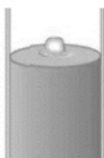
In plant tissue culture, plant hormones are added to the meristem cells to regulate growth and differentiation to form roots and shoots. These hormones include auxin and cytokinin. The experiment set up is shown in Fig. 1.1



**Fig. 1.1**

The effects of various compositions of auxin and cytokinin on the cluster of meristem cells are summarised in Table 1.1.

**Table 1.1**

Concentration of auxin / $\text{mg L}^{-1}$	Concentration of cytokinin / $\text{mg L}^{-1}$	Observation
0	0	
10	0	
8	4	
6	6	
4	8	
0	10	

- (b) With reference to Table 1.1, state three conclusions on the effect of auxin and cytokinin on plant growth and differentiation. [3]

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The plant hormone auxin plays a key role in growth and differentiation in plants by altering the expression of selected genes. Genes that are activated or repressed by the presence of auxin are known as auxin-responsive genes (ARGs).

ARG expression is controlled by two transcription factors, auxin response factor and auxin repressor. Binding of auxin response factor to ARE recruits the auxin repressor. Fig. 1.2 shows how auxin controls the expression of an ARG.

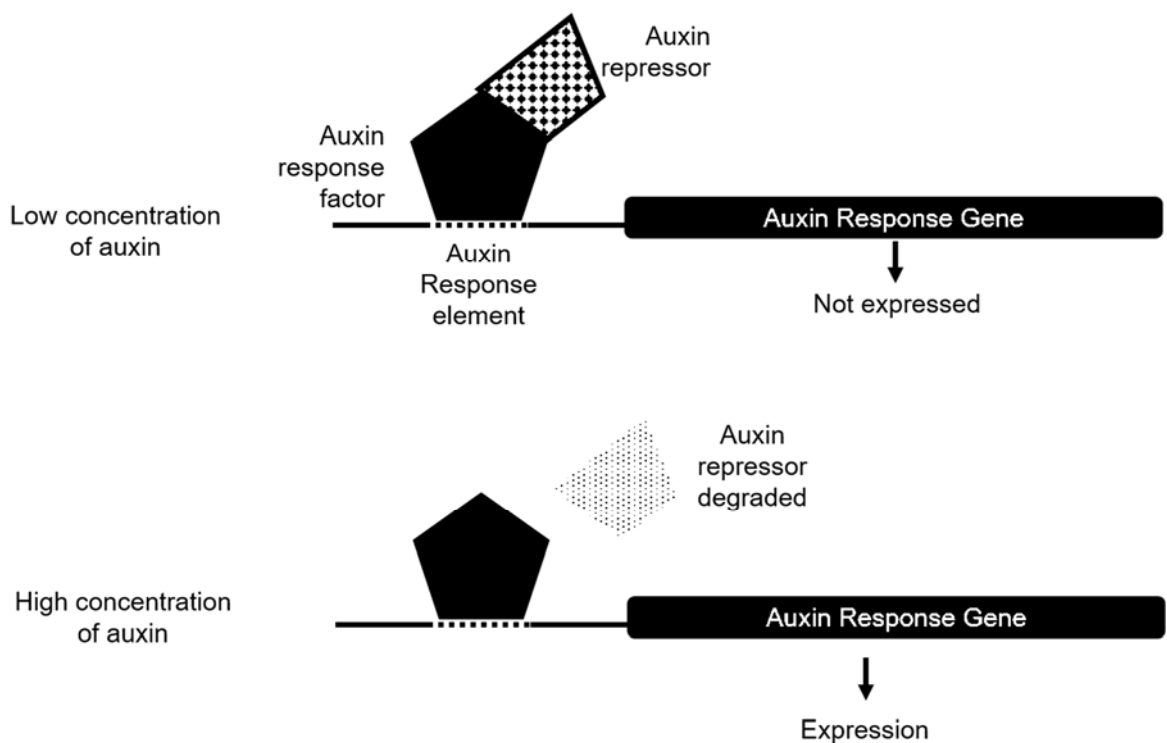


Fig. 1.2

- (c) Explain why auxin repressor interacts specifically with auxin response factor. [2]

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- (d) With reference to Fig. 1.2, state the level at which the gene expression of the following proteins are controlled. [2]

(i) Protein product of ARG

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(ii) Auxin repressor

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- (e) Describe the role of an enzyme involved in each level of control stated in (d). [4]

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For many years, bacteria have been genetically manipulated to produce therapeutic proteins for human diseases.

In recent years, plant molecular farming, the practice of using plants to produce human therapeutic proteins, has gained the attention of many pharmaceutical companies. Plants are modified by introducing human gene sequences into their genomes, which serve as templates for protein synthesis.

**(f)** Describe how protein synthesis in bacteria cells differ from plant cells. [3]

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Plant molecular farming produces therapeutic proteins such as clotting factor XIII.

Individuals suffering from haemophilia A cannot produce functional clotting factor XIII due to a point mutation. They suffer from severe bleeding and need injections of clotting factor XIII throughout their life.

**(g)** Describe how a point mutation can lead to the production of clotting factor XIII with reduced function. [3]

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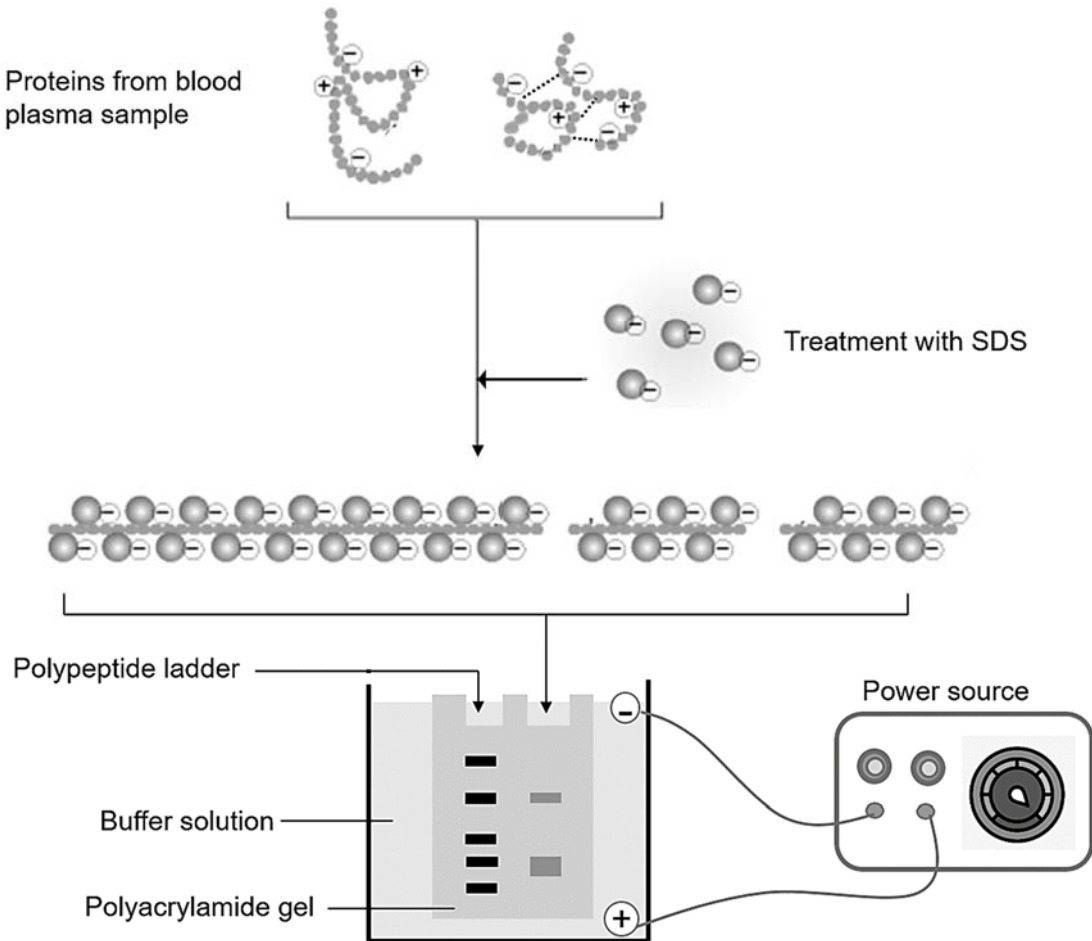
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A study investigates the presence of plant-derived blood clotting factor XIII after injection into a patient suffering from haemophilia A. Blood plasma is extracted from the patient and the proteins in the sample are separated by a technique known as sodium dodecyl sulfate - polyacrylamide gel electrophoresis (SDS-PAGE).

In SDS-PAGE, proteins are first treated with the chemical SDS before they are inserted into wells in a polyacrylamide gel for gel electrophoresis. The proteins are then separated on the basis of size, using the same principle as agarose gel electrophoresis. SDS-PAGE is illustrated in Fig. 1.3.



**Fig. 1.3**

**(h)** With reference to Fig. 1.3,

**(i)** describe the effect of SDS treatment on proteins from the blood plasma, and [2]

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- (ii) describe how polyacrylamide gel electrophoresis is used to separate and determine the length of SDS-treated proteins. [4]

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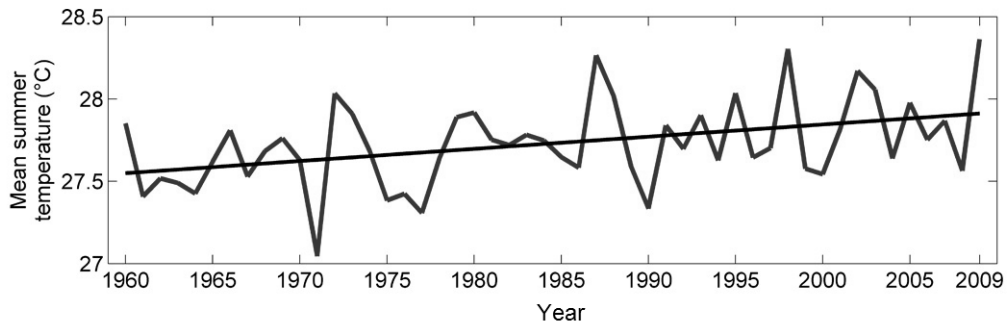
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[Total: 25]

- 2 Rising global temperatures are causing an increase in the frequency and severity of extreme climatic events like heat waves.

A study on heat waves in India tracked the mean summer temperatures from 1960 to 2009 and attributed the temperature changes to greenhouse gas emissions. Scientists warned that if greenhouse gas emissions continue to rise at the current rates, there may be severe impact on crop yield and livestock that can lead to population mortality.

Fig. 2.1 shows the result of this study.



**Fig. 2.1**

Source: Mora et. al., 2017

- (a) With reference to Fig. 2.1, describe the change in summer temperatures since 1960 and explain how this may be attributed to greenhouse gas emissions. [3]

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To better understand the impact of heat waves on population mortality, a concurrent study on crop yield was conducted during the same time period. Table 2.1 summarises the yield of wheat and maize plants.

**Table 2.1**

crop	mass of harvest / million tonnes		change in yield / %
	1960	2009	
Wheat		127.40	+ 30
Maize	78.20		+ 5

- (b) (i) Complete Table 2.1. [2]

(ii) Explain the change in wheat yield from 1960 to 2009. [2]

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(iii) Scientists attributed the lesser increase in maize yield to decreased viability of maize seeds. Explain why this may be true. [2]

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(c) State why such increases in crop yields will not sustain with further increase in temperatures. [2]

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Buffaloes play a major role in sustaining India’s agriculture. In another study on heat waves, scientists used buffalo T lymphocytes to investigate the effect of heat stress on livestock’s vulnerability to diseases.

The expression of HSP60, a heat-shock protein, is upregulated in response to heat stress. Fig. 2.2 shows the role of HSP60 in PKC signaling. PKC signaling is triggered by the CXCR4 receptor.

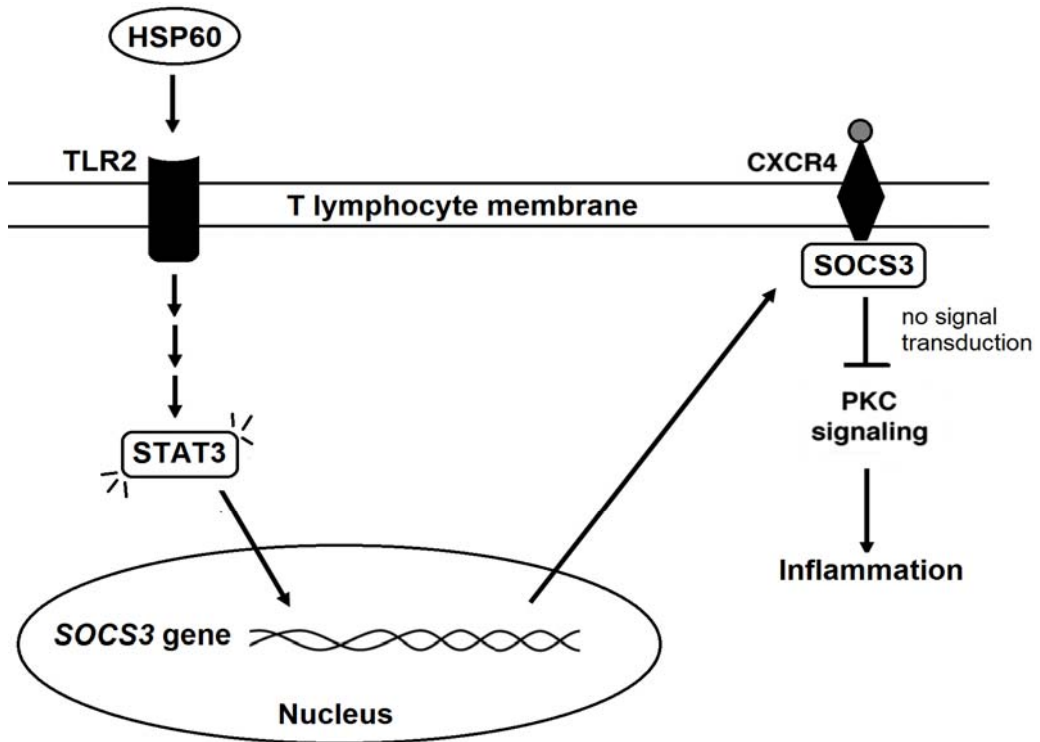


Fig. 2.2

- (d) (i) Inflammation is part of the innate immune response.  
Describe what is meant by innate immune response.

[2]

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- (ii) With reference to Fig. 2.2, describe how heat stress results in decreased inflammation in buffaloes. [5]

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- (iii) Suggest how decreased inflammation increases buffaloes' vulnerability to diseases. [2]

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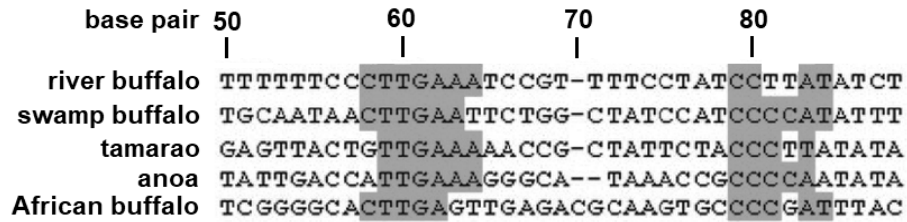
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Further investigation of HSP60 protein reveals molecular homology across various species of buffaloes.

Fig. 2.3 shows the DNA sequences of the same segment of *HSP60* gene in various buffalo species. Shaded regions indicates similarity with the common ancestor.



**Fig. 2.3**

(e) Explain how the molecular data in Fig. 2.3 supports Darwin’s theory of evolution. [4]

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(f) State which species of buffalo is most closely related to the common ancestor. [1]

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[Total: 25]

**Section B**

Answer **one** question in this section.

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

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

Your answers must be in continuous prose, where appropriate.

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

**3 (a)** Describe the polymerisation of different types of biomolecules in a plant and explain how these biomolecules allow plant growth and survival. [15]

**(b)** All living organisms (autotrophs and heterotrophs) require energy to survive. Outline the processes in which they obtain energy and explain the advantage of each process to the organism. [10]

[Total: 25]

**4 (a)** Cancer is a disease associated with abnormal cell division with the potential to invade other parts of the body. Outline how genetic and environmental factors cause cancer and explain why it is challenging to cure cancer. [15]

**(b)** Discuss the role of constituent biomolecules of the cell surface membrane in the movement of substances across the membrane. Explain the need for a variety of transport mechanisms. [10]

[Total: 25]

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# RIVER VALLEY HIGH SCHOOL

## YEAR 6

### PRELIMINARY EXAMINATION

CANDIDATE  
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#### BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

14 Sep 2018

2 hours

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

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For Examiner's Use	
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<b>1</b>	<b>/ 25</b>
<b>2</b>	<b>/ 25</b>
<b>Section B</b>	<b>/ 25</b>
<b>Total</b>	<b>/ 75</b>

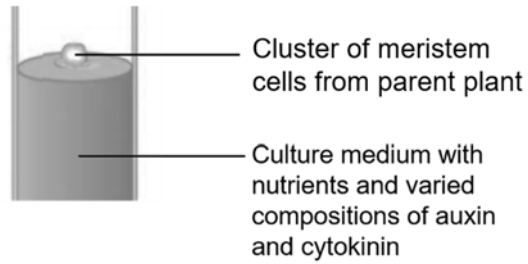
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**Section A**

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

- 1** Plant tissue culture is a technique to produce an entire plant using undifferentiated meristem cells. A cluster of meristem cells can be extracted and stimulated with growth hormones to differentiate to form different types of cells that give rise to an entire plant.
- (a) Suggest why meristem cells from any part of a plant can be used to produce the entire plant in plant tissue culture. [2]
- 1. The meristem cell contains all the DNA/genes/genetic material of the plant.**
  - 2. The meristem cell is totipotent.**


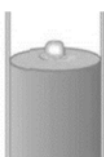




In plant tissue culture, plant hormones are added to the meristem cells to regulate growth and differentiation to form roots and shoots. These hormones include auxin and cytokinin. The experiment set up is shown in Fig. 1.1



**Fig. 1.1**

The effects of various compositions of auxin and cytokinin on the cluster of meristem cells are summarised in Table 1.1.

**Table 1.1**

Concentration of auxin / $\text{mg L}^{-1}$	Concentration of cytokinin / $\text{mg L}^{-1}$	Observation
0	0	
10	0	
8	4	
6	6	
4	8	
0	10	

(b) With reference to Table 1.1, state three conclusions on the effect of auxin and cytokinin on plant growth and differentiation. [3]

1. Both auxin and cytokinin are required for cell division / plant formation.
2. Equal concentration of auxin and cytokinin leads to growth/cell division but no differentiation.
3. High auxin concentration and low cytokinin concentration leads to cells differentiating to root.
4. Low auxin concentration and high cytokinin concentration leads to cell differentiating to shoot.

The plant hormone auxin plays a key role in growth and differentiation in plants by altering the expression of selected genes. Genes that are activated or repressed by the presence of auxin are known as auxin-responsive genes (ARGs).

ARG expression is controlled by two transcription factors, auxin response factor and auxin repressor. Binding of auxin response factor to ARE recruits the auxin repressor. Fig. 1.2 shows how auxin controls the expression of an ARG.

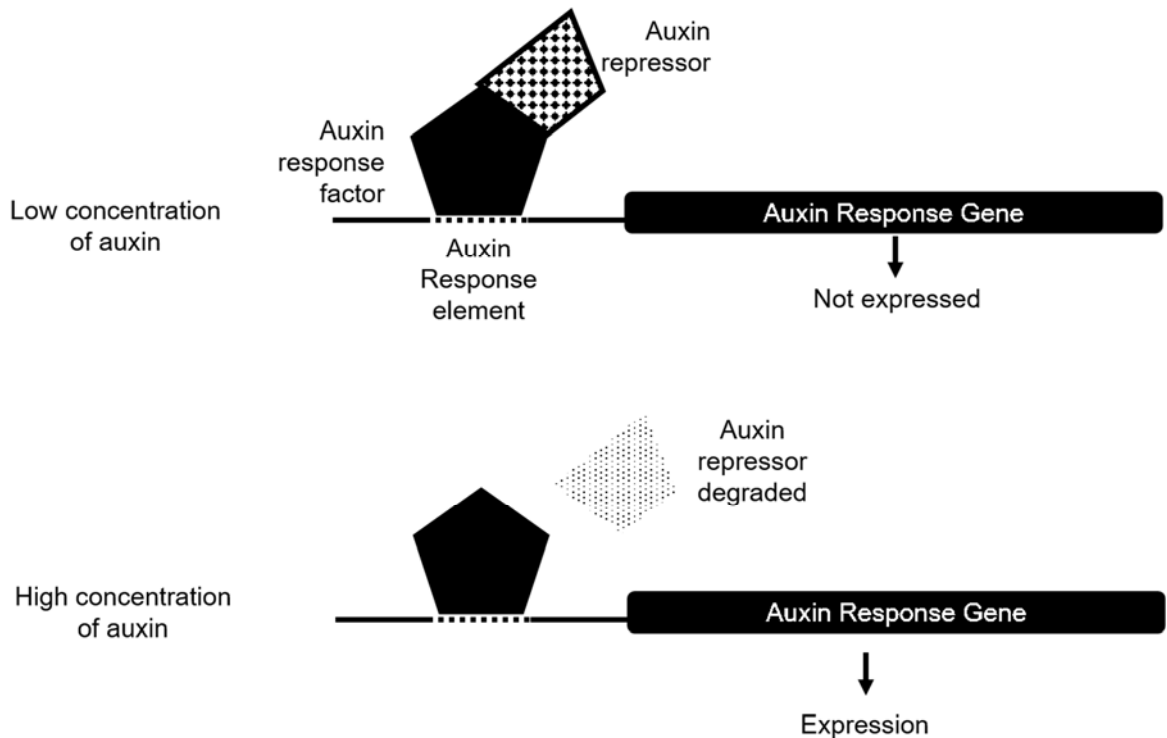


Fig. 1.2

- (c) Explain why auxin repressor interacts specifically with auxin response factor. [2]
1. Auxin repressor and auxin response factor interact at binding sites,
  2. that are complementary shape,
  3. and contains amino acid residues,
  4. that can form (compatible) R group interactions.
- 
- (d) With reference to Fig. 1.2, state the level at which the gene expression of the following proteins are controlled. [2]
- (i) Protein product of ARG
- Transcriptional control**
- 
- (ii) Auxin repressor
- Post-translational control**
- 
- (e) Describe the role of an enzyme involved in each level of control stated in (d). [4]
1. RNA polymerase,
  2. binds to promoter of auxin response gene
  3. to initiate transcription.
- 
4. Proteasome,
  5. recognise ubiquitin-tagged auxin repressor,
  6. hydrolyses auxin repressor
- or
7. Enzyme transferring ubiquitin to auxin repressor,
  8. tag auxin repressor for degradation
  9. by proteasome.

For many years, bacteria have been genetically manipulated to produce therapeutic proteins for human diseases.

In recent years, plant molecular farming, the practice of using plants to produce human therapeutic proteins, has gained the attention of many pharmaceutical companies. Plants are modified by introducing human gene sequences into their genomes, which serve as templates for protein synthesis.

(f) Describe how protein synthesis in bacteria cells differ from plant cells. [3]

<b>Feature</b>	<b>Bacteria</b>	<b>Plant cell</b>
<b>Order of transcription and translation</b>	<b>Transcription and translation occur simultaneously</b>	<b>Translation begins only after transcription is completed</b>
<b>Post transcriptional modification</b>	<b>No post transcriptional modification</b>	<b>Modified by adding 5' capping, RNA splicing, 3' polyadenylation</b>
<b>Post-translational modification</b>	<b>No post translational modification</b>	<b>Modified by glycosylation, phosphorylation, cleavage etc.</b>
<b>Ribosomes involved</b>	<b>70S ribosomes</b>	<b>80S ribosomes</b>
<b>Location</b>	<b>Transcription and translation in cytoplasm</b>	<b>Transcription in nucleus, Translation in cytoplasm/rough endoplasmic reticulum</b>

Plant molecular farming produces therapeutic proteins such as clotting factor XIII.

Individuals suffering from haemophilia A cannot produce functional clotting factor XIII due to a point mutation. They suffer from severe bleeding and need injections of clotting factor XIII throughout their life.

- (g) Describe how a point mutation can lead to the production of clotting factor XIII with reduced function. [3]

1. Base-pair substitution in clotting factor XIII gene
2. resulting to missense mutation,
3. change in corresponding mRNA codon,
4. change in corresponding amino acid,
5. with different (R group) properties.
6. Resulting polypeptide chain will not fold properly,
7. changing its three-dimensional structure/shape.

Or

8. Base-pair insertion/deletion at the end of the clotting factor XIII gene
9. resulting in frameshift,
10. change in small number of terminal mRNA sequence,
11. change in corresponding amino acid at the end of the polypeptide chain,
12. with different (R group) properties.
13. Resulting polypeptide chain will not fold properly,
14. hanging its three-dimensional structure/shape.

A study investigates the presence of plant-derived blood clotting factor XIII after injection into a patient suffering from haemophilia A. Blood plasma is extracted from the patient and the proteins in the sample are separated by a technique known as sodium dodecyl sulfate - polyacrylamide gel electrophoresis (SDS-PAGE).

In SDS-PAGE, proteins are first treated with the chemical SDS before they are inserted into wells in a polyacrylamide gel for gel electrophoresis. The proteins are then separated on the basis of size, using the same principle as agarose gel electrophoresis. SDS-PAGE is illustrated in Fig. 1.3.

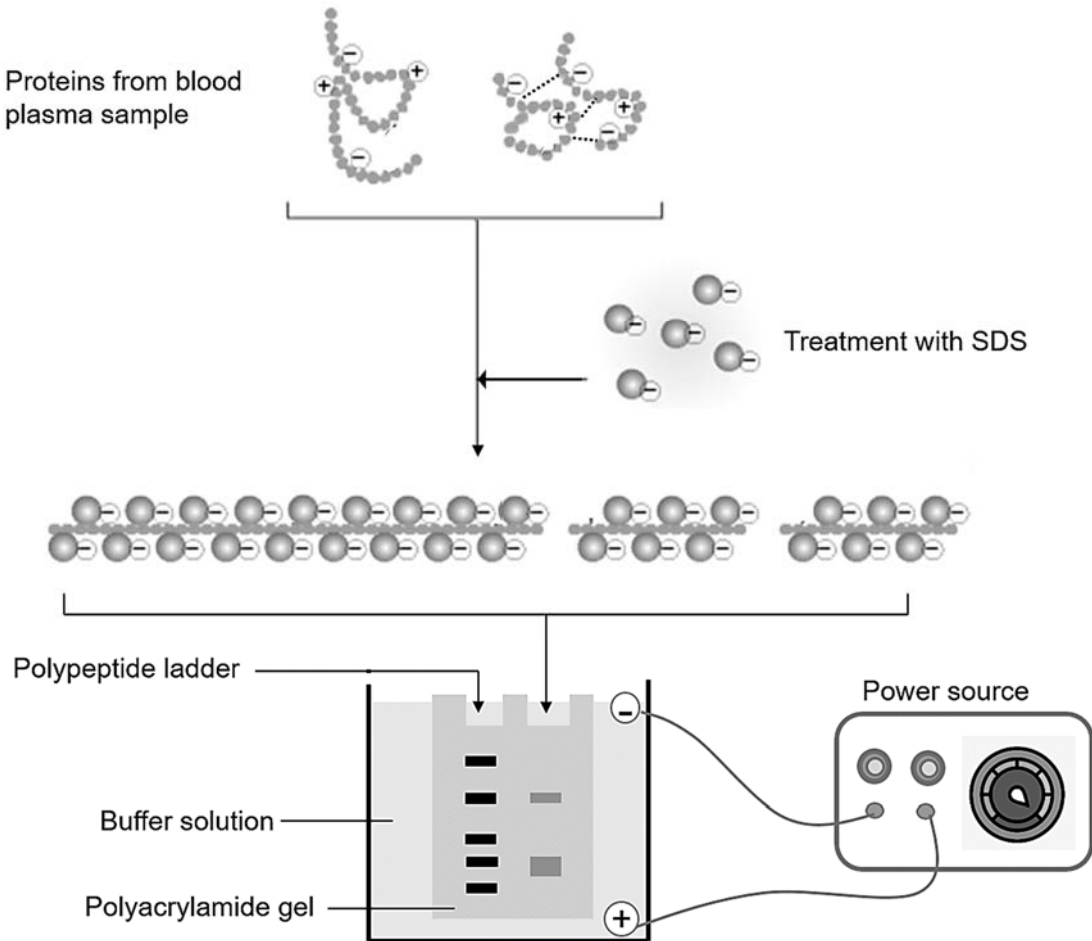


Fig. 1.3

(h) With reference to Fig. 1.3,

(i) describe the effect of SDS treatment on proteins from the blood plasma, and [2]

1. SDS coat/bind to proteins,
  2. break R group interactions
- causes proteins to
3. unfold
  4. form linear polypeptides.
  5. separate (quaternary protein) into subunits.
  6. be negatively charged.

(ii) describe how polyacrylamide gel electrophoresis is used to separate and determine the length of SDS-treated proteins. [4]

1. Proteins loaded into wells at the negative electrode,
2. when a direct current is applied/electric field set up,
3. causes polypeptide to migrate towards positive electrode.
4. Shorter polypeptide migrate through the pores of the polyacrylamide gel faster than longer polypeptides.
5. Less resistance for the shorter polypeptides to move through the pores of the gel,
6. found nearer to the positive electrode.
7. Polypeptide ladder used to calibrate size of polypeptide,
8. positions protein compared with polypeptide ladder.

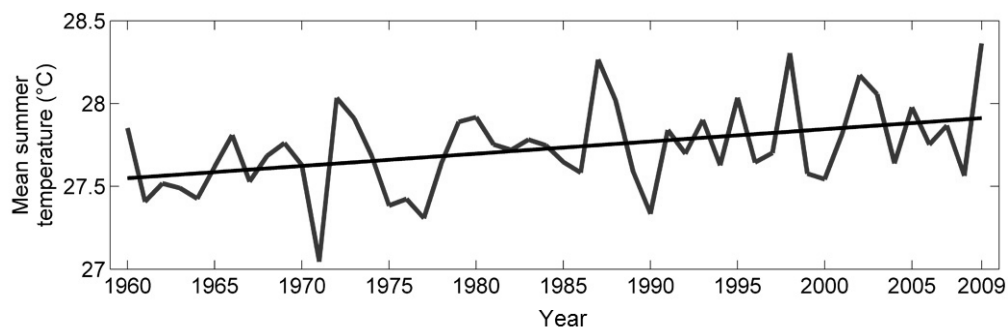
\_\_\_\_\_  
\_\_\_\_\_

[Total: 25]

- 2 Rising global temperatures are causing an increase in the frequency and severity of extreme climatic events like heat waves.

A study on heat waves in India tracked the mean summer temperatures from 1960 to 2009 and attributed the temperature changes to greenhouse gas emissions. Scientists warned that if greenhouse gas emissions continue to rise at the current rates, there may be severe impact on crop yield and livestock that can lead to population mortality.

Fig. 2.1 shows the result of this study.



**Fig. 2.1**

Source: Mora et. al., 2017

- (a) With reference to Fig. 2.1, describe the change in summer temperatures since 1960 and explain how this may be attributed to greenhouse gas emissions. [3]

1. Mean summer temperatures increase from 27.6°C to 27.9°C from 1960 to 2009.
2. This is due to increased CO<sub>2</sub>
3. and methane discharge,
4. that reabsorbs infrared radiation,
5. causing retention of solar heat in (Earth's) atmosphere.

To better understand the impact of heat waves on population mortality, a concurrent study on crop yield was conducted during the same time period. Table 2.1 summarises the yield of wheat and maize plants.

**Table 2.1**

crop	mass of harvest / million tonnes		change in yield / %
	1960	2009	
Wheat	98.00	127.40	+ 30
Maize	78.20	82.11	+ 5

- (b) (i) Complete Table 2.1. [2]

(ii) Explain the change in wheat yield from 1960 to 2009. [2]

1. Increase in crop yield,
2. due to higher CO<sub>2</sub> concentration,
3. and higher temperature,
4. thus increased carbon fixation / rate of photosynthesis
5. resulting in greater plant mass.

(iii) Scientists attributed the lesser increase in maize yield to decreased viability of maize seeds. Explain why this may be true. [2]

1. Accelerated growth in maize
2. results in lesser time for seed growth / maturation.
3. Most seeds do not develop into mature plants for harvest.

(c) State why such increases in crop yields will not sustain with further increase in temperatures. [2]

**Further increase in temperature may cause**

1. denaturation of enzymes halts metabolic activities.
2. droughts that limit water supply.
3. floods that drown crops.
4. more weeds that competes with crops.
5. more pests that destroys crops.



Buffaloes play a major role in sustaining India's agriculture. In another study on heat waves, scientists used buffalo T lymphocytes to investigate the effect of heat stress on livestock's vulnerability to diseases.

The expression of HSP60, a heat-shock protein, is upregulated in response to heat stress. Fig. 2.2 shows the role of HSP60 in PKC signaling. PKC signaling is triggered by the CXCR4 receptor.

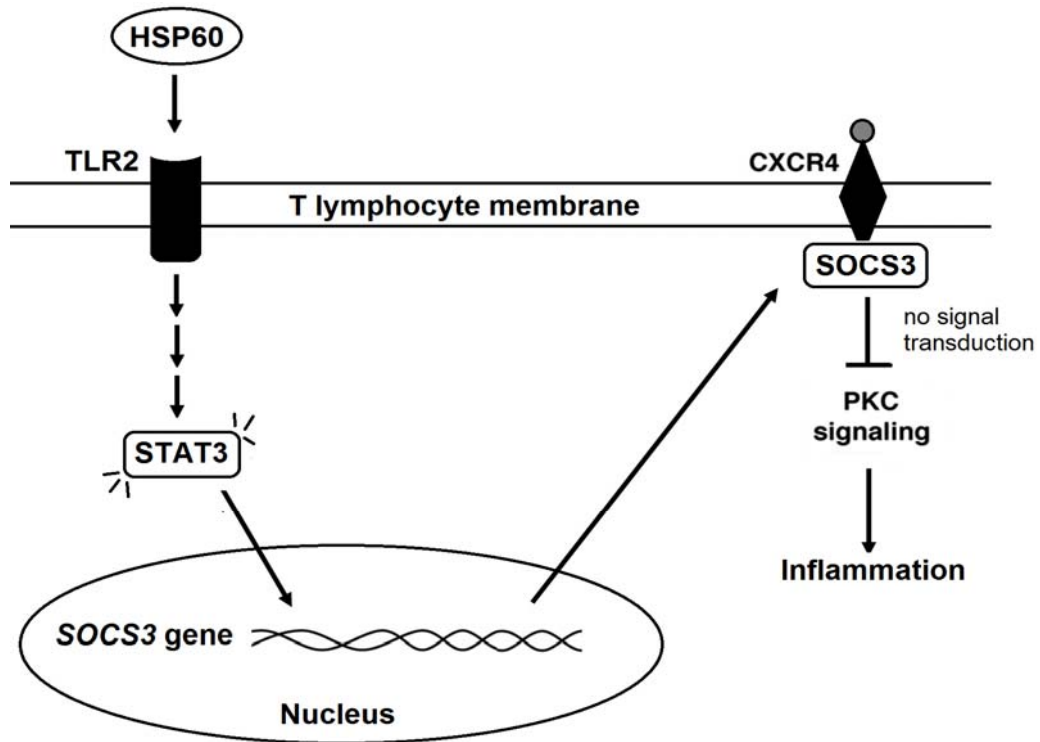


Fig. 2.2

- (d) (i) Inflammation is part of the innate immune response.  
Describe what is meant by innate immune response.

[2]

1. Innate immunity is genetically determined.
2. It provides broad defences against infection and is
3. the first line of defence / activated almost immediately.
4. It responds the same way for every antigen encounter / not specific to any pathogen.

- (ii) With reference to Fig. 2.2, describe how heat stress results in decreased inflammation in buffaloes. [5]
1. Heat stress increases concentration of HSP60,
  2. causing increase frequency of (HSP-TLR2) signalling.
  3. HSP60 binds to TLR2,
  4. activating TLR2,
  5. resulting in activation of STAT3 (relay proteins).
  6. (activated) STAT3 enters the nucleus
  7. and act as a transcription factor / initiate transcription
  8. of SOCS3 gene,
  9. resulting in synthesis of SOCS3 protein.
  10. SOCS3 binds to CXCR4,
  11. preventing trigger of the PKC signalling pathway.
- (iii) Suggest how decreased inflammation increases buffaloes' vulnerability to diseases. [2]
1. Reduced immune cells at site of infection.
  2. Increases opportunity for pathogens to proliferate in buffalo.

Further investigation of HSP60 protein reveals molecular homology across various species of buffaloes.

Fig. 2.3 shows the DNA sequences of the same segment of *HSP60* gene in various buffalo species. Shaded regions indicates similarity with the common ancestor.

	base pair	50	60	70	80
river buffalo		TTTTTTC	CCTTGAAAT	CCGT-	TTTCCTATCCTTATATCT
swamp buffalo		TGCAATA	ACTTGAATT	CTGG-	CTATCCATCCCCATATTT
tamarao		GAGTTACT	TGTTGAAAA	ACCG-	CTATTCTACCCTTATATA
anoa		TATTGACC	ATTGAAAG	GGCA--	TAAACCGCCCCAATATA
African buffalo		TCGGGGC	ACTTGAGTT	GAGACG	CAAGTGCCCCGATTTAC

**Fig. 2.3**

(e) Explain how the molecular data in Fig. 2.3 supports Darwin's theory of evolution. [4]

1. Identical nucleotide at base pair 59 / 60 / 61 / 62 / 79 / 80 for all species
2. Consequences of descent from a common ancestor
3. as buffaloes more suited to the environment reproduce to pass on favorable alleles to offspring.
4. Nucleotide variation at base pair 58 / 63 / 64 / 81 / 82 / 84
5. Consequence of (descend with) modification
6. Different environment favours different phenotypes
7. giving rise to variation (in reaction to heat stress).

(f) State which species of buffalo is most closely related to the common ancestor. [1]

**Swamp buffalo.**

[Total: 25]

## Section B

Answer **one** question in this section.

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

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

Your answers must be in continuous prose, where appropriate.

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

- 3 (a)** Describe the polymerisation of different types of biomolecules in a plant and explain how these biomolecules allow plant growth and survival. [15]

**Formation**

1. starch
2. formed from  $\alpha$ -glucose
3. when hydroxyl groups from two glucose molecules react
4. to form  $\alpha(1-4)$  glycosidic bonds
5. and  $\alpha(1-6)$  glycosidic bonds
6. forming amylose
7. and amylopectin
8. through condensation reactions
  
9. cellulose
10. formed from  $\beta$ -glucose
11. every other  $\beta$ -glucose is inverted
12. forming  $\beta(1-4)$  glycosidic bonds
  
13. Proteins
14. formed from amino acids
15. when carboxyl group of one amino acid
16. reacts with the amino group of another
17. to form a peptide bond (through a condensation reaction)
  
18. DNA
19. and RNA
20. formed from nucleotides / nucleoside triphosphates
21. when 3'-OH group of one nucleotide
22. reacts with the 5' phosphate group of an incoming nucleotide

23. to form a phosphoester bond (through a condensation reaction)

**Growth and Survival**

***Starch***

24. Storage of energy

25. to provide substrate for aerobic respiration

***Cellulose***

26. Structural support

27. Help the plant to gain light (for photosynthesis)

28. Withstand osmotic pressure

***Proteins***

29. Enzymes

30. To carry out metabolic processes

31. Transcription factors

32. for regulation of gene expression

33. carrier/channel/transport proteins

34. for membrane transport / chemiosmosis

35. hormones / receptors

36. for cell signalling

37. cytoskeleton

***DNA / RNA***

38. contain gene sequence

39. tRNA / rRNA synthesis

40. allow protein synthesis

- (b) All living organisms (autotrophs and heterotrophs) require energy to survive. Outline the processes in which they obtain energy and explain the advantage of each process to the organism. [10]

#### Photosynthesis

1. Plants harness light energy
2. using photosynthetic pigments
3. to produce ATP and NADPH
4. for activation
5. and reduction
6. of carbon (in Calvin Cycle)
7. to synthesise glucose.

#### Advantage

8. Utilises energy source that is readily available
9. Ability to utilise inorganic source of carbon

#### Aerobic Respiration

10. plants and animals release chemical energy
11. through a series of redox reactions / oxidative breakdown of
12. respiratory substrates
13. catalysed by enzymes
14. produce ATP
15. by substrate level phosphorylation
16. and chemiosmosis

#### Advantage

17. Convert (chemical) energy to readily usable forms in living cells
18. Relatively large amount of ATP synthesised (compared to anaerobic respiration)

#### Anaerobic Respiration

19. undergo alcoholic fermentation
20. in yeast and plants
21. lactate fermentation
22. in mammals
23. regenerate  $\text{NAD}^+$
24. for glycolysis to proceed

#### Advantage

25. Can produce ATP in absence of oxygen

[Total: 25]

- 4 (a) Cancer is a disease associated with abnormal cell division with the potential to invade other parts of the body. Outline how genetic and environmental factors cause cancer and explain why it is challenging to cure cancer. [15]

**Genetic factors**

1. Gain in function mutation
2. of proto-oncogenes
3. resulting in hyperactive / degradation-resistant / excessive protein
4. causing overstimulation of cell cycle
  
5. Loss of function mutation
6. Of tumour suppressor genes
7. result in non-functional or no protein
8. leading to loss of normal restraints on cell cycle
- 9.

**Environmental factors**

10. Exposure to ultraviolet light
11. Thymine-thymine dimersation
12. causes base-pair mutation
  
13. Ionising radiation / X-ray
14. causes double-strand break
15. leading to chromosomal mutation
  
16. Carcinogenic chemicals
17. causes intercalation of DNA
18. cause base-pair mutation
  
19. Viruses
20. introduces oncogenes / disrupts tumour suppressor genes
21. leading to compromised immune system

**Challenging to cure cancer**

22. Multiple gene mutations / metabolic processes, difficult to rectify
23. Ability to divide indefinitely / obtain nutrients for growth, difficult to restrain growth / spread
24. Located at sites that are difficult for drug access
25. Difficult to differentiate between normal and cancer cells, difficult to target
26. Located in vital tissues / organs, cannot be removed without compromising body function
27. Difficult to fully eradicate, possibility of relapse
28. Symptoms only detectable at late stages, widespread of cancer cells is challenging to remove

- (b) Discuss the role of constituent biomolecules of the cell surface membrane in the movement of substances across the membrane. Explain the need for a variety of transport mechanisms. [10]

**1. Phospholipids**

- 2. Non polar / hydrophobic hydrocarbon tails**
- 3. acts as a barrier**
- 4. to large / polar substances**
- 5. Transient gaps between phospholipid molecules**
- 6. allows for passage of small substances**
- 7. forms vesicles**
- 8. containing substance of large size / quantity**
- 9. Channel / carrier proteins**
- 10. offers hydrophilic pathways**
- 11. to transport specific substances**
- 12. that are small and charged / polar**

**13. Receptor proteins and**

- 14. Coat proteins**
- 15. allows for specificity**
- 16. in transport of substances of large size/ quantity**

**17. Cholesterol**

- 18. fits between phospholipid molecules**
- 19. Restrict movement**
- 20. of small substances**

**A variety of transport mechanisms needed to cater to transport of substances**

- 21. with different shape / charge / size / polarity**
- 22. down or against concentration gradient**
- 23. using a variety of energy source (such a ATP, light and free energy)**
- 24. coupled to other metabolic process (like oxidative phosphorylation)**
- 25. AVP**

[Total: 25]



# RIVER VALLEY HIGH SCHOOL

## YEAR 6 PRELIMINARY EXAMINATION

CANDIDATE  
NAME

CENTRE  
NUMBER

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CLASS

INDEX  
NUMBER

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**H2 BIOLOGY**

**9744/04**

Paper 4 Practical

**28 Aug 2018**

**2 hours 30 minutes**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

### READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your centre number, index number, class and name 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 will lose marks if you do not show your working, or if you do not use appropriate units.

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

Shift	
Laboratory	
For Examiner's Use	
1	/ 22
2	/ 15
3	/ 13
<b>Total</b>	<b>/ 50</b>

This Question Paper consists of **15** printed pages and **1** blank page.

Answer **all** questions.

- 1 Lipase, **E**, catalyses the hydrolysis of triglycerides into fatty acids and glycerol.

The substrate for **E** will be the triglycerides present in milk, labelled **M**.

The end-point of this hydrolysis can be determined by using an indicator, **I**, which changes colour when the fatty acids are produced.

You are required to:

- prepare different concentrations of the lipase solution, **E**
- investigate the effect of different concentrations of **E** on the hydrolysis of triglycerides in milk.

You are provided with:

labelled	contents	hazard	volume / cm <sup>3</sup>
<b>M</b>	milk	none	40
<b>W</b>	distilled water	none	50
<b>I</b>	indicator solution	stains	30
<b>A</b>	solution of alkali	irritant	40
<b>E</b>	5% lipase solution	irritant	50

You are required to dilute the 5% lipase solution, **E**, to provide a range of known concentrations using **simple** dilution.

Decide on the further concentrations of lipase solution you will use in your investigation in addition to the 5% solution.

You will need to prepare 10 cm<sup>3</sup> of each lipase solution.

- (a) (i) Prepare the space below to show the concentration of each lipase solution, the volumes of **E** and the volumes of **W**.

[3]

- (ii) Describe and explain the expected trend in the time taken to reach the end-point as the concentration of lipase solution increases. [2]

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*Before starting the investigation, read through steps 1-8 and prepare a table in (a)(iii).*

**Proceed as follows.**

- 1 Prepare **all** the concentrations of lipase solutions you have listed in (a)(i).
- 2 Put 2 cm<sup>3</sup> of **M** into each test-tube.
- 3 Put 2 cm<sup>3</sup> of **I** into each test-tube containing **M** and gently shake.
- 4 Put 3 cm<sup>3</sup> of **A** into each test-tube containing **M** and **I** and gently shake so that all the mixture turns orange. *Note that the mixtures might be different shades of orange.*
- 5 Put 2 cm<sup>3</sup> of **E** into one of the test-tubes from step 4 and mix well. Wait for 300.0s. This will be the colour of the end-point.
- 6 Repeat step 5 with **all** concentrations of enzyme solution.
- 7 Start the stopwatch.
- 8 Record the time when each end-point is reached. If the time taken to reach end-point for any one concentration is longer than 300.0 seconds, record as 'more than 300.0'.

(iii) Record your results in a suitable table in the space below. [3]

(iv) Calculate the rate of hydrolysis for 5% lipase concentration.  
You should show your working and use appropriate units. [2]

(v) Identify **one** significant source of error in measuring the dependent variable and describe how it affects your results. [2]

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- (vi) Other than enzyme concentration, temperature has significant impact on the rate of lipase hydrolysis.

Suggest how you would modify this investigation to obtain an accurate optimum temperature for the activity of **E**. [3]

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- (b) Some students studied the effect of temperature on the rate of lipase hydrolysis, using a different method that involves determining the presence of triglycerides at various time intervals.

The students' results are shown in Table 1.1.

**Table 1.1**

Temperature / °C	Rate of lipase hydrolysis / mol dm <sup>-3</sup> s <sup>-1</sup>
10	23.0
20	52.0
30	68.5
40	35.0
50	0.5

- (i) Describe a chemical test that can be used to determine the presence of triglyceride in a sample solution. [2]

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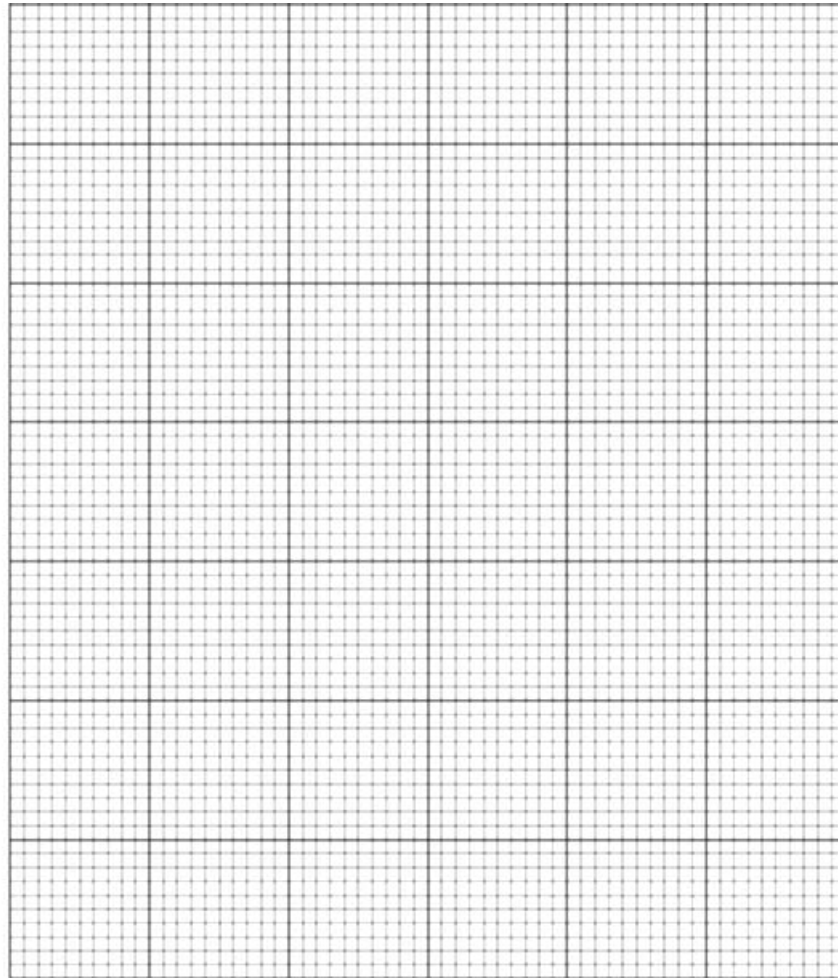
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- (ii) Use the grid to display the results shown in Table 1.1 in an appropriate form.

[3]



- (iii) Explain the decrease in rate of lipase hydrolysis after 30°C.

[2]

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[Total: 22]

- 2 Tuberculosis (TB) is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*. *M. tuberculosis* in the body provokes an immune response, resulting in the production of specific antibodies.

In a test used to detect TB, a modified antibody **A** specific to *M. tuberculosis* is used. Binding of this antibody to *M. tuberculosis* gives rise to an observable result when tested with test reagent **X**.

You are provided with:

- the blood serum of three patients in microfuge tubes labelled **P1**, **P2**, and **P3**
- a suspension of *M. tuberculosis* in a microfuge tube labelled **T**
- distilled water in a microfuge tube labelled **W**
- a solution of the modified antibody in a microfuge tube labelled **A**
- test reagent **X** in a microfuge tube labelled **X**

**You are recommended to wear suitable eye protection and gloves. Any splashes on skin should be washed off immediately.**

You are required to carry out the test and determine the observations associated with a positive test.

You will then test the blood serums and determine which of the patients should be diagnosed with TB.

**You should take care when using the Pasteur pipettes to ensure no cross-contamination of samples and reagents occur.**

**Proceed as follows.**

- 1 Label the wells of the microtiter plate **T**, **W**, **P1**, **P2** and **P3**.
- 2 Add 2 drops of **T** and **W** into the appropriately labelled wells.
- 3 Add two drops of antibody **A** into wells **T** and **W**.
- 4 Add two drops of test reagent **X** into wells **T** and **W**, and leave for 10 seconds.

- (a) Describe your results of testing samples **T** and **W**. [1]

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- 5 Add 2 drops of **P1**, **P2** and **P3** into the appropriately labelled wells.
- 6 Add two drops of antibody **A** into wells **P1**, **P2** and **P3**.
- 7 Add two drops of test reagent **X** into wells **P1**, **P2** and **P3**, and leave for 10 seconds.

(b) Record your results and conclusions in Table 2.1

[2]

**Table 2.1**

sample	observation	Presence of <i>M. tuberculosis</i>
<b>P1</b>		
<b>P2</b>		
<b>P3</b>		

(c) Explain why antibody **A** cannot be used to detect if a patient is infected with other species of bacteria.

[2]

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- (d) Treatment of drug-resistant strains of *M. tuberculosis* requires more than one antibiotic to be used simultaneously. A common treatment involves administering a cocktail solely comprising two component antibiotics, isoniazid and rifampicin.

The relative concentrations of each antibiotic in the cocktail determines its effectiveness. Effective treatment with the cocktail will result in the bacteria being hydrolysed to its constituent biomolecules after 24 hours of exposure.

**Table 2.2**

cocktail number	relative concentration of isoniazid to rifampicin
1	20-80
2	80-20

A student administered two different cocktails, as shown in Table 2.2, on drug-resistant *M. tuberculosis*, before repeating the test in question 2. He found that both cocktails were ineffective in killing the bacteria.

The student hypothesised that the cocktail is only effective when the relative concentration of each antibiotic component is at least 30%.

Design an experiment to determine the cocktail with the most effective relative concentrations of component antibiotics.

In your plan, you must use:

- a suspension of drug-resistant *M. tuberculosis* in a water-bath at 30°C (3 cm<sup>3</sup> of this culture will be required for inoculation of each additional culture)
- a sterile solution of 100% isoniazid
- a sterile solution of 100% rifampicin
- a water-bath at 30°C
- a colourimeter

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

- syringes
- 5 cm<sup>3</sup> microfuge tubes
- timer, e.g. stopwatch
- a biosafety cabinet
- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes and pipette fillers, glass rods, etc.







**3** During this question you will require access to a microscope and slide **S1**.

You are required to use a sharp pencil for drawings.

A blood smear can be used to look for abnormalities in blood cells. Observations made from blood smears allow doctors to diagnose certain blood disorders or other medical conditions.

In a blood smear, mature red blood cells and two categories of white blood cells can be observed clearly. The two categories of white blood cells are lymphocytes and phagocytes.

Mature red blood cells do not have nucleus, but white blood cells contain a nucleus. The shape of lymphocyte's nucleus is round but the shape of phagocyte's nucleus is lobed (dumbbell-shaped, C-shaped etc.).

**(a)** Observe the cells in slide **S1**.

Identify **one** red blood cell and **one** phagocyte.

Use the space provided to draw to the same scale, labelled diagrams of [5]

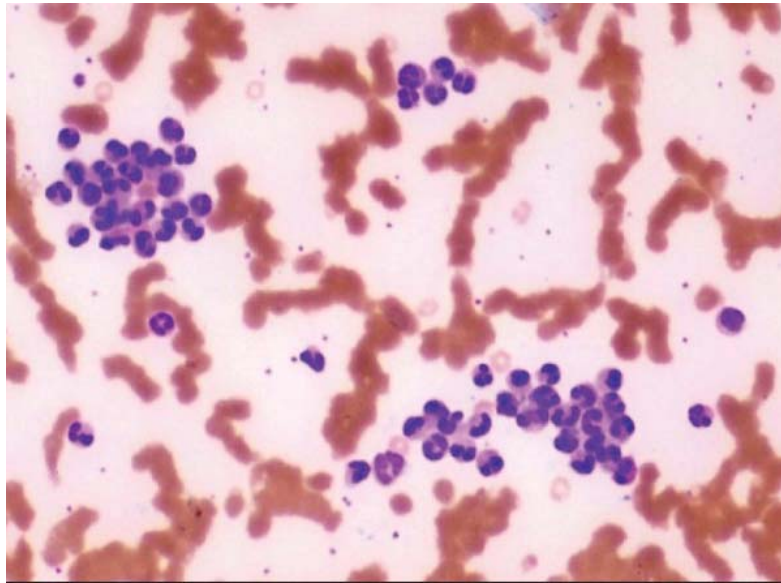
**(i)** a red blood cell,

**(ii)** a phagocyte.

Slide **S1** is a microscope slide with blood smear of individual **A**.

Fig 3.1 is a photomicrograph of a blood smear of individual **B** viewed at x400.

Both blood smears have been stained using the same technique.



**Fig 3.1**

- (b) (i)** Using a suitable form, record observable differences between the blood smear of individual **B** in Fig 3.1 and the individual **A** on slide **S1**. [3]

- (ii)** Individual **B** suffers from pain and shortness of breath. With reference to Fig 3.1, and your own knowledge, suggest reasons for these symptoms. [2]

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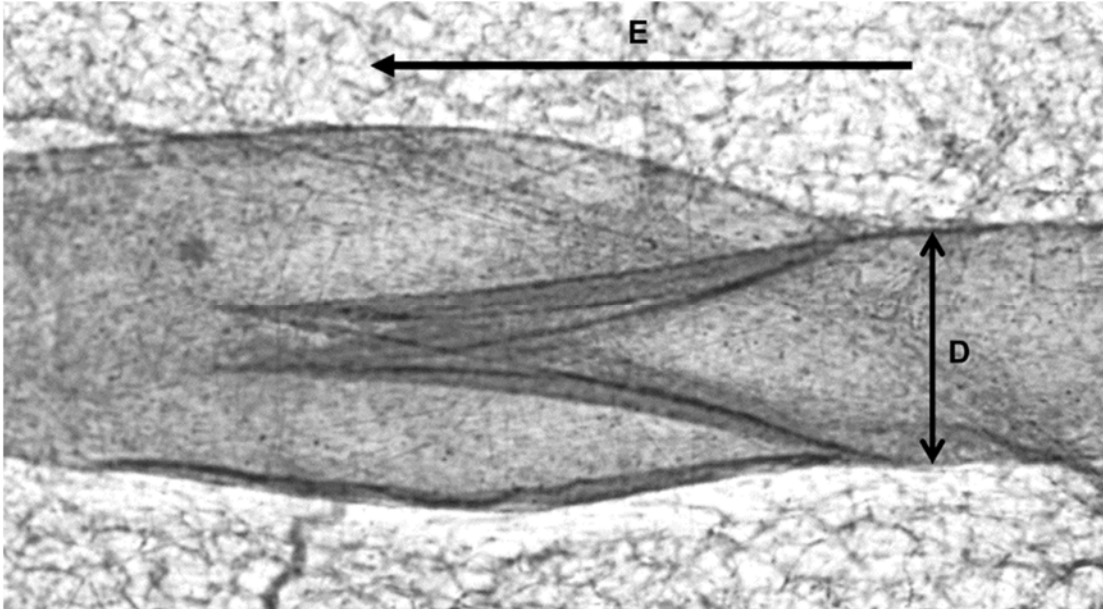
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Lymph is a fluid containing white blood cells, especially lymphocytes, the cells that attack bacteria in the blood. Lymph flows through a network of lymphatic vessels, transporting white blood cells to tissues of the lymphatic system. The lymphatic system includes the bone marrow, thymus and lymph nodes.

Fig 3.2 shows the longitudinal section of a lymphatic vessel with a pair of flap-like structures, known as a valve. Arrow **E** in the photomicrograph shows the direction of lymph flow.

You are not expected to be familiar with this specimen.



X 400.0

**Fig 3.2**

- (c) Calculate the actual diameter of the narrowest region of the lymph vessel, indicated by line **D**. Show your working clearly. [2]

Actual length of lumen: \_\_\_\_\_  $\mu\text{m}$

- (d) With reference to Fig 3.2, describe an observable structural adaptation that allows the lymphatic vessel to transport lymph around the body. [1]

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[Total: 13]

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**2018 RVHS Year 6 Preliminary Examinations  
P4 Confidential Instructions**

Practical Exam	Apparatus (per student)		Materials	
<u>Question 1</u>	2	12 cm <sup>3</sup> syringes	~50 cm <sup>3</sup>	Milk labelled <b>M</b>
	2	6 cm <sup>3</sup> syringes	~60 cm <sup>3</sup>	Distilled water labelled <b>W</b>
	1	500 cm <sup>3</sup> beaker labelled <b>Waste</b>	30 cm <sup>3</sup>	0.1% turmeric solution labelled <b>I</b>
	8	Paper towels	40 cm <sup>3</sup>	0.3% sodium carbonate solution labelled <b>A</b>
	6	Medium plastic vials	50 cm <sup>3</sup>	5% lipase solution labelled <b>E</b>
	6	Test tubes		
	1	Test tube rack		
	1	Stopwatch		
	1	Marker		
<u>Question 2</u>	4x	Pasteur pipettes	1 cm <sup>3</sup>	HCl in each microfuge tube labelled <b>P1, P3, T</b>
	1x	Microtiter plate	1 cm <sup>3</sup>	Distilled water in each microfuge tube labelled <b>P2, W, A</b>
	1x	Permanent marker		Universal indicator in a microfuge tube labelled <b>X</b>
	1x	Microfuge tube rack	1 cm <sup>3</sup>	
<u>Question 3</u>	1x	Ruler	1 x	Microscope slide labelled <b>S1</b> (2 students to 1)
	1x	Microscope (2 Students to 1)		

**Preparation of solutions and reagents**

**M**, at least 40 cm<sup>3</sup> of whole milk in a beaker or container, labelled **M**.  
The milk must be full fat (no fat removed) e.g. cows' or goats' milk.  
This is sufficient for 1 candidate.

**W**, at least 50 cm<sup>3</sup> of distilled water in a beaker or container, labelled **W**.  
This is sufficient for 1 candidate.

**I**, at least 30 cm<sup>3</sup> of 0.1% turmeric solution in a beaker or container, labelled **I**.

This is prepared by putting 0.1 g of turmeric (ground turmeric spice as used in cooking) in 5 cm<sup>3</sup> of 70% ethanol (industrial methylated spirits) in a beaker or container, and stirring to dissolve for 5 minutes. Make up to 100 cm<sup>3</sup> with distilled water. (Ignore residue left in the bottom.)

Turmeric solution may lose its colour with time. It must be prepared **within one hour** of use by candidates, including those candidates who start with **Question 2**.

This is sufficient for 3 candidates.

**A**, at least 40 cm<sup>3</sup> of 0.3% sodium carbonate solution in a beaker or container, labelled **A**.

This is prepared by putting 0.3 g of anhydrous sodium carbonate in 80 cm<sup>3</sup> of distilled water in a beaker and stirring to dissolve. Make up to 100 cm<sup>3</sup> with distilled water.

This is sufficient for 2 candidates.

**E**, at least 50 cm<sup>3</sup> of 5% Lipase solution (supplied by Cambridge) in a beaker or container, labelled **E**.

This is prepared by putting 5 cm<sup>3</sup> of the Lipase enzyme solution into 70 cm<sup>3</sup> of distilled water in a beaker while stirring. Make up to 100 cm<sup>3</sup> with distilled water. It must be prepared **within one hour** of use by candidates, including those candidates who start with **Question 2**.

This is sufficient for 2 candidates.



# RIVER VALLEY HIGH SCHOOL

## YEAR 6 PRELIMINARY EXAMINATION

CANDIDATE  
NAME

CENTRE  
NUMBER

S				
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CLASS

INDEX  
NUMBER

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**H2 BIOLOGY**

**9744/04**

Paper 4 Practical

**28 Aug 2018**

**2 hours 30 minutes**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

### READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your centre number, index number, class and name 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 will lose marks if you do not show your working, or if you do not use appropriate units.

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

<b>Shift</b>	
<b>Laboratory</b>	
<b>For Examiner's Use</b>	
<b>1</b>	<b>/ 22</b>
<b>2</b>	<b>/ 15</b>
<b>3</b>	<b>/ 13</b>
<b>Total</b>	<b>/ 50</b>

Answer **all** questions.

- 1 Lipase, **E**, catalyses the hydrolysis of triglycerides into fatty acids and glycerol.

The substrate for **E** will be the triglycerides present in milk, labelled **M**.

The end-point of this hydrolysis can be determined by using an indicator, **I**, which changes colour when the fatty acids are produced.

You are required to:

- prepare different concentrations of the lipase solution, **E**
- investigate the effect of different concentrations of **E** on the hydrolysis of triglycerides in milk.

You are provided with:

labelled	contents	hazard	volume / cm <sup>3</sup>
<b>M</b>	milk	none	40
<b>W</b>	distilled water	none	50
<b>I</b>	indicator solution	stains	30
<b>A</b>	solution of alkali	irritant	40
<b>E</b>	5% lipase solution	irritant	50

You are required to dilute the 5% lipase solution, **E**, to provide a range of known concentrations using **simple** dilution.

Decide on the further concentrations of lipase solution you will use in your investigation in addition to the 5% solution.

You will need to prepare 10 cm<sup>3</sup> of each lipase solution.

- (a) (i) Prepare the space below to show the concentration of each lipase solution, the volumes of **E** and the volumes of **W**.

[3]

**Table showing dilution of E**

<b>Concentration of lipase solution / %</b>	<b>Volume of E / cm<sup>3</sup></b>	<b>Volume of W / cm<sup>3</sup></b>
1	2.0	8.0
2	4.0	6.0
3	6.0	4.0
4	8.0	2.0
5	10.0	0.0

Shows at least 5 linear dilutions of equal intervals for lipase solution

Correct volumes of E

Correct volumes of W

- (ii) Describe and explain the expected trend in the time taken to reach the end-point as the concentration of lipase solution increases. [2]
1. As concentration of lipase increases, time taken to reach end-point decreases
  2. More lipase-triglyceride / enzyme-substrate complex formed per unit time
  3. More fatty acids formed per unit time

*Before starting the investigation, read through steps 1-8 and prepare a table in (a)(iii).*

**Proceed as follows.**

- 1 Prepare **all** the concentrations of lipase solutions you have listed in (a)(i).
- 2 Put 2 cm<sup>3</sup> of **M** into each test-tube.
- 3 Put 2 cm<sup>3</sup> of **I** into each test-tube containing **M** and gently shake.
- 4 Put 3 cm<sup>3</sup> of **A** into each test-tube containing **M** and **I** and gently shake so that all the mixture turns orange. *Note that the mixtures might be different shades of orange.*
- 5 Put 2 cm<sup>3</sup> of **E** into one of the test-tubes from step 4 and mix well. Wait for 300.0s. This will be the colour of the end-point.
- 6 Repeat step 5 with **all** concentrations of enzyme solution.
- 7 Start the stopwatch.
- 8 Record the time when each end-point is reached. If the time taken to reach end-point for any one concentration is longer than 300.0 seconds, record as 'more than 300.0'.

(iii) Record your results in a suitable table in the space below.

[3]

**Table showing effect of lipase concentration on time taken to reach end-point**

Concentration of lipase solution / %	Time taken to reach end-point / s
1	200.1
2	135.2
3	86.4
4	52.3
5	37.3

Correct heading with units

Whole number for lipase concentration; 1 dp for time

Shortest time for 5% lipase and longest time for lowest lipase concentration

(iv) Calculate the rate of hydrolysis for 5% lipase concentration.

You should show your working and use appropriate units.

[2]

Rate of hydrolysis for 5% lipase concentration

$$= \frac{1}{37.3}$$

$$= 0.0268 \text{ s}^{-1}$$

1. Working showing  $\frac{1}{\text{time}}$

2. Correct calculation and units

(v) Identify **one** significant source of error in measuring the dependent variable and describe how it affects your results. [2]

1. Visual determination of colour of end-point is subjective
2. May result in over- or under- estimation of time taken to reach end-point

1. Reaction in some test-tubes have started before starting the stopwatch
2. May result in underestimation of time taken to reach end-point

(vi) Other than enzyme concentration, temperature has significant impact on the rate of lipase hydrolysis.

Suggest how you would modify this investigation to obtain an accurate optimum temperature for the activity of **E**. [3]

1. (Equilibrate) **M, I, A** and **E** in (thermostatically-controlled) water bath set to 10, 20, 30, 40 and 50°C
2. Determine end point using a pH sensor connected to a datalogger
3. Repeat experiment by narrowing intervals for temperatures with shorter time taken to reach end-point

**OR**

Plot of graph of data points and identify the temperature that corresponds to the shortest time taken to reach end point

- (b) Some students studied the effect of temperature on the rate of lipase hydrolysis, using a different method that involves determining the presence of triglycerides at various time intervals.

The students' results are shown in Table 1.1.

**Table 1.1**

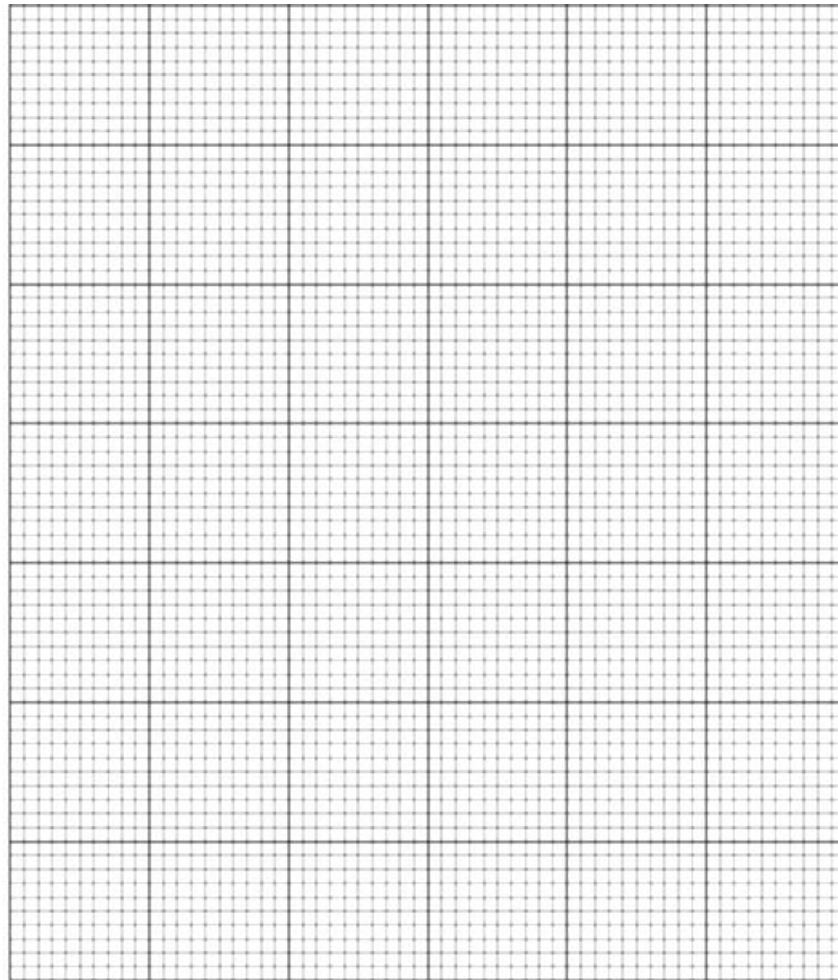
Temperature / °C	Rate of lipase hydrolysis / mol dm <sup>-3</sup> s <sup>-1</sup>
10	23.0
20	52.0
30	68.5
40	35.0
50	0.5

- (i) Describe a chemical test that can be used to determine the presence of triglyceride in a sample solution. [2]

1. Add equal volumes of sample solution and ethanol
2. (Shake vigorously and) centrifuge mixture
3. Decant top ethanol layer into (equal) volume of water
4. If triglyceride were present, white emulsion is observed

- (ii) Use the grid to display the results shown in Table 1.1 in an appropriate form.

[3]



1. HU: Correct heading with units for both axes
2. P: Accurate plot points
3. C: Smooth and best-fit curve

- (iii) Explain the decrease in rate of lipase hydrolysis after 30°C.

[2]

1. Increase in kinetic energy
2. breaks hydrogen bonds and hydrophobic interactions in lipase
3. causing active site to lose its three dimension conformation
4. Lipase is denatured

[Total: 22]

- 2 Tuberculosis (TB) is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*. *M. tuberculosis* in the body provokes an immune response, resulting in the production of specific antibodies.

In a test used to detect TB, a modified antibody **A** specific to *M. tuberculosis* is used. Binding of this antibody to *M. tuberculosis* gives rise to an observable result when tested with test reagent **X**.

You are provided with:

- the blood serum of three patients in microfuge tubes labelled **P1**, **P2**, and **P3**
- a suspension of *M. tuberculosis* in a microfuge tube labelled **T**
- distilled water in a microfuge tube labelled **W**
- a solution of the modified antibody in a microfuge tube labelled **A**
- test reagent **X** in a microfuge tube labelled **X**

**You are recommended to wear suitable eye protection and gloves. Any splashes on skin should be washed off immediately.**

You are required to carry out the test and determine the observations associated with a positive test.

You will then test the blood serums and determine which of the patients should be diagnosed with TB.

**You should take care when using the Pasteur pipettes to ensure no cross-contamination of samples and reagents occur.**

**Proceed as follows.**

- 1 Label the wells of the microtiter plate **T**, **W**, **P1**, **P2** and **P3**.
- 2 Add 2 drops of **T** and **W** into the appropriately labelled wells.
- 3 Add two drops of antibody **A** into wells **T** and **W**.
- 4 Add two drops of test reagent **X** into wells **T** and **W**, and leave for 10 seconds.

**(a)** Describe your results of testing samples **T** and **W**. [1]

1. **T** – red colour observed
2. **W** – green colour observed;

- 5 Add 2 drops of **P1**, **P2** and **P3** into the appropriately labelled wells.
- 6 Add two drops of antibody **A** into wells **P1**, **P2** and **P3**.
- 7 Add two drops of test reagent **X** into wells **P1**, **P2** and **P3**, and leave for 10 seconds.

(b) Record your results and conclusions in Table 2.1

[2]

**Table 2.1**

sample	observation	Presence of <i>M. tuberculosis</i>
<b>P1</b>	mixture turned red	present
<b>P2</b>	mixture remained green	absent
<b>P3</b>	mixture turned red	present

1. Correct observations
2. Correct conclusions

(c) Explain why antibody **A** cannot be used to detect if a patient is infected with other species of bacteria.

[2]

1. Other species of bacteria will have different antigens / lack the antigens (of *M. tuberculosis*)
2. Antibody **A** cannot bind to the antigen / is specific to *M. tuberculosis* antigen
3. will always show a negative result

- (d) Treatment of drug-resistant strains of *M. tuberculosis* requires more than one antibiotic to be used simultaneously. A common treatment involves administering a cocktail solely comprising two component antibiotics, isoniazid and rifampicin.

The relative concentrations of each antibiotic in the cocktail determines its effectiveness. Effective treatment with the cocktail will result in the bacteria being hydrolysed to its constituent biomolecules after 24 hours of exposure.

**Table 2.2**

cocktail number	relative concentration of isoniazid to rifampicin
1	20-80
2	80-20

A student administered two different cocktails, as shown in Table 2.2, on drug-resistant *M. tuberculosis*, before repeating the test in question 2. He found that both cocktails were ineffective in killing the bacteria.

The student hypothesised that the cocktail is only effective when the relative concentration of each antibiotic component is at least 30%.

Design an experiment to determine the cocktail with the most effective relative concentrations of component antibiotics.

In your plan, you must use:

- a suspension of drug-resistant *M. tuberculosis* in a water-bath at 30°C (3 cm<sup>3</sup> of this culture will be required for inoculation of each additional culture)
- a sterile solution of 100% isoniazid
- a sterile solution of 100% rifampicin
- a water-bath at 30°C
- a colourimeter

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

- syringes
- 5 cm<sup>3</sup> microfuge tubes
- timer, e.g. stopwatch
- a biosafety cabinet
- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes and pipette fillers, glass rods, etc.

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary

- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[10]

### Mark Scheme

#### Independent variable:

1. States that independent variable is relative concentration of component antibiotics and uses at least uniformly-spaced relative concentrations

#### Dependent variable:

2. Intensity of red/green colouration of reaction mixture

#### Controlled variables:

3. Ref. to controlling temperature at 30°C with thermostatically controlled water-bath
4. Identify and describe another variable to be controlled

#### Scientific Theory and Reasoning:

5. Explains that hydrolysed bacteria do not have antigens for antibody **A** to bind to

#### Method:

6. Shows how to perform a simple dilution to obtain the specified relative concentrations
7. Use of colourimeter (to obtain absorbance values)
8. Describe how to determine the cocktail with most effective relative concentrations of antibiotics

#### Reliability:

9. Performs at least two more repeats and replicates with new reagents

#### Accuracy:

10. Repeating with decreased intervals of relative concentrations to obtain more data to achieve experimental aim

#### Control:

11. Perform a negative control with cocktail replaced with equivolume of distilled water
-

Recording:

12. Shows how results are to be presented in the form of a table with IV and DV in appropriate column/rows

Risk/safety:

13. Refers to use of a biosafety cabinet in performing the procedure / Test reagents (**X, A**) are irritants, wear goggles and gloves to prevent contact / Antibiotics may cause allergic reactions, wear goggles and gloves to prevent contact

#### SAMPLE REPORT

Aim	To investigate the most effective relative concentrations of isoniazid to rifampicin to treat tuberculosis
Independent variable	Relative concentrations of isoniazid to rifampicin - 70-30, 60-40, 50-50, 40-60, 30-70
Dependent variable	Intensity of green colouration of reaction mixture
Controlled variable	1. Temperature of thermostatically-controlled water-bath – 30°C
	2. Volume of drug administered – 0.5 cm <sup>3</sup>
	3. Volume of drug-resistant <i>M. tuberculosis</i> culture – 3 cm <sup>3</sup>
	4. Duration of incubation – 24 hours

#### Scientific Theory and Reasoning

Effective treatment with the antibiotic cocktail results in the *M. tuberculosis* being hydrolysed to its constituent biomolecules. The hydrolysed bacteria do not have antigens for antibody **A** to bind to, and when tested with antibody **A** and test reagent **X**, the reaction mixture will remain green.

1. Perform a simple dilution to obtain different relative concentrations of antibiotics to the dilution table shown below.

Table showing dilution of component antibiotics

Drug	Relative concentrations of isoniazid to rifampicin	Volume of drug prepared / cm <sup>3</sup>	Volume of 100% isoniazid added / cm <sup>3</sup>	Volume of 100% rifampicin added / cm <sup>3</sup>
3	70-30	5.0	3.5	1.5
4	60-40	5.0	3.0	2.0
5	50-50	5.0	2.5	2.5
6	40-60	5.0	2.0	3.0
7	30-70	5.0	1.5	3.5

2. Perform all experiments in a biosafety cabinet.
3. To a microfuge tube, add 1 cm<sup>3</sup> of drug D1. Label this tube "Drug D1".

4. Repeat step 3, replacing the 1 cm<sup>3</sup> of drug D1 with the drugs containing different relative concentrations of isoniazid and rifampicin. Label the tubes accordingly.
5. Add 3 cm<sup>3</sup> of the drug-resistant *M. tuberculosis* into each of the tubes.
6. Incubate the bacteria in a thermostatically-controlled water bath set at 30°C for 24 hours.
7. After incubation, label the wells of a microtiter plate. Test sample from drug D1 with antibody **A** and test reagent **X**.
8. After 1 minute, place 1 cm<sup>3</sup> of reaction mixture into a cuvette, and measure the intensity of green colouration with the colourimeter. Record the absorbance values
9. Repeat steps 7-8 for the remaining samples tested.
10. Performs two replicates and repeat the experiment twice with new reagents.
11. After determining the relative concentration of component antibiotics that is most effective in killing *M. tuberculosis*, decrease the intervals of relative concentrations tested for more accurate determination of the relative concentration of component antibiotics needed to achieve the experimental aim.
12. The cocktail with the most effective relative concentration of antibiotics will result in a reaction mixture with the highest intensity of green colouration.

Table showing the effect of relative antibiotic concentrations on absorbance of reaction mixture

Relative concentrations of isoniazid to rifampicin	Absorbance, A			
	$A_1$	$A_2$	$A_3$	$\bar{A}$
70-30				
60-40				
50-50				
40-60				
30-70				

Risk Assessment:

1. *M. tuberculosis* is infectious. Perform experiment in a biosafety cabinet.
2. *M. tuberculosis* is infectious. Wear gloves and goggles to avoid contact with the bacterium.
3. Isoniazid and rifampicin may trigger allergic reactions. Wear gloves and goggles to avoid contact with the antibiotics.
4. Test reagent **X** is an irritant. Wear gloves and goggles to avoid contact with the test reagent.

[Total: 15]

3 During this question you will require access to a microscope and slide **S1**.

You are required to use a sharp pencil for drawings.

A blood smear can be used to look for abnormalities in blood cells. Observations made from blood smears allow doctors to diagnose certain blood disorders or other medical conditions.

In a blood smear, mature red blood cells and two categories of white blood cells can be observed clearly. The two categories of white blood cells are lymphocytes and phagocytes.

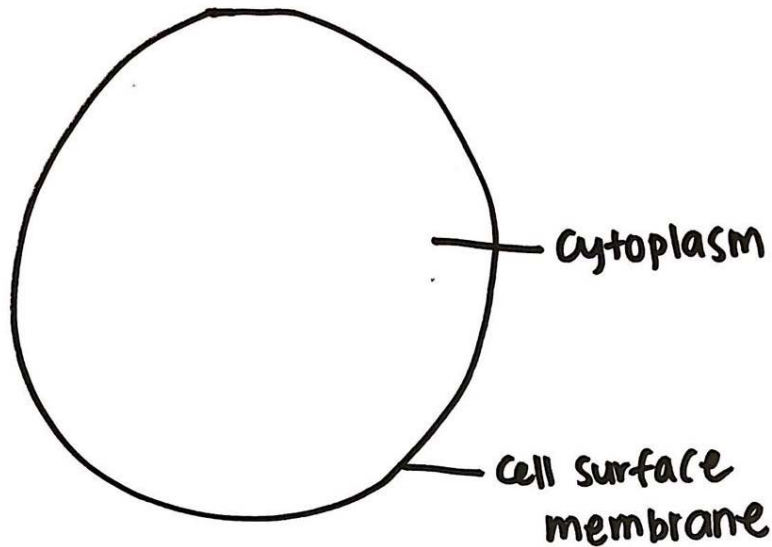
Mature red blood cells do not have nucleus, but white blood cells contain a nucleus. The shape of lymphocyte's nucleus is round but the shape of phagocyte's nucleus is lobed (dumbbell-shaped, C-shaped etc.).

(a) Observe the cells in slide **S1**.

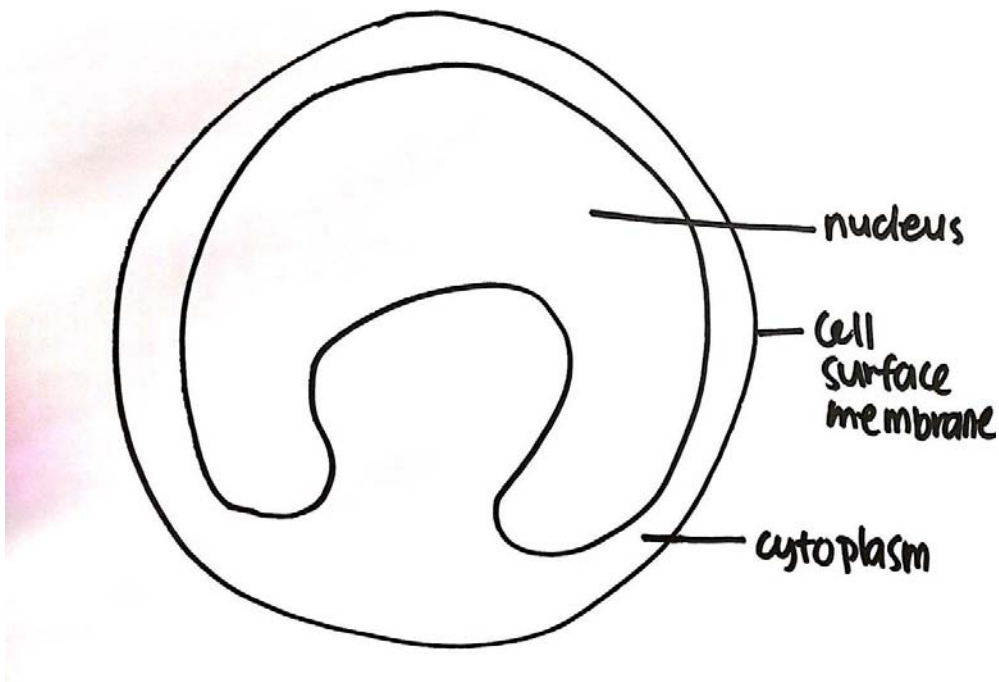
Identify **one** red blood cell and **one** phagocyte.

Use the space provided to draw to the same scale, labelled diagrams of [5]

(i) a red blood cell,



(ii) a phagocyte.



Correct cells drawn – RBC – cell without nucleus

Correct cells drawn – Phagocyte – cell with nucleus

Proportions – Red blood cell smaller than phagocyte

Two correct labels – Cell surface membrane, cytoplasm, nucleus

Continuous clear lines

Slide **S1** is a microscope slide with blood smear of individual **A**.

Fig 3.1 is a photomicrograph of a blood smear of individual **B** viewed at x400.

Both blood smears have been stained using the same technique.

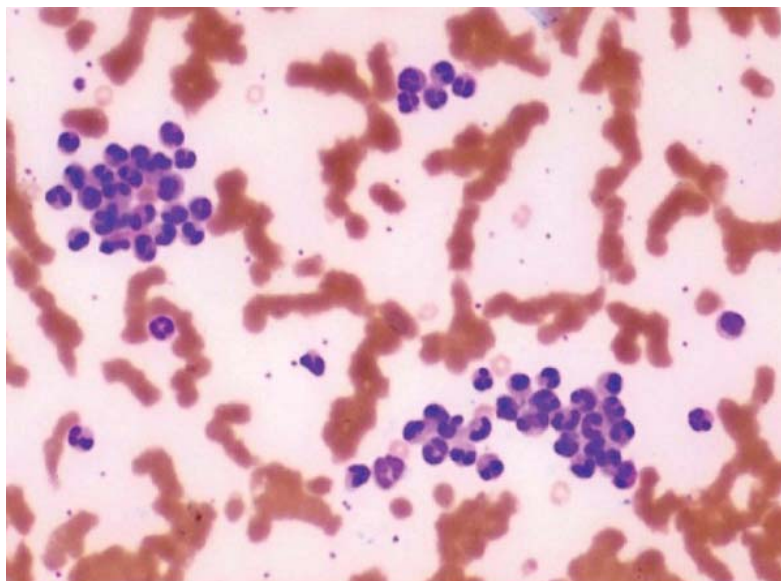


Fig 3.1

- (b) (i) Using a suitable form, record observable differences between the blood smear of individual **B** in Fig 3.1 and the individual **A** on slide **S1**. [3]

**Table showing the observable difference between Fig 3.2 and S1**

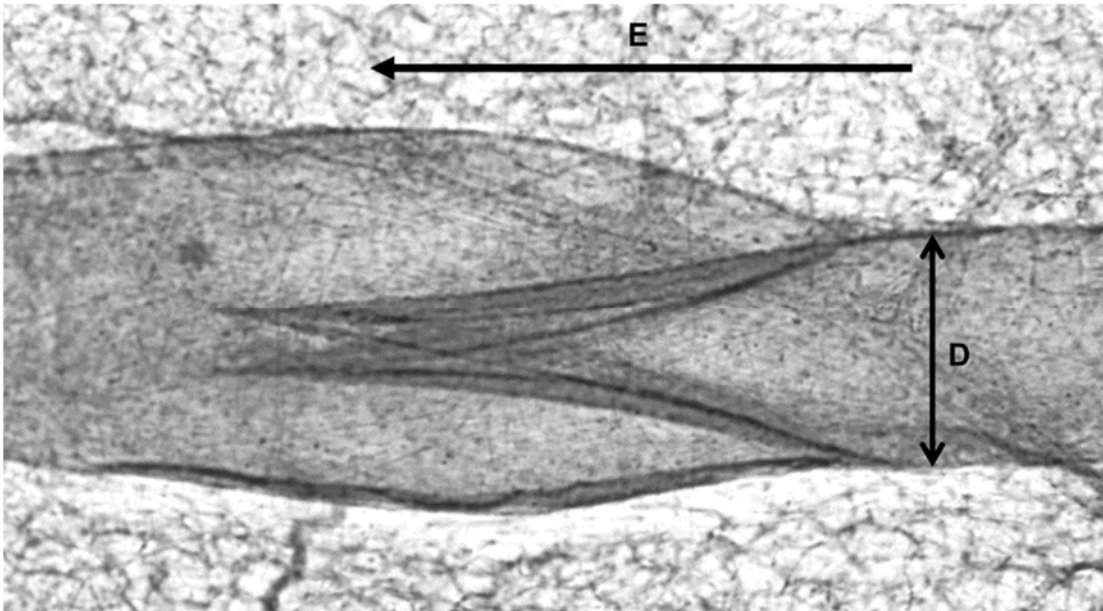
Feature	Fig 3.2	S1
Number of WBC/cells with nucleus	More WBC	Lesser WBC
Clustering of white blood cell	Yes	No
Clustering of red blood cell	Yes	No

- (ii) Individual **B** suffers from pain and shortness of breath. With reference to Fig 3.1, and your own knowledge, suggest reasons for these symptoms. [2]
1. Red blood cell obstruct oxygen transport leading to organ damage
  2. Red blood cells accumulate in the spleen (for destruction), leading to enlargement of spleen
  3. Red blood cell haemolyse easily, resulting in anaemia
  4. Possible inflammation event where cytokines are release, leading to pain

Lymph is a fluid containing white blood cells, especially lymphocytes, the cells that attack bacteria in the blood. Lymph flows through a network of lymphatic vessels, transporting white blood cells to tissues of the lymphatic system. The lymphatic system includes the bone marrow, thymus and lymph nodes.

Fig 3.2 shows the longitudinal section of a lymphatic vessel with a pair of flap-like structures, known as a valve. Arrow **E** in the photomicrograph shows the direction of lymph flow.

You are not expected to be familiar with this specimen.



X 400.0

Fig 3.2

- (c) Calculate the actual diameter of the narrowest region of the lymph vessel, indicated by line **D**. Show your working clearly. [2]

**Actual length = Image size/magnification**

**Actual length = [Image size (measure after printing)/400.0] x 10<sup>4</sup>**

**77.5 (Image size 3.1) or 75 (Image size 3.0)**

Actual diameter : \_\_\_\_\_ μm

- (d) With reference to Fig 3.2, describe an observable structural adaptation that allows the lymphatic vessel to transport lymph around the body. [1]

1. **Has a lumen which can be filled lymph**
2. **Has valves/muscular flaps which does not allow blood to flow in the opposite direction/blackflow of blood**

[Total: 13]

