RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION II

CANDIDATE NAME											
CENTRE NUMBER	S					CLASS		INDEX NUMBER			

H2 BIOLOGY **9744/01**

Paper 1 Multiple Choice **22 Sep 2017**

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.

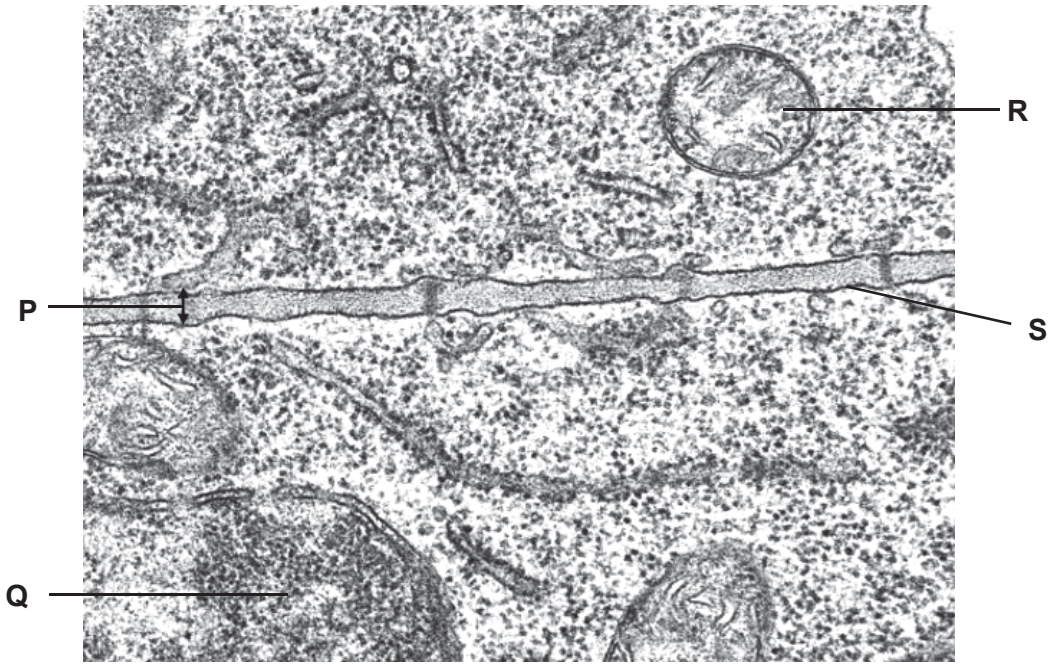
There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C**, and **D**.
Choose the one you consider correct and record your choice **in soft pencil** on the separate Answer Sheet.

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 **20** printed pages.

1 The figure below shows an electron micrograph with two plant cells.



Peter v. Sengbusch - b-online@botanik.uni-hamburg.de

Which of the following statements correctly describes the labelled structures?

1 **R** contains circular DNA and is found in both prokaryotic and eukaryotic cells.

2 **P** has a fluid mosaic structure and regulates the movement of substances between the two plant cells.

3 **S** acts as a selective permeable barrier.

4 **Q** contains enzymes which play an important role in cell specialisation.

A 1 and 3

B 3 and 4

C 1, 2 and 3

D All of the above

2 Which of the following statements regarding stem cells are not correct?

1 Stem cells are present within various organs of the adult body.

2 Stem cells can develop into a whole organism when implanted into the womb.

3 Stem cells can be grown indefinitely in culture under appropriate culture conditions.

4 Stems cells isolated from a 3-5 day old human embryo can differentiate into only one kind of cells.

5 Induced pluripotent stem cells have the same developmental potential as embryonic stem cells.

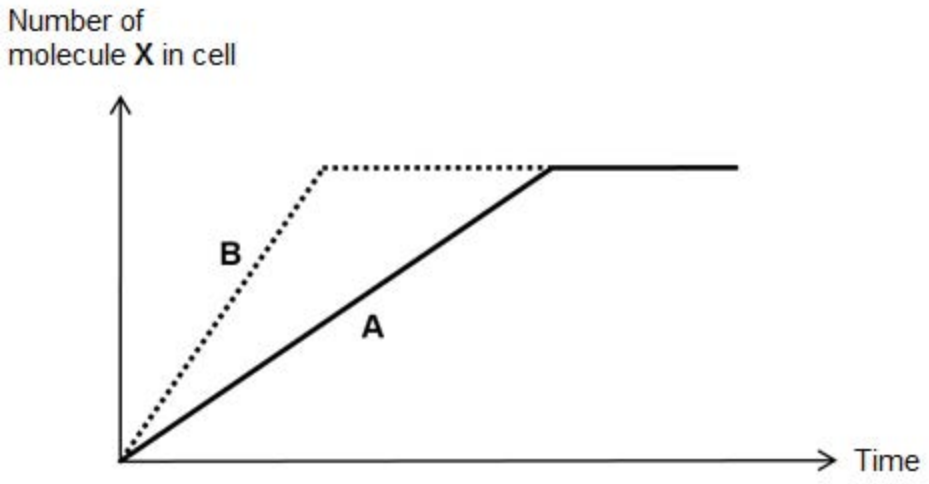
A 1 and 3 only

B 2 and 4 only

C 2, 3 and 5

D 1, 2 and 3

3 Graph **A** shows the transport of molecule **X**, with the help of carrier proteins, over time.



A student predicted that the alteration of one variable would result in graph **B**.

Which row shows the correct transport process and the alteration in variable that would result in graph **B**?

	transport process	**alteration resulting in graph B**
A	facilitated diffusion	increase in environmental temperature to 90 °C
B	active transport	increase in concentration of **X** in cell
C	facilitated diffusion	increase in number of carrier proteins
D	active transport	increase in availability of ATP

4 A student prepared three solutions of sugars, **X**, **Y** and **Z**, and diluted them to varying concentrations. A sample of each was heated with Benedict's reagent, with or without prior acid hydrolysis. The results are shown below.

	concentration of solution/moldm^{-3}					
	0.0001		0.001		0.01	
	no acid	with acid	no acid	with acid	no acid	with acid
X	Blue solution	Blue solution	Green mixture	Green mixture	Orange mixture	Orange mixture
Y	Blue solution	Green mixture	Blue solution	Green mixture	Blue mixture	Orange mixture
Z	Blue solution	Green mixture	Green mixture	Green mixture	Orange mixture	Orange mixture

Based on the results, which of the following conclusions are not correct?

A Solution **Y** does not consist of monosaccharides.

B Solution **X** and solution **Y** consists of disaccharides only.

C Solution **X** consists of monosaccharides only.

D Solution **Z** contains disaccharides.

5 The R groups of two amino acids are shown below.

amino acid	R group
Serine	$-CH_2-OH$
Alanine	$-CH_3$

When placed in aqueous medium, where in a globular protein will these amino acids be found?

A Both serine and alanine will be found in the interior of the globular protein.

B Both serine and alanine will be found on the exterior of the globular protein.

C Alanine will be found in the interior, and serine on the exterior of the globular protein.

D Alanine will be found on the exterior, and serine in the interior of the globular protein.

6 The equations below show the relationship between an enzyme (**E**) and its substrate (**S**), product (**P**) and an inhibitor (**I**).

Pathway **A**: **E** + **S** → **E** + **P**

Pathway **B**: **E** + **S** + **I** → **E** + **S** + **I**

In the above reactions, assume that

- increasing the concentration of **S** increases the activity of the enzyme,
- at low substrate concentrations the presence of **I** reduces rate of reaction velocity, and
- the same maximum rate of reaction can be reached in the presence or absence of **I**.

Which mechanism is operating in pathway **B**?

A Positive feedback

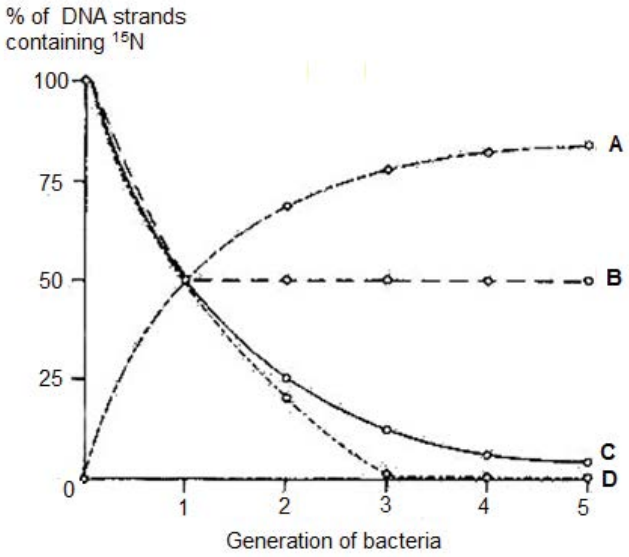
B Negative feedback

C Competitive inhibition

D Non-competitive inhibition

7 Bacteria were cultured in a medium containing heavy nitrogen (^{15}N) until all their DNA were labelled. These bacteria were then grown in a medium containing only light nitrogen (^{14}N) for five generations. The percentage DNA strands containing ^{15}N in each generation was estimated.

Which curve provides evidence that each daughter DNA molecule produced consists of a parental strand and a newly synthesised daughter strand?



8 Part of the amino acid sequence in β-globin chains of normal and mutant haemoglobin are shown.

Normal haemoglobin	thr-pro-glu-glu
Mutant haemoglobin	thr-pro-val-glu

Possible mRNA codons for these amino acids are

Glutamine (glu)	GAA GAG
Threonine (thr)	ACU ACC
Proline (pro)	CCU CCC
Valine (val)	GUA GUG

Which tRNA molecule is not involved in the formation of this part of amino acid sequence in mutant haemoglobin?

A

B

C

D

9 Tay-Sachs disease is characterised by abnormal accumulation of lipid-related compounds, which results in deterioration of cognitive and motor abilities.

It is caused by an autosomal recessive mutation in the allele coding for hexosaminidase A (HEXA), an enzyme that regulates the metabolism of phospholipids.

The base triplets in part of the coding DNA sequences for a normal HEXA allele and a mutant Tay-Sachs allele, as well as their corresponding amino acids are shown.

Normal HEXA allele	CGT Arg	ATA Ile	TCC Ser	TAT Tyr	GCC Gly	CCT Pro	GAC… Asp	
Tay-Sachs allele	CGT Arg	ATA Ile	TCT Ser	ATC Ile	CTA Leu	TGC Cys	CCC Pro	TGA… Thr

Which combination correctly describes the nature of mutation that results in the Tay-Sachs allele?

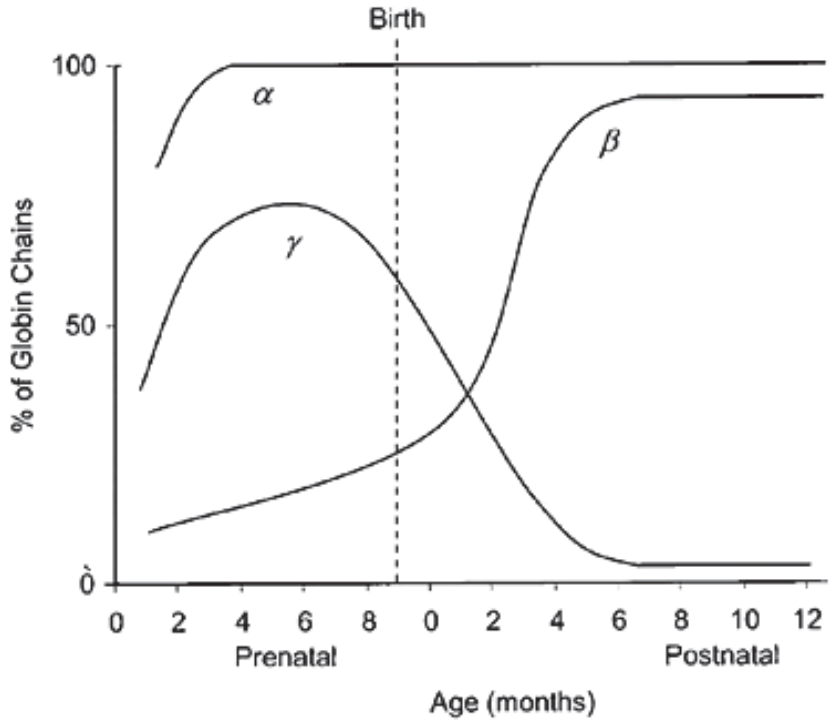
	changes to nucleotide sequences	**alteration of reading frame**	**length of polypeptide**
A	Deletion of 2 bases	Yes	Shorter
B	Insertion of 2 bases	Yes	Longer
C	Substitution of 4 bases	No	Unchanged
D	Insertion of 4 bases	Yes	Longer

10 Which row correctly identifies the characteristics of the human genome?

	promoter	**histone proteins bound to DNA**	**centromeres**	**repeated sequences**
A	Multiple	Always	Position varies for every chromosome	Absent
B	One	Always	Position varies for every bivalent	Present
C	Multiple	Sometimes	Position varies for every bivalent	Present
D	One	Sometimes	Position varies for every chromosome	Absent

11 The globin gene family in humans consists of α, β and γ genes. These genes code for the globin chains that make up haemoglobin and are expressed at different levels during different developmental stages.

The graph shows the expression of the various globin chains during the prenatal (fetal) and postnatal (after birth) periods.



Which of the following cannot account for the differences in the levels of expression of globin chains?

A Methyl groups are added to regulatory sequences of γ-globin genes during the postnatal period, allowing for some proteins to bind.

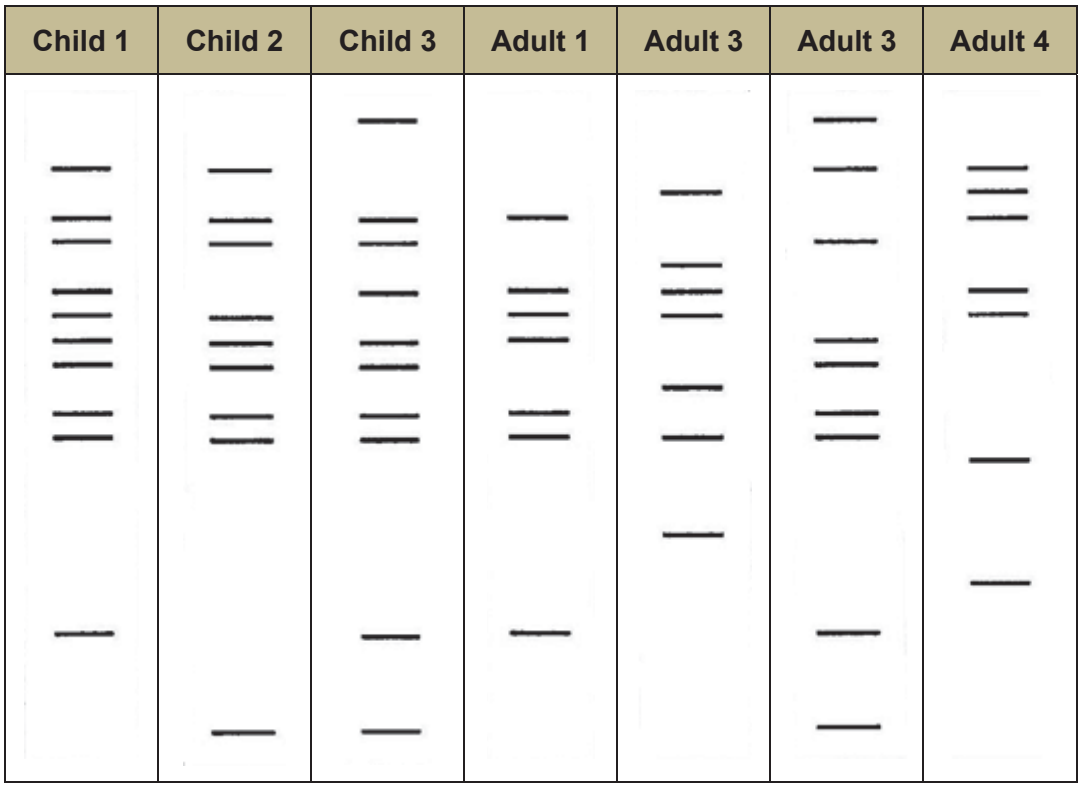
B A growth factor triggers the expression of a transcription factor that increases the rate of β-globin gene expression during the postnatal period.

C Alternative splicing occurs in the mature mRNA of the α-globin and β-globin genes, resulting in differences in the rate of expression of globin chains during the prenatal period.

D The shortening of poly(A) tail in the mRNA of globin genes reduces its stability, resulting in a decrease in the rate of expression of γ-globin chains during the postnatal period.

12 Seven skeletons were found in an unidentified grave. To establish the relationship between these seven individuals, DNA were isolated from these skeletons and then analysed using gel electrophoresis.

The results obtained from the skeletons, three children and four adults, are shown below.



Other analysis showed that all three children have the same parents. Which two adults may be the parents of these children?

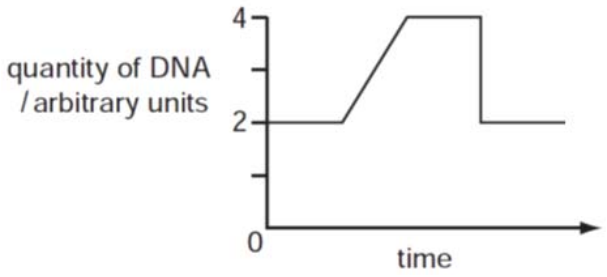
A Adults 1 and 2

B Adults 1 and 3

C Adults 2 and 3

D Adults 2 and 4

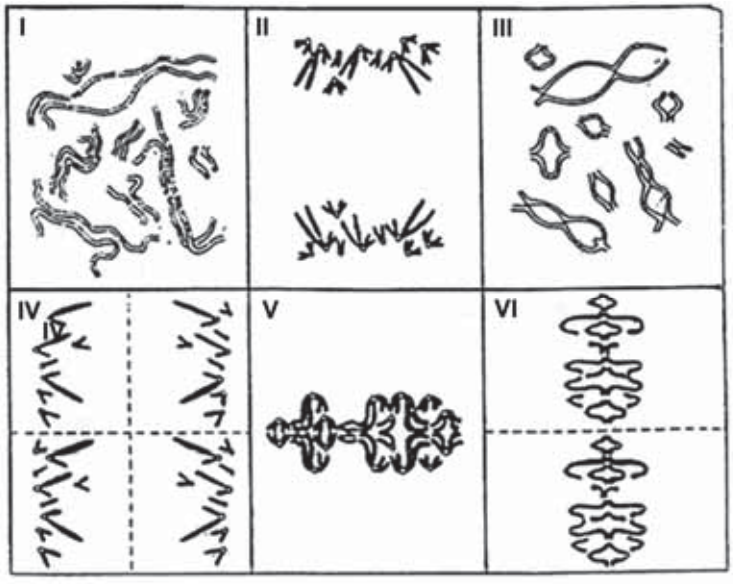
13 The graph shows the change in the quantity of DNA in a cell with one pair of chromosomes during a cell division.



Which nucleus is formed as a result of this division?

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

14 The diagram depicts the behaviour of chromosomes at various stages of meiosis of the same cell.



Which of the following shows the correct order of the stages?

A **III → V → II → VI → IV → I**

B **III → I → V → II → VI → IV**

C **II → III → I → V → VI → IV**

D **I → III → V → II → VI → IV**

15 Which of the following are necessary for tumourgenesis to occur?

1 Gain of function mutation to proto-oncogenes

2 Loss of function mutation of tumour suppressor genes

3 Inactivation of telomerase enzymes preventing cell apoptosis

4 Production of chemical factors that induce angiogenesis

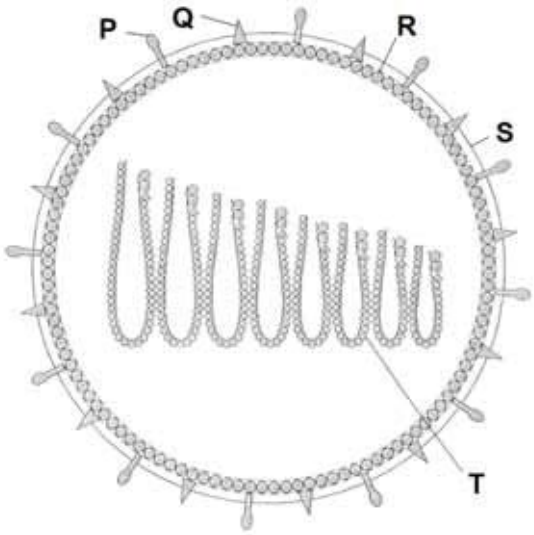
A 1 only

B 1 and 2 only

C 1, 2 and 3 only

D All of the above

16 The diagram shows the structure of an influenza virus.



Which of the following statements concerning the lettered components are correct?

1 Mutations that disrupt the function of **R** will result in the inability of the virus to initiate infection in the host cell.

2 **P** and **Q** are unlikely targets for vaccination because they undergo mutation constantly.

3 New influenza viruses acquire **S** from host cell during budding.

4 The host cell enzymes are not required to form the complementary RNA from **T**.

A 1 and 2 only

B 3 and 4 only

C 1, 2 and 3

D 2, 3 and 4

17 Which statements about viruses are true?

1 They encode genes for synthesising their own ATP.

2 They are single-cell organisms.

3 They can have genomes made of DNA.

4 They package ribosomes into their virion.

5 They can have a single-stranded or double-stranded RNA genomes.

6 They can have a membrane-like envelope.

A 5 and 6 only

B 3, 5 and 6

C 1, 3, 5 and 6

D All of the above

18 Which of the following statements about the *lac* operon are correct?

1 *lac Z*, *lac Y* and *lac A* are structural genes that will be expressed when the operator is switched on.

2 In the absence of alloactose, the repressor protein will be unable to bind to the operator.

3 When glucose and lactose are available and the repressor becomes inactive as allolactose binds to it.

4 *lac Y* codes for a protein that increases uptake of lactose from environment.

5 Catabolite activator protein binds to promoter to increase rate of transcription.

A 1 and 2

B 1 and 3

C 1, 2 and 5

D 3, 4 and 5

19 A black-haired female rabbit was crossed with a white-haired male rabbit. Eight offspring were born. Two were white-haired males, two were white-haired females and all the others were black-haired females.

What can be deduced about the inheritance of hair colour in rabbits?

A Hair colour is sex-linked in rabbits.

B The allele for black hair is dominant to the allele for white hair.

C The allele for white hair is dominant to the allele for black hair.

D The results of this cross are inconclusive.

20 Two genes, Q and R, affect the size of the petals and the pigmentation of a flower.

Gene Q has two alleles, Q^L and Q^A. The genotype Q^LQ^L produces large petals, Q^LQ^A produces small petals, and in Q^AQ^A, petals are absent.

Gene R has two alleles. R produces a red pigment and is dominant over the allele r that produces no pigment.

A plant that is heterozygous at both gene loci was selfed. How many different phenotypes will be observed in the next generation?

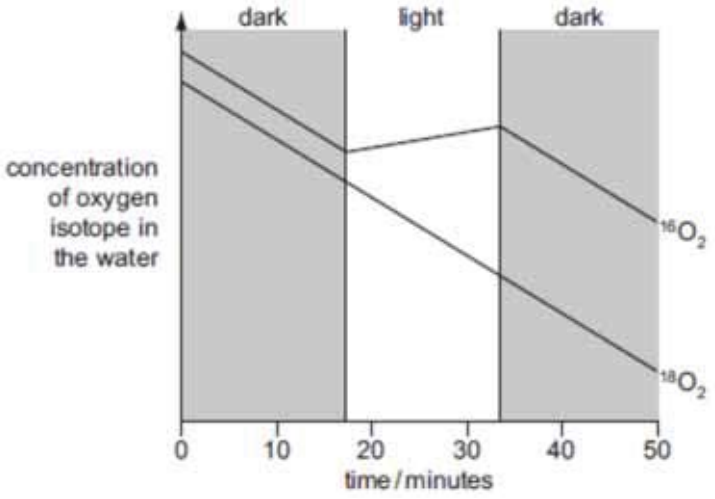
A 4

B 6

C 9

D 12

21 The common isotope of oxygen is ^{16}O. Air containing $^{16}O_2$ and $^{18}O_2$ was bubbled through a suspension of algae for a limited period. After this, the concentration of these two isotopes of oxygen in the water was monitored for the next 50 minutes whilst the algae were subjected to periods of dark and light. The results are shown in the diagram.



What is the best explanation for these results?

A Both isotopes of oxygen are used by the algae in the dark in respiration, but in the light oxygen is produced from water in photorespiration.

B The algae can distinguish chemically between the two isotopes.

C The algae produce oxygen from the water used in photosynthesis, but only in the light.

D The two isotopes have different rates of diffusion.

22 After vigorous exercise, changes occur in the muscle tissue. Compared with 'at rest' conditions, what will the changes be?

	ATP	lactate	pH
A	decreased	increased	decreased
B	increased	increased	increased
C	decreased	decreased	increased
D	increased	decreased	decreased

23 The hormone insulin binds to the tyrosine kinase receptors and initiates various signal transduction pathways to generate cellular responses. Which of the following shows the correct sequence of events, following the binding of insulin to the receptor?

1 phosphorylation of tyrosine residues

2 signal amplification

3 dimerisation of tyrosine kinase receptor

4 signal transduction

5 activation of transcription factors

A 1 → 3 → 2 → 4 → 5

B 3 → 4 → 1 → 2 → 5

C 1 → 3 → 5 → 4 → 2

D 3 → 1 → 4 → 2 → 5

24 During pregnancy, glucose is transferred from the bloodstream of the mother to the bloodstream of the foetus through the placenta.

In an experiment conducted on a pregnant female subject, experiments **X** and **Y** were conducted with control periods of no treatment before them.

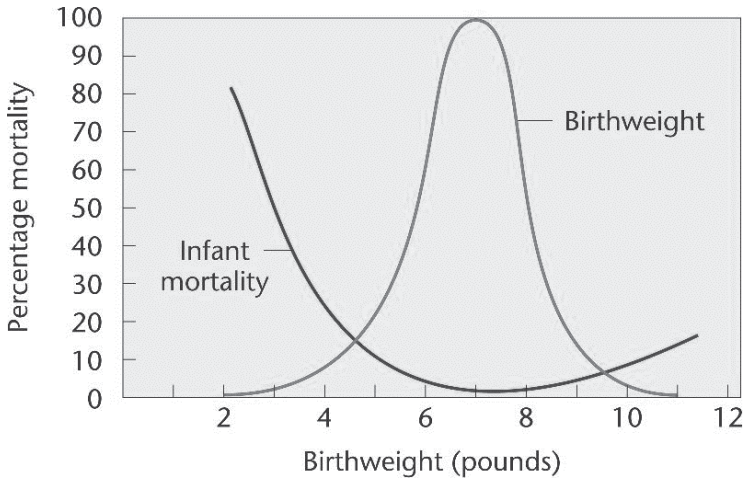
Measurements of blood glucose levels in both mother and foetus were made. Also, the glucose transfer rates from mother to placenta, and from placenta to foetus were monitored. The experimental data is shown in the table below.

Experiment	glucose concentration / mg cm^{-3}		glucose transfer rate / mg min^{-1}	
	maternal blood	foetal blood	from mother to placenta	from placenta to foetus
control period	54	15	38	9
after X	54	9	38	16
control period	52	14	39	8
after Y	211	30	58	34

Which of the following is likely to describe experimental steps **X** and **Y**?

	X	Y
A	Glucagon injection given to foetus	Insulin injection given to mother
B	Insulin injection given to foetus	Glucagon injection given to foetus
C	Insulin injection given to mother	Glucagon injection given to foetus
D	Insulin injection given to foetus	Glucose injection given to mother

25 The graph below shows the relationship between birthweight and infant mortality in humans.



What type of selection is demonstrated above?

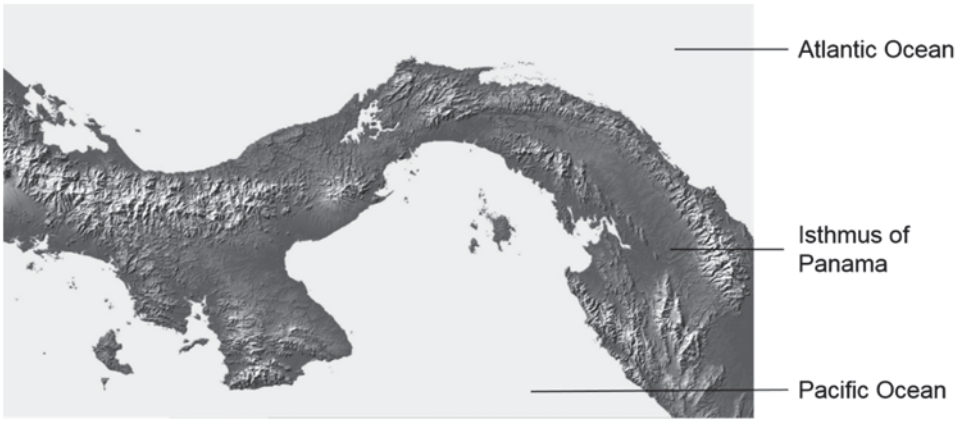
A Directional selection

B Disruptional selection

C Stabilising selection

D Artificial selection

26 The formation of the Isthmus of Panama around 3 million years ago (*Mya)* led to the separation of the Pacific and Atlantic oceans. Pistol shrimps of the *Alpheus* genus can be found in both oceans, surrounding the Isthmus. *Alpheus nuttingi* resides in the Atlantic ocean and *Alpheus millsae* resides in the Pacific ocean.



Despite being physically separated, *A. nuttingi* and *A. millsae* are morphologically and genetically very similar. The two species have also been shown to be capable of interbreeding in captivity. Which of the following statements are likely to be true?

1 *A. nuttingi* and *A. millsae* are derived from a common ancestral species.

2 The formation of the Isthmus resulted in geographical isolation of the two species 3 *Mya*.

3 *A. nuttingi* and *A. millsae* are two separate species because they are geographically isolated.

4 Similar environmental conditions around the Isthmus exerted similar selection pressures, leading to convergent evolution between *A. nuttingi* and *A. millsae*.

A 1 only

B 1 and 3

C 2 and 3

D 3 and 4

27 Myxomatosis is a viral disease of rabbits. It spreads rapidly and most rabbits die within 14 days of being infected. Myxomatosis has been deliberately used to reduce the number of rabbits in countries where they are a significant crop pest.

The initial release of the virus caused populations to fall by over 90%. Resistance to myxomatosis increased in the 70 years following initial release, so at the present time up to 50% of infected rabbits are able to survive.

Which of the following statements could explain the increasing frequency of resistance to myxomatosis in the years following release of the virus?

1 In populations with high incidences of myxomatosis, mutations leading to resistance are more likely to occur.

2 Infected rabbits die quickly, hence the alleles that code for myxomatosis are eliminated from the population.

3 The initial release of the virus led to a bottleneck event, greatly altering the frequency of alleles in rabbit populations.

4 During disease outbreaks there is greater food availability for the surviving rabbits, increasing the probability that they survive.

A 4 only

B 1 and 2 only

C 2 and 4 only

D 2, 3 and 4 only

28 Which statements correctly describe lymphocytes?

1 Each B lymphocyte has the ability to make several types of antibody molecules.

2 Some B lymphocytes and T lymphocytes become memory cells.

3 Plasma cells secrete antibodies into the blood plasma.

4 Some T lymphocytes stimulate macrophages to kill infected cells.

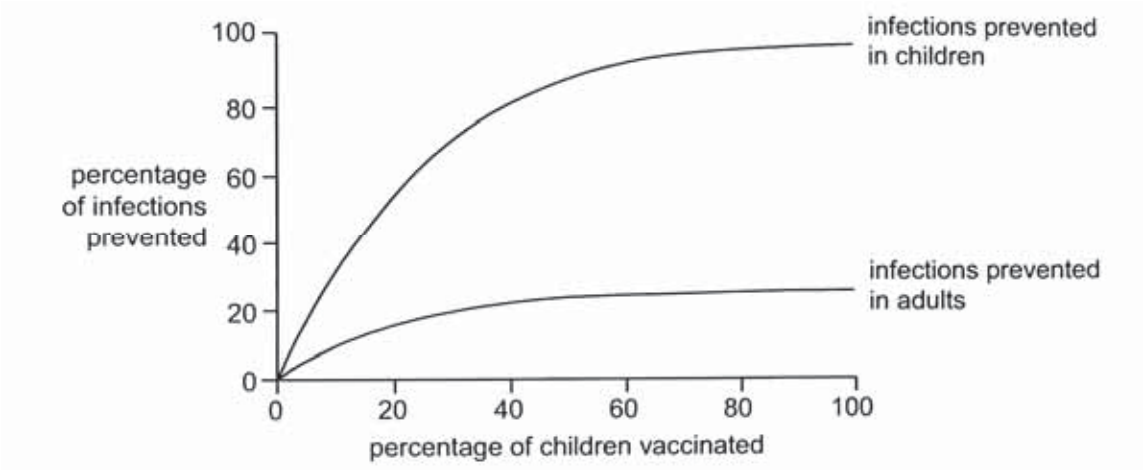
A 1, 2, 3 and 4

B 1, 2 and 3 only

C 2, 3 and 4 only

D 1 and 4 only

29 When sufficient individuals are vaccinated, the disease transmission cycle can be broken. The diagram shows the effect of vaccination of children on the prevention of infection.



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

1 When approximately 80% of children are vaccinated, the cycle of disease transmission in children is broken.

2 Vaccination of children reduces the percentage of infections in both adults and children.

3 The effect on adult infections is less than that of infection in children, because adults will have been vaccinated as children.

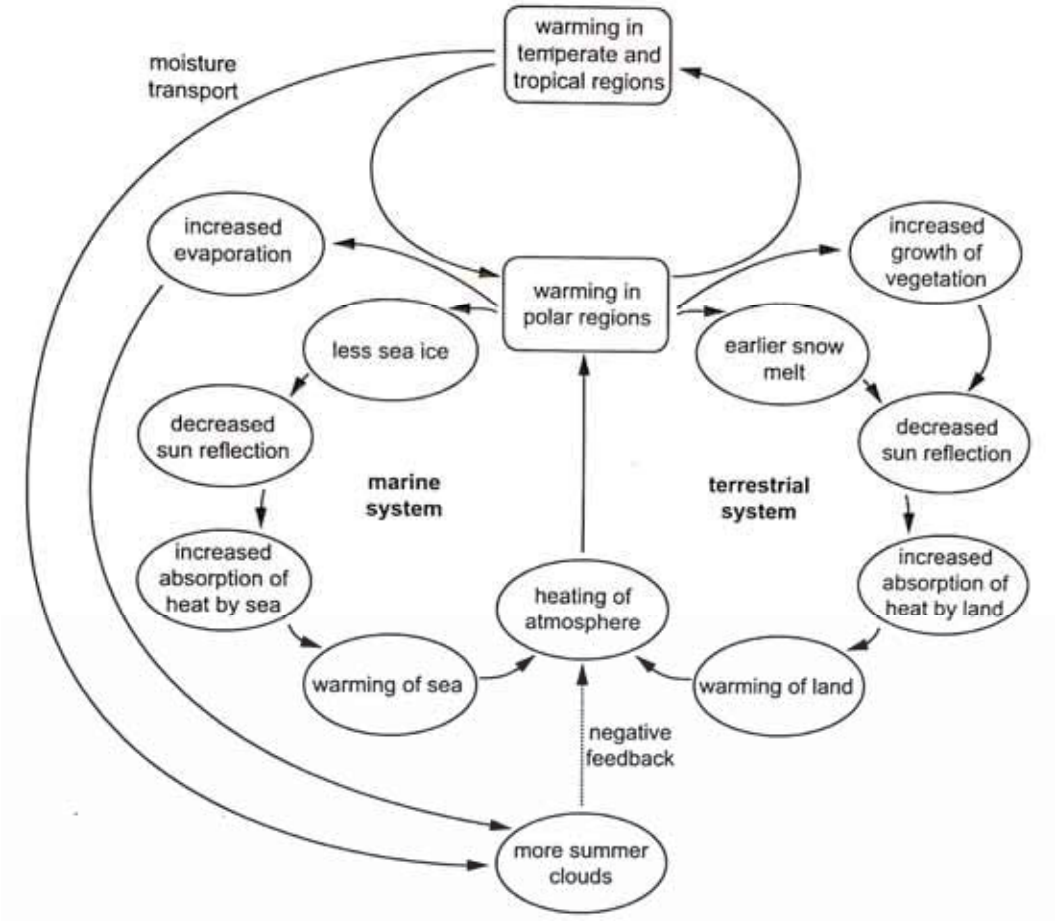
A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

30 The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.



Which effect of higher temperatures in the polar regions could increase global warming?

A Increased evaporation leads to more rainfall, which absorbs heat from the land and sea.

B Melting of ice and snow results in less reflection of sunlight and more heat absorption by the earth.

C Melting of sea ice causes more cloud formation which increases absorption of heat in the atmosphere.

D Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.

RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION II

CANDIDATE NAME											
CENTRE NUMBER	S					CLASS		INDEX NUMBER			

H2 BIOLOGY **9744/02**

Paper 2 Structured Questions **11 Sep 2017**

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.

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

For Examiner's Use	
1	/ 9
2	/ 13
3	/ 8
4	/ 10
5	/ 12
6	/ 15
7	/ 10
8	/ 11
9	/ 12
Total	/ 100

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

Answer **all** questions.

1 Fig. 1.1 shows an electron micrograph of part of a plant cell.

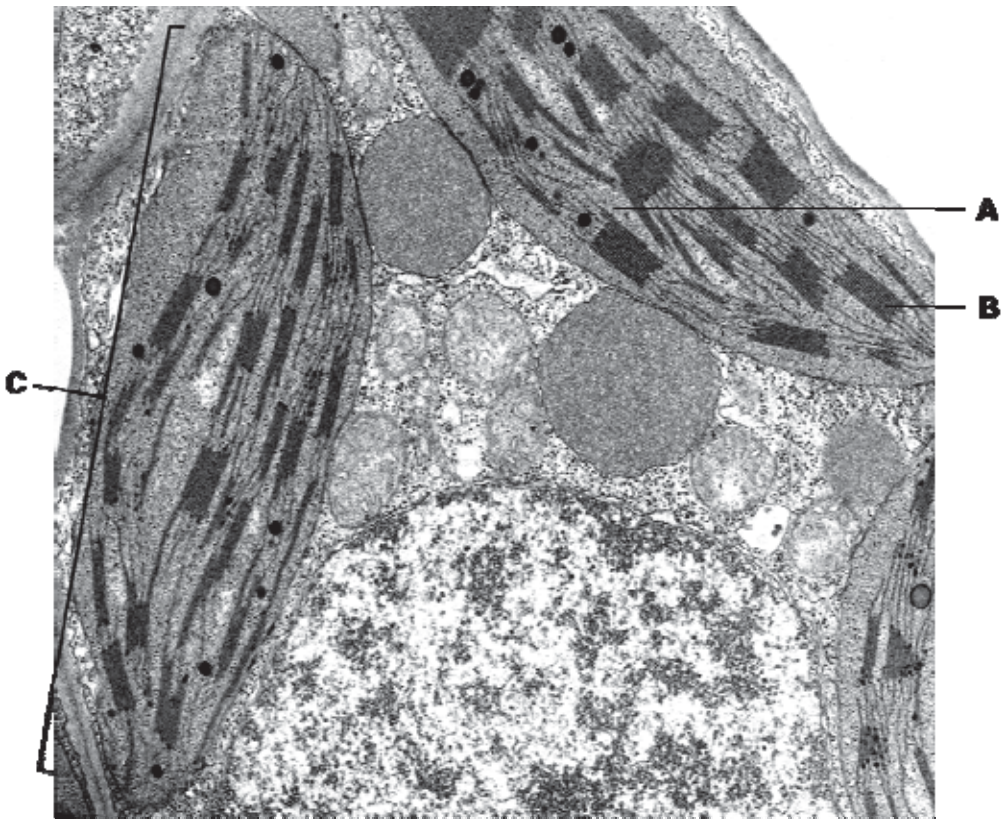


Fig. 1.1

(a) Identify region **A** and state its function. [2]

(b) Describe how the structure of the membrane at **B** allows it to perform its function. [3]

Cyanobacteria are prokaryotic cells that are capable of carrying out photosynthesis. The structure of a cyanobacteria is shown in Fig. 1.2.

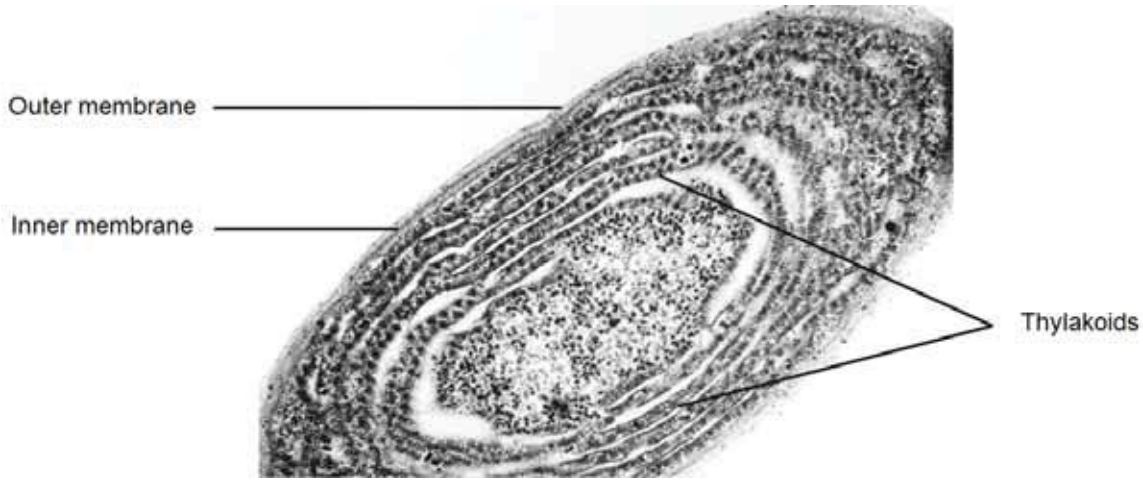


Fig. 1.2

(c) With reference to Fig. 1.1 and Fig. 1.2, compare the visible structures of cyanobacteria with that of **C**. [2]

Cyanobacteria are considered to be the ancestors of structure **C**. They continued to function after being engulfed by primitive eukaryotic cells and evolved over time. This theory is known as the endosymbiont hypothesis.

(d) State **two** features of structure **C** that provide support for this hypothesis. [2]

[Total: 9]

2 Fig. 2.1 shows the structure of a G-protein coupled receptor (GPCR).

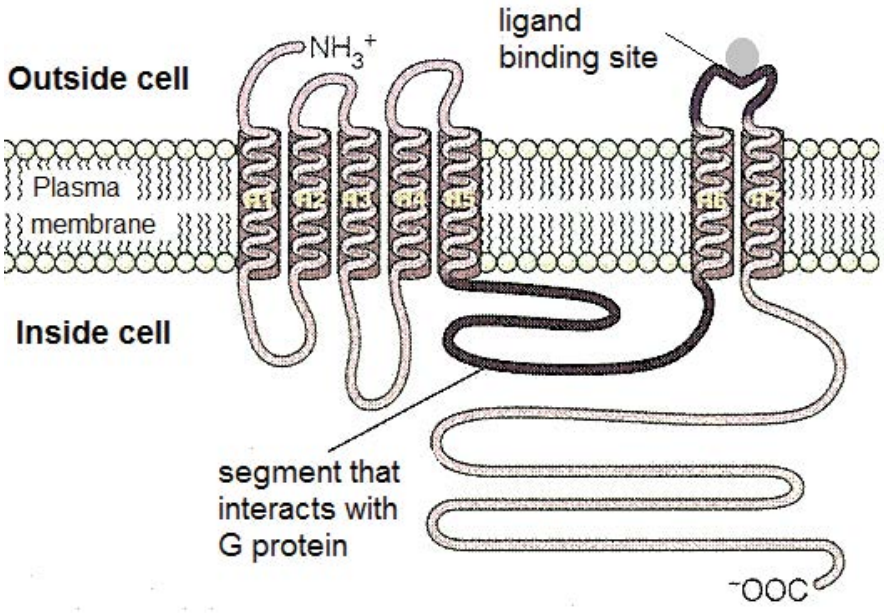


Fig. 2.1

(a) Describe how the structure of GPCR is adapted to its function. [3]

One of the cellular events resulting from glucagon binding to GPCR, shown in Fig. 2.1, is the activation of glycogen phosphorylase which breaks down glycogen to glucose.

(b) (i) Describe how binding of glucagon leads to activation of glycogen phosphorylase. [3]

(ii) Explain why liver cells store glucose in the form of glycogen. [3]

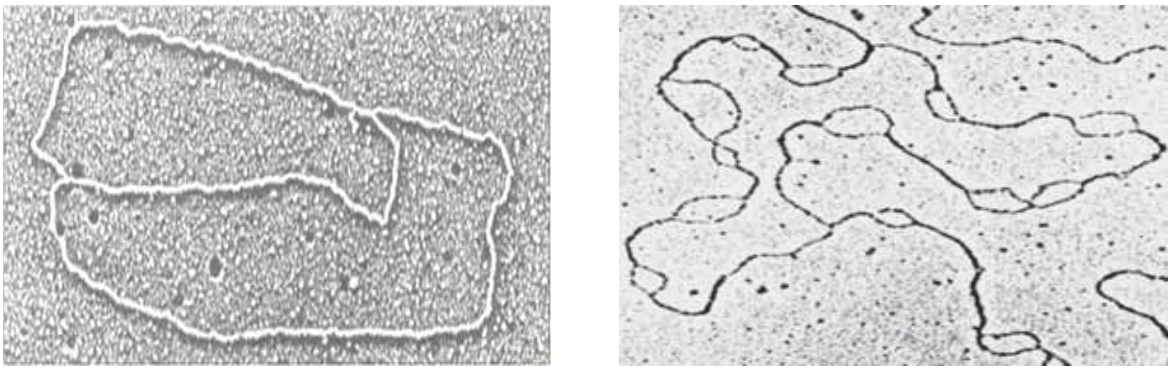
The binding of glucagon to GPCR leads to an increase in blood glucose level partly due to the action of glucose transporters. Glucose transporters transport glucose via facilitated diffusion.

(c) (i) Explain what is meant by facilitated diffusion. [2]

(ii) Explain why glucose transporters are necessary to facilitate this process. [2]

[Total: 13]

3 Fig. 3.1 shows DNA replication in an *Escherichia coli* (**A**) and in a mammalian cell (**B**). Diagrams are not shown to scale.



A **B**

Fig. 3.1

(a) State **one** way in which the DNA replication in these two organisms differs and explain the advantage of this to the mammalian cell. [2]

(b) Explain why DNA replication is said to be semi-conservative. [2]

End replication problem is a fundamental problem associated with replicating DNA in eukaryotes.

Some cells contain telomerase, which is responsible for extending the ends of DNA in eukaryotes. Fig. 3.2 shows the action of a telomerase enzyme.

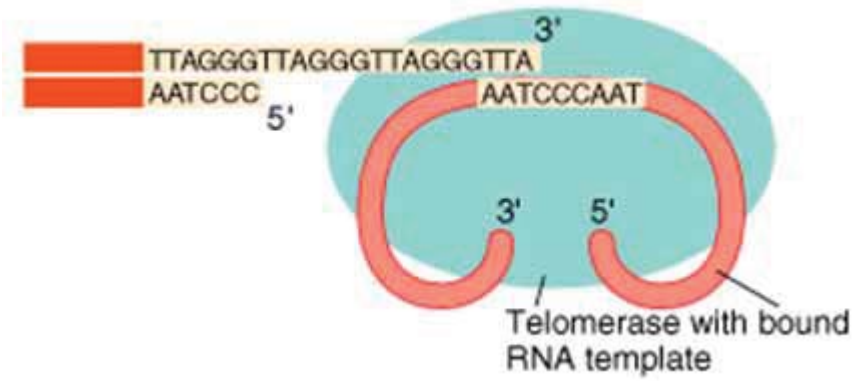


Fig. 3.2

(c) Explain how the end-replication problem arises. [2]

(d) With reference to Fig. 3.2, state **two** differences between transcription and the process of lengthening of DNA ends. [2]

[Total: 8]

4 Huntington's disease is a rare neurodegenerative disorder targeting the central nervous system. Transcriptional dysregulation is one of the commonly observed molecular abnormalities affected in this disease. Recent evidence suggests the involvement of a mutant Huntingtin protein in the processes regulating condensation of DNA, leading to activation of DNA damage response and death of nerve cells. DNA in various levels of condensation can be observed in the nerve cell nucleus. Fig. 4.1 shows one of the levels of condensation of chromatin.

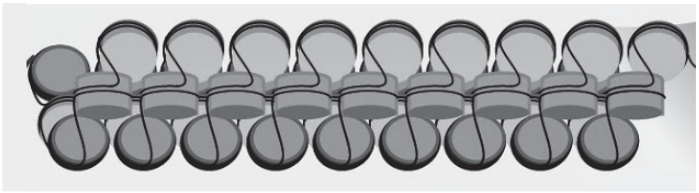


Fig. 4.1

(a) It is postulated that mutant Huntingtin protein facilitates packing of DNA into structure shown in Fig. 4.1. Describe how the DNA double helix is condensed into this structure. [2]

(b) The chromosomal condensation in **(a)** is the main reason for the commonly observed transcriptional dysregulation in Huntington's disease. Explain how transcription is affected. [3]

It is observed that nerve cells could remove Huntingtin proteins via ubiquitination of specific amino acids. However, the mechanism that triggers ubiquitination is unclear. In a study to determine the mechanism for degradation of Huntingtin proteins, selected amino acids were investigated and the results are shown in Table 4.1.

Table 4.1

	13th amino acid: serine	16th amino acid: serine	6th amino acid: lysine	9th amino acid: lysine	15th amino acid: lysine	Fate of Huntingtin protein
Trial 1	de-phosphorylated	de-phosphorylated	ubiquitin not attached	ubiquitin not attached	ubiquitin not attached	remains active
Trial 2	phosphorylated	de-phosphorylated	ubiquitin not attached	ubiquitin not attached	ubiquitin not attached	remains active
Trial 3	de-phosphorylated	phosphorylated	ubiquitin not attached	ubiquitin not attached	ubiquitin not attached	remains active
Trial 4	phosphorylated	phosphorylated	ubiquitin attached	ubiquitin attached	ubiquitin attached	degraded

(c) With reference to Table 4.1,

(i) state the level of control for Huntingtin gene expression. [1]

(ii) describe the events at the selected amino acids that triggers the degradation of Huntingtin proteins. [2]

(iii) describe how ubiquitination results in the removal of mutant Huntingtin protein. [2]

[Total: 10]

5 Fig. 5.1 shows the structure of a T4 virus.

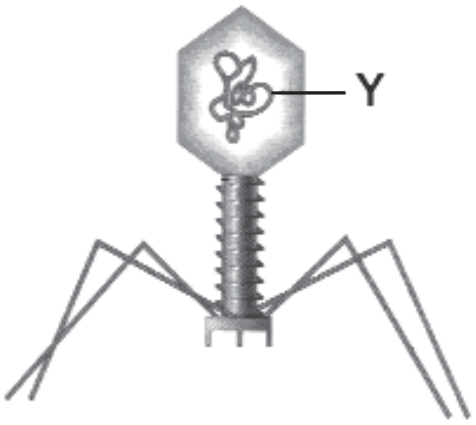


Fig. 5.1

(a) Identify structure **Y**. [1]

The T4 virus cannot reproduce by itself and relies upon a host cell for reproduction.

(b) State specifically why T4 viruses rely on host cells for their reproduction. [2]

T4 viruses use bacteria as its host. Fig. 5.2 shows the results of an experiment in which T4 viruses were added to a culture of bacteria. Samples of the culture were then taken at intervals to determine the number of free T4 viruses present.

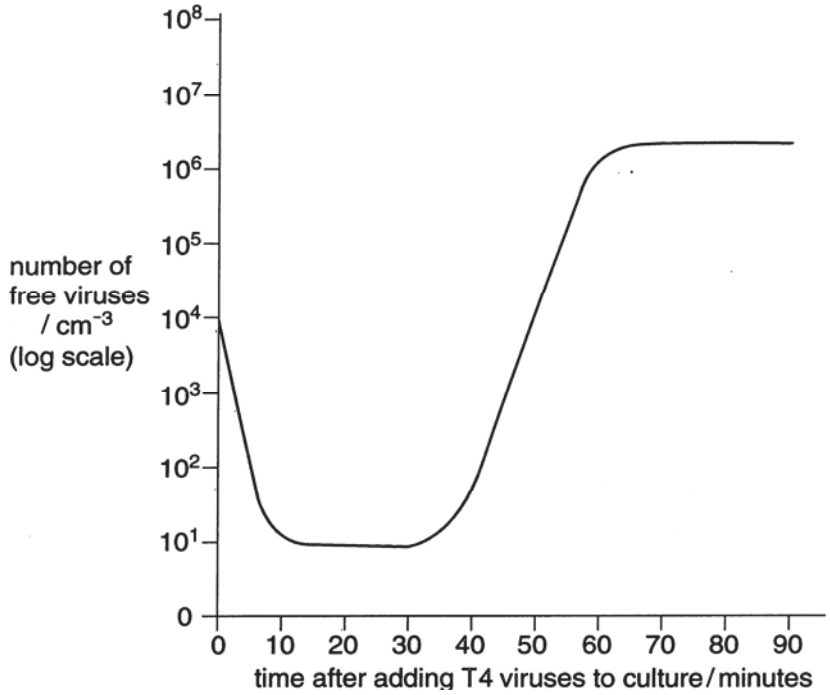


Fig. 5.2

(c) With reference to Fig. 5.2, describe and explain the changes in number of free T4 viruses

(i) in the first 10 minutes; [2]

(ii) between 30 and 60 minutes. [3]

A scientist carried out an investigation using T4 virus and two strains of bacteria: $\mathbf{B^+}$ cells which can grow in media without lysine and $\mathbf{B^-}$ cells which only grow when supplied with lysine. The procedure is shown in Fig. 5.3.

T4 are mixed with $\mathbf{B^+}$ cells

↓

T4 are isolated from the culture and added to $\mathbf{B^-}$ cells

↓

$\mathbf{B^-}$ cells are plated on medium lacking lysine

↓

Growth observed on medium

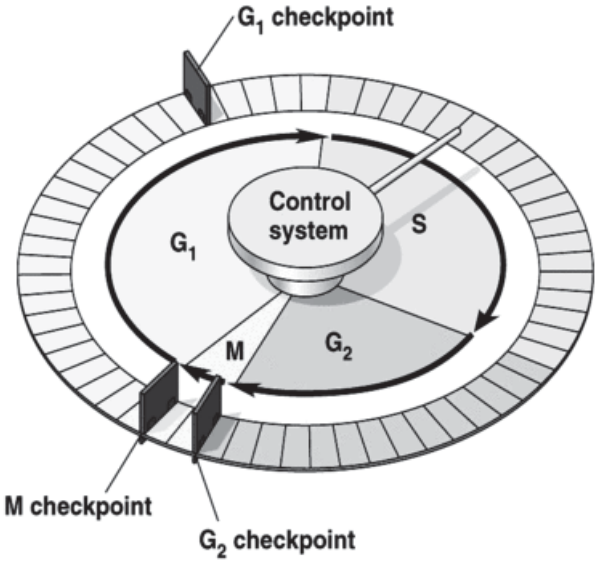
Fig. 5.3

(d) (i) Explain the observations made by the scientist. [3]

(ii) Suggest **one** other potential benefit of the process mentioned in **(d)(i)** for the recipient bacteria. [1]

[Total: 12]

6 The cell cycle is an ordered sequence of events involving two stages that culminates in cell growth and division into daughter cells. It is an essential mechanism by which all living things reproduce.



Pearson Education Inc., 2017

Fig. 6.1

(a) With reference to Fig. 6.1, name the longest stage of the cell cycle and discuss the main events in this stage. [3]

Fig. 6.2 shows a cell viewed from the spindle pole during cell cycle.

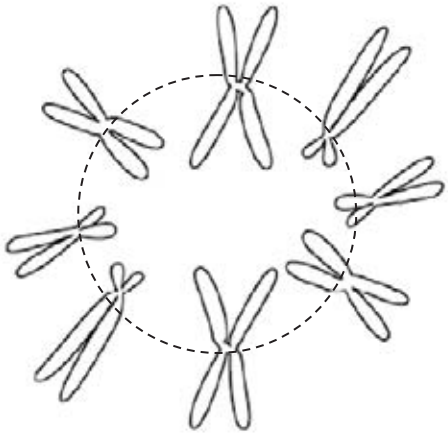


Fig. 6.2

(b) **(i)** State the type of nuclear division and name the stage shown in Fig. 6.2. [1]

type of nuclear division _____

stage _____

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

_____

_____

_____

_____

(c) With reference to Fig. 6.2, complete Table 6.1 to show the number of chromosomes and mass of DNA in each nucleus during different phases of mitosis. [2½]

Table 6.1

	Number of chromosomes per nucleus	**Mass of DNA per nucleus / µg**
Prophase of mitosis		170
Metaphase of mitosis		
Telophase of mitosis		

Mutations in *ras* proto-oncogenes are among the most common events in cancer. Gain-of-function mutations in *ras* proto-oncogenes are known to result in dysregulation of the cell cycle due to faults in signalling pathways.

(d) Explain what is meant by proto-oncogenes. [1½]

(e) Explain how a mutant Ras protein may lead to cancer. [3]

(f) Other than cancer cells, *ras* gene expression is also upregulated in embryonic stem cells. However, the latter does not result in a disease phenotype.

Explain what embryonic stem cells are. [2]

[Total: 15]

7 The coat colour of Labrador retriever dogs are determined by genes at two loci. The presence of the dominant alleles **B** and **E** results in black coats, whilst the presence of only the dominant allele **E** results in brown coats. Individuals that are homozygous recessive at the **E/e** locus will have golden coats.

A true breeding male retriever with a black coat was crossed with a female retriever with a golden coat. The resulting F_1 offspring all had black coats and the same genotype. A test cross was conducted for the F_1 individuals.

(a) State the genotype of the F_1 individuals. [1]

(b) Using the symbols for the alleles stated above, draw a genetic diagram to explain the test cross. [3]

(c) Name and describe the type of interaction between the gene loci. [3]

The pedigree shown in Fig. 7.1 shows the inheritance of coat colour in a family of Labrador retrievers.

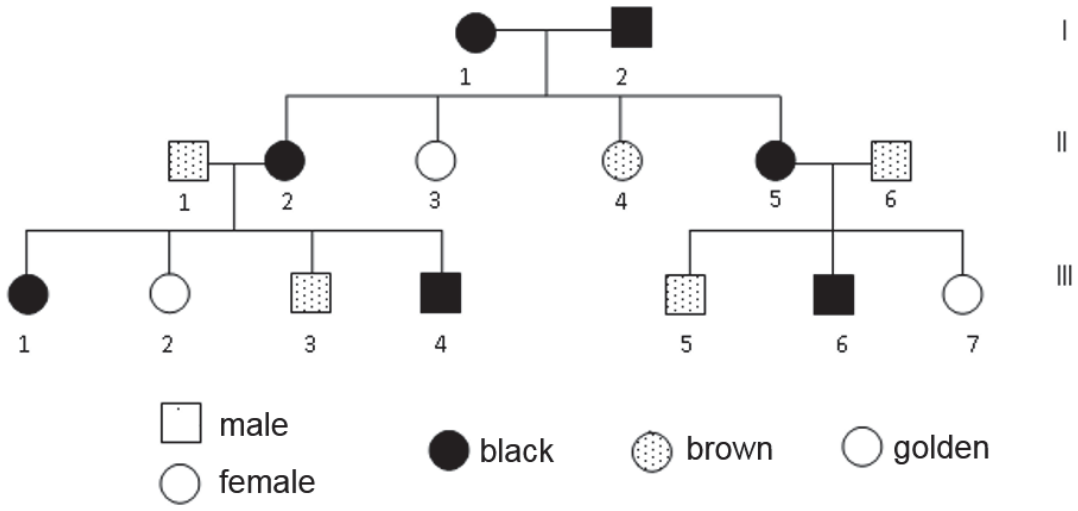


Fig. 7.1

(d) **(i)** State the genotype of individual II-1. [1]

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

[Total: 10]

8 Fig. 8.1 is an electron micrograph of a mitochondrion.

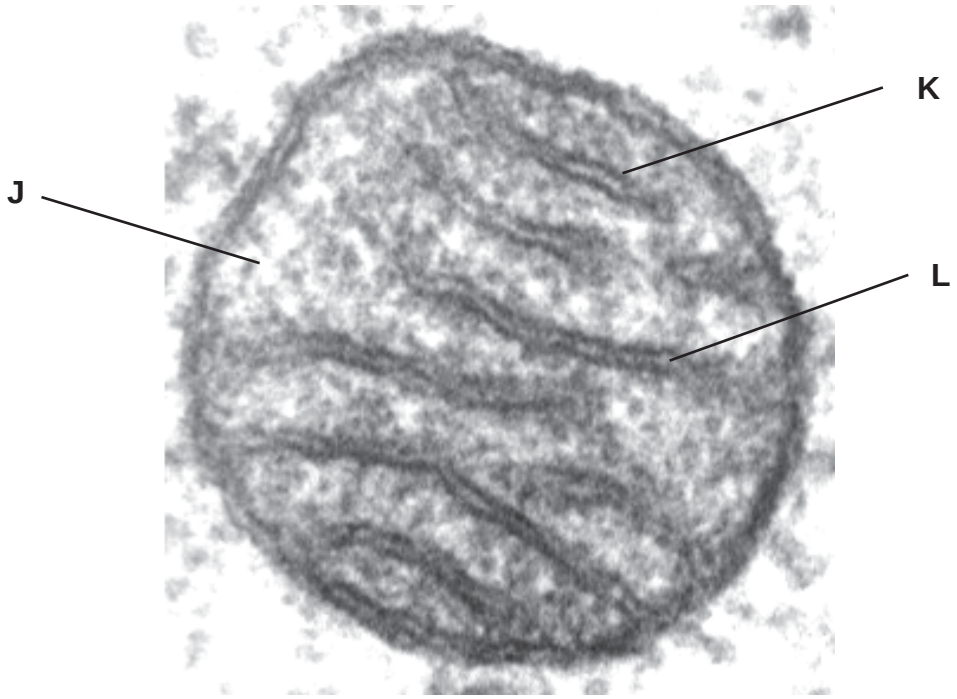


Fig. 8.1

(a) (i) Identify structures **J** and **K**. [1]

J _____

K _____

(ii) Describe how structure **J** is adapted to its function. [1]

_____

_____

(b) (i) State the role of high concentration of protons at **L**. [1]

_____

_____

(ii) Explain how the high concentration of protons is generated at **L**. [3]

In an investigation to determine the effect of chemical **M** on respiration, mitochondria were incubated in four ways:

1. with glucose
2. with pyruvate
3. with glucose and chemical **M**
4. with pyruvate and chemical **M**

The results are summarised in Table 8.1.

Table 8.1

	CO_2 evolution	O_2 consumption	ATP production by oxidative phosphorylation
Glucose	x	x	x
Pyruvate	✓	✓	✓
Glucose + chemical **M**	x	x	x
Pyruvate + chemical **M**	✓	✓	x

(c) (i) Explain why carbon dioxide is produced when mitochondria are incubated with pyruvate but not when incubated with glucose. [3]

(ii) Suggest why when mitochondria were incubated with pyruvate and chemical **M**, oxygen consumption occurs but not ATP production. [2]

[Total: 11]

9 Tetanus is a disease caused by a bacterium. When the tetanus bacteria enter the body they release a toxin which causes muscular rigidity and extreme pain. Children in the United Kingdom are routinely vaccinated against tetanus at an early age.

Fig. 9.1 is a diagram that shows three B lymphocytes (**P**, **Q** and **R**) and the events that occur during an immune response to the tetanus toxin.

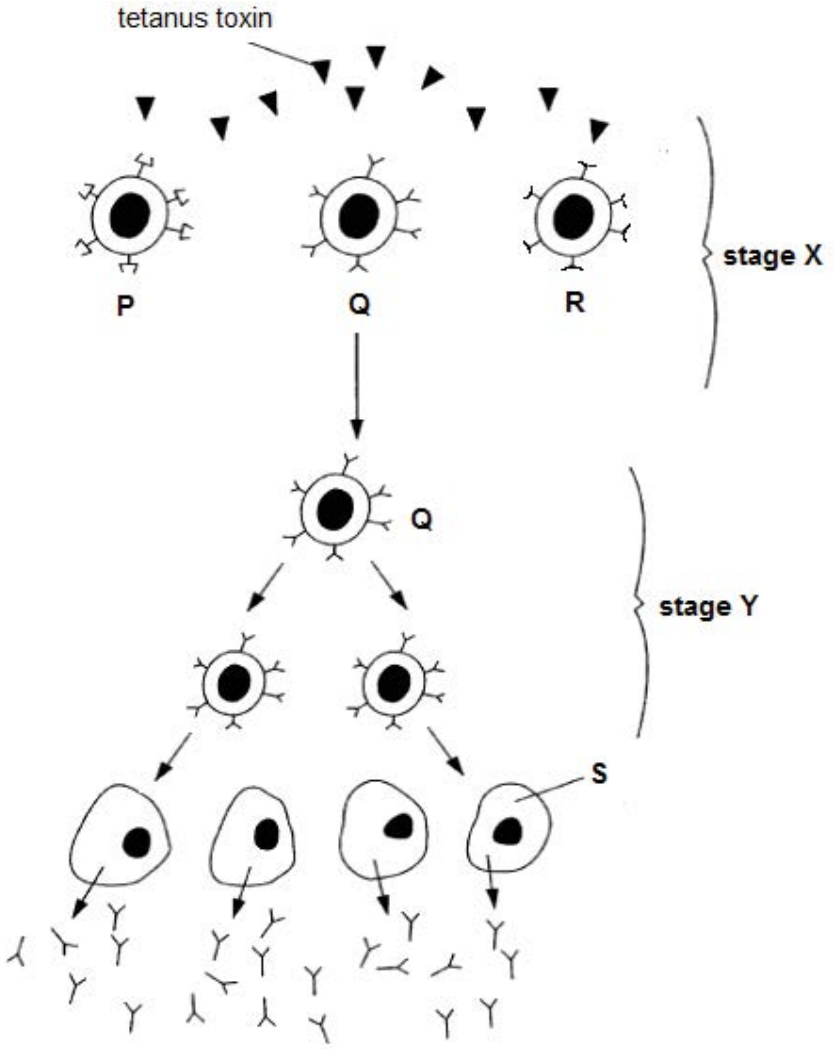


Fig. 9.1

(a) Explain what is happening at stages **X** and **Y** in the immune response to tetanus toxin. [2]

Fig. 9.2 shows an antibody molecule secreted by cell **S**.

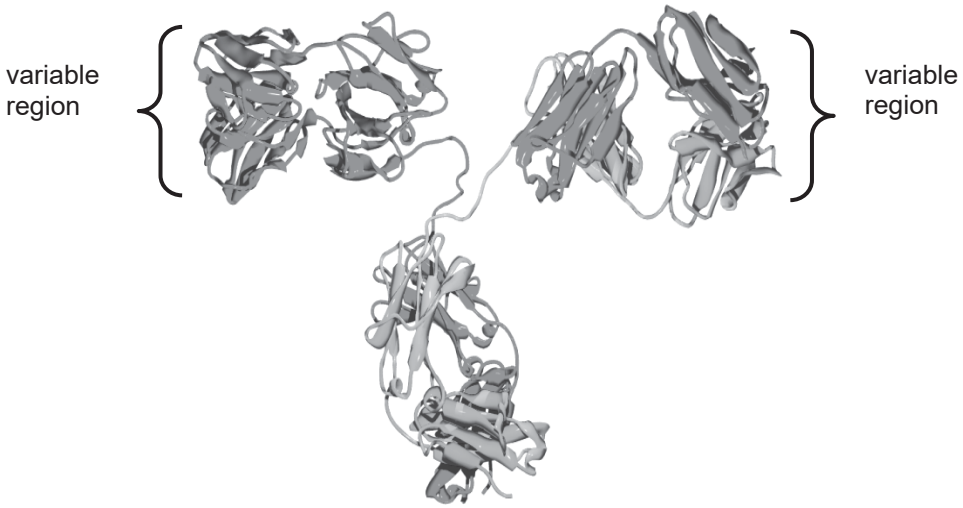


Fig. 9.2

(b) Describe how the antibody is folded from linear polypeptide chains. [4]

A study investigated active and passive immunity to tetanus toxin. One person, **G**, was injected with antibodies to the tetanus toxin. Another person, **H**, was injected with the vaccine for tetanus and produced antibodies as a result. Blood samples were taken from **G** and **H** at regular intervals over the following weeks and analysed for antibodies against tetanus.

The results of the study are shown in Fig. 9.3.

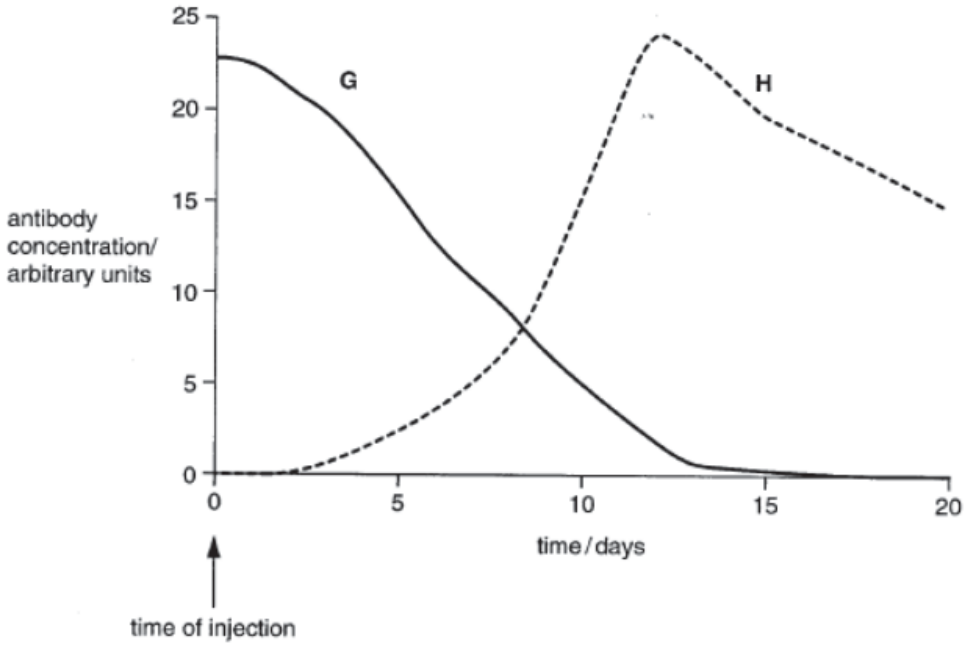


Fig. 9.3

(c) Explain why the type of immunity gained by **G** is described as passive immunity. [2]

(d) With reference to Fig. 9.1 and Fig. 9.3, explain why there is a slow increase in antibody concentration in the curve for **H**. [2]

(e) Explain why person **H** is considered to be better protected against future exposure to the tetanus toxin, compared to person **G**. [2]

[Total: 12]

RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION II

CANDIDATE NAME											
CENTRE NUMBER	S					CLASS		INDEX NUMBER			

H2 BIOLOGY **9744/03**

Paper 3 Long Structured and Free-response Questions **20 Sep 2017**

2 hours

Additional Materials: Writing paper

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 on the separate writing paper provided.

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

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

For Examiner's Use	
Section A	
1	**/19**
2	**/18**
3	**/ 13**
Section B	
4 or 5	**/25**
Total	**/ 75**

This document consists of **17** printed pages and **3** blank pages.

Section A

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

1 The Galapagos Islands is an archipelago approximately 1400 kilometers off the Western coast of Ecuador. It consists of more than 40 islands, including the small and isolated island Daphne Major. The map of the islands, and its location in relation to mainland Ecuador and Cocos Island, is shown in Fig. 1.1.

Fig. 1.1

There are now at least 13 species of finches on the Galapagos Islands, each filling a different niche on different islands. All of them evolved from one ancestral species, which colonised the islands only a few million years ago.

Molecular analysis was carried out on the nucleotide sequences of the Galapagos Islands finches and the Cocos finch, found on the island of Cocos, 830 km North-east of the Galapagos Islands. Fig. 1.2 shows the phylogeny of these finches as constructed from the molecular data obtained.

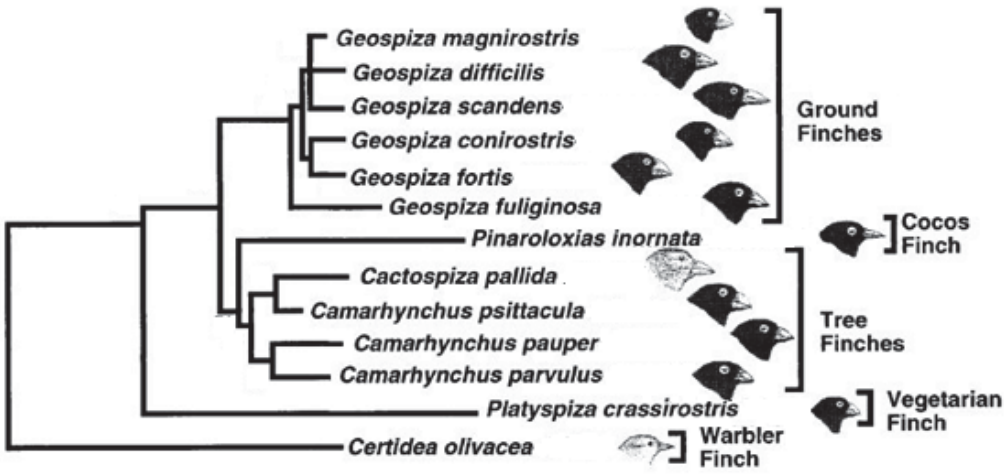


Fig. 1.2

(a) Explain how DNA sequences can be used to determine evolutionary relatedness between species. [2]

(b) Suggest how the Cocos finch might be derived from the same common ancestor as the Galapagos finches, despite its lack of proximity to the Galapagos Islands. [1]

A long-term study of the medium ground finch, *Geospiza fortis*, was carried out on the island of Daphne Major. Ground finches have bills particularly suited to eating seeds. Seeds eaten by the population of *G. fortis* are of a variety of sizes and are from a range of plants. Fig. 1.3 shows a male *G. fortis*.

Fig. 1.3

In 1977, a severe drought affected the Galapagos Islands. The number of different plant species producing seeds and total seed abundance was greatly reduced for the population of *G. fortis*.

Scientists have postulated that the severity of the drought experienced may have been exacerbated by the rise in atmospheric CO_2 concentrations due to human activities.

(c) Explain how the emission of greenhouse gases such as CO_2 may be linked to the onset of drought. [2]

The population size of *G. fortis* on Daphne Major fell by over 85% as a result of the 1977 drought.

In years with good rainfall there is an abundance of small, soft seeds that are favoured by *G. fortis*, especially those individuals with smaller bills. In years of drought, small seeds are scarce. Individuals of *G. fortis* with small bills are rarely successful in extracting seeds from the large, spiky, tough fruits of *Tribulus cistoides* (Fig. 1.4), which was the main source of seeds at the time.

Fig. 1.4

Table 1.1 shows results for mean mass and mean bill size of mature *G. fortis* before and after the drought. The individuals measured after the drought were a subset of the first sample, allowing a direct comparison of the changes that occurred.

Table 1.1

Date of sampling	Sample size	Phenotypic feature measured			
		Mass / g	Bill length / mm	Bill depth / mm	Bill width / mm
1976 (May)	642	15.79	10.68	9.42	8.68
1978 (March)	85	16.85	11.07	9.96	9.01
Percentage change			+3.65		+3.80

(d) (i) Complete Table 1.1 to show the percentage change in mass and bill depth from 1976 (May) to 1978 (March). [1]

(ii) After the drought, the population of *G. fortis* had significantly higher mean mass and larger mean bill size than the pre-drought population.

Name the type of natural selection that was occurring. [1]

(e) Explain how the changes in bill size that occurred in the population of *G. fortis* on Daphne Major provide support for Darwin's explanation of how natural selection operates. [3]

Current temperatures in the Galapagos archipelago rarely exceed 30°C, even in the summer months. However, climate scientists have warned that in light of global warming, temperatures in the archipelago may soon increase.

The Intergovernmental Panel on Climate Change has forecasted a rise in global average temperatures of up to 5°C over the next century.

(f) With reference to Fig. 1.1, suggest how global warming may affect the survival of the finches in the Galapagos Islands. [2]

Scientists have also suggested that changes in carbon dioxide concentration in the atmosphere changes the stomatal density of plants.

43 different species of plants from a range of habitats were grown at normal atmospheric carbon dioxide concentration and at increased carbon dioxide concentration.

The mean stomatal density of each species was determined at both concentrations of carbon dioxide. The percentage change in stomatal density at the increased carbon dioxide concentration compared to the stomatal density at normal atmospheric carbon dioxide concentration was calculated for each species. Table 1.2 summarises the changes to mean stomatal density due to increased atmospheric carbon dioxide concentration for the species investigated.

Table 1.2

Percentage change in stomatal density (to the nearest 10%)	Number of species
+40	2
+30	2
+20	4
+10	2
-10	7
-20	9
-30	9
-40	8

(g) Account for the results shown in Table 1.2. [5]

The experiment showed that plants are able to show significant changes in their phenotype in response to changes in the environment.

(h) Suggest why plants need to be able to show changes in their phenotype within their lifetime. [2]

[Total: 19]

2 Dengue fever is a mosquito-borne disease caused by the dengue virus. Fig. 2.1 shows the structure of a dengue virus.

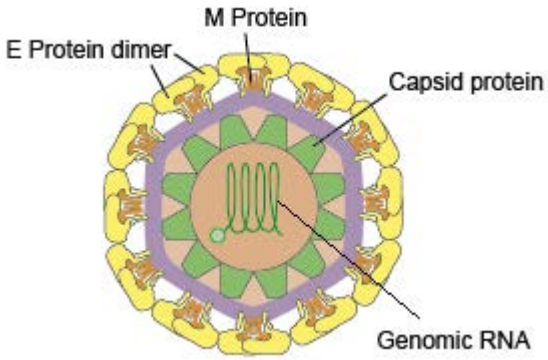


Fig. 2.1

(a) List **two** ways in which the structure of dengue virus is similar to the human immunodeficiency virus. [2]

Dengue viruses consist of four serotypes, DENV-1 to DEV-4. The rapid identification of dengue virus serotypes isolated from patients' blood is important for clinical investigations. One of the methods used for identification of serotypes is DNA sequencing, which is a process of determining the precise order of nucleotides within a DNA molecule.

One of the DNA sequencing methods is based on the use of chain terminators, which are special nucleotides. Fig 2.2 shows the structure of a special nucleotide with a cytosine base.

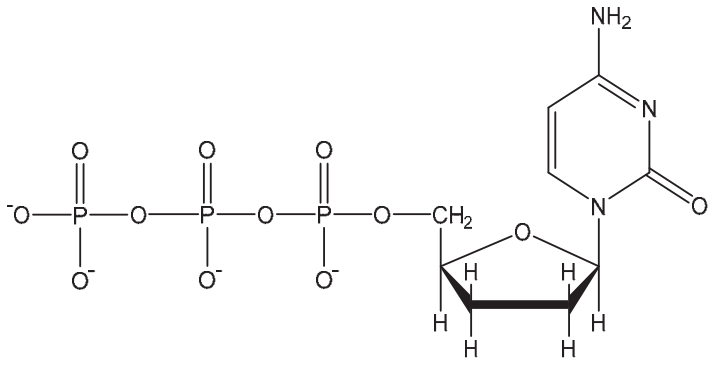


Fig 2.2

If a special nucleotide is added to a growing DNA strand, the chain is not extended any further. Each special nucleotide is labelled with a fluorescent dye, using a different colour for each of the four bases.

Fig 2.3 shows how a DNA chain ending with one of the special nucleotides is replicated.

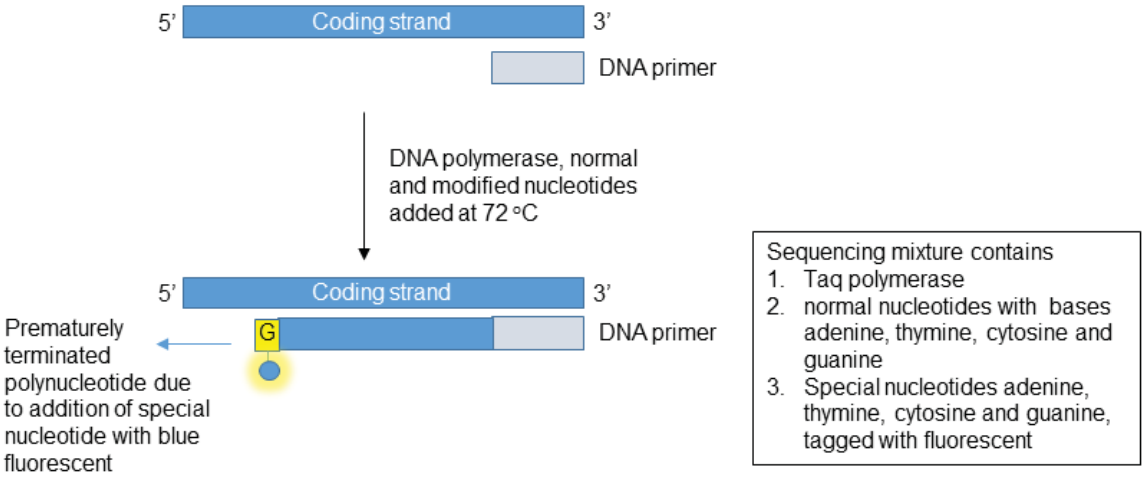


Fig. 2.3

(b) Suggest why the addition of special nucleotides would lead to the premature termination of replication. [2]

This method of DNA sequencing described in Fig 2.3, can produce many DNA fragments terminated by a special nucleotide tagged with a florescent. Fig 2.4 shows a set of such fragments, where each fragment differs by 1 nucleotide.

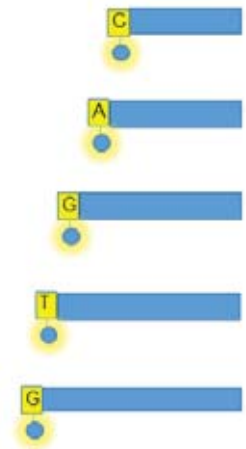


Fig. 2.4

These fragments are loaded onto an agarose gel, shown in Fig 2.5, and separated by a modified version of gel electrophoresis.

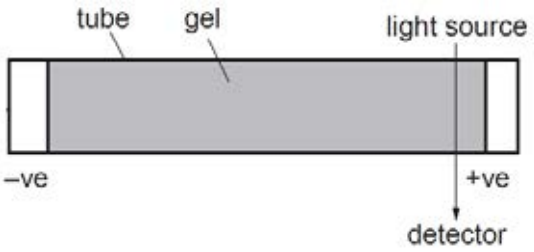


Fig 2.5

The order in which the fragments reach the light source and detector shown in Fig 2.5 is C, A, G, T.

(c) Explain why the DNA fragments will migrate and reach the detector in this order. [3]

Dengue virus is a major threat to health in tropical countries around the world, with 390 million people infected each year. To date, there are no vaccines for dengue virus.

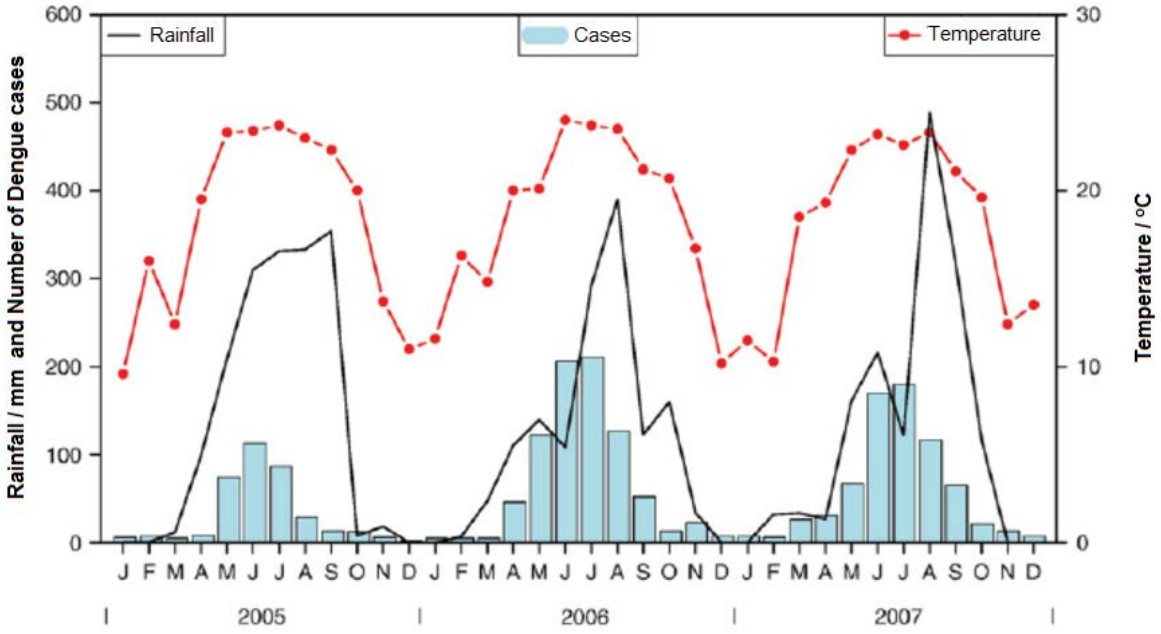
(d) Suggest why there is no effective vaccine to protect against dengue. [2]

(e) Antibiotics are not used to treat viral infections.

Explain why antibiotics do not affect viruses. [2]

The *Aedes aegypti* mosquito is the main vector that transmits the viruses that cause dengue. The viruses are passed on to humans through the bites of an infective female *A. aegypti* mosquito, which mainly acquires the virus while feeding on the blood of an infected person.

Fig. 2.6 shows the monthly number of dengue cases in Sakon Nakhon Province, Thailand, from January 2005 to December 2007.



Source: Monthly district level risk of dengue occurrences in Sakon Nakhon Province, Thailand. The Science of the total environment. 408 (2010). 5521-8.

Fig. 2.6

(f) Explain how temperature affects the number of dengue cases in Thailand. [3]

(g) Other than climate change, state and explain how **two** other factors can contribute to the increase in the number of dengue cases. [2]

The primary preventative measure to reduce dengue infections is the control of mosquito populations. Traditional methods of mosquito control using insecticides are not viable in the long term, as new and stronger versions of insecticides must continually be developed. Biological approaches are now being used as an alternative to control mosquito populations.

Researchers are experimenting with release of *Wolbachia*-infected mosquitoes as a means of suppressing *Aedes* mosquito populations. When male mosquitoes with *Wolbachia* mate with wild female mosquitoes without *Wolbachia*, eggs laid by these female mosquitoes will be sterile. The technique requires the release of a large number of male mosquitoes to reduce the overall mosquito population.

(h) State the **one** advantage and **one** disadvantage of using the biological method. [2]

[Total: 18]

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3 Tuberculosis (TB) is a disease caused by the bacterium *Mycobacterium tuberculosis*, and accounts for more than 1 million deaths annually. Some of the symptoms of infection include shortness of breath, fever, chest pains and coughing up blood.

Fig. 3.1. shows the transmission and infection of *M. tuberculosis*.

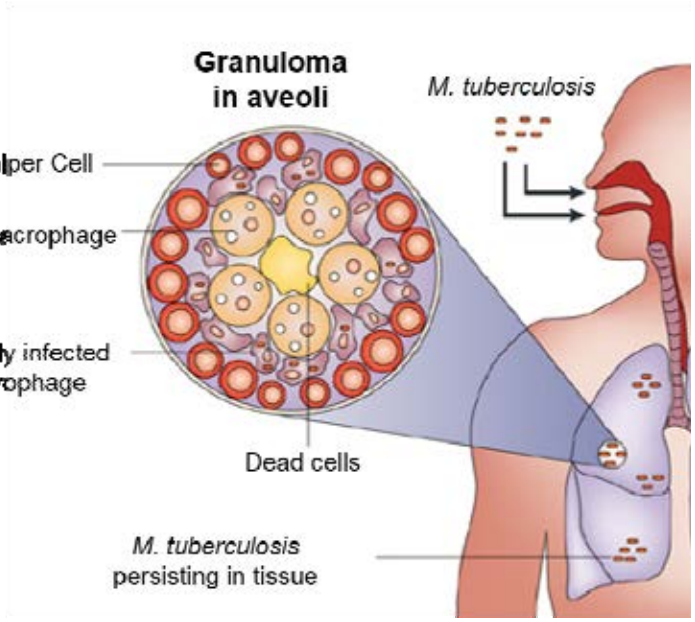

Fig. 3.1

The immune response to TB results in the formation of granulomas. These cellular aggregates restrict the spread of the infection, but fail to kill all of the bacteria. This results in a tight interplay between *M. tuberculosis* and the host cells within the granulomas during the latent stage of infection.

Foamy macrophages are granuloma-specific cells that are characterised by the accumulation of large amounts of lipids contained within numerous lipid vacuoles. These macrophages are formed as a result of prolonged interaction with *M. tuberculosis.*

(a) Describe how TB is transmitted. [2]

(b) With reference to Fig. 3.1 and your own knowledge, describe the formation of granulomas in *M. tuberculosis* infections. [3]

M. tuberculosis have mycobacterial cell walls that are different from other bacterial cell walls due to their thick lipid coating. The cell walls consist of arabinogalactan, a biopolymer of two monosaccharides, complexed with mycolic fatty acids. Fig. 3.2 shows the structure of a *M. tuberculosis* mycobacterial cell wall, compared with that of a common bacteria.

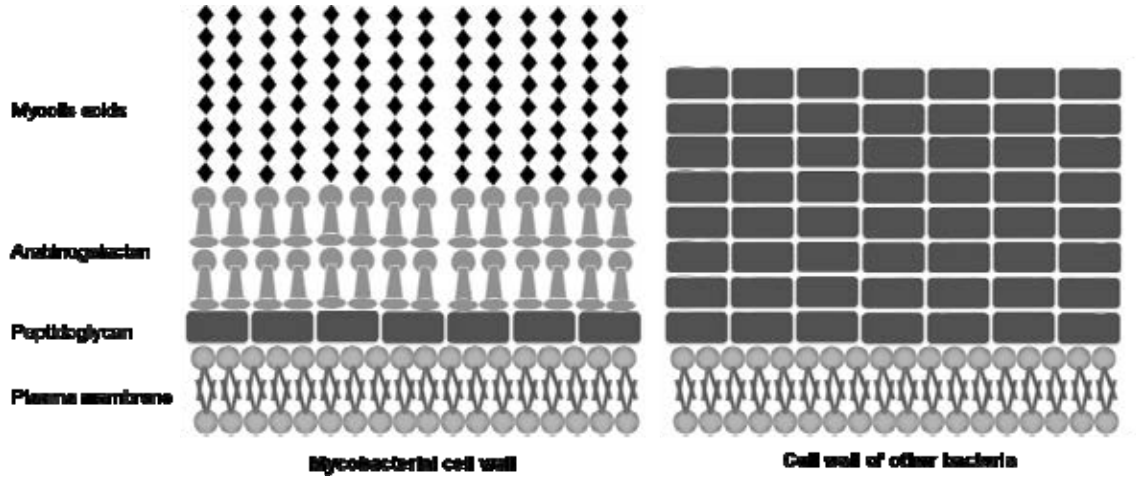

Fig. 3.2

(c) With reference to Fig. 3.1 and 3.2, suggest how the persistence of *M. tuberculosis* within the granulomas allows it to replicate intracellularly. [2]

Treatment of TB uses antibiotics to kill the bacteria. Effective treatment with traditional bacteriacidal antibiotics such as penicillin are ineffective. Antibiotics such as isoniazid and rifampicin are used instead for a prolonged period of time in order to ensure successful treatment of TB.

(d) With reference to Fig. 3.2, explain why administering penicillin will not effectively treat TB. [2]

Isoniazid is administered as a prodrug, and must be activated by a bacterial enzyme known as KatG. Upon activation, isoniazid inhibits the action of fatty acid synthase, inhibiting the synthesis of mycolic acids and thus preventing the synthesis of the mycobacterial cell wall.

Alarmingly, strains of *M. tuberculosis* that display resistance to isoniazid have been increasingly common. Scientists studied the genome of a resistant strain K131, and noted that there were numerous mutations identified in the 2.0-2.5Mb region. Fig. 3.3 shows the complete genome of K131.

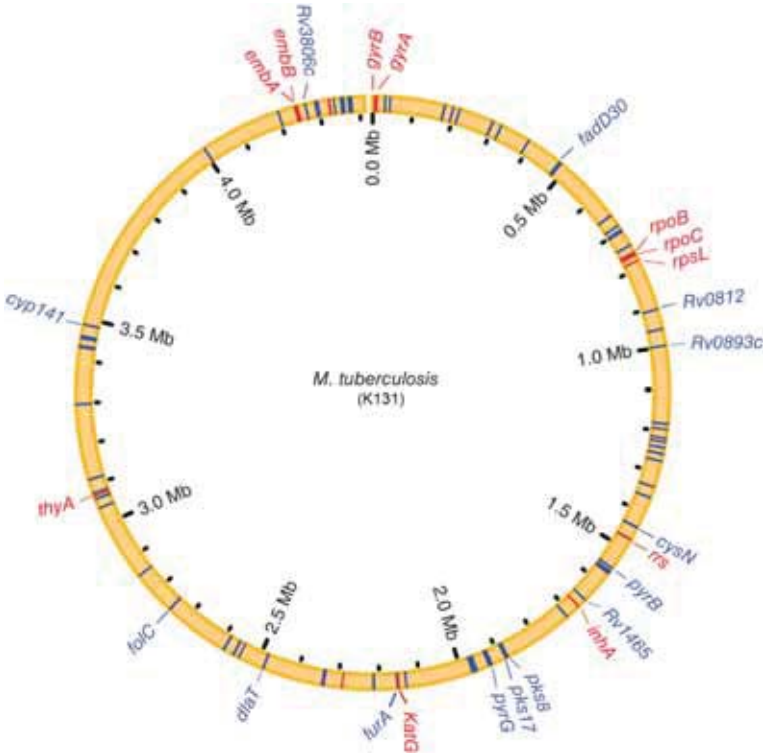

Fig. 3.3

(e) Explain how strain K131 is resistant to isoniazid. [4]

[Total: 13]

Section B

Answer **one** question in this section.

Write your answers on the separate writing paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

A **NIL** return is necessary if you have not attempted this section.

4 **(a)** Discuss the role of complementarity in cellular mechanisms. [12]

(b) Explain how genetic recombination occurs in B lymphocytes and the advantages of each process. [13]

[Total: 25]

5 **(a)** Explain what is meant by mutation, and outline its advantages and disadvantages to animals. [13]

(b) Describe the role of proteins in the transformation of energy from the environment to plant cells for their survival. [12]

[Total: 25]

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2017 Year 6 Prelim II Practical Exam Preparation List

Practical Exam	Apparatus (per student)	Materials
Question 1	2x 12 cm^3 syringes 2x 6 cm^3 syringes 4x test-tubes 3x boiling tubes 1x test-tube rack 1x rubber bung with delivery tube (bung to fit boiling tube) 1x glass rod 1x stopwatch 1x permanent marker 4x paper towels 1x 500 cm^3 beaker 1x thermometer 1x distilled water bottle 1x ethanol spray	40 cm^3 7% yeast suspension, labelled **Y** 25 cm^3 0.01 mol dm^{-3} calcium hydroxide with bromothymol blue indicator, labelled **C** 25 cm^3 0.05 mol dm^{-3} hydrochloric acid, labelled **H** 20 cm^3 0.2 mol dm^{-3} glucose solution, labelled **G** 20 cm^3 0.2 mol dm^{-3} sucrose solution, labelled **S** 20 cm^3 distilled water, labelled **W** Supply of hot water and plastic cups
Question 2	1x light microscope (1 between 2 students) 3x microscope slide 3x cover slip 1x mounting needle 1x petri dish 1x forceps 1x scalpel 1x white tile	10 cm^3 1 mol dm^{-3} potassium nitrate, in drop bottle 1x 2 cm segment of rhubarb

Remarks for Q1

Chemical Y

Do not use Brewer's yeast

Y, at least 50 cm^3 of a 7.0% yeast cell suspension with glucose added **10** to **15** minutes before the candidates start Question 1 (also the starting yeast cell suspension for Question 2).
As the yeast cell suspension will froth, it should be prepared in a large container.

7.0 g of dried yeast (**for baking**) is added to 80 cm^3 of warm distilled water, stirred and made up to 100 cm^3 with warm distilled water. This should be kept at a temperature between 35 °C and 40 °C.

This is sufficient for 2 candidates.

10 to **15** minutes before the candidates start Question 1 add the glucose.
Sprinkle 20 g of glucose, a little at a time, onto the surface of the yeast cell suspension, stirring continuously. Keep warm between 35 °C and 40 °C until needed.
When ready to put into beakers for each candidate, it is suggested that the yeast cell suspension is decanted into a new beaker or container leaving the froth behind.

50 cm^3 of the yeast cell suspension should be given to each candidate in a beaker or container, labelled **Y**. The beaker or container needs to be large enough to hold at least 250 cm^3 since the yeast will froth.

Chemical H

H, at least 30 cm^3 of 0.05 mol dm^{-3} hydrochloric acid in a beaker or container, labelled **H**.

This is sufficient for 1 candidate.

(Safety: Acid **must** be added to water. Water must **not** be added **to** acid.)

To dilute 1.00 mol dm^{-3} hydrochloric acid, add 5 cm^3 of the acid to 95 cm^3 of distilled water in a beaker or container.

Chemical C

C, at least 70 cm^3 of 0.01 mol dm^{-3} calcium hydroxide, in a beaker or container, labelled **C**.

This should be coloured blue by putting approximately 5 cm^3 of bromothymol blue indicator into the 70 cm^3 of **C**.

C is prepared by dissolving 0.74 g of calcium hydroxide in 500 cm^3 of distilled water, mixing well then making up to 1000 cm^3 with distilled water. This makes a solution which may remain cloudy. (If you do not have a balance which measures to 0.01 g then 0.7 g of calcium hydroxide is acceptable.)

This is sufficient for 14 candidates.

To prepare bromothymol blue indicator:

- Put 0.1 g of bromothymol blue into a beaker or container.
- Put 16 cm^3 of 0.01 mol dm^{-3} sodium hydroxide solution into the same beaker and mix well to dissolve the bromothymol blue.
- Make up to 250 cm^3 with distilled water.

To prepare 0.01 mol dm^{-3} sodium hydroxide solution:

- Using forceps, put 4 g of sodium hydroxide into a beaker or container with 80 cm^3 of distilled water.
- Mix well to dissolve.
- Make up to 100 cm^3 with distilled water. This is the stock solution of 1 mol dm^{-3} sodium hydroxide solution.
- Put 1 cm^3 of this stock solution into a beaker or container and make up to 100 cm^3 with distilled water.

RIVER VALLEY HIGH SCHOOL

YEAR 6 PRELIMINARY EXAMINATION II

CANDIDATE NAME									
CENTRE NUMBER	S					CLASS		INDEX NUMBER	

H2 BIOLOGY **9744/04**

Paper 4 Practical **28 Aug 2017**

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

Additional Materials: As listed in the Apparatus and Materials List.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your class, index number 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	**/ 19**
3	**/ 14**
Total	**/ 55**

This Question Paper consists of **16** printed pages.

Answer **all** questions.

Question 1

In this question, you will investigate the effect of glucose and sucrose on the rate of respiration in yeast cells.

You are provided with:

- 40 cm^3 yeast cell suspension, labelled **Y**
- 25 cm^3 blue alkaline solution, labelled **C**
- 25 cm^3 hydrochloric acid, labelled **H**
- 20 cm^3 of 0.2 mol dm^{-3} glucose solution, labelled **G**
- 20 cm^3 of 0.2 mol dm^{-3} sucrose solution, labelled **S**
- 20 cm^3 of distilled water, labelled **W**

*Read through steps **1** to **12** and prepare a table to record your results in step **(c)**, before starting the investigation.*

Stage 1

Perform the following steps to activate the yeast cells in **Y** to prepare for **stage 3**

1 Label 3 boiling tubes **B1**, **B2**, and **B3**. Add 10 cm^3 of **Y** into each of the boiling tubes.

2 Add 10 cm^3 of **G**, **S**, **W** into boiling tubes **B1**, **B2**, and **B3**, respectively.

3 Start the stopwatch. Leave the tubes aside for at least 15 minutes, before beginning on **stage 3**. During this time, you should attempt the rest of the question.

Stage 2

C, an alkaline solution, is blue because it contains an indicator.

Carbon dioxide reacts with **C** when bubbled into it. When enough carbon dioxide reacts with **C**, the indicator will change from blue to yellow (even if the mixture is cloudy). This is the end-point.

If only a small volume of carbon dioxide is bubbled into **C** then the indicator will remain blue. The end-point can then be reached by adding hydrochloric acid, **H**, slowly until the indicator turns from blue to yellow. The volume of **H** is then recorded.

The volume of **H** added to reach the end-point indicates how much carbon dioxide had reacted with **C**. The lesser the amount of carbon dioxide is bubbled into **C**, the more volume of **H** will need to be added to **C** to get the end-point.

You are required to find the volume of **H** needed to reach the end-point when **no** carbon dioxide has been bubbled into **C**.

4 Put 5 cm^3 of **C** into a test-tube.

5 Use a 6 cm^3 syringe, containing 3 cm^3 of **H**, to put drops of **H** into **C** as shown in Fig. 1.1. Mix well as you add **H**, until the end-point is reached. You may need to fill the syringe again.

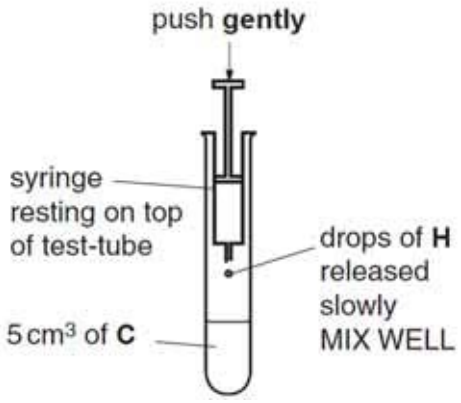


Fig. 1.1

(a) Record the volume of **H** needed to reach the end-point. [1]

Volume of **H** needed = _____ cm^3

Stage 3

You are required to investigate the effect of glucose and sucrose on the release of carbon dioxide from a yeast cell suspension using apparatus set up as in Fig.1.2, and the tubes prepared in **stage 1**.

Yeast cells release carbon dioxide from some of their metabolic reactions when provided with respiratory substrates. Tube **B1** contains glucose as the respiratory substrate, whilst tube **B2** contains sucrose.

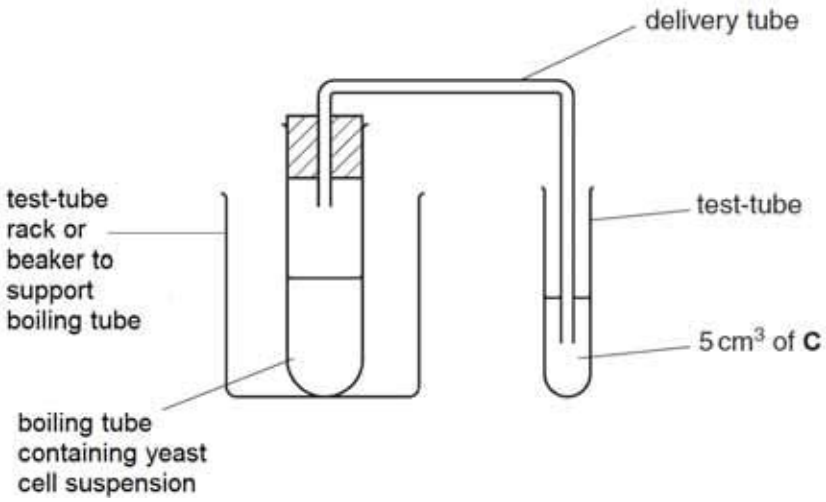


Fig.1.2

(b) State which sugar is expected to lead to a higher rate of carbon dioxide release by yeast cells. Explain your answer. [2]

Before proceeding with steps 6-12, ensure that 15 minutes have elapsed since stage 1.

6 Prepare and maintain a water bath at 40°C.

7 Label 3 test-tubes **T1**, **T2** and **T3**. Add 5 cm^3 of **C** into each of the three test-tubes.

8 Place tube **B1** in the water bath and allow it to equilibrate for 2 minutes.

9 Put the bung containing the delivery tube into tube **B1**, as shown in Fig. 1.2. Ensure that the seal is airtight.

10 Put the end of the delivery tube into solution **C** in **T1**. Using a stopwatch, allow the carbon dioxide produced by the yeast to bubble into **C** for 2 minutes.

11 After removing the delivery tube, repeat **step 5** to determine the volume of **H** needed to reach end-point and record your result in **(c)**. If **C** has already reached end-point, record '0'.

12 Repeat steps **8** to **11** for the tubes **B2** and **B3**.

(c) Record your results for each tube in a suitable form in the space below. [4]

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

The addition of 1 cm^3 of **H** into **C** is equivalent to 2.2 mg of carbon dioxide.

(e) Calculate the exact amount of carbon dioxide produced by the yeast suspension from boiling tubes **B1** and **B2** during the experiment. Show your working clearly. [2]

B1 _____ mg

B2 _____ mg

(f) State the purpose of including boiling tube **B3** in the investigation. [1]

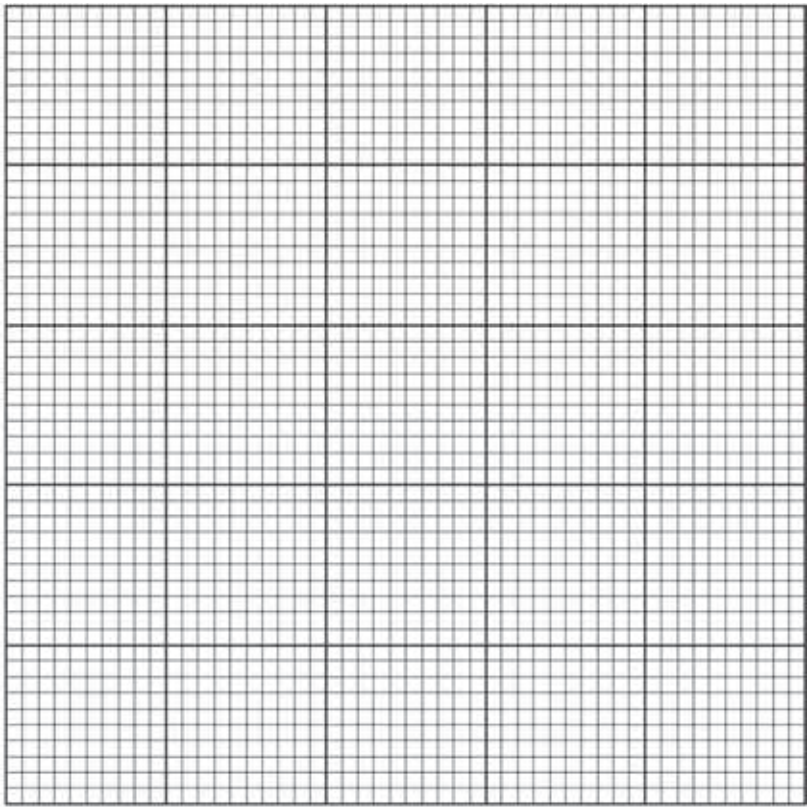
(g) Identify **one** significant source of error and suggest a modification to the method that would overcome this. [2]

In a separate study, a student used a modified version of the apparatus shown in Fig.1.2 to investigate the effect of temperature on the release of carbon dioxide from a yeast cell suspension. The results of the study are presented in Table 1.1.

Table 1.1

Temperature / °C	Volume of carbon dioxide evolved / cm^3
25.0	93
30.0	126
35.0	160
40.0	180
45.0	156

(h) Use the grid provided to plot the data given in Table 1.1. [4]



(i) Explain the relationship between the variables in yeast respiration. [4]

[Total: 22]

Question 2

During this question you will require access to a microscope.

You are required to investigate the effects of potassium nitrate and lead nitrate solutions on cells of the plant material with which you have been supplied. Peel off one or two strips of epidermis from the most deeply pigmented areas of the plant tissue. Remove as little of the underlying tissue as possible. Cut the epidermis so that you have two squares of tissue, each about 5 mm x 5 mm. Place these in a dish of distilled water.

Mount one piece of tissue on a microscope slide in **distilled water** under a cover slip.

Mount the other pieces in **1 mol dm^{-3} potassium nitrate** solution.

Label your slides appropriately.

Examine the tissue mounted in distilled water, using your microscope. Find an area of the tissue where pigmented cells occur, preferably as a single layer.

(a) Describe the distribution of the coloured contents within the cells. [1]

Observe the piece of tissue mounted in 1 mol dm^{-3} potassium nitrate solution, using your microscope.

(b) **(i)** After about one minute, make a large drawing to show the detailed structure of **one** epidermal cell which is typical of the most deeply coloured cells which you can see.

On your drawing, label the positions of the:

- cell wall
- cell surface membrane. [4]

(ii) Account **fully** for the change in appearance of the cells when placed in 1 mol dm^{-3} potassium nitrate solution. [3]

Heavy metals such as lead and copper are toxic to plants.

(c) Predict the appearance of the epidermal cells if the epidermis is mounted in **1 mol dm^{-3} lead nitrate** solution. Explain your predictions. [3]

Fig. 2.1 shows the view of a mammalian white blood cell, using an eyepiece graticule and the high-power objective lens of a microscope.

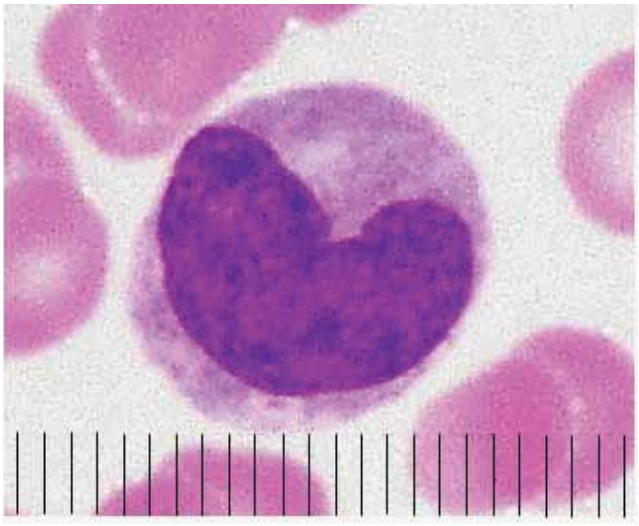


Fig. 2.1

(d) Use a table to record **three** observable differences between the blood cell in Fig. 2.1 and the cell you saw in **(a)**. [3]

(e) **(i)** The student calibrated the eyepiece graticule against a stage micrometer with the following results:

Number of eyepiece graticule divisions across 5 stage micrometer divisions = 25

One stage micrometer division = 0.01 mm

Use this information to calculate the actual length of the cell.

Show the steps and units in your calculation. [3]

Actual length of the cell _____

(ii) Calculate the magnification of the blood cell in Fig. 2.1.

Show your working. [2]

Magnification _____

[Total: 19]

Question 3

Industrial wastewater contains high concentrations of fats, like oil and grease, which may pollute fresh water and influence aquatic environments. The use of lipase enzymes to remove oil and grease from the wastewater is an effective and environmentally-friendly treatment method. Chemicals are added to the wastewater to emulsify the fats and break them up into smaller fat droplets, increasing the surface area for lipase to break them down into fatty acids and glycerol at a higher rate.

In wastewater treatment, enzymes are used on a large scale. However, enzymes are costly and most are only commercially available in liquid or dehydrated forms. As such, once added to the wastewater treatment mixture, they cannot be recovered to be re-used, thus driving up the cost of treatment.

Researchers postulated that the immobilisation of lipase in alginate beads would allow the enzymes to be re-used, leading to cost savings. The enzymes can be added to sodium alginate and immobilised in the beads as shown in Fig. 3.1.

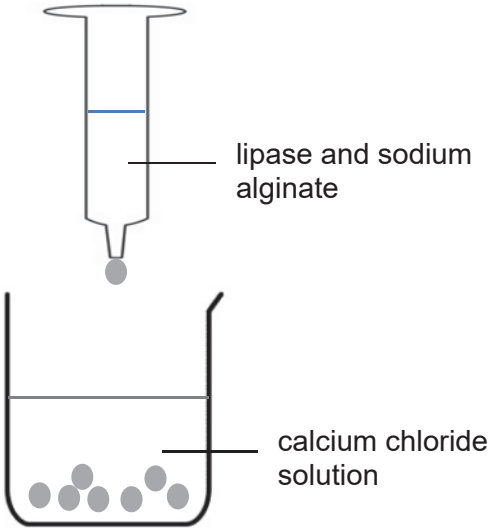


Fig. 3.1

Full-fat milk can be used as a substrate for the immobilised lipase enzymes. Bile salts act like detergents and can be used to emulsify the fats without affecting the pH. Sodium carbonate is a base that can be added to standardise the milk to an alkaline pH, prior to treatment with lipase.

The monitoring of the pH of the reaction mixture from a predetermined start to end-point pH can be used to measure the activity of the immobilised lipase.

Using this information and your own knowledge, design an experiment to find the concentration of lipase needed to form immobilised lipase beads with the same activity as free enzymes (non-immobilised).

You must use:

- 10% lipase solution
- industrial 3% lipase
- sodium alginate suspension
- calcium chloride solution
- full-fat milk
- sodium carbonate solution
- 5% bile salts solution
- a pH meter with a digital display to 2 decimal places
- stopwatch

You may select from the following apparatus:

- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rod, etc.
- syringes

Your plan should:

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

[Total: 14]

RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION II

CANDIDATE NAME											
CENTRE NUMBER	S					CLASS		INDEX NUMBER			

H2 BIOLOGY **9744/01**

Paper 1 Multiple Choice **22 Sep 2017**

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.
name in the spaces at the top of this page.
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 **16** printed pages.

1 The figure below shows an electron micrograph with two plant cells.

Peter v. Sengbusch - b-online@botanik.uni-hamburg.de

Which of the following statements correctly describes the labelled structures?

1 **R** contains circular DNA and is found in both prokaryotic and eukaryotic cells.

2 **P** has a fluid mosaic structure and regulates the movement of substances between the two plant cells.

3 **S** acts as a selective permeable barrier.

4 **Q** contains enzymes which play an important role in cell specialisation.

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

2 Which of the following statements regarding stem cells are not correct?

1 Stem cells are present within various organs of the adult body.

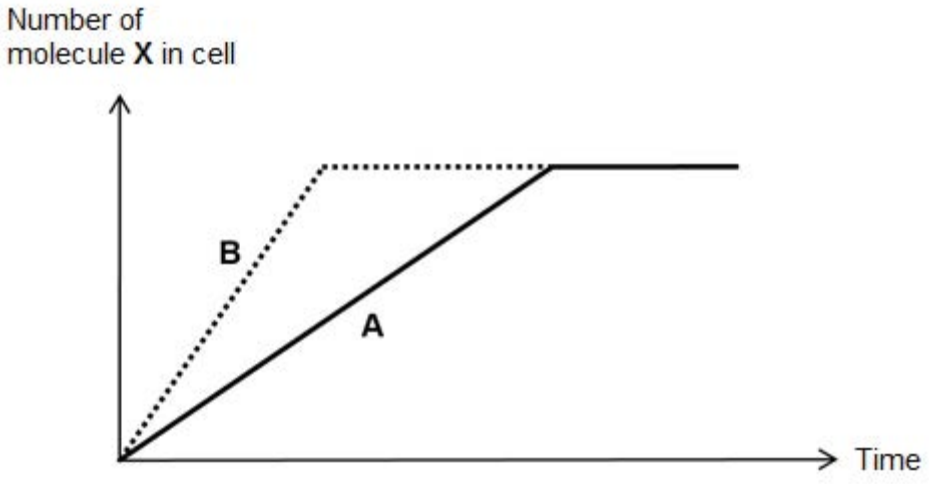
2 Stem cells can develop into a whole organism when implanted into the womb.

3 Stem cells can be grown indefinitely in culture under appropriate culture conditions.

4 Stems cells isolated from a 3-5 day old human embryo can differentiate into only one kind of cells.

	5 Induced pluripotent stem cells have the same developmental potential as embryonic stem cells.	
	A	1 and 3 only
	B	2 and 4 only
	C	2, 3 and 5
	D	1, 2 and 3

3 Graph **A** shows the transport of molecule **X**, with the help of carrier proteins, over time.



A student predicted that the alteration of one variable would result in graph **B**.

Which row shows the correct transport process and the alteration in variable that would result in graph **B**?

		Transport process	Alteration resulting in graph **B**
	A	facilitated diffusion	increase in environmental temperature to 90 °C
	B	active transport	increase in concentration of **X** in cell
	C	facilitated diffusion	increase in number of carrier proteins
	D	active transport	increase in availability of ATP

4 A student prepared three solutions of sugars, **X**, **Y** and **Z**, and diluted them to varying concentrations. A sample of each was heated with Benedict's reagent, with or without prior acid hydrolysis. The results are shown below.

	Concentration of solution/moldm^{-3}		
	0.0001	**0.001**	**0.01**

	no acid	with acid	no acid	with acid	no acid	with acid
X	Blue solution	Blue solution	Green mixture	Green mixture	Orange mixture	Orange mixture
Y	Blue solution	Green mixture	Blue solution	Green mixture	Blue mixture	Orange mixture
Z	Blue solution	Green mixture	Green mixture	Green mixture	Orange mixture	Orange mixture

Based on the results, which of the following conclusions is not correct?

A	Solution **Y** does not consist of monosaccharides.
B	Solution **X** and solution **Y** consists of disaccharides only.
C	Solution **X** consists of monosaccharides only.
D	Solution **Z** contains disaccharides.

5 The R groups of two amino acids are shown below.

Amino acid	R group
Serine	$-CH_2-OH$
Alanine	$-CH_3$

When placed in aqueous medium, where in a globular protein will these amino acids be found?

A	Both serine and alanine will be found in the interior of the globular protein.
B	Both serine and alanine will be found on the exterior of the globular protein.
C	Alanine will be found in the interior, and serine on the exterior of the globular protein.
D	Alanine will be found on the exterior, and serine in the interior of the globular protein.

6 The equations below show the relationship between an enzyme (**E**) and its substrate (**S**), product (**P**) and an inhibitor (**I**).

Pathway **A**: **E** + **S** → **E** + **P**

Pathway **B**: **E** + **S** + **I** → **E** + **S** + **I**

In the above reactions, assume that

- increasing the concentration of **S** increases the activity of the enzyme,

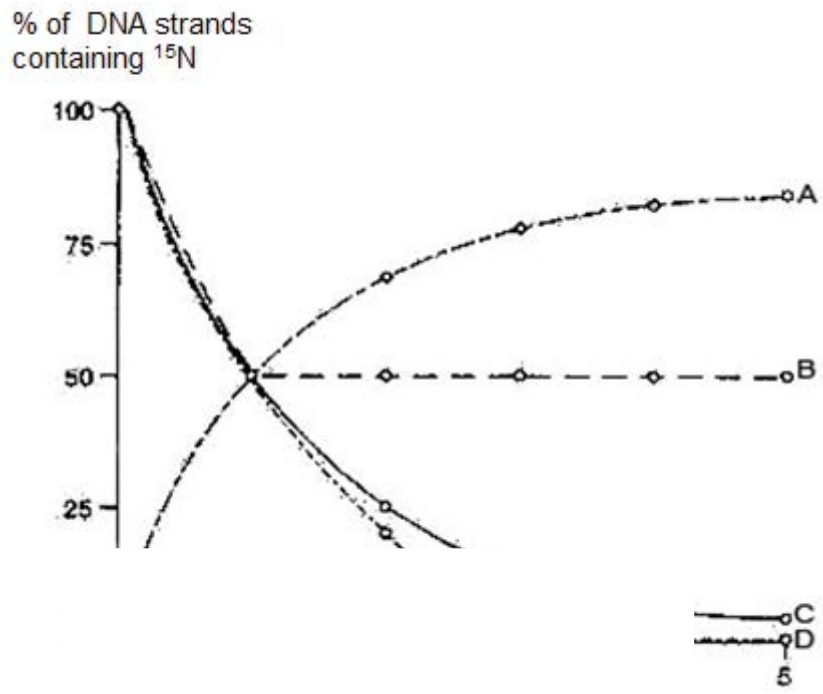
- at low substrate concentrations the presence of **I** reduces rate of reaction velocity, and
- the same maximum rate of reaction can be reached in the presence or absence of **I**.

Which mechanism is operating in pathway **B**?

A	Positive feedback
B	Negative feedback
C	Competitive inhibition
D	Non-competitive inhibition

7 Bacteria were cultured in a medium containing heavy nitrogen (^{15}N) until all their DNA were labelled. These bacteria were then grown in a medium containing only light nitrogen (^{14}N) for five generations. The percentage DNA strands containing ^{15}N in each generation was estimated.

Which curve provides evidence that each daughter DNA molecule produced consists of a parental strand and a newly synthesised daughter strand? **C**



8 Part of the amino acid sequence in β-globin chains of normal and mutant haemoglobin are shown.

Normal haemoglobin	thr-pro-glu-glu

Mutant haemoglobin	thr-pro-val-glu

Possible mRNA codons for these amino acids are

Glutamine (glu)	GAA GAG
Threonine (thr)	ACU ACC
Proline (pro)	CCU CCC
Valine (val)	GUA GUG

Which tRNA molecule is not involved in the formation of this part of amino acid sequence in mutant haemoglobin?

	A	B	C	D
				

9 Tay-Sachs disease is characterised by abnormal accumulation of lipid-related compounds, which results in deterioration of cognitive and motor abilities.

It is caused by an autosomal recessive mutation in the allele coding for hexosaminidase A (HEXA), an enzyme that regulates the metabolism of phospholipids.

The base triplets in part of the coding DNA sequences for a normal HEXA allele and a mutant Tay-Sachs allele, as well as their corresponding amino acids are shown.

Normal HEXA allele	**CGT**	**ATA**	**TCC**	**TAT**	**GCC**	**CCT**	**GAC…**	
	Arg	**Ile**	**Ser**	**Tyr**	**Gly**	**Pro**	**Asp**	
Tay-Sachs allele	**CGT**	**ATA**	**TCT**	**ATC**	**CTA**	**TGC**	**CCC**	**TGA…**
	Arg	**Ile**	**Ser**	**Ile**	**Leu**	**Cys**	**Pro**	**Thr**

Which combination correctly describes the nature of mutation that results in the Tay-Sachs allele?

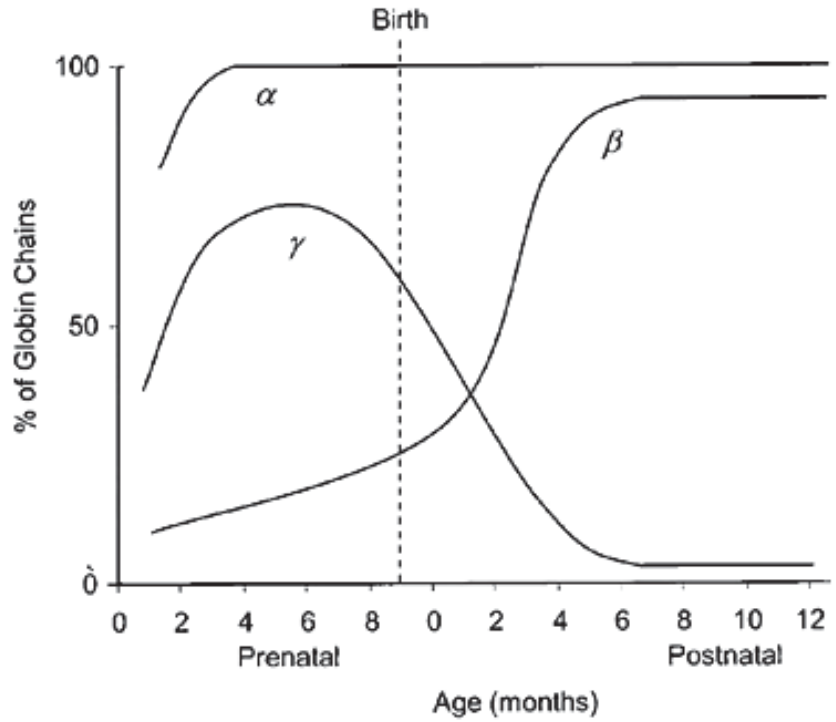
		Changes to nucleotide sequences	Alteration of reading frame	Length of polypeptide
	A	Deletion of 2 bases	Yes	Shorter
	B	Insertion of 2 bases	Yes	Longer
	C	Substitution of 4 bases	No	Unchanged
	D	Insertion of 4 bases	Yes	Longer

10 Which row correctly identifies the characteristics of the human genome?

		Promoter	Histone proteins bound to DNA	Centromeres	Repeated sequences
	A	Multiple	Always	Position varies for every chromosome	Absent
	B	One	Always	Position varies for every bivalent	Present
	C	Multiple	Sometimes	Position varies for every bivalent	Present
	D	One	Sometimes	Position varies for every chromosome	Absent

11 The globin gene family in humans consists of α, β and γ genes. These genes code for the globin chains that make up haemoglobin and are expressed at different levels during different developmental stages.

The graph shows the expression of the various globin chains during the prenatal (fetal) and postnatal (after birth) periods.

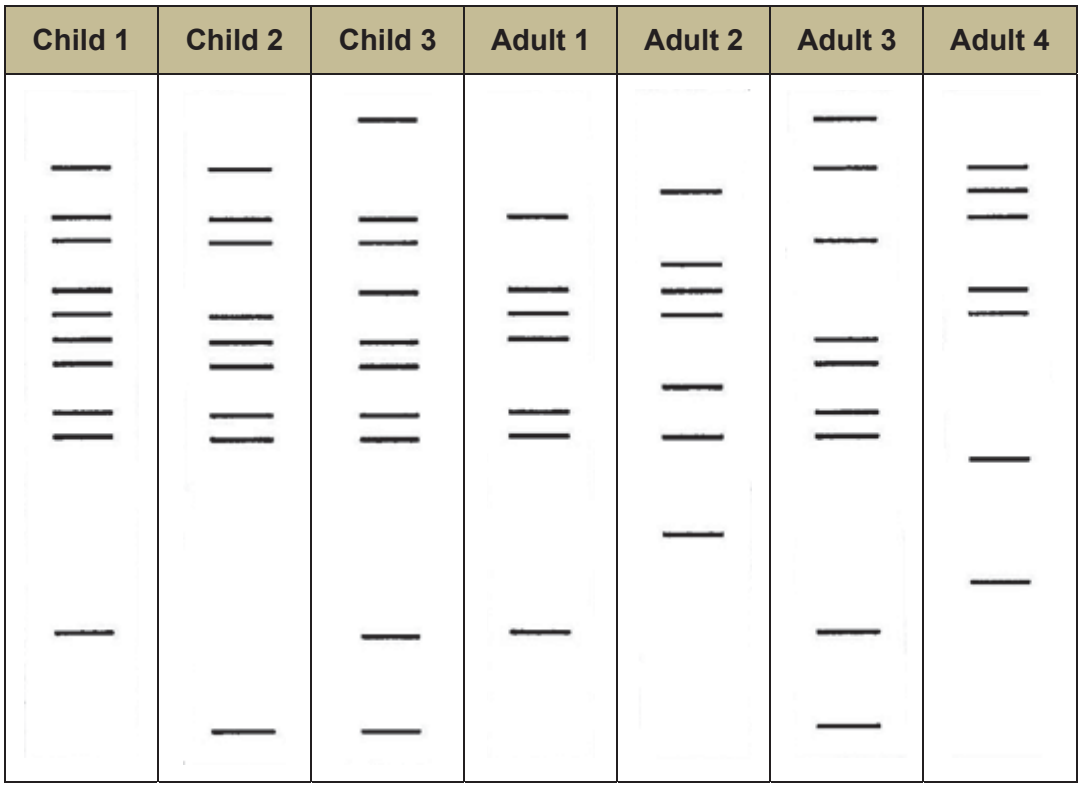


Which of the following cannot account for the differences in the levels of expression of globin chains?

A	Methyl groups are added to regulatory sequences of γ-globin genes during the postnatal period, allowing for some proteins to bind.
B	A growth factor triggers the expression of a transcription factor that increases the rate of β-globin gene expression during the postnatal period.
C	Alternative splicing occurs in the mature mRNA of the α-globin and β-globin genes, resulting in differences in the rate of expression of globin chains during the prenatal period.
D	The shortening of poly(A) tail in the mRNA of globin genes reduces its stability, resulting in a decrease in the rate of expression of γ-globin chains during the postnatal period.

12 Seven skeletons were found in an unidentified grave. To establish the relationship between these seven individuals, DNA were isolated from these skeletons and then analysed using gel electrophoresis.

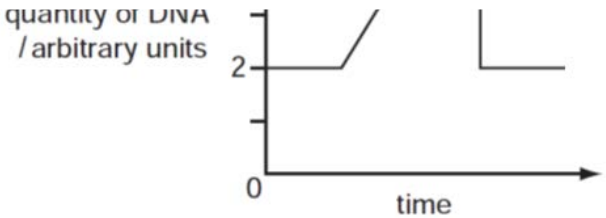
The results obtained from the skeletons, three children and four adults, are shown below.



Other analysis showed that all three children have the same parents. Which two adults may be the parents of these children?

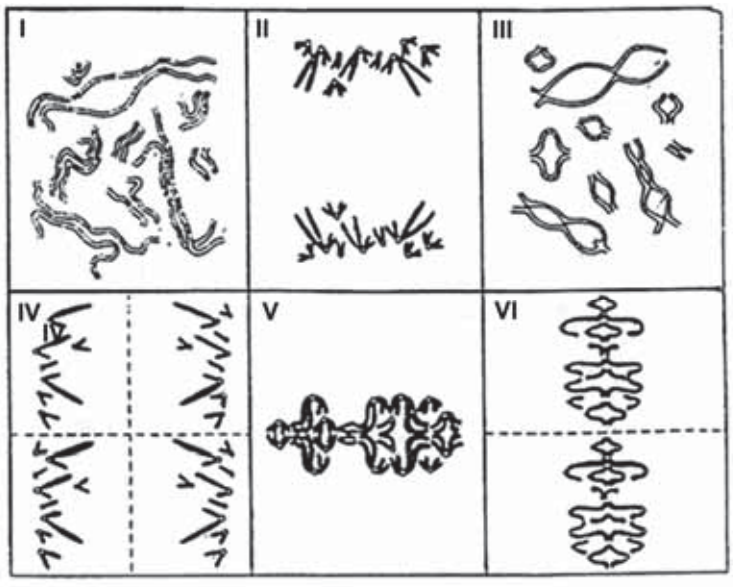
	A	Adults 1 and 2
	B	Adults 1 and 3
	C	Adults 2 and 3
	D	Adults 2 and 4

13 The graph shows the change in the quantity of DNA in a cell with one pair of chromosomes during a cell division.



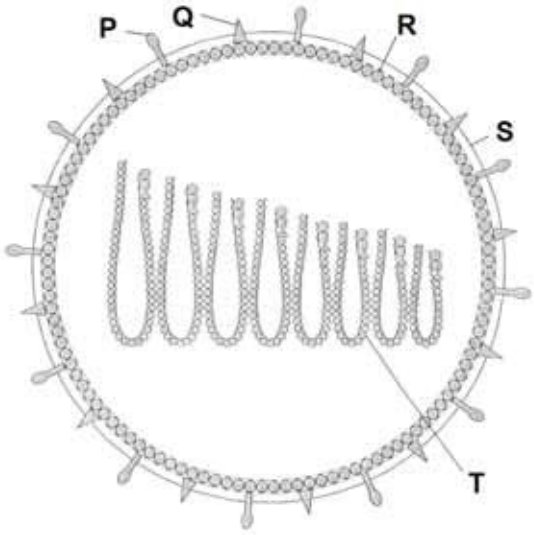
Which nucleus is formed as a result of this division?

	A	B	C	D
				

14	The diagram depicts the behaviour of chromosomes at various stages of meiosis of the same cell.  Which of the following shows the correct order of the stages?	
	A	**III → V → II → VI → IV → I**
	B	**III → I → V → II → VI → IV**
	C	**II → III → I → V → VI → IV**
	D	**I → III → V → II → VI → IV**

15	Which of the following are necessary for tumourgenesis to occur? 1 Gain of function mutation to proto-oncogenes 2 Loss of function mutation of tumour suppressor genes 3 Inactivation of telomerase enzymes preventing cell apoptosis 4 Production of chemical factors that induce angiogenesis	
	A	1 only
	B	1 and 2 only

	C	1, 2 and 3 only
	D	All of the above

16	The diagram shows the structure of an influenza virus.  Which of the following statements concerning the lettered components are correct? 1 Mutations that disrupt the function of **R** will result in the inability of the virus to initiate infection in the host cell. 2 **P** and **Q** are unlikely targets for vaccination because they undergo mutation constantly. 3 New influenza viruses acquire **S** from host cell during budding. 4 The host cell enzymes are not required to form the complementary RNA from **T**.	
	A	1 and 2 only
	B	3 and 4 only
	C	1, 2 and 3
	D	2, 3 and 4

17	Which statements about viruses are true? 1 They encode genes for synthesising their own ATP. 2 They are single-cell organisms. 3 They can have genomes made of DNA. 4 They package ribosomes into their virion.

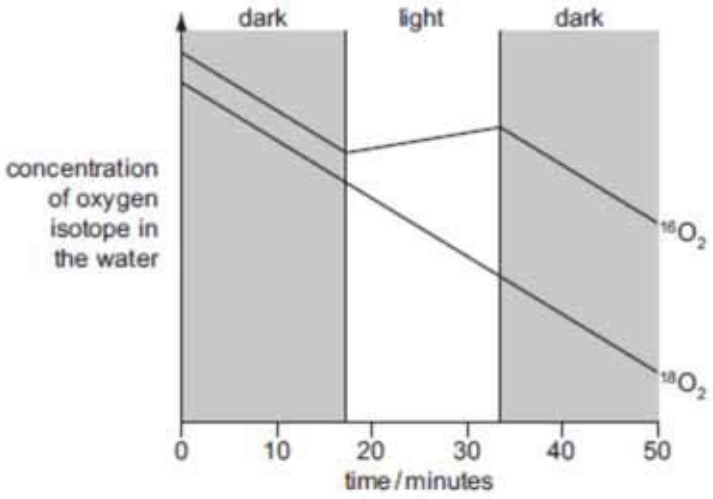
	5 They can have a single-stranded or double-stranded RNA genomes. 6 They can have a membrane-like envelope.	
	A	5 and 6 only
	B	3, 5 and 6
	C	1, 3, 5 and 6
	D	All of the above

18	Which of the following statements about the *lac* operon are correct? 1 *lac Z*, *lac Y* and *lac A* are structural genes that will be expressed when the operator is switched on. 2 In the absence of alloactose, the repressor protein will be unable to bind to the operator. 3 When glucose and lactose are available and the repressor becomes inactive as allolactose binds to it. 4 *lac Y* codes for a protein that increases uptake of lactose from environment. 5 Catabolite activator protein binds to promoter to increase rate of transcription.	
	A	1 and 2
	B	1 and 3
	C	1, 2 and 5
	D	3, 4 and 5

19	A black-haired female rabbit was crossed with a white-haired male rabbit. Eight offspring were born. Two were white-haired males, two were white-haired females and all the others were black-haired females. What can be deduced about the inheritance of hair colour in rabbits?	
	A	Hair colour is sex-linked in rabbits.
	B	The allele for black hair is dominant to the allele for white hair.
	C	The allele for white hair is dominant to the allele for black hair.
	D	The results of this cross are inconclusive.

20	Two genes, Q and R, affect the size of the petals and the pigmentation of a flower. Gene Q has two alleles, Q^L and Q^A. The genotype Q^LQ^L produces large petals, Q^LQ^A

	produces small petals, and in Q^AQ^A, petals are absent. Gene R has two alleles. R produces a red pigment and is dominant over the allele r that produces no pigment. A plant that is heterozygous at both gene loci was selfed. How many different phenotypes will be observed in the next generation?	
	A	4
	B	6
	C	9
	D	12

21	The common isotope of oxygen is ^{16}O. Air containing $^{16}O_2$ and $^{18}O_2$ was bubbled through a suspension of algae for a limited period. After this, the concentration of these two isotopes of oxygen in the water was monitored for the next 50 minutes whilst the algae were subjected to periods of dark and light. The results are shown in the diagram.  What is the best explanation for these results?	
	A	Both isotopes of oxygen are used by the algae in the dark in respiration, but in the light oxygen is produced from water in photorespiration.
	B	The algae can distinguish chemically between the two isotopes.
	C	The algae produce oxygen from the water used in photosynthesis, but only in the light.
	D	The two isotopes have different rates of diffusion.

22	After vigorous exercise, changes occur in the muscle tissue. Compared with 'at rest' conditions, what will the changes be?

		ATP	lactate	pH
	A	decreased	increased	decreased
	B	increased	increased	increased
	C	decreased	decreased	increased
	D	increased	decreased	decreased

23 The hormone insulin binds to the tyrosine kinase receptors and initiates various signal transduction pathways to generate cellular responses. Which of the following shows the correct sequence of events, following the binding of insulin to the receptor?

1 phosphorylation of tyrosine residues
2 signal amplification
3 dimerisation of tyrosine kinase receptor
4 signal transduction
5 activation of transcription factors

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

24 During pregnancy, glucose is transferred from the bloodstream of the mother to the bloodstream of the foetus through the placenta.

In an experiment conducted on a pregnant female subject, experiments **X** and **Y** were conducted with control periods of no treatment before them.

Measurements of blood glucose levels in both mother and foetus were made. Also, the glucose transfer rates from mother to placenta, and from placenta to foetus were monitored. The experimental data is shown in the table below.

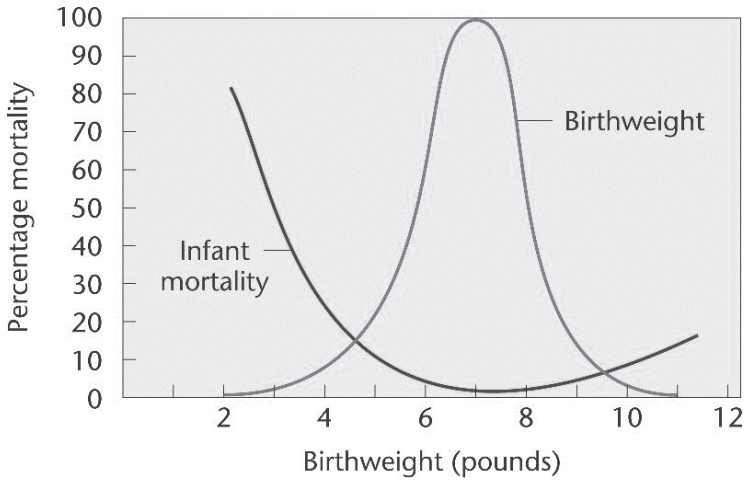
Experiment	Glucose concentration / mg cm^{-3}		Glucose transfer rate / mg min^{-1}	
	Maternal blood	Foetal blood	From mother to placenta	From placenta to foetus
Control period	54	15	38	9
After **X**	54	9	38	16
Control period	52	14	39	8

	After **Y**	211	30	58	34

Which of the following is likely to describe experimental steps **X** and **Y**?

		X	**Y**
	A	Glucagon injection given to foetus	Insulin injection given to mother
	B	Insulin injection given to foetus	Glucagon injection given to foetus
	C	Insulin injection given to mother	Glucagon injection given to foetus
	D	Insulin injection given to foetus	Glucose injection given to mother

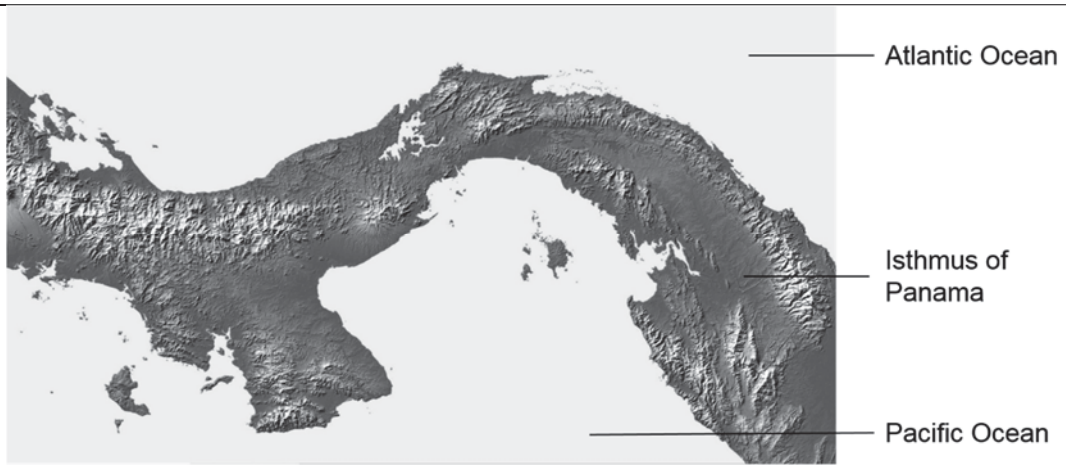
25 The graph below shows the relationship between birthweight and infant mortality in humans.



What type of selection is demonstrated above?

	A	Directional selection
	B	Disruptional selection
	C	Stabilising selection
	D	Artificial selection

26 The formation of the Isthmus of Panama around 3 million years ago (*Mya)* led to the separation of the Pacific and Atlantic oceans. Pistol shrimps of the *Alpheus* genus can be found in both oceans, surrounding the Isthmus. *Alpheus nuttingi* resides in the Atlantic ocean and *Alpheus millsae* resides in the Pacific ocean.



Despite being physically separated, *A. nuttingi* and *A. millsae* are morphologically and genetically very similar. The two species have also been shown to be capable of interbreeding in captivity. Which of the following statements are likely to be true?

1 *A. nuttingi* and *A. millsae* are derived from a common ancestral species.

2 The formation of the Isthmus resulted in geographical isolation of the two species 3 *Mya*.

3 *A. nuttingi* and *A. millsae* are two separate species because they are geographically isolated.

4 Similar environmental conditions around the Isthmus exerted similar selection pressures, leading to convergent evolution between *A. nuttingi* and *A. millsae*.

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

27 Myxomatosis is a viral disease of rabbits. It spreads rapidly and most rabbits die within 14 days of being infected. Myxomatosis has been deliberately used to reduce the number of rabbits in countries where they are a significant crop pest.

The initial release of the virus caused populations to fall by over 90%. Resistance to myxomatosis increased in the 70 years following initial release, so at the present time up to 50% of infected rabbits are able to survive.

Which of the following statements could explain the increasing frequency of resistance to myxomatosis in the years following release of the virus?

1 In populations with high incidences of myxomatosis, mutations leading to resistance are more likely to occur.

2 Infected rabbits die quickly, hence the alleles that code for myxomatosis are eliminated from the population.

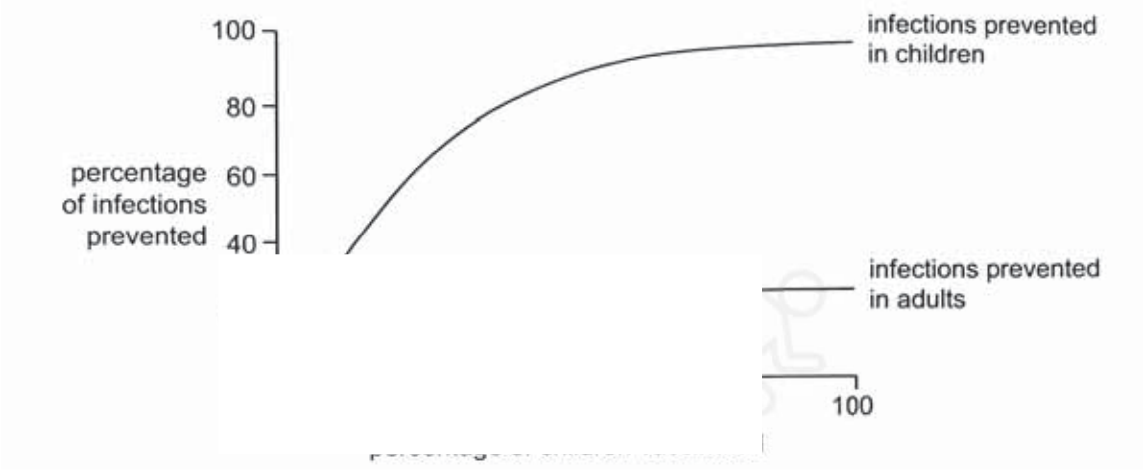
3 The initial release of the virus led to a bottleneck event, greatly altering the frequency of alleles in rabbit populations.

4 During disease outbreaks there is greater food availability for the surviving

		rabbits, increasing the probability that they survive.
	A	4 only
	B	1 and 2 only
	C	2 and 4 only
	D	2, 3 and 4 only

28	Which statements correctly describe lymphocytes? 1 Each B lymphocyte has the ability to make several types of antibody molecules. 2 Some B lymphocytes and T lymphocytes become memory cells. 3 Plasma cells secrete antibodies into the blood plasma. 4 Some T lymphocytes stimulate macrophages to kill infected cells.	
	A	1, 2, 3 and 4
	B	1, 2 and 3 only
	C	2, 3 and 4 only
	D	1 and 4 only

29 When sufficient individuals are vaccinated, the disease transmission cycle can be broken. The diagram shows the effect of vaccination of children on the prevention of infection.



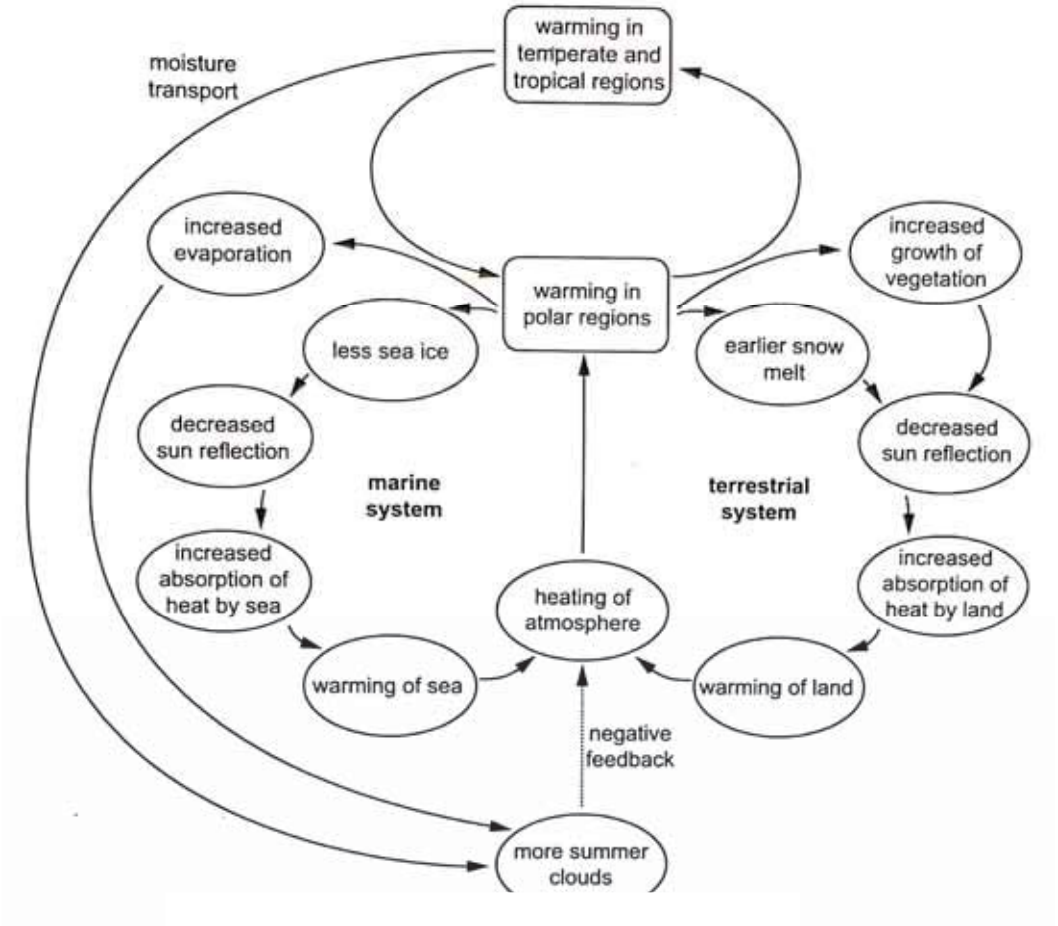
What can be concluded about the effect of vaccination of children from this data?

1 When approximately 80% of children are vaccinated, the cycle of disease transmission in children is broken.

2 Vaccination of children reduces the percentage of infections in both adults and children.

3 The effect on adult infections is less than that of infection in children, because

	adults will have been vaccinated as children.	
	A	1, 2 and 3
	B	1 and 2 only
	C	1 and 3 only
	D	2 and 3 only

30	The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.  Which effect of higher temperatures in the polar regions could increase global warming?	
	A	Increased evaporation leads to more rainfall, which absorbs heat from the land and sea.
	B	Melting of ice and snow results in less reflection of sunlight and more heat absorption by the earth.
	C	Melting of sea ice causes more cloud formation which increases absorption of heat in the atmosphere.

	D	Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.

RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION II

CANDIDATE NAME											
CENTRE NUMBER	S					CLASS		INDEX NUMBER			

H2 BIOLOGY **9744/02**

Paper 2 Structured Questions **11 Sep 2017**

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.

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

For Examiner's Use	
1	/ 9
2	/ 13
3	/ 8
4	/ 10
5	/ 12
6	/ 15
7	/ 10
8	/ 11
9	/ 12
Total	/ 100

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

Answer **all** questions.

1 Fig. 1.1 shows an electron micrograph of part of a plant cell.

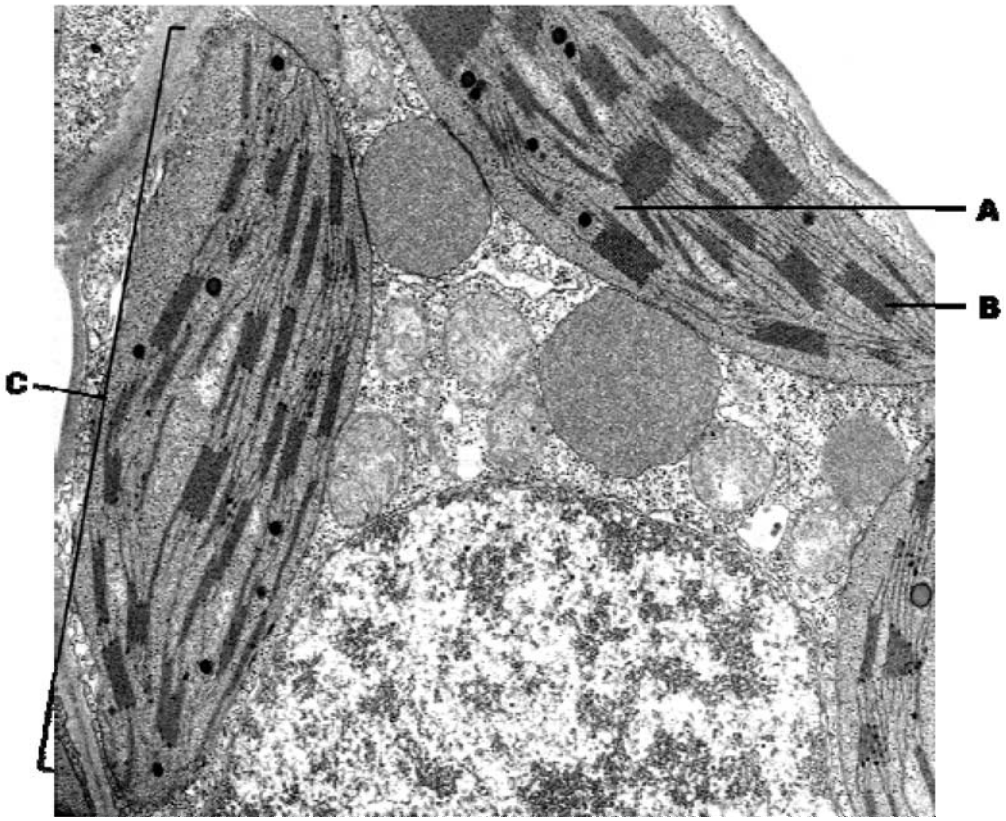


Fig. 1.1

(a) Identify region **A** and state its function. [2]

1. **Stroma (of chloroplast);;**
2. **Site of light independent reactions / Calvin cycle;;**

(b) Describe how the structure of the membrane at **B** allows it to perform its function. [3]

1. **(S) Large surface area of thylakoid membrane;**
2. **(F) Holds photosystems for light absorption / ETC for transfer of electrons;**
3. **(S) Thylakoid membrane impermeable to H^+;**
4. **(F) Allows proton gradient to be generated (for chemiosmosis);**
5. **(S) Contains ATP synthase;**
6. **(F) For phosphorylation of ADP to ATP / ATP synthesis.**

Cyanobacteria are prokaryotic cells that are capable of carrying out photosynthesis. The

structure of a cyanobacteria is shown in Fig. 1.2.

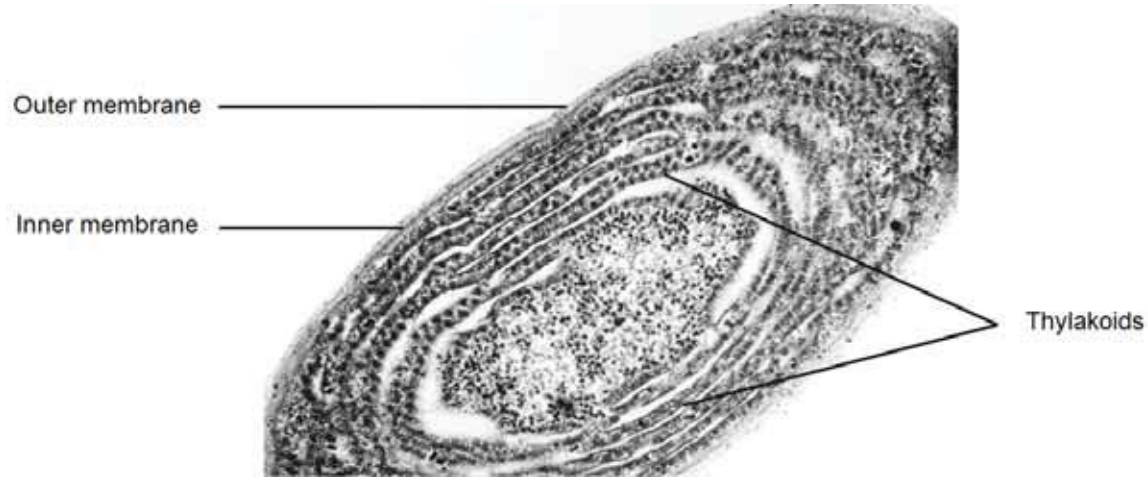


Fig. 1.2

(c) With reference to Fig. 1.1 and Fig. 1.2, compare the visible structures of cyanobacteria with that of **C**. [2]

Similarities (1 max)

1. **Both are bound by two membranes;;**
2. **Both have thylakoids;;**

Differences (1 max)

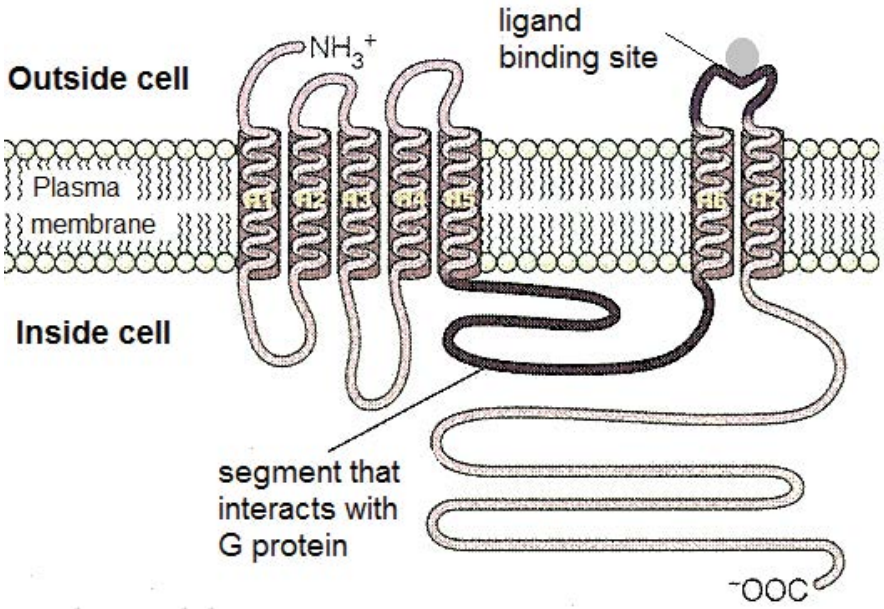
Feature	Chloroplast	Cyanobacteria
Grana	Present	Absent;;
Intergranal lamellae	Present	Absent;;

Cyanobacteria are considered to be the ancestors of structure **C**. They continued to function after being engulfed by primitive eukaryotic cells and evolved over time. This theory is known as the endosymbiont hypothesis.

(d) State **two** features of structure **C** that provide support for this hypothesis. [2]

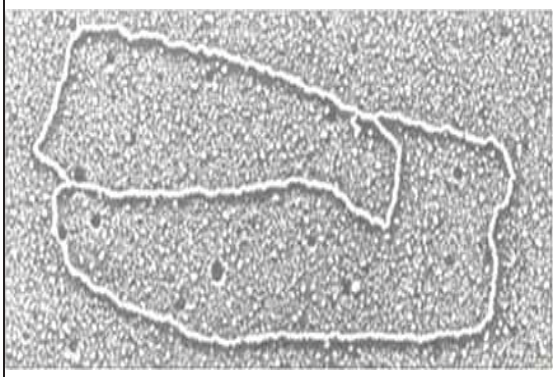
1. **contains circular DNA;;**
2. **has 70S ribosomes;;**
3. **divides via binary fission;;**

[Total: 9]

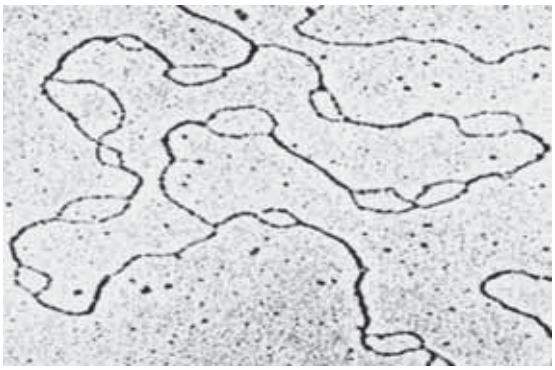
2	Fig. 2.1 shows the structure of a G-protein coupled receptor (GPCR).  **Fig. 2.1**			
	(a)	Describe how the structure of GPCR is adapted to its function.		[3]
		1. (S) The seven α-helices are mainly hydrophobic; **2. (S) can interact with the hydrocarbon tails of phospholipids via hydrophobic interaction;** **3. (F) embeds GPCR in the cell surface membrane;** **4. (S) has an extracellular binding site;** **5. (F) for binding to complementary shape ligand;** **6. (S) has an intracellular binding site / segment;** **7. (F) (for binding to G protein) for activation of G protein;** **8. (F) to transduce extracellular signals for activation of intracellular proteins / signal transduction;**		
	One of the cellular events resulting from glucagon binding to GPCR, shown in Fig. 2.1, is the activation of glycogen phosphorylase which breaks down glycogen to glucose.			
	(b)	**(i)**	Describe how binding of glucagon leads to activation of glycogen phosphorylase.	[3]
			1. (binding of glucagon to ligand binding site on GPCR) causes conformation change of receptor; **2. GTP displace GDP in G protein;** **3. activating it;**	

			4. and move along membrane to activate adenylyl cyclase; **5. Catalyse conversion of ATP to cAMP;** **6. Activation of protein kinase A;** **7. Activate phosphorylation cascade;**	
		(ii)	Explain why liver cells store glucose in the form of glycogen.	[3]
			1. (large molecule) insoluble in water and will not exert osmotic or chemical influence on the cell;; **2. anomeric carbon is involved in glycosidic bond making glycogen stable and unreactive;;** **3. extensively branched, hence is compact in shape;;**	
	The binding of glucagon to GPCR leads to an increase in blood glucose level partly due to the action of glucose transporters. Glucose transporters transport glucose via facilitated diffusion.			
	(c)	**(i)**	Explain what is meant by facilitated diffusion.	[2]
			1. Net movement of glucose; **2. down concentration gradient;** **3. via channel /carrier protein;** **4. without additional investment of energy;**	
		(ii)	Explain why glucose transporters are necessary to facilitate this process.	[2]
			1. glucose is polar;; **2. cannot diffuse across <u>hydrophobic</u> core;** **3. of membrane/phospholipid layer;**	
				[Total: 13]

3 Fig. 3.1 shows DNA replication in an *Escherichia coli* (**A**) and in a mammalian cell (**B**). Diagrams are not shown to scale.



A



B

Fig. 3.1

(a) State **one** way in which the DNA replication in these two organisms differs and explain the advantage of this to the mammalian cell. [2]

1. Single origin of replication in bacterium but multiple origin of replication in mammalian cell;; Accept: multiple replication sites / bubbles

2. Larger / longer DNA, speed up replication;;

(b) Explain why DNA replication is said to be semi-conservative. [2]

1. Parental DNA strands separate / ref. to H bonds break;

2. Both strands acts as a <u>template</u> for synthesis of daughter strand;

3. Each daughter DNA molecule consists of one parental strand and one newly synthesised strand of DNA;;

End replication problem is a fundamental problem associated with replicating DNA in eukaryotes.

Some cells contain telomerase, which is responsible for extending the ends of DNA in eukaryotes. Fig. 3.2 shows the action of a telomerase enzyme.

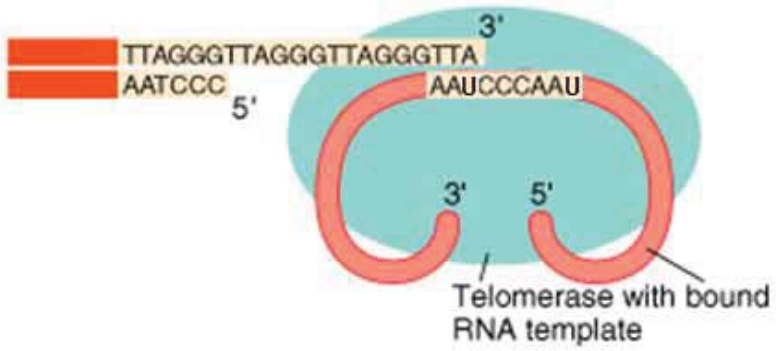


Fig. 3.2

(c) Explain how the end-replication problem arises. [2]

1. **due to the specificity of DNA polymerase;**
2. **the RNA primers complementary to the 3' ends (of the template DNA);**
3. **cannot be replaced after their removal;**
4. **without a 3' hydroxyl group on the DNA strand for DNA polymerase to add nucleotides to;**

(d) With reference to Fig. 3.2, state **two** differences between transcription and the process of lengthening of DNA ends. [2]

Feature	Lengthening of DNA	Transcription
Template	RNA	DNA
Monomers	DNA nucleotides	RNA nucleotides
Enzyme involved	Telomerase	RNA polymerase
Product synthesised	DNA	RNA

1 mark for each comparative statement

Any two

[Total: 8]

4 Huntington's disease is a rare neurodegenerative disorder targeting the central nervous system. Transcriptional dysregulation is one of the commonly observed molecular abnormalities affected in this disease. Recent evidence suggests the involvement of a mutant Huntingtin protein in the processes regulating condensation of DNA, leading to activation of DNA damage response and death of nerve cells. DNA in various levels of condensation can be observed in the nerve cell nucleus. Fig. 4.1 shows one of the levels of condensation of chromatin.

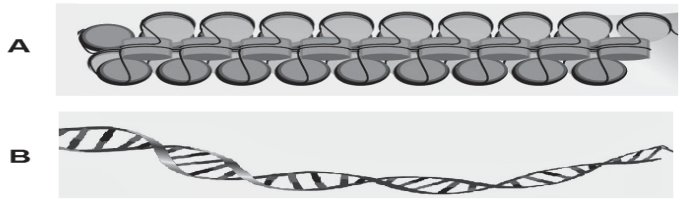


Fig. 4.1

(a) It is postulated that mutant Huntingtin protein facilitates packing of DNA into structure shown in Fig. 4.1. Describe how the DNA double helix is condensed into this structure. [2]

1. **DNA coils around histone octamer;**
2. **Forming 'beads on a string' structure' / 10 nm chromatin fibre / nucleosome fibre;**
3. **Histone H1 further interacts;**
4. **with linker DNA; giving rise to the structure**

(b) The chromosomal condensation in **(a)** is the main reason for the commonly observed transcriptional dysregulation in Huntington's disease. Explain how transcription is affected. [3]

1. **Downregulation of transcription;;**
2. **DNA is condensed / highly folded;**
3. **Promoter not accessible;**
4. **for binding of RNA polymerase / transcription factors;**
5. **to initiate transcription;**

It is observed that nerve cells could remove Huntingtin proteins via ubiquitination of specific amino acids. However, the mechanism that triggers ubiquitination is unclear.

In a study to determine the mechanism for degradation of Huntingtin proteins, selected amino acids were investigated and the results are shown in Table 4.1.

Table 4.1

	13th amino acid: serine	16th amino acid: serine	6th amino acid: lysine	9th amino acid: lysine	15th amino acid: lysine	Fate of Huntingtin protein
Trial 1	De-	De-	Ubiquitin not	Ubiquitin not	Ubiquitin not	Remains

	phosphorylated	phosphorylated	attached	attached	attached	active
Trial 2	Phosphorylated	De-phosphorylated	Ubiquitin not attached	Ubiquitin not attached	Ubiquitin not attached	Remains active
Trial 3	De-phosphorylated	Phosphorylated	Ubiquitin not attached	Ubiquitin not attached	Ubiquitin not attached	Remains active
Trial 4	Phosphorylated	Phosphorylated	Ubiquitin attached	Ubiquitin attached	Ubiquitin attached	Degraded

(c) With reference to Table 4.1,

(i) state the level of control for Huntingtin gene expression. [1]

Post-translation;;

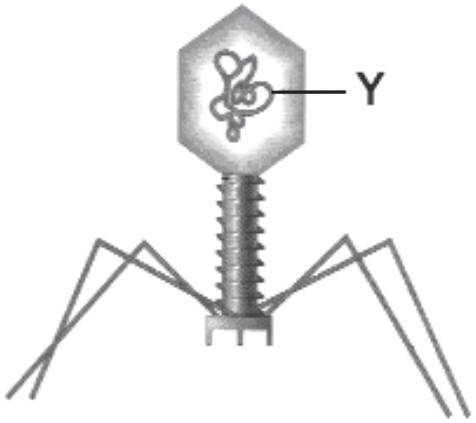
(ii) describe the events at the selected amino acids that triggers the degradation of Huntingtin proteins. [2]

1. **Phosphorylation of serine residues;**
2. **at position 13 and 16;**
3. **ubiquitination of lysine residues;**
4. **at positions 6, 9, and 15;**

(iii) describe how ubiquitination results in the removal of mutant Huntingtin protein. [2]

1. **Ubiquitin marks the mutant Huntingtin protein for degradation;;**
2. **Proteasomes recognises ubiquitin (tag) on protein;**
3. **and hydrolyses / breaks down protein into peptide / amino acids;**

[Total: 10]

5	Fig. 5.1 shows the structure of a T4 virus.  **Fig. 5.1**		
	(a)	Identify structure **Y**.	[1]
		Double-stranded deoxyribonucleic acid;;	
	The T4 virus cannot reproduce by itself and relies upon a host cell for reproduction.		
	(b)	State specifically why T4 viruses rely on host cells for their reproduction.	[2]
		1. lacks a named enzyme (e.g. RNA polymerase / DNA polymerase);; **2. lacks a named organelle (e.g. golgi apparatus for protein modification / RER for protein synthesis);;** **3. lacks a named molecule for protein synthesis / DNA replication;;** **4. lacks a named energy resources, e.g. ATP;;**	
	T4 viruses use bacteria as its host. Fig. 5.2 shows the results of an experiment in which T4 viruses were added to a culture of bacteria. Samples of the culture were then taken at intervals to determine the number of free T4 viruses present.		

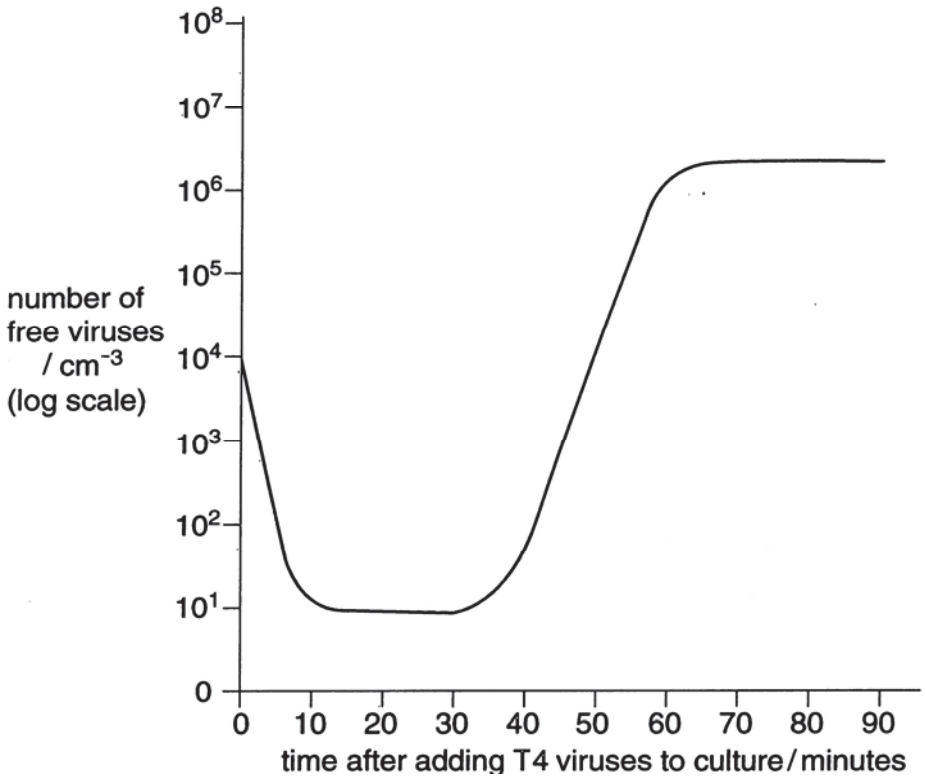


Fig. 5.2

	(c)	With reference to Fig. 5.2, describe and explain the changes in number of free T4 viruses		
		(i)	in the first 10 minutes;	[2]
			1. number of free viruses decreases from 10^4 to 10^1 cm^{-3};; **2. Due to attachment of viruses on the *E. coli*;;** **Reject: viruses enter host cell**	
		(ii)	between 30 and 60 minutes.	[3]
			1. number of free viruses increases from 10^1 to 10^6 cm^{-3};; **2. due to lysis of host cell to release viruses;;** **3. (increase in number of viruses from 10^4 to 10^6) due to multiplication of viruses;;**	

A scientist carried out an investigation using T4 virus and two strains of bacteria: **B^+** cells which can grow in media without lysine and **B^{--}** cells which only grow when supplied with lysine. The procedure is shown in Fig. 5.3.

T4 are mixed with **B^+** cells

↓

T4 are isolated from the culture and added to **B^{--}** cells

↓

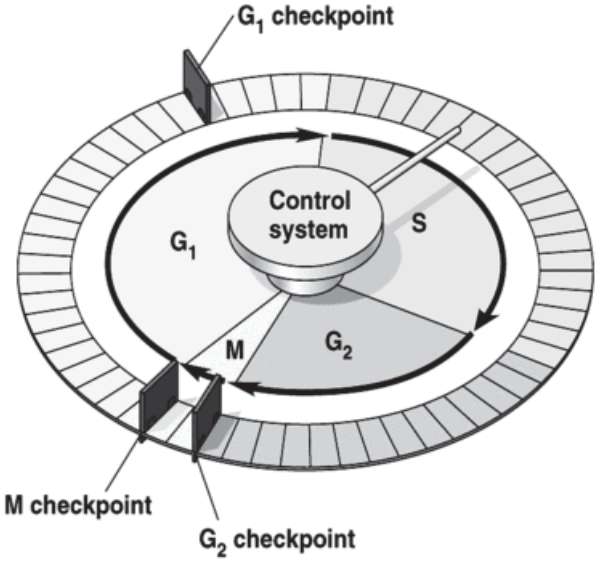
B^{--} cells are plated on medium lacking lysine

↓

Growth observed on medium

Fig. 5.3

	(d)	**(i)**	Explain the observations made by the scientist.	[3]
			1. (Generalised) transduction; **2. T4 infects B^+ cell;** **3. Fragment of B^+ DNA confers ability to produce lysine;** **4. are accidentally packaged into phage capsid;** **5. Upon release from B^+ cell, transducing phage <u>infects</u> new B^- cell;** **6. B^+ DNA incorporated into B^- DNA (via homologous exchange);** **Penalise 1 mark for lack of contextualisation**	
		(ii)	Suggest **one** other potential benefit of the process mentioned in **(d)(i)** for the recipient bacteria.	[1]
			1. Develop antibiotic resistance/ xenobiotic (chemical) resistance;; **2. Ability to utilise a new metabolite;;**	
				[Total: 12]

6	The cell cycle is an ordered sequence of events involving two stages that culminates in cell growth and division into daughter cells. It is an essential mechanism by which all living things reproduce.  *Pearson Education Inc., 2017* **Fig. 6.1**		
	(a)	With reference to Fig. 6.1, name the longest stage of the cell cycle and discuss the main events in this stage.	[3]
		1. Interphase;; **2. Accumulation of energy stores / ATP;** **3. Synthesis of proteins;** **4. Synthesis of (cytoplasmic) organelles;** **5. Replication of centrioles;** **6. DNA replication;** **R: synthesis of nucleic acids**	
	Fig. 6.2 shows a cell viewed from the spindle pole during cell cycle.		

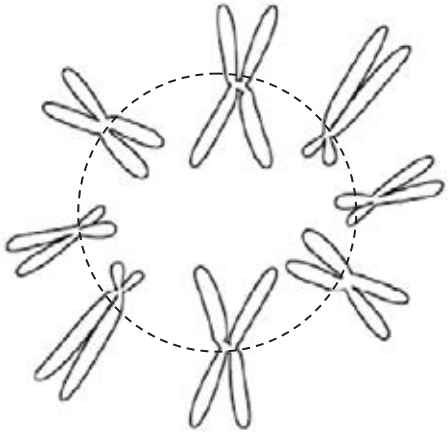


Fig. 6.2

(b) **(i)** State the type of nuclear division and name the stage shown in Fig. 6.2. [1]

Type: mitosis;

Stage: metaphase;

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

1. **Chromosomes lined up at metaphase plate singly (∴not meiosis I);;**
2. **(4) pairs of homologous chromosome present (∴ not meiosis II);;**

(c) With reference to Fig. 6.2, complete Table 6.1 to show the number of chromosomes and mass of DNA in each nucleus during different phases of mitosis. [2½]

Table 6.1

	Number of chromosomes per nucleus	Mass of DNA per nucleus / µg
Prophase of mitosis	**8;**	170
Metaphase of mitosis	**8;**	**170;**
Telophase of mitosis	**8;**	**85;**

Mutations in *ras* proto-oncogenes are among the most common events in cancer. Gain-of-function mutations in *ras* proto-oncogenes are known to result in dysregulation of the cell cycle due to faults in signalling pathways.

	(d)	Explain what is meant by proto-oncogenes.	[1½]
		1. Normal genes; **2. which codes for a protein;** **3. that promotes <u>normal</u> cell division;**	
	(e)	Explain how a mutant Ras protein may lead to cancer.	[3]
		1. Hyperactive / degradation-resistant Ras protein;; **2. relays <u>signal</u> from growth factor / triggers <u>kinase cascade</u>;** **3. in the absence of growth factor;** **4. Resulting in proteins that stimulate cell cycle;** **5. thus uncontrolled cell division;**	
	(f)	Other than cancer cells, *ras* gene expression is also upregulated in embryonic stem cells. However, the latter does not result in a disease phenotype. Explain what embryonic stem cells are.	[2]
		1. unspecialised cell / pluripotent; **2. can divide and grow <u>indefinitely</u>;** **3. differentiate into any cell type except those that form the placenta and the umbilical cord under appropriate conditions;** **4. found I inner cell mass of blastocyst;**	
			[Total: 15]

7 The coat colour of Labrador retriever dogs are determined by genes at two loci. The presence of the dominant alleles **B** and **E** results in black coats, whilst the presence of only the dominant allele **E** results in brown coats. Individuals that are homozygous recessive at the **E/e** locus will have golden coats.

A true breeding male retriever with a black coat was crossed with a female retriever with a golden coat. The resulting F_1 offspring all had black coats and the same genotype. A test cross was conducted for the F_1 individuals.

(a) State the genotype of the F_1 individuals. [1]

BbEe / BBEe;;

(b) Using the symbols for the alleles stated above, draw a genetic diagram to explain the test cross. [3]

F_1 phenotypes Black x Golden
F_1 cross BbEe x bbee ;

F_1 gametes (BE) (Be) (bE) (be) ; (be) ;

Random Fertilization (as shown in the Punnett Square)

	(BE)	(Be)	(bE)	(be)
(be)	BbEe Black	Bbee Golden	bbEe Brown	bbee; Golden;

Offspring phenotypic ratio 1 Black : 2 Golden : 1 Brown ;

OR

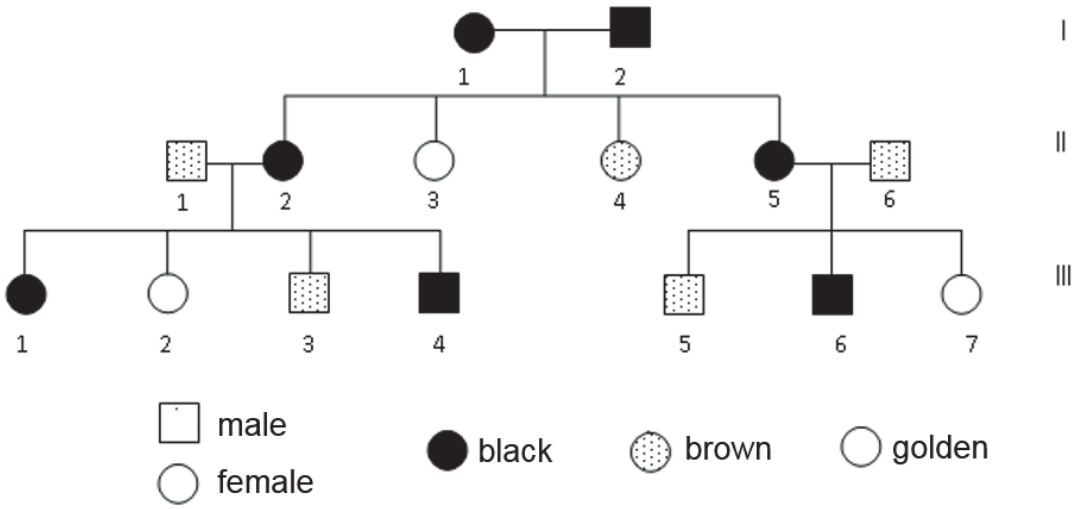
F_1 phenotypes Black x Golden
F_1 cross BBEe x bbee ;

F_1 gametes (BE) (Be) ; (be) ;

Random Fertilization (as shown in the Punnett Square)

	(BE)	(Be)
(be)	BbEe Black	Bbee Golden

Offspring phenotypic ratio 1 Black : 1 Golden;

	(c)		Name and describe the type of interaction between the gene loci.	[3]
			1. (recessive) Epistasis;; **2. ee is epistastic over the B/b locus;** **3. gene E encodes for enzyme E;** **4. converts golden precursor;** **5. to brown pigment;** **6. gene B encodes enzyme B;** **7. converts brown pigment to black pigment;**	
	The pedigree shown in Fig. 7.1 shows the inheritance of coat colour in a family of Labrador retrievers.  **Fig. 7.1**			
	(d)	**(i)**	State the genotype of individual II-1.	[1]
			bbEe;;	
		(ii)	Explain your answer in **d(i)**.	[2]
			1. Individual II-1 is brown, genotype must be bbE_;; **2. Individual II-1 has golden offspring, must be heterozygous at E/e locus;;**	
				[Total: 10]

8 Fig. 8.1 is an electron micrograph of a mitochondrion.

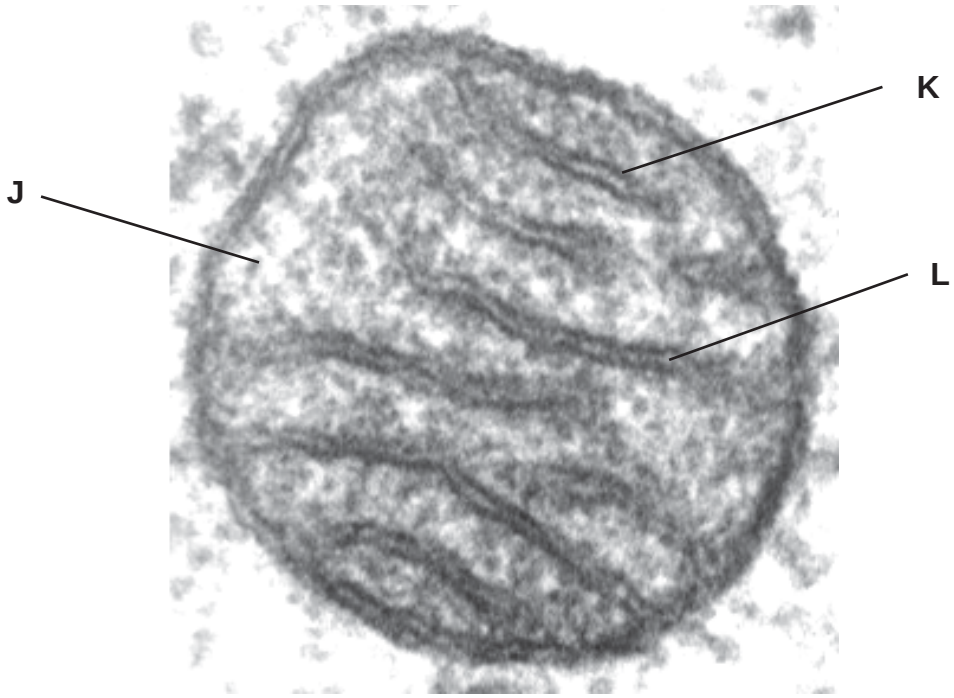


Fig. 8.1

	(a)	**(i)**	Identify structures **J** and **K**.	[1]
			J **(mitochondrial) Matrix;**	
			K **inner (mitochondrial) membrane / crista;**	
		(ii)	Describe how structure **J** is adapted to its function.	[1]
			Matrix contains enzymes for Krebs cycle / link reaction;;	
	(b)	**(i)**	State the role of high concentration of protons at **L**.	[1]
			It acts as a source of potential energy for the synthesis of ATP by ATP synthase;;	
		(ii)	Explain how the high concentration of protons is generated at **L**.	[3]
			1. electrons from NADH / $FADH_2$; **2. passes along a chain of electron carriers (releasing energy in a series of small steps);** **3. free energy released;** **4. is used to pump protons;** **5. from matrix into intermembrane space;**	

			6. inner mitochondrial membrane is impermeable to ions;	
		In an investigation to determine the effect of chemical **M** on respiration, mitochondria were incubated in four ways: 1. with glucose 2. with pyruvate 3. with glucose and chemical **M** 4. with pyruvate and chemical **M** The results are summarised in Table 8.1.		
	(c)	**(i)**	Explain why carbon dioxide is produced when mitochondria are incubated with pyruvate but not when incubated with glucose.	[3]
			1. no glycolytic enzymes in mitochondria; **2. glycolysis does not occur in the mitochondria / glycolysis can only occur in the cytosol;** **3. glucose cannot be oxidised to form pyruvate;** **4. pyruvate can enter mitochondria but glucose cannot;** **5. CO_2 produced by decarboxylation in link reaction;** **6. and Krebs cycle;**	
		(ii)	Suggest why when mitochondria are incubated with pyruvate and chemical **M**, oxygen consumption occurs but not ATP production.	[2]
			1. Chemical M only block ATP synthase so no phosphorylation of ADP/no flow of H^+ down concentration gradient (through ATP synthase);; **2. Chemical M does not affect ETC to transfer electrons to oxygen;;**	
				[Total: 11]

Table 8.1

	CO_2 evolution	O_2 consumption	ATP production by oxidative phosphorylation
Glucose	x	x	x
Pyruvate	✓	✓	✓
Glucose + chemical **M**	x	x	x
Pyruvate + chemical **M**	✓	✓	x

9 Tetanus is a disease caused by a bacterium. When the tetanus bacteria enter the body they release a toxin which causes muscular rigidity and extreme pain. Children in the United Kingdom are routinely vaccinated against tetanus at an early age.

Fig. 9.1 is a diagram that shows three B lymphocytes (**P**, **Q** and **R**) and the events that occur during an immune response to the tetanus toxin.

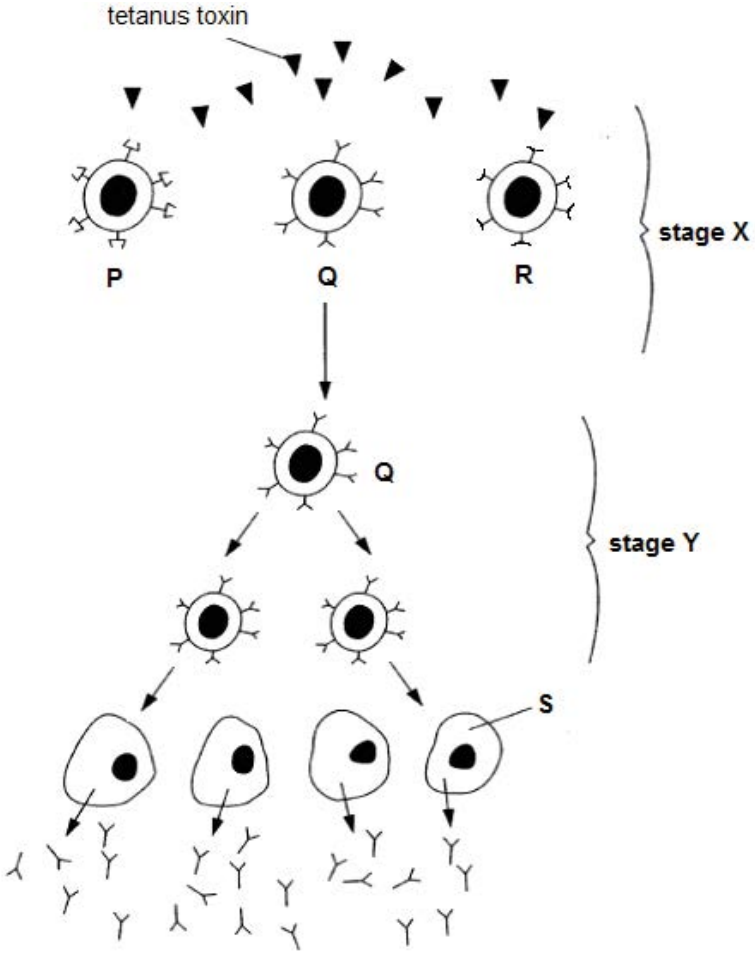


Fig. 9.1

(a) Explain what is happening at stages **X** and **Y** in the immune response to tetanus toxin. [2]

X:

1. **Only Q has receptor / clonal selection;**
2. **Receptor and toxin have complementary shape;;**

Y:

1. **Q undergoes clonal expansion / form clone / divide / increase number / mitosis;**

Fig. 9.2 shows an antibody molecule secreted by cell **S**.

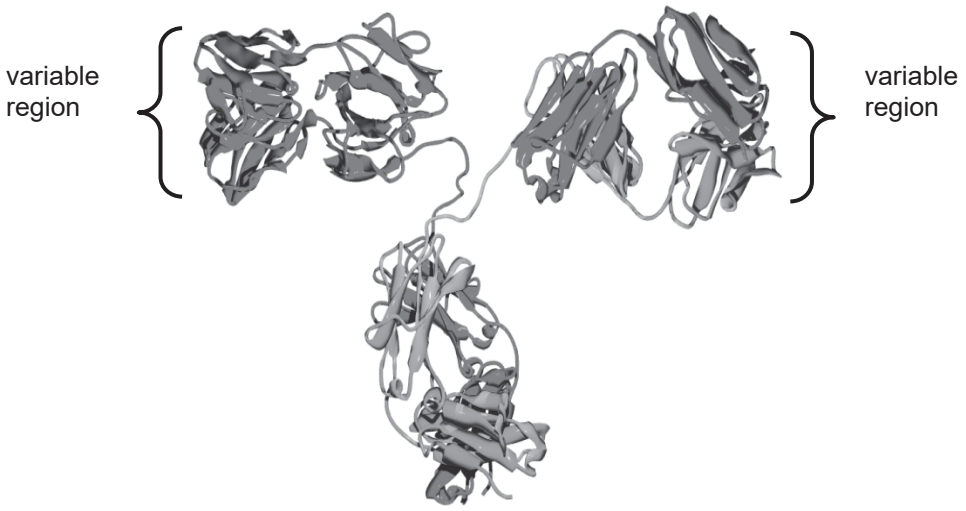


Fig. 9.2

	(b)	Describe how the antibody is folded from linear polypeptide chains.	[4]
		1. Localised folds; **A: (H) bonds between CO and NH groups** **2. along the polypeptide backbone;** **3. give rise to α-helix;** **4. and β-pleated sheets;** **5. Interactions between R groups of amino acid residues;** **6. bends the (secondary) structure into tertiary / precise / compact / globular shape;** **7. (quaternary structure) consist of 4 polypeptide chains;** **8. 2 heavy chains and 2 light chains;**	

A study investigated active and passive immunity to tetanus toxin. One person, **G**, was injected with antibodies to the tetanus toxin. Another person, **H**, was injected with the vaccine for tetanus and produced antibodies as a result. Blood samples were taken from **G** and **H** at regular intervals over the following weeks and analysed for antibodies against tetanus.

The results of the study are shown in Fig. 9.3.

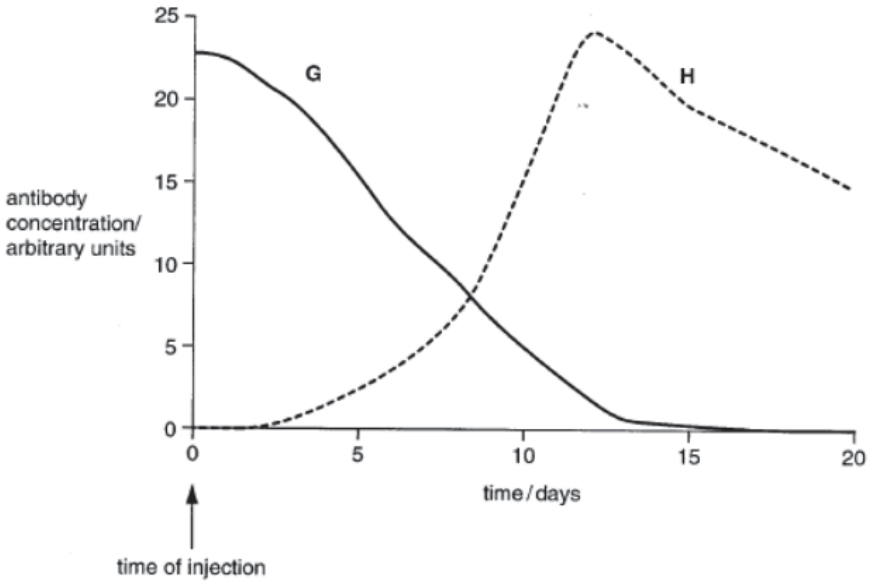


Fig. 9.3

(c) Explain why the type of immunity gained by **G** is described as passive immunity. [2]

1. **No immune response elicited;**
2. **Antibodies, not made / come from other source;**
3. **High concentration / figure from graph, immediately / after injection / on Day 0-1;**
4. **Antibody concentration fall / AW;**
5. **Does not last long / only approximately 2 weeks / temporary;**

(d) With reference to Fig. 9.1 and Fig. 9.3, explain why there is a slow increase in antibody concentration in the curve for **H**. [2]

Time needed for

1. **Antigen presentation;;**
2. **Activation of T helper cells;;**
3. **Clonal expansion / mitosis / AW;;**
4. **Differentiation of B cells into plasma cells;;**
5. **Antibody synthesis / release from plasma cell;;**

Any two

	(e)	Explain why person **H** is considered to be better protected against future exposure to the tetanus toxin, compared to person **G**.		[2]
		1. Person H has immunological memory / memory cells; **2. able to elicit a secondary response;** **3. which is rapid;** **4. and allows a larger production of antibody;**		
				[Total: 12]

RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION II

CANDIDATE NAME											
CENTRE NUMBER	S					CLASS		INDEX NUMBER			

H2 BIOLOGY **9744/03**

Paper 3 Long Structured and Free-response Questions **20 Sep 2017**

2 hours

Additional Materials: Writing Paper

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 on the separate writing paper provided.

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

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

For Examiner's Use	
Section A	
1	**/19**
2	**/18**
3	**/ 13**
Section B	
4 or 5	**/25**
Total	**/ 75**

This document consists of **18** printed pages.

Section A

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

1 The Galapagos Islands is an archipelago approximately 1400 kilometers off the Western coast of Ecuador. It consists of more than 40 islands, including the small and isolated island Daphne Major. The map of the islands, and its location in relation to mainland Ecuador and Cocos Island, is shown in Fig. 1.1.

Fig. 1.1

There are now at least 13 species of finches on the Galapagos Islands, each filling a different niche on different islands. All of them evolved from one ancestral species, which colonised the islands only a few million years ago.

Molecular analysis was carried out on the nucleotide sequences of the Galapagos Islands finches and the Cocos finch, found on the island of Cocos, 830 km North-east of the Galapagos Islands. Fig. 1.2 shows the phylogeny of these finches as constructed from the molecular data obtained.

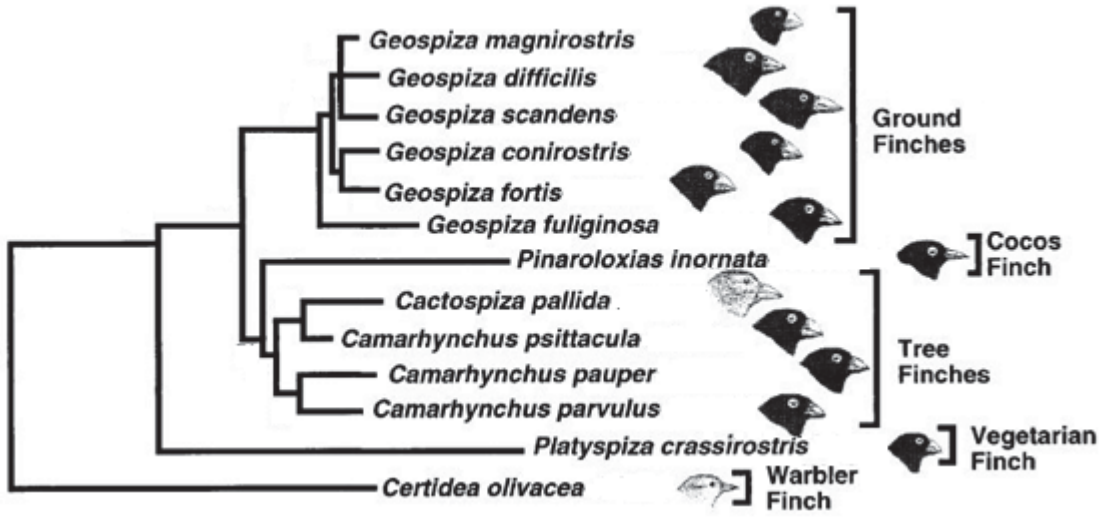


Fig. 1.2

(a) Explain how DNA sequences can be used to determine evolutionary relatedness between species. [2]

1. **Compare homologous DNA sequences/ same gene;**
2. **found in different species;**
3. **The fewer the differences in the DNA sequences of homologous genes between species, the more closely related the species are (vice-versa);;**

(b) Suggest how the Cocos finch might be derived from the same common ancestor as the Galapagos finches, despite its lack of proximity to the Galapagos Islands. [1]

1. **Last common ancestor to Galapagos and Cocos finch first dispersed to Cocos from Ecuador, then to the Galapagos islands;;**
2. **Last common ancestor to both finches was transported to Cocos islands due to human factors (by air/ship) from Ecuador / Galapagos Islands;;**
3. **Last common ancestor to both finches was dispersed to Cocos island by an extreme weather event;;**

A long-term study of the medium ground finch, *Geospiza fortis*, was carried out on the island of Daphne Major. Ground finches have bills particularly suited to eating seeds. Seeds eaten by the population of *G. fortis* are of a variety of sizes and are from a range of plants. Fig. 1.3 shows a male *G. fortis*.

Fig. 1.3

In 1977, a severe drought affected the Galapagos Islands. The number of different plant species producing seeds and total seed abundance was greatly reduced for the population of *G. fortis*.

Scientists have postulated that the severity of the drought experienced may have been exacerbated by the rise in atmospheric CO_2 concentrations due to human activities.

(c) Explain how the emission of greenhouse gases such as CO_2 may be linked to the onset of drought. [2]

1. **Increased concentration of greenhouse gases in atmosphere;**
2. **traps heat and warms atmospheric temperature / leads to warming due to the greenhouse effect;**
3. **Increased evaporation as a result of rising global temperatures;**
4. **Lead to dryer environments / longer summers;**

The population size of *G. fortis* on Daphne Major fell by over 85% as a result of the 1977 drought.

In years with good rainfall there is an abundance of small, soft seeds that are favoured by *G. fortis*, especially those individuals with smaller bills. In years of drought, small seeds are scarce. Individuals of *G. fortis* with small bills are rarely successful in extracting seeds from the large, spiky, tough fruits of *Tribulus cistoides* (Fig. 1.4), which was the main source of seeds at the time.

Fig. 1.4

Table 1.1 shows results for mean mass and mean bill size of mature *G. fortis* before and

after the drought. The individuals measured after the drought were a subset of the first sample, allowing a direct comparison of the changes that occurred.

Table 1.1

Date of sampling	Sample size	Phenotypic feature measured			
		Mass / g	Bill length / mm	Bill depth / mm	Bill width / mm
1976 (May)	642	15.79	10.68	9.42	8.68
1978 (March)	85	16.85	11.07	9.96	9.01
Percentage change		**+6.71**	+3.65	**+5.73**	+3.80

(d) **(i)** Complete Table 1.1 to show the percentage change in mass and bill depth from 1976 (May) to 1978 (March). [1]

(ii) After the drought, the population of *G. fortis* had significantly higher mean mass and larger mean bill size than the pre-drought population.

Name the type of natural selection that was occurring. [1]

Directional selection;;

(e) Explain how the changes in bill size that occurred in the population of *G. fortis* on Daphne Major provide support for Darwin's explanation of how natural selection operates. [3]

1. **Mutation leads to phenotypic variation in population;**
2. **Individuals have different bill size;**
3. **Lack of small seeds / larger, tougher seeds exerts selective pressure;**
4. **Birds with bigger bills can break open seeds;**
5. **Better able to survive and reproduce;**
6. **Pass on favourable alleles to offspring;**
7. **Over time, increased frequency of alleles for big bills in population;**

Current temperatures in the Galapagos archipelago rarely exceed 30°C, even in the summer months. However, climate scientists have warned that in light of global warming, temperatures in the archipelago may soon increase.

The Intergovernmental Panel on Climate Change has forecasted a rise in global average temperatures of up to 5°C over the next century.

(f) With reference to Fig. 1.1, suggest how global warming may affect the survival of the finches in the Galapagos Islands. [2]

1. **Finches will migrate polewards / to islands in the South as they seek cooler temperatures;;**
2. **If temperature increases too much, finches may not be capable of flying out of the archipelago and will perish / go extinct;;**
3. **Melting of glaciers leads to rising sea levels which will flood islands, reducing availability of habitats;;**
4. **If sea level rise excessively leading to islands being submerged, finches may not be capable of flying out of the archipelago and will perish / go extinct;;**

Scientists have also suggested that changes in carbon dioxide concentration in the atmosphere changes the stomatal density of plants.

43 different species of plants from a range of habitats were grown at normal atmospheric carbon dioxide concentration and at increased carbon dioxide concentration.

The mean stomatal density of each species was determined at both concentrations of carbon dioxide. The percentage change in stomatal density at the increased carbon dioxide concentration compared to the stomatal density at normal atmospheric carbon dioxide concentration was calculated for each species. Table 1.2 summarises the changes to mean stomatal density due to increased atmospheric carbon dioxide concentration for the species investigated.

Table 1.2

Percentage change in stomatal density (to the nearest 10%)	Number of species
+40	2
+30	2
+20	4
+10	2
-10	7
-20	9
-30	9
-40	8

(g) Account for the results shown in Table 1.2. [5]

		1. 10 species show an increase in stomatal density;; 2. 33 species show a decrease in stomatal density;; **Increased CO_2 concentration leads to** 3. Increase in global average temperature; 4. Decreased in availability of rainwater; **Effects of decreased stomata density** 5. Minimise water loss due to transpiration; 6. Ensure sufficient water (in periods of drought); 7. Plant still able to get sufficient CO_2 for photosynthesis; **Plants increase stomatal density** 8. Allow for increased heat loss; 9. Prevent enzymes from denaturing / ensure metabolic processes can continue;	
	The experiment showed that plants are able to show significant changes in their phenotype in response to changes in the environment.		
	(h)	Suggest why plants need to be able to show changes in their phenotype within their lifetime.	[2]
		1. Plants are not mobile / cannot migrate;; 2. Changes in phenotype allow the plant to maximise their chance of survival;;	
			[Total: 19]

2 Dengue fever is a mosquito-borne disease caused by the dengue virus. Fig. 2.1 shows the structure of a dengue virus.

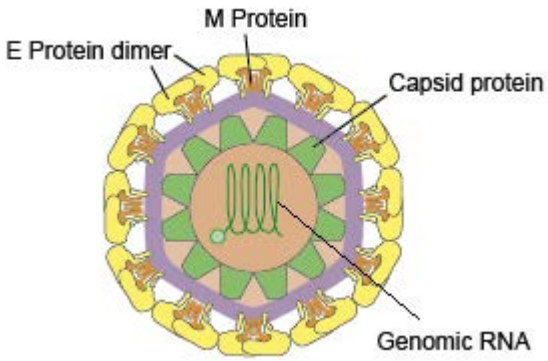


Fig. 2.1

(a) List **two** ways in which the structure of dengue virus is similar to the human immunodeficiency virus. [2]

1. **Genome made up of RNA;;**
2. **Viral genome enclosed in capsid;;**
3. **Glycoproteins found on envelope;;**

Dengue viruses consist of four serotypes, DENV-1 to DEV-4. The rapid identification of dengue virus serotypes isolated from patients' blood is important for clinical investigations. One of the methods used for identification of serotypes is DNA sequencing, which is a process of determining the precise order of nucleotides within a DNA molecule.

One of the DNA sequencing methods is based on the use of chain terminators, which are special nucleotides. Fig 2.2 shows the structure of a special nucleotide with a cytosine base.

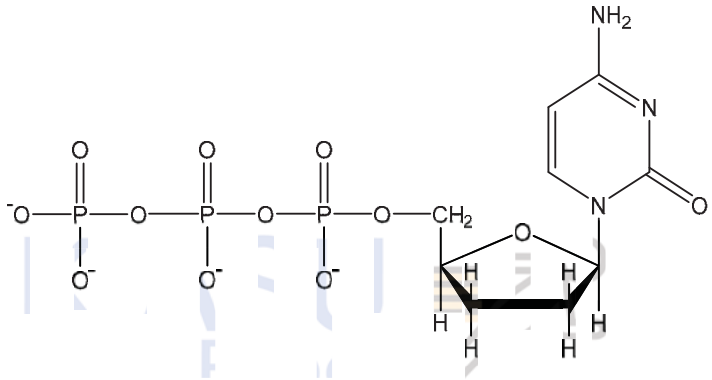


Fig 2.2

If a special nucleotide is added to a growing DNA strand, the chain is not extended any further. Each special nucleotide is labelled with a fluorescent dye, using a different colour for each of the four bases.

Fig 2.3 shows how a DNA chain ending with one of the special nucleotides is replicated.

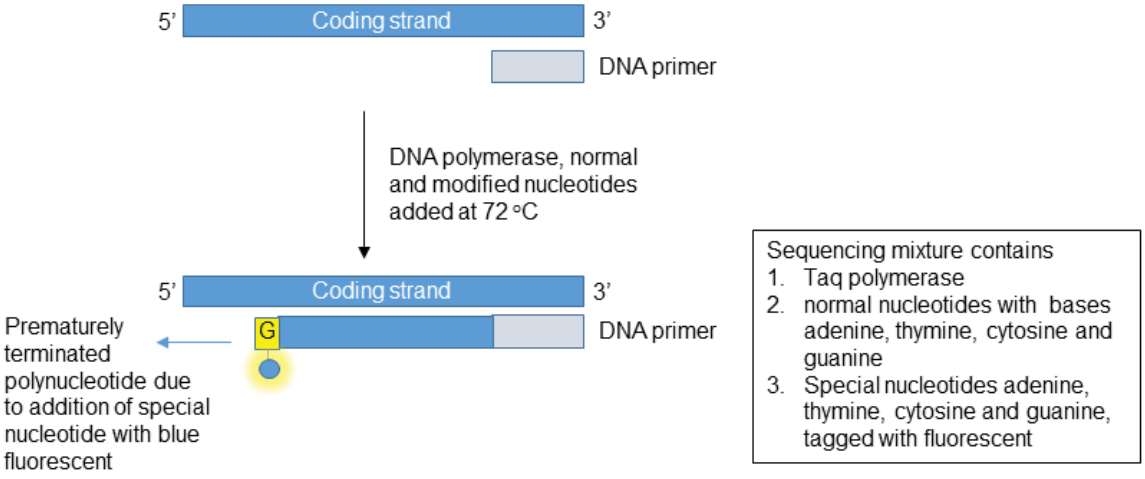


Fig. 2.3

	(b)	Suggest why the addition of special nucleotides would lead to the premature termination of replication.	[2]
		1. Since special nucleotide lacks hydroxyl group on 3' carbon of pentose;; **2. the incorporated special nucleotide cannot form phosphoester bond with incoming dNTP / nucleotide;;**	

This method of DNA sequencing described in Fig 2.3, can produce many DNA fragments terminated by a special nucleotide tagged with a florescent. Fig 2.4 shows a set of such fragments, where each fragment differs by 1 nucleotide.

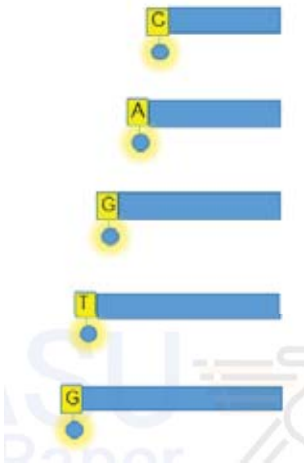


Fig. 2.4

These fragments are loaded onto an agarose gel, shown in Fig 2.5, and separated by a modified version of gel electrophoresis.

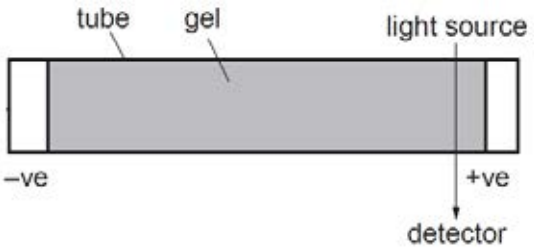


Fig 2.5

The order in which the fragments reach the light source and detector shown in Fig 2.5 is C, A, G, T.

(c) Explain why the DNA fragments will migrate and reach the detector in this order. [3]

1. **DNA is negatively charged;**
2. **Migrate towards (the detector at) positive electrode;**
3. **Separated on the basis of size of DNA fragments;**
4. **Shorter DNA fragment migrate through the pores of the agarose gel faster than longer DNA fragment/ vice versa;**
5. **Fragment ending with C is the shortest;**
6. **Migrate through the pores of the agarose gel fastest/ vice versa;**

Dengue virus is a major threat to health in tropical countries around the world, with 390 million people infected each year. To date, there are no vaccines for dengue virus.

(d) Suggest why there is no effective vaccine to protect against dengue. [2]

1. **there are four serotypes of dengue virus, each with slightly different viral proteins;;**
2. **not possible to stimulate the body to generate antibodies against all four types at once;;**

(e) Antibiotics are not used to treat viral infections.

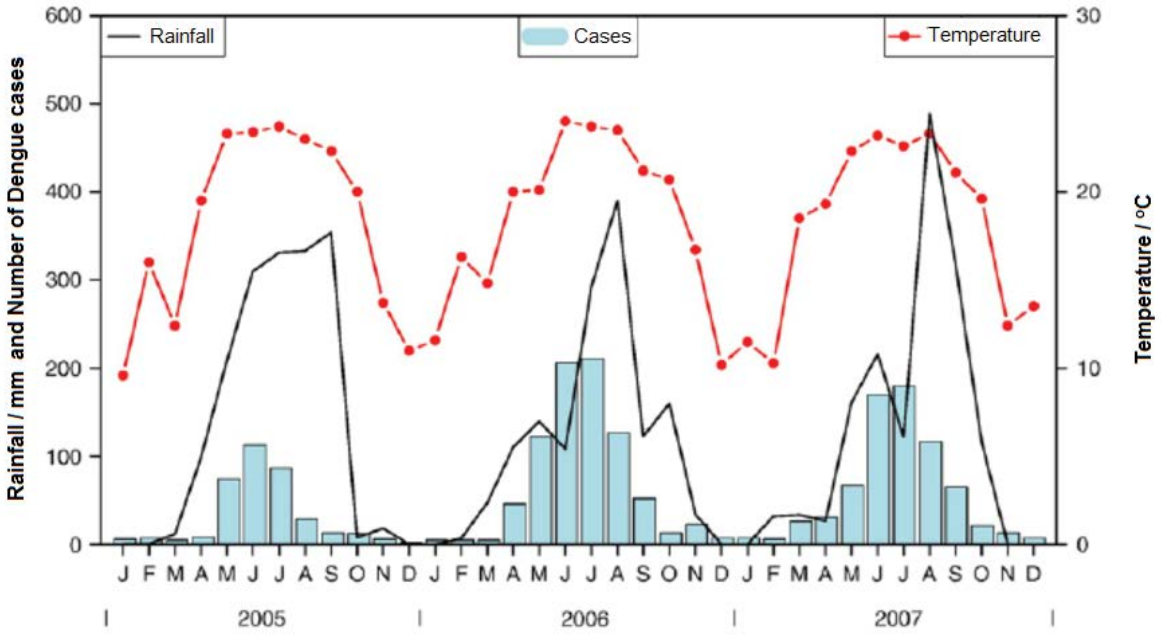
Explain why antibiotics do not affect viruses. [2]

1. **antibiotics (only) used against bacteria (and some fungi);;**
2. **idea that antibiotics act on a cell structure not possessed by virus;;**
   e.g. viruses, do not have, a cell wall / ribosomes
3. **suggestion that viruses are, inside host cells not within reach of antibiotic;;**

any two

The *Aedes aegypti* mosquito is the main vector that transmits the viruses that cause dengue. The viruses are passed on to humans through the bites of an infective female *A. aegypti* mosquito, which mainly acquires the virus while feeding on the blood of an infected person.

Fig. 2.6 shows the monthly number of dengue cases in Sakon Nakhon Province, Thailand, from January 2005 to December 2007.



Source: Monthly district level risk of dengue occurrences in Sakon Nakhon Province, Thailand. The Science of the total environment. 408 (2010). 5521-8.

Fig. 2.6

	(f)	Explain how temperature affects the number of dengue cases in Thailand.	[3]
		1. Increased temperature, increased dengue occurrences; **2. accelerates emergence of mosquitoes / life cycle shorten;** **3. increasing mosquito population;** **4. reduce extrinsic incubation period of virus in insect;** **5. increasing the number of infective vector;** **6. female mosquitoes digest blood faster and feed more frequently;**	
	(g)	Other than climate change, state and explain how **two** other factors can contribute to the increase in the number of dengue cases.	[2]
		1. Increased rainfall; more breeding sites for mosquitoes; **2. lack of effective mosquito control; increase in mosquito populations;** **3. increased movement of people; increase spread of virus;** **4. increased population density; increase transmission between**	

		humans; **5. AVP;;**	
	The primary preventative measure to reduce dengue infections is the control of mosquito populations. Traditional methods of mosquito control using insecticides are not viable in the long term, as new and stronger versions of insecticides must continually be developed. Biological approaches are now being used as an alternative to control mosquito populations. Researchers are experimenting with release of *Wolbachia*-infected mosquitoes as a means of suppressing *Aedes* mosquito populations. When male mosquitoes with *Wolbachia* mate with wild female mosquitoes without *Wolbachia*, eggs laid by these female mosquitoes will be sterile. The technique requires the release of a large number of male mosquitoes to reduce the overall mosquito population.	
	(h)	State the **one** advantage and **one** disadvantage of using the biological method.	[2]
		Advantage **1. Prevent development of resistance to insecticide;;** **Disadvantage** **1. need to be reapplied over time as the population of mosquitoes gradually returns;;** **2. need to continually cultivate large number of male mosquitoes;;**	
			[Total: 18]

3 Tuberculosis (TB) is a disease caused by the bacterium *Mycobacterium tuberculosis*, and accounts for more than 1 million deaths annually. Some of the symptoms of infection include shortness of breath, fever, chest pains and coughing up blood.

Fig. 3.1. shows the transmission and infection of *M. tuberculosis*.

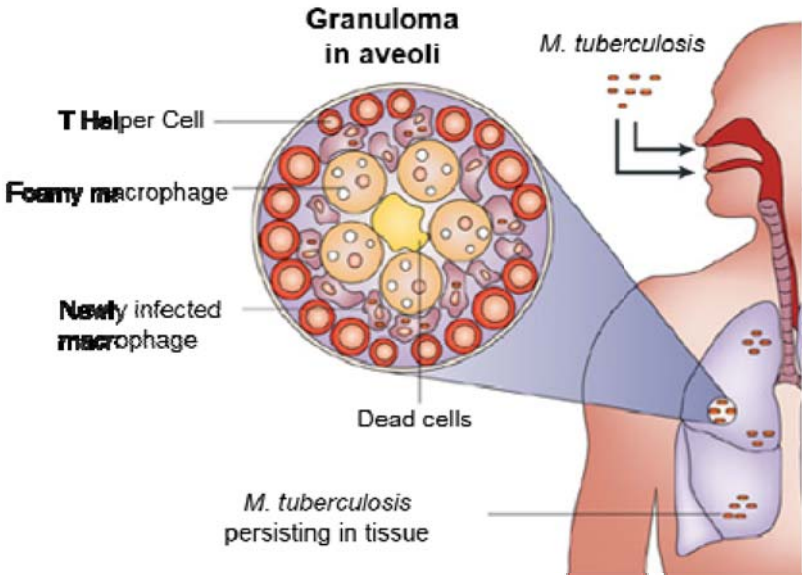
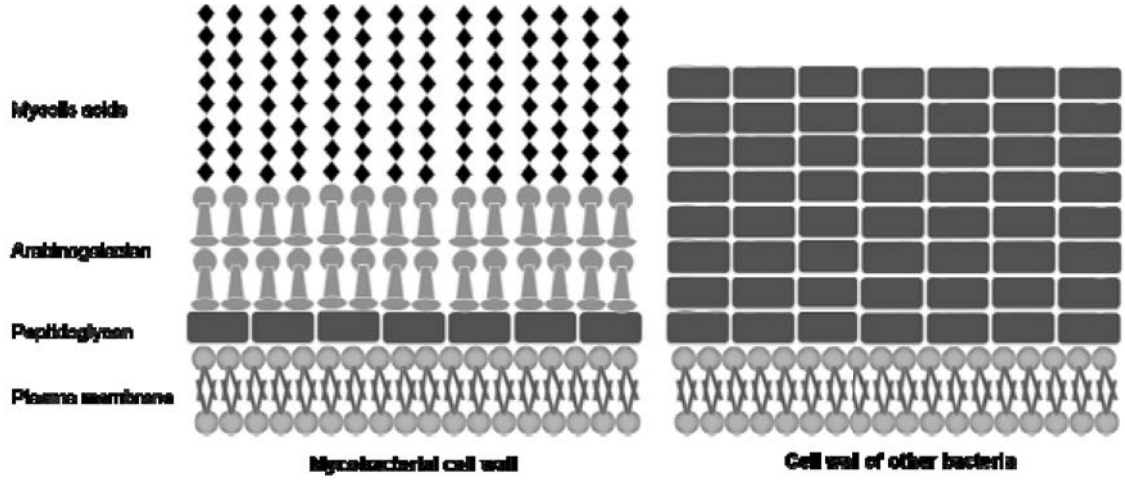


Fig. 3.1

The immune response to TB results in the formation of granulomas. These cellular aggregates restrict the spread of the infection, but fail to kill all of the bacteria. This results in a tight interplay between *M. tuberculosis* and the host cells within the granulomas during the latent stage of infection.

Foamy macrophages are granuloma-specific cells that are characterised by the accumulation of large amounts of lipids contained within numerous lipid vacuoles. These macrophages are formed as a result of prolonged interaction with *M. tuberculosis.*

	(a)	Describe how TB is transmitted.	[2]
		1. *M. tuberculosis;* **2. in airborne particles / droplet nuclei;** **3. enters the upper respiratory tract;** **4. and reaches the alveoli of lungs;**	
	(b)	With reference to Fig. 3.1 and your own knowledge, describe the formation of granulomas in *M. tuberculosis* infections.	[3]
		1. *M. tuberculosis* ingested by alveolar macrophages; **2. Replicate intracellularly;** **3. Destroy alveolar macrophages;** **4. Infect more macrophages;**	

		5. Leads to activation of T lymphocytes; **6. Which surround infected macrophages;** **7. Forming a barrier shell;**	
	M. tuberculosis have mycobacterial cell walls that are different from other bacterial cell walls due to their thick lipid coating. The cell walls consist of arabinogalactan, a biopolymer of two monosaccharides, complexed with mycolic fatty acids. Fig. 3.2 shows the structure of a *M. tuberculosis* mycobacterial cell wall, compared with that of a common bacteria.  **Fig. 3.2**	
	(c)	With reference to Fig. 3.1 and 3.2, suggest how the persistence of *M. tuberculosis* within the granulomas allows it to replicate intracellularly.	[2]
		1. Foamy macrophages provide lipids;; **2. For the formation of new mycolic acids;;**	
	Treatment of TB uses antibiotics to kill the bacteria. Effective treatment with traditional bacteriacidal antibiotics such as penicillin are ineffective. Antibiotics such as isoniazid and rifampicin are used instead for a prolonged period of time in order to ensure successful treatment of TB.		
	(d)	With reference to Fig. 3.2, explain why administering penicillin will not effectively treat TB.	[2]
		1. Penicillin only interferes with the interpeptide linking of peptidoglycan; **2. But does not prevent formation of arabinogalactan;** **3. Newly synthesised still has protective cell wall;** **4. Will not die from osmotic instability / autolysis;**	

Isoniazid is administered as a prodrug, and must be activated by a bacterial enzyme known as KatG. Upon activation, isoniazid inhibits the action of fatty acid synthase, inhibiting the synthesis of mycolic acids and thus preventing the synthesis of the mycobacterial cell wall.

Alarmingly, strains of *M. tuberculosis* that display resistance to isoniazid have been increasingly common. Scientists studied the genome of a resistant strain K131, and noted that there were numerous mutations identified in the 2.0-2.5Mb region. Fig. 3.3 shows the complete genome of K131.

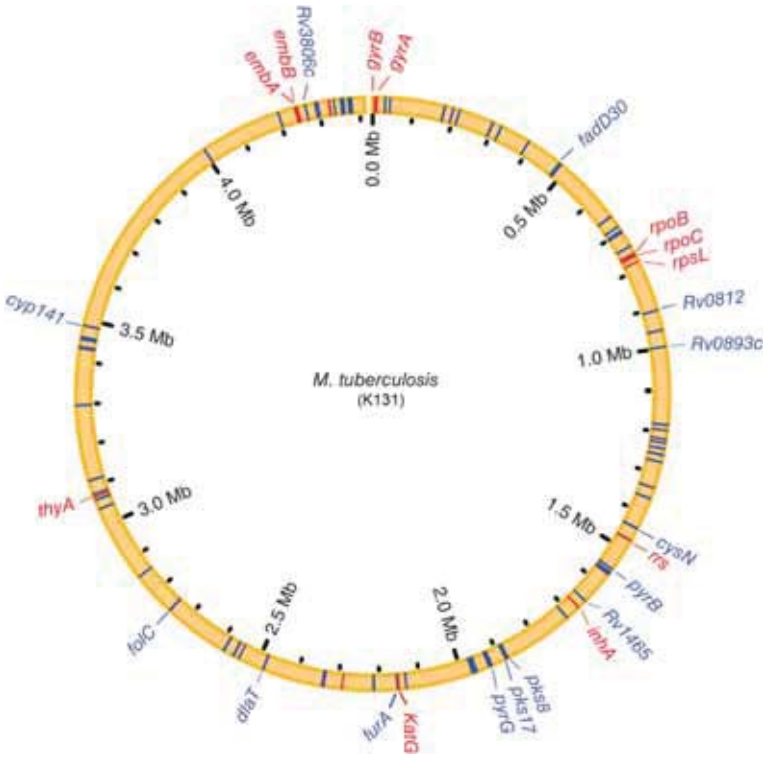


Fig. 3.3

	(e)	Explain how strain K131 is resistant to isoniazid.	[4]
		1. *KatG* is located in the 2.0-2.5Mb region; **2. Mutation to the gene would alter the mRNA encoded;** **3. Amino acid sequence of KatG altered;** **4. Affect folding of KatG;** **5. Change in conformation of active site;** **6. Unable to bind to isoniazid to activate it;** **7. Fatty acid synthase function not inhibited;** **8. Mycolic acids still synthesised;**	
			[Total: 13]

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 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

4	**(a)**	Discuss the role of complementarity in cellular mechanisms.	[12]
		1. Complementary shape;; **2. Complementary base pairing;;** **3. Complementary interaction;;** **4. allows for <u>specificity</u> of reaction;;** **<u>Complementary shape</u>** **5. Substrate(s) fit into the active site of enzyme;** **6. via lock and key hypothesis;** **7. And induced fit hypothesis;** **8. To form enzyme-substrate complex;** **9. DNA to fit into binding site of proteins** **10. To regulate replication;** **11. And gene expression;** **12. Ligand/ signaling molecule to fit into binding site of receptors;** **13. Allows for cell signaling;** **14. Binding of substances to transport proteins;** **15. Allows for movement of substances across cell membrane;** **16. and viral entry;** **<u>Complementary interaction</u>** **17. H bonds between polar groups;** **18. Hydrophobic interaction between non-polar groups;** **19. Ionic bonds between oppositely charged groups;** **20. Allows for folding of polypeptide into 3D shape;** **21. Stability of biomolecules;**	

		Complementary base pair **22. A-T (A-U) and C-G;** **23. Allows for stability of DNA double helix;** **24. Allows for replication of DNA;** **25. Allows for the synthesis of mRNA/transcription;** **26. allows for the binding of (anticodon on) tRNA to (codon on) mRNA;**	
	(b)	Explain how genetic recombination occurs in B lymphocytes and the advantages of each process.	[13]
		1. Somatic recombination; **2. occurs during development of B lymphocytes;** **3. via removal of intervening (DNA) sequences;** **4. followed by joining of gene segments;** **5. by enzymes;** **6. At variable regions of immunoglobulin heavy chain gene locus;** **7. Rearrangement of D and J gene segments;** **8. followed by rearrangement of V gene segment;** **9. VDJ exon joined to the constant segments;** **10. during RNA splicing;** **11. At variable regions of immunoglobulin light chain gene locus;** **12. Rearrangement of V and J gene segments;** **13. VJ exon joined to the C segments;** **14. during RNA splicing;** **15. Hypermutation;** **16. occurs during clonal expansion of B lymphocytes;** **17. in variable region of immunoglobulin chains;** **18. These point mutations;** **19. in (rearranged) VDJ gene segments;** **20. occurs at higher rate than normal mutations;** **21. Class switching;** **22. occurs during clonal expansion of B lymphocytes;** **23. in constant region of immunoglobulin chains;**	

		24. **where one constant region is replaced by another constant region;** **Advantages:** 25. **Somatic recombination gives rise to <u>antibody diversity</u>;** 26. **to respond to large <u>diversity</u> of (molecular structures associated with) pathogens;** 27. **Hypermutation allows for formation of immunoglobulin with higher <u>affinity</u> for <u>antigens</u> / affinity maturation;;** 28. **Class switching results in different <u>classes</u> of antibodies;** 29. **with the same <u>antigen specificity</u>;** 30. **allowing for variable <u>effector</u> functions;** **QWC:** **Scientific argumentation exemplified by citing one advantage for each of the three processes;;**	
			[Total: 25]

5	**(a)**	Explain what is meant by mutation, and outline its advantages and disadvantages to animals.	[13]
		<u>Explain what is meant by mutation</u> 1. **Inherited change in nucleotide sequence;;** 2. **Base-pair insertion, deletion and substitution;;** 3. **Changes to chromosome structure and number;;** **<u>Single Gene Disorder</u>** 4. **Sickle cell anaemia;** 5. **Base-pair substitution;** 6. **In β-globin gene;** 7. **Reduced ability to carry oxygen;** **<u>Multi Gene Disorder</u>** 8. **Accumulation of mutations;** 9. **Lead to the development of cancer;** 10. **Gain of function of proto-oncogenes;** 11. **Loss of function mutation in tumour-suppresor genes;**	

		12. Loss of cell cycle checkpoints / uncontrolled cell division; **<u>Chromosomal Mutations</u>** **13. Non-disjunction of chromosomes;** **14. During meiosis;** **15. Leads to aneuploidy / polyploidy;** **16. gives rise to a named genetic disease (Turner / Klinefetler / Down syndrome);** **<u>Evolutionary significance</u>** **17. Raw material for evolution;** **18. Gives rise to phenotypic variation;** **19. Allows natural selection to take place (select for different phenotypes);** **20. increase chance of survival of species;** **21. lead to microevolution / speciation;** **<u>Increased affinity of antibodies</u>** **22. Mutations in VDJ / VJ regions;** **23. B lymphocytes produce antibodies with <u>higher affinity</u>;** **24. Leading to affinity maturation;** **25. More effective immune response;** ***QWC:*** ***Implications of mutations clearly communicated to include at least 1 advantage and 2 disadvantages;;***	
	(b)	Describe the role of proteins in the transformation of energy from the environment to plant cells for their survival.	[12]
		1. Light energy is converted to chemical energy; **2. via photosynthesis;** **3. for cells to respire / carry out metabolic processes;** **4. Proteins bind photosynthetic pigments;** **5. to form photosystems;** **6. for capturing of photons;** **7. Electron transport chain; consists of proteins like** **8. cytochromes;**	

		9. ferredoxin; 10. arranged in progressively lower energy levels; 11. Energy released powers (intermembrane) protein pumps; 12. to generate proton gradient; 13. NADP+ reductase protein; 14. catalyses formation of NADPH; 15. ATP synthase protein; 16. utilises energy from chemiosmosis / proton gradient; 17. to catalyses formation of ATP 18. Peptide enzyme catalyses the photolysis of water; 19. to replace electrons on PSII 20. that contributes to proton gradient; 21. RUBP carboxylase protein; 22. catalyses fixation of carbon dioxide; 23. to ribulose bisphosphate; 24. Peptide enzymes catalyses formation of glycosidic bonds; 25. to synthesis glucose molecules; 26. for energy storage;	
			[Total: 25]

RIVER VALLEY HIGH SCHOOL

YEAR 6 PRELIMINARY EXAMINATION II

CANDIDATE NAME									
CENTRE NUMBER	S					CLASS		INDEX NUMBER	

H2 BIOLOGY **9744/04**

Paper 4 Practical **28 Aug 2017**

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

Additional Materials: As listed in the Apparatus and Materials List.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your class, index number 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	**/ 19**
3	**/ 14**
Total	**/ 55**

Answer **all** questions.

Question 1

In this question, you will investigate the effect of glucose and sucrose on the rate of respiration in yeast cells.

You are provided with:

- 40 cm^3 yeast cell suspension, labelled **Y**
- 25 cm^3 blue alkaline solution, labelled **C**
- 25 cm^3 hydrochloric acid, labelled **H**
- 20 cm^3 of 0.2 mol dm^{-3} glucose solution, labelled **G**
- 20 cm^3 of 0.2 mol dm^{-3} sucrose solution, labelled **S**
- 20 cm^3 of distilled water, labelled **W**

*Read through steps **1** to **12** and prepare a table to record your results in step **(c)**, before starting the investigation.*

Stage 1

Perform the following steps to activate the yeast cells in **Y** to prepare for **stage 3**

1 Label 3 boiling tubes **B1**, **B2**, and **B3**. Add 10 cm^3 of **Y** into each of the boiling tubes.

2 Add 10 cm^3 of **G**, **S**, and **W** into boiling tubes **B1**, **B2**, and **B3**, respectively.

3 Start the stopwatch. Leave the tubes aside for at least 15 minutes, before beginning on **stage 3**. During this time, you should attempt the rest of the question.

Stage 2

C, an alkaline solution, is blue because it contains an indicator.

Carbon dioxide reacts with **C** when bubbled into it. When enough carbon dioxide reacts with **C**, the indicator will change from blue to yellow (even if the mixture is cloudy). This is the end-point.

If only a small volume of carbon dioxide is bubbled into **C** then the indicator will remain blue. The end-point can then be reached by adding hydrochloric acid, **H**, slowly until the indicator turns from blue to yellow. The volume of **H** is then recorded.

The volume of **H** added to reach the end-point indicates how much carbon dioxide had reacted with **C**. The lesser the amount of carbon dioxide is bubbled into **C**, the more volume of **H** will need to be added to **C** to get the end-point.

You are required to find the volume of **H** needed to reach the end-point when **no** carbon dioxide has been bubbled into **C**.

4 Put 5 cm^3 of **C** into a test-tube.

5 Use a 6 cm^3 syringe, containing 3 cm^3 of **H**, to put drops of **H** into **C** as shown in

Fig. 1.1. Mix well as you add **H**, until the end-point is reached. You may need to fill the syringe again.

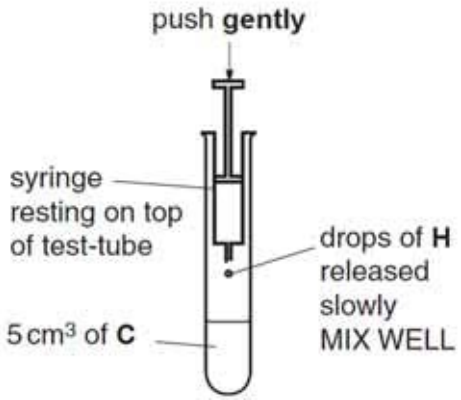


Fig. 1.1

	(a)	Record the volume of **H** needed to reach the end-point.	[1]

PDO

1. **Correct value;**
   Acceptable range 1.0 – 2.0 cm³

2. **Precision;**
   1 d.p.

Volume of **H** needed = _____ cm³

Stage 3

You are required to investigate the effect of glucose and sucrose on the release of carbon dioxide from a yeast cell suspension using apparatus set up as in Fig.1.2, and the tubes prepared in **stage 1**.

Yeast cells release carbon dioxide from some of their metabolic reactions when provided with respiratory substrates. Tube **B1** contains glucose as the respiratory substrate, whilst tube **B2** contains sucrose.

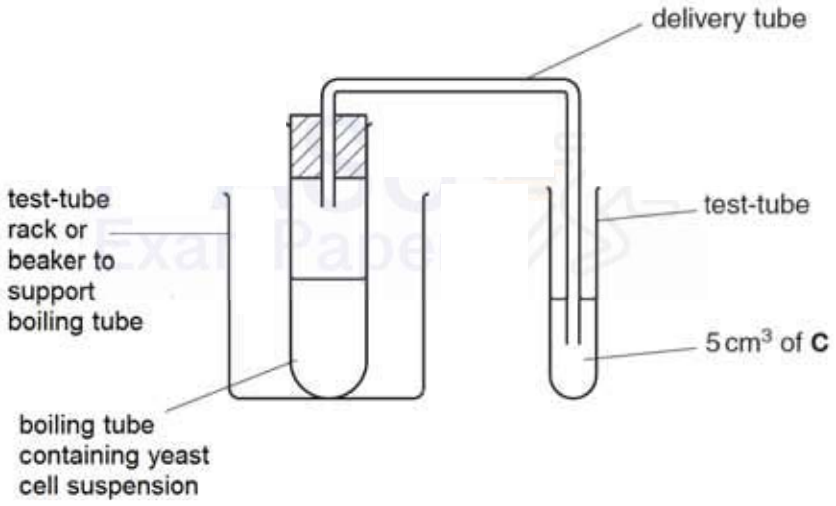


Fig.1.2

(b) State which sugar is expected to lead to a higher rate of carbon dioxide release by yeast cells. Explain your answer. [2]

ACE

Glucose

1. **Readily used as a respiratory substrate by yeast;;**
2. **Unlike sucrose which must first be hydrolysed;;**

Sucrose

3. **Hydrolysis of one molecule of sucrose produces two molecules of sugars;;**
4. **Higher concentration of respiratory substrates for respiration;;**

Before proceeding with steps 6-12, ensure that 15 minutes have elapsed since stage 1.

6 Prepare and maintain a water bath at 40°C.

7 Label 3 test-tubes **T1**, **T2** and **T3**. Add 5 cm^3 of **C** into each of the three test-tubes.

8 Place tube **B1** in the water bath and allow it to equilibrate for 2 minutes.

9 Put the bung containing the delivery tube into tube **B1**, as shown in Fig. 1.2. Ensure that the seal is airtight.

10 Put the end of the delivery tube into solution **C** in **T1**. Using a stopwatch, allow the carbon dioxide produced by the yeast to bubble into **C** for 2 minutes.

11 After removing the delivery tube, repeat **step 5** to determine the volume of **H** needed to reach end-point and record your result in **(c)**. If **C** has already reached end-point, record '0'.

12 Repeat steps **8** to **11** for the tubes **B2** and **B3**.

(c) Record your results for each tube in a suitable form in the space below. [4]

Table showing effect of different substrates on the volume of H needed to reach end-point

Type of substrate	Volume of H added / cm^3
Glucose	
Sucrose	
Distilled water	

PDO

1. **Title (T);;**
   "Table showing effect of different substrates on volume of H needed to reach end-point"

2. **Heading with Units (H);;**
   Independent variable: Type of substrate
   Dependent variable: Volume of H added / cm^3

3. **Precision (P);;**
   Volume recorded to 1 d.p.

MMO

4. **Trend (Tr);;**
   Volume of H added for B3 should be same as ≤ (a) and highest volume for B3

(d)	Discuss what these results suggest about the relationship predicted in part **(b)**.	[2]
	ACE 1. **Comment on how actual results match the proposed relationship;;** 2. **Comment on how this affects the confidence/reliability in the proposed relationship / hypothesis ;;**	
The addition of 1 cm^3 of **H** into **C** is equivalent to 2.2 mg of carbon dioxide.		
(e)	Calculate the exact amount of carbon dioxide produced by the yeast suspension from boiling tubes **B1** and **B2** during the experiment. Show your working clearly.	[2]
	ACE 1. **Correct working;;** **Subtract reading in (c) from answer in (a)** 2. **Correct working;** **Multiply by 2.2mg** 3. **Correct calculation;**	
(f)	State the purpose of including boiling tube **B3** in the investigation.	[1]
	ACE 1. **To show that the evolution of carbon dioxide is due to the addition of glucose and sucrose / sugar;;**	

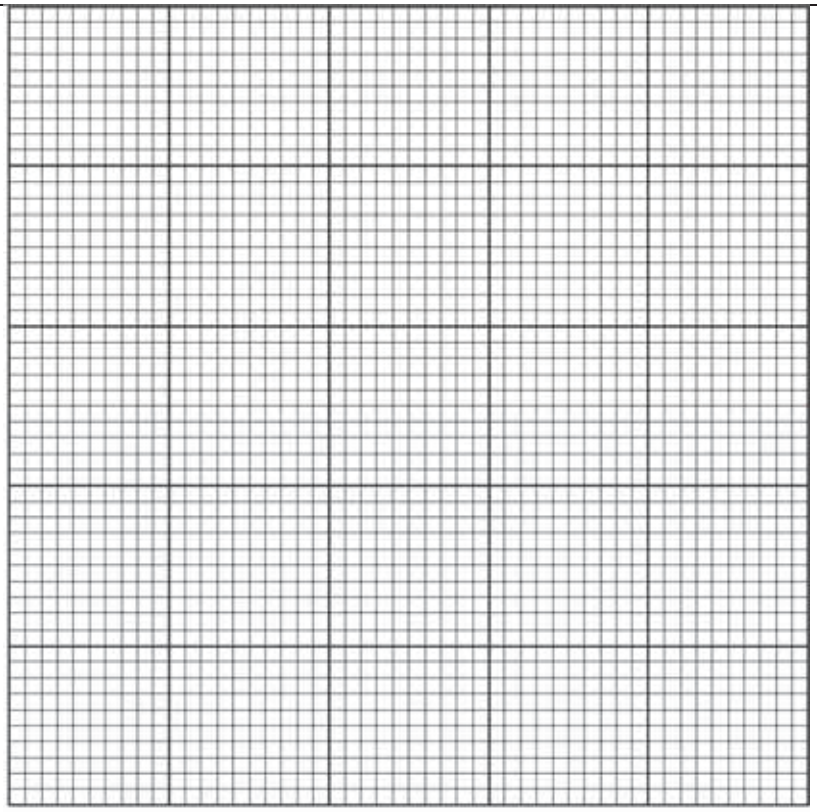
	(g)	Identify **one** significant source of error and suggest a modification to the method that would overcome this.	[2]
		ACE **Error** **1. Visual determination of colour change at end-point is subjective;;** **Modification** **2. Use a colourimeter to determine precisely the colour intensity at end-point;;**	

In a separate study, a student used a modified version of the apparatus shown in Fig.1.2 to investigate the effect of temperature on the release of carbon dioxide from a yeast cell suspension. The results of the study are presented in Table 1.1.

Table 1.1

Temperature / °C	Volume of carbon dioxide evolved / cm^3
25.0	93
30.0	126
35.0	160
40.0	180
45.0	156

	(h)	Use the grid provided to plot the data given in Table 1.1.	[4]



PDO

1. **Title (T);**
   "Graph showing effect of temperature on volume of carbon dioxide evolved"

2. **Heading with units (H&U);;**
   x-axis: Temperature / °C
   y-axis: Volume of carbon dioxide evolved / cm^3

3. **Precision (P);**
   x-axis: 1 d.p.
   y-axis: whole no.

4. **Scale (S);**
   Graph takes up at least 50% of grid
   Divisions are equidistant

5. **Plotted points (PP);;**
   All data plotted accurately to within half a small square on the grid
   If the scale is awkward, the points do not need checking

6. **Best-fit Line (L);**
   Smooth curve of best fit with no extrapolation

	(i)	Explain the relationship between the variables in yeast respiration.	[4]
		ACE 1. **Respiration carried out by temperature-sensitive enzymes;** **As temperature increases,** 2. **enzymes and substrates gain more kinetic energy;**	

		3. **increase in frequency of effective collisions between enzyme and substrate;** 4. **increase in number of ES complexes formed per unit time;** 5. **more CO_2 given off per unit time;** **As temperature increase beyond optimum,** 6. **enzyme molecule vibrate so vigorously that the hydrogen bonds and hydrophobic interactions (between the R groups of amino acid residues) begin to break;** 7. **shape of active site not complementary to that of substrates / some enzymes denature;** 8. **less CO_2 given off per unit time;**	
			[Total: 22]

Question 2

During this question you will require access to a microscope.

You are required to investigate the effects of potassium nitrate and lead nitrate solutions on cells of the plant material with which you have been supplied. Peel off one or two strips of epidermis from the most deeply pigmented areas of the plant tissue. Remove as little of the underlying tissue as possible. Cut the epidermis so that you have two squares of tissue, each about 5 mm x 5 mm. Place these in a dish of distilled water.

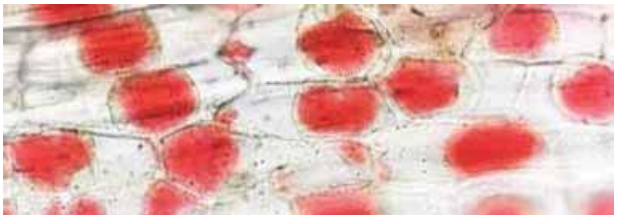
Mount one piece of tissue on a microscope slide in **distilled water** under a cover slip.

Mount the other pieces in **1 mol dm^{-3} potassium nitrate** solution.

Label your slides appropriately.

Examine the tissue mounted in distilled water, using your microscope. Find an area of the tissue where pigmented cells occur, preferably as a single layer.

	(a)	Describe the distribution of the coloured contents within the cells.	[1]
		uniform distribution of coloured content within the cell;; 	
	Observe the piece of tissue mounted in 1 mol dm^{-3} potassium nitrate solution, using your microscope		
	(b)	**(i)** After about one minute, make a large drawing to show the detailed structure of **one** epidermal cell which is typical of the most deeply coloured cells which you can see. On your drawing, label the positions of: • a cell wall • a cell surface membrane.	[4]

			1. (T) Title (high power detailed drawing of one epidermal cell, w.m., X400); **2. (P) Thin walls;** **3. (S) Shape (length longer than width) ;** **4. (D) Cell membrane detached from cell wall;** **5. Labels (cell wall, cell surface membrane) – 1 mark each** 	
		(ii)	Account **fully** for the change in appearance of the cells when placed in 1 mol dm^{-3} potassium nitrate solution.	[3]
			1. 1 $moldm^{-3}$ sodium nitrate has a more negative water potential than the cell content; **2. water leaves cells;** **3. by osmosis;** **4. from a region of less negative water potential to a region of more negative water potential;** **5. loss of water caused the cell surface membrane to pull away from the cell wall;** **6. retention of pigments in the vacuole because of its high molar mass;** **7. this phenomenon is known as plasmolysis;** **8. the gap is filled with potassium nitrate solution;**	
	Heavy metals such as lead and copper are toxic to plants.			
	(c)	Predict the appearance of the epidermal cells if the epidermis is mounted in **1 mol dm^{-3} lead nitrate** solution. Explain your predictions.		[3]
			1. pigments leaked out of the cells / content dispersed;; **2. (heavy metal - lead) disrupts structure of membrane protein;;** **3. loss of membrane selective permeability;;**	
	Fig. 2.1 shows the view of a mammalian white blood cell, using an eyepiece graticule and the high-power objective lens of a microscope.			

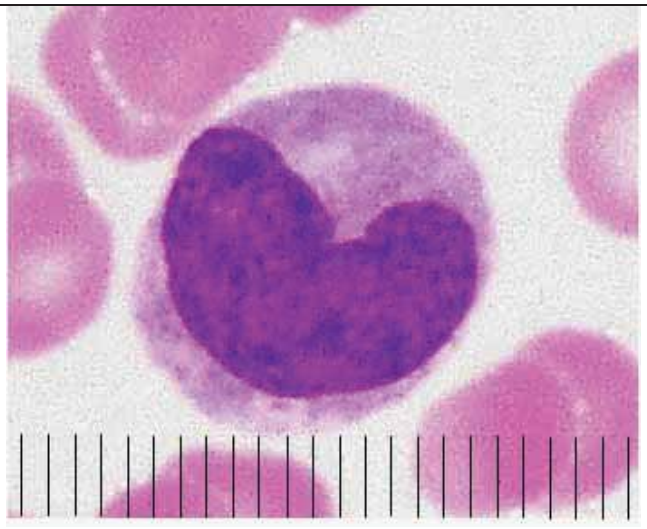


Fig. 2.1

	(d)		Use a table to record **three** observable differences between the blood cell in Fig. 2.1 and the cell you saw in **(a)**.	[3]
			1. Absence of cell wall;; **2. U shaped nucleus;;** **3. Nucleus took up >50% of cell size;;** **4. Nucleus in the centre of cell;;** **5. Round shaped cell;;**	
	(e)	**(i)**	The student calibrated the eyepiece graticule against a stage micrometer with the following results: Number of eyepiece graticule divisions across 5 stage micrometer division = 25 One stage micrometer division = 0.01 mm	
			Use this information to calculate the actual length of the cell. Show the steps and units in your calculation.	[3]
			1 division on eyepiece graticule = (0.01x5)/25 = 0.002 mm = 2 μm;; **Actual length of cell = 14;; x 2 = 28 μm;;**	
		(ii)	Calculate the magnification of the blood cell in Fig. 2.1. Show your working.	[2]
			Magnification = diagram size / actual size;; **Magnification = 4.8 cm / 18 μm = X1714.3 (1 d.p.);;**	
				[Total: 19]

Question 3

Industrial wastewater contains high concentrations of fats, like oil and grease, which may pollute fresh water and influence aquatic environments. The use of lipase enzymes to remove oil and grease from the wastewater is an effective and environmentally-friendly treatment method. Chemicals are added to the wastewater to emulsify the fats and break them up into smaller fat droplets, increasing the surface area for lipase to break them down into fatty acids and glycerol at a higher rate.

In wastewater treatment, enzymes are used on a large scale. However, enzymes are costly and most are only commercially available in liquid or dehydrated forms. As such, once added to the wastewater treatment mixture, they cannot be recovered to be re-used, thus driving up the cost of treatment.

Researchers postulated that the immobilisation of lipase in alginate beads would allow the enzymes to be re-used, leading to cost savings. The enzymes can be added to sodium alginate and immobilised in the beads as shown in Fig. 3.1.

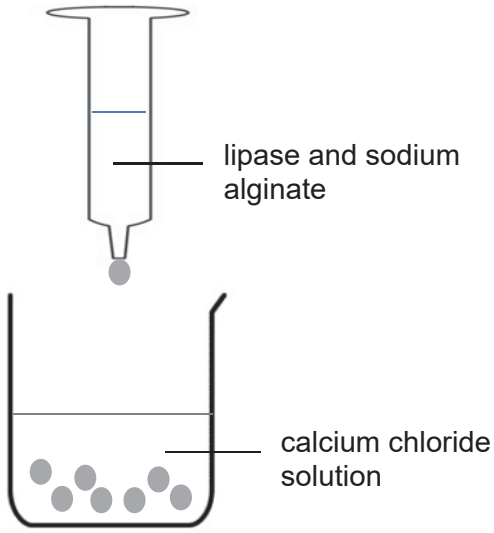


Fig. 3.1

Full-fat milk can be used as a substrate for the immobilised lipase enzymes. Bile salts act like detergents and can be used to emulsify the fats without affecting the pH. Sodium carbonate is a base that can be added to standardise the milk to an alkaline pH, prior to treatment with lipase.

The monitoring of the pH of the reaction mixture from a predetermined start to end-point pH can be used to measure the activity of the immobilised lipase.

Using this information and your own knowledge, design an experiment to find the concentration of lipase needed to form immobilised lipase beads with the same activity as free enzymes (non-immobilised).

You must use:

- 10% lipase solution
- industrial 3% lipase
- sodium alginate suspension
- calcium chloride solution
- full-fat milk
- sodium carbonate solution
- 5% bile salts solution

- a pH meter with a digital display to 2 decimal places
- stopwatch

You may select from the following apparatus:

- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rod, etc.
- syringes

Your plan should:

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

[Total: 14]

Relate independent variable to dependent variable

Reaction: Lipase is a biological catalyst which catalyses the hydrolysis of lipids into glycerol and fatty acids.

How to measure dependent variable

Fatty acid produced neutralises the alkali in milk, leading to a decrease in pH of the reaction mixture.

Time taken for pH to decrease from 10.00 to 7.00 can be used to measure the rate of reaction.

Describe and explain of expected trend

With the increase in concentration of lipase, the frequency of successful collision between substrate (lipids) and enzyme (lipase) increases. As more enzyme-substrate complexes are formed per unit time, more fatty acid formed per unit time. Hence time taken for the pH to decrease to 7.00 decreases.

Independent variable

Concentration of lipase

Range: 10%, 8%, 6%, 4%, 2%

Dependent variable

Time taken for the pH to decrease from 10.00 to 7.00

Controlled variables

Controlled Variable	Appropriate Quantity
Temperature of incubation	40°C
Volume of milk used	5 cm^3
Volume of lipase used	2 cm^3
Volume of bile salts	1 cm^3
Volume of sodium carbonate	5 cm^3

Independent variable:

States that independent variable is concentration of lipase and uses at least five different uniformly-spaced concentrations;;

Dependent variable:

Time taken for pH to reach stated end-point;;

Controlled variables:

Describe two identified variables;;

And describe how they are controlled;; ;;

Experimental Procedures

Dilution of lipase:

Table showing dilution 10% lipase solution

Final concentration of lipase / %	Final volume of diluted lipase / cm^3	Volume of stock added / cm^3	Volume of distilled water added / cm^3
10	5.0	10.0	0.0
8	5.0	8.0	2.0
6	5.0	6.0	4.0
4	5.0	4.0	6.0
2	5.0	2.0	8.0

Method:

Plans suitable method to vary lipase concentration;;

Preparation of immobilised lipase:

1. **mix 2 cm^3 of lipase with 2 cm^3 of sodium alginate**
2. **Pour the mixture into a syringe**
3. **Drip mixture into calcium chloride solution**
4. **Wash the beads with distilled water**
5. **Repeat for each concentration of lipase**

Method:

Plan suitable method to immobilise lipase in beads

Set up for immobilised lipase:

1. **Set up at water bath at 40°C using a 500 cm^3 beaker**
2. **add 5 cm^3 of milk into a test-tube**
3. **Add 1 cm^3 of bile salts solution to emulsify the fats**
4. **Using the pH meter, add sufficient (e.g. 5 cm^3) sodium carbonate solution so that the pH of the solution in the test-tube reaches pH 10.**
5. **Place all the lipase beads into another test-tube**
6. **place both tubes in the water bath 40°C for 2 minutes to equilibrate to temperature**
7. **put in the pH probe and ensure the reading is 10.00**
8. **transfer the 5 cm^3 milk into the test tube containing immobilised lipase and start timing**
9. **Record the time taken for the pH to reach 7.00**
10. **Repeat steps 2 – 9 for each concentration of lipase enzyme**

Method:

Devise a method that equilibrate the enzymes and substrate to temperature;;

Method:

Standardise the starting pH of mixture e.g. pH 10 by adding a fixed volume of sodium carbonate;;

Method:

Plans a suitable procedure that involves monitoring the change in pH towards a set end-point pH;;

Set up for free lipase:
Same procedure as above except that 2 cm^3 of lipase is added into a test tube

Method:

Plan a method to carry out the same procedure but with equal volume of free enzyme

Producing accurate and reliable results

- **For each concentration of lipase enzyme, repeat the entire procedure to obtain three replicates**
- **Repeat the entire experiment two more times**

Reliability:

Ref to repeating at least two more times with different lipase concentration;;

Definition of control Negative control

A negative control is subjected to the same factors as that for the experiment, except that lipase is replaced by an equivolume of distilled water
It is expected that the pH remains at 10.00 regardless of the incubation time.
This proves that it is indeed lipase that hydrolyses the fats causing pH to decrease.

Control:

Ref to control experiment without substrate;;

Data manipulation

Processing of data – mean / average
rate of reaction = 1/t

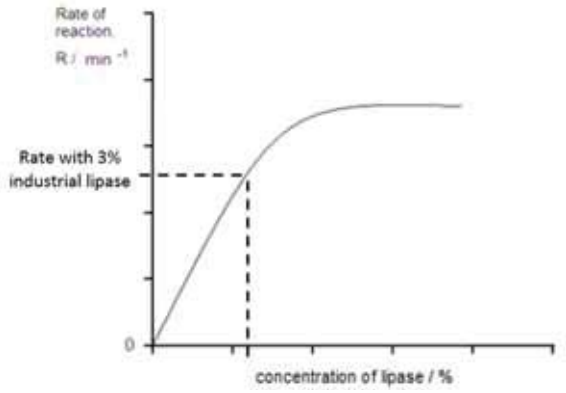
Table showing the effect of concentration of lipase on rate of reaction

Lipase concentration, C/ %	Time taken for pH to change from 10.00 to 7.00, t/ min				Rate of reaction, R/ min^{-1}
	t_1	t_2	t_3	$\bar{t}$	
10					
8					
6					
4					
2					

Recording:

Shows how results are to be presented in the form of a table with IV (concentration of lipase) and dependent variable (time taken for pH to change from 10.00 to 7.00) in appropriate column/rows;

Graph showing the effect of concentration of lipase on rate of reaction

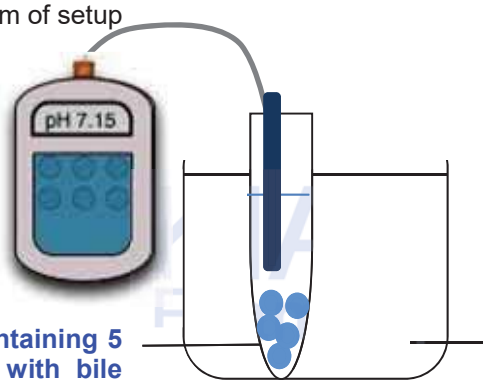


To find out the concentration of lipase to make immobilised enzymes, plot a standard curve with the data obtained. The concentration of lipase to use is then obtained by using the graph to determine the lipase concentration that gives the same rate of reaction as 3% industrial lipase (free enzymes).

Accuracy:

States how lipase concentration can be determined by comparing to reaction by free enzymes

Labelled diagram of setup



Test tube containing 5 cm^3 of milk with bile salts at pH10, and 2 cm^3 of free / immobilised lipase

water bath at 40°C

Risk assessment and precautions taken

- **Wear gloves and goggles to prevent contact with lipase which is an irritant.**
- **Use a piece of rag to hold the beaker containing hot water (when**

Risk/safety:

Refers to hazard and precaution;;

preparing water bath) to prevent burns / scalds Correct use of technical and scientific terms **e.g. catalyse, enzyme-substrate complex, active site, complementary, acidic**	