



RIVER VALLEY HIGH SCHOOL

JC2 PRELIMINARY EXAMINATION

CANDIDATE
NAME

CENTRE
NUMBER

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CLASS

21J

INDEX
NUMBER

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BIOLOGY

9744/01

Paper 1 Multiple Choice

23 September 2022

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 and 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 **24** printed pages.

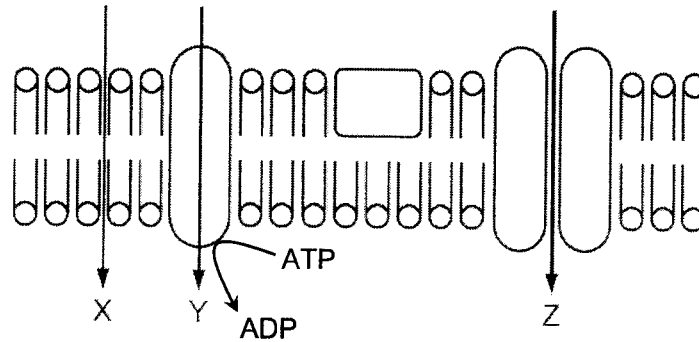
- 1 The electron micrograph shows part of several eukaryotic cells.



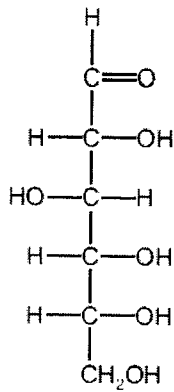
Which of the following statements are correct?

- 1 Both P and Q contain templates for transcription.
 - 2 Q contains ribosomal RNA which is involved in peptide bond synthesis.
 - 3 R has a fluid mosaic structure and regulates the movement of substances between the two cells.
 - 4 S is the site of pyruvate synthesis.
- A** 1, 2, 3 and 4
B 1, 2 and 4 only
C 1 and 3 only
D 2 and 4 only

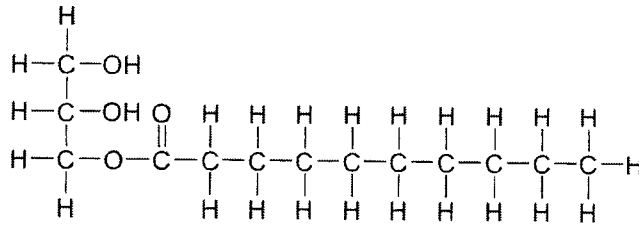
- 2 The diagram shows three pathways, X, Y and Z, through which substances can move across a cell surface membrane.



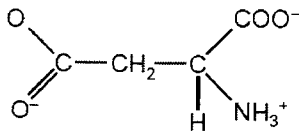
Which row correctly identifies all possible pathways through which substances 1, 2, 3 and 4 could use to enter the cell?



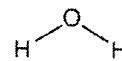
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2



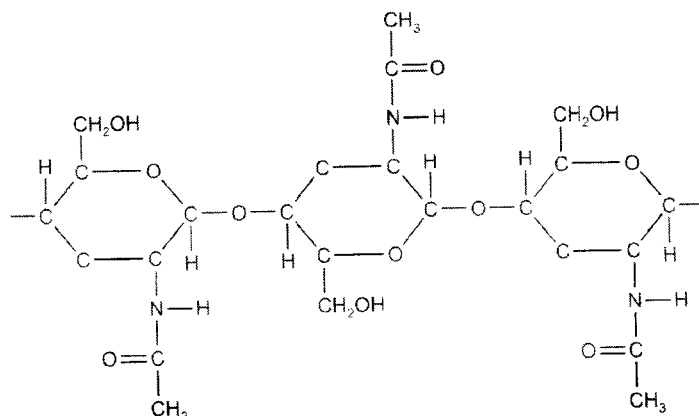
3



4

	X	Y	Z
A	2, 4	3	1, 3, 4
B	2, 4	1, 3	1, 3
C	2	1, 3	1, 3
D	2	3	1, 3, 4

- 3 The diagram shows the structure of part of a polysaccharide, chitin, found in the cell walls of certain fungi.



Which statements are true for **both** chitin and cellulose?

- 1 Each polysaccharide is composed of two different monosaccharides.
 - 2 Each polysaccharide can form cross linkages via hydrogen bonds between chains.
 - 3 Their monosaccharides are joined by 1,4-glycosidic bonds.
 - 4 Every second monosaccharide in the polysaccharide chain is rotated by 180°.
- A** 1, 2 and 3
B 2, 3 and 4
C 2 and 4 only
D 3 and 4 only

4 Which row about the structure of proteins is correct?

	primary structure	secondary structure	quaternary structure
A	is the result of translation of an mRNA molecule by a ribosome into a chain of amino acids	occurs because of attraction between R groups of amino acid residues	is the sub-unit polypeptides that link together to form a protein
B	is the number of amino acids present in a protein	is the coiling of a chain of amino acids to form a β -pleated sheet or α -helix	contains two types of polypeptide that interact forming the shape of a protein
C	is synthesised by ribosomes in the cytoplasm	is the left-handed spiral formed by the primary structure	is formed by four polypeptides and an additional prosthetic group attached to the protein
D	is the sequence of amino acids in a protein coded by DNA	is formed by hydrogen bonding at intervals along the polypeptide backbone	is formed by the linking together of more than one polypeptide to form a protein

5 Hydrogenated vegetable oils are unsaturated fats that have been converted to saturated fats.

Which property of the fats will have changed?

- 1 Their melting point has increased.
- 2 There will be an increase in the ratio of carbon to hydrogen atoms.
- 3 Their hydrocarbon chains will fit together more closely.

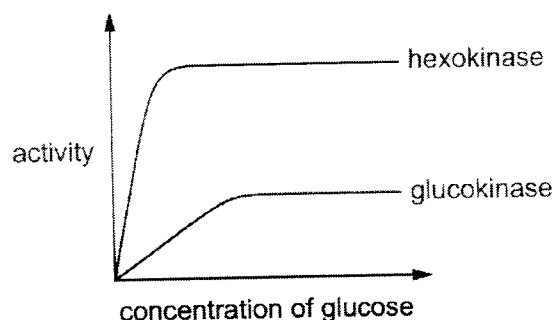
- A** 1, 2 and 3
B 1 and 2 only
C 1 and 3 only
D 2 and 3 only

6

- 6 The enzymes glucokinase in the liver and hexokinase in the brain both catalyse the phosphorylation of glucose during glycolysis:



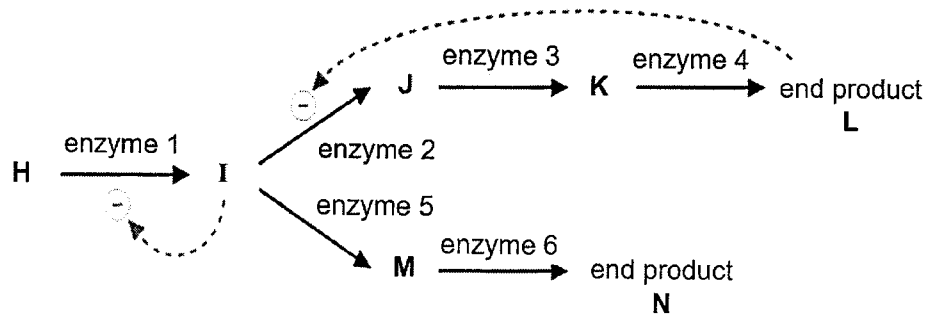
The graph shows the activity of each enzyme measured at different concentrations of glucose.



Which statements correctly describe the differences between the two enzymes?

- 1 At low concentrations of glucose, temperature is limiting the activity of glucokinase only.
 - 2 At high concentrations of glucose, the difference between the total amount of products formed by hexokinase and glucokinase remains constant.
 - 3 Contact residues at the active site of hexokinase bind to glucose with greater affinity than that of glucokinase.
 - 4 Hexokinase becomes saturated with glucose at a lower concentration of glucose than glucokinase.
- A** 1, 3 and 4
B 2 and 3 only
C 2 and 4 only
D 3 and 4 only

- 7 The diagram shows a biosynthesis pathway.



The addition of substance **X** resulted in the following:

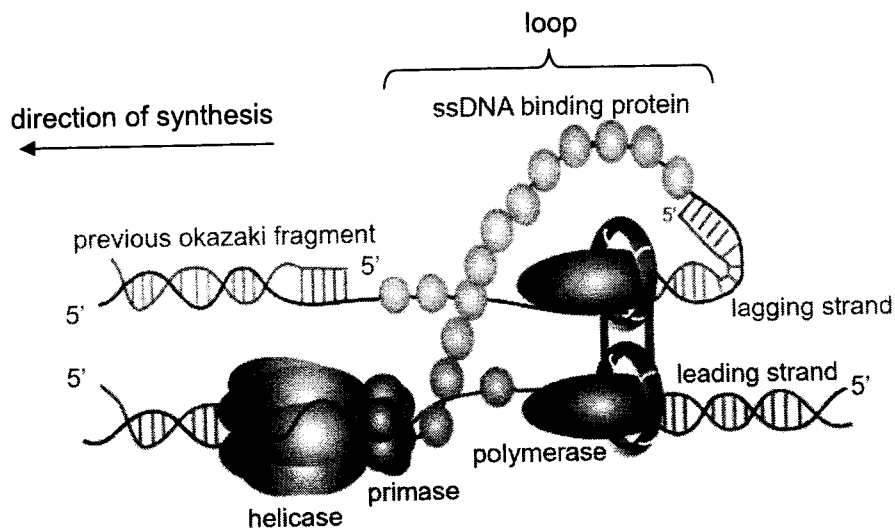
- no change in the concentration of metabolite **H**
- accumulation of metabolite **I**
- low concentrations of metabolite **J** and **K** and end product **N**

Further addition of metabolite **I** results in the formation of more end product **N**, but not end product **L**.

What does the information indicate about substance **X**?

- A** It reacts with metabolite **J** to form metabolite **K**.
- B** It is an allosteric activator of enzyme 1.
- C** It is a non-competitive inhibitor of enzyme 3.
- D** It is a competitive inhibitor of enzyme 5.

- 8 The diagram shows the synthesis of the leading and lagging strands during DNA replication. The lagging strand template forms a loop at the replication fork.



Which statements explain why looping is needed during DNA replication?

- 1 The anti-parallel nature of the DNA strands.
- 2 DNA polymerase joins new nucleotides to the 3' end of the growing strand.
- 3 Single stranded DNA can be maintained to act as templates for polymerases.
- 4 Both DNA polymerases can then synthesise daughter strands in the same overall direction.

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

- 9 The DNA sequence CCAAGAAGTCGACAAACA was transcribed and translated to synthesise the polypeptide chain gly-ser-ser-ala-val-cys.

A mutation in the sequence resulted in a polypeptide chain that was shortened from six to two amino acids.

Which mutations might have occurred to result in the outcome observed?

- 1 A single base pair substitution from G to T.
- 2 A single base pair substitution from G to C.
- 3 Addition of a base pair at the 3rd mRNA codon.

- A 1, 2 and 3
B 1 and 2 only
C 1 and 3 only
D 2 and 3 only

- 10 The following statements describe non-coding DNA in eukaryotes.

- 1 Presence of repeating sequences.
- 2 Number of nucleotides varies in different cells.
- 3 May be bound by proteins.

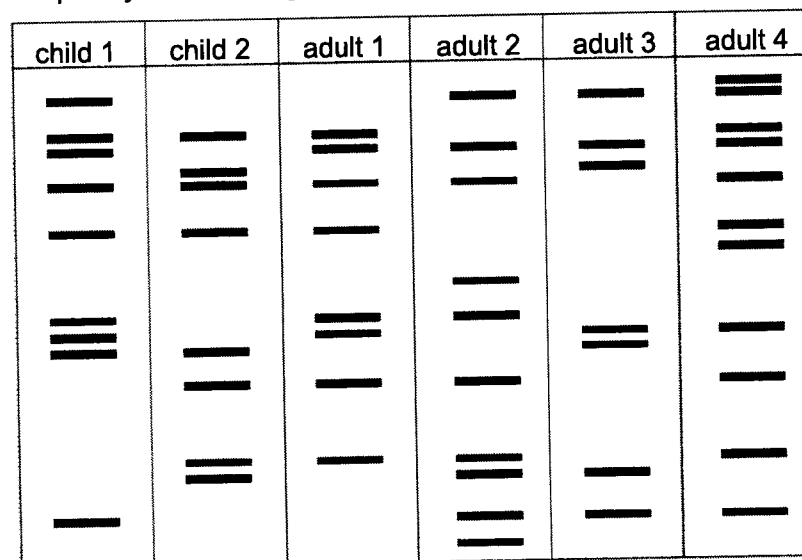
Which statement(s) apply **only** to non-coding DNA present outside of genes?

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

- 11 Which row describing the effect of a modification to the regulation of gene expression in eukaryotes is correct?

	modification	effect
A	mutation of intron splice sites	aggregation of misfolded proteins in cytoplasm
B	inactivation of poly-A-polymerase	accumulation of mRNAs in nucleus
C	loss-of-function mutation in eukaryotic initiation factors	inability to synthesise mRNA
D	over-expression of histone methyltransferase	upregulation of expression for a large variety of genes

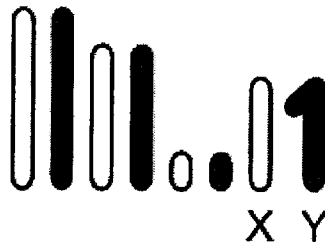
- 12 DNA fingerprinting was used to identify the parents of two children. Short tandem repeats of a particular locus were selectively amplified using polymerase chain reaction and the products subsequently underwent gel electrophoresis. The results are shown below.



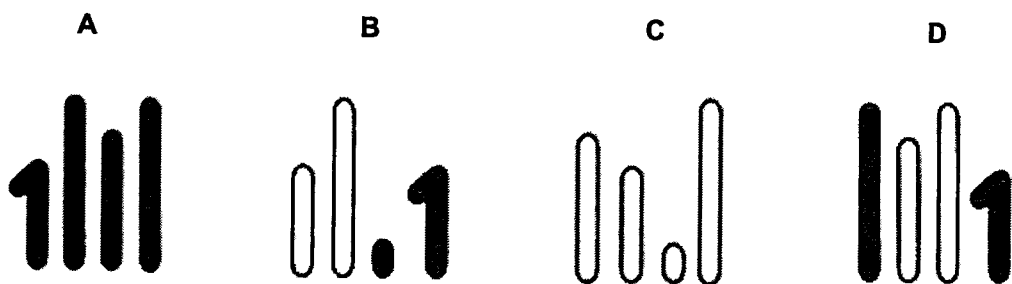
Given that both the children have the same pair of parents, which two adults may be their parents?

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

- 13 The mitotic cell cycle is carefully controlled by a cell-cycle control system. Which of these statements explain why the mitotic cell cycle requires control?
- 1 To ensure sufficient time for DNA errors to be repaired.
 - 2 To allow for genetic variation in daughter cells.
 - 3 To induce apoptosis upon detection of any DNA damage.
 - 4 To ensure that cells grow to an appropriate size for cell division.
- A 1 and 2 only
 B 1 and 4 only
 C 2 and 3 only
 D 3 and 4 only
- 14 The diagram shows the four pairs of homologous chromosomes present in the germ cell of a male fruit fly, *Drosophila melanogaster*.



Given that crossing over does not occur during prophase I, which set of chromosomes shows the genetic variation resulting from independent assortment in the nucleus of a sperm cell?



- 15 The Philadelphia chromosome is associated with the development of several forms of leukaemia. The Philadelphia chromosome is formed when:

- one end of chromosome 9 and one end of chromosome 22 breaks
- part of the *BCR* gene that lies at broken end of chromosome 22 fuses with the *ABL1* gene that is part of the fragment of chromosome 9

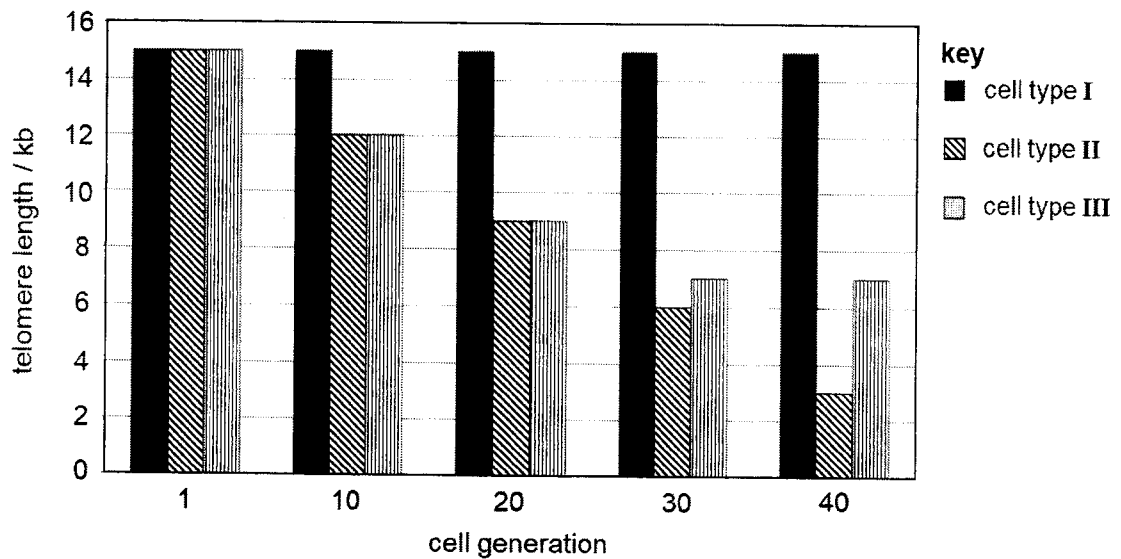
When the *BCR-ABL1* fused gene is expressed, a protein that exhibits high tyrosine kinase activity is produced.

Which statement(s) cannot be concluded with the information above?

- 1 *BCR-ABL1* gene is a proto-oncogene as the gene product stimulates cell division.
- 2 Multiple copies of *BCR* gene results in the development of cancer.
- 3 The Philadelphia chromosome is an example of chromosomal translocation.

- A 1, 2 and 3
B 1 and 2 only
C 1 and 3 only
D 2 only

16 The graph shows the telomere length of three different cell types I to III.

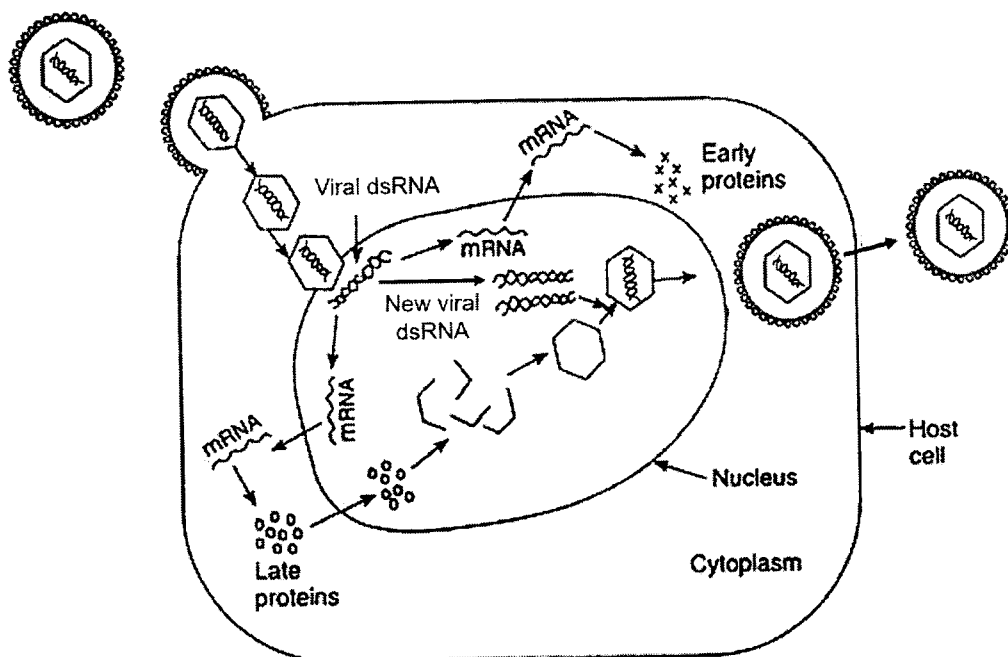


What may be concluded from the graph above?

- 1 Cells of type I and III are capable of long term self-renewal.
- 2 Cells of type II do not contain mutations in tumour suppressor genes.
- 3 Cells of type I can be induced to differentiate by environmental signals.
- 4 Cells of type III can proliferate uncontrollably.

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

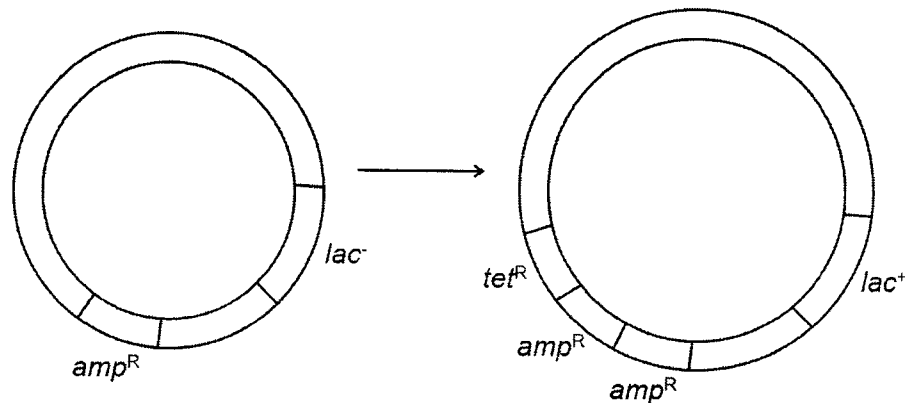
- 17 The diagram shows the reproductive cycle of a virus in a host cell.



Which statement correctly describes the reproductive cycle of this virus?

- A It is an enveloped virus that enters the host cell via receptor-mediated endocytosis.
- B The viral genes serve as templates to form RNA molecules with negative configuration to synthesise early and late proteins.
- C Synthesis of new viral genome is carried out by the same enzyme as in the influenza virus.
- D The viral progeny is released via budding.

- 18 Which environment could account for the changes in the bacterial chromosome as shown in the diagram?



key

amp^R – ampicillin resistance gene

tet^R – tetracycline resistance gene

lac^+ – lac operon present

lac^- – lac operon absent

- A** Exposure of actively dividing bacteria to mutagens.
- B** A single bacterial colony grown in culture medium containing lambda phages.
- C** Bacteria grown in culture medium with other strains of heat-killed bacteria.
- D** Bacteria grown in culture medium containing tetracycline.

- 19 The activities of the *lac* operon in four different *E. coli* strains, cultured in different nutrient media, were investigated. The results are shown in the table below.

<i>E. coli</i> strain	nutrient present in media	conformational state of <i>lac</i> repressor	β -galactosidase
1 (normal)	glucose	active	absent
	lactose	inactive	present
2 (mutant)	glucose	active	present
3 (mutant)	lactose	active	absent
4 (mutant)	lactose	inactive	absent

Which statements could explain these results?

- 1 A mutation in the *lac I* gene in strain 3.
 - 2 A mutation in the operator of the *lac* operon in strain 2.
 - 3 A mutation in the promoter of the *lac* operon in strain 4.
 - 4 A mutation that swapped the positions of the promoter and operator in the *lac* operon in strain 2.
- A** 1, 2, 3 and 4
- B** 1, 2 and 3 only
- C** 1 and 2 only
- D** 3 and 4 only

- 20 Coat colour in domestic cats is controlled by two genes. Information of these genes are given in the table below.

gene location	symbol	phenotype
chromosome 2	B	black coat colour
	b	brown coat colour
X chromosome	X^G	ginger coat colour
	X^g	absence of ginger colour X^G is expressed even in the presence of the B allele

During the development of female cats, one X chromosome in each cell is inactivated at random. Consequently, in female cats that are heterozygous at both gene loci, skin cells may be in a patch of ginger fur or black fur depending on whether they have developed from a cell with an active **X^G** allele or **X^g** allele. Cats with this form of colouring are called tortoiseshell cats.

A male cat heterozygous for black coat is mated with a female cat with tortoiseshell coat. What proportion of their kittens would be expected to have the tortoiseshell colouring?

- A 0.125
- B 0.25
- C 0.5
- D 0.75

- 21 In domestic poultry, the gene for white feathers is dominant to the gene for dark feathers and the gene for frizzled feathers is dominant to normal feathers. Pure-breeding poultry which were homozygous for dark, frizzled feathers were crossed with pure-breeding poultry bearing white, normal feathers. The F1 were test-crossed and the phenotypes of offspring were recorded. The results are shown.

white frizzled	39
dark frizzled	79
white normal	68
dark normal	46

The chi-squared test can be used to determine the probability that offspring ratio fits the expected ratio.

The formula for the chi-squared test is:

$$\chi^2 = \sum \frac{(O - E)^2}{E} \quad v = c - 1$$

Part of the probability table for chi-squared values is shown below.

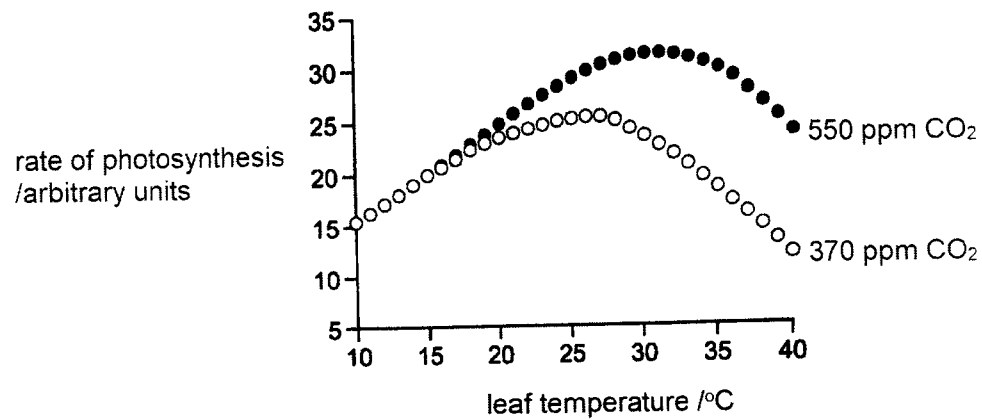
degrees of freedom	probability, p			
	0.10	0.05	0.01	0.001
1	2.71	3.84	6.64	10.83
2	4.61	5.99	9.21	13.82
3	6.25	7.82	11.35	16.27
4	7.78	9.49	13.28	18.47

Which combination correctly describes the conclusion of the χ^2 test?

	probability	loci of genes
A	< 0.05	different chromosomes
B	< 0.05	same chromosomes
C	> 0.05	different chromosome
D	> 0.05	same chromosome

- 22 Which statement concerning chrysanthemum plants, of the genus *Dendranthema*, is a valid example of how the environment may affect the phenotype?
- A Identical genetic crosses performed between varieties of *Dendranthema* result in a greater proportion of offspring plants with plastids exhibiting a yellow colour when grown in a field and a greater proportion of offspring plants with colourless plastids when grown in a glass house.
 - B Anthocyanins and anthoxanthins are vacuolar pigments, whereas xanthophylls and carotenes are pigments found in membrane-bound organelles known as plastids. These, together with molecules known as co-pigments, are responsible for the variation observed in petal colour in *Dendranthema*.
 - C The seeds of a cross between *Dendranthema weyrichii* and *Dendranthema grandiflora* produce plants that are far more frost-tolerant and exhibit an extended flowering season compared with both parent plants.
 - D The seeds of a cross between *Dendranthema weyrichii* (height varying between 12.5 – 15.0 cm) and *Dendranthema grandiflora* (height varying between 8.0 – 25.0 cm) produce plants, when grown in natural day length, of a height varying between 55.0 – 71.0 cm.

- 23 The graph shows the results of increased concentration of carbon dioxide on soy bean photosynthesis at various leaf temperatures. Carbon dioxide concentration is measured in ppm (parts per million). Light intensity was at an optimum level.

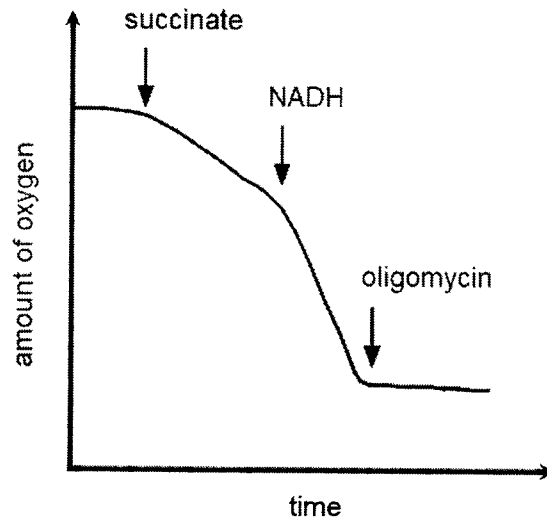


Which statement(s) concerning the data in the graph is valid?

- 1 When temperature is limiting, increased carbon dioxide concentration increases the rate of photosynthesis.
- 2 At all temperatures up to 27.5 °C, temperature is the only limiting factor for both carbon dioxide concentrations.
- 3 At all temperatures, carbon dioxide concentration is the main limiting factor.
- 4 The photosynthetic rate obtained at the optimum temperature for 370 ppm CO₂ could be achieved at a temperature around 7.5 °C lower using an increased concentration of 550 ppm CO₂.

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

- 24 A suspension of mitochondria was prepared in a buffer containing ADP and inorganic phosphate (Pi). The oxygen concentration in the buffer was monitored carefully and recorded as shown below. At the times indicated, a specific reagent was added to the buffer. Throughout the experiment, the concentrations of ADP and Pi were in excess.



Which one of the following shows correctly from the highest to the lowest, the rate of ATP production after the addition of the three chemicals?

	highest rate	→	lowest rate
A	succinate		oligomycin
B	NADH		oligomycin
C	succinate		NADH
D	oligomycin		succinate

25 The steps involved in a cell-signalling pathway are listed.

- binding of ligand to receptor binding site
- phosphorylation of receptor
- synthesis of second messengers
- activation of the enzyme adenylyl cyclase
- initiation of a protein kinase cascade
- binding of protein to DNA sequences

What is the 3rd common step that occurs during **both** insulin and glucagon signalling?

- A synthesis of second messengers
- B activation of the enzyme adenylyl cyclase
- C initiation of a protein kinase cascade
- D binding of protein to DNA sequence

26 Before the settlement of California in the 1800s, the elk population was very large. By about 1900, there were only a few dozen elk left due to hunting.

Owing to protection, there are now about 3000 elk living in a small number of isolated herds.

Unfortunately, some of the elk in all the herds have difficulty grazing due to a shortened lower jaw, as a result of having one copy of a mutated allele. These elk can be observed in subsequent generations.

Which statements best explain the observations?

- 1 There was a mutation affecting jaw size in some of the herds.
- 2 There was random mating within each herd.
- 3 The mutated allele is preserved in the population due to heterozygote protection.
- 4 The current elk distribution demonstrates a founder effect.

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

- 27** Lord Howe Island is relatively small, volcanic island that formed approximately 6.4 – 6.9 million years ago. Two species of palm, *H. forsteriana* and *H. belmoreana*, are found on this island and had descended from one ancestor species.

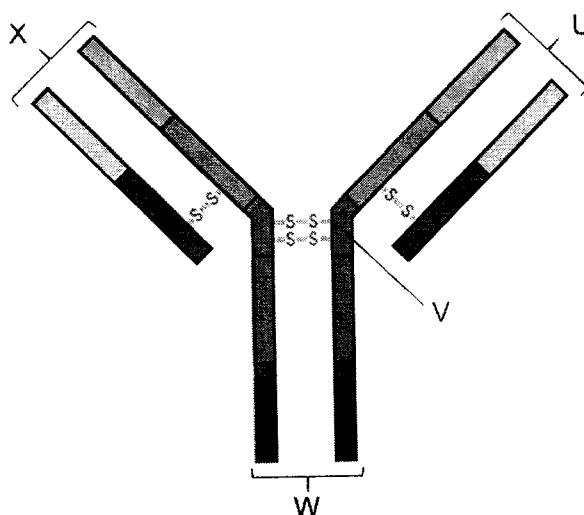
To investigate speciation of the two palm species, the following findings are listed.

- 1 Two populations from the ancestral species develop variation in soil tolerance. One population grows in neutral to acidic soil while the other grows in soils rich in calcarenite which has a more basic pH.
- 2 Calcarenite soils are poor in nutrients which will delay the physiological development of palm.
- 3 The soils on most parts of Lord Howe Island are mainly neutral to acidic, except at low lying areas where alkaline soils are found.
- 4 The peak flowering of each species is separated by approximately six weeks and has limited overlap.

What is the correct sequence to explain this speciation?

- A** 1 → 2 → 3 → 4
- B** 2 → 4 → 3 → 1
- C** 3 → 1 → 2 → 4
- D** 4 → 2 → 1 → 3
- 28** Which statement about immunity is correct?
- A** Immunity following a vaccination lasts for a greater length of time than natural passive immunity.
- B** Antibody injection results in artificial active and artificial passive immunity.
- C** Natural active immunity provides a faster response to infection than artificial active immunity.
- D** Antigen presentation by specific B lymphocytes only occurs with natural immunity.

- 29 The diagram shows the simplified structure of an antibody.



Which statement is correct?

- A U and X are unique antigen-binding sites that allow the antibody to bind to two different antigens.
- B V allows for flexibility of the antibody to bind to antigens.
- C W varies across different classes of antibodies due to alternative splicing of heavy chain mRNA.
- D X undergoes somatic hypermutation during B lymphocyte development in bone marrow.
- 30 Dengue disease is spread by *Aedes aegypti* and *Aedes albopictus* mosquitoes.
- Which of these risk factors increases the probability of developing severe dengue disease following infection?
- A increased resistance of the vector to insecticides
- B exposure to different mosquito species
- C people living in more crowded conditions due to an increase in human populations
- D having a chronic disease such as diabetes



RIVER VALLEY HIGH SCHOOL

JC 2 PRELIMINARY EXAMINATION

CANDIDATE
NAME

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CLASS 21J

INDEX
NUMBER

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BIOLOGY

9744/02

Paper 2 Structured Questions

12 September 2022

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 ON 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	
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Total	

This document consists of **28** printed pages.

Answer all questions.

- 1 In the lung, epithelial cells have a thin layer of watery mucus on their surface to trap particles.

Fig. 1.1 shows a series of processes that occur at the cell surface membrane of an epithelial cell, involving a channel protein called the Cystic Fibrosis Transmembrane Conductance Regulator (CFTR).

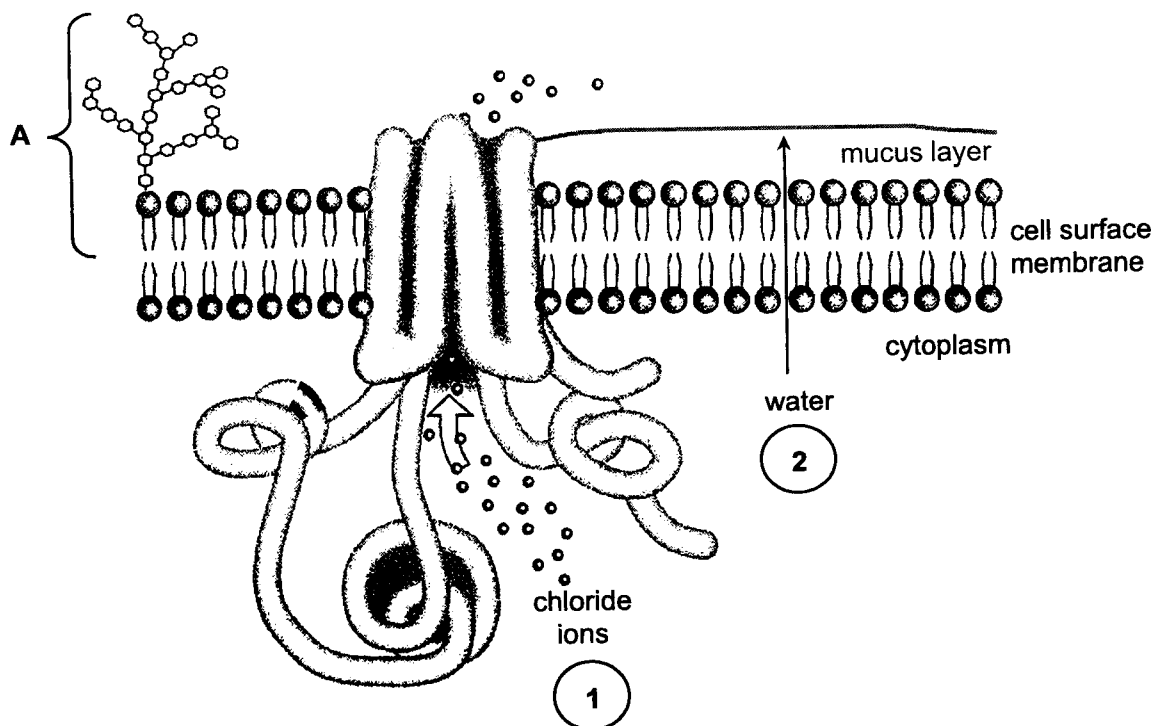


Fig. 1.1

- (a) Identify the structure labelled A and state its role. [2]

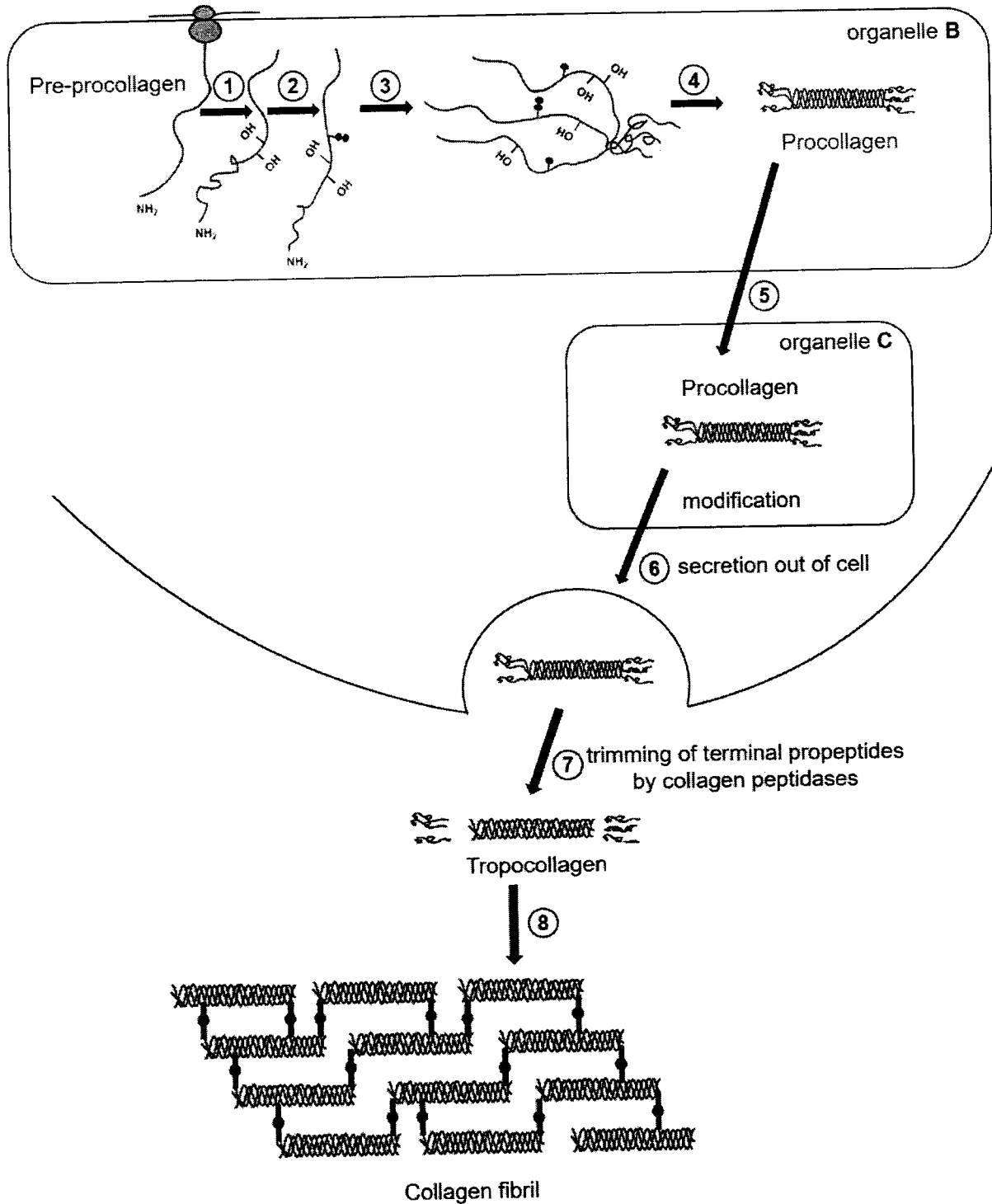
structure _____

role _____

(b) (i) Explain why chloride ions can only cross cell surface membranes via CFTR. [3]

(ii) Explain why absence of CFTR results in more viscous mucus. [2]

Fig. 1.2 shows the stages during the synthesis of collagen.



key

OH: hydroxyl group

● : sugar

Fig. 1.2

(c) (i) Identify organelles **B** and **C** in Fig. 1.2. [2]

organelle **B** _____

organelle **C** _____

(ii) With reference to Fig. 1.2, describe how tropocollagen is synthesised from pre-procollagen. [3]

(iii) The feet of elephants are covered in padding to support the mass of the elephant. This padding is made up of a large number of cells surrounded by connective tissue containing many fibres of collagen. Explain how **stage 8** contributes to the function of the padding. [2]

(iv) Suggest why collagen fibril is assembled outside the cell. [1]

[Total: 15]

- 2 Glucoside hydrolase (GH) is an enzyme of important commercial use. GH can be immobilised in alginate beads to improve its physical and biochemical properties. A study was carried out to investigate the effect of pH on the activity of free GH and immobilised GH. Equal concentrations of free GH and immobilised GH were used.

Fig. 2.1 shows the results of this study.

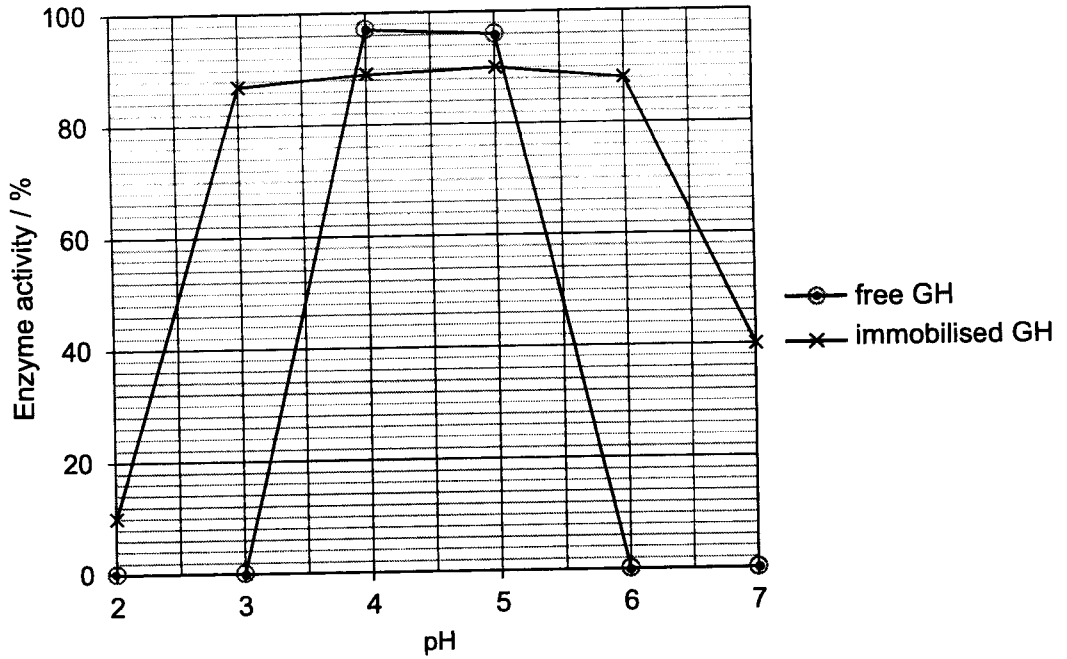


Fig. 2.1

- (a) With reference to Fig. 2.1, describe **two** differences between the activity of free GH and immobilised GH.

Suggest an explanation for each of the two differences.

[4]

difference 1 and explanation: _____

difference 2 and explanation: _____

GH is an enzyme responsible for hydrolysing α -1,4-glycosidic bonds in carbohydrates, such as amylose and amylopectin.

(b) Using GH as an example, explain induced-fit hypothesis. [2]

Fig. 2.2 shows a molecule of amylose and a molecule of RNA (not drawn to scale).

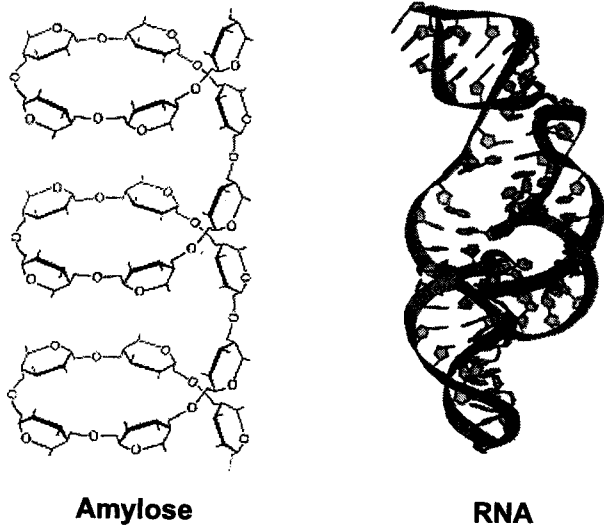


Fig. 2.2

(c) Describe in what ways the helical structures in both amylose and RNA differ. [2]

[Total: 8]

3 Fig. 3.1 shows a diagram of RNA polymerase during transcription of the β -globin gene.

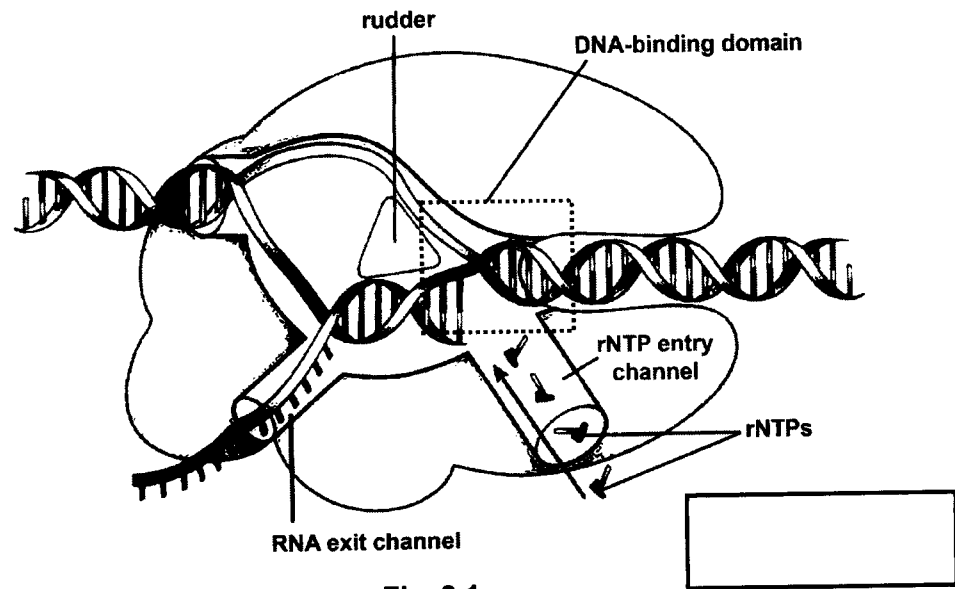


Fig. 3.1

(a) (i) In the box on Fig. 3.1, label with an arrow to show the direction of transcription. [1]

(ii) With reference to Fig. 3.1, describe how the structure of RNA polymerase allows it to perform its function. [2]

Actinomycin D and cycloheximide are drugs used in the treatment of chronic leukemia, and are involved in the inhibition of β -globin synthesis.

Fig. 3.2 shows the results obtained when each drug is added to immature red blood cells in separate experiments. The thickness and intensity of the bands indicate the amount of β -globin mRNA or β -globin protein present. Results have been adjusted to allow for direct comparison.

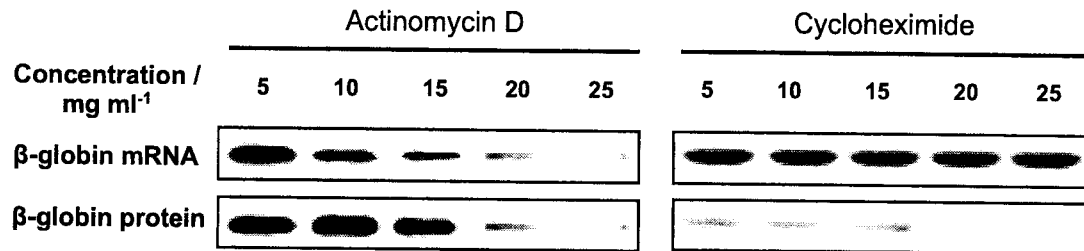


Fig. 3.2

- (b) (i) State the drug that inhibits the following processes in β -globin synthesis. [1]

transcription _____
translation _____

- (ii) Justify your answer in (b)(i). [3]

- (c) Describe **two** features of the genetic code. [2]

[Total: 9]

4 Cancer is a genetic disease. Despite this, only around 10% of all cancers are inherited.

(a) Suggest **two** reasons why a cancer that occurs in a parent does not always occur in the offspring. [2]
in the offspring.

Acute myeloid leukemia (AML) is a rare and extremely rapid developing cancer in human. AML results from aberrant proliferation and differentiation of mutated myeloid cells in the bone marrow. Large numbers of malfunctioning differentiated cells then result in symptoms such as fatigue, unusual bruising, and a high number of infections.

Patients with AML display mutations in many genes but mutations in *FLT3* and *DNMT3A* are most prevalent. *FLT3* and *DNMT3A* are a type of receptor tyrosine kinase and DNA methyltransferase respectively.

Fig. 4.1 shows the development of AML in the bone marrow.

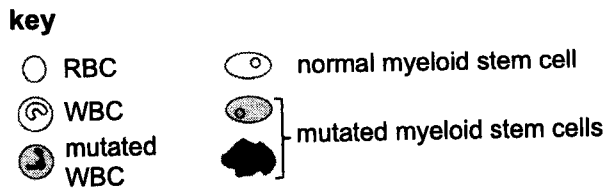
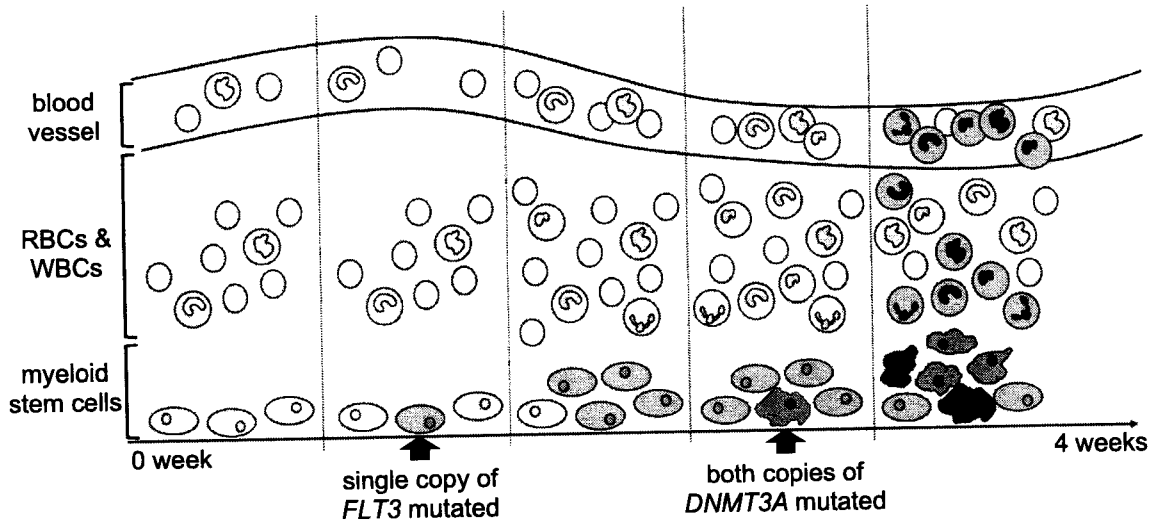
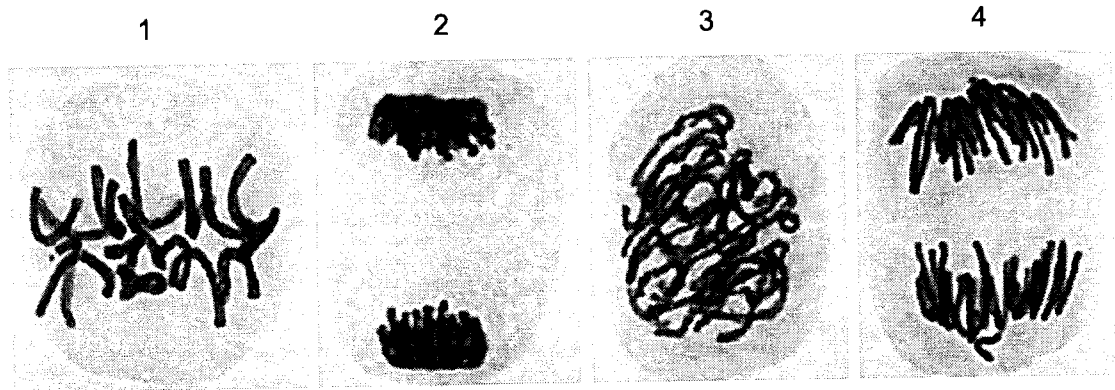


Fig. 4.1

- (b) Outline how the mutations in myeloid stem cells result in the changes visible in Fig. 4.1 and the formation of multiple secondary sites of tumour development. [4]

Myeloid stem cells were obtained from a patient at 0 week. The photomicrographs below show the myeloid stem cells in various stages of nuclear division.



(c) (i) State which cell(s) contain twice as many chromosomes as a cell in resting phase from the same patient. [1]

(ii) With reference to cells 1, 2 and 4, describe in correct order the behaviour of chromosomes in these stages of nuclear division. [3]

[Total: 10]

- 5 Haemagglutinin (HA) protein of influenza virus is a homotrimeric protein complex. Each subunit is coded for by the *HA* gene present on one of its eight genomic segments.

Fig. 5.1 shows one of the subunits.

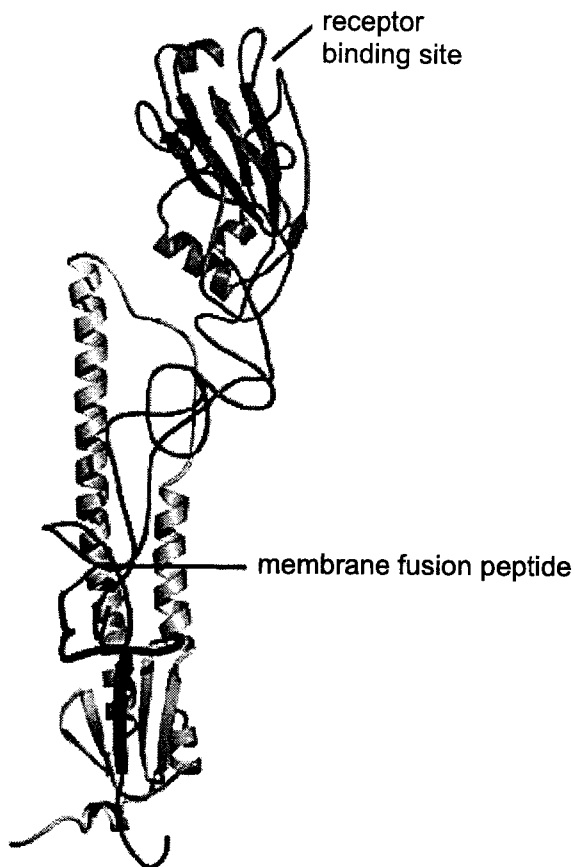


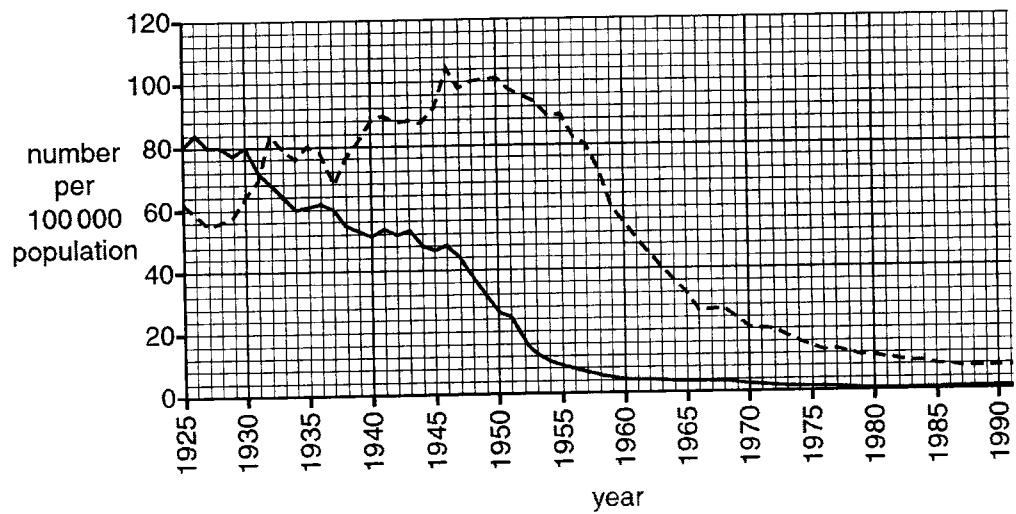
Fig. 5.1

- (a) Outline how the identified features in Fig. 5.1 facilitate influenza infection. [3]

(b) Explain how influenza virus with eight genomic segments can result in a pandemic. [2]

Fig. 5.2 shows the number of deaths from influenza and the number of new cases of influenza from 1925 to 1991 in Country K.

An antiviral drug for influenza was introduced in Country K for widespread use in 1930. The antiviral drug specifically targets non-envelope viral proteins to reduce the influenza's ability to multiply.



key
 — deaths from influenza
 - - - - new cases of influenza

Fig. 5.2

6 Gene expression in eukaryotic cells is regulated at multiple levels.

Fig. 6.1 shows the regulation of transferrin receptor (TfR) expression using Iron Response Element-Binding Proteins (IRE-BP). IRE-BP binds to IREs which are loop structures found on the mRNA.

TfRs are present on the cell surface and are involved in the uptake of extracellular iron.

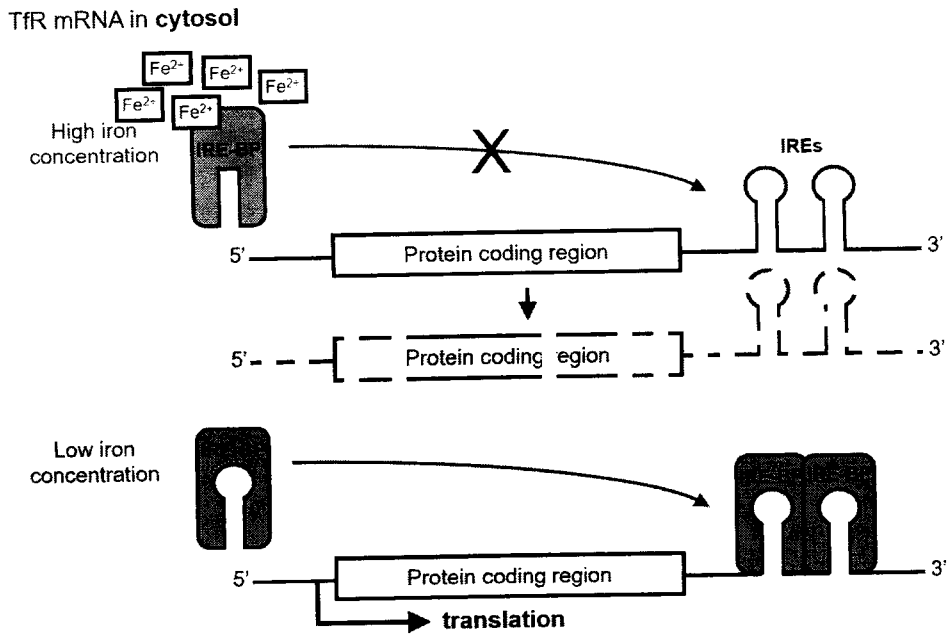


Fig. 6.1

(a) (i) State the level of regulation shown in Fig. 6.1. [1]

(ii) Explain how a change in cytosolic iron concentration results in an increased uptake of extracellular iron. [4]

Ferritin proteins are involved in the storage of iron taken into the cell by TfRs. The regulation of ferritin expression is shown in Fig. 6.2.

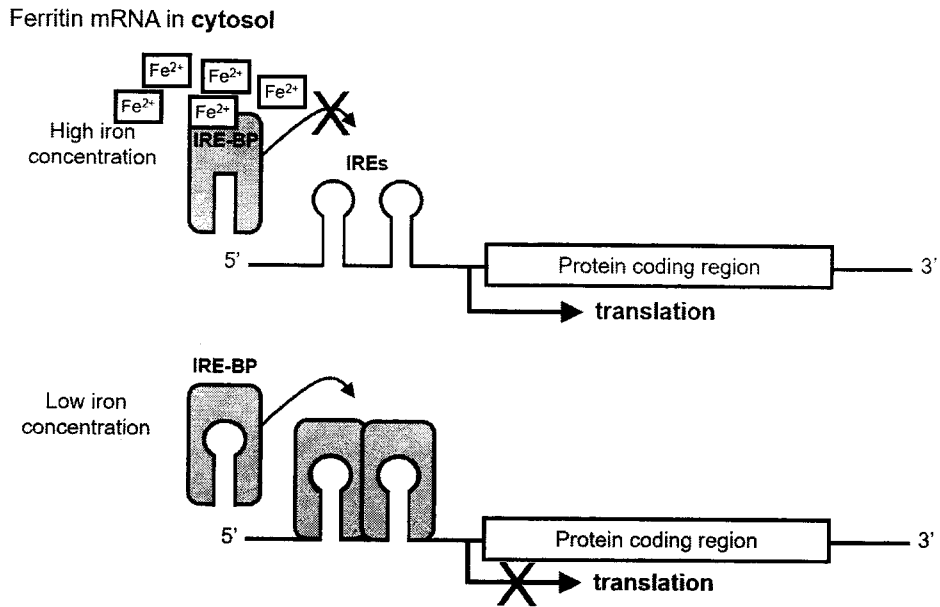


Fig. 6.2

(b) Outline two differences in the regulation of ferritin and TfR expression. [2]

At a different level of regulation, activators and repressors act on distal elements to control the rate of transcription.

(c) Describe how activators alter the expression of a gene. [3]

[Total: 10]

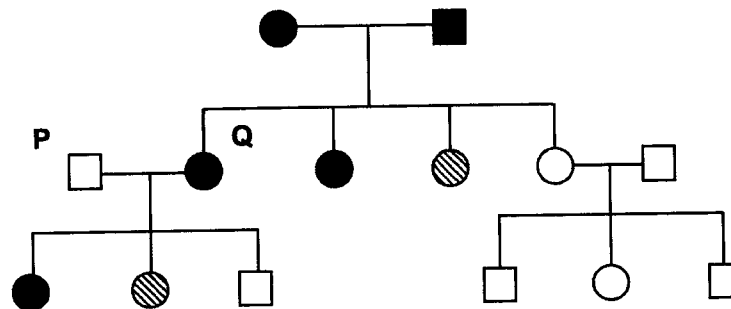
- 7 Dachshunds have three basic coat types: wire-, smooth- or long-haired. These are affected by two genes, **H/h** and **G/g**. The presence of **H** always results in wire hair. When long-haired dogs are crossed amongst themselves, they always produce long-haired puppies.

Two groups of dogs heterozygous for both genes are crossed and the results from this cross are shown in Table 7.1.

Table 7.1

phenotype	number of offspring
wire-haired	90
smooth-haired	22
long-haired	8

Fig. 7.1 shows the pedigree for inheritance of coat type in Dachshunds.



key

● wire-haired female

◐ smooth-haired female

○ long-haired female

■ wire-haired male

◑ smooth-haired male

□ long-haired male

Fig. 7.1

- (a) Draw a genetic diagram in the space below showing the cross between **P** and **Q**.

Use the symbols given and show all possible genotypes and phenotypes for the offspring of these parents.

[4]

- (b) In any genetic cross, the observed results are usually different from the expected results.

Suggest **one** reason why such a difference may occur, referring only to events after meiosis.

[1]

Other than variation in coat type, dogs also display variation in their coat colours.

Table 7.2 shows the colour scale and number of dogs showing each of the phenotypes.

Table 7.2

colour						
colour scale	1	2	3	4	5	6
number of dogs	114	216	305	350	288	133

- (c) Distinguish between the two types of variation shown in coat type and coat colour in dogs. [3]

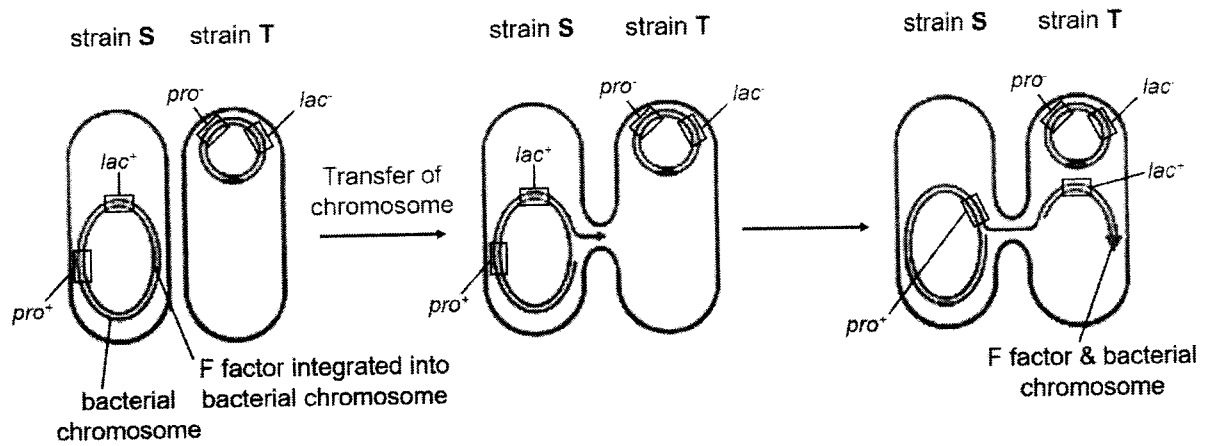
[Total: 8]

- 8 (a) (i) Using the *trp* operon as an example, explain what is meant by negative gene regulation. [1]

- (ii) Explain why a single base-pair insertion in the regulatory gene of the *trp* operon may lead to an over-production of tryptophan. [5]

An investigation was conducted to study gene transfer between two strains of *E. coli*, **S** and **T**. Bacterial cells of strain **S** are able to synthesise proline and metabolise lactose, while bacterial cells of strain **T** are unable to carry out both processes.

Fig. 8.1 shows the process of gene transfer during the investigation.



key

- pro^+ : gene for proline synthesis present
- lac^+ : gene for lactose metabolism present
- pro^- : gene for proline synthesis absent
- lac^- : gene for lactose metabolism absent

Fig. 8.1

(b) (i) With reference to Fig. 8.1, describe the gene transfer process between *E. coli* strains **S** and **T**. [3]

The two strains were mixed together in suspension in two separate experiments, for an incubation period of 10 minutes and 60 minutes respectively. At the end of the incubation, bacterial cells were then plated on an agar medium containing lactose and deficient in proline.

Table 8.1 shows the results of the two experiments.

Table 8.1

<i>E. coli</i> strain	colonies present in nutrient agar	
	after 10 minutes incubation	after 60 minutes incubation
S	94	95
T	42	93

- (ii) Explain why there is a larger number of *E. coli* strain T colonies when the two strains were incubated together for 60 minutes as compared to 10 minutes.

[2]

[Total: 11]

- 9 Fig. 9.1 shows the phylogenetic relationship of four different species of snapping shrimps obtained based on comparison of nucleotide sequence.

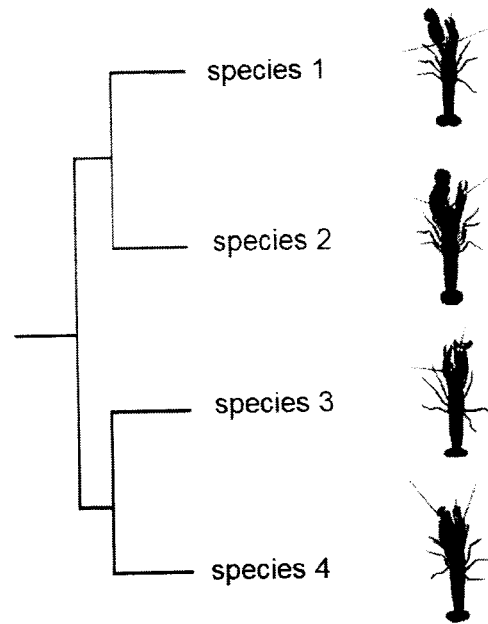


Fig. 9.1

- (a) Describe how molecular data was used to construct the phylogenetic tree. [2]

Twenty million years ago, there was a gap between the continents of North America and South America through which the waters of the Caribbean Sea and Pacific Ocean flowed freely.

The snapping shrimps lived in this area between North America and South America.

About 3 million years ago, volcanic activity and sedimentation formed a narrow strip of land, Isthmus of Panama, joining North America and South America.

Fig. 9.2 shows the current distribution these four species.

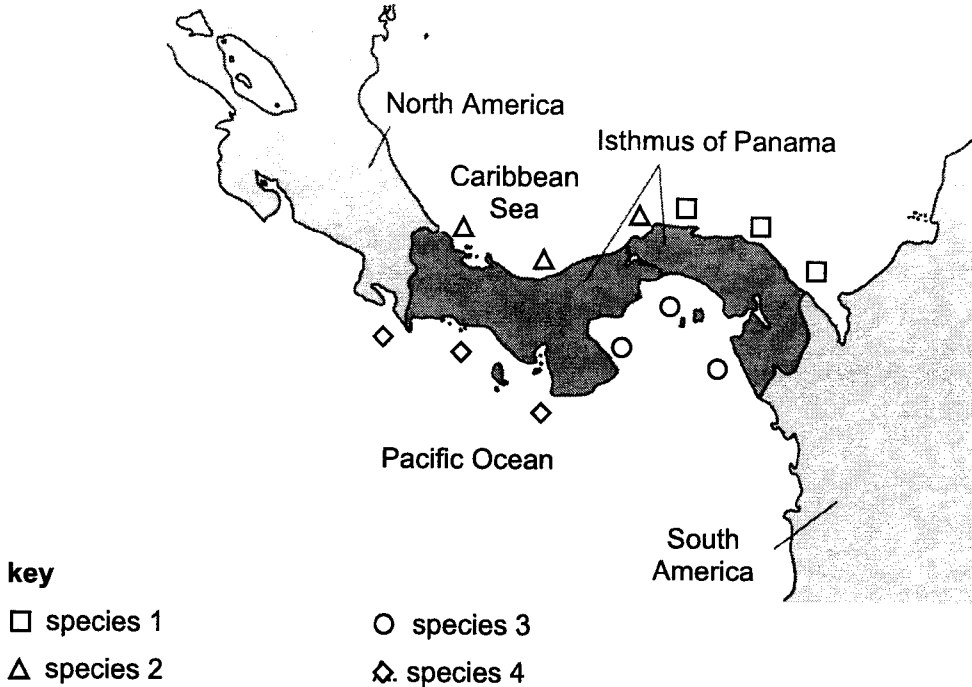


Fig. 9.2

Using information from Fig. 9.1 and Fig. 9.2,

- (b) (i) explain how biogeography and anatomical homology of snapping shrimps support Darwin's theory of evolution. [4]

(ii) suggest why breeding between species 1 and species 2 is possible. [1]

(c) Explain how fossil records can also be used as evidence for evolutionary change of species. [2]

[Total: 9]

- 10 (a) Describe the role of T lymphocytes in the immune response against *Mycobacterium tuberculosis* infection. [3]

- (b) Explain **two** ways in which immunoglobulin differ from penicillin in response to infections by pathogen. [2]

[Total: 5]

11 El Niño phenomenon is characterised by increased temperatures in the oceans.

(a) Explain how El Niño affects the corals. [2]

(b) (i) Describe how **one** human activity increases global sea temperatures. [1]

(ii) Suggest how reduction in the diversity of coral reefs reduces biodiversity. [2]

[Total: 5]



RIVER VALLEY HIGH SCHOOL

JC 2 PRELIMINARY EXAMINATION

CANDIDATE
NAME

CENTRE
NUMBER

S				
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CLASS

21J

INDEX
NUMBER

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BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

13 September 2022

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 ON ANY BARCODES.

Section A

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

Section B

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

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

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

For Examiner's Use	
Section A	
1	
2	
3	
Section B	
Total	

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

Section A

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

- 1 In plants, photosynthesis takes place in chloroplasts, which contain different types of photosynthetic pigments.

(a) Describe the role of different types of photosynthetic pigments in the photoactivation of chlorophyll. [3]

Scientists suggested that chloroplasts may have originated from prokaryotic cells that continue to function after becoming engulfed by primitive eukaryotic cells.

(b) Other than genomic features, describe **two** evidence that support this hypothesis. [2]

Saline soils, with high concentration of sodium ions (Na^+), are a major problem in many parts of the world. Most plant crop species are unable to tolerate high concentrations of sodium ions.

An experiment was conducted to determine the effect of salt (NaCl) concentration on the overall light-dependent reactions and separately on photophosphorylation activities involving photosystem I and photosystem II.

Table 1.1 shows the results of this experiment on a plant crop species.

Table 1.1

concentration of NaCl / mol dm^{-3}	photosynthetic activity / % activity relative to activity at 0 mol dm^{-3} of NaCl		
	photosystem I	photosystem II	overall light-dependent reactions
0.0	100	100	100
0.1	100	58	80
0.2	98	51	59
0.3	101	35	57
0.4	99	32	39
0.5	100	17	35

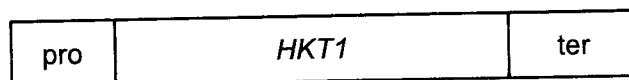
Adapted from El-Sheekh MM, Journal of Plant Physiology, 2004

- (c) With reference to activities involving the photosystems, predict and explain what will happen to the growth of the plant as salt concentration continues to increase above 0.5 mol dm^{-3} .

[3]

Recently one group of Na^+ transporters, HKT1, in root cells was found to be important for salt tolerance in plants. HKT1 actively removes Na^+ from the xylem sap. This prevents transport to and accumulation of Na^+ in the shoot.

Scientists have successfully isolated *HKT1* gene from salt-tolerant plants to create a *HKT1* gene construct as shown in Fig. 1.1.



key

pro – root cell-specific promoter

ter – termination sequence

HKT1 – gene from salt-tolerant plant

Fig. 1.1

HKT1 gene construct was then used to produce salt-tolerant transgenic plant. A transgenic plant refers to a plant whose DNA is modified by inserting a gene from another source.

Fig. 1.2 shows the process of how salt-tolerant transgenic plants is formed.

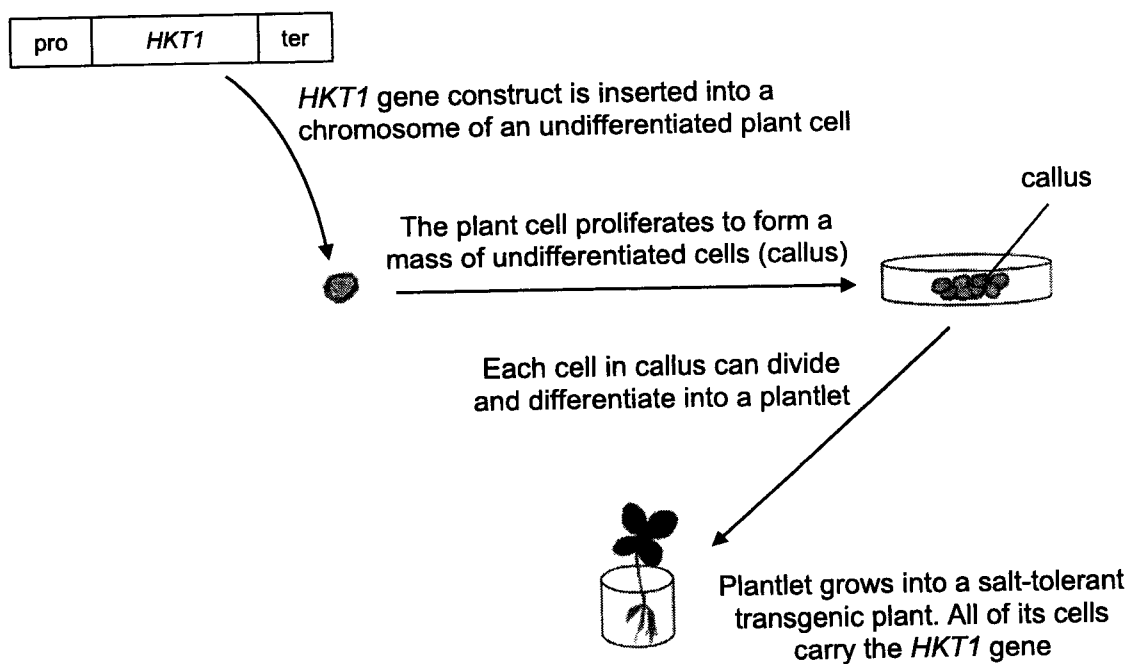


Fig. 1.2

- (d) (i) Explain why the root cell-specific promoter was included in the *HKT1* gene construct. [2]

- (ii) Cells from the callus in Fig. 1.2 are similar to zygotic stem cells in humans.
 Explain why these callus cells can be used to produce the entire plant. [2]

Screening was conducted to verify that the 1.7 kb *HKT1* gene has been inserted into the transgenic plant's chromosome. The screening consisted of the following stages:

- DNA was isolated from the transgenic plant.
- The DNA was cut with restriction enzyme and the fragments produced were separated by gel electrophoresis.
- Detection of *HKT1* gene was then carried out.
- Fig. 1.3 shows the region where the radioactive probe binds to on the plant chromosome. The location of restriction site is indicated by *.

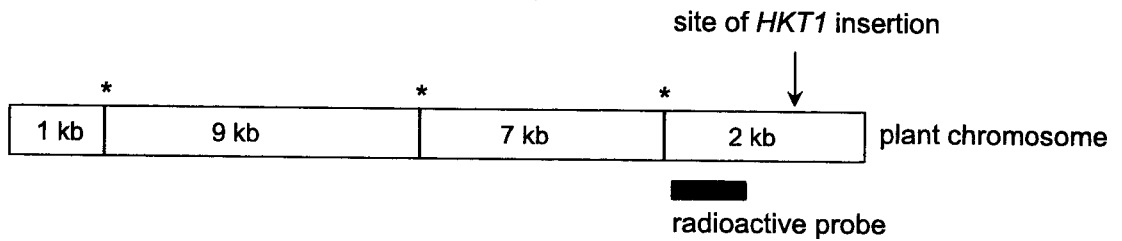


Fig. 1.3

- (e) Outline how detection of *HKT1* gene was carried out. [3]

An experiment was performed on three groups of transgenic plants (T1, T2 and C) to investigate the effect of *HKT1* gene on plant growth in soils of different salinity. The three groups of plants were as follows:

T1	Transgenic plants containing one copy of the <i>HKT1</i> gene
T2	Transgenic plants containing two copies of the <i>HKT1</i> gene
C	Control plants without <i>HKT1</i> gene

The fresh weight of the plants was determined one week after growing in soils containing different concentrations of NaCl and is shown in Fig.1.4.

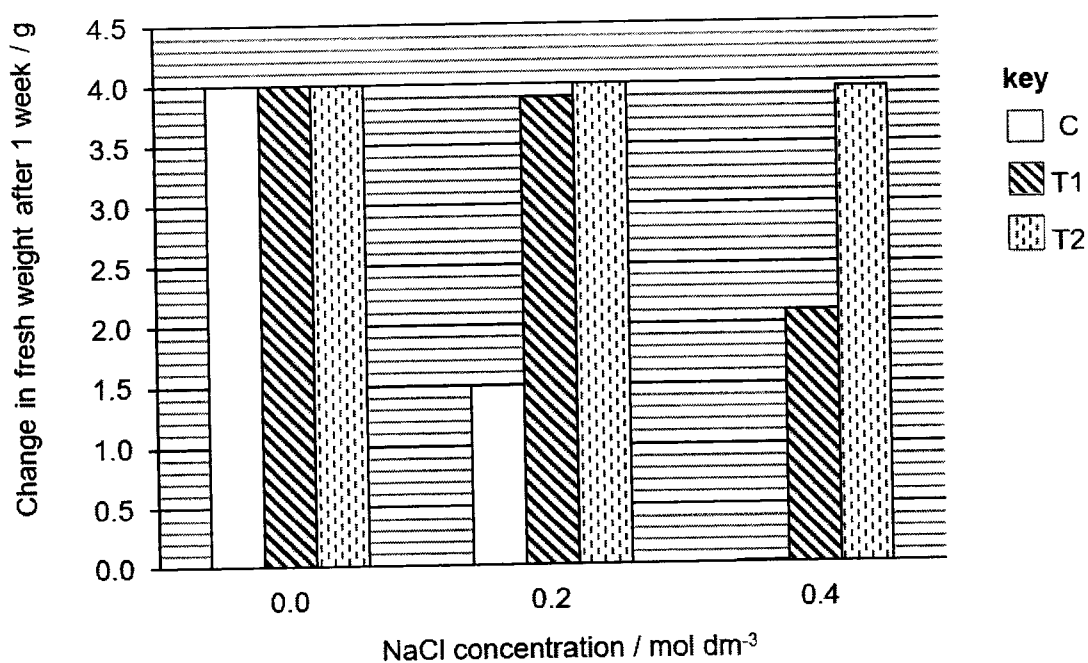


Fig. 1.4

- (f) (i) With reference to Fig. 1.4, describe the effect of *HKT1* gene on the change in fresh weight of plants at each concentration of NaCl. [3]

- (ii) explain the difference in the change in fresh weight of T1 and T2 plants. [1]

Fig. 1.5 is a schematic representation of the regions present in the HKT1 transporter, a membrane bound protein.



key
○ transmembrane (hydrophobic) regions ■ ATP-binding site
— hydrophilic regions

Fig. 1.5

- (g) Explain how the different regions shown in Fig. 1.5 allow HKT1 transporter to perform its function. [3]

Certain plants can adapt to changes in environment by changing the amount of plant hormones, auxin and cytokinin, produced.

Fig. 1.6 shows the effect of drought and mineral nutrient deficiency on auxin and cytokinin biosynthesis in these plants.

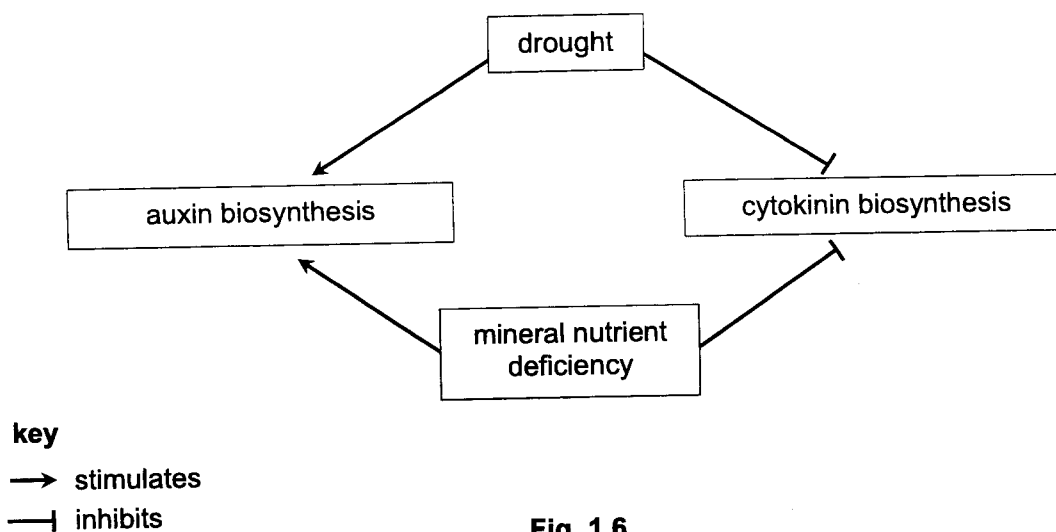


Fig. 1.6

The effects of various ratios of auxin to cytokinin on plant growth are summarised in Table 1.2. The extent of growth is shown on a scale increasing from + to +++.

Table 1.2

ratio of auxin to cytokinin	growth of shoot	growth of root
10:0	no growth	+++
8:2	no growth	++
6:4	no growth	+
5:5	no growth	no growth
4:6	+	no growth
2:8	++	no growth
0:10	+++	no growth

(h) Using Table 1.2 and Fig. 1.6, explain how these plants can survive under conditions of drought and mineral nutrient deficiency.

[3]

[Total: 25]

- 2 An open reading frame (ORF) is the DNA sequence between a start and stop codon. ORFs are commonly used to predict the presence of genes.

Fig. 2.1 shows the same sample sequence and three possible ORFs due to different possible reading frames. Start codons are underlined and bolded, and stop codons are underlined and italicised.

- 1 **ATG** CAA TGG GGA AAT GTT ACC CTT ATT GAG GTA AGA CAG ATT *TAA*
 2 A TGC ATT GGG GAA **ATG** TTA CCC TTA TTG AGG *TAA* GAC AGA TTT AA
 3 AT GCA **ATG** GGG AAA TGT TAC CCT TAT *TGA* GGT AAG ACA GAT TTA A

Fig. 2.1

- (a) Using your knowledge of genomic organisation, explain why the use of ORF is more effective in predicting genes in prokaryotic genome than in eukaryotic genome. [1]

- (b) Outline how the ORF region of sequence 2 may be amplified from a colony of bacteria cells. [4]

Question 2 continues on page 12

Researchers investigated the possible relationships of ORFs and non-coding sequences with the prokaryote genome size.

Fig. 2.2 shows the relationship between **number of ORFs** and genome size.

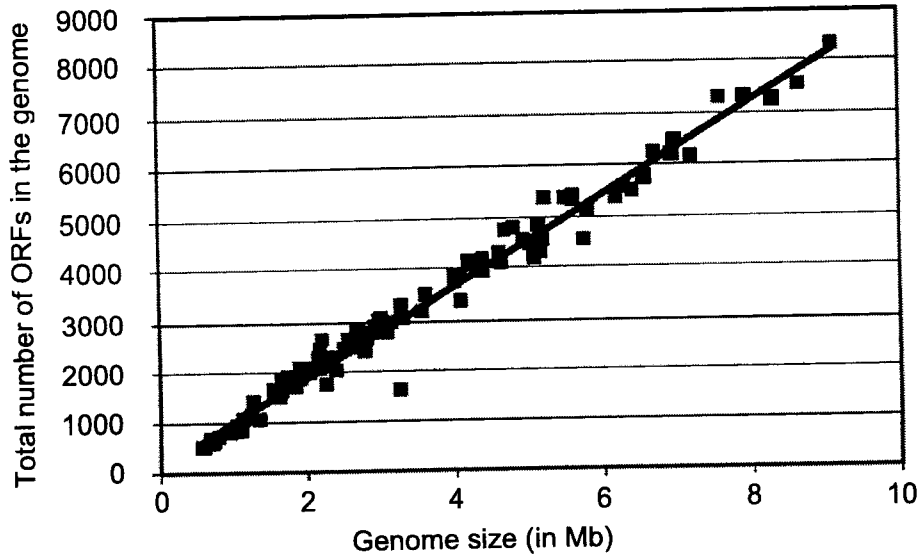


Fig. 2.2

Fig. 2.3 shows the relationship between the **size of non-coding DNA** and genome size.

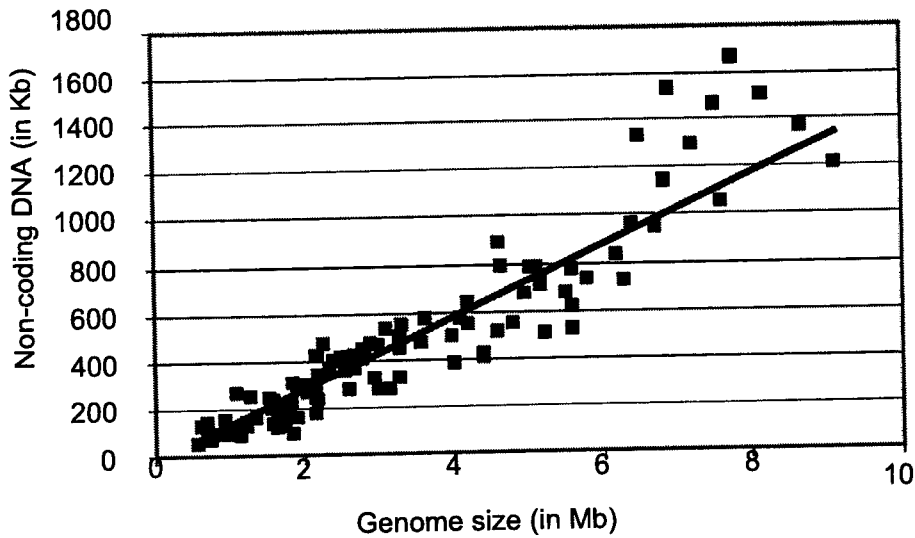


Fig. 2.3

Adapted from Konstantinidis and Tiedje, PNAS, 2004

- (c) (i) Put a tick (✓) in one box to indicate which relationship shows a weaker correlation between the two variables investigated. [1]

Fig. 2.2 Fig. 2.3

- (ii) With reference to your answer in (c)(i), evaluate the extent to which the variable investigated can predict the genome size of the prokaryote. [3]

Obligate endocellular parasites are one of the smallest genome-sized prokaryotic species. Fig. 2.4 shows how symbiotic relationship with their host affected genome size in terms of the number of genes and non-coding sequences.

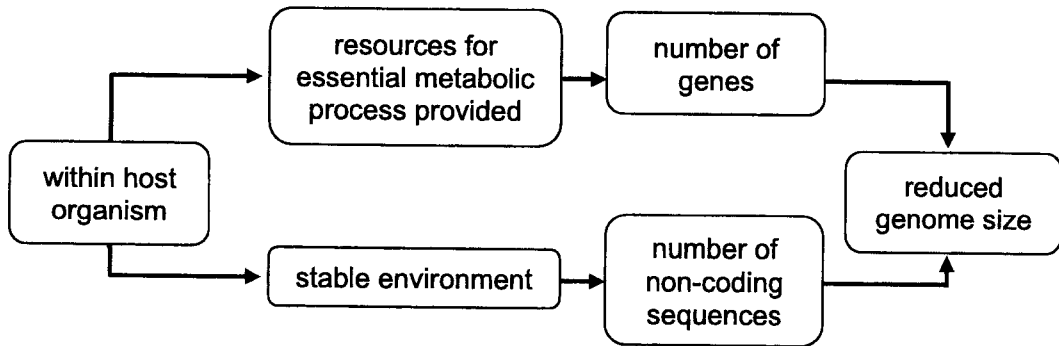


Fig. 2.4

- (d) With reference to Fig. 2.4, explain how symbiotic relationship of obligate endocellular prokaryotes with host organisms results in a reduced genome size. [3]

Compared with RNA viruses, prokaryotes have a lower mutation rate.

(e) (i) Name an RNA virus.

[1]

(ii) Explain why prokaryotes have a lower mutation rate compared to RNA viruses.

[2]

[Total: 15]

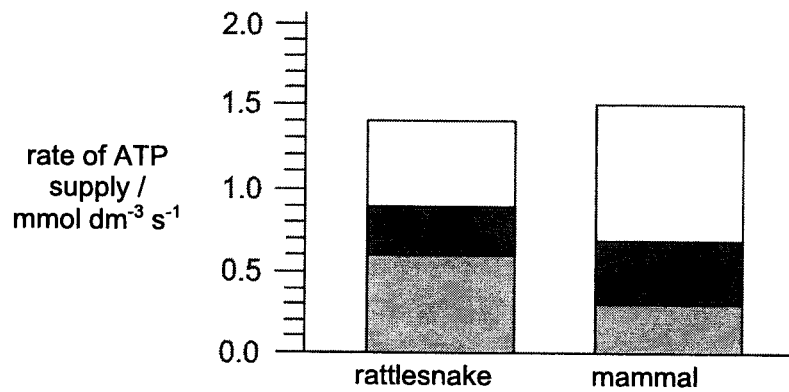
3 Rattlesnakes contain a tailshaker muscle which causes a rattling sound upon contraction.

(a) Explain how oxygen uptake by muscle cells changes when the tailshaker muscle contracts.

[3]

An investigation was conducted to study the tailshaker muscle and a mammalian muscle.

Fig. 3.1 shows the rate and sources of ATP supply in the tailshaker muscle and the mammalian muscle during contraction.



key
 □ – ATP from oxidative phosphorylation
 ■ – ATP from Krebs cycle
 ▨ – ATP from glycolysis only

Fig. 3.1

(b) Using Fig. 3.1, calculate the amount of ATP supplied by anaerobic respiration in the tailshaker muscle in 1 minute.

Show your working clearly.

[2]

Table 3.1 shows the changes in activities in the two muscles during contraction, relative to when the muscles are at rest.

Table 3.1

	change in blood flow / ml min ⁻¹	change in O ₂ uptake by muscle cells / μmol g ⁻¹	change in lactate content in blood / mmol dm ⁻³
tailshaker muscle during rattling	+9.2	+0.148	+2.0
mammalian muscle during contraction	+5.0	+0.180	+5.0

Adapted from Kemper et al., PNAS, 2001

- (c) Using the data from Table 3.1, explain why the tailshaker muscle is able to rely on anaerobic respiration for a longer time during rattling as compared to the mammalian muscle. [2]

Over the years, climate change has resulted in a rise in mean global temperatures. In Southwestern Europe, scientists collected data on the long-term population trends of a snake species and the rise in temperature in the region from 1980 to 2020, as shown in Fig. 3.2.

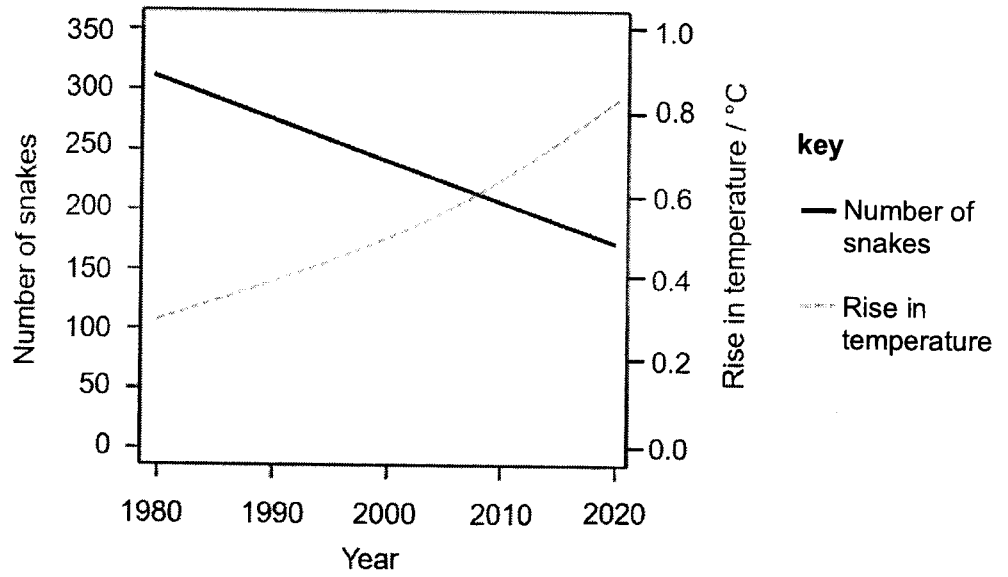


Fig. 3.2

(d) (i) With reference to Fig. 3.2, describe the impact of the rise in temperatures in Southwestern Europe on the number of snakes. [1]

(ii) Suggest reasons for the change in number of snakes from 1980 to 2020. [2]

[Total: 10]

Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

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

- 4 (a) Outline the functions of proteins involved in DNA replication and DNA condensation to form a chromosome in eukaryotes. [15]
- (b) Describe the structure of viruses and explain the significance of viruses in evolution. [10]
- [Total: 25]

- 5 (a) Outline the functions of proteins involved in processes which lower high blood glucose concentration. [15]
- (b) Describe how the structure of antibody is related to its function and explain the significance of cell signaling in immune response. [10]
- [Total: 25]

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