

NAME : \_\_\_\_\_

CLASS : \_\_\_\_\_

 **JURONG PIONEER JUNIOR COLLEGE**  
**JC2 Preliminary Examination 2022**

**BIOLOGY**  
**Higher 2**

**9744/01**  
**23 September 2022**

Paper 1 Multiple Choice

**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, class and index number on the Answer Sheet in the spaces provided unless this has been done for you.

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 document consists of **21** printed pages and **1** blank page.

1 Which cell structures contain rRNA?

- 1 chloroplast
- 2 mitochondrion
- 3 nucleus
- 4 smooth endoplasmic reticulum

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

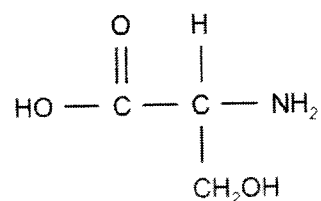
2 It is now possible to detect and follow the movement of single fluorescent molecules in living cells. For example, tracking the movement of fluorescent molecules of RNA polymerase in the bacterium *Escherichia coli* shows that some of these molecules move randomly through the cytoplasm (mobile molecules) but others remain in one place (immobile molecules).

Which statement explains one of these observations in *E. coli* about fluorescent RNA polymerase?

- A The immobile molecules are attached to DNA and are transcribing DNA into mRNA in the cytoplasm.  
B The immobile molecules are trapped inside the nuclear envelope and are transcribing DNA into mRNA.  
C The mobile molecules are attached to 70S ribosomes and are translating mRNA to protein.  
D The mobile molecules are attached to 80S ribosomes that move randomly through the cytoplasm.

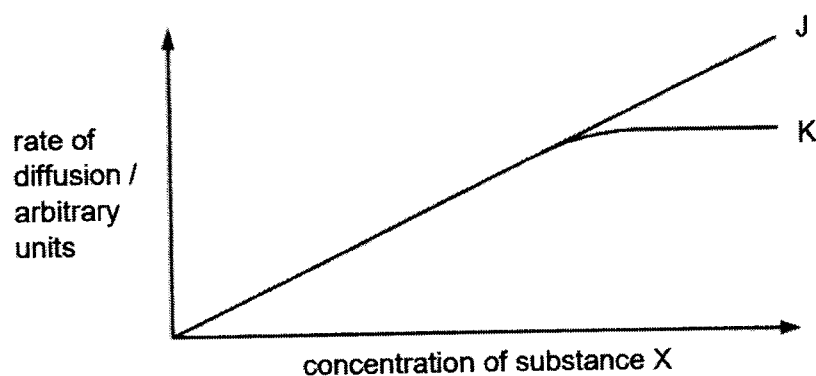
- 3 Which statements about glycosidic bonds are correct?
- 1 They occur by condensation reactions between the OH groups of two molecules.
  - 2 They occur only between glucose molecules.
  - 3 The bonds can only be formed between carbon 1 and carbon 4 or carbon 1 and carbon 6 of adjacent molecules.
  - 4 Hydrolysis of the bonds releases energy.
- A 1, 2 and 3  
B 1 and 4  
C 2 and 4  
D 3 and 4
- 4 Which properties of phospholipids explain why single layers of phospholipids added to water immediately form bilayers?
- 1 The hydrophobic fatty acid chains repel water molecules so that the tails pack together.
  - 2 The non-polar fatty acid chains are attracted to each other by hydrophobic interactions.
  - 3 Hydrogen bonds form between the phosphate groups and water.
- A 1, 2 and 3  
B 1 and 2 only  
C 1 and 3 only  
D 2 and 3 only

- 5 The diagram shows a molecule.



Which test on a polymer of this molecule would give a positive result?

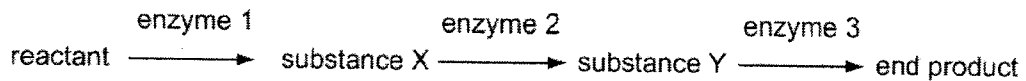
- A adding biuret solution  
 B adding iodine in potassium iodide solution  
 C heating with Benedict's solution  
 D shaking with ethanol then pouring into water
- 6 The graph shows rates of simple diffusion and facilitated diffusion of substance X across the cell surface membrane.



Which row is correct?

	graph K	explanation
<b>A</b>	simple diffusion	simple diffusion allows the concentrations of substance X inside and outside the cell to be equal in a shorter time
<b>B</b>	facilitated diffusion	facilitated diffusion is limited by the number of protein channels in the membrane
<b>C</b>	simple diffusion	simple diffusion is limited by the number of transient gaps in the membrane
<b>D</b>	facilitated diffusion	facilitated diffusion is limited by the amount of ATP available

7 A metabolic pathway is shown here.



What would be the effect of adding a small amount of a non-competitive inhibitor of enzyme 2?

- A Enzyme 2 would be denatured.
- B Substance X would increase in concentration.
- C Substance Y would no longer be formed.
- D The initial reactant would no longer be metabolised.
- 8 Biomolecules that are specific to particular types of cell, including stem cells, are known as cell markers. These markers can be proteins, glycoproteins or glycolipids. Some examples are listed.
- Zygotic stem cells are positive for ZScan4 and OCT4 but negative for CD34 and CD45.
  - Embryonic stem cells at the 32-celled stage are positive for OCT4 and negative for ZScan4, CD34 and CD45.
  - Blood stem cells that give rise to white blood cells are positive for CD34 and negative for ZScan4 and OCT4.
  - In later developmental stages, some blood stem cells become positive for CD45.
  - Differentiated blood cells are negative for ZScan4, OCT4 and CD34 but most types are positive for CD45.

Which statement is consistent with this information?

- A Cells with the CD34 cell marker are multipotent.
- B Cells with the CD45 cell marker are multipotent.
- C Cells with the OCT4 cell marker are totipotent.
- D Cells with the ZScan4 cell marker are pluripotent.

- 9 A piece of a DNA molecule contains 84 base pairs. The table shows the number of adenine and cytosine bases in one or both of the DNA strands in this piece of DNA molecule.

base	strand 1	strand 2
adenine	28	23
cytosine	15	

How many guanine bases are present in this piece of DNA molecule?

- A** 18
- B** 33
- C** 36
- D** 41
- 10 In 2009, the H1N1 influenza outbreak caused nearly 15 000 deaths worldwide. The highly virulent virus was formed by antigenic shift.
- Which statement is most likely to have resulted in antigenic shift?
- A** Chance mutations occurring in a strain of influenza, giving rise to novel haemagglutinin proteins.
- B** Recombination of viral genes within a host cell during infection.
- C** Simultaneous infection of a cell by two or more strains of influenza.
- D** High error rate in influenza RNA-dependent RNA polymerase resulting in new strains upon viral reproduction.

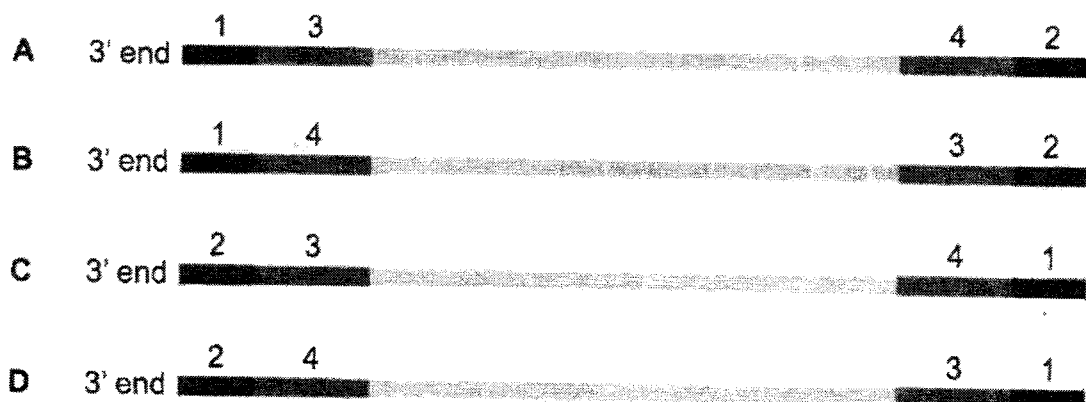
11 Which row correctly describes the transfer of DNA from one bacterium to another?

	binary fission	transduction	conjugation
<b>A</b>	bacterial chromosome and plasmids pass to daughter cells	DNA transferred by bacteriophage from one bacterium to another	single strand of F plasmid transferred from one bacterium to another
<b>B</b>	bacterial chromosome and plasmids pass to daughter cells	bacterial cell takes up foreign DNA from culture medium	double strand of F plasmid transferred from one bacterium to another
<b>C</b>	only plasmids pass to daughter cells	DNA transferred by bacteriophage from one bacterium to another	single strand of F plasmid transferred from one bacterium to another
<b>D</b>	only plasmids pass to daughter cells	bacterial cell takes up foreign DNA from culture medium	double strand of F plasmid transferred from one bacterium to another

12 Processing of mRNA in eukaryotes results in a molecule that has four regions, in addition to the translated exon.

- 1 a poly-A tail
- 2 a cap consisting of modified guanine nucleotides
- 3 an untranslated region immediately before the translation start codon
- 4 an untranslated region after the translation termination sequence

Which diagram shows the correct arrangement of these regions in the processed mRNA molecule?



13 During agarose gel electrophoresis, which factors affect the rate of migration of DNA fragments through the gel?

- 1 density of loading dye
- 2 size of agarose gel
- 3 size of DNA fragments
- 4 voltage used

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

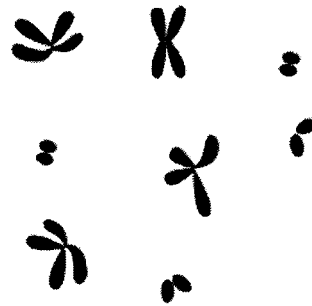
14 How many statements about gene mutations are correct?

- 1 Gene mutations are always inherited and never acquired during an individual's lifetime.
- 2 Gene mutations always give rise to recessive alleles.
- 3 Gene mutations may have no effect on the encoded proteins.
- 4 Gene mutations may result in new phenotypes.

- A 1  
B 2  
C 3  
D 4



- 15 The diagram shows the chromosomes of a typical plant cell at the metaphase stage of mitosis.



Which row describes this cell during metaphase?

	diploid number (2n) for the plant	structures present at metaphase		
		cell wall	centriole	spindle
<b>A</b>	4	✓	x	✓
<b>B</b>	8	x	✓	✓
<b>C</b>	8	✓	x	✓
<b>D</b>	16	✓	✓	x

- 16 The DNA in cells that are dividing is much more sensitive to damage by ionising radiation than the DNA in cells in interphase. There are mechanisms to repair damaged DNA but if these mechanisms cannot repair the DNA sufficiently, then the cell dies.

Which statements explain why ionising radiation is used to treat cancer?

- 1 Exposure to ionising radiation on its own does not increase the risk of cancer.
- 2 Dysregulation of the checkpoints of cell division is common in cancer cells and leads to uncontrolled cell division.
- 3 Proteins needed for DNA repair are often ineffective in cancer cells due to mutation of their genes.

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

**17** Which statements describe the significance of meiosis?

- 1 results in haploid cells that fuse to form a cell with a full complement of chromosomes
- 2 contributes to genetic diversity, which is necessary for natural selection
- 3 ensures that offspring will have the same genes as the fitter parent
- 4 improves the relative fitness of a species

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

**18** Which statement describes Mendel's law of independent assortment?

- A** Allele pairs separate during gamete formation and recombine during fertilisation.  
**B** Allele pairs for different genes separately independently during gamete formation.  
**C** Unlinked genes are assorted with a 9 : 3 : 3 : 1 ratio in a dihybrid cross.  
**D** Allele pairs for the same gene are assorted independently during gamete formation.

19 Retinitis pigmentosa is a rare degenerative disease of the retina that leads eventually to blindness.

Two forms of the disease are as follows:

- Usher syndrome, caused by an autosomal recessive allele, *USH2A*, of a gene on chromosome 1
- a form of the disease affecting rhodopsin, caused by an autosomal dominant allele of the *RHO* gene on chromosome 3.

A man who does not carry *USH2A* has a single copy of the *RHO* mutation. A woman has Usher syndrome.

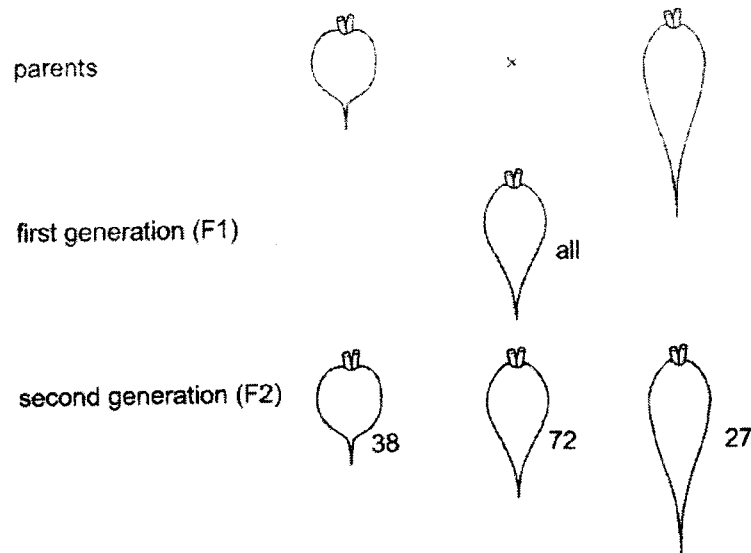
What is the probability of their first child having retinitis pigmentosa?

- A 0.1875
- B 0.2500
- C 0.5000
- D 0.5625

**20** Radishes can have different root shapes.

In 1924, a geneticist tried to work out the genetic basis of this variation. He crossed pure-breeding 'round' and pure-breeding 'conical' radishes to produce an F1 generation. The F1 offspring were then crossed to produce an F2 generation.

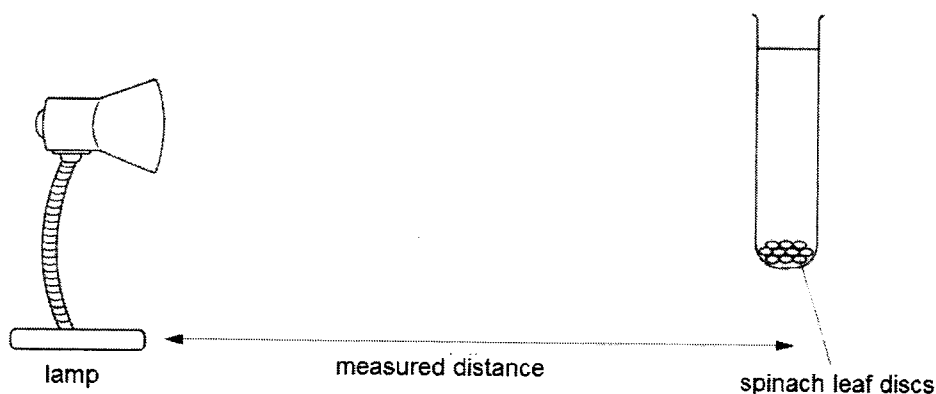
He presented his results as a diagram.



Which conclusion about the variation of root shape could explain his results?

- A It is an example of continuous variation controlled by three or more genes with additive effects.
- B It is an example of continuous variation controlled by one or two genes with additive effects.
- C It is an example of discontinuous variation controlled by one gene with two alleles showing codominance.
- D It is an example of discontinuous variation controlled by one gene with multiple alleles.

- 21 A student carried out an investigation into the effect of light intensity on photosynthesis. Several groups of spinach leaf discs were placed in test tubes of water. The discs all sank to the bottom of the tubes. Each tube was placed at a measured distance from a lamp.



As photosynthesis occurs, the build-up of oxygen gas in the leaf discs causes them to rise from the bottom of the tubes upwards. The results are shown in the table below.

tube number	distance from lamp / mm	time taken for five discs to float / s
1	50	125
2	100	210
3	150	360
4	200	600
5	250	none floated in the time available

Which of these statements are true?

- 1 The compensation point occurs between 200 and 250 mm.
  - 2 A variable which is controlled is the distance of the tube from the light source.
  - 3 The time taken for the discs to rise is directly proportional to the distance from the lamp.
- A 1, 2 and 3  
 B 1 and 3 only  
 C 1 only  
 D 2 and 3 only

**22** Which statements apply both to respiration in aerobic conditions and to respiration in anaerobic conditions in the muscle cells of a mammal?

- 1 They both lead to the release of  $\text{CO}_2$ .
- 2 They both result in the production of ATP.
- 3 They both begin in the mitochondrial matrix.
- 4 They both involve the reduction of NAD.

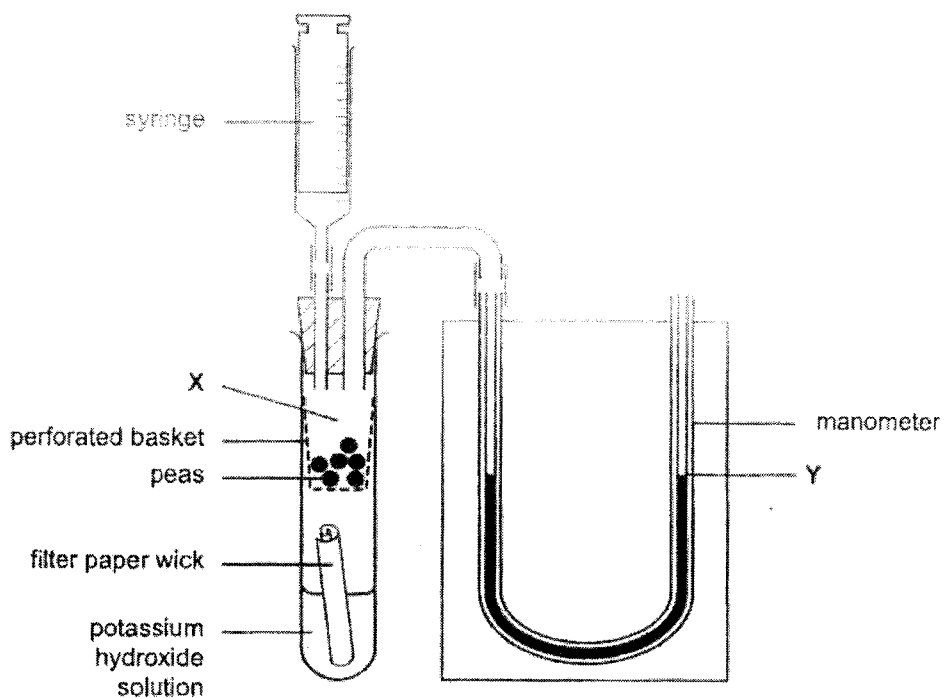
**A** 1 and 2

**B** 1 and 3

**C** 2 and 4

**D** 3 and 4

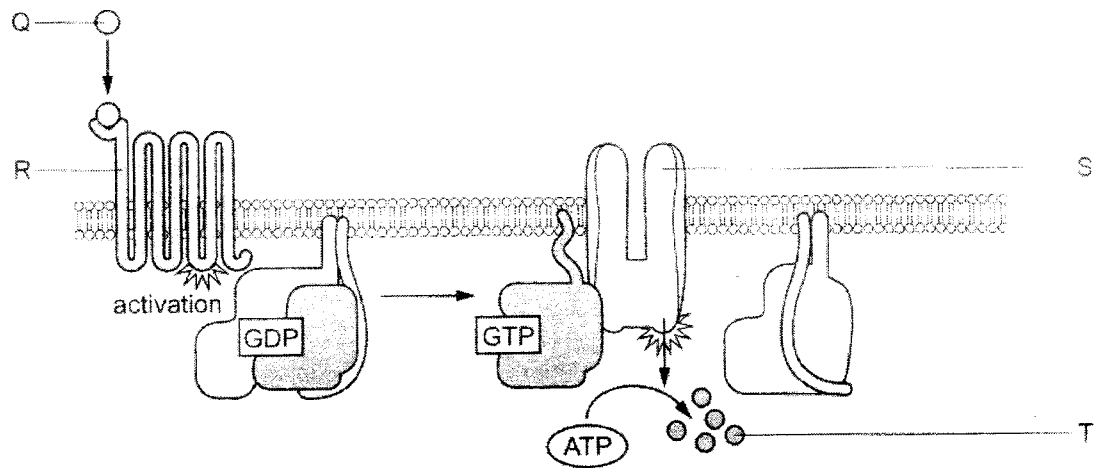
- 23 The diagram shows a respirometer that is used to measure gaseous exchange in peas. The set-up is maintained at a constant temperature.



What happens to the gas pressure at X and to the fluid level at Y?

	gas pressure at X	fluid level at Y
A	falls	falls
B	falls	rises
C	rises	rises
D	rises	falls

24 The diagram shows part of a cell signalling pathway in a liver cell.



Which row correctly identifies the molecules labelled in the diagram?

	Q	R	S	T
<b>A</b>	glucagon	G-protein linked receptor	adenyl cyclase	cyclic AMP
<b>B</b>	glucagon	G-protein linked receptor	G-protein	ADP
<b>C</b>	insulin	tyrosine kinase receptor	phosphatase	cyclic AMP
<b>D</b>	insulin	tyrosine kinase receptor	adenyl cyclase	ADP



- 25** Zebras with some horizontal stripes are bitten less frequently by tsetse flies than those with only vertical stripes. These flies carry diseases that infect zebras.

Which combination of statements could explain an increase in the proportion of individuals with horizontal stripes in a population of zebras over several generations?

- 1 Tsetse flies are a selection pressure.
- 2 Compared with other zebras, zebras with some horizontal stripes are likely to get fewer diseases from tsetse flies.
- 3 On average, zebras with some horizontal stripes live longer as they are more resistant to disease.
- 4 Zebras with some horizontal stripes pass the allele responsible for these stripes to their offspring.

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

- 26** Which does **not** contribute to a shift in allele frequencies in populations?

- A** acquisition of new traits in an organism's lifetime  
**B** change in selection pressure from the environment  
**C** differential reproductive success  
**D** stabilising selection

27 Sarawak is an area of South-East Asia that is largely covered by tropical rainforest. Logging has been allowed in large parts of the forest. A study was carried out to estimate the population size of different species of mammals living in the rainforest:

- before logging
- immediately after logging
- two years after logging
- four years after logging

The table shows the results of the study for six species of mammals. Where numbers were too small to measure the population density, the species were recorded as "present".

mammal	mean number of animals km <sup>-2</sup>			
	before logging	immediately after logging	two years after logging	four years after logging
marbled cat	present	0	0	0
small-clawed otter	present	0	0	0
giant squirrel	5	1	4	1
treeshrew	10	5	10	38
small squirrel	16	24	104	19
barking deer	3	1	10	present

Which statements are possible reasons why marbled cats and small-clawed otters are no longer found in this area?

- 1 Population numbers of marbled cats and small-clawed otters were small prior to logging.
- 2 Marbled cats and small-clawed otters are carnivorous and the numbers of prey fell.
- 3 Marbled cats and small-clawed otters were more likely to migrate to other areas.

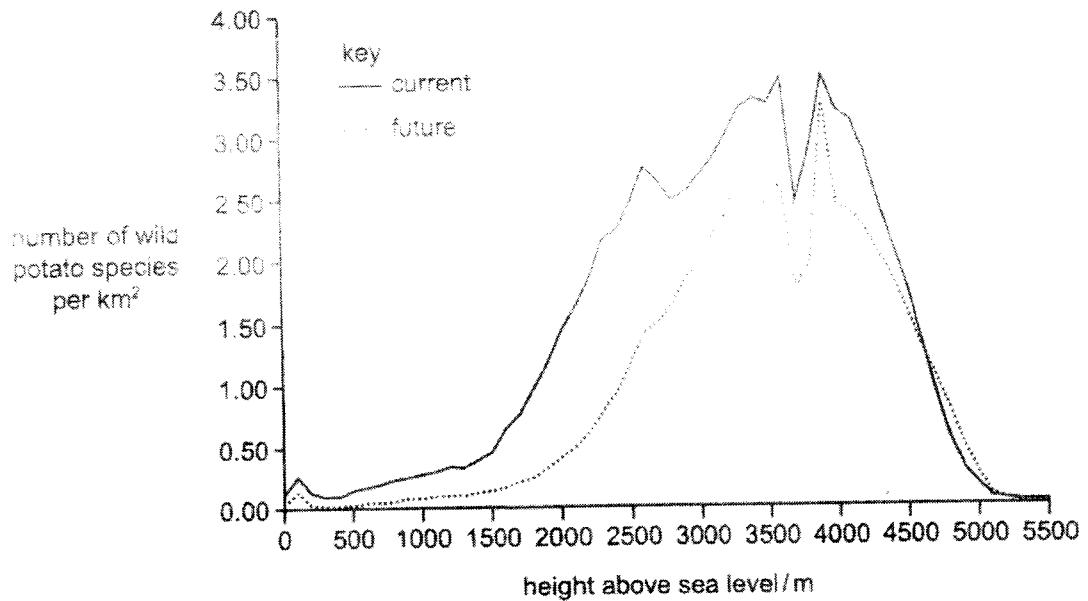
- A** 1, 2 and 3  
**B** 1 and 3 only  
**C** 2 and 3 only  
**D** 2 only

- 28** The table shows the relative proportions of plasma and memory B cells circulating in the blood of a person during a secondary immune response. The relative proportions are given at four different times, A, B, C and D.

At which time will the total number of circulating B lymphocytes be greatest?

	relative proportions	
	plasma cells	memory B cells
<b>A</b>	0	5
<b>B</b>	1	4
<b>C</b>	3	2
<b>D</b>	4	1

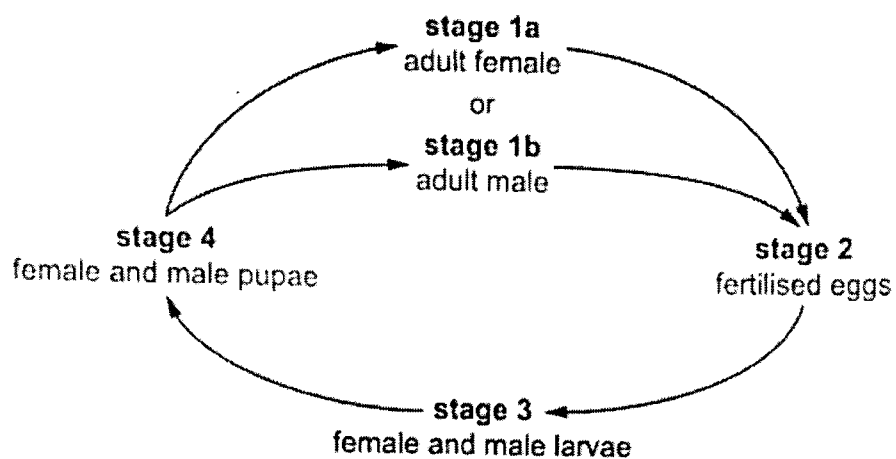
- 29 The ecological niche of over one hundred wild potato species have been analysed in their natural habitats. Projections have been made about the future of these species if global warming occurs. One type of projection is shown on the graph.



Which conclusions about the future effects of climate change can be drawn directly from this graph?

- 1 Some wild potato species may become extinct.
  - 2 The distribution of wild potato species may shift north.
  - 3 The distribution of some wild potato species may shift to a greater height above sea level.
  - 4 There will be less diversity of wild potato species at 5000 m above sea level.
- A 1 and 3  
B 1 only  
C 2 and 4  
D 2 only

30 The diagram shows the life-cycle of the *Aedes aegypti* mosquito.



At which of the stages of the life-cycle can the mosquito become infected with the dengue disease virus?

- A 1a, 1b, 3 and 4
- B 1a and 1b only
- C 1a only
- D 1b, 3 and 4 only

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NAME : \_\_\_\_\_

CLASS : \_\_\_\_\_



**JURONG PIONEER JUNIOR COLLEGE**  
**JC2 Preliminary Examination 2022**

**BIOLOGY**  
**Higher 2**

**9744/02**  
**13 September 2022**

Paper 2 Structured Questions

**2 hours**

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

**READ THESE INSTRUCTIONS FIRST**

Write your class 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.

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

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

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

For Examiner's Use	
1	
2	
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7	
8	
9	
10	
11	
<b>Total</b>	

This document consists of **31** printed pages and **1** blank page.

Answer all questions.

- 1 Fig. 1.1 is an electron micrograph of a cell in the pancreas with structures labelled X and Y.

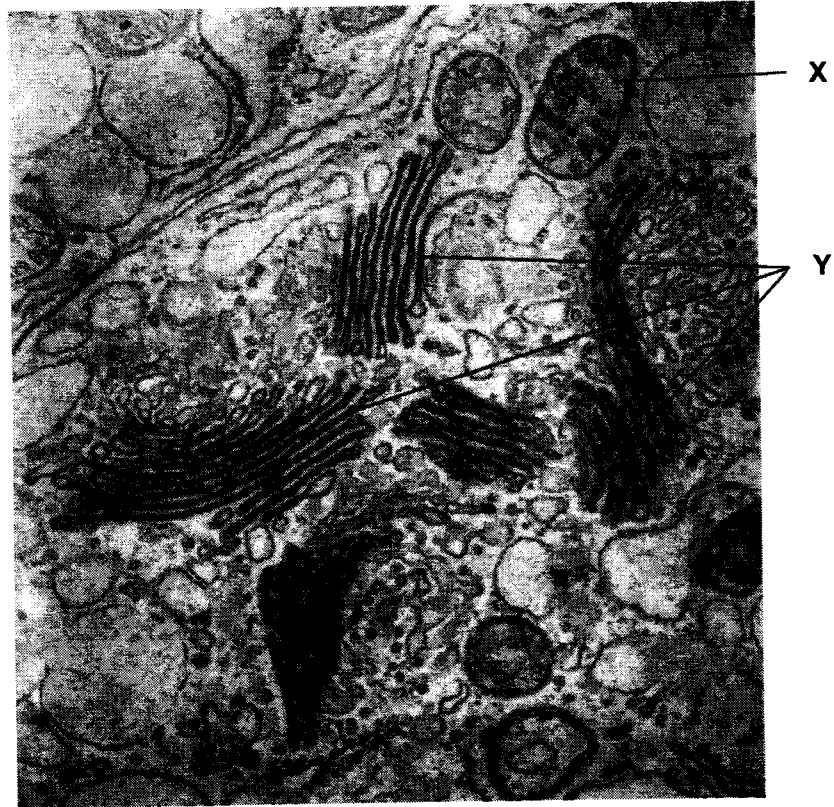


Fig. 1.1

- (a) Identify structures X and Y. In each case, outline one visible feature that allows the structure to perform its functions.

structure X .....

visible feature related to its functions .....

.....

.....

structure Y .....

visible feature related to its functions .....

.....

.....

[4]



Protein production involves a complex sequence of events and number of cell structures. Cells in the pancreas secrete enzymes, such as amylase, into a duct.

- (b) The first column in Table 1.1 shows some of the events that occur in the production of amylase in cells in the pancreas and its eventual release from the cell.

**Table 1.1**

event	sequence of events (numbers)	cell location (letters)
exocytosis		<b>F</b>
protein modification		
secretory vesicle formation		
transcription		
translation		

- (i) In Table 1.1, write the sequence in which the events occur, using 1 as the first process in the sequence. [1]
- (ii) From the list **A** to **F**, choose **one** cell location for each event and write the letter in Table 1.1. Each letter may be used once, more than once, or not at all. The first example, **F**, has been completed for you.

- A** Golgi apparatus  
**B** lysosome  
**C** nucleus  
**D** rough endoplasmic reticulum  
**E** smooth endoplasmic reticulum  
**F** cell surface membrane

[1]

(c) Explain how amylase that are secreted by cells in the pancreas are packaged into vesicles.

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..... [4]

[Total: 10]

2 Fig. 2.1 shows a section of the cell membrane of a red blood cell.

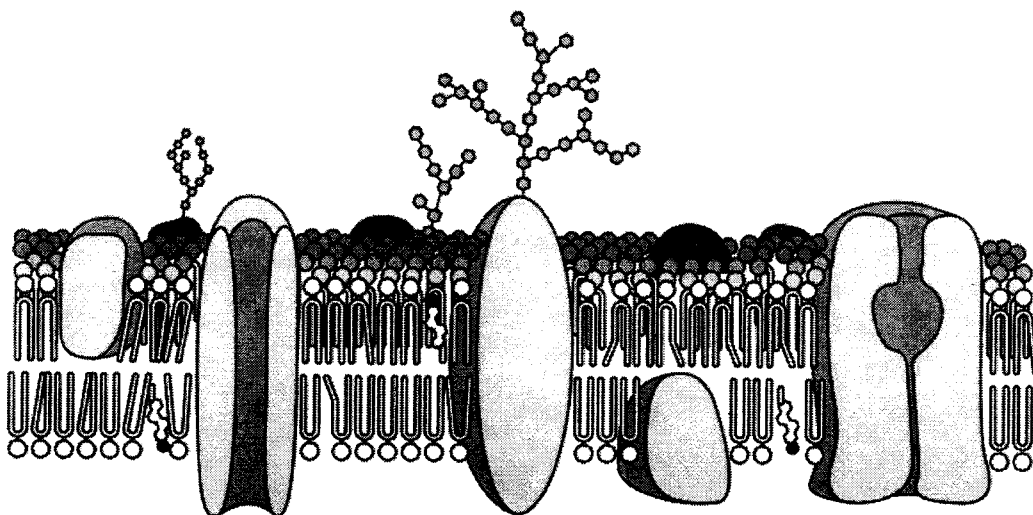


Fig. 2.1

- (a) The arrangement of the various constituent biomolecules supports the fluid mosaic model of the cell membrane.

Explain why the cell membrane is referred to as fluid mosaic.

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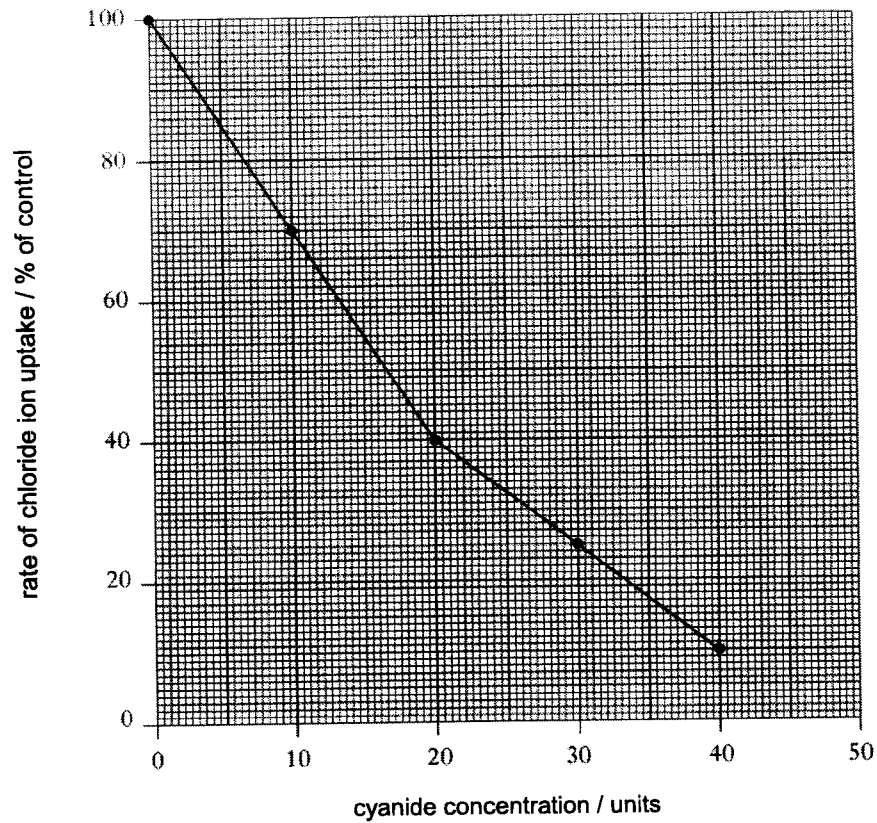
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.....

..... [3]

Cyanide is a poison that inhibits cytochrome c oxidase involved in aerobic respiration.

Fig. 2.2 shows how cyanide concentration affects the uptake of chloride ions by red blood cells. The rates of chloride ion uptake are given as percentages of those obtained in a control experiment with no cyanide.



**Fig. 2.2**

- (b) It is known that the uptake of chloride ions requires the presence of transmembrane proteins.

Explain why chloride ions cannot freely pass through the phospholipid bilayer of membranes.

.....

.....

.....

..... [2]

(c) With reference to Fig. 2.2,

(i) describe how cyanide concentration affects the rate of chloride ion uptake

.....  
.....  
.....  
..... [2]

(ii) identify how chloride ions are moved across the membrane of the red blood cells

..... [1]

(iii) account for your answer in (c)(ii).

.....  
.....  
.....  
..... [2]

[Total: 10]

- 3 The DNA double helix can be successfully compacted into a nucleus with a diameter that is only a millionth of the length of DNA.

(a) Explain how DNA can be successfully compacted into a nucleus.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
..... [4]

Semi-conservative DNA replication occurs in the nucleus. This begins at the origins of replication, where the enzyme helicase causes the DNA molecule to unwind and unzip, causing the two parental strands to separate.

(b) Outline the role of **three other** enzymes in DNA replication.

.....  
.....  
.....  
.....  
.....  
..... [3]

Besides DNA replication, transcription also occurs in the nucleus.

- (c) Complete Table 3.1 using a tick (✓) to indicate which features apply to each of the processes. Use a cross (✗) for features that do **not** apply. The first row has been completed for you.

**Table 3.1**

feature	DNA replication	transcription
a single-stranded molecule is produced	✗	✓
hydrogen bonds are broken		
both strands of DNA act as templates		
covalent bonds are formed		

[3]

[Total: 10]

- 4 Fig. 4.1 shows some of the main structural features of an influenza virus. PA, PB1 and PB2 are RNA polymerases.

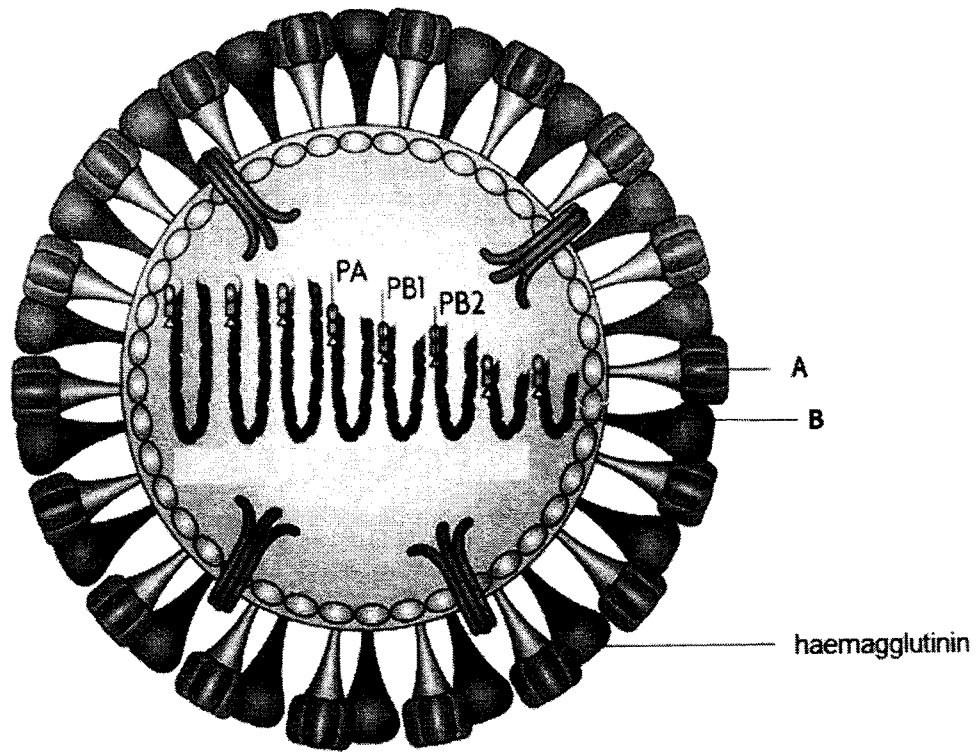


Fig. 4.1

- (a) Identify the labelled structures and state their functions.

structure A .....

function .....

.....

structure B .....

function .....

.....

[4]



(b) Explain why the influenza virus requires its own RNA polymerases PA, PB1 and PB2.

.....  
..... [1]

(c) Discuss how viruses challenge the cell theory.

.....  
.....  
.....  
..... [2]

(d) Oseltamivir is an antiviral inhibitor used for the treatment of infection with influenza viruses.

Fig. 4.2 shows the number of copies of influenza genome per cm<sup>3</sup> plasma in two groups of infected patients – one group treated with oseltamivir and another control group without oseltamivir.

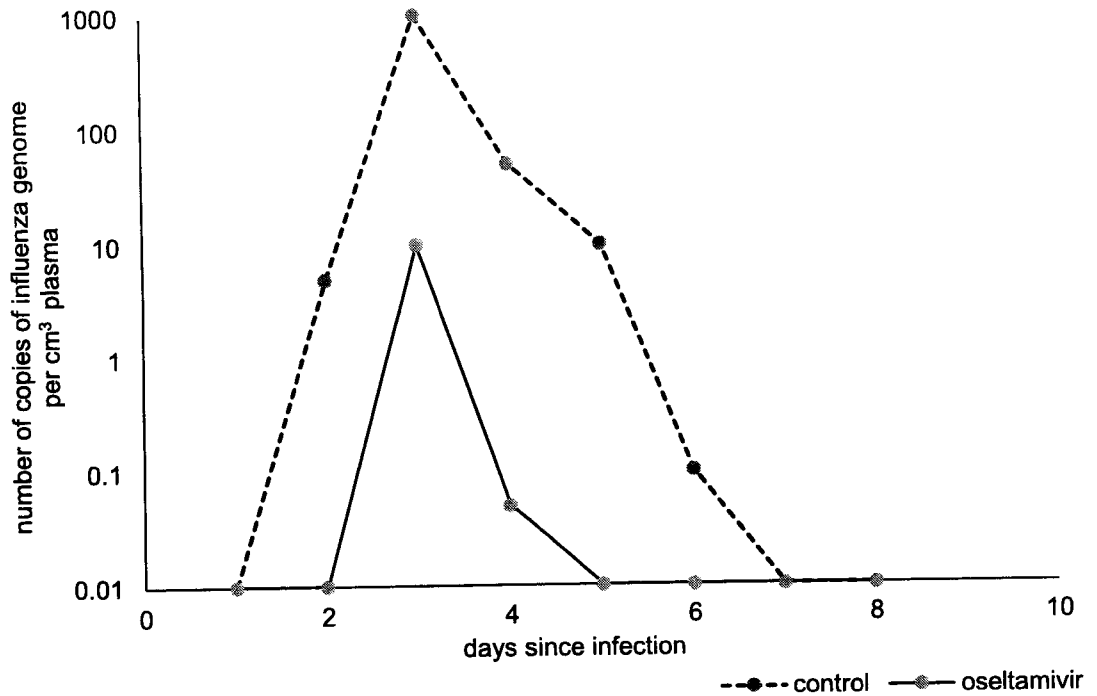


Fig. 4.2

Describe the effect of oseltamivir on the number of copies of influenza genome in patients, as shown in Fig. 4.2.

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.....

.....

.....

.....

.....

..... [3]

[Total: 10]

- 5 (a) Describe **two** ways in which the *lac* operon is **similar** to the *trp* operon.

.....  
.....  
.....  
..... [2]

- (b) Describe **four** ways in which the *lac* operon is **different** from the *trp* operon.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
..... [4]

- (c) Suggest the advantages to bacteria of arranging some genes in operons.

.....  
.....  
.....  
..... [2]

[Total: 8]

6 The polymerase chain reaction (PCR) is commonly used in medical and biological research to produce large quantities of DNA from a very small original sample.

(a) The main steps of one PCR method are shown in Fig. 6.1.

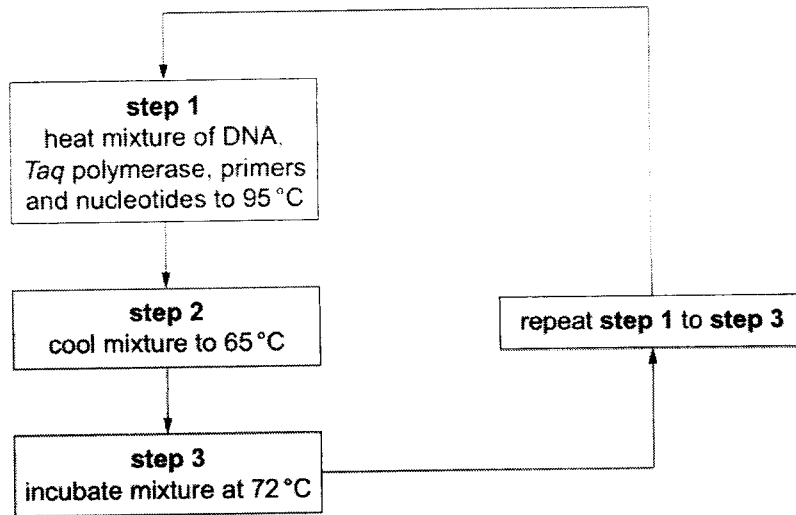


Fig. 6.1

(i) Explain why it is necessary to heat the mixture to 95 °C (step 1).

.....  
.....  
.....  
..... [2]

(ii) Explain why the enzyme *Taq* polymerase, rather than any other type of DNA polymerase, is used in PCR.

.....  
.....  
.....  
..... [2]

Another molecular technique used in medical and biological research is Southern blotting followed by nucleic acid hybridisation.

To visualise the results, autoradiography is carried out at the end. The images formed on the photographic X-ray film would correspond to the bands that contain the DNA sequence of interest.

**(b)** Outline the process of Southern blotting and nucleic acid hybridisation.

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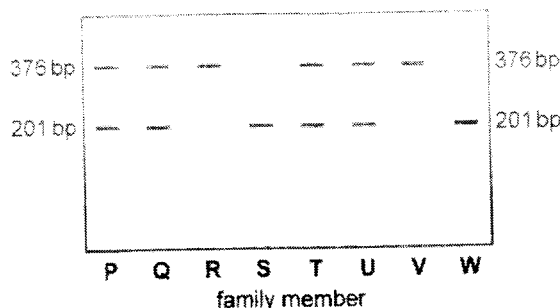
.....

..... [4]

Sickle cell anaemia is a genetic disease caused by a recessive mutant allele of the  $\beta$ -globin gene.

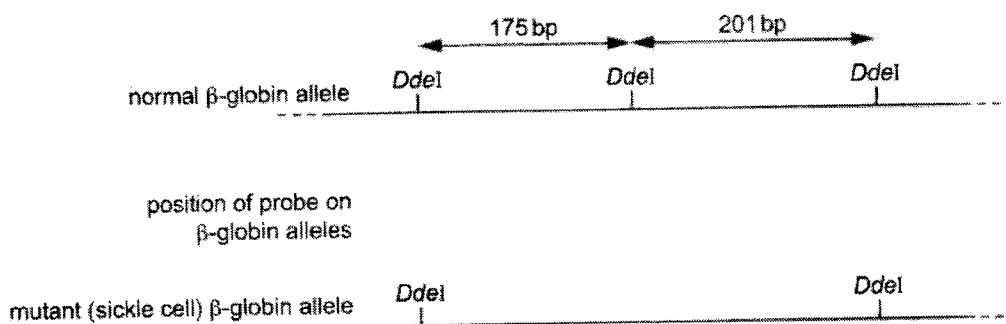
Scientists investigated the inheritance of the disease in one family. DNA was collected from each family member. PCR, restriction enzyme digestion using the enzyme *DdeI*, gel electrophoresis, Southern blotting and nucleic acid hybridisation were carried out.

Fig. 6.2 shows the autoradiography results from the final stage of this investigation.



**Fig. 6.2**

Fig. 6.3 shows where the restriction enzyme *DdeI* cuts within the two different  $\beta$ -globin alleles and the sizes of the fragments produced.



**Fig. 6.3**

(c) Using the information from Fig. 6.2,

- (i) indicate in Fig. 6.3 the position of the probe that was used [1]
- (ii) state which family members suffer from sickle cell anaemia.

..... [1]

[Total: 10]

**Question 7 starts on page 18**

7 Fig. 7.1 shows an animal cell in a stage of the mitotic cell cycle.

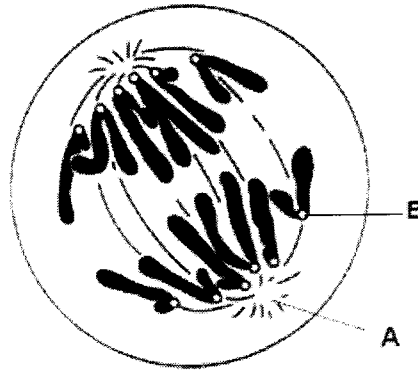


Fig. 7.1

(a) A pair of rod-like structures can be found in region A.

State **one other** feature of these structures and outline their role during mitosis in animal cells.

feature .....

.....

role .....

.....

[2]

(b) Identify structure B and outline its structure and function.

B .....

structure .....

.....

function .....

.....

[3]



- (c) With reference to Fig. 7.1, state **two** observable differences between the behaviour of chromosomes in mitosis and meiosis.

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..... [2]

- (d) The stages and checkpoints of the mitotic cell cycle are closely regulated. Explain the need to regulate the mitotic cell cycle tightly.

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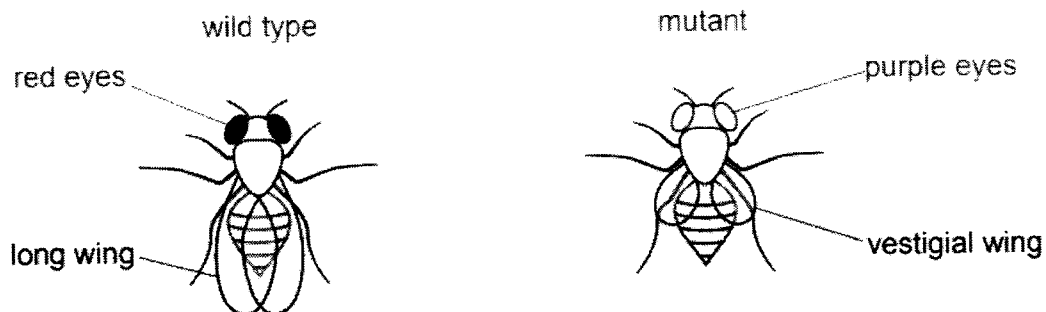
..... [3]

[Total: 10]

- 8 The fruit fly, *Drosophila melanogaster*, feeds on sugars found in damaged fruits.

A fruit fly with normal features is described as wild type. It has red eyes and its wings are longer than its abdomen. There are mutant variations such as purple eyes or short (vestigial) wings.

Fig. 8.1 shows a wild type fruit fly and a mutant fruit fly with purple eyes and vestigial wings.



**Fig. 8.1**





- The genes coding for eye colour and wing length are located on the same chromosome.
- Allele **R** for red eyes is dominant to allele **r** for purple eyes.
- Allele **N** for long wings is dominant to allele **n** for vestigial wings.

- (a) A wild type fruit fly, heterozygous for both genes, was crossed with a fruit fly that was homozygous recessive for both genes.

Table 8.1 is a summary of the cross.

Complete Table 8.1.

Table 8.1

	wild type parent		double homozygous recessive parent	
parental phenotype	..... X .....			
parental genotype	..... X .....			
offspring				
offspring genotype	.....	.....	.....	.....
offspring phenotype	..... .....	..... .....	..... .....	..... .....
number of offspring	1339	1195	151	154

[4]

- (b) A statistical test showed that the results of the cross were significantly different from those expected.

State the name of the statistical test used and explain why it would be useful to carry out the test on these results. No calculations are required to answer this question.

statistical test .....

explanation .....

..... [2]

- (c) Describe and explain the difference between the results of the cross in Table 8.1 and those expected.

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..... [4]

[Total: 10]

- 9 The red poppy, *Papaver rhoeas*, and several species of daisy often co-exist as weeds of wheat fields.

Fig. 9.1 shows changes in the percentage frequency of red poppies and daisies in an area of wheat fields over a six year period from 1998 to 2003. From 1985, the herbicide metsulfuron-methyl was used to control weeds in this area of wheat fields. This practice continued throughout the six year period.

1998 showed the first occurrence of a red poppy known as biotype X. This red poppy had a specific mutation not present in normal red poppies.

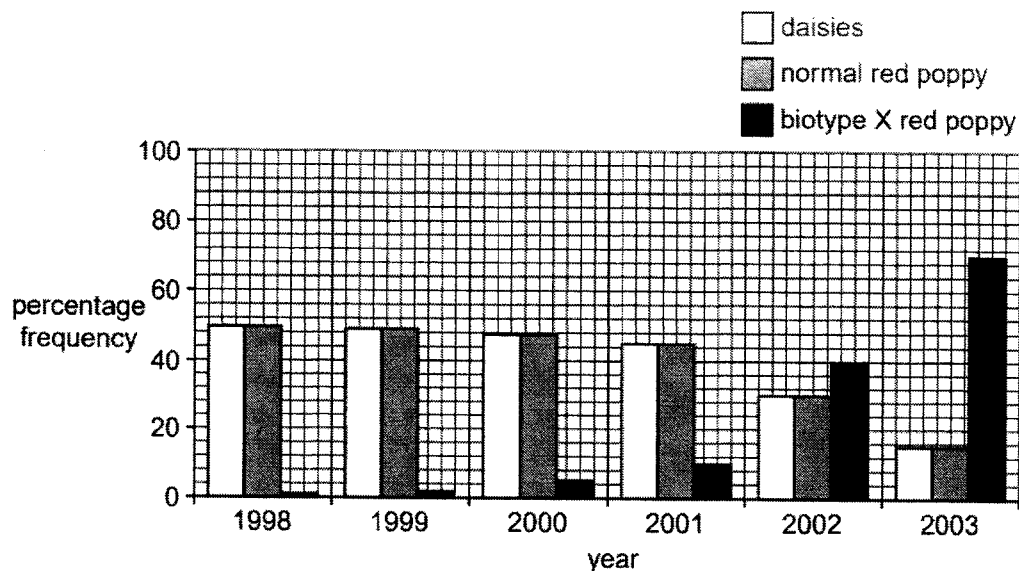


Fig. 9.1

- (a) Describe how the percentage frequencies of red poppies and daisies changed over the six year period.

.....

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..... [3]

- (b) Suggest a reason for the distinct difference in percentage frequencies of normal red poppies and biotype X red poppy in the year 2003.

.....  
..... [1]

Although biotype X red poppy and normal red poppies continue to grow within the same geographical location, after numerous generations, biotype X red poppy may eventually become a different species from the normal red poppies.

- (c) Suggest why biotype X red poppy may eventually become a different species from the normal red poppies.

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..... [2]

Daisies belong to the *Compositae* family, which is the largest family of flowering plants comprising more than 25 000 species. Many important evolutionary questions about the diversity in this family remain unanswered due to the lack of evidence to support major nodes of the phylogeny.

- (d) Explain the advantages of using molecular methods to determine phylogenetic relationships within the *Compositae* family.

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..... [3]

Fossil evidence indicates that flowering plants first appeared about 125 million years ago and they have since been rapidly diversifying. The comparison of chloroplast genomes could provide insight into the evolution of flowering plants.

- (e) Explain how evidence based on homologies identified in chloroplast genomes support Darwin's theory of evolution.

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..... [2]

Although plant fossils are usually rare compared to fossils of bones, teeth and shells, there are many great fossil sites in the world that have excellent preservation of plant materials.

- (f) Suggest why plant fossils are usually rare.

.....  
..... [1]

[Total: 12]

10 Measles is a common viral infection. A vaccine has been available for measles since the 1960s. There are vaccination programmes for many diseases including measles. Babies are born with a passive immunity to measles so the vaccine is not given in the first few months after birth.

(a) Explain how active immunity differs from passive immunity.

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.....

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..... [3]



The World Health Organisation (WHO) publishes data on the vaccination programmes for infectious diseases. The WHO recommends vaccination rates of over 90% of children.

Each health authority in a country reports its success in vaccinating children in their district. The WHO uses these figures to estimate the percentage of districts in each country that vaccinate 90% of children against measles.

The WHO also collects statistics on death rates of children under the age of 5 from all causes, including infectious diseases.

Fig. 10.1 shows these statistics for 24 countries for the year 2007.

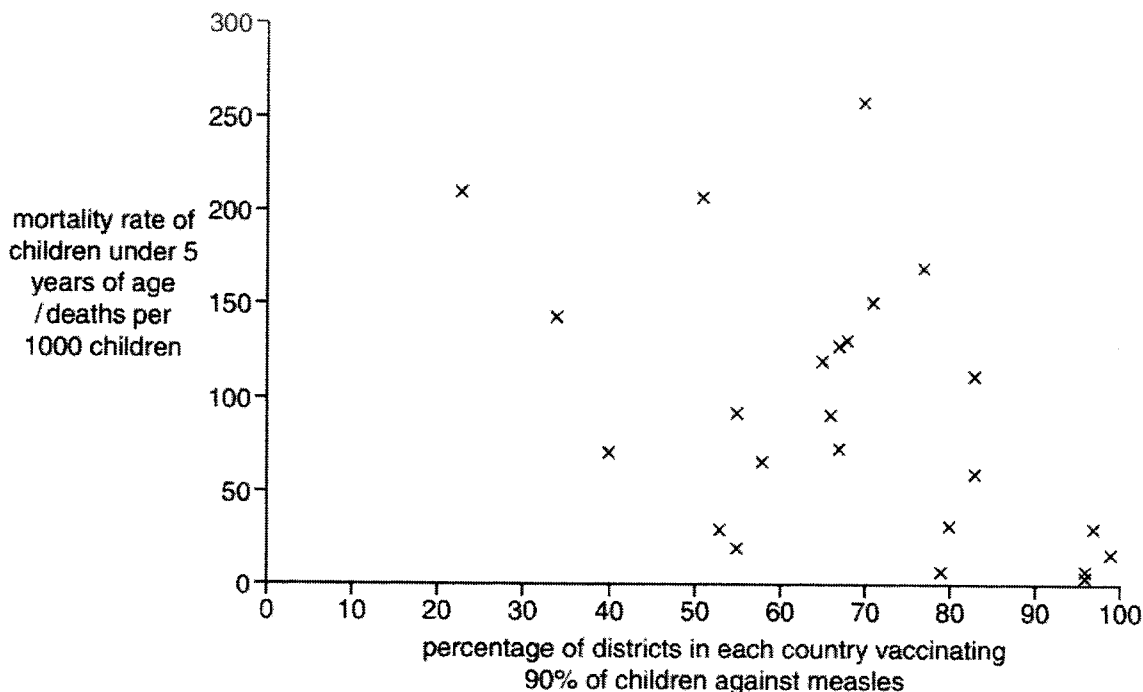


Fig. 10.1

(b) Use the information in Fig. 10.1 to explain why the WHO recommends immunisation of 90% of children.

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..... [2]

[Total: 5]

**Question 11 starts on page 29**

11 The concept of climate change and global warming has been of concern to scientists for many years.

- (a) One way to collect data about atmospheric concentrations of greenhouse gases in the past is to study samples of ice from ice sheets in Antarctica. Ice samples from deep in the ice sheets were formed hundreds of thousands of years ago, while those near the surface were formed recently.

As ice forms, small bubbles of air are trapped in the ice. These air bubbles can be analysed to determine the concentration of carbon dioxide present. It is also possible to use chemical techniques to determine when the air bubbles were trapped.

Scientists studying climate change measured carbon dioxide concentrations in air bubbles from ice samples of known age, collected from near the surface.

Fig. 11.1 shows the concentration of carbon dioxide measured in air bubbles that were trapped in ice from 1959 to 1990. Direct measurements of atmospheric carbon dioxide from 1948 to 1978 are also shown.

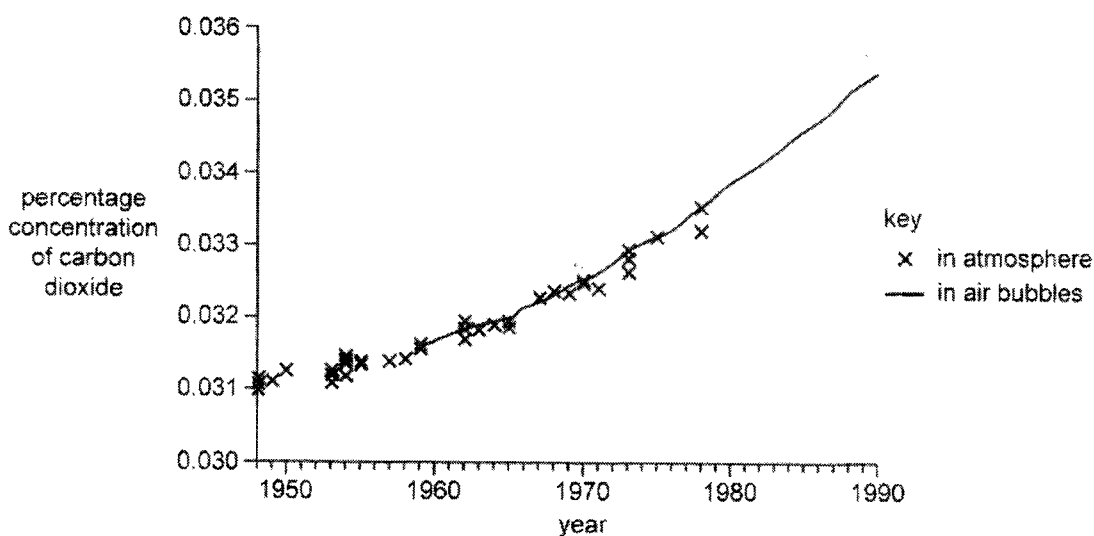


Fig. 11.1

With reference to the information provided, suggest and explain how climate change scientists can estimate atmospheric carbon dioxide concentrations 10 000 years ago.

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..... [2]

- (b) Volcanic eruptions, which eject large volumes of gases such as water vapour and carbon dioxide to heights of 16 to 32 kilometres above the Earth's surface, have had an effect on the climate of the Earth.

Toba is a volcano in Sumatra that erupted approximately 12 000 years ago. Fig. 11.2 shows the location of Sumatra.

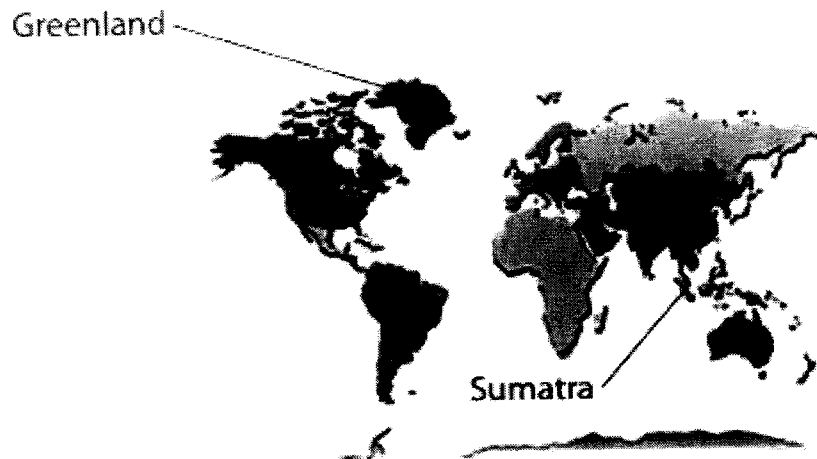


Fig. 11.2

Fig. 11.3 shows the changes to sea levels, compared to the present day, in the oceans around Greenland.

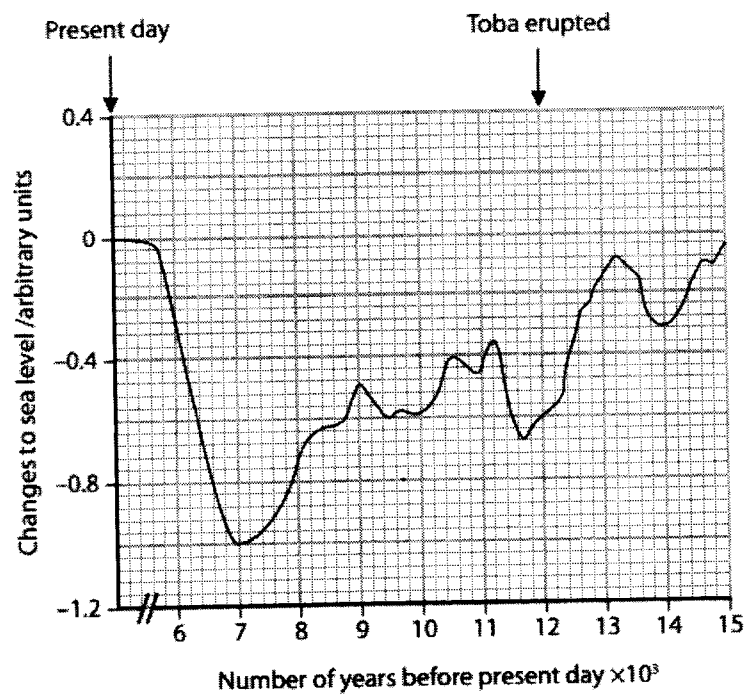


Fig. 11.3

It is claimed that the volcanic eruption of Toba caused a change in world climate.

- (i) Describe the evidence in Fig. 11.3 that supports this claim.

.....  
..... [1]

- (ii) Suggest why this claim may not be true.

.....  
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.....  
..... [2]

[Total: 5]

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NAME : \_\_\_\_\_

CLASS : \_\_\_\_\_



**JURONG PIONEER JUNIOR COLLEGE**  
**JC2 Preliminary Examination 2022**

**BIOLOGY**  
**Higher 2**

**9744/03**  
**21 September 2022**

Paper 3 Structured and Free-response Questions

**2 hours**

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

**READ THESE INSTRUCTIONS FIRST**

Write your class 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.

**Section A**

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

**Section B**

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

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

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

For Examiner's Use	
1	
2	
3	
<b>Section B</b>	
<b>Total</b>	

This document consists of **20** printed pages.

**Question 1 starts on page 3**



**Section A**

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

- 1** Colorectal cancer and hepatocellular carcinoma (HCC) are amongst the leading causes of cancer-related deaths worldwide. Colorectal cancer is the cancer of the colon or rectum. It is amongst the top three causes of cancer in both men and women globally, with more than a million people diagnosed with colorectal cancer each year.

Most colorectal cancers are due to old age and lifestyle factors, with only a small number of cases due to underlying genetic factors.

- (a)** State two environmental causes of cancer.

.....

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..... [2]



(c) Different types of gene mutation have been found to affect tumour suppressor genes.

Explain why a base pair deletion in a tumour suppressor gene is more likely to produce a non-functional protein than a base pair substitution.

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.....  
..... [3]

Unlike colorectal cancer, the incidence of HCC can be attributed to different genetic and epigenetic alterations. Epigenetics refers to heritable states of gene expression without alteration to the DNA sequence itself. Epigenetic changes such as DNA hypermethylation or hypomethylation, dysregulation of histone modification patterns, chromatin remodelling and aberrant expression of micro-RNAs (miRNAs) are associated with HCC.

miRNAs are non-coding single-stranded RNAs that are typically 19 to 25 nucleotides in length. They mostly function as negative gene regulators by binding to their complementary sequence located at the 3' untranslated region of their target mRNA, thereby forming miRNA-mRNA duplexes and silencing gene expression.

(d) State the level at which miRNAs regulate gene expression.

..... [1]

- (e) Fig. 1.2 shows how chronic liver damage and the replacement of normal liver tissue by fibrous scar tissue can lead to liver cirrhosis. Cirrhosis is generally irreversible once it occurs; more often than not, it leads to HCC.

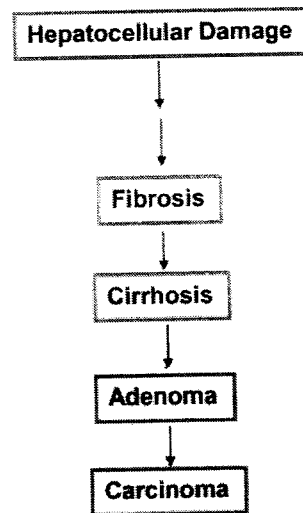


Fig. 1.2

A study investigated the association between differential levels of miRNA expression in liver cirrhosis. Non-cirrhotic and cirrhotic liver samples were used and the results are shown in Fig. 1.3.

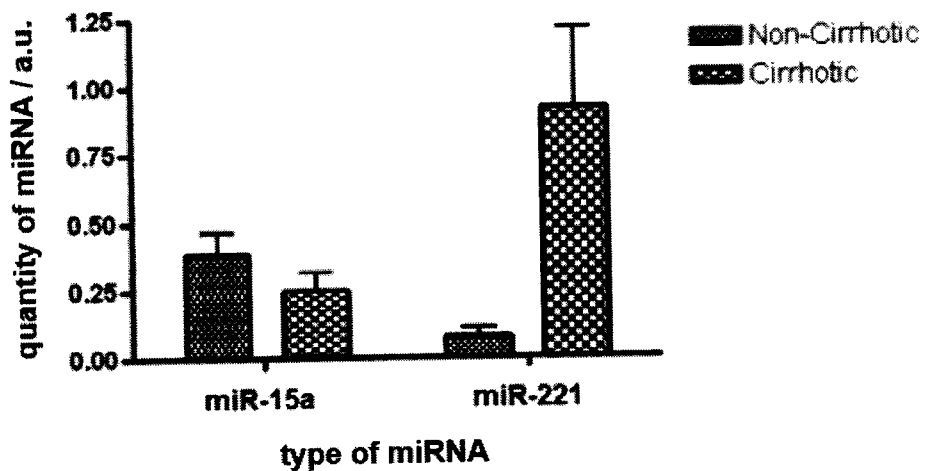


Fig. 1.3

- (i) Compare the effect of the relative quantities of miRNA in leading to liver cirrhosis.

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 ..... [3]

- (ii) 'oncomiRs' are miRNAs that promote oncogenesis by negatively regulating important tumour suppressor genes. On the other hand, 'anti-oncomiRs' are miRNAs that exert tumour-suppressive effects by repressing oncogenes.

Deduce if miR-15a and miR-221 is an 'oncomiR' or 'anti-oncomiR' and justify your answer.

miR-15a .....

justification .....

.....

.....

miR-221 .....

justification .....

.....

.....

[4]

(f) The molecular genetics of HCC have recently been extensively characterised. One of the most consistent epigenetic changes in HCC is that of DNA hypermethylation at the promoters of target genes.

(i) Describe how DNA hypermethylation at promoters can alter expression levels of the target genes.

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 .....  
 .....  
 ..... [3]

(ii) The *p16INK4a* gene is located on chromosome 9 and is one of the most frequently altered genes observed in HCC. The prevalence of hypermethylation of its promoter in various types of liver tissues are shown in Tables 1.1 and 1.2.

**Table 1.1**

sample	percentage of samples which showed <i>p16INK4a</i> promoter hypermethylation
HCC	54.5
non-tumourous	15.6

**Table 1.2**

sample	percentage of samples which showed <i>p16INK4a</i> promoter hypermethylation
cirrhotic	22.7
non-cirrhotic	9.2

Predict whether *p16INK4a* is an oncogene or tumour suppressor gene and suggest a possible role of its protein product in the cell cycle.

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 .....  
 ..... [2]

- (g) Another common hallmark of HCC is that of telomerase reactivation.

A student made the following claim:

*"In eukaryotes, telomerase synthesises additional lengths of DNA that are added to the ends of chromosomes, thus solving the end-replication problem that results from each round of DNA replication."*

- (i) Account for the end-replication problem.

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..... [4]

- (ii) Evaluate the validity of the student's claim that the addition of DNA to chromosomal ends solves the end-replication problem.

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..... [2]

- (iii) Telomerase is **not** present in prokaryotic cells. Suggest why prokaryotes do **not** have telomerase.

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..... [2]

[Total: 30]

2 Gene expression in eukaryotes is regulated at different levels and involves various regulatory proteins and enzymes. At translational level of regulation, regulatory proteins such as translation initiation factors and translational repressors are involved.

(a) Describe how gene expression may be regulated by translational repressors.

.....  
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..... [2]

Another regulatory protein, ubiquitin, is a highly conserved protein comprising 76 amino acids, ubiquitously expressed in all tissues in eukaryotes.

(b) State the role of ubiquitin in regulating gene expression in eukaryotes.

.....  
..... [1]

Fig. 2.1 shows the structure of an ubiquitin molecule.

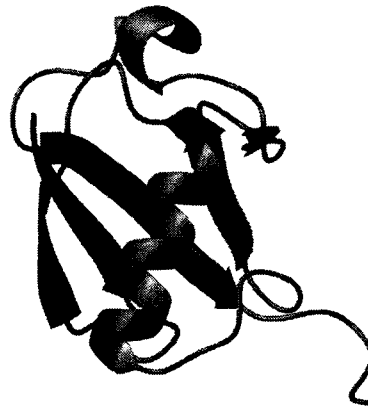


Fig 2.1

(c) Describe **two** similarities between the secondary structures found in ubiquitin.

.....  
.....  
.....  
..... [2]



Ubiquitin is synthesised at cytosolic ribosomes. mRNA, tRNA and rRNA are involved in the synthesis of ubiquitin.

(d) Describe the roles of tRNA in the synthesis of ubiquitin.

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.....

[2]

During protein synthesis, transcription precedes translation. Researchers measured the error rates during transcription and translation in yeast cells. The results are shown in Table 2.1.

Table 2.1

process	error rate
transcription	$10^{-5}$ per base
translation	$10^{-3}$ per codon

(e) Suggest why such a difference in error rates during transcription and translation is tolerated by the yeast cell.

.....

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[3]

[Total: 10]

- 3 Algae are aquatic photosynthetic protocists. Some researchers genetically modified the unicellular alga, *Chlorella vulgaris*, to try to increase the rate of the light independent stage of photosynthesis.

*C. vulgaris* was modified to increase the expression of the gene coding for aldolase. Aldolase is an enzyme that causes an increase in the concentration of rubisco.

Two cultures of *C. vulgaris*, one that was not genetically modified (unmodified) and one genetically modified, were grown under controlled conditions for 14 days. Samples were taken from the cultures at regular intervals during the 14 days to obtain measurements of dry mass. The results are shown in Fig. 3.1.

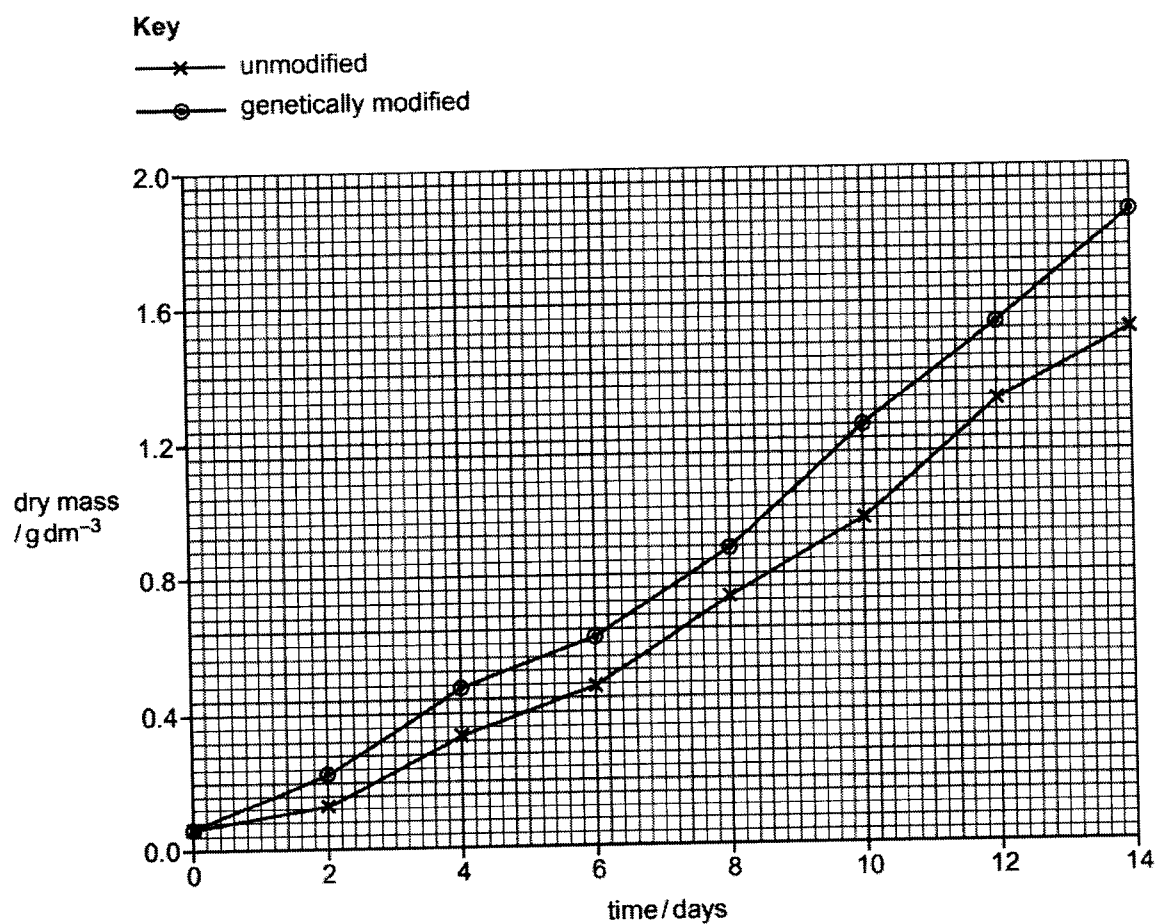


Fig. 3.1

(a) With reference to Fig. 3.1, describe the differences between the results for the two cultures.

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..... [3]

(b) Explain how the Calvin cycle was affected by the genetic modification of *C. vulgaris*.

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..... [3]

- (c) Intermediate products of the Calvin cycle are needed to produce organic molecules for use by the cell. One such organic molecule is phospholipid, a major constituent of cell membranes.

Outline the functions of membranes within cells.

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..... [3]

- (d) Planting large numbers of trees is one way to reduce global atmospheric CO<sub>2</sub> concentration. Large scale culture of genetically modified *C. vulgaris* could also reduce global atmospheric CO<sub>2</sub> concentration.

Suggest one advantage of using genetically modified *C. vulgaris* instead of trees to reduce global atmospheric CO<sub>2</sub> concentration.

.....  
..... [1]

[Total: 10]

NAME : \_\_\_\_\_

CLASS : \_\_\_\_\_

**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) Describe how transformation, transduction and conjugation give rise to variation in prokaryotic genomes and explain why genetic variation is important in bacteria. [15]
- (b) Describe the structures and organisation of viral, prokaryotic and eukaryotic genomes. [10]

[Total: 25]

- 5 (a) Outline and contrast chemiosmosis in photosynthesis and respiration. [15]
- (b) Describe how the molecular structure and properties of cellulose are related to its functions. [10]

[Total: 25]

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