



**HWA CHONG INSTITUTION**  
**JC2 Preliminary Examinations**  
**Higher 2**

CANDIDATE NAME

CT GROUP

21S7\_\_

CENTRE NUMBER

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INDEX NUMBER

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**BIOLOGY****9744/01**

Paper 1 Multiple Choice

**20 September 2022**

Additional Materials: Multiple Choice Answer Sheet

**1 hour****INSTRUCTIONS TO CANDIDATES**

1. Write your **name**, **CT group**, **Centre number** and **index number** in the spaces provided at the top of this cover page.
2. Fill in your particulars on the Multiple Choice Answer Sheet. Write your **NRIC number** and shade accordingly.
3. 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.
4. At the end of the paper, you are to submit **only** the Answer Sheet.

**INFORMATION FOR CANDIDATES**

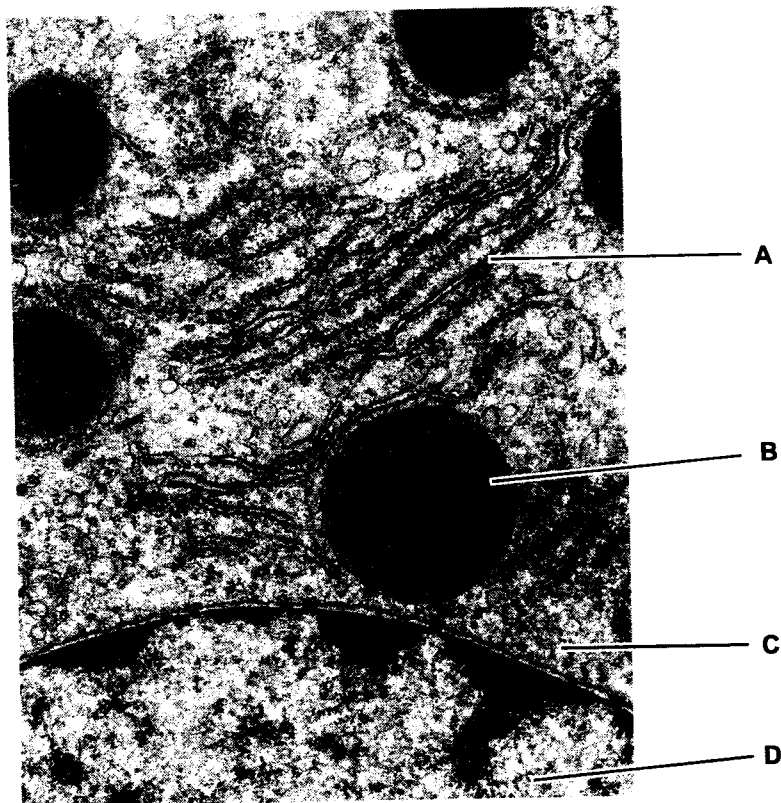
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

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

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

- 1 The electronmicrograph shows part of a eukaryotic cell with structures labelled A, B, C and D.



Which statement is correct?

- A Rough endoplasmic reticulum divides the cytoplasm into compartments and is studded with numerous ribosomes, which synthesise proteins.
- B Mitochondrion is an energy transducer where fats and sugars are reduced to produce ATP.
- C Cytoplasm is an aqueous matrix containing proteins and DNA for transcription.
- D Euchromatin is a loosely coiled form of chromatin that is associated with proteins called histones.

- 2 What are the essential structural features of viruses?

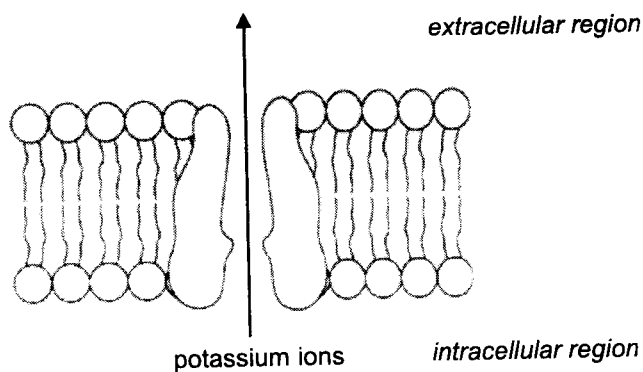
- 1 non-cellular
- 2 protein coat
- 3 both DNA and RNA
- 4 either DNA or RNA

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

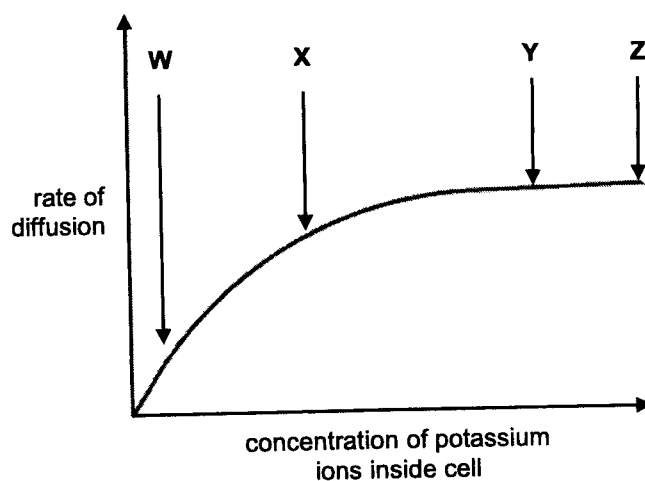
- 3 Which row correctly describes the primary, secondary, tertiary and quaternary structures of some proteins?

	primary structure	secondary structure	tertiary structure	quaternary structure
<b>A</b>	determines the folding of the polypeptide	depends on hydrogen bonding between the side-chains of amino acids	defines the overall shape and folding of the protein	formed when two or more identical polypeptides join together
<b>B</b>	defines the order of amino acids in the polypeptide	usually forms immediately after polypeptide synthesis	is held together by all the types of bonding that occur in proteins	found in globular proteins such as haemoglobin but never in fibrous proteins
<b>C</b>	involves covalent bonds only	involves hydrogen bonding	essential for the function of enzymes and receptors	formed when two or more polypeptides join together
<b>D</b>	involves peptide bonds between the side-chains of amino acids	involves folding between local regions within a polypeptide molecule	changes reversibly when bound to non-competitive inhibitors	can involve hydrogen bonds, covalent bonds and hydrophobic interactions

- 4 The diagram shows part of a cell surface membrane. The arrow shows the path taken by potassium ions when they diffuse through the membrane out of a cell.



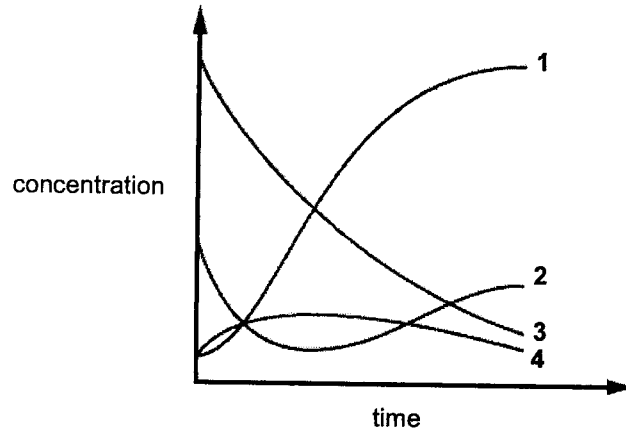
The graph shows how the rate of diffusion of potassium ions across the cell surface membrane is affected by the concentration of potassium ions within the cells.



Which row is correct?

	region W to X: limiting factor on the rate of diffusion	region Y to Z: limiting factor on the rate of diffusion
A	concentration of potassium ions inside the cell	number of potassium channels
B	number of potassium channels	concentration of potassium ions outside the cell
C	concentration of potassium ions inside the cells	slower rate of potassium ions passing through the channels
D	concentration of potassium ions outside the cell	minimum rate of potassium ions passing through the channels

- 5 The graph shows how the concentration of components of an enzyme-catalysed reaction changes with time.



Which row is correct?

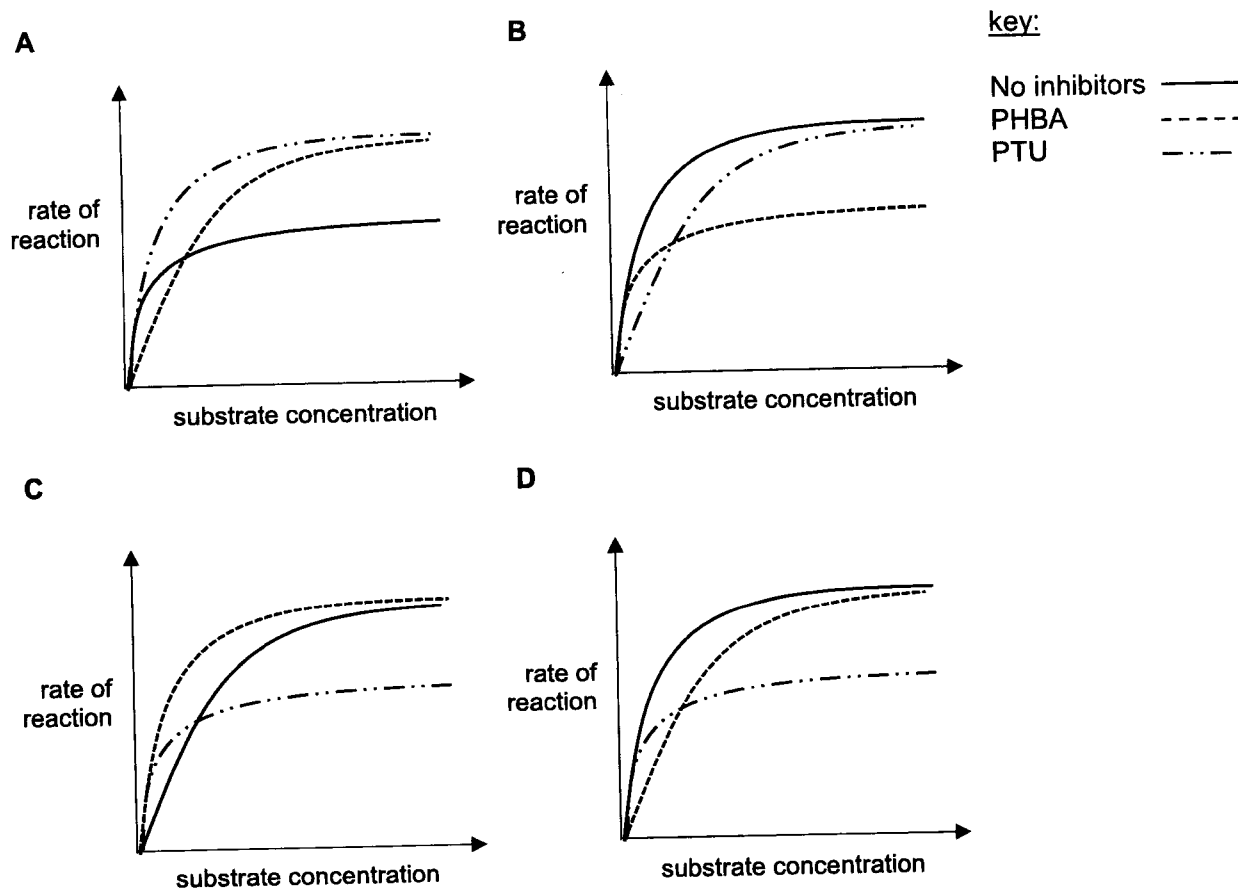
	enzymes with empty active sites	substrates	products	enzyme-substrate complexes
<b>A</b>	1	2	4	3
<b>B</b>	2	3	1	4
<b>C</b>	4	1	3	2
<b>D</b>	3	4	2	1

- 6 Catechol oxidase is an enzyme found in fruits that oxidises catechol into a quinone, which causes browning.

Commercial catechol oxidase could be inhibited by the following chemicals:

- parahydroxybenzoic acid (PHBA), a chemical structurally similar to catechol
- pheynlthiourea (PTU), which binds to a copper atom in the enzyme away from the active site.

Which graph correctly shows the activity of the two inhibitors?

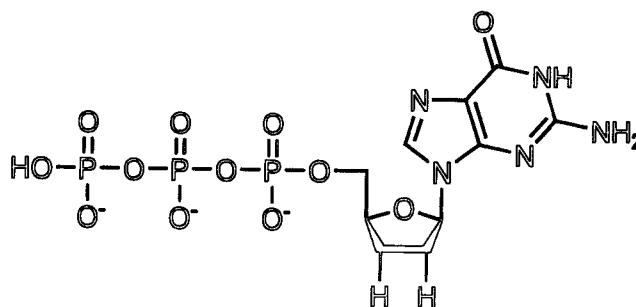


- 7 Which statements are **true** about stem cells?

- 1 Stem cells extracted from any tissue can immediately differentiate into skin cells with the introduction of appropriate transcription factors.
- 2 One potential side effect of any stem cell-based therapy is the formation of a tumour.
- 3 Human embryonic stem cells are removed at an early stage of embryonic development from a region of the blastocyst known as the inner cell mass.
- 4 Any stem cell can develop into a whole organism when implanted into the uterus.

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

- 8 The diagram shows the structure of a nucleotide that can fit the active site of DNA polymerase.



Which statement predicts the effect that the nucleotide has on DNA replication?

- A The nucleotide cannot be added to the 3' end of the growing DNA strand.
- B The nucleotide can be added to the 3' end of the growing DNA strand but will not allow the next nucleotide to be added to it.
- C The nucleotide can be added to the 3' end of the growing DNA strand and will also allow the next nucleotide to be added to it.
- D The nucleotide can be added to the 3' end of the growing DNA strand and will also allow the next nucleotide to be added to it, but it will be replaced by upstream DNA synthesis later.
- 9 Some of the stages of transcription in a eukaryotic cell are listed.
- 1 TATA box binding protein binds to the promoter on DNA.
  - 2 A poly(A) signal is transcribed.
  - 3 RNA polymerase dissociates from the transcription initiation complex.
  - 4 Twenty-three nucleotides of RNA are synthesised allowing the transcription initiation complex to move away from the core promoter.
  - 5 General transcription factors and RNA polymerase bind at promoter on DNA, forming the transcription initiation complex.

Using the information provided above, what is the order in which these stages occur?

- A 1 → 5 → 2 → 3 → 4
- B 1 → 5 → 4 → 3 → 2
- C 5 → 1 → 4 → 3 → 2
- D 5 → 4 → 1 → 2 → 3
- 10 During metaphase of mitosis, a scientist stains the chromosomes of a diploid animal cell with fluorescent dye to allow the telomeres to be observed.

This cell has 26 chromosomes.

How many telomeres will the scientist observe?

- A 26                      B 52                      C 78                      D 104

- 11 Three parts of a chromosome and their functions are listed.

part	function
p1 centromere	f1 holds the coils of DNA together
p2 histone proteins	f2 holds two chromatids together
p3 telomere	f3 prevents loss of genes

Which row shows the correct match of all the parts with their functions?

<b>A</b>	p1 and f1	p2 and f2	p3 and f3
<b>B</b>	p1 and f2	p2 and f1	p3 and f3
<b>C</b>	p1 and f2	p2 and f3	p3 and f1
<b>D</b>	p1 and f3	p2 and f1	p3 and f2

- 12 Casein is a major protein found in mammalian milk. The two flowcharts show the pathways for production of casein.

Fig. 1a shows the pathway for the production of casein when the mammals are producing milk.

Fig. 1b shows the pathway when the mammals are not producing milk.

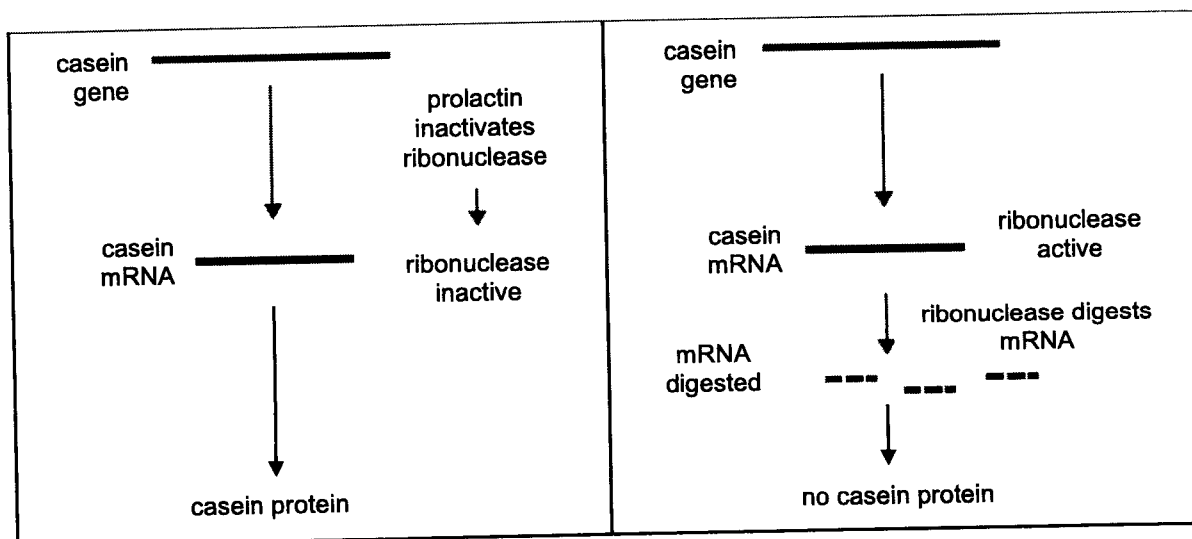


Fig. 1a

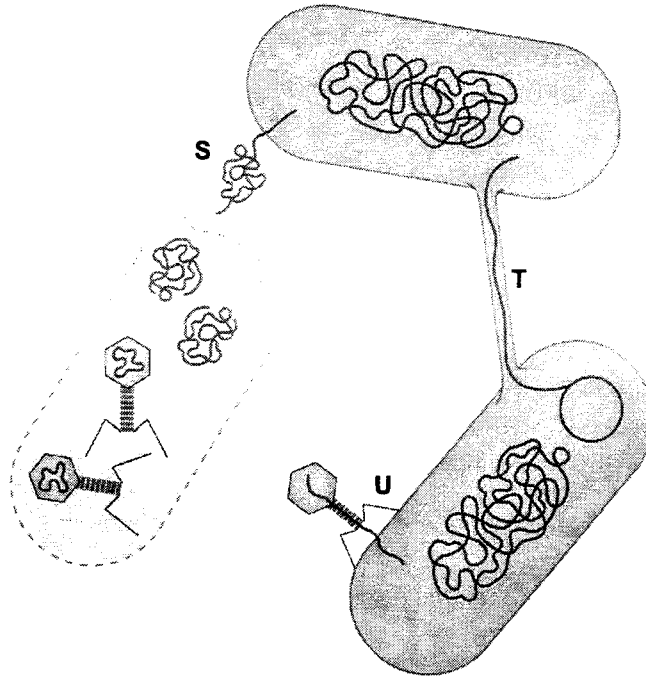
Fig. 1b

Which conclusion can be made from the information provided?

- A** Ribonuclease controls expression of the casein gene at the transcriptional level.
- B** Casein is a repressor protein for milk production in mammals.
- C** The hormone prolactin allows for the expression of the casein gene.
- D** Mammals produce milk only in the absence of the hormone prolactin, which acts as a repressor protein.



- 13 The diagram shows three processes, **S**, **T** and **U** by which genetic information can be exchanged between bacterial cells.



Which statements are correct?

- 1 Processes **S** and **U** involves the transfer of random DNA from donor to recipient bacterial cell.
- 2 Processes **S** and **T** involves the transfer of DNA that leads to an increased genetic variation in both donor and recipient bacterial cells.
- 3 Only processes **T** and **U** lead to an increase in the bacterial cell number.
- 4 All three processes require the exchange of chromosomal DNA between two bacterial cells to be homologous.

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

- 14 Which row correctly describes the metabolism of lactose and tryptophan in *E. coli* cells?

	<i>lac</i> operon	<i>trp</i> operon
<b>A</b>	repressible operon	inducible operon
<b>B</b>	codes for enzymes involved in anabolic pathway	codes for enzymes involved in catabolic pathway
<b>C</b>	allolactose is a corepressor	tryptophan is an inducer
<b>D</b>	transcription occurs in the presence of lactose	transcription occurs in the absence of tryptophan

- 15 Factor V is a protein circulating in blood that is necessary for proper blood clotting.

A single mutation to the *Factor V* gene leads to the replacement of amino acid arginine with glutamine. This forms an abnormal Factor V which remains active and leads to excessive clotting.

The table shows the mRNA codons for both arginine and glutamine respectively.

amino acid	mRNA codon
arginine	CGU, CGC, CGA, CGG, AGA, AGG
glutamine	CAA, CAG

Which correctly describes the events leading up to the formation of the abnormal Factor V?

- A** A single pyrimidine substitution.
- B** A single purine substitution.
- C** A single pyrimidine insertion.
- D** A single purine deletion.

- 16 A student sets out to compare DNA from monkeys living in different parts of Bukit Timah Nature Reserve. During the course of research, he amplified a 500 bp sequence from the monkey's mitochondrial genome using PCR.

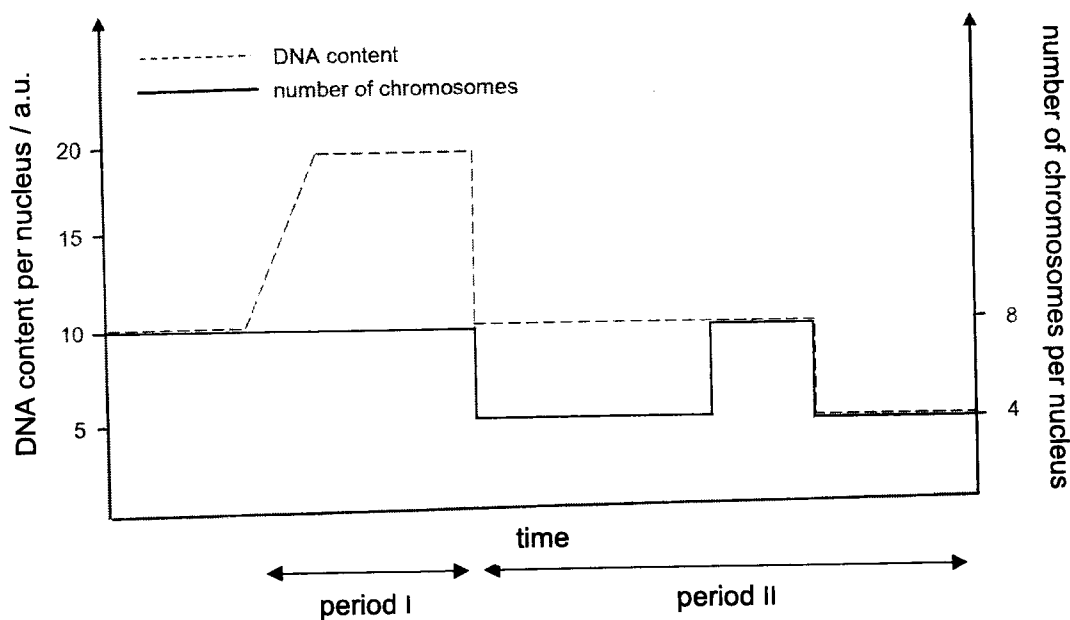
The flow chart shows the steps taken by the student.

- step 1 – isolate mitochondrial DNA (mtDNA) from each monkey's hair follicles.  
 ↓  
 step 2 – amplify the mtDNA at a precise location.  
 ↓  
 step 3 – verify that mtDNA amplification was successful using gel electrophoresis.  
 ↓  
 step 4 – sequence the mtDNA fragments from the gel and compare the samples.

Which row is correct?

	step	description
<b>A</b>	1	requires the extraction of linear, double-stranded DNA from follicular cells
<b>B</b>	2	usually requires a reaction mixture containing two single-stranded DNA primers
<b>C</b>	3	verifies that mtDNA amplification is successful if two bands appear upon staining of the agarose gel with methylene blue
<b>D</b>	4	requires the application of single-stranded, radioactively-labelled probes.

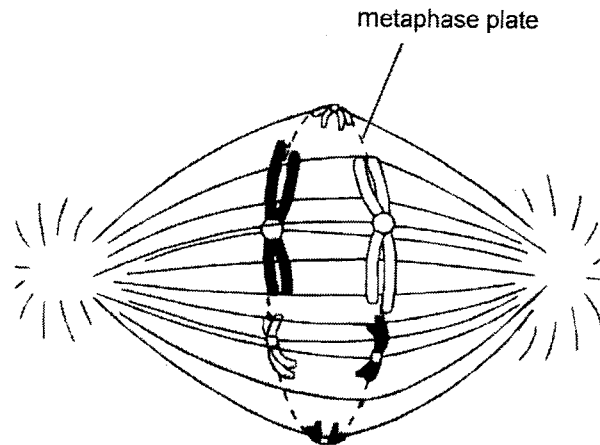
- 17 The diagram shows the DNA content and the number of chromosomes in a nucleus of a cell at various stages of a cell cycle.



Which statement is true regarding the diagram?

- A S and G<sub>1</sub> phases of interphase occur in period I of the cell cycle.
- B Processes leading to genetic variation occurs only in period II of the cell cycle.
- C Equational division only occurs during period II of the cell cycle.
- D Genetically identical daughter cells are produced in period II of the cell cycle.

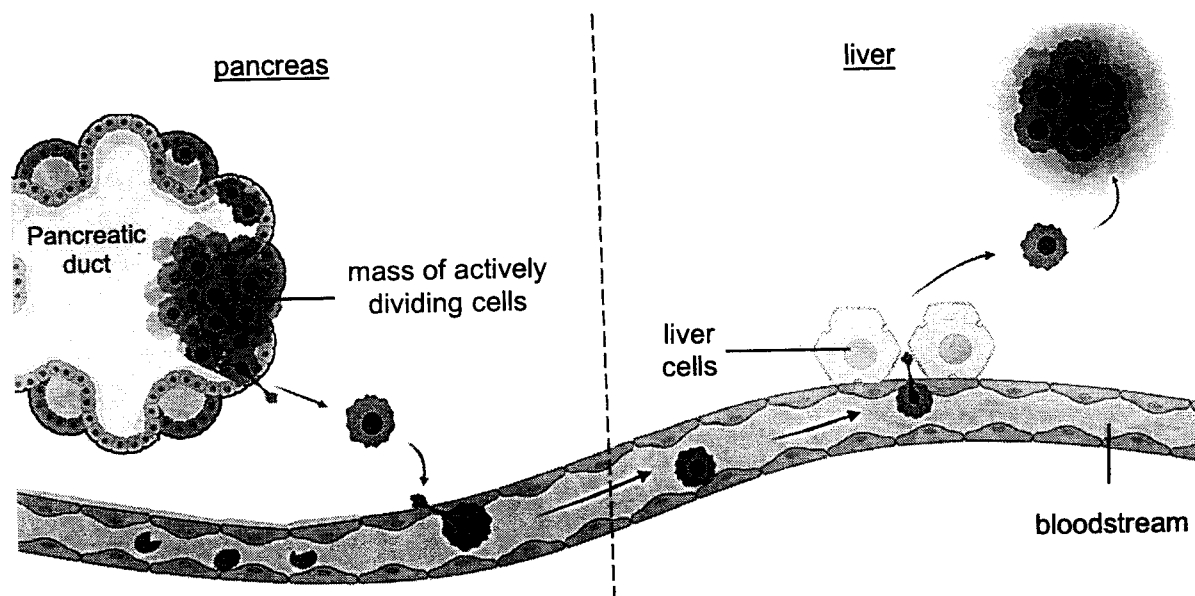
- 18 The diagram shows a newly discovered cell undergoing cell division. This cell contains 20  $\mu\text{g}$  of DNA before undergoing interphase.



Which statement is correct?

- A In the next stage of cell division, the polar microtubules in the cell start to slide past one another, elongating the animal cell.
- B Crossing over has occurred between two pairs of homologous chromosomes in this diploid cell.
- C The cell contains six chromosomes at the end of telophase I of meiosis.
- D Cytokinesis will occur after meiosis II to produce four haploid cells, each containing 5  $\mu\text{g}$  of DNA.

- 19 The diagram illustrates some processes in the development of cancer in humans.

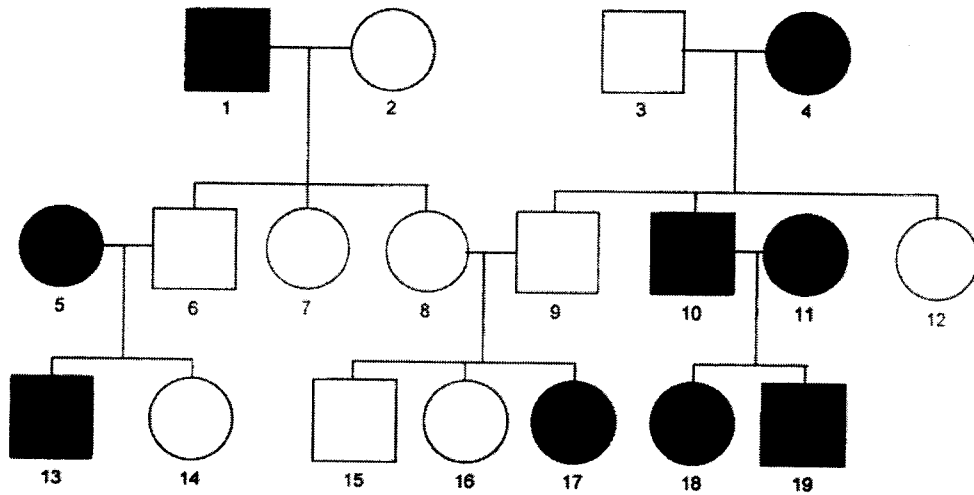


Which statements are correct?

- 1 The mass of actively dividing cells in the pancreatic duct displays a lack of contact inhibition.
- 2 The bloodstream allows the pancreatic cells to migrate from the pancreas to the liver to form a secondary tumour.
- 3 The mass of cells in the liver undergoes repeated rounds of cell division, giving rise to clones of malignant cancer cells which may invade the surrounding tissues in the liver.

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

- 20 The pedigree of a family with a novel disease causing mutation is shown.



Which is the correct mode of inheritance?

- A sex-linked recessive
  - B sex-linked dominant
  - C autosomal recessive
  - D autosomal dominant
- 21 The table shows the results of an early investigation into the genetic control of phenotypic variation.

The dry masses of 5493 bean seeds collected from many plants were classified into nine categories.

mass of bean / mg	51-150	151-250	251-350	351-450	451-550	551-650	651-750	751-850	851-950
number of beans	5	38	370	1676	2255	928	187	32	2

Which statement correctly describes these data and could account for the variation shown?

- A The phenotypic variation is continuous and could be the result of two unlinked genes acting on their own.
- B The phenotypic variation is continuous and could be the result of several unlinked genes acting on their own.
- C The phenotypic variation is discontinuous and could be the result of two linked genes acting on their own.
- D The phenotypic variation is discontinuous and could be the result of several linked genes acting on their own.

- 22 Both the genes for body colour and wing length in fruit flies are found on chromosome 2.

Pure breeding *Drosophila* flies with brown bodies and vestigial wings were crossed with pure breeding *Drosophila* flies with black bodies and long wings. All offspring in the F1 generation had brown bodies with long wings.

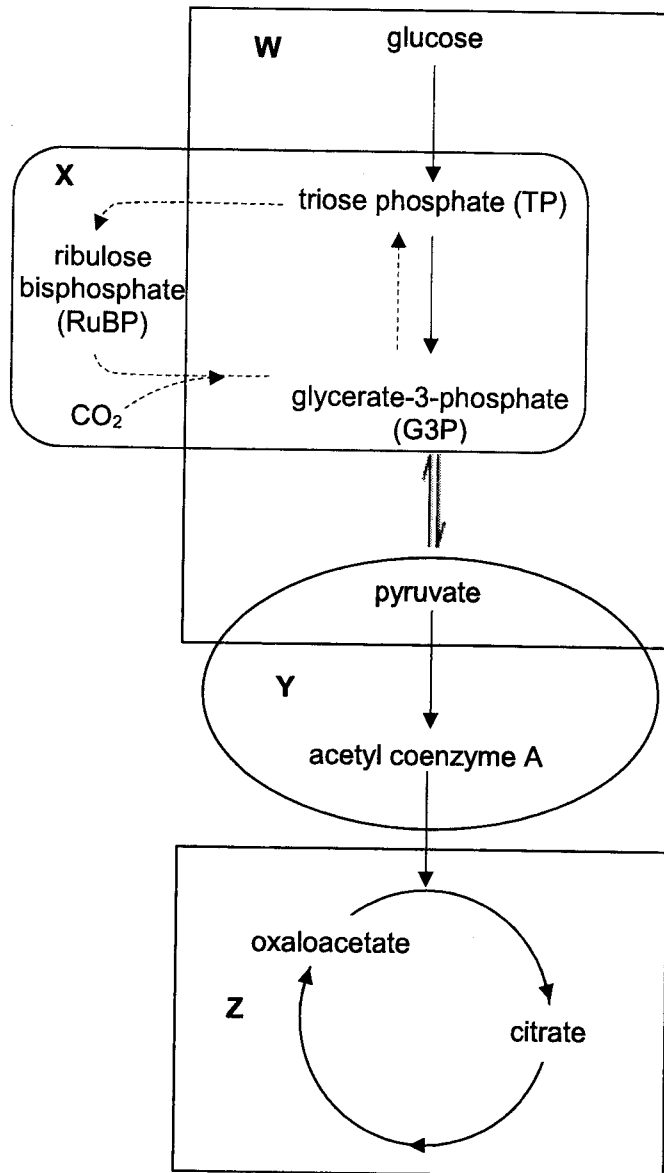
The F1 generation was crossed with flies with black bodies and vestigial wings and a total of 400 offspring were obtained.

Which row is correct?

	brown body, vestigial wings	black body, vestigial wings	brown body, long wings	black body, long wings
A	27	173	170	30
B	103	101	97	99
C	172	30	34	164
D	73	27	226	74



- 23 Some metabolic pathways that take place in a plant cell are shown below. Processes W, X, Y and Z are labelled.



Which statement is correct?

- A Process W results in the net formation of two molecules of NADH and two molecules of ATP.
- B Process X involves the formation of ATP from decarboxylation.
- C Process Y occurs in the cytoplasm and involves pyruvate dehydrogenase with the removal of one carbon dioxide.
- D Process Z involves the reduction of coenzymes NAD and FAD using up ATP in the process.

24 How many statement(s) regarding alcoholic fermentation and lactic acid fermentation are correct?

- 1 Alcoholic fermentation involves the loss of one carbon dioxide molecule in the conversion of a molecule of pyruvate to ethanol.
- 2 Lactic acid fermentation involves pyruvate as the electron donor for the reduction process.
- 3 The products of both processes can eventually be completely oxidized in the presence of oxygen.

A 0

B 1

C 2

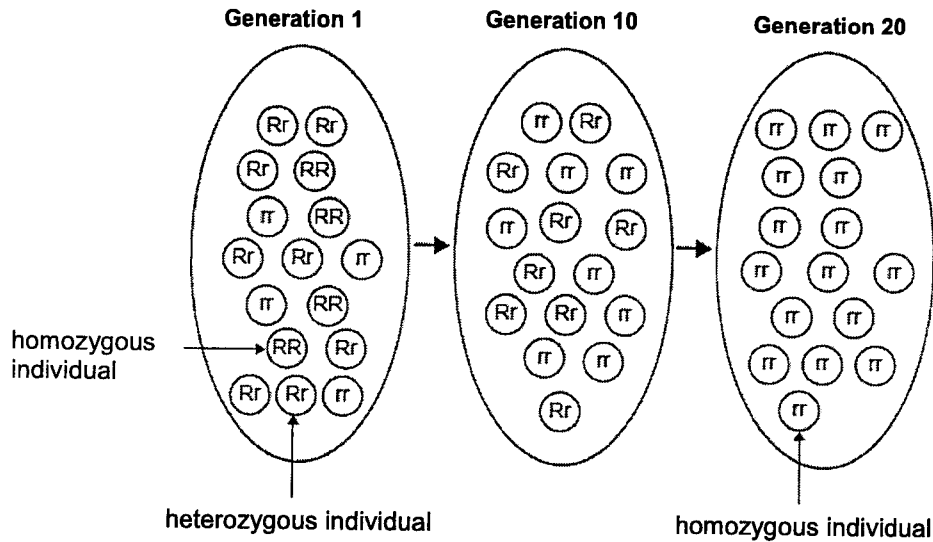
D 3

25 Signal transduction can take many steps. The activation of a protein kinase cascade is part of the signal transduction pathway.

Which row is true about the signal transduction pathway?

	allows for amplification of a signal for a response of larger magnitude	allows for amplification of a signal for more than one cellular response	allows for multiple regulatory steps
<b>A</b>	√	√	√
<b>B</b>	√	x	x
<b>C</b>	x	√	√
<b>D</b>	x	x	x

- 26 The diagram shows the gene pool of a population over 20 generations.



What is a possible conclusion that can be made?

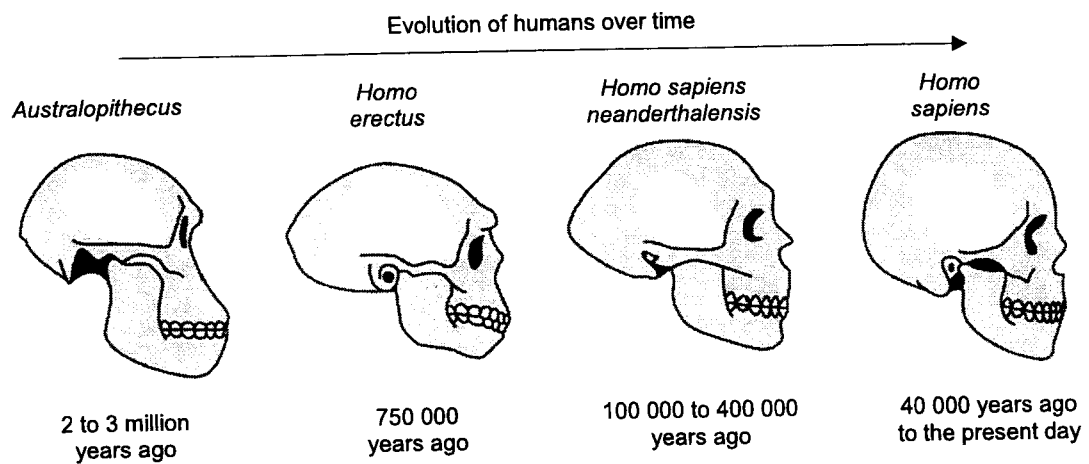
- A Genetic diversity is increasing in this population.  
 B Individuals with the genotype RR had a selective advantage in this population.  
 C The frequency of each allele is equal in Generation 1 but not in other generations.  
 D New advantageous alleles for this gene were introduced as individuals joined this population.
- 27 Soay sheep, a primitive breed of domesticated sheep, live wild on the small and remote Scottish island of Hirta.

Studies have shown that the mean size of an adult Soay sheep has been decreasing over the past thirty years.

Which statements could explain the decrease in mean size of adult Soay sheep on Hirta?

- 1 Stabilising selection is occurring, with the largest and smallest sheep being selected against.
  - 2 Small lambs are less likely to survive their first winter than large lambs.
  - 3 Climate change has led to milder winters, so smaller lambs are surviving to adulthood.
  - 4 Food has become scarcer and smaller sheep need less food than larger sheep.
- A 1 only  
 B 1 and 3 only  
 C 2 and 4 only  
 D 3 and 4 only

28 The diagram shows the evolution of humans using fossil records.

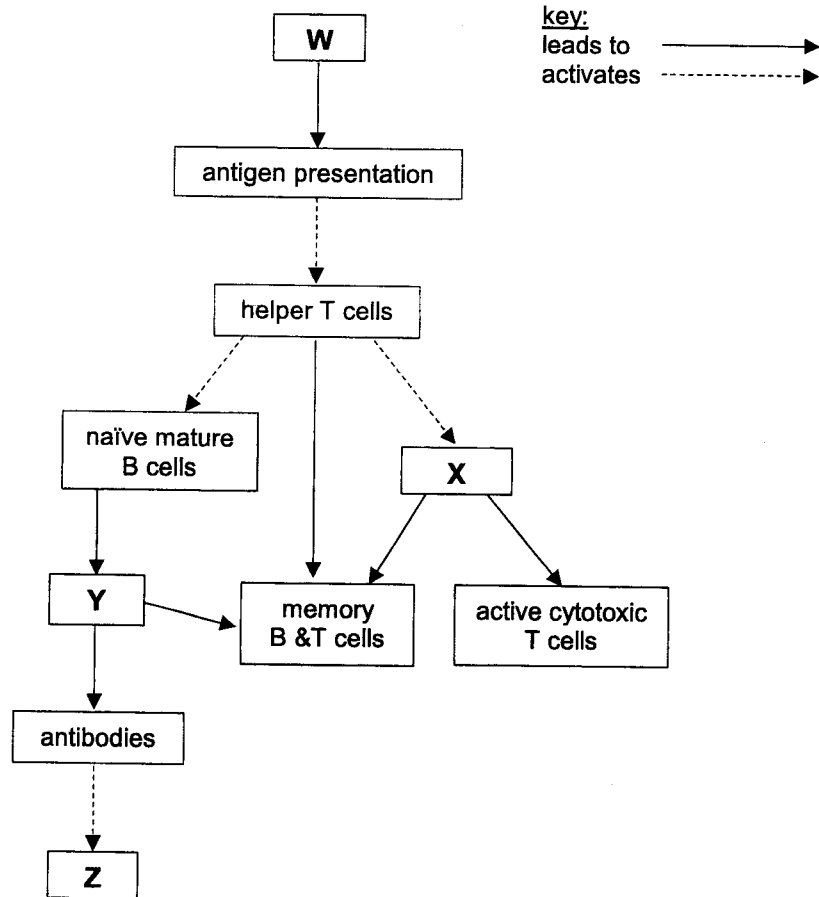


Which statements are correct?

- 1 As humans evolved, the volume of the skull progressively increased, showing descent with modification.
- 2 *Homo erectus* and *Homo sapiens neanderthalensis* existed at different time periods and hence were reproductively isolated.
- 3 *Australopithecus* was the recent common ancestor of *Homo sapiens*.
- 4 There is a greater variety of human fossils in younger rocks.

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

- 29 The flowchart of an immune response is shown, where **W**, **X**, **Y** and **Z** are components involved in the immune response.



Which statement is correct?

- A** **W** is a HIV provirus that infected a T cell in an immunocompromised patient.
- B** **X** is a cytotoxic T cell that is activated to remove circulating pathogens.
- C** **Y** is formed when B cells undergo somatic recombination after activation by T helper cells.
- D** **Z** are proteins that associate together to result in lysis of pathogenic bacteria.

- 30 Chikungunya is an infection caused by the chikungunya virus (CHIKV). CHIKV is spread in humans via two types of mosquitoes – *Aedes albopictus* and *Aedes aegypti*.

When chikungunya was first identified in 1952, it had a low level of circulation in West Africa, with infection rates linked to rainfall. Beginning in the 1960s, periodic cycles of outbreak and dormancy were documented in Africa and Asia, with the *Aedes aegypti* as the main vector.

However, in 2005, re-emergence and outbreaks of chikungunya were recorded in Africa, Asia and the Americas. Genetic analysis of the 2005 variant of CHIKV showed a change in the viral coat protein, allowing for the virus to multiply more easily in mosquito cells. This mutation allowed the virus to use the *Aedes albopictus* as a vector.

Four explanations by scientists to explain the spread of CHIKV from Africa to Asia and Americas are listed:

- 1 Increased rainfall from climate change leading to increase in mosquito larval habitats.
- 2 *Aedes albopictus* had a selective advantage over *Aedes aegypti* as a vector because they occupy the same ecological niche.
- 3 Increased global temperatures leading to an increased geographical range of *Aedes* mosquito to temperate regions.
- 4 Decreased overwintering success of mosquitoes leading to longer life cycles of mosquito, leading to more offspring produced by the mosquitoes.

Which of the statements are possible to explain the 2005 outbreak of chikungunya?

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

---END OF PAPER---

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9744 H2 Biology / JC2 Preliminary Examinations / Paper 1



**HWA CHONG INSTITUTION**  
**JC2 Preliminary Examinations**  
**Higher 2**

CANDIDATE NAME

CT GROUP

21S7\_\_

CENTRE NUMBER





INDEX NUMBER




**BIOLOGY****9744/02**

Paper 2 Structured Questions

**22 August 2022**

Candidates answer on the Question Paper.

**2 hours**

No Additional Materials are required.

**INSTRUCTIONS TO CANDIDATES**

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

There are **eleven** questions.

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

**INFORMATION FOR CANDIDATES**

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.

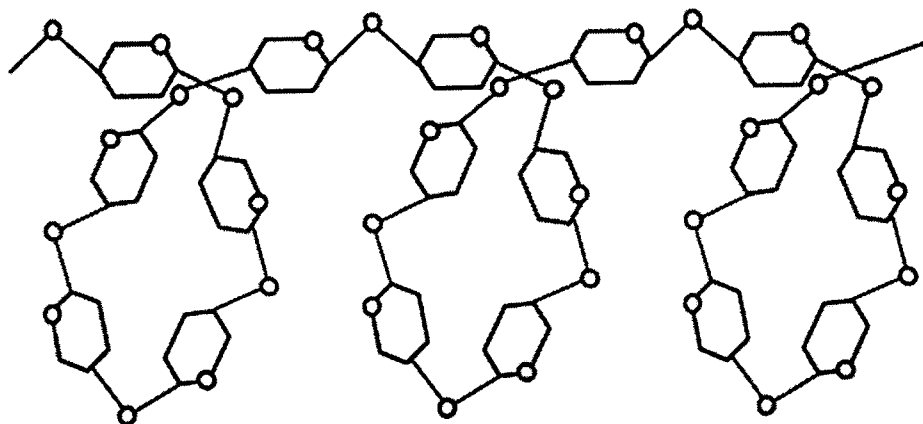
You are reminded of the need for good English and clear presentation in your answers.

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

This document consists of **30** printed pages.

**QUESTION 1**

Fig. 1.1 shows the structure of amylose, a component of the polymer starch.



**Fig. 1.1**

- (a) Describe the main features of amylose visible in Fig. 1.1.

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..... [2]

- (b) Explain how the structure of amylose makes it suitable for its function.

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..... [2]



Single-stranded amylose in an aqueous solution gradually forms a double helix.

(c) Suggest how the double helix structure of amylose is formed.

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

Collagen is another polymer that can be found in living organisms.

(d) (i) State **two** ways in which the structure of collagen differs from the structure of starch.

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..... [2]

(ii) Explain how **one** of the differences stated in (d)(i) allows collagen to perform its function.

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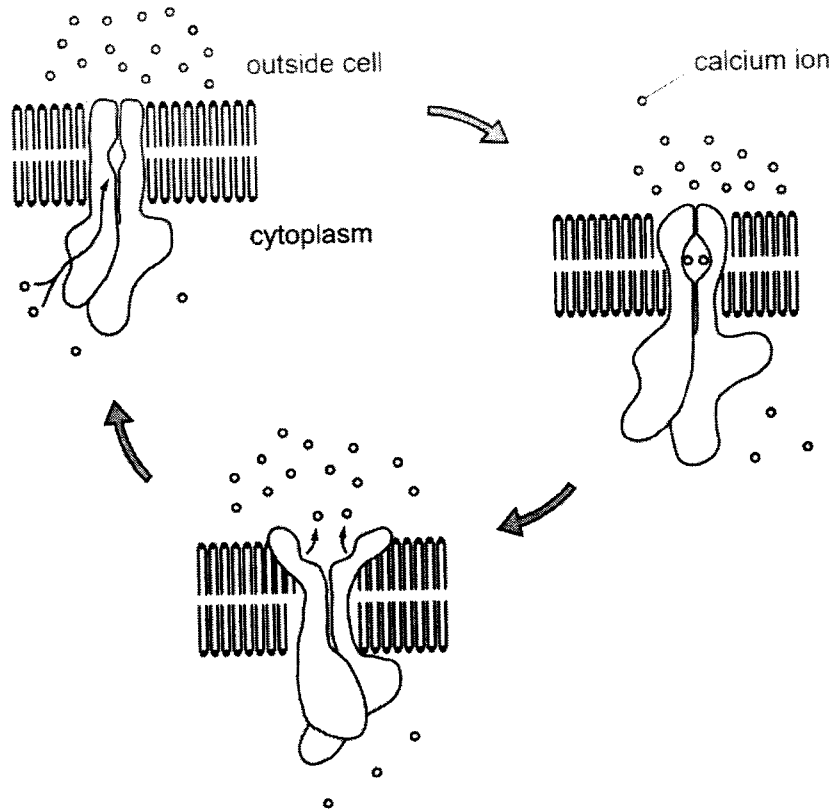
[Total: 9]

**QUESTION 2**

Cell surface membranes are involved with the movement of substances into and out of cells.

Calcium pumps in cell surface membranes maintain a concentration of calcium ions inside the cytoplasm that is a thousand times lower than outside the cell.

Fig. 2.1 shows the movement of calcium ions across a cell surface membrane.



**Fig. 2.1**

(a) With reference to Fig. 2.1,

(i) explain why calcium ions do not pass through the phospholipid bilayer.

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..... [2]

(ii) state and describe the process by which calcium ions are moved across the membrane.

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(b) With reference to the fluid mosaic model, discuss how high temperature affects membrane permeability.

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

[Total: 9]

**QUESTION 3**

(a) State the central dogma of molecular biology.

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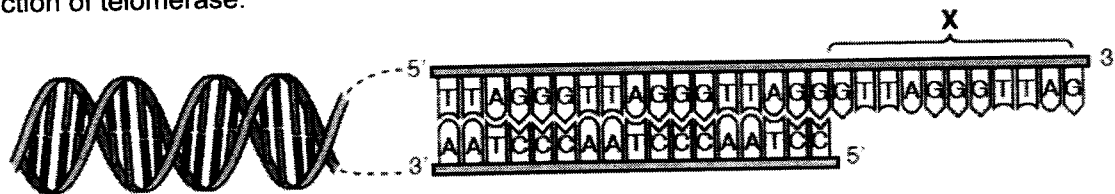
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..... [3]

Telomeres are repeating sequences of bases located at the ends of DNA molecules. These repeating sequences do not code for proteins.

The enzyme telomerase ensures that telomeres do not shorten each time DNA is replicated.

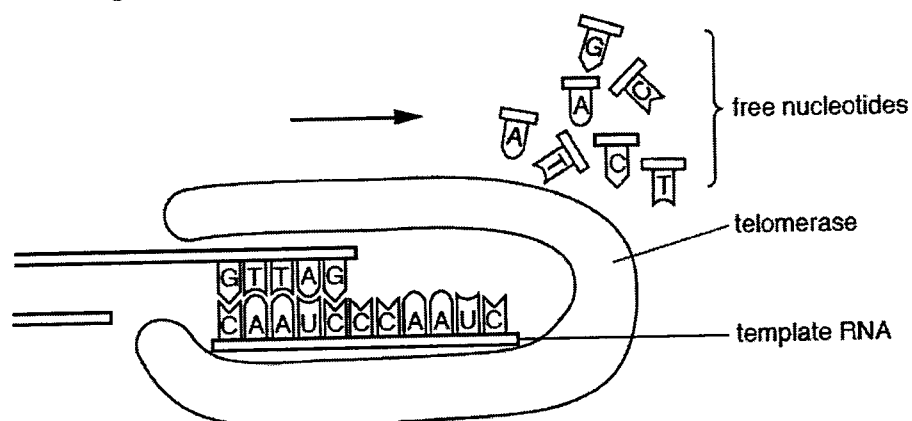
Fig. 3.1 shows the end of a DNA molecule during replication. DNA polymerase cannot attach to the region labelled **X**, so it cannot complete the synthesis of the new strand without the action of telomerase.



**Fig. 3.1**

Telomerase synthesises additional lengths of DNA that are added to the telomere. These additional lengths are used by DNA polymerase to complete the process of replication.

Fig. 3.2 is an enlarged view of region **X** to show the action of the enzyme telomerase.



**Fig. 3.2**

Telomerase contains a short length of RNA that acts as a template for the synthesis of DNA as shown in Fig. 3.2.

(b) Explain how a molecule of telomerase synthesises additional lengths of DNA.

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..... [4]

(c) Explain why the action of telomerase challenges the central dogma of molecular biology.

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

(d) Telomerase is not present in prokaryotic cells.

Suggest why prokaryotes do not have telomerase.

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..... [2]

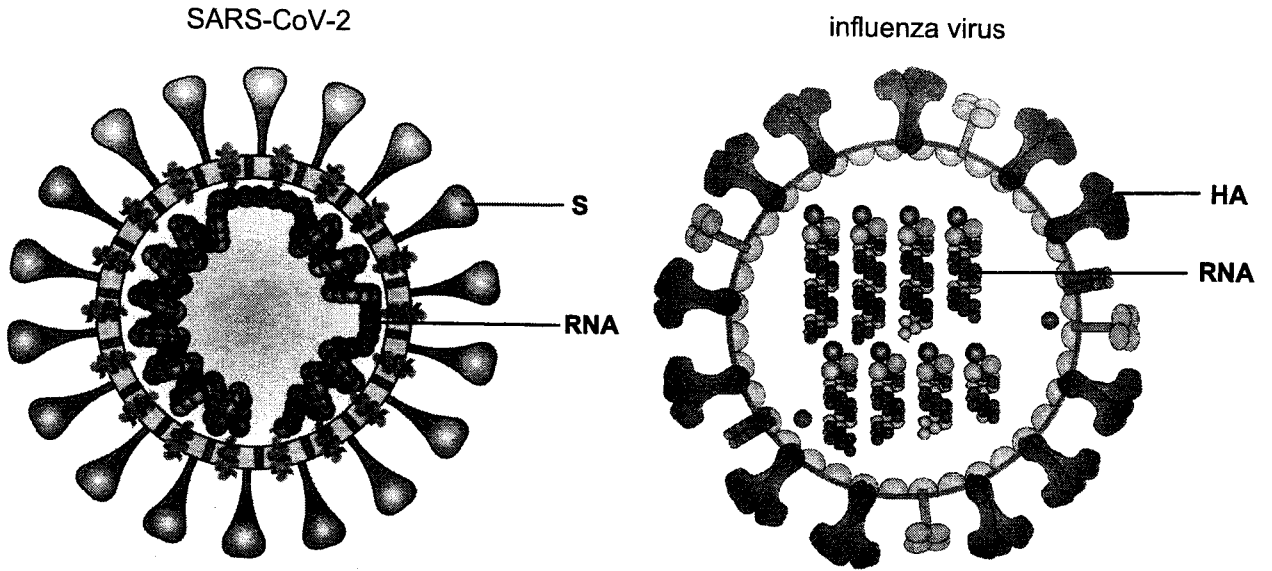
[Total: 11]

**QUESTION 4**

Influenza and COVID-19 are both contagious respiratory illnesses caused by different viruses. COVID-19 is caused by infection with a coronavirus, SARS-CoV-2, first identified in 2019. Flu is caused by infection with an influenza virus.

Fig. 4.1 shows the structures of the SARS-CoV-2 and influenza virus respectively.

Both **S** and **HA** are glycoproteins embedded in the viral envelope of the respective viruses and serve the same function.



**Fig. 4.1**

(a) Compare the structures of SARS-CoV-2 and influenza virus.

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..... [3]

Fig. 4.2 shows part of the reproductive cycle of SARS-CoV-2 virus, where the entry of the virus is facilitated by host cell surface receptors, ACE2 and PRS2.

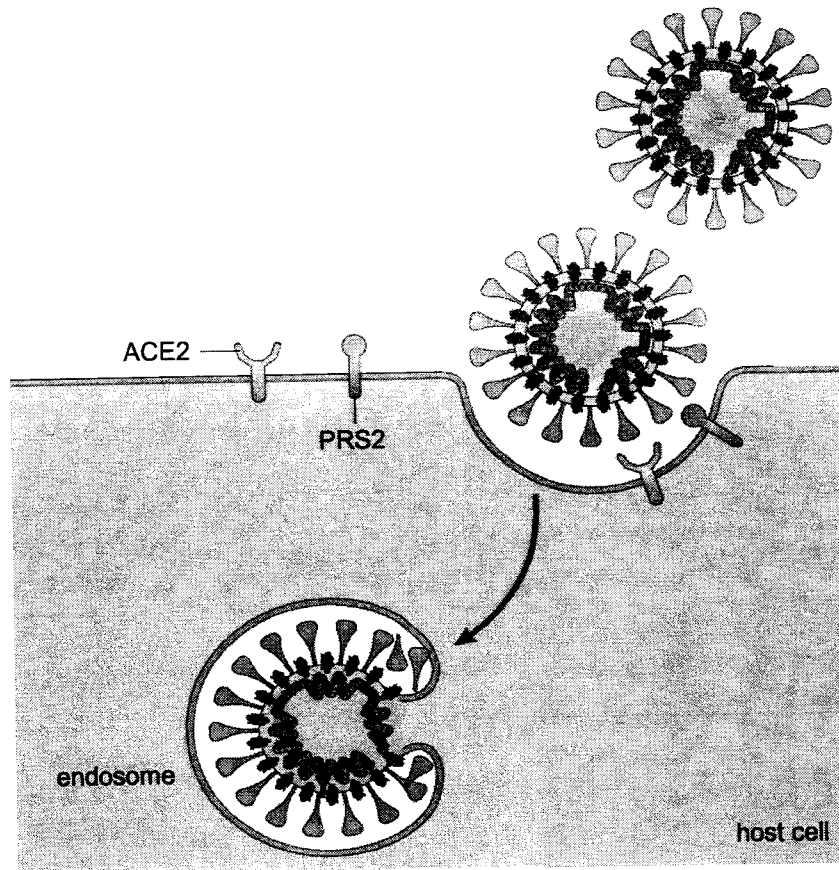


Fig. 4.2



(b) Describe how the SARS-CoV-2 virus enters a host cell.

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..... [3]

(c) There are at least three variants of the SARS-CoV-2 virus since its discovery in 2019.

Identify and describe one type of variation in viral genomes that may lead to the formation of new strains of the SARS-CoV-2 virus.

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..... [3]

[Total: 9]

**QUESTION 5**

Sickle cell anaemia is an autosomal recessive disorder:

- allele Hb<sup>A</sup> codes for the normal  $\beta$ -globin polypeptide of haemoglobin
- allele Hb<sup>S</sup>, caused by a base substitution mutation, codes for an abnormal  $\beta$ -globin polypeptide.

People who are heterozygous (Hb<sup>A</sup>Hb<sup>S</sup>) have sickle cell trait (SCT). For a child to inherit sickle cell anaemia (Hb<sup>S</sup>Hb<sup>S</sup>), both parents must have SCT.

The mutation which produces Hb<sup>S</sup> changes the sixth codon of the  $\beta$ -globin gene from GAG to GTG.

The abnormal haemoglobin molecules (HbS) form fibres in low partial pressures of oxygen.

**(a)** Explain how this mutation causes the HbS to form fibres.

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..... [3]

DNA profiling can be used in genetic screening programme for chronic diseases like sickle cell anaemia.

Polymerase chain reaction (PCR) is usually carried out before the extracted DNA can be profiled.

**(b)** Suggest why PCR may be needed before the extracted DNA can be profiled.

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..... [2]

To test for the presence of Hb<sup>S</sup>, PCR is carried out on the extracted DNA with two specific primers. The normal-specific primer detects GAG whereas the mutant-specific primer detects GTG.

(c) (i) Describe the role of primers in PCR.

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..... [2]

(ii) Explain how the use of two specific primers allows the detection of the normal, sickle cell anaemia, and SCT genotypes.

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..... [3]

[Total: 10]

**QUESTION 6**

Cancer is a disease in which normal control over cellular processes in humans are lost and malignant tumours formed.

(a) Outline how cancer is caused.

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

The BRCA2 protein is involved in suppressing the development of tumours. It is encoded for by the tumour suppressor gene, *BRCA2*.

(b) Describe the normal role of the *BRCA2* gene.

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..... [3]



**QUESTION 7**

In humans, the control of hair colour involves an epistatic gene interaction.

Allele **M** codes for the production of the pigment eumelanin, which results in black hair. It is dominant to **m**, which codes for the pigment phaeomelanin that results in red hair.

Allele **T** codes for the transporter that is required for the deposition of pigments in hair. Individuals that express the genotype **tt** are unable to deposit pigments and are albinos.

- (a) Explain the term *epistatic gene interaction* in this context.

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..... [2]

- (b) A couple with black hair has three children, each with a different hair colour.  
Draw a genetic diagram to explain these results.

[4]

The cross between two black-haired individuals in part (b) is expected to follow a 9:3:4 ratio.

However, scientists believe that the distribution of people with black hair may be more concentrated towards the equator where black hair offers some protection against the sun's stronger UV rays.

A chi-square ( $\chi^2$ ) test was then carried out on 960 volunteers living at the equator to test this hypothesis.

Table 7.1 shows the distribution of hair colour among these 960 individuals.

(c) (i) Complete Table 7.1 to show the expected numbers of individuals with each phenotype.

**Table 7.1**

hair colour	observed number of individuals	expected number of individuals
black	579	
red	165	
albino	216	

[1]

A chi-square ( $\chi^2$ ) test was carried out to compare the observed results with the expected ratio. The formula for the chi-square ( $\chi^2$ ) test is given as follows:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Table 7.2 is the table of probabilities.

**Table 7.2**

degrees of freedom	probability		
	0.10	0.05	0.01
1	2.71	3.84	6.64
2	4.69	5.99	9.21
3	6.25	7.82	11.35
4	7.78	9.49	13.28



(ii) Using the formula above, calculate the  $\chi^2$  value for the observed results. Show your working clearly.

$\chi^2$  value: ..... [1]

(iii) Explain the conclusion that may be drawn from your  $\chi^2$  value in (c)(ii).

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..... [3]

[Total: 11]

**QUESTION 8**

Photosynthesis is a complex process involving the transfer of light energy into chemical energy. It consists of a light-dependent stage and a light-independent stage.

- (a) Explain the role of proteins involved in the light-dependent stage.

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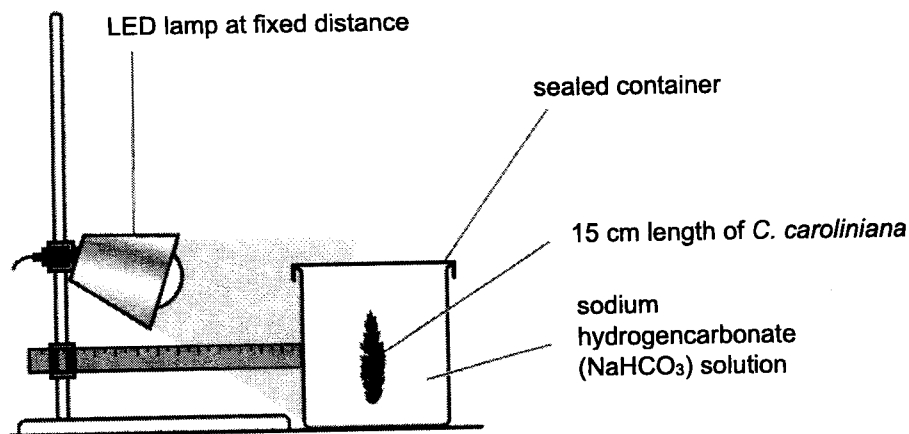
.....

..... [2]

- (b) The rate of photosynthesis is affected by many environmental factors.

A student carried out an experiment to investigate the relationship between the concentration of carbon dioxide available to an aquatic plant, *Cabomba caroliniana*, and its rate of photosynthesis.

Fig. 8.1 shows the experimental set-up for this investigation.



**Fig. 8.1**

The concentration of carbon dioxide was varied using six different concentrations of sodium hydrogencarbonate ( $\text{NaHCO}_3$ ) solution. The rate of photosynthesis was obtained by calculating the percentage change in dissolved oxygen concentration in the solution over five minutes.



- (ii) The percentage change in dissolved oxygen for *C. caroliniana* at  $0.00 \text{ mol dm}^{-3}$  of  $\text{NaHCO}_3$  solution is negative.

Suggest reasons for this negative value.

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..... [2]

- (iii) To minimise temperature changes, the student decided to use an LED lamp as a light source. LED lamps release very little heat energy.

Explain the importance of minimising temperature changes in this experiment.

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

[Total: 11]

**QUESTION 9**

*Bombus pratorum* and *Bombus terrestris* are two British species of bumble bees.

These bumble bees live in colonies founded by a female queen bee who lays eggs. The eggs develop into female worker bees, who collect food (nectar and pollen) and look after the young and the nest.

When the number of worker bees starts to decrease, young queens and males are produced and they mate. The mated queens survive winter underground and start new colonies the following spring.

(a) (i) State why the two bee species share the first name *Bombus*.

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

(ii) Describe how it is possible to confirm, over a long period of time, whether *Bombus pratorum* and *Bombus terrestris* belong to different species.

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..... [2]

Fig. 9.1 shows the number of worker bees of *B. pratorum* and *B. terrestris* observed at one location over a year.

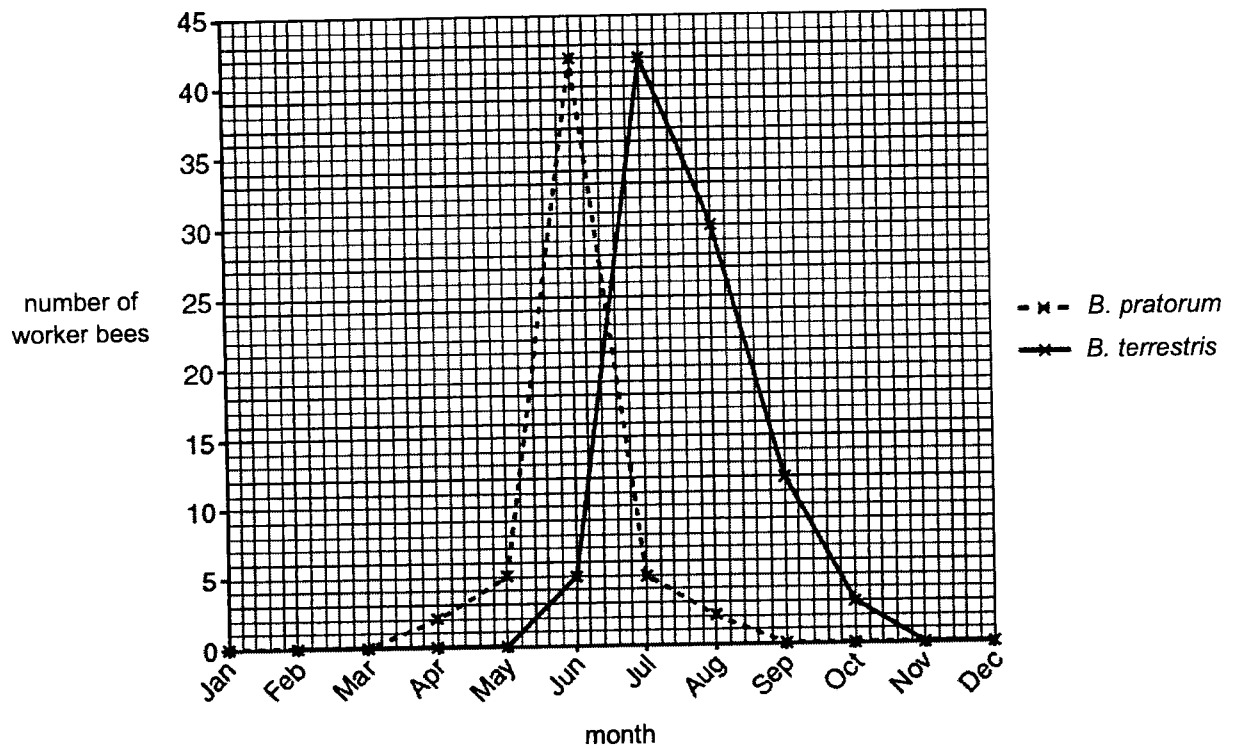


Fig. 9.1

Table 9.1 shows some differences in the food collecting behaviour of worker bees of these species.

Table 9.1

species of bumble bee	mean depth of flower visited / mm	visits to flowers when only nectar is collected / %	visits to flowers when only pollen is collected / %	visits to flowers when both nectar and pollen are collected / %
<i>B. pratorum</i>	7.4	23	10	67
<i>B. terrestris</i>	6.3	80	11	9



**QUESTION 10**

(a) Describe the innate immune response.

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..... [2]

Diseases of the immune system can result in the impairment of the

- innate immune response only
- the adaptive immune response only
- or both.

These patients exhibit distinct differences in their ability to detect and eliminate infections.

Fig. 10.1 shows the microorganism count in three patients, A, B and C with infections over time. Patients A and B have differing impairment to their immune systems while patient C does not.

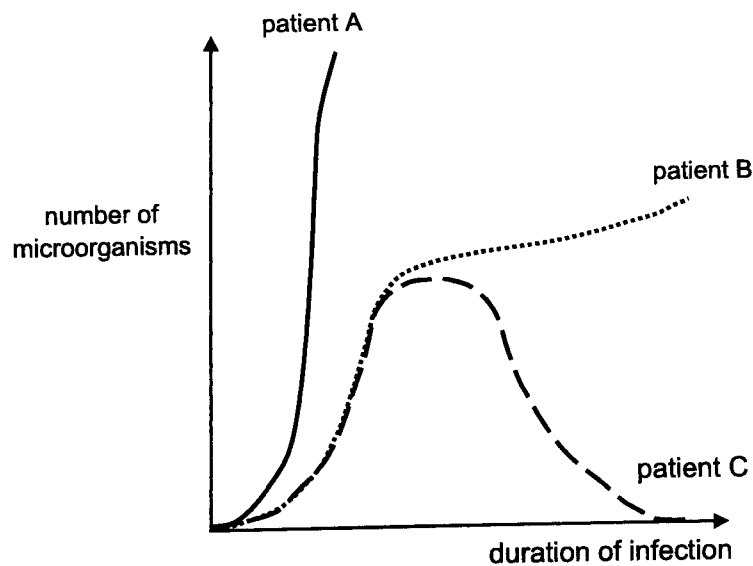


Fig. 10.1



(b) Explain which immune responses are impaired in patients A and B.

patient A .....

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patient B .....

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..... [3]

[Total: 5]

**QUESTION 11**

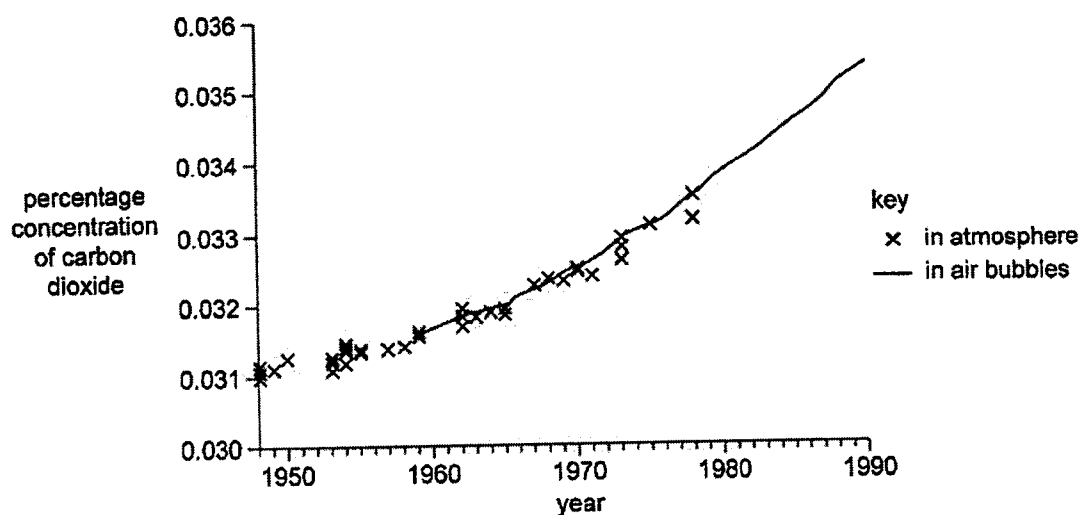
The concept of climate change and global warming has been of concern to scientists for many years.

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**

- (a) 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]

It is possible to estimate past temperatures by analysing the ratio of the hydrogen isotope  $^1\text{H}$  to the hydrogen isotope  $^2\text{H}$  in ice samples. The ratio of the  $^1\text{H}$  to  $^2\text{H}$  increases as the temperature increases.

Fig. 11.2 shows the ratio of  $^1\text{H}$  to  $^2\text{H}$  in ice samples formed over the last 800 000 years and the corresponding atmospheric carbon dioxide concentrations.

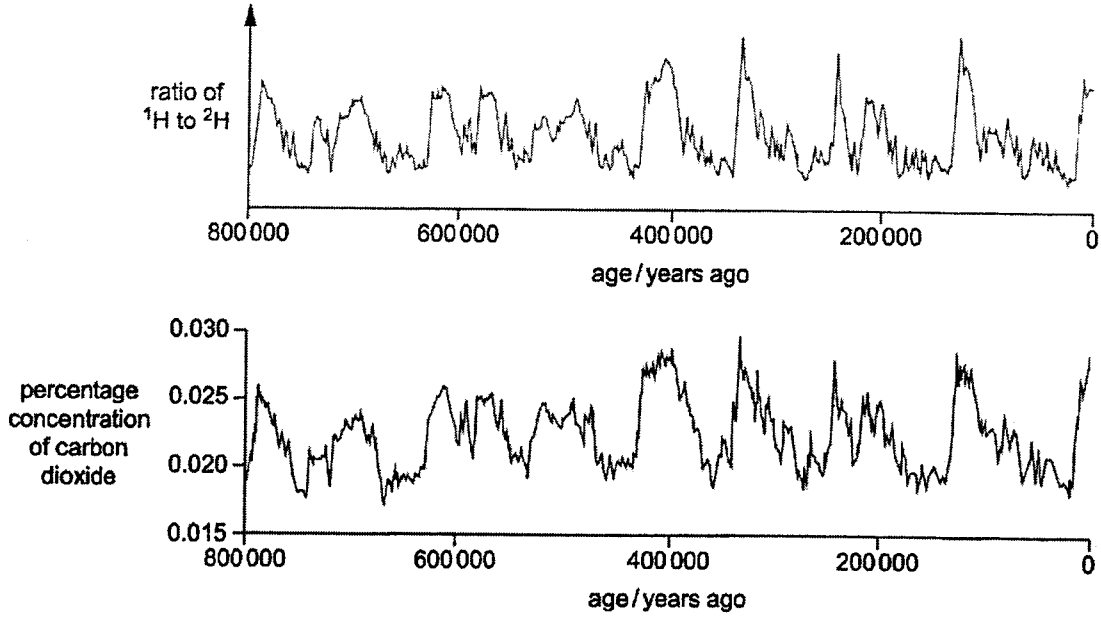


Fig. 11.2

(b) Use Fig. 11.2 to comment on changes in temperature over the last 800 000 years.

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..... [2]

- (c) Explain why the data in Fig. 11.2 do **not** provide enough evidence to conclude that increased concentrations of greenhouse gases cause climate change.

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..... [2]

[Total: 6]

--- END OF PAPER ---

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**HWA CHONG INSTITUTION**  
**JC2 Preliminary Examinations**  
**Higher 2**

CANDIDATE NAME

CT GROUP

21S7 \_\_\_

CENTRE NUMBER




INDEX  
NUMBER



**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.

**INSTRUCTIONS TO CANDIDATES**

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

**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.

**INFORMATION FOR CANDIDATES**

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.

You are reminded of the need for good English and clear presentation in your answers.

For Examiners' Use	
1	/ 30
2	/ 10
3	/ 10
4 or 5	/ 25
<b>Total</b>	<b>/ 75</b>

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

**BOOKLET I**  
**SECTION A**

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

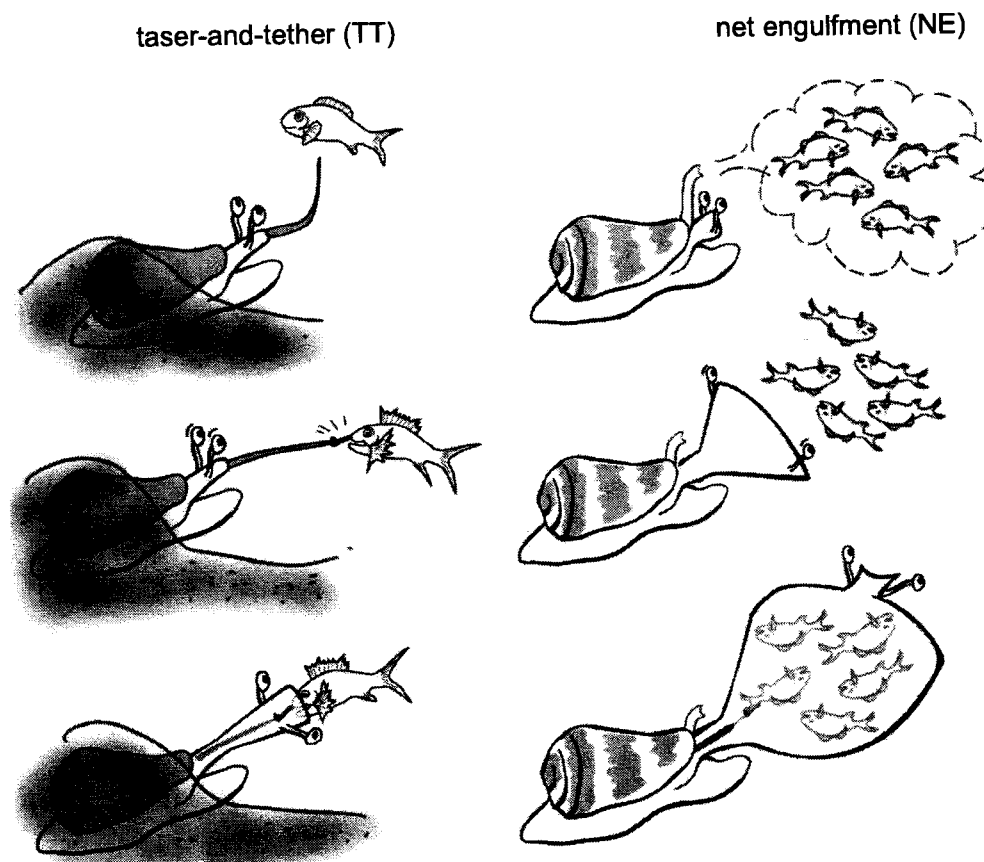
**QUESTION 1**

Tropical cone snails are small, slow-moving marine animals. They are carnivores, which hunt and kill prey that include fish.

Fig. 1.1 shows two different hunting behaviours exhibited by cone snails. Both hunting behaviours use conotoxins that are made up of a cocktail of different types of proteins.

The hunting behaviours include:

- taser-and-tether (TT), where electricity and conotoxins are discharged resulting in instantaneous immobilization of prey
- net-engulfment (NE), where a cloud of conotoxins is released to stun nearby fish and the muscular walls of the rostrum (false mouth) extends out to form a massive funnel to engulf multiple prey fish.



**Fig. 1.1**

(a) Suggest and explain which hunting method is more efficient.

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[3]

The conotoxins bind to the membrane-bound receptors on the muscle cells in fish to immobilise them.

(b) Suggest how a cocktail of proteins instead of a single protein is advantageous for the cone snail.

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[3]

Insulin and  $\rho$ -TIA are two types of proteins commonly found in conotoxins.

(c) Describe how insulin is able to trigger a response inside the muscle cell.

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[4]

$\rho$ -TIA binds to the receptors on the muscle cells preventing the flow of calcium ions into the muscle cells, rendering them ineffective.

To investigate the effects of conotoxins,  $\rho$ -TIA protein was administered on zebrafish to evaluate the escape response of the fish.

Details of the study includes:

- the use of four groups of zebrafish labelled groups 1 to 4
- group 1 zebrafish was administered with different concentrations of unmodified  $\rho$ -TIA protein
- groups 2 to 4 were each administered with different concentrations of modified  $\rho$ -TIA protein, where each group was given  $\rho$ -TIA protein with different amino acid sequences deleted
- the escape response of zebrafish were then recorded where a higher score corresponded to a higher chance of escape.

Fig. 1.2 shows the results of the study.

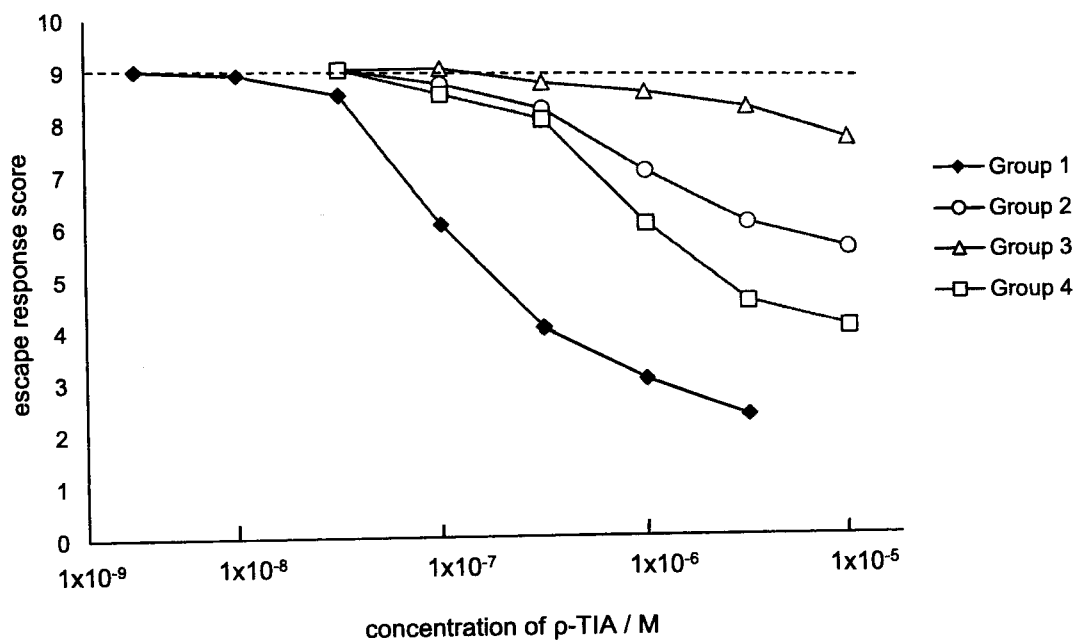


Fig. 1.2

(d) (i) Describe the effect of unmodified  $\rho$ -TIA on the escape response of zebrafish.

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[1]





Marine cone snails are found in tropical marine environments and are particularly prominent around coral reefs and other shallow-water tropical marine habitats. A single coral reef may have over 30 different species of *Conus*.

Fig 1.3 shows:

- (a) the distribution of three common species of cone snails, *C. tulipa*, *C. geographus* and *C. kinoshitai*, which are endemic to the Philippine islands  
 (b) the annual temperature range of the waters around the Philippine islands  
 (c) shells of some cone snails collected around the Philippine islands.

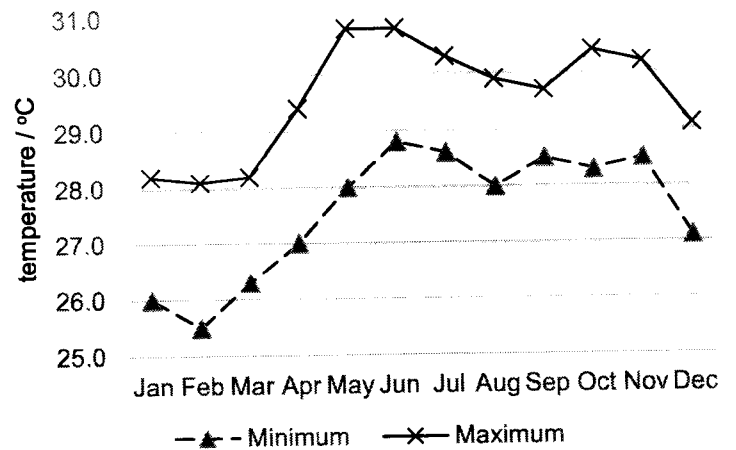
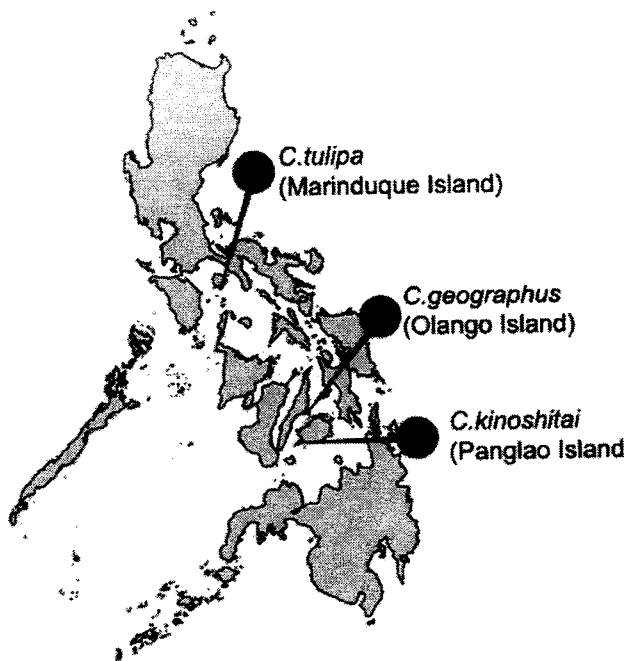


Fig 1.3(a)  
 Fig 1.3(b)

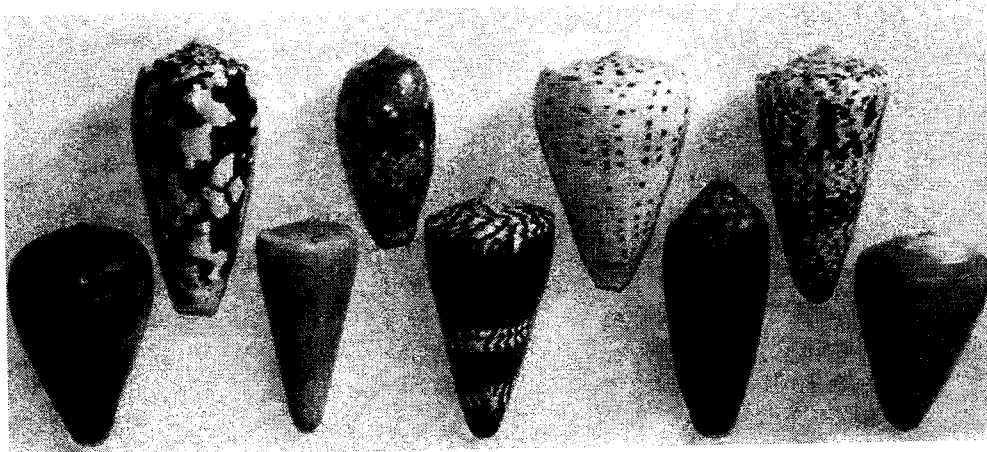


Fig. 1.3(c)

(e) With reference to Fig. 1.3,

(i) suggest reasons for the high number of species found at the coral reefs.

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[2]

(ii) describe and explain the predicted effect of global warming on the distribution of cone snails within the Philippines.

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[4]

(iii) identify one challenge of using morphology to classify cone snails.

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[1]

Fig. 1.4 shows the nucleotide base sequences of a length of DNA from the gene coding for cytochrome protein in six of the closely-related cone snail species found in the Philippine islands.

<i>Conus geographus</i>	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	T	C	T	G	G	A
<i>Conus abbreviatus</i>	G	-	-	-	-	-	-	-	-	-	-	-	-	A	T	C	T	G	G	C	
<i>Conus ammiralis</i>	G	A	C	A	T	G	G	T	A	T	A	T	G	A	T	C	T	G	G	G	
<i>Conus catus</i>	T	A	C	A	T	G	G	A	A	T	A	T	G	A	T	C	T	G	G	A	
<i>Conus auricomus</i>	C	-	-	A	T	G	G	T	A	T	A	T	G	A	T	C	T	G	G	G	
<i>Conus distans</i>	A	A	C	G	T	G	G	A	A	T	G	T	G	A	T	C	C	G	G	A	

Fig. 1.4

- (f) (i) Suggest why it is useful to include gaps as indicated by dashes in Fig. 1.4 when aligning the nucleotide sequences.

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[1]

- (ii) Explain what conclusions can be drawn from the data in Fig. 1.4.

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[3]

- (iii) Explain why there is insufficient evidence from Fig. 1.4 to draw conclusions about the evolutionary relationships between cone snails.

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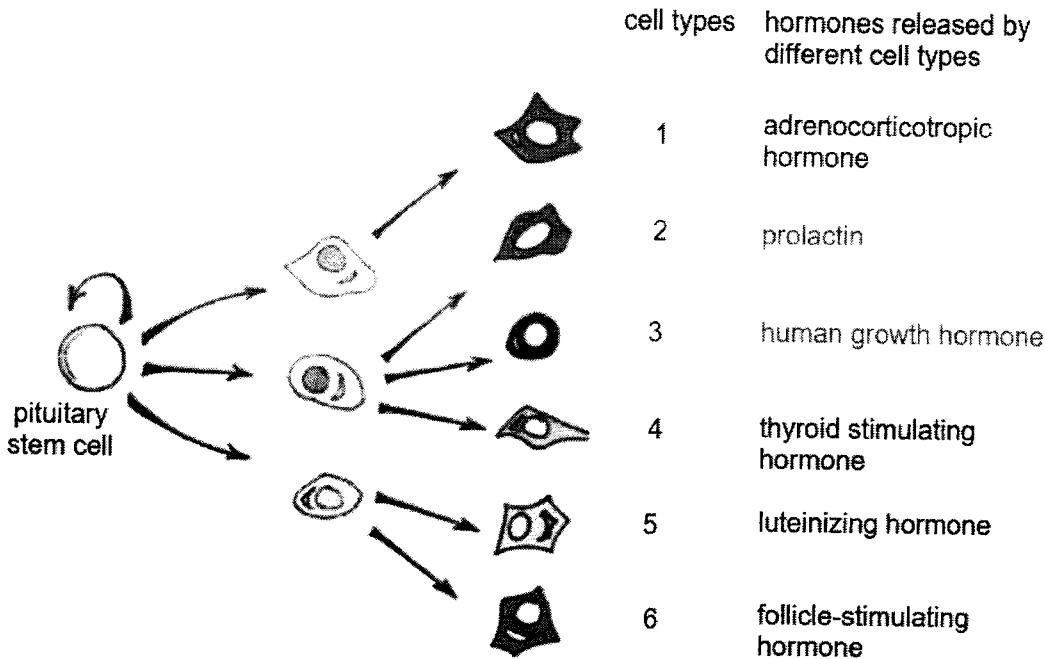
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[2]

[Total: 30]

**QUESTION 2**

Fig. 2.1 shows the terminal differentiation of different cell types derived from a pituitary stem cell.



**Fig. 2.1**

(a) State and explain the potency of the pituitary stem cell in Fig. 2.1.

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[2]

Human growth hormone (hGH) is a peptide hormone that has important roles in growth during childhood. Children who do not produce enough hGH are described as hGH-deficient and grow slower than other children.

Current treatment involves daily injections of hGH to increase growth rate. An alternative treatment still being researched on is stem cell therapy where stem cells carrying the normal allele for hGH is introduced to induce expression in hGH-deficient children.

- (b) Explain how one feature of stem cells enables them to be a possible preferred treatment over hGH injections.

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[2]

hGH is one of many proteins in the body whose secretion or production is controlled by a person's sleep-wake pattern.

The sleep-wake pattern describes when, during a 24 hour day, a person is asleep and when they are awake. For example:

- pattern 1 – asleep during the night and awake during the day (normal)
- pattern 2 – asleep during the day and awake during the night.

Researchers identified genes that have their expression changed by a person's sleep-wake pattern. They collected mRNA from:

- a group of people with sleep-wake pattern 1
- the same group of people whose sleep-wake pattern was changed to pattern 2.

- (c) (i) Suggest why mRNA was collected for this study instead of DNA.

.....  
.....

[1]

A summary of the results is shown in Table 2.1.

**Table 2.1**

sleep-wake pattern	number of genes with increased expression		
	during the day	during the night	all the time
pattern 1	661	733	108
pattern 2	134	95	8

(ii) Describe how changing the sleep-wake pattern from pattern 1 to pattern 2 affects the number of genes expressed.

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[2]

(iii) Explain how light can result in increased or decreased gene expression at certain times of the day.

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[3]

[Total: 10]

**QUESTION 3**

Tuberculosis (TB) is the leading cause of death in people living with HIV globally. Early screening for either TB in HIV patients or HIV in TB patients is important as patients may not exhibit symptoms until at a later stage, resulting in higher mortality rate.

- (a) Explain why symptoms of HIV and TB only appear at the later stages of infection.

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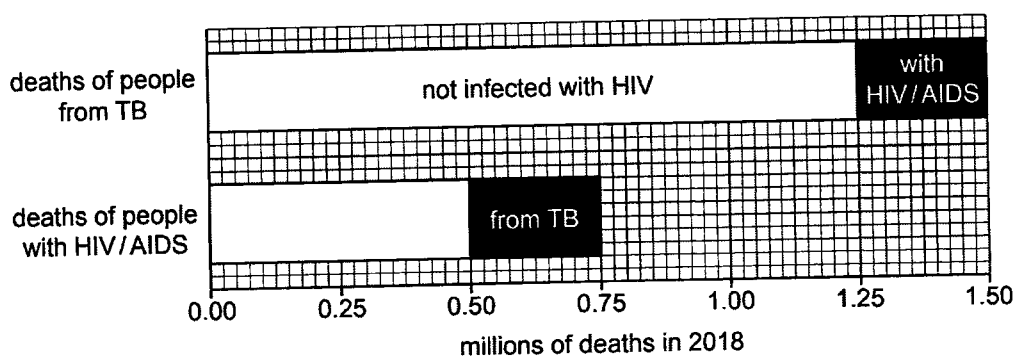
[3]

The World Health Organisation (WHO) introduced a strategy in 2015 to end the global TB epidemic. An important part of the strategy is to:

- identify people at risk of becoming infected with TB
- use methods to prevent transmission of TB.

Four years later in 2019, the World Health Organization (WHO) Global Tuberculosis Report for 2019 published data on the estimated number of deaths from TB and HIV/AIDS in 2018. All deaths of people from TB who were infected with HIV were also counted as deaths of people with HIV/AIDS.

Fig. 3.1 shows these data. The dark grey boxes show the estimated number of deaths of people from TB who were also counted as deaths of people with HIV/AIDS.

**Fig. 3.1**





**SECTION B**

Answer **one** question in this section.

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

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

Your answers must be in continuous prose, where appropriate.

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

**QUESTION 4**

Cell division enables the continuity of life based on the production of different types of cells via mitosis and meiosis. These processes are essential for evolution to occur.

- (a) Compare the behaviour of chromosomes in the two different types of cell division. [15]
- (b) Discuss how the meiotic cell cycle is crucial for evolution to occur.  
[10]

[Total: 25]

**QUESTION 5**

- (a) Compare the processes in which energy is released in aerobic and anaerobic respiration. [15]

Plants are important indicators used by scientists to study the effects of environmental stress caused by climate change.

- (b) Discuss the effects of climate change on the rich biodiversity of plants in the tropics.  
[10]

[Total: 25]



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Lined writing area consisting of multiple horizontal lines for text entry.



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**--- END OF PAPER---**

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9744 H2 Biology / JC2 Preliminary Examinations / Paper 3