NAME : _____ CLASS : _____

JURONG PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination 2023

BIOLOGY
Higher 2

9744/02
29 August 2023

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

Answer **all** questions.

1 Fig. 1.1 shows a diagram of a cell surface membrane.

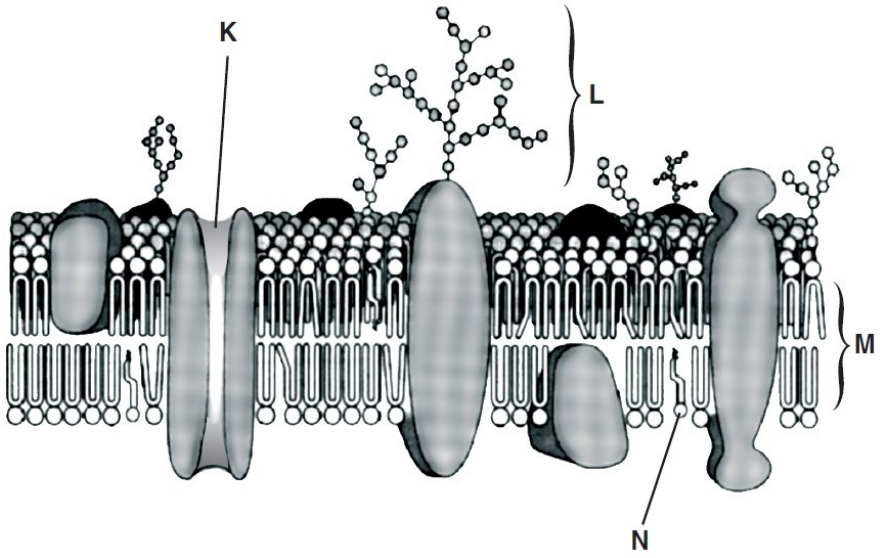

Fig. 1.1

(a) The structure of the cell surface membrane is described as a fluid mosaic.

Explain what is meant by the term *fluid mosaic*.

..... [2]

Fluid:
1. **"Fluid" means that the <u>phospholipids and proteins</u> are free to <u>move</u> within the membrane ;**
2. **Phospholipids are held by weak hydrophobic interactions and hence move about rapidly by diffusion in their own layers ;**

[Max 1]

Mosaic:
3. **Proteins are embedded within the phospholipid bilayer in a random manner ;**

(b) Outline the functions of the following components of the cell surface membrane.

K .....

L .....

M .....

N .....

[4]

1. **K: channel proteins that help to regulate the movement of polar molecules or charged ions across membranes, via facilitated diffusion ;**
2. **L: involved in <u>cell-cell recognition</u> where the carbohydrate chain of (glyco)proteins serves as markers/identification tags, that distinguishes one cell from another ;**
3. **M: the hydrophobic core of membranes acts as a <u>selective barrier</u>, <u>restricting the movement of charged ions or polar molecules across the membrane</u> into the cell ;**
4. **N: maintains membrane fluidity / increases the stability and flexibility of membranes ;**
   OR
5. **N: acts like a plug, reducing the escape or entry of charged ions and small polar molecules through the membrane ;**

(c) In an investigation, animal cells were exposed to different concentrations of glucose. The rate of uptake of glucose into the cells across the cell surface membrane was determined for each concentration.

Fig. 1.2 shows the results.

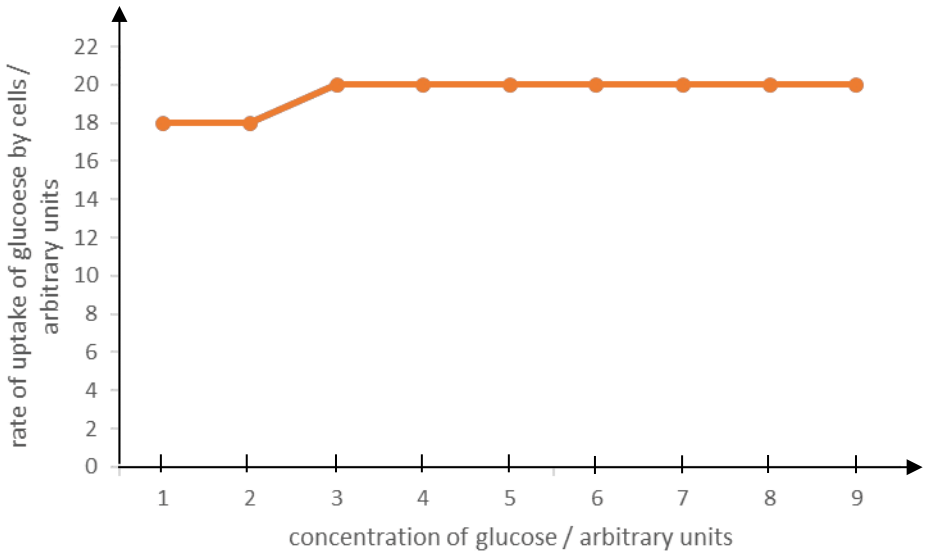

Fig. 1.2

Using the information in Fig. 1.2, explain how the results of the investigation support the idea that glucose enters cells by active transport.

..... [2]

1. **(Active transport because) As concentration of glucose increases from 1 arbitrary unit to 9 arbitrary units, rate of uptake of glucose increases from 18 arbitrary units to 20 arbitrary units and levels off ;**
2. **Rate shown is independent of concentration (except at low concentration) ;**
3. **Not facilitated diffusion because the rate of uptake did not start at 0 arbitrary unit and increase with increasing glucose concentration up to a plateau/constant rate (because no more transport proteins available/all proteins in use) ;**
4. **Not passive diffusion as rate would continue to rise ;**

(d) Active transport also involves other water-soluble substances such as Na^+ and K^+, and the use of ATP to provide the energy needed for their transport through carrier proteins.

Outline **other** features of active transport.

..... [2]

1. **Movement of substances against concentration gradient / from lower to higher concentration ;**
2. **Carrier protein has specific binding site(s) ;**
3. **Binding causes protein to undergo conformational change / change of shape ;**

[Total: 10]

2 Fibroblasts are one of the cell types of connective tissues. The cells synthesise and secrete collagen, which forms part of the supporting external cellular environment, known as the extracellular matrix.

Fig. 2.1 shows the primary structure of a section of a polypeptide chain of collagen.

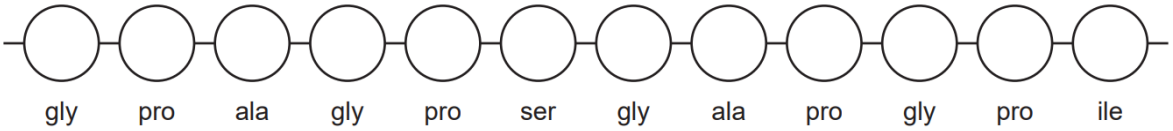

Fig. 2.1

(a) Explain how the primary structure shown in Fig. 2.1 indicates that the structure of the polypeptide is suited to be a component of a collagen molecule.

..... [3]

1. **every third / high proportion of, amino acid in the polypeptide is glycine ;**
2. **glycine is small/smallest amino acid / has H as R-group ;**
3. **glycine allows the (three helical) polypeptides to (lie close together and) form a tight coil, resulting in a tropocollagen/triple helix ;**
   A glycine presence allows a, compact / AW, triple helix
4. **gly (-NH) can form hydrogen bonds with (C=O in pro of) other polypeptides of triple helix ;**
5. **<u>Three helical polypeptides</u> (wind tightly around each other, and) are bound to one another by <u>intermolecular hydrogen bonds</u>, forming a tropocollagen / triple helix ;**
6. **AVP (from CIE) ;**
   pro / ala, also small amino acids (for tight coiling)
   high proportion of smaller amino acids / amino acids with small side chains
   A high proportion of glycine if mp1 not given and mp2 is
   pro can form hydroxyproline for stability
   ref. insoluble and (some), amino acids with non-polar R-groups (e.g. ala)

A: gly for glycine

(b) After final processing in the Golgi body, collagen is released to the outer surface of the cell by exocytosis.

Describe the process of exocytosis.

..... [3]

1. **Secretory vesicles containing collagen (bud off from cisternae at trans face of Golgi body) move towards the cell surface membrane ;**
2. **The membrane of the secretory vesicles <u>fuses</u> with the cell surface membrane ;**
3. **vesicles moved by microtubules / cytoskeleton (to cell surface membrane) ;**
4. **ATP required/active process ;**
5. **releasing insulin out of the fibroblasts via exocytosis.**

(c) Hydrolytic enzymes, known as collagenases, are secreted by cells in an inactive form.

Cells also secrete inhibitors of collagenases. The activity of the enzymes and inhibitors is regulated so that the development and maintenance of the extracellular matrix is controlled.

(i) State and explain what the outcome will be for the composition of the extracellular matrix if collagenase inhibitor activity is needed.

..... [2]

State
1. **collagen continues to be synthesised / released ;**
   A: increase in collagen / maintenance of collagen

Explain
2. **collagen, not broken down / not hydrolysed / breakdown prevented / less hydrolysis ;**
   A: ECM for collagen
3. **collagen does not fit into active site / active site changes shape + no / few enzyme substrate complexes form ;**

(d) Fig. 2.2 is a photograph of two African elephants, *Loxodonta africana*.

Fig. 2.2

The feet of elephants are protected by structures under the skin known as cushions. The cushions are made up of a large number of cells surrounded by connective tissue containing many fibres of collagen. The collagen fibres help to maintain the structure of the cushion.

The cushion in the foot is very strong and is able to resist extremely large forces acting on it due to the large mass of the elephant.

Suggest how the structure of a collagen fibre can help the cushions resist these large forces.

..... [2]

1. **The ends of the parallel tropocollagens are staggered and covalent cross-links form between these ends / the carboxyl end of one tropocollagen and the amino end of another tropocollagen ;**
2. **The out-of-step cross-links lead to the formation of collagen fibrils, leading to <u>greater / high tensile strength</u> to resist these large forces ;**

OR

3. **The covalent cross-linking of tropocollagen molecules form collagen fibril and the collagen fibrils are further assembled to form collagen fibres ;**
4. **Results in structural protein that is flexible but inelastic, resulting in collagen having <u>greater / high tensile strength</u> to resist these large forces ;**

[Total: 10]

3 A tyrosine kinase receptor (TKR) is a protein complex found in the cell surface membrane of mammalian cells.

TKR has two components involved in the process of cell signalling:

- a receptor for the signalling molecule (ligand)
- an enzyme that catalyses the transfer of a phosphate group from ATP to an intracellular protein.

Fig. 3.1 is a diagram to show how TKR is involved in cell signalling.

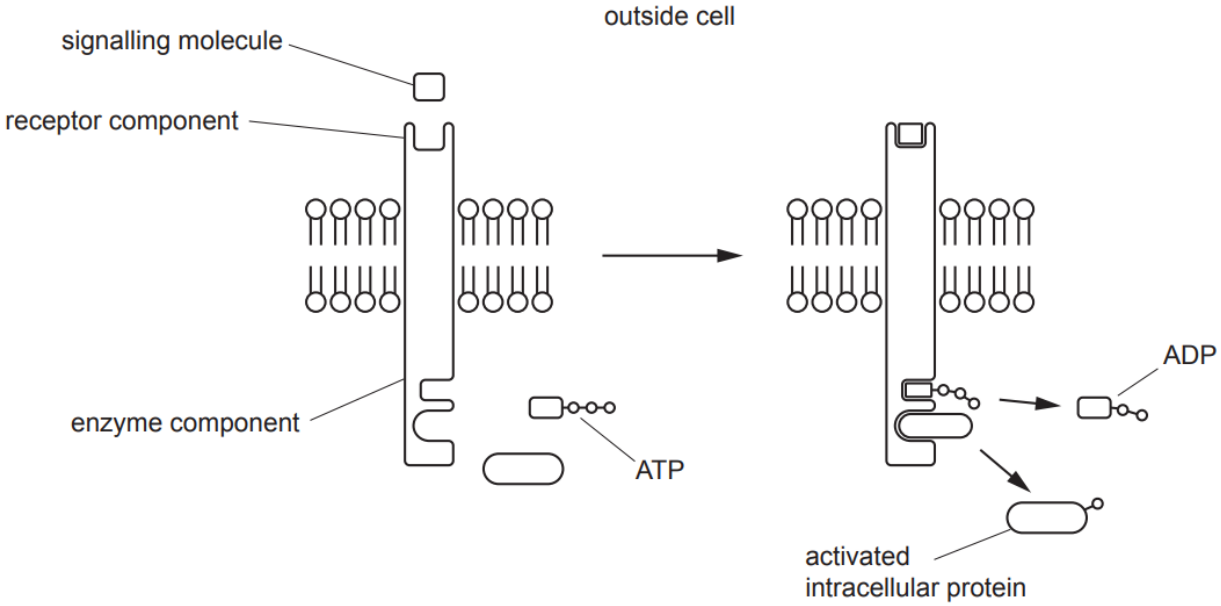

Fig. 3.1

(a) Most enzymes are specific to one reaction.

With reference to Fig. 3.1, state how the structure of an enzyme provides its specificity.

..... [1]

1. Shape / tertiary structure / 3D conformation of active site is complementary to substrate/(intracellular) protein/ATP ;
A: substrate comp to active site

(b) Explain the effect on TKR of increasing temperatures beyond the optimum temperature.

..... [3]

1. **(Beyond the optimum temperature) Heat has disrupted the hydrogen bonds and hydrophobic interactions within the secondary and tertiary structures of TKR ;**
2. **resulting in <u>loss of specific 3D conformation of TKR</u> and its <u>active site</u>, TKR is denatured ;**
3. **The substrate/(intracellular) protein/ATP can no longer bind to the active site of TKR to form enzyme-substrate (E-S) complexes, decreasing the rate of formation of E-S complexes and decreasing the rate of products formed/rate of transfer of a phosphate group from ATP to an intracellular protein ;**

<u>Note</u>: Define enzyme-substrate complex before writing it as "E-S complex".

The drug GNF-5 is used in the treatment of some cancers. GNF-5 affects the activity of TKR by binding to the enzyme component of the complex.

Researchers investigated the effect of GNF-5 on the activity of TKR using different concentrations of ATP solution. In an experiment, the activity of TKR was measured with no GNF-5 **and** with GNF-5.

The results are shown in Fig. 3.2.

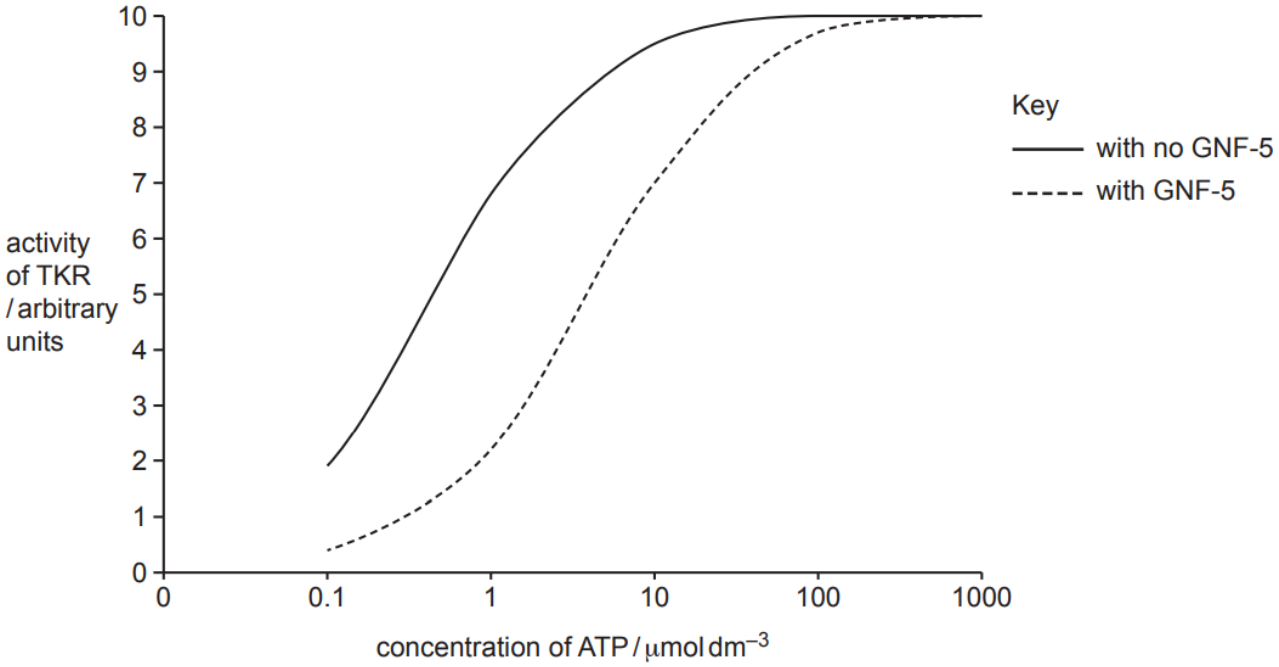

Fig. 3.2

(c) The researchers concluded that GNF-5 acts as an inhibitor of the enzyme component of TKR and that it is a competitive inhibitor.

Use Fig. 3.2 to provide evidence for these conclusions.

..... [3]

1. **At lower concentrations of ATP/substrate, lower rate of activity/ lower activity of TKR with GNF-5 OR at ATP concentrations below 100 µmol dm^{-3}, rate of activity with GNF-5 is always lower than with no GNF-5' ;**
2. **As substrate concentration increases, effect of GNF-5 decreases / effect of GNF-5 can be overcome by high substrate concentration ;**
3. **Maximum activity of TKR / maximum rate of reaction / V_{max} is the same at 10 arbitrary units ;**

accept comparative data quotes to support answers
for ATP concentration, must use µmol dm^{-3} at least once

(d) A mutation of the gene coding for TKR results in changes to the enzyme component of TKR. This altered form of TKR is known as T315L.

The effect of GNF-5 on the activity of T315L was also investigated.

The results of this investigation are shown in Fig. 3.3.

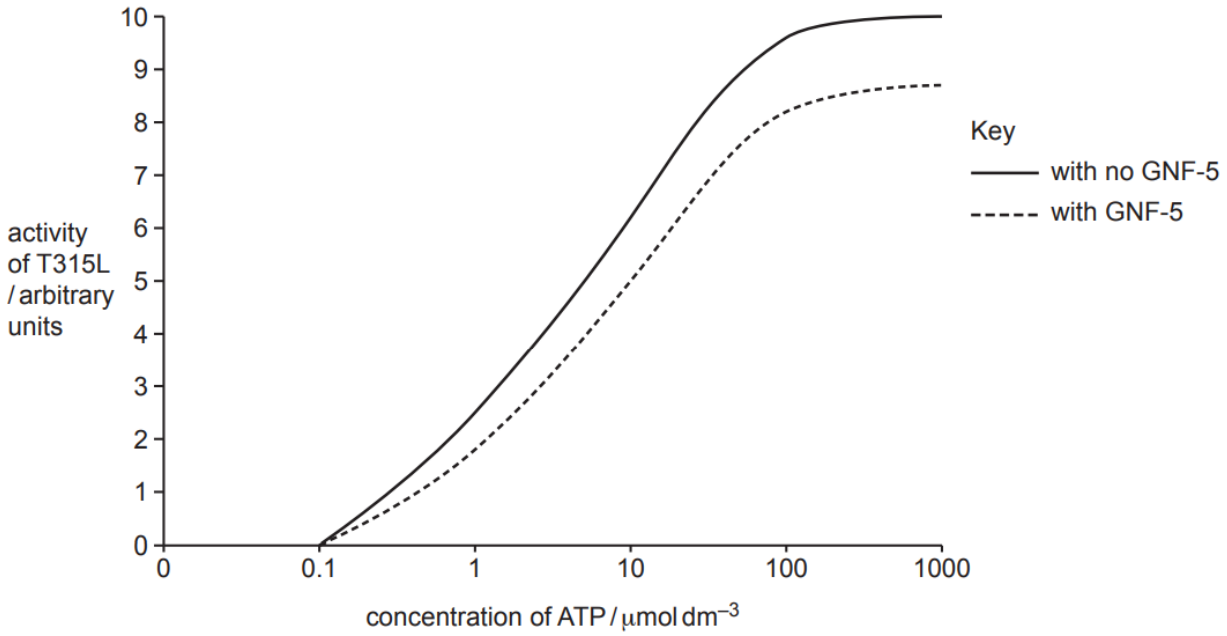

Fig. 3.3

Use Fig. 3.2 and Fig. 3.3 to:

(i) State how the activity of T315L differs from TKR when **no** GNF-5 was present.

..... [1]

1. **When concentration of ATP is 0.1 μmol dm^{-3} , there is no activity for T315L / activity of T315 is lower at 0 arbitrary units while there is activity for TKR / activity of TKR is higher at 2 arbitrary units ;**
   OR
2. **Maximum rate of reaction / V_{max} is reached for T315L at a higher concentration of ATP at 100 μmol dm^{-3} while maximum rate of reaction / V_{max} is reached for TKR at a lower concentration of ATP at 10 μmol dm^{-3} ;**

accept comparative data quotes to support answers
for ATP concentration, must use μmol dm^{-3} at least once

(ii) State how the effect of GNF-5 on T315L differs from the effect of GNF-5 on TKR.

..... [2]

1. **With GNF-5, activity of T315L does not reach maximum rate of reaction/V_{max} while activity of TKR reaches maximum rate of reaction/V_{max} ;**
2. **GNF-5 acts as a non-competitive inhibitor of T315L while GNF-5 acts as a competitive inhibitor of TKR ;**
3. **GNF-5 has less of an effect at low concentrations on activity of T315L while it has more of an effect at low concentrations on activity of TKR ;**

Any 2

accept comparative data quotes to support answers
A: drug, enzymes

[Total: 10]

4 **(a)** Explain the meaning of the terms:

(i) gene

..... [1]

1. **a specific sequence of nucleotides in the DNA which codes for a polypeptide or a RNA ;**

(ii) codon.

..... [1]

1. **a triplet of nucleotides/bases on the mRNA that codes for a specific amino acid;**

(b) Fig. 4.1 shows part of the sequence of events in the assembly of the enzyme lysozyme which consists of 129 amino acids.

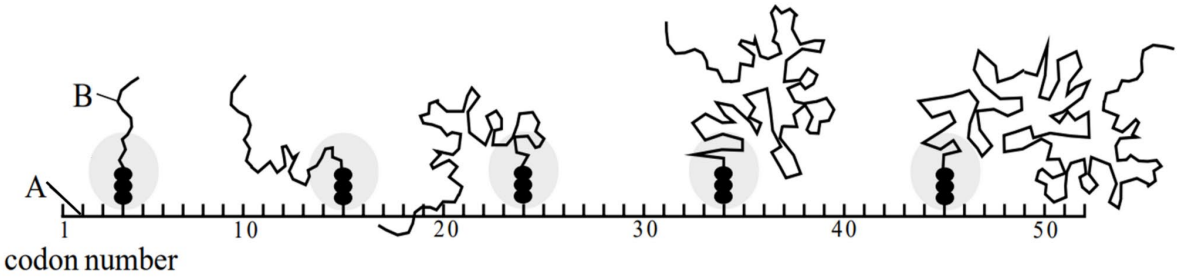

Fig. 4.1

(i) Identify structures **A**, and **B**.

A .....

B .....

[2]

1. **A – mRNA/messenger RNA ;**
2. **B – polypeptide ;**

(ii) Describe how the α-helix of the secondary structure of lysozyme is held together.

..... [1]

1. **maintained by the formation of (intramolecular) hydrogen bonds between the (O of) C=O group and (the H of the) -NH group of every fourth peptide bond ;**

(iii) Describe one reason why ATP is required for assembly of lysozyme.

..... [1]

1. **provide energy for formation of aminoacyl tRNA / joining of tRNA and an amino acid ;**
2. **formation of peptide bonds (between adjacent amino acids by peptidyl transferase) ;**
3. **movement of transport vesicle from rER to Golgi body ;**
4. **required in transcription for the synthesis of RNA ;**

(c) Lysozyme is capable of splitting a polysaccharide found in the bacterial cell wall.

Fig. 4.2 shows the structure of this polysaccharide. Lysozyme catalyses the hydrolysis of the β (1-4) bond between N-acetylglucosamine and N-acetylmuramic acid residues of bacterial cell walls.

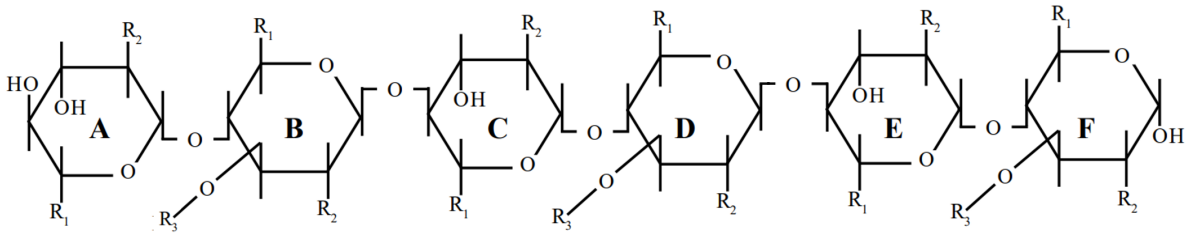

Fig. 4.2

Explain the significance of the assembly process shown in Fig. 4.1 to the activity of lysozyme shown in Fig. 4.2.

..... [4]

1. **During translation, the sequence of bases in lysozyme's mRNA is converted into a sequence of amino acids (in a polypeptide chain) ;**
2. **The primary structure of lysozyme contains information for lysozymes' folding into a specific shape ;**
3. **The polypeptide chain is further bent, coiled and folded extensively to form a specific / precise 3D conformation, (forming a functional lysozyme) ;**
4. **active site present in lysozyme ;**
5. **the specific conformation of the active site confers the specificity of lysozyme ;**
6. **only polysaccharide / substrate of complementary shape / disaccharide of N-acetylglucosamine and N-acetylmuramic acid residues, fits into active site ;**

[Total: 10]

5 Scientists have produced structures known as virosomes, which are used as transport vehicles for cellular delivery of biologically active macromolecules into the cytoplasm of target cells. Biologically active macromolecules are carried in the central area. Virosomes do not cause disease.

Fig. 5.1 is a diagram of a section through a virosome.

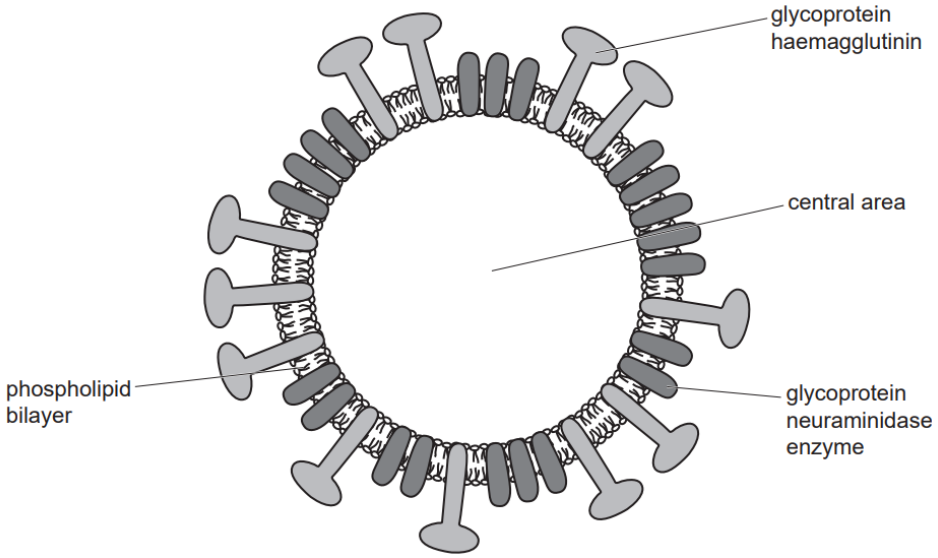

Fig. 5.1

(a) State one difference between the structure of a virosome and an influenza virus.

..... [1]

In virosomes,
1. **no nucleic acid / genetic material / RNA segments ;**
2. **no capsid / protein coat / capsomere ;**

(b) The glycoproteins haemagglutinin and neuraminidase are found in the influenza virus and in the virosomes. Haemagglutinin binds to a receptor in the cell surface membrane of target cells.

Explain how the virosomes deliver biologically active macromolecules into target cells.

..... [3]

1. **The virosome enters the target cells by <u>receptor-mediated endocytosis</u> ;**
2. **whereby <u>the target cell surface membrane invaginates</u> and <u>pinches off</u>, engulfing / placing the virosome in an <u>endocytic vesicle</u> which <u>enters the cytoplasm</u> ;**
3. **<u>Acidification</u> causes the <u>virosome phospholipid bilayer</u> to <u>fuse</u> with the <u>endocytic vesicle membrane</u>, releasing the contents / biologically active macromolecules ;**

(c) In influenza virus, neuraminidase removes parts of the host cell receptors that bind to haemagglutinin. This helps newly-formed viruses to leave host cells.

Drugs have been developed to act on neuraminidase. These drugs prevent viruses from leaving host cells.

Suggest and explain how these drugs act to prevent viruses leaving cells.

..... [3]

1. **Drugs can be inhibitors of neuraminidase ;**
2. **Competitive inhibitor enters and binds to the active site and competes with the substrate for binding at the enzyme's active site ;**
   OR
   Non-competitive inhibitor binds to allosteric site and enzyme's 3D conformation is changed such that the conformation of its active site is altered and the substrate can no longer bind to the enzyme's active site ;

   (SEPARATE POINT! ANOTHER ROLE OF DRUGS! NOT INHIBITOR ROLE ANYMORE)
3. **Drugs may act by breaking down / hydrolysing neuraminidase / disrupting the bonds within the secondary and tertiary structures of neuraminidase resulting in <u>loss of specific 3D conformation of enzyme</u> and its <u>active site</u>, neuraminidase is denatured and substrate can no longer bind to the enzymes' active site ;**

4. **no / less enzyme-substrate complexes formed ;**
5. **Host cell receptor is (still) complementary to haemagglutinin and haemagglutinin remain attached to the receptor (so newly formed virus does not leave the cells) ;**

   Pt 1/3 and Pt 5 compulsory

(d) The number of cases of influenza is reported to the World Health Organization (WHO) by countries throughout the world so that global data are collected. Fig. 5.2 shows the global data collected between January 2008 and December 2012.

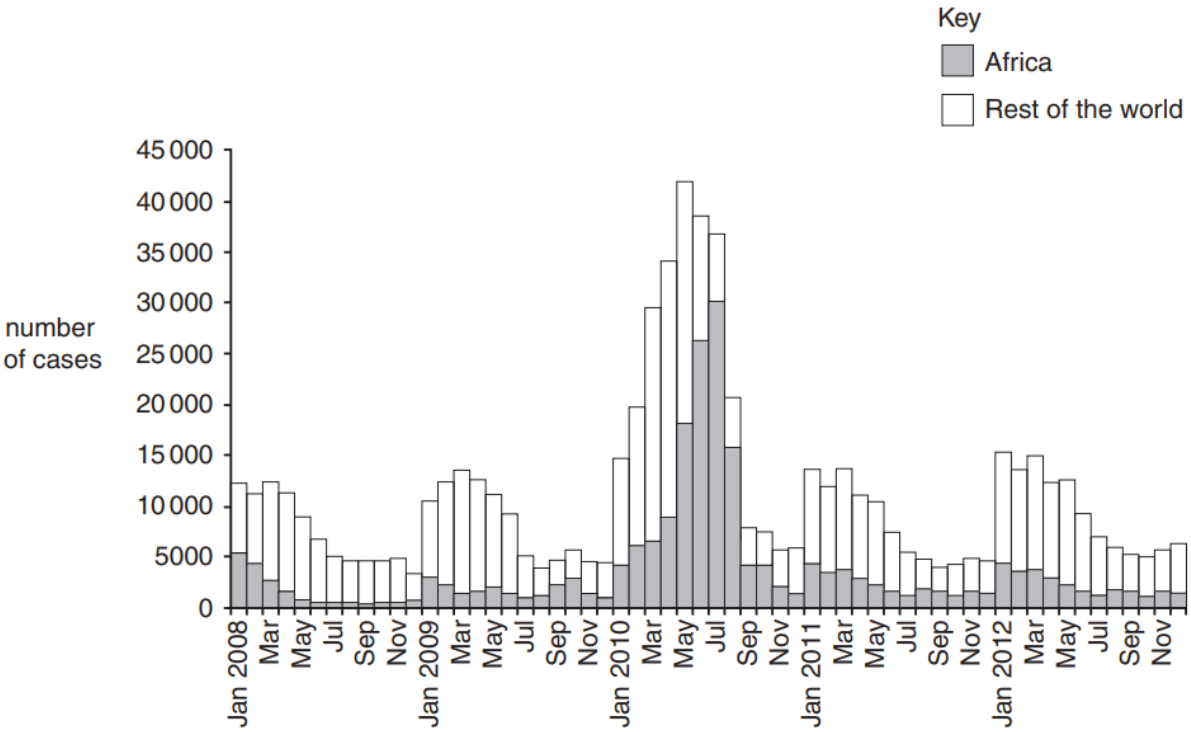

Fig. 5.2

Use the data in Fig. 5.2 to describe the pattern shown in the number of cases of influenza reported to the WHO between January 2008 and December 2012.

..... [3]

1. **number of cases fluctuates between 2008 to 2012 / in all years ;**
2. **number of cases (much) higher in 2010 ;**
3. **highest number of cases in 2010, 42 000 – 43 000 cases ;**
   - **24 000 cases in April 2010 in rest of the world**
   - **30 000 cases in July 2010 in Africa**
4. **numbers are higher at beginning of each year (than at end) ;**
5. **five outbreaks /peaks ; A four as no data before Jan 2008**
6. **numbers of cases in rest of world are greater than in Africa in every year except 2010 / numbers of cases in Africa were less than in the rest of the world in every year except 2010 ;**

[Total: 10]

6 The polymerase chain reaction (PCR) is used to produce large amounts of DNA from a very small original sample. The main stages of a PCR are shown in Fig. 6.1.

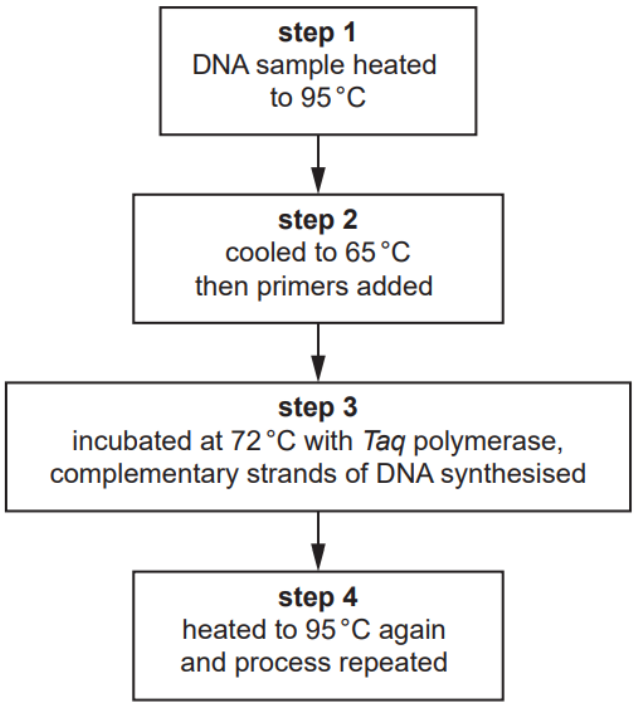

Fig. 6.1

(a) **(i)** Explain why the DNA sample is heated to 95 °C in **step 1**.

..... [2]

1. **To separate the two strands /denature DNA ; A make single-stranded DNA**
2. **by breaking hydrogen bonds between complementary bases of double-stranded DNA ;**
3. **so that bases are exposed to produce template strands for (complementary) copying ;**

(ii) Explain why primers are added in **step 2**.

..... [2]

1. **Primer binds/anneals to (single-stranded) DNA by complementary base pairing ;**
2. **idea of attaching close to the specific section of DNA i.e. at the 3' end of target sequence OR <u>mark out the section of DNA</u> / <u>start</u> and the <u>end</u> of the <u>target sequence to be amplified</u> ;**
3. **Primers provide a <u>free 3' –OH end</u> for *Taq* polymerase to add deoxyribonucleotides/dNTPs to elongate a new strand of DNA ;**
4. ~~**(DNA) polymerase only attaches to double-stranded DNA ;**~~
5. **(primers) reduce re-annealing of separated strands ;**

(iii) Explain why the enzyme *Taq* polymerase is used in **step 3**.

..... [2]

1. **<u>synthesises complementary DNA strands / rest of the new strand of DNA</u> by adding dNTPs and catalysing the formation of phosphodiester bonds between adjacent dNTPs ;**
2. **(Taq polymerase), is heat stable/works at high temperature ;**
3. **(so) does not need to be added again for each cycle / needs replacing only after a number of cycles OR other polymerases need replacing regularly ;**
4. **process is, more efficient / faster (than normal DNA polymerase) ;**

(b) After an organism dies, its DNA gradually breaks down. However, cells in bones that were buried hundreds of years ago may still yield small amounts of DNA that can be extracted, amplified using PCR and then analysed. Mitochondrial DNA (mtDNA) is often used because there are usually more than 100 copies of it in one cell, compared with only two copies of nuclear DNA.

For example, in 1994, mtDNA from bones that had been found in a grave in Russia was analysed to confirm that these were the remains of the royal family, who were known to have been killed in 1918. The mtDNA extracted from the bones was compared with the mtDNA from a living relative of the family.

The family tree of the Russian royal family and some of their relatives is shown in Fig. 6.2.

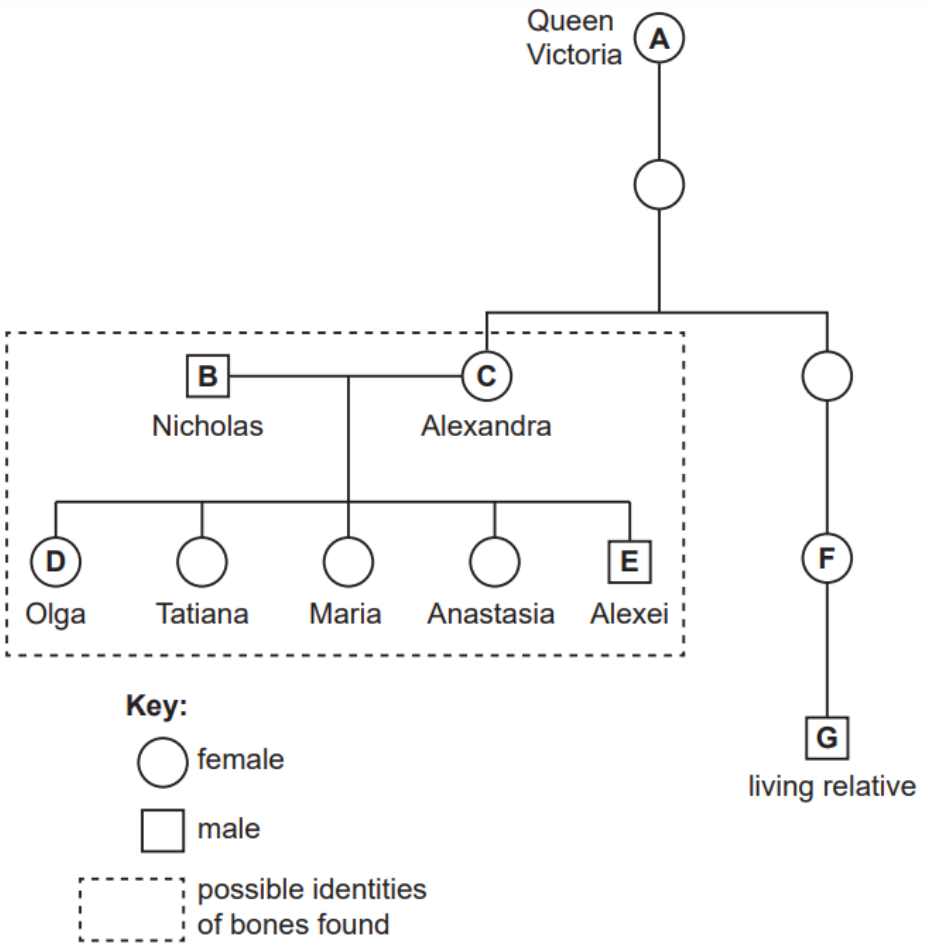

Fig. 6.2

(i) Explain why there are usually more than 100 copies of mtDNA in a cell, but only two copies of nuclear DNA.

..... [2]

1. **many mitochondria per cell but only one nucleus ;**
2. **cell is diploid / has two copies of each chromosome (in nucleus) ;**

(ii) All of the mitochondria in a zygote come from the egg, not the sperm.

List the **letters** of the people in the family tree in Fig. 6.2 who would be expected to have mtDNA identical to the mtDNA of the living relative, **G**.

..... [1]

1. **A, C, D, E, F ;**

(c) Despite the widespread application of PCR, the technology still has some limitations. Outline one limitation of PCR.

..... [1]

1. **Too sensitive as a minute amount of contaminant DNA which contain a sequence complementary to the primers can be amplified, leading to misleading result ;**
2. **Prior information of the target DNA sequence is required in order to design specific primers for selective amplification of the target DNA ;**
3. **Size range of the DNA fragments that can be amplified / cloned is limited to 0.1 - 5 kb ;**
4. **There is infidelity of DNA replication as Taq polymerase has no proofreading function ;**

[Total: 10]

7 (a) Fig. 7.1 is a photomicrograph of animal cells in stages of the mitotic cell cycle.

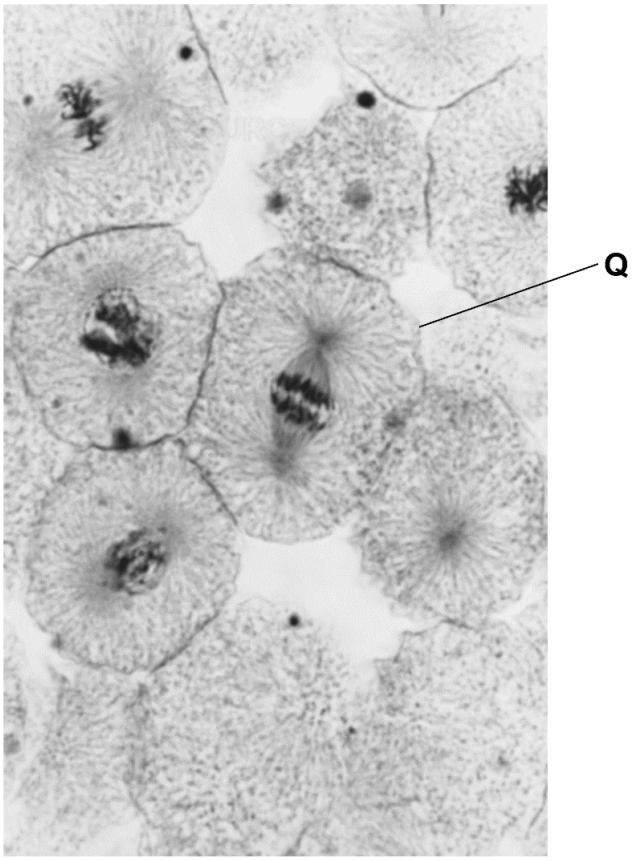

Fig. 7.1

(i) Name the stage of mitosis shown in cell Q.

..... [1]

1. anaphase ;

(ii) Outline the roles of mitosis in a healthy animal.

..... [2]

1. (compulsory) production of genetically identical daughter cells ;

2. growth ;
R growth of cells repair of tissues (by replacement of cells) ;
3. replacement of, old / dead /damaged / worn out, cells ;

R: asexual reproduction

(b) Uncontrolled mitosis can cause cancer in humans.

Paclitaxel is a drug used in the treatment of some forms of cancer.

Researchers investigated the effect of Paclitaxel on the mitotic cell cycle of cancer cells.

- The cancer cells were grown for two days and then divided into groups.
- Each group was treated with a different concentration of Paclitaxel.

After 28 hours (one cell cycle):

- the percentage of cells in stages of mitosis was calculated.
- the ratio of the number of cells in anaphase to the number of cells in metaphase was determined.

The results of the investigation are shown in Fig. 7.2.

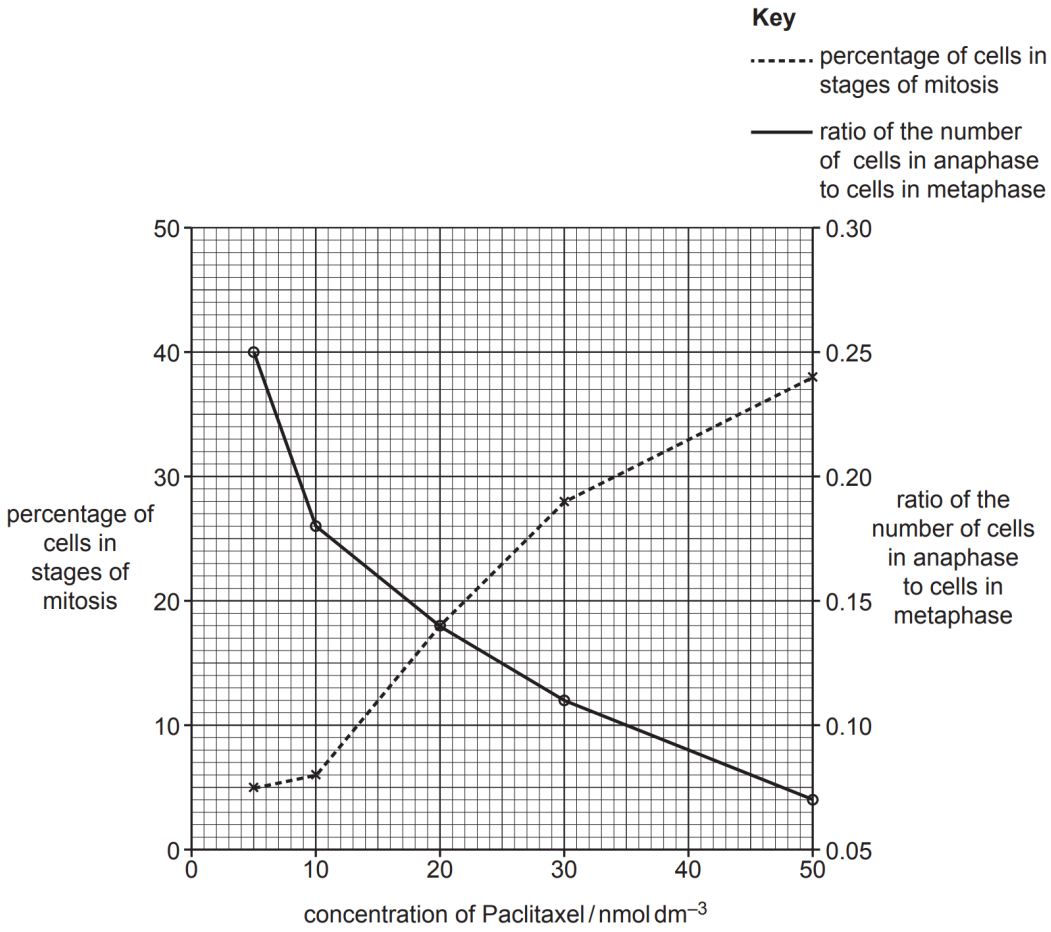

Fig. 7.2

With reference to Fig. 7.2, describe the results and suggest an explanation for the effect of Paclitaxel on the mitotic cell cycle.

..... [4]

Describe (max 3)

1. **as concentration of Paclitaxel increases, the ratio of cells in anaphase to those in metaphase decreases ;**
2. **as the concentration of Paclitaxel increases, the percentage of cells in mitosis increases ;**
3. **use of data to support a described trend ;**
   5 nmol dm^{-3} Paclitaxel, 5% of cells in stages of mitosis, 50 nmol dm^{-3} Paclitaxel, 38% of cells in stages of mitosis /
   5 nmol dm^{-3} Paclitaxel, 0.25 cells in anaphase to cells in metaphase, 50 nmol dm^{-3} Paclitaxel, 0.07 cells in anaphase to cells in metaphase

Explanation

4. **(idea of) as concentration of Paclitaxel increases, more cells stop in metaphase / spend more time in metaphase / fewer cells are able to move into anaphase ;**

Suggested mechanism for halt in metaphase (max 1)

5. **centromeres do not divide ;**
6. **prevents spindle fibres shortening ;**
7. **prevents movement of chromatids to opposite poles (because sister chromatids still held together) ;**
8. **cells do not pass the (metaphase) checkpoint ;**

(c) Multiple myeloma is a type of cancer in the bone marrow where some of the stem cells start to produce abnormal blood cells.

Some treatments available are stem cell transplantation, immunotherapy and chemotherapy.

(i) In stem cell transplantation, stem cells are collected from the bone marrow of the person with multiple myeloma. Healthy stem cells are isolated and grown in the laboratory. Radiation is then used to destroy all stem cells and cancerous cells in the bone marrow. Finally, large numbers of the healthy stem cells grown in the laboratory are returned to the bone marrow.

Suggest the role of stem cells in this treatment of multiple myeloma.

..... [3]

1. **Stem cells (grown in the lab) can undergo mitosis / divide ;**
2. **Stem cells are undifferentiated / unspecialised ;**
3. **(when back in the person being treated) stem cells can differentiate / specialise, into (all) <u>blood cell</u> types ;**
   A: are multipotent
4. **To re-populate / replace / bring back to normal levels, the person's own <u>blood cell</u> supply ;**
   A: tissue repair

[Total: 10]

8 Two unlinked genes control the production of yellow flavone pigment in petals of Dahlia flowers. The petal colour also depends on the degree of hydroxylation of colourless precursor of the flavone pigment.

The dominant allele, **A**, of one gene produces dark yellow pigment due to higher degree of hydroxylation by the gene product. No pigment is produced by the recessive allele, **a**. The dominant allele, **B**, of the second gene produces a light yellow pigment due to lower degree of hydroxylation by the gene product. The recessive allele, **b**, has no hydroxylation effect.

When no yellow pigment is produced the petals are white.

This is an example of dominant epistasis.

(a) Explain the term dominant epistasis in this context.

..... [3]

1. **The petal / flower colour is controlled by <u>two genes</u> (gene A/a and gene B/b) occupying different loci ;**
2. **when gene A/a contains a copy of allele A at the gene loci, it hides the effect of gene B/b, <u>A_ is epistatic over the B/b locus</u> ;**
   OR
3. **when a copy of dominant allele A is at the gene loci, it hides the effect of gene B/b, <u>A_ is epistatic over the B/b locus</u> ;**
4. **A copy of dominant allele A results in dark yellow petals / flower (A _ _ _), a copy of dominant allele B (aa B _) results in light yellow petals / flower, homozygous for the recessive allele at gene B/b (aa bb) results in white petals / flower ;**

(b) Plants with the genotypes **AABB** and **aabb** were crossed and the resulting F1 generation was test-crossed.

Draw a genetic diagram of the test-cross to show the genotypes and phenotypes of the parents and offspring.

State the ratio of phenotypes of the offspring.

Parental/F1 phenotypes: **dark yellow flower** **X** **white flower**

Parental/F1 genotypes: **AaBb** **X** **aabb** ;

Gametes **(AB)** **(Ab)** **(ab)** **(aB)** **(ab)** ;

Fertilisation:

	(AB)	**(aB)**	**(Ab)**	**(ab)**
(ab)	**AaBb**	**aaBb**	**Aabb**	**aabb**

Offspring/F2 genotype : **AaBb** **Aabb** : **aaBb** : **aabb** ;

Offspring/F2 phenotype : **dark yellow flower** : **light yellow flower** : **white flower** ;

2 dark yellow flower : 1 light yellow flower : 1 white flower ;
ratio of phenotypes ..... [5]

(c) Explain why it would be useful to carry out a chi-squared test on these results. No calculations are required to answer this question.

..... [2]

1. **to determine if the <u>observed results</u> (2:1:1) are <u>significantly different</u> from the <u>expected results</u> (1:1:1:1) ;**
2. **to estimate the <u>probability</u> that differences between observed and expected results were <u>due to chance</u> ;**

[Total: 10]

9 (a) Fig. 9.1 is a diagram of a section through a mitochondrion.

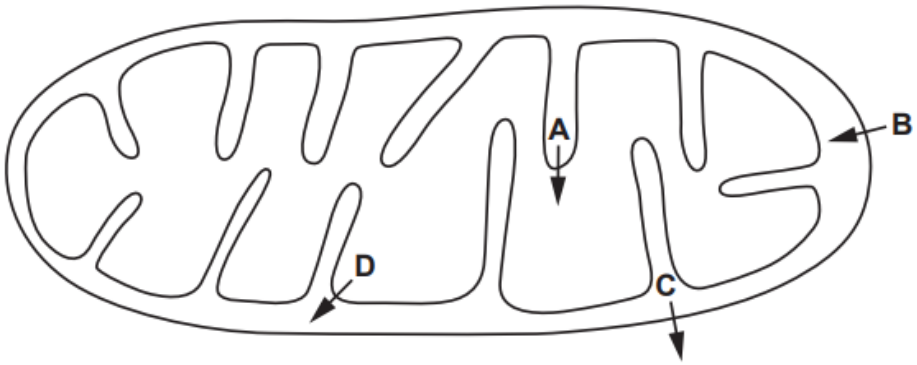

Fig. 9.1

The four arrows, **A**, **B**, **C** and **D**, show the movement of molecules and ions.

Use the letters to identify all the arrows that show:

(i) active transport of protons

..... [1]

D

(ii) diffusion of carbon dioxide.

..... [1]

C & D

(iii) Name two molecules, other than coenzymes, that are found in the mitochondrial matrix and explain their role in aerobic respiration. [3]

..... [2]

1. **pyruvate, for link reaction to form acetylCoA / to form NADH / be dehydrogenated ;**
2. **enzymes to catalyse, link reaction / Krebs cycle ;**
3. **oxygen, to combine with electrons and protons to form water ;**
4. **DNA / RNA / 70s ribosomes, to form cytochrome oxidase / ATP synthase / electron carriers ;**
5. **oxaloacetate to, accept acetyl / form citrate ;**
6. **citrate to, form reduced NAD / be dehydrogenated ;**
7. **water as a, solvent / medium for reactions ;**

(b) Some factory workers in the early 20th century were exposed to chemical X and experienced serious side-effects.

Chemical X increases the permeability of the inner mitochondrial membrane to protons, causing some protons to leak out into the matrix.

(i) Explain why people exposed to chemical X show decreased production of ATP.

..... [1]

1. smaller / less steep, proton gradient ;
2. fewer protons diffuse through ATP synthase ;

(ii) Suggest and explain why chemical X causes increased production of pyruvate and lactate.

..... [1]

Increase production of pyruvate
1. ATP required for cell metabolism, less ATP produced via OP, hence faster / increase, rate of glycolysis ;
+
Increase production of lactate
2. More / increase, anaerobic respiration to regenerate NAD for glycolysis ;

(c) Describe one difference between the process of chemiosmosis in mitochondria and the process of chemiosmosis in chloroplasts.

..... [1]

	feature	**mitochondria**	**chloroplast**	
1.	**process**	**oxidative phosphorylation**	**photophosphorylation**	**;**
2.	**location**	**takes place at the inner mitochondrial membrane / crista(e)**	**takes place at the thylakoid membrane**	**;**
3.	**source of protons**	**reduced NAD / reduced FAD, give H+ / e-**	**photolysis of water / PS1 / special chlorophyll a, give H+ / e- ;**	**;**
4.	**electrochemical gradient of protons**	**H+ accumulates in intermembrane space**	**H+ accumulates in thylakoid, lumen / space**	**;**
5.	**final electron acceptor**	**Oxygen**	**NADP**	**;**
6.	**end product**	**formation of water**	**reduced NADP**	**;**

(d) In an experiment on respiration, two different populations of yeast cells were used: A and B.

- Yeast cells in population A had no mitochondria in their cells.
- Yeast cells in population B had mitochondria in their cells.

Both populations were provided with glucose in solution and the concentration of ATP was measured every minute for seven minutes.

Fig. 9.2 shows the results of the experiment.

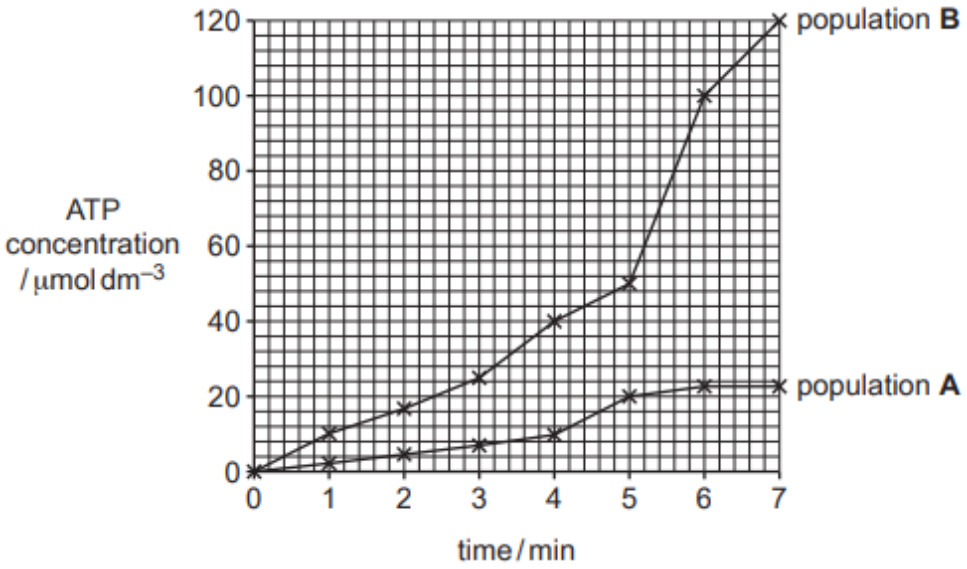

Fig. 9.2

Describe and explain the differences in results between population A and population B, as shown in Fig. 9.2.

..... [3]

Describe

1. **Population B produces more ATP than population A + (Paired data quote) 120 μmoldm^{-3} vs 22 μmoldm^{-3} ;**
2. **Production of ATP increases at a higher rate for population B than for population A ;**

Explain

3. **population B carries out, glycolysis / substrate level phosphorylation and oxidative phosphorylation ;**
4. **population A only carries out, glycolysis / respiration in anaerobic conditions / ethanol fermentation / substrate level phosphorylation ;**
   OR
5. **population A cannot carry out oxidative phosphorylation ;**

[Total: 10]

10 Tuberculosis (TB) and influenza are examples of infectious diseases.

(a) Name a species of organism that causes TB.

..... [1]

1. ***Mycobacterium tuberculosis*** **;**

(b) B-lymphocytes are activated to form plasma cells during immune responses.

Antibodies can be collected from human blood donors and used to treat people that may have been infected with a pathogen. This prevents them becoming ill with the disease.

Explain why this treatment does not prevent people becoming ill if they are infected again with the same pathogen.

..... [4]

1. **artificially acquired passive immunity ;**
2. **antibodies are, broken down (in the body / blood) ;**
   R: 'antibodies die', A: OWTTW
3. **no immune response developed, no long-term / only temporary, immunity ;**
   I primary / secondary
   A: no formation of immunological memory
4. **memory cells not produced ;**
   A: memory cells only produced, in active immunity / during an immune response / after presentation of antigen
5. **no, clonal selection / clonal expansion / antibodies produced ;**

[Total: 5]

11 Fig. 11.1 shows how climate change has resulted in changes in the global average temperature, sea level and snow cover in the Northern Hemisphere over the years.

The changes are reflected as difference from the 1960 – 1990 average and also as absolute changes, except for the global average sea level.

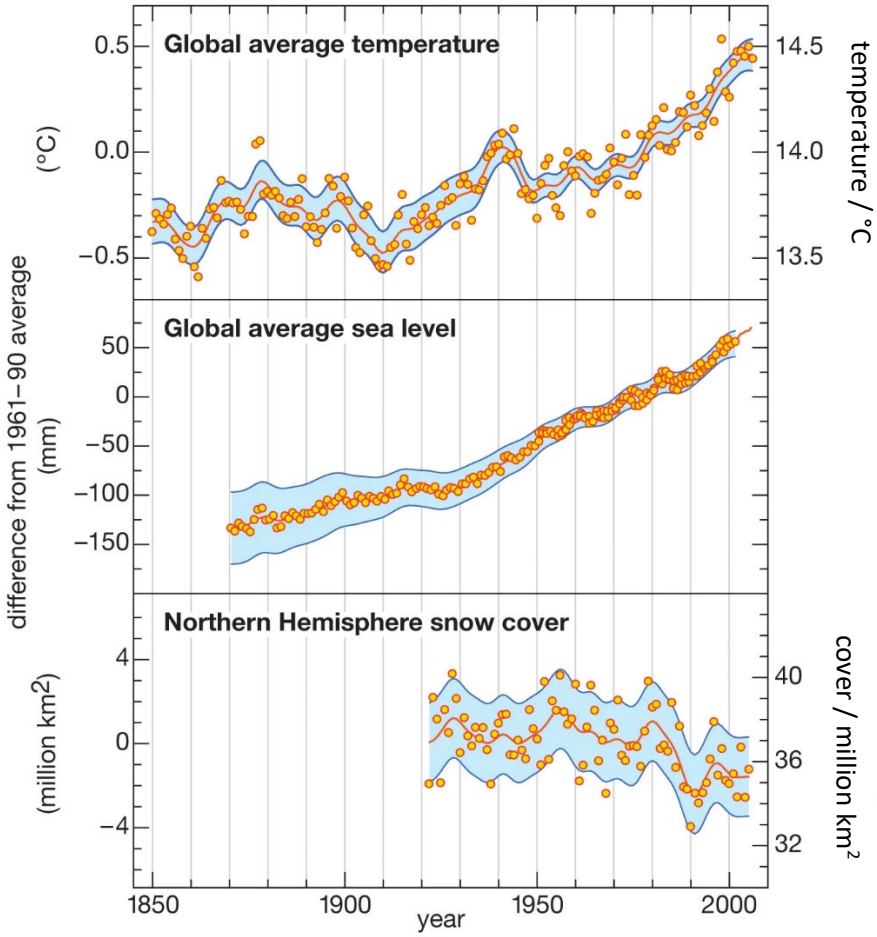

Fig. 11.1

(a) With reference to Fig. 11.1, suggest how the increase in global mean temperature has affected the global average sea level and the extent of Northern Hemisphere snow cover over the years.

..... [2]

1. **Increase in global mean temperature (13.7°C to 14.5°C) has resulted in a decrease in Northern Hemisphere snow level (37 million km^2 to 35 million km^2) and an increase in global average sea level ;**
2. **This is because increase in the global mean temperature caused the melting of the Northern hemisphere snow cover ;**
3. **Global average sea level rises due to the thermal expansion of water and melting of the Northern hemisphere snow cover ~~and associated reduction in surface albedo~~ ;**

The graphs in Fig. 11.2 showed the annual change in latitude and depth of 140 marine species along the north-eastern United States coast and in the eastern Bering Sea.

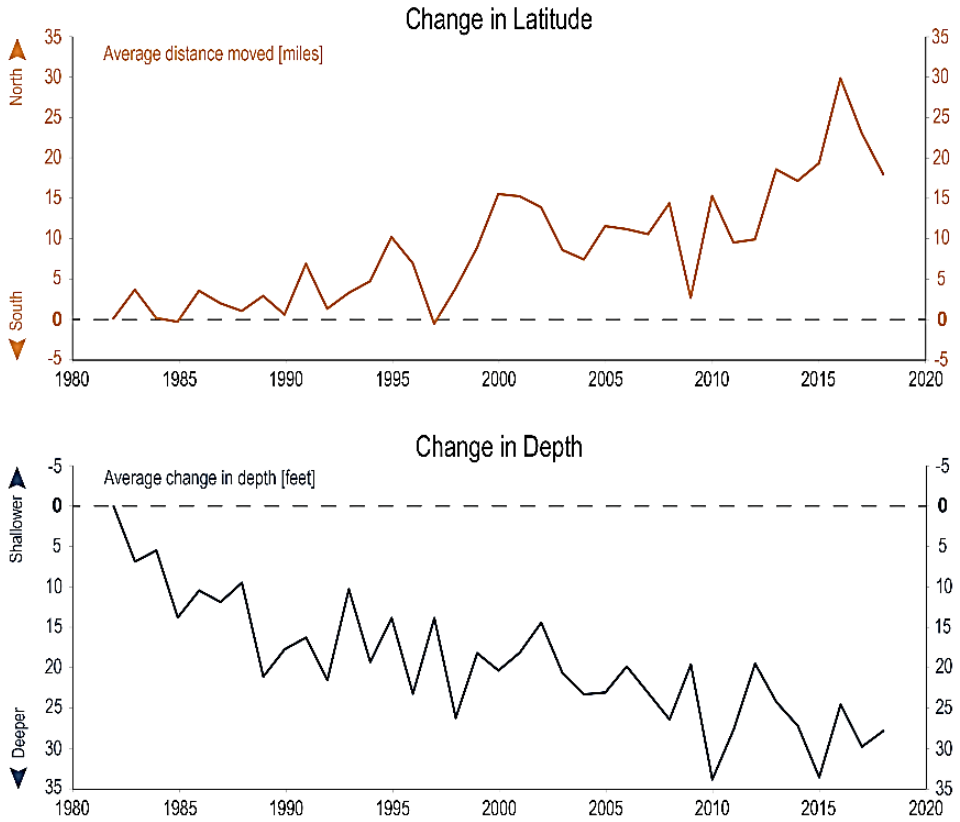

Fig. 11.2

(b) With reference to Fig. 11.1 and Fig. 11.2, describe and explain the behaviour of the marine species and the effects of this behaviour.

..... [3]

1. **Increased global mean temperature lead to ocean warming ;**
2. **The marine species shifted to colder areas of the sea at higher latitudes (North) and to deeper parts of the sea ;**
3. **This may put them at competition with other species and cause ecological disruptions / separation of preys from predators ;**

[Total: 5]