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.

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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11	
Total	

This document consists of **29** printed pages and **3** blank pages.

Answer **all** questions.

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

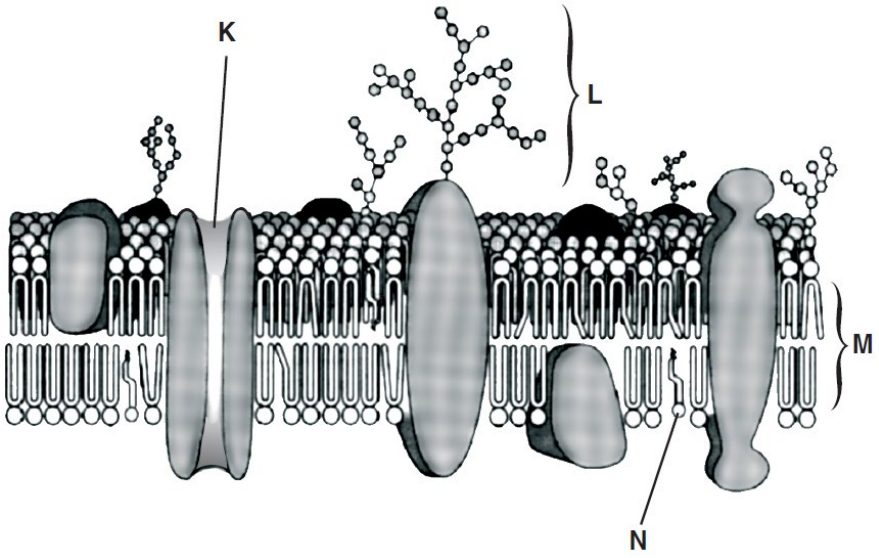

Fig. 1.1

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

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

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

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L .....

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M .....

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N .....

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(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.

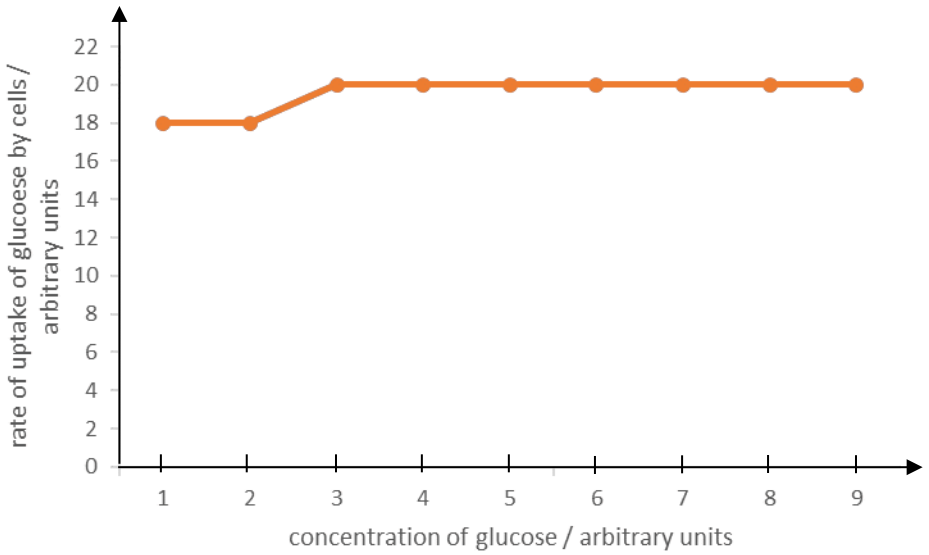

Fig. 1.2

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

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(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.

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[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.

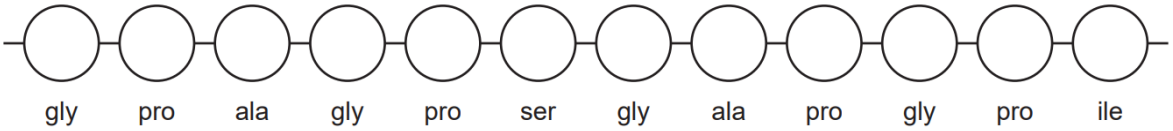

Fig. 2.1

(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.

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(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.

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(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.

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(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.

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[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.

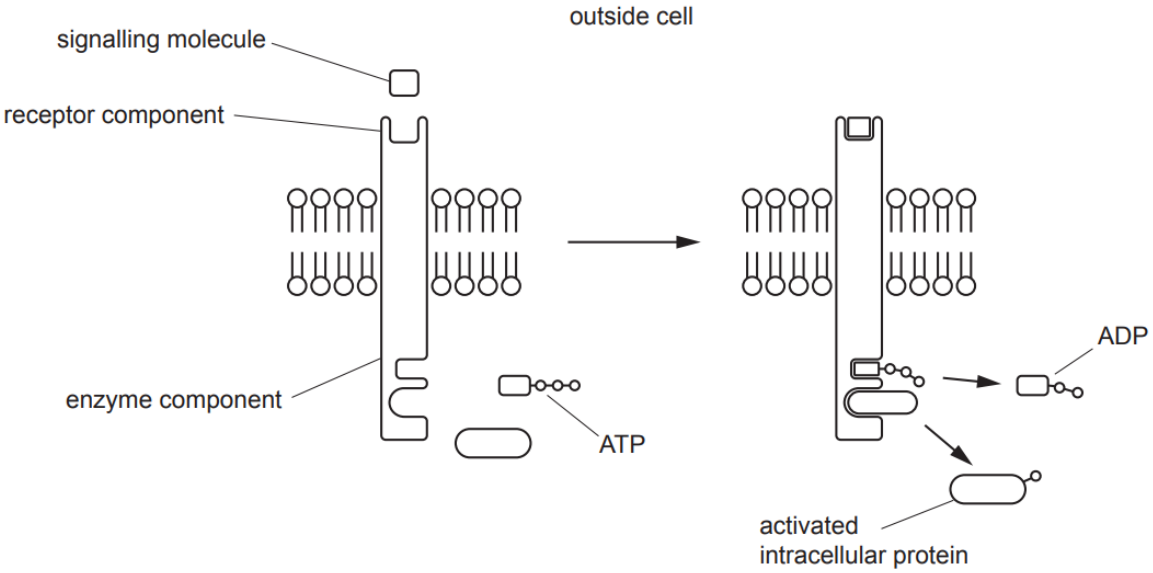

Fig. 3.1

(a) Most enzymes are specific to one reaction.

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

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

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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.

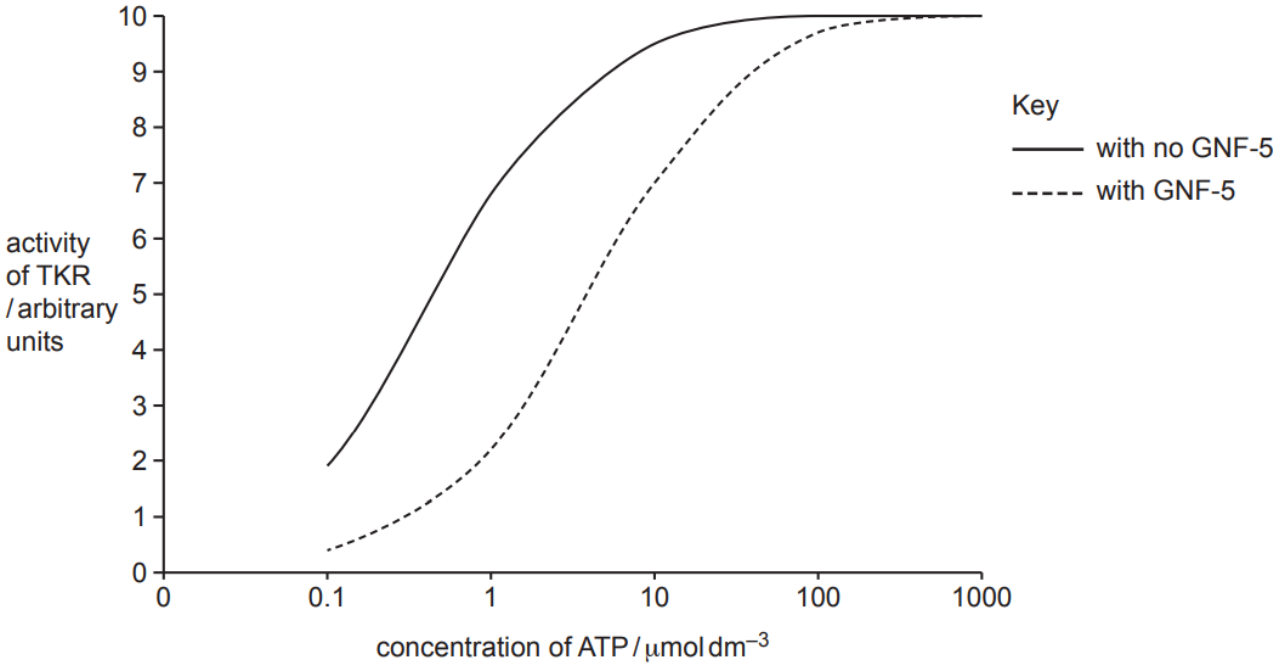

Fig. 3.2

(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.

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(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.

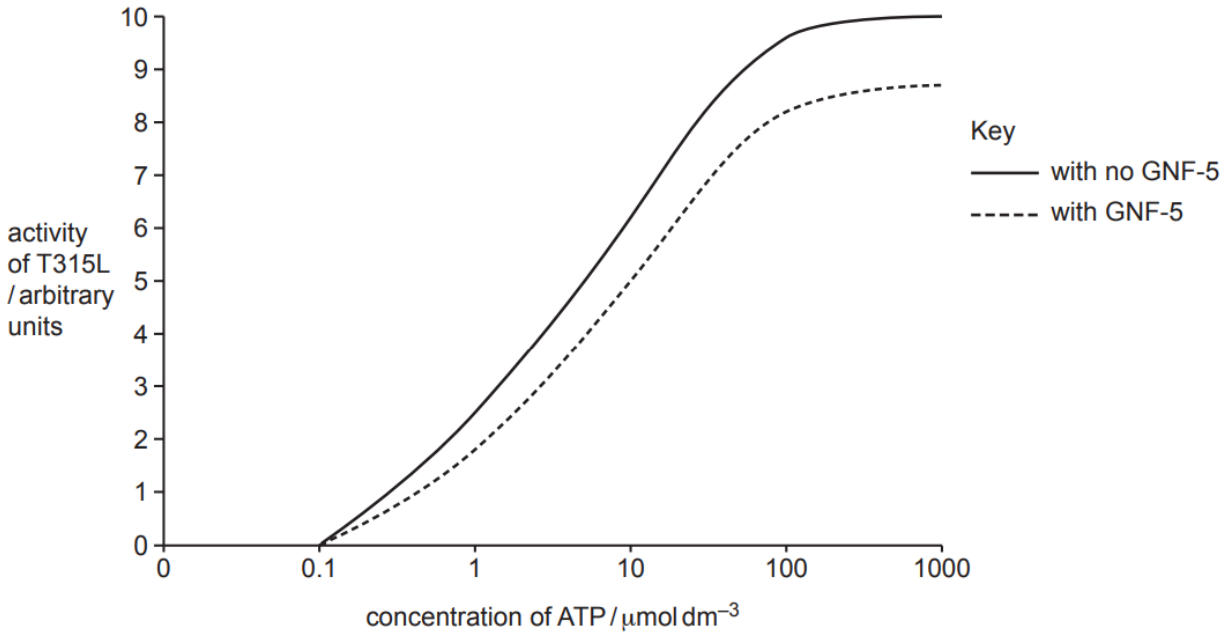

Fig. 3.3

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.

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

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[Total: 10]

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

(i) gene

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(ii) codon.

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

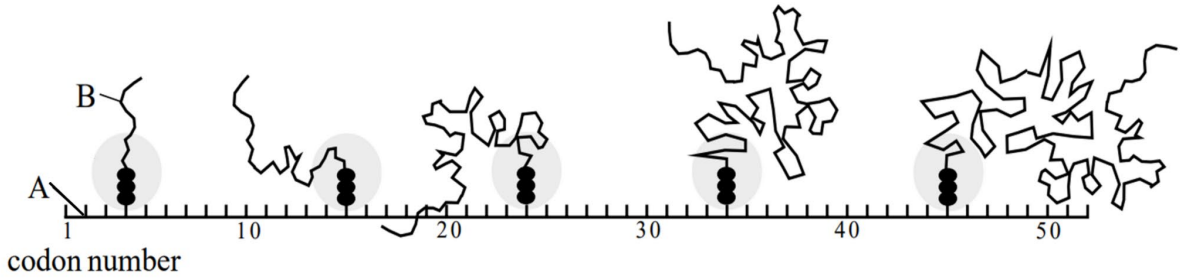

Fig. 4.1

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

A .....

B .....

[2]

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

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..... [1]

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

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(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.

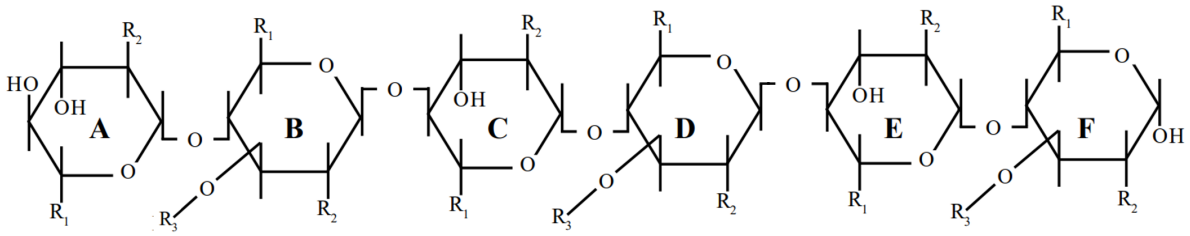

Fig. 4.2

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

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[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.

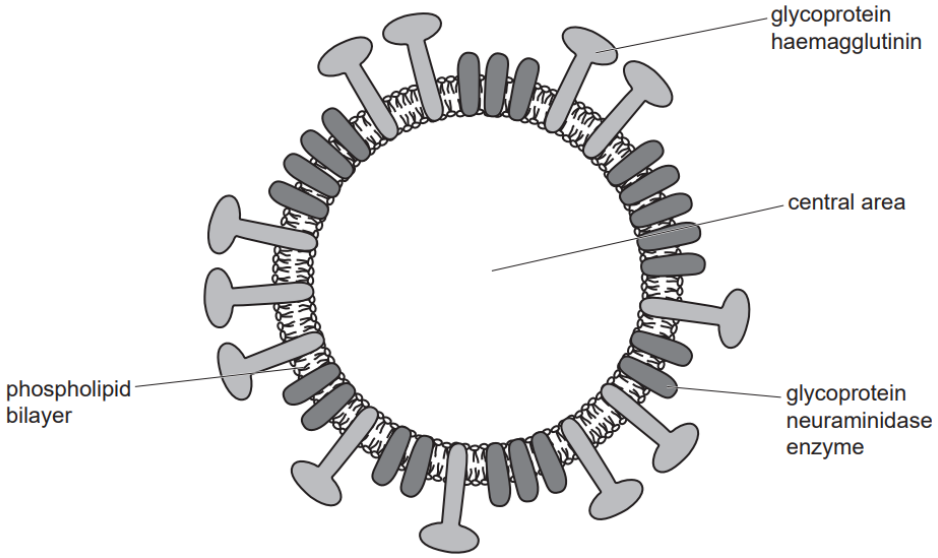

Fig. 5.1

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

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..... [1]

(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.

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(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.

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(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.

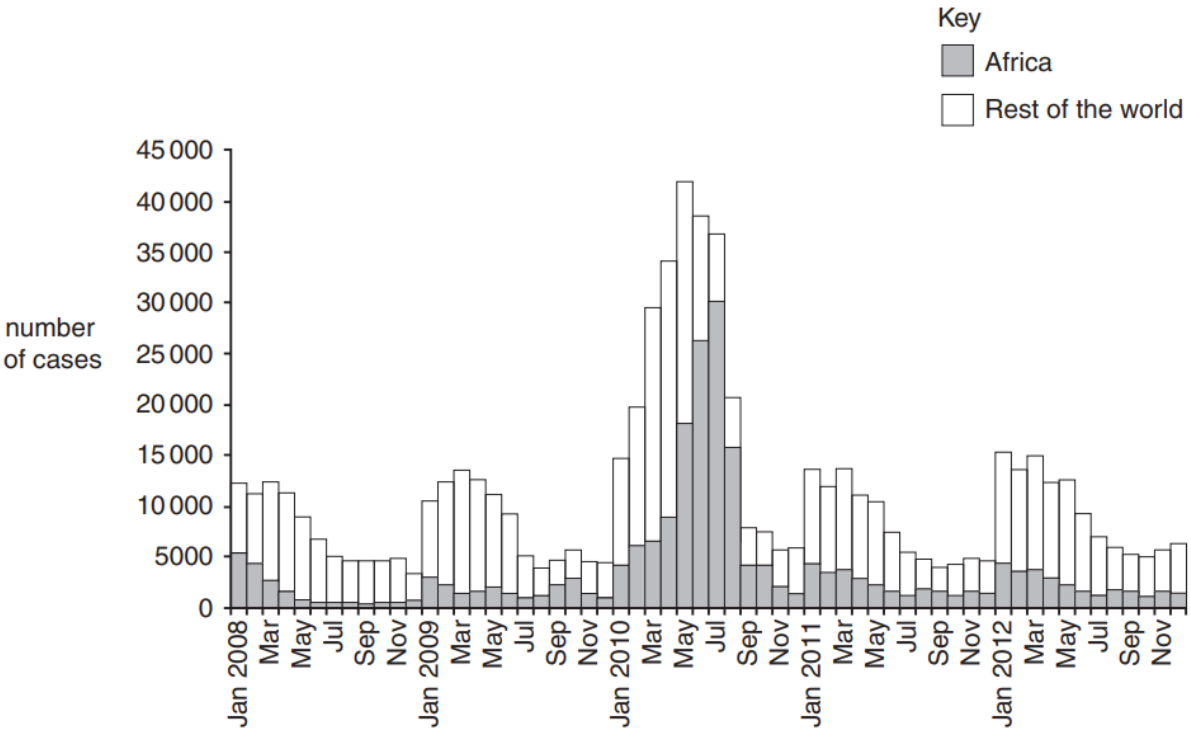

Fig. 5.2

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.

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[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.

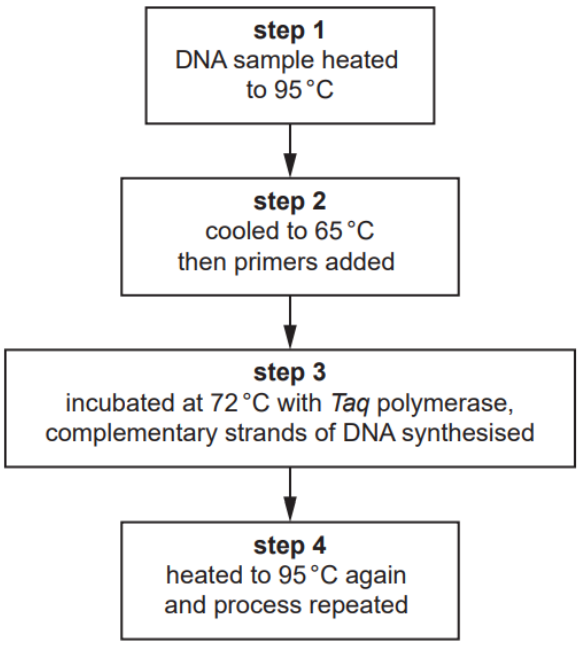

Fig. 6.1

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

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

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

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(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.

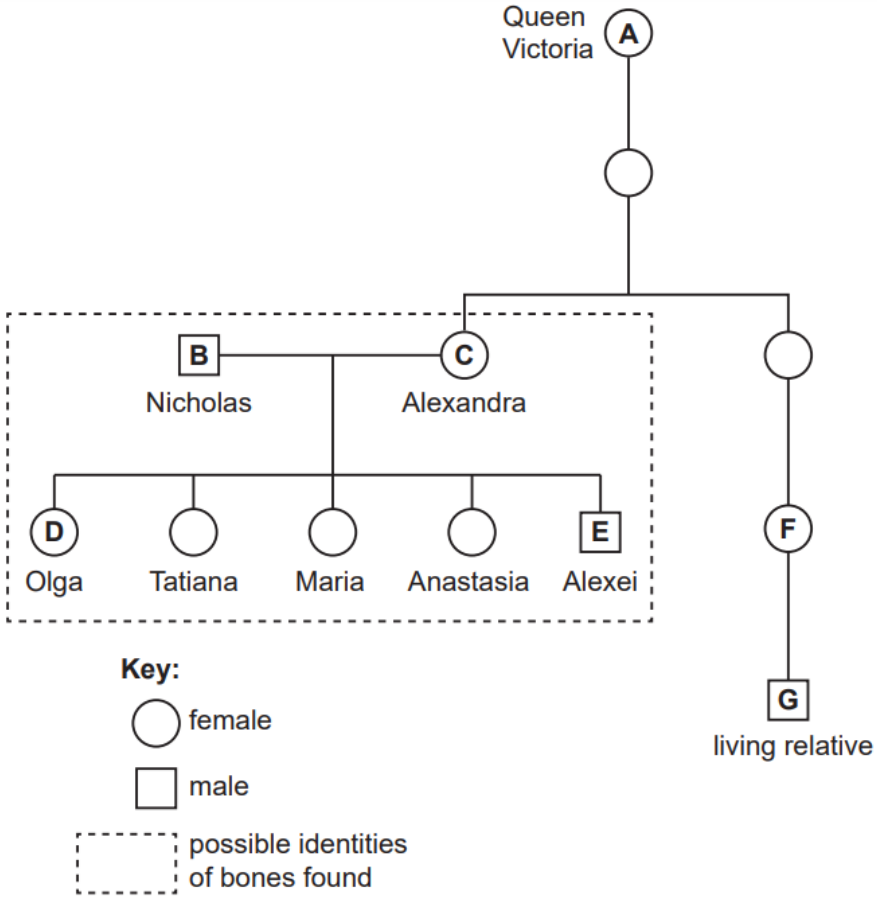

Fig. 6.2

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

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..... [2]

(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**.

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

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[Total: 10]

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

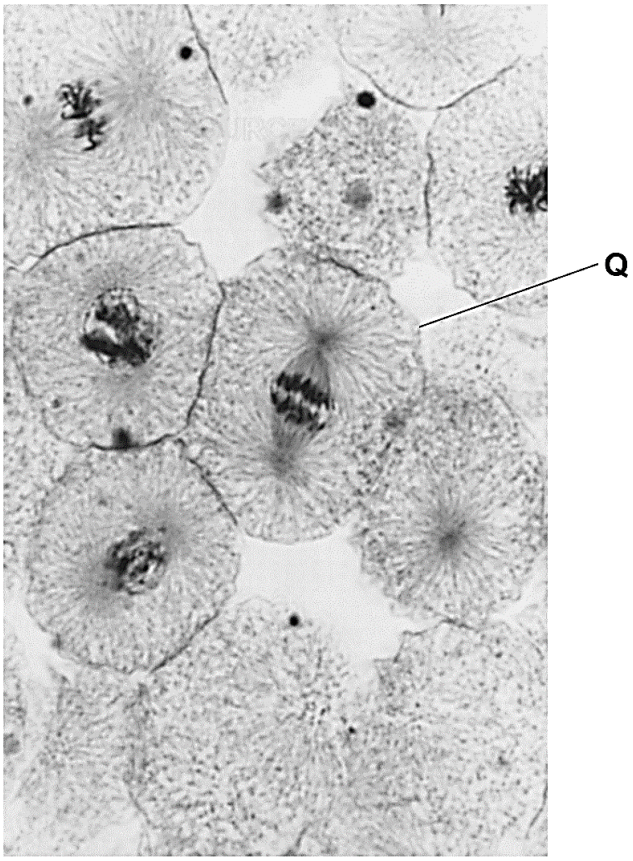

Fig. 7.1

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

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

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..... [2]

Question 7 continues on page 20

(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.

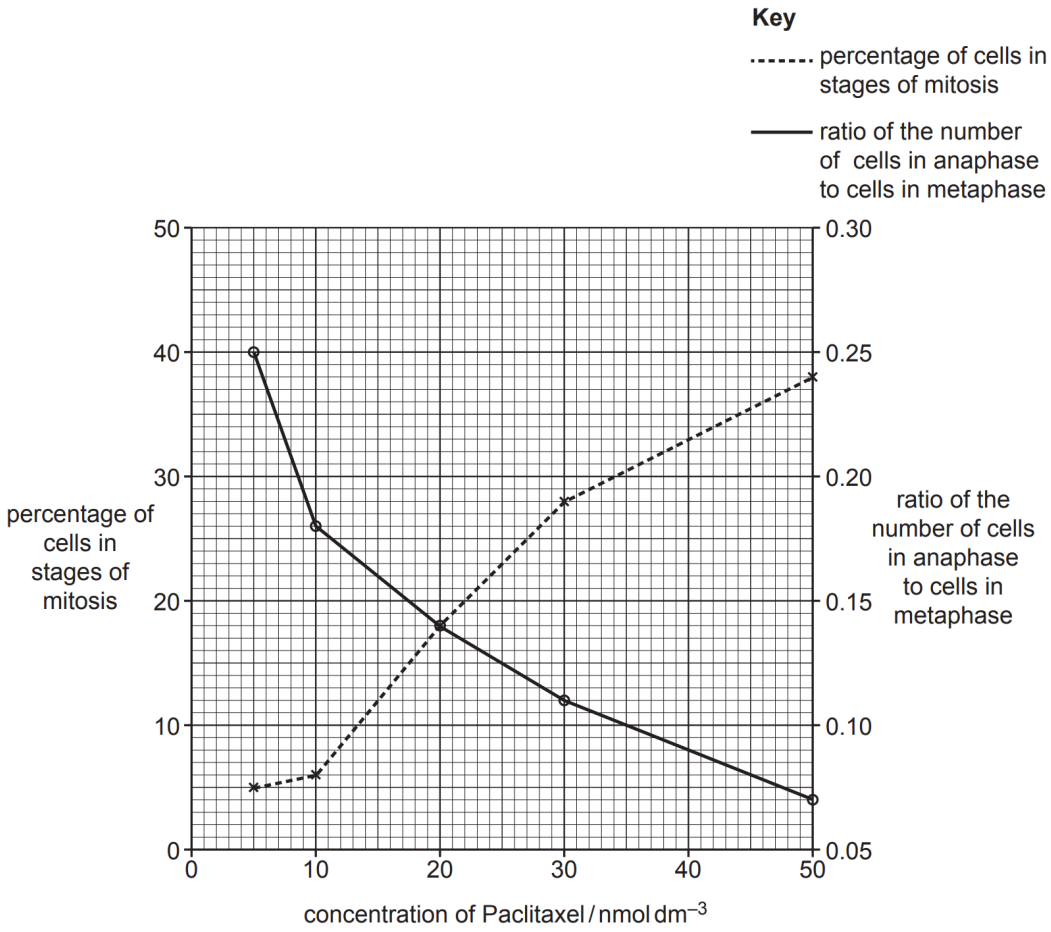

Fig. 7.2

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

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(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.

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[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.

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(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.

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.

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..... [2]

[Total: 10]

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

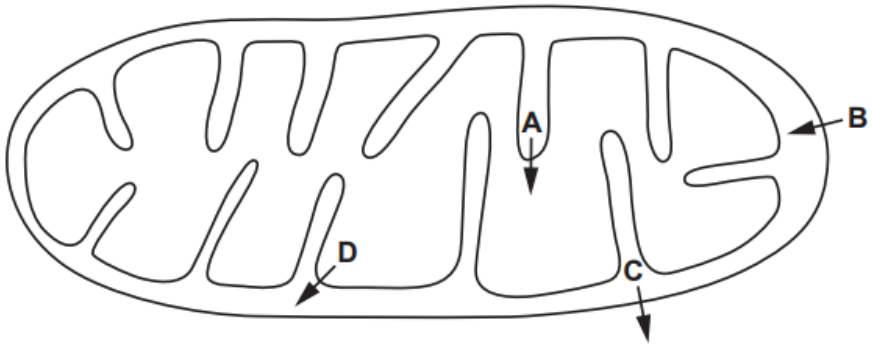

Fig. 9.1

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]

(ii) diffusion of carbon dioxide.

..... [1]

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

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..... [2]

(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.

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..... [1]

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

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

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..... [1]

(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.

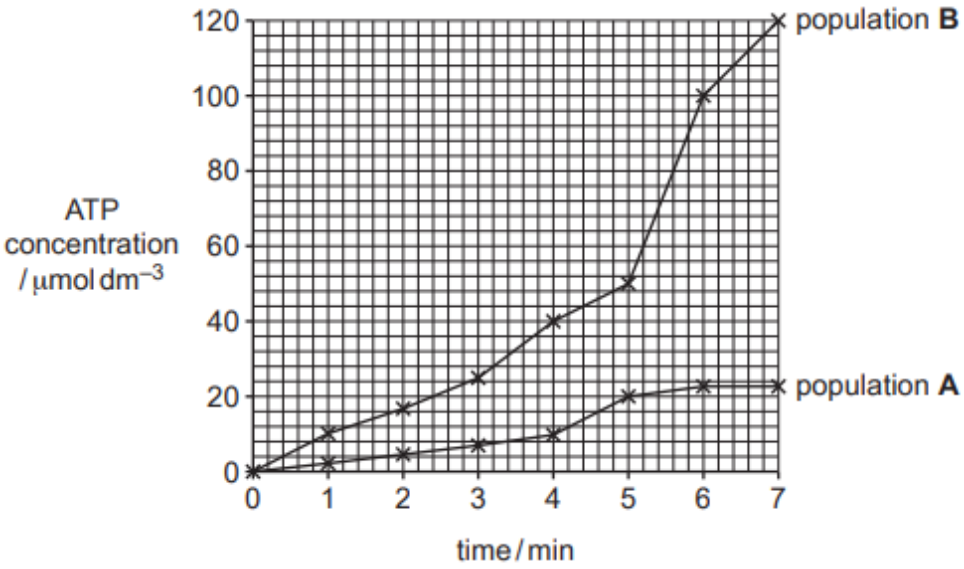

Fig. 9.2

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

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[Total: 10]

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

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

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(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.

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[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.

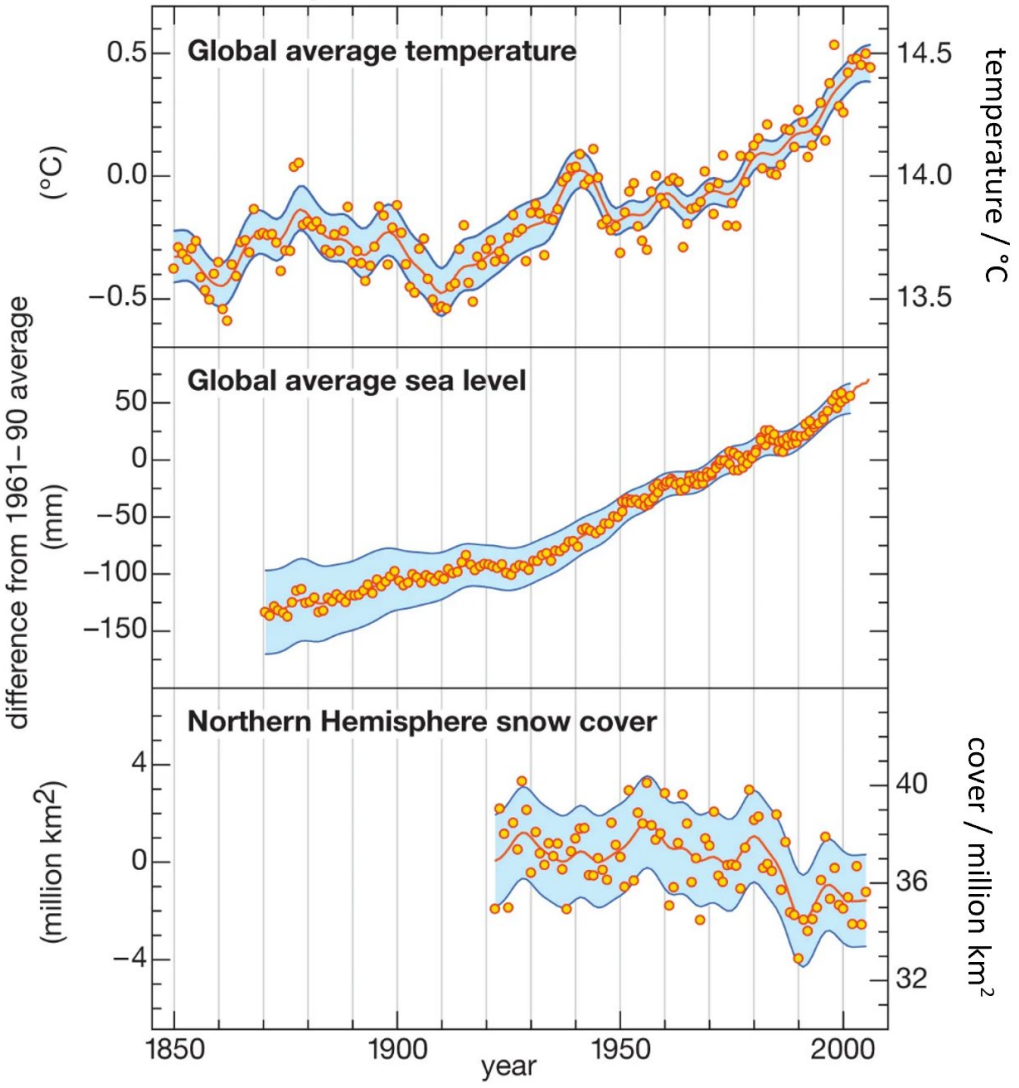

Fig. 11.1

(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.

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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.

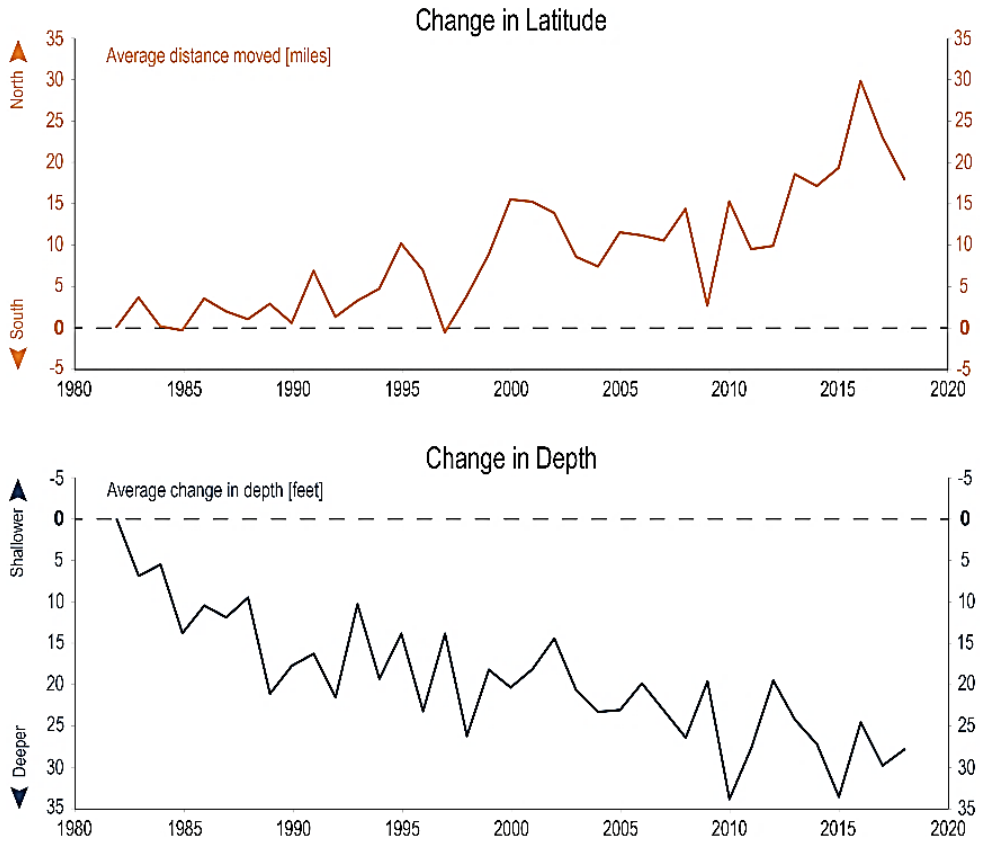

Fig. 11.2

(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.

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[Total: 5]

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