NAME : _____ CLASS : _____

JURONG PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination 2024

BIOLOGY
Higher 2

9744/02
27 August 2024

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 **31** printed pages and **1** blank page.

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Answer **all** questions

1 (a) Fig. 1.1 shows a single-celled organism called *Chlamydomonas*.

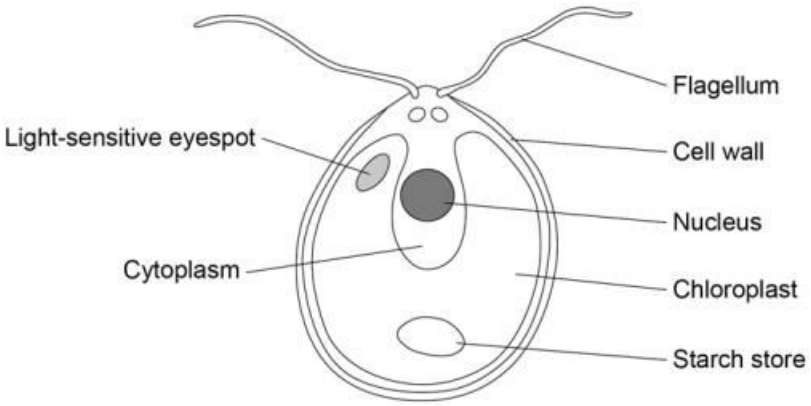

Fig. 1.1

(i) Name **two** structures that could be present inside the nucleus.

.....

(ii) *Chlamydomonas* lives in freshwater ponds. It uses its flagella to swim towards light of moderate intensity but away from very bright light.

Using information in Fig. 1.1, explain the advantage of this behaviour.

.....

..... [2]

(iii) Oligosaccharides are carbohydrates that contain three to ten monomers in their chain. *Chlamydomonas* use oligosaccharides to synthesise glycoproteins, which are transported to cell surface membranes.

Describe the roles of the rough endoplasmic reticulum and the Golgi body in synthesising glycoproteins.

.....

..... [2]

(b) A *Chlamydomonas* cell has two flagella. These flagella contain a single type of protein. A flagellum consists of a bundle of 242 filaments. Each filament consists of 7500 protein molecules. Each protein molecule contains 900 amino acid units.

In an investigation, a culture of *Chlamydomonas* was treated in a way that caused them to lose their flagella without any other damage to the cells. The flagella grew back to their original length in 60 minutes.

How many amino acid molecules would be incorporated into each growing flagellum per minute?

Show your working.

amino acid molecules incorporated per minute .....
[2]

(c) The researchers investigated the rate at which the flagella grew in two different media.

1 a medium containing puromycin, which prevents translation by attaching to ribosomes

2 a control medium

The results are shown in Fig. 1.2.

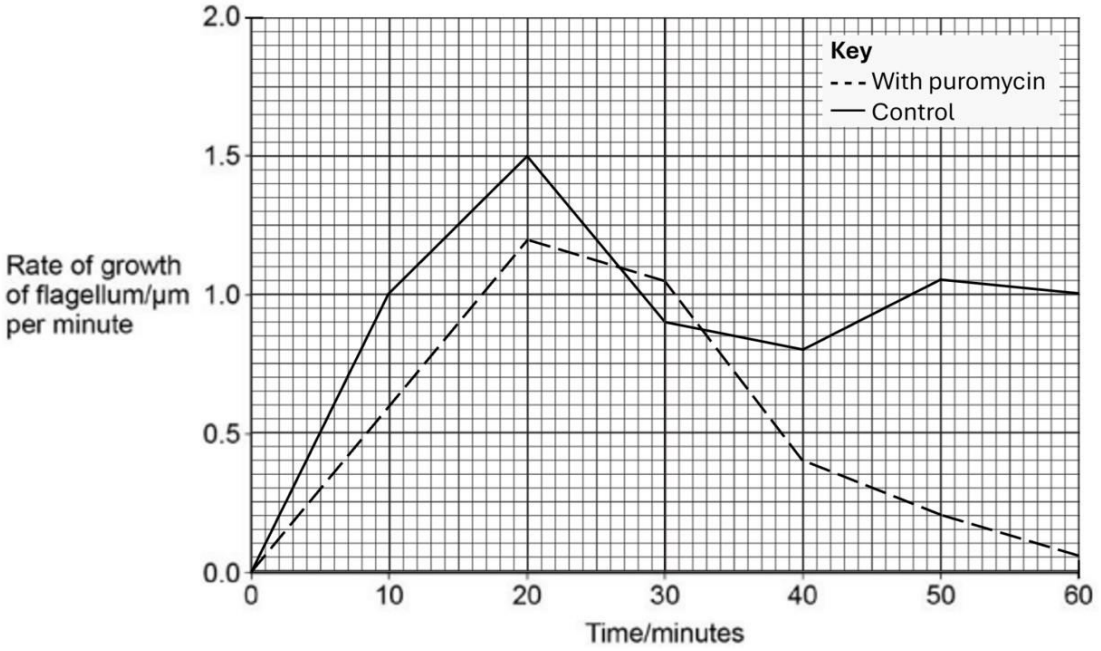

Fig. 1.2

(i) Describe how the rate of growth was affected by puromycin.

.....

..... [2]

(ii) The researchers concluded that some of the regrowth uses protein molecules already present in the cell.

Explain the evidence for this conclusion.

.....

..... [2]

[Total: 12]

Question 2 starts on page 8.

2 Enzymes have important roles in living organisms. Fig. 2.1a shows lactase, a crucial enzyme in the human digestive system produced by enterocytes. It is located on the surface of the microvilli, specifically within the brush border membrane.

Fig 2.1b shows the enzyme anchored at its C-terminal end, with the catalytic portion extending into the intestinal lumen. This strategic positioning enables lactase to efficiently catalyse the cleavage of lactose, the major carbohydrate in milk, into its constituent absorbable monosaccharides, glucose and galactose. Lactase's function is vital for the nourishment of newborn mammals, whose primary source of nutrition is milk.

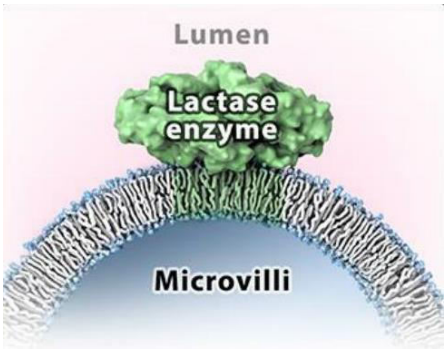

Fig. 2.1a

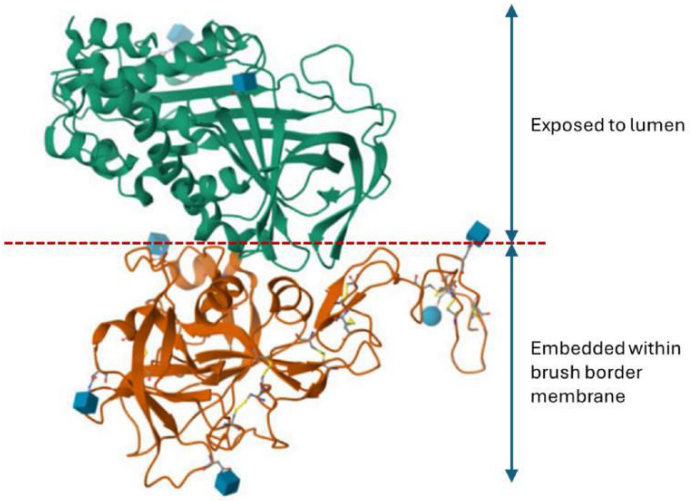

Fig. 2.1b

(a) The enzyme lactase is made up of 1023 amino acids. Fig. 2.2 shows the positions in the polypeptide chain of five amino acids found at the active site of lactase.

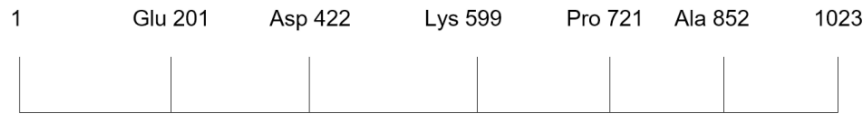

Fig. 2.2

(i) With reference to the information in Fig. 2.1 and Fig. 2.2, describe how amino acid residues at different positions in lactase may be brought together in the active site when lactase is synthesised by the cell.

.....

.....

(ii) Suggest reasons why lactase is anchored with the catalytic portion extending into the intestinal lumen.

.....

..... [2]

(b) People with lactose intolerance can drink lactose-free milk. Lactose-free milk is produced by treating milk with lactase.

There are two ways of removing lactose from milk:

- mixing a solution of lactase with the milk (free lactase)
- enclosing the lactase inside permeable beads and pouring the milk over them (immobilised lactase).

Fig. 2.3 shows these two methods.

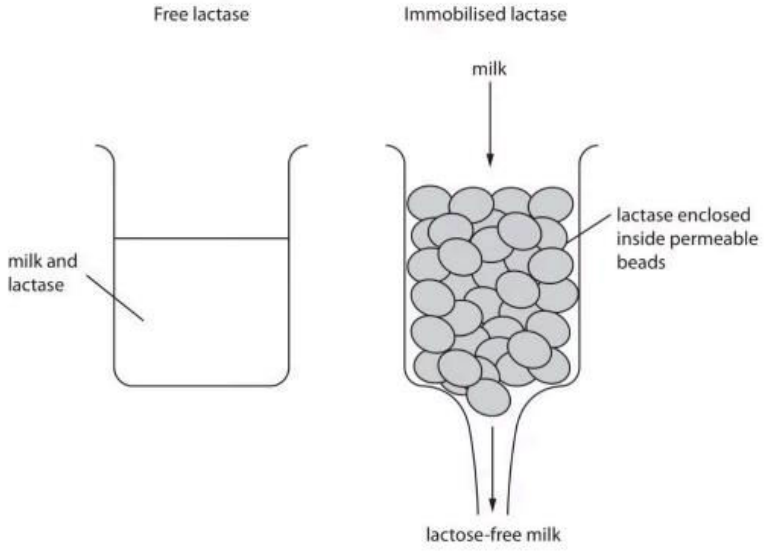

Fig. 2.3

Table 2.1 shows the effect of pH on the activity of free lactase and immobilised lactase.

Table 2.1

pH	activity of free lactase / a.u.	activity of immobilised lactase / a.u.
2	0	0
3	0	38
4	75	75
5	94	98
6	63	76
7	56	63
8	28	35

Explain the effects of pH on the activity of these two enzymes.

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[Total: 10]

3 The influenza virus belongs to the *Orthomyxoviridae* family. It primarily infects the respiratory tract of humans and animals. Fig. 3.1 shows an influenza virus.

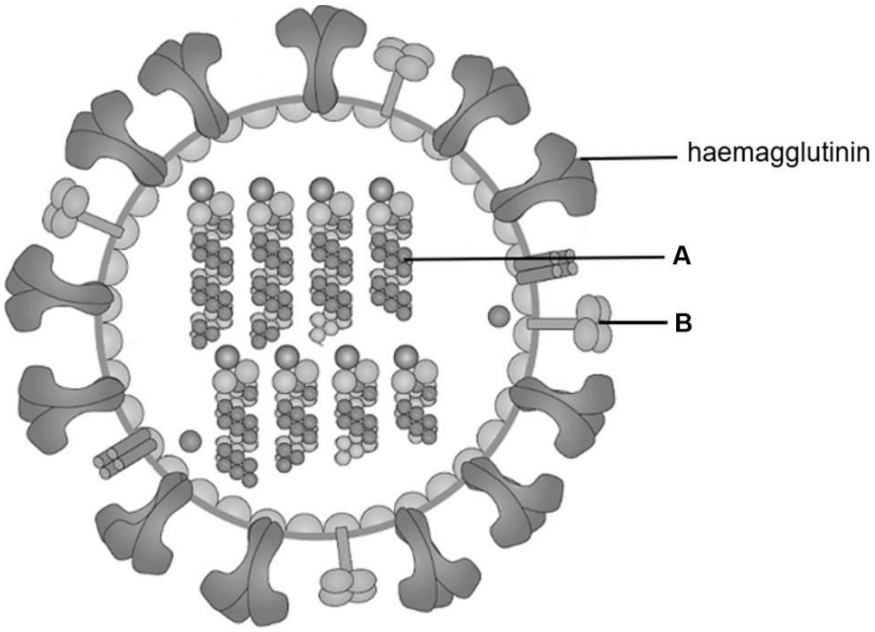

Fig. 3.1

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

structure **A** .....

function .....

.....

structure **B** .....

function .....

.....

[4]

PA, PB1 and PB2 are RNA polymerases that are found in influenza virus.

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

.....

..... [2]

Fig. 3.2 illustrates the annual influenza death toll and the number of new influenza cases in Country Z from 1925 to 1991.

In 1930, an antiviral drug designed to hinder the multiplication of the influenza virus by targeting non-envelope viral proteins was introduced for widespread use in Country Z.

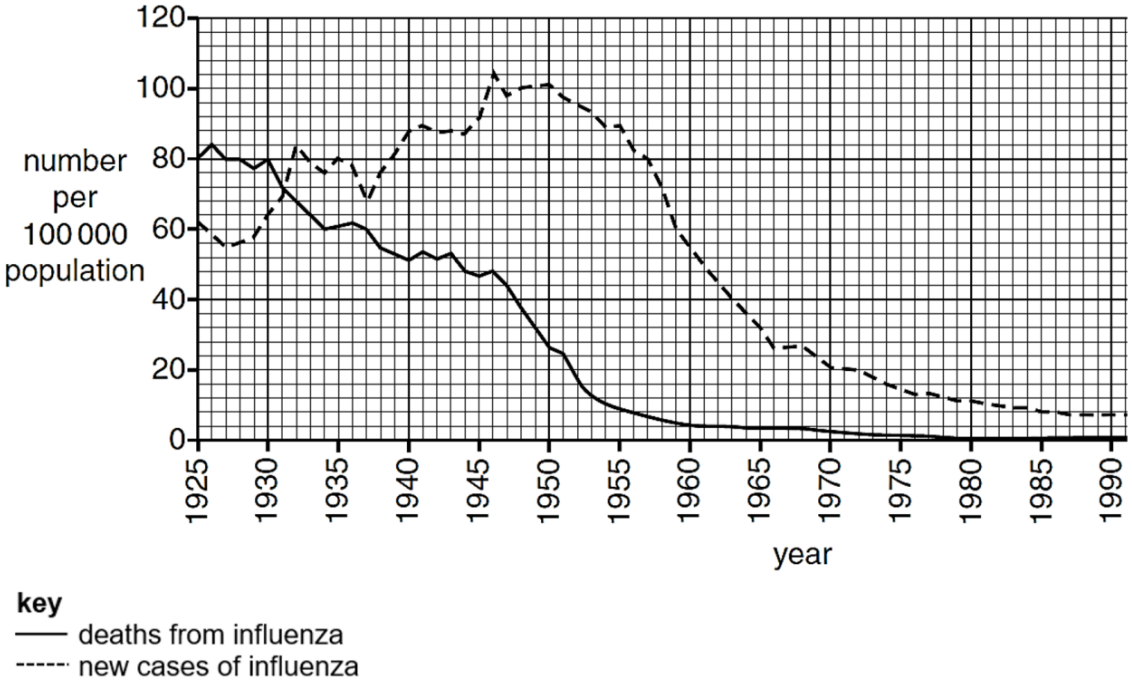

Fig. 3.2

(c) Using Fig. 3.2, account for the difference in the ten-year effect of the introduction of the antiviral drug on the number of deaths and number of new cases of influenza.

.....

.....

..... [4]

[Total: 10]

4 **(a)** The *lac* operon is a section of DNA present in the genome of *Escherichia coli*. The structural genes of the *lac* operon are only fully expressed when the bacteria are exposed to high lactose concentrations.

Fig. 4.1 is a diagram showing the *lac* operon and a nearby region of the *E. coli* genome.

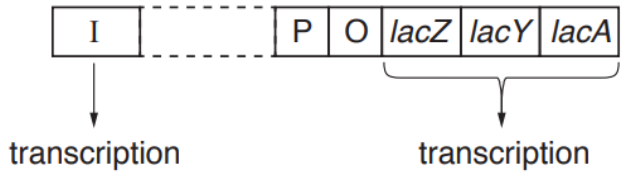

Fig. 4.1

(i) Fig. 4.1 shows how the *lac* operon consists of structural genes and regulatory sequences.

Use Fig. 4.1 to identify **two** structural genes.

Complete Table 4.1 to name each structural gene and its product.

Table 4.1

structural gene	name of gene product

[2]

(ii) Explain the role of the *lacI* gene in the regulation of the *lac* operon.

.....

.....

(b) The *lac* operon codes for inducible enzymes. Repressible operons code for repressible enzymes.

Suggest **and** explain why it is an advantage to a prokaryote to have a repressible operon.

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.....

(c) Another operon found in prokaryotes is the *trp* operon.

Fig. 4.2 summarises the structure and control of the *trp* operon.

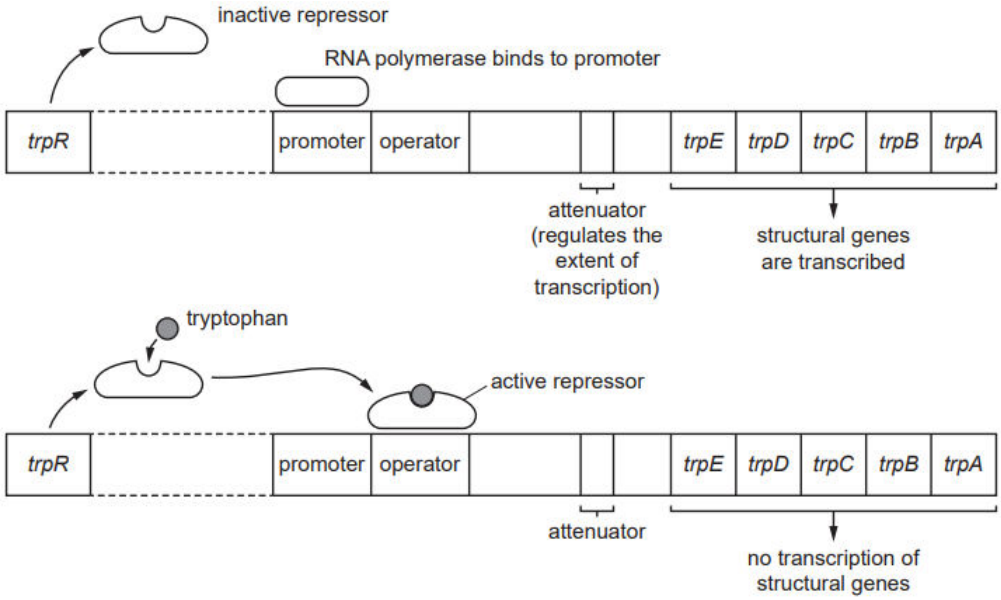

Fig. 4.2

Describe the differences in control between the *lac* operon and the *trp* operon.

.....

..... [2]

[Total: 10]

5 There are a few mutations affecting the production of fetal haemoglobin, HbF, and normal adult haemoglobin, HbA.

- The Hb^A allele codes for the normal β-globin polypeptide of haemoglobin.
- The Hb^S allele, caused by a base substitution mutation, codes for an abnormal β-globin polypeptide.

(a) Fetal haemoglobin, HbF, is produced by the fetus until just before birth, when adult haemoglobin begins to be made. By the age of six months, adult haemoglobin has replaced most of the HbF. This change occurs when the genes coding for HbF are switched off and the genes coding for adult haemoglobin are switched on.

- A base substitution, British-198, causes fetal haemoglobin to continue to be produced.
- Normally by the age of six months, the concentration of HbF reduces to less than 1% of total haemoglobin.
- With the British-198 mutation, the concentration of HbF may be as high as 20% of total haemoglobin in an adult.
- HbF has a higher affinity for oxygen at low partial pressures of oxygen than adult haemoglobin. Individuals who have both sickle cell anaemia and British-198 mutation have reduced symptoms of sickle cell anaemia.

Suggest why having the British-198 mutation reduces the symptoms of sickle cell anaemia.

.....

..... [2]

(b) Gel electrophoresis can be carried out to test individuals for the different versions of haemoglobin: HbA, HbS and HbF.

- A buffer with alkaline pH is used to make all haemoglobin molecules negatively charged.
- HbS molecules have an additional positive charge compared to HbA. HbF shows an intermediate positive charge.

(i) Describe and explain how gel electrophoresis is used to diagnose sickle cell anaemia.

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.....

.....

(ii) Four individuals had their haemoglobin analysed by gel electrophoresis. One of the individuals was heterozygous for the Hb^A and Hb^S alleles and had a condition known as sickle cell trait (SCT). Some of the results are shown in Fig. 5.1. In Fig. 5.1, lane 1 and lane 5 are complete.

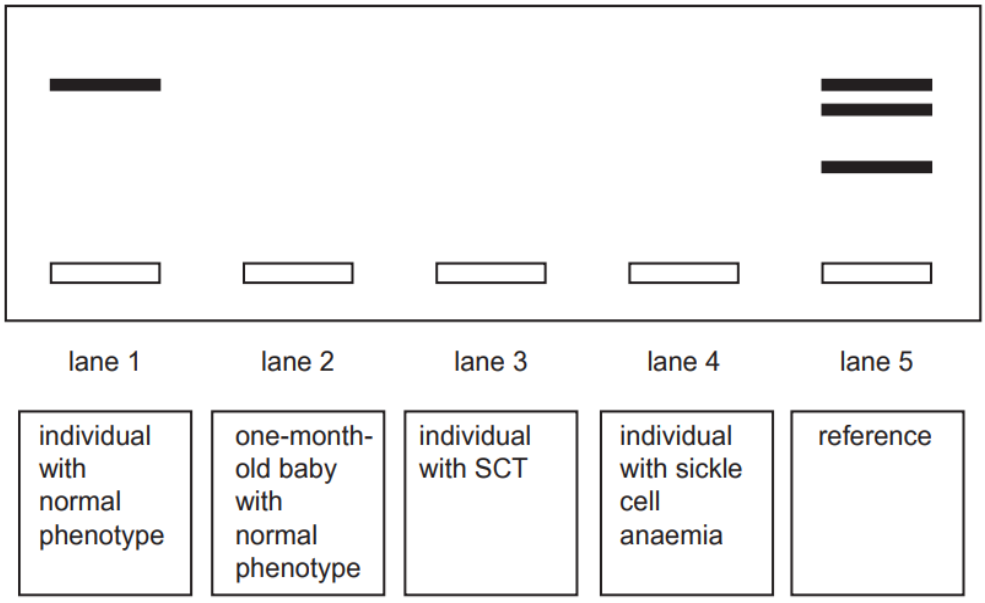

Fig. 5.1

Predict the results for the individuals analysed, by adding bands to lanes **2**, **3** and **4** on Fig. 5.1. [2]

[Total: 9]

6 During interphase and mitosis of the cell cycle, the chromosomes within a cell go through several changes. Each chromosome is composed of DNA complexed with proteins.

(a) In interphase, individual chromosomes are too diffuse to be visible using a microscope. In this stage, the chromosomal material is known as chromatin.

Name the proteins that are complexed with DNA and form part of chromatin.

..... [1]

(b) Chromosomes are most visible under a microscope during the metaphase stage of mitosis.

Fig. 6.1 shows chromosome 11 at the metaphase stage of mitosis.

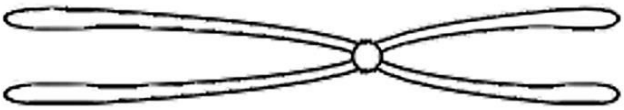

Fig. 6.1

Complete Fig. 6.2 to show the metaphase stage of mitosis with a homologous pair of chromosomes 11 in an animal cell.

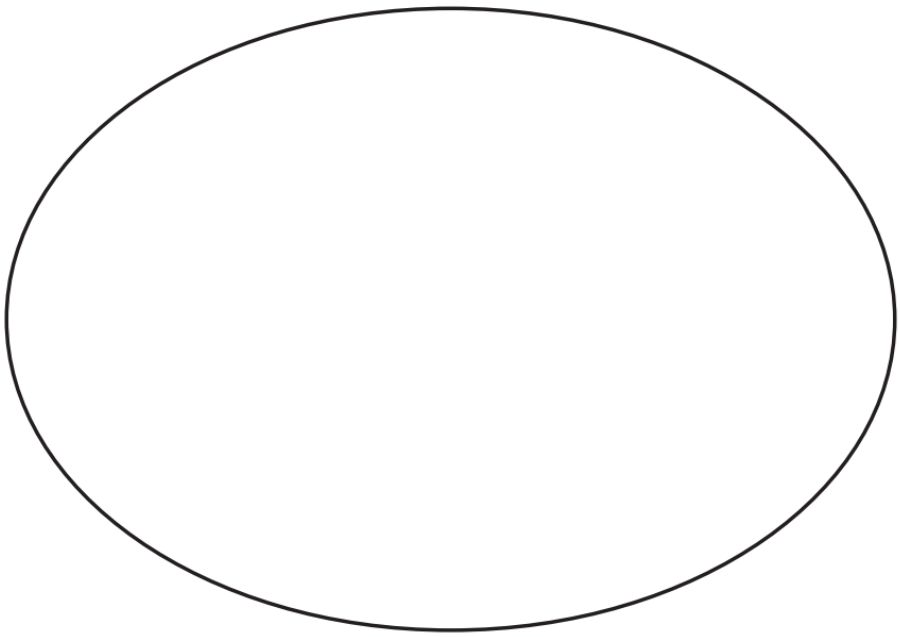

Fig. 6.2

[2]

(c) Outline the changes that occur to the structure and behaviour of chromosome 11:

- from the start of the S phase to the end of interphase
- during prophase of mitosis.

.....

.....

(d) State how mitosis maintains genetic stability in an organism.

.....

..... [2]

[Total: 8]

7 *Thespesia populnea*, a flowering plant can be found throughout the tropical regions of the world. It is commonly found along roadside as it can tolerate full sun, high wind and dry conditions.

The fruit colour of *Thespesia populnea* is either yellow or brown, and the fruit coat texture can be either smooth or wrinkled.

- The allele **A** for yellow is dominant over the allele **a** for brown.
- The allele **B** for smooth coat is dominant over allele **b** for wrinkled coat.

The inheritance of fruit colour and fruit coat texture is controlled by genes that display autosomal linkage.

(a) Explain what is meant by autosomal linkage.

.....

..... [2]

(b) A dihybrid cross was carried out between a pure-breeding plant with yellow and smooth fruit and a pure-breeding plant with brown and wrinkled fruit to produce the F1 generation. The offspring from the F1 generation is crossed with a plant with brown and wrinkled fruit. The results of this cross are shown in Table 7.1.

Table 7.1

offspring phenotype	number of offspring
yellow and smooth fruit	125
brown and wrinkled fruit	125
yellow and wrinkled fruit	10
brown and smooth fruit	10

Suggest how the results shown in Table 7.1 supports that the genes for fruit colour and coat texture display autosomal linkage.

.....

..... [2]

(c) Use the symbols, **A, a** and **B, b** to draw a genetic diagram to explain the results in Table 7.1.

[4]

(d) Outline how you would use chi-squared test to determine whether the observed results differ significantly from the expected results. No calculations or formula are required to answer this question.

.....

..... [2]

[Total: 10]

8 Fig. 8.1 is a transmission electron micrograph of a chloroplast.

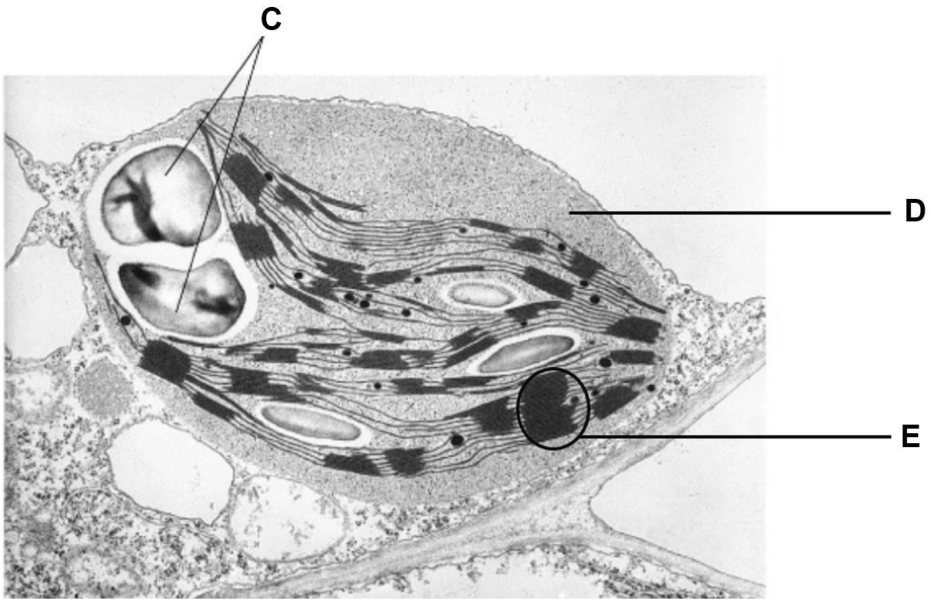

Fig. 8.1

(a) Name the structures labelled **C**, **D** and **E** in Fig. 8.1.

C .....

D .....

E .....

[3]

The light dependent reactions in photosynthesis involve non-cyclic and cyclic photophosphorylation.

(b) Explain how non-cyclic photophosphorylation differs from cyclic photophosphorylation.

.....

.....

Laboratory experiments were carried out to investigate the effect of day length (light exposure period) on the rate of photosynthesis in common eelgrass, *Zostera marina*.

- The temperature was controlled at 4 ^{o}C.
- A fixed concentration of carbon dioxide dissolved in water was used.
- The day length was different for five groups of *Z. marina*.
- This was maintained for 10 days to allow *Z. marina* to adapt to these conditions.
- After 10 days, the rate of photosynthesis was measured for each group under the same controlled conditions.

Table 8.1 shows the results of the experiment.

Table 8.1

day length / hours	rate of photosynthesis / arbitrary units
12	2.5
14	5.0
16	7.0
18	11.0
20	18.0

(c) With reference to Table 8.1, describe **and** explain the effect of increasing day length on the rate of photosynthesis for the *Z. marina*.

.....

.....

..... [4]

[Total: 10]

9 Australia's unique biodiversity includes tens of thousands of native animal species, with a significant proportion being endemic.

(a) The dingo, belonging to the genus *Canis*, is a wild canine native to Australia, believed to have arrived on the continent around 4000 years ago.

The distribution of some of the species belonging to the genus *Canis* is shown in Fig. 9.1.

The dingo and the grey wolf species have distinct ranges but the ranges of the three species of jackal overlap in East Africa.

The domestic dog, *Canis familiaris*, is found worldwide and it can breed with all other members of the genus to form fertile hybrids.

Fig. 9.1

Table 9.1 shows whether members of different species of the genus *Canis* are able to breed with each other.

Table 9.1

key: ✓ = able to interbreed ✗ = unable to interbreed **?** = interbreeding unknown

	dingo	grey wolf	golden jackal	side-striped jackal	black-backed jackal	domestic dog
dingo	✓	?	?	?	?	✓
grey wolf	?	✓	?	?	?	✓
golden jackal	?	?	✓	✗	✗	✓
side-striped jackal	?	?	✗	✓	✗	✓
black-backed jackal	?	?	✗	✗	✓	✓
domestic dog	✓	✓	✓	✓	✓	✓

(i) Suggest the type of isolating mechanism **preventing**:

- the three species of jackal interbreeding

.....

- the dingo mating with all the other members of the genus *Canis* apart from the domestic dog.

.....

(ii) Using the information in Fig. 9.1 and Table 9.1, state:

- **one** reason why the members of the genus *Canis* could be described as one species

.....

- **one** reason why they should be described as separate species.

.....

(b) The zebra finch, *Taeniopygia castanotis*, is native to arid regions throughout Australia. The variation in clutch size of zebra finches was investigated over several years. The clutch size refers to the number of eggs a bird lays in its nest. The data from the investigations are shown in Fig. 9.2.

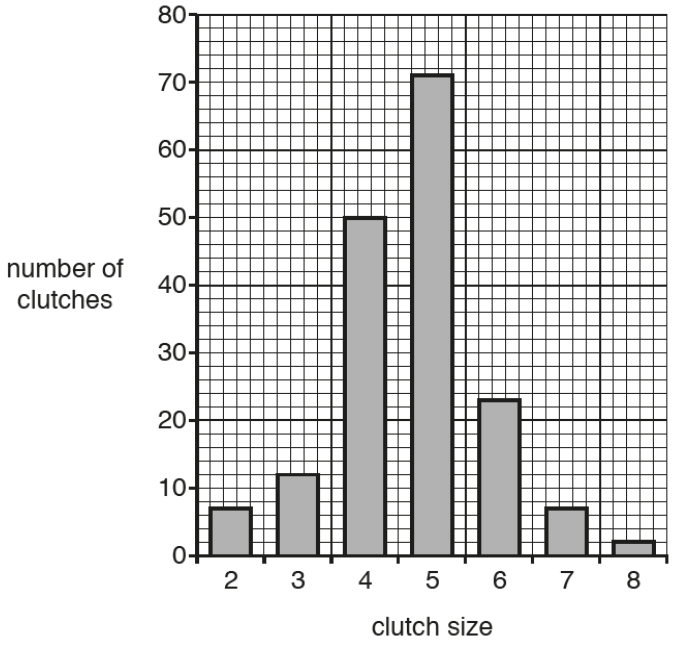

Fig. 9.2

(i) Describe the pattern shown by the data in Fig. 9.2.

.....

..... [2]

(ii) The data in this investigation were collected over 60 years ago.

The same investigation, carried out today, would produce the same pattern of results.

Explain how the selection factors acting on zebra finches would maintain the same pattern of results.

.....

.....

..... [4]

[Total: 10]

10 Fig. 10.1 is a diagram of a protein in the cell surface membrane of a macrophage from a mouse.

Macrophages use these proteins in antigen presentation. Non-self antigens bind to the proteins and are involved in the activation of specific T lymphocytes during the immune response.

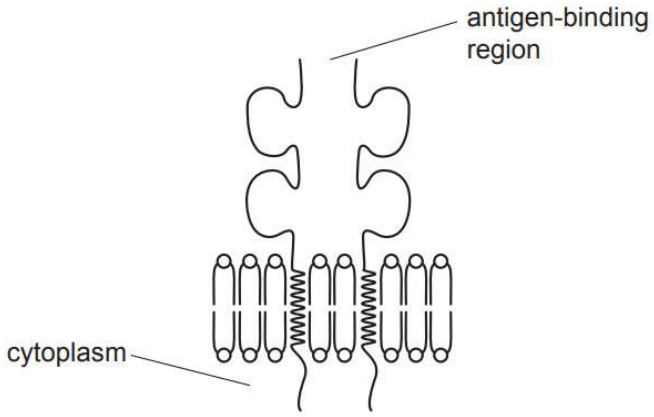

Fig. 10.1

(a) State what is meant by a non-self antigen.

.....

(b) Some pathogens enter human cells. Macrophages partially digest these pathogens and present antigens to T lymphocytes during immune responses.

With reference to Fig. 10.1, explain how T lymphocytes respond to infection by a specific type of pathogen.

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.....

..... [4]

[Total: 5]

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

Plant biodiversity varies throughout the world and is dependent on many factors, particularly climate.

Fig. 11.1 shows the relationship between the number of plant genera and the mean annual rainfall in seven countries.

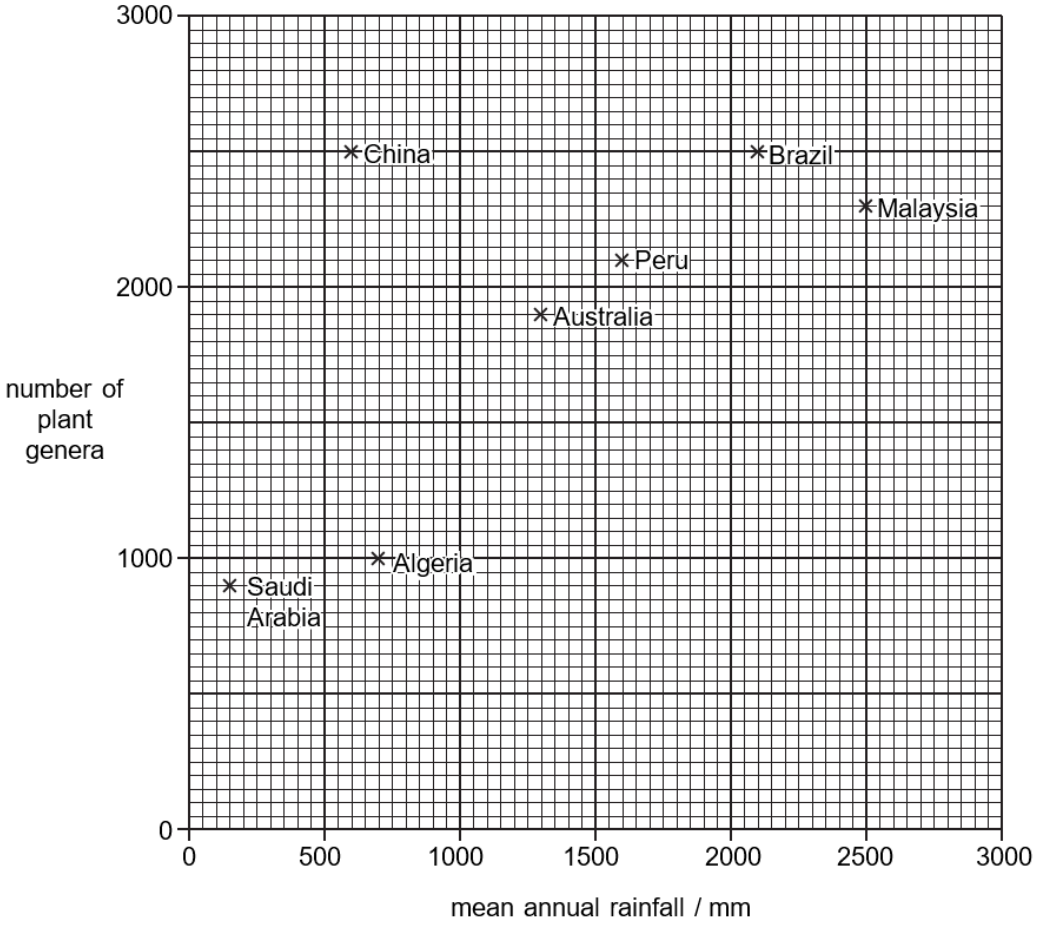

Fig. 11.1

(a) Describe the relationship between the number of plant genera and the mean annual rainfall in these seven countries.

.....

..... [2]

(b) Suggest how human activity can contribute to climate change and its effect on plant biodiversity.

.....

.....

..... [4]

[Total: 6]