H2

ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2

2022 JC2 PRELIMINARY EXAMINATIONS

CANDIDATE NAME	
CLASS	INDEX NUMBER

BIOLOGY 9744/02

PAPER 2 **13 SEPTEMBER 2022**
SHORT STRUCTURED QUESTIONS **TUESDAY**

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

2 HOURS

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

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

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

For Examiner's Use	
1	/ 10
2	/ 11
3	/ 9
4	/ 10
5	/ 10
6	/ 10
7	/ 10
8	/ 10
9	/ 10
10	/ 5
11	/ 5
Total	**/100**

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

Answer **all** the questions.

1 Chitin, the second most abundant organic polymer after cellulose on Earth, is found in the cell walls of fungi and the exoskeleton of insects. Both chitin and cellulose serve as structural polysaccharides.

The chitin polysaccharide consists of N-acetylglucosamine. Fig. 1.1 shows the structure of chitin.

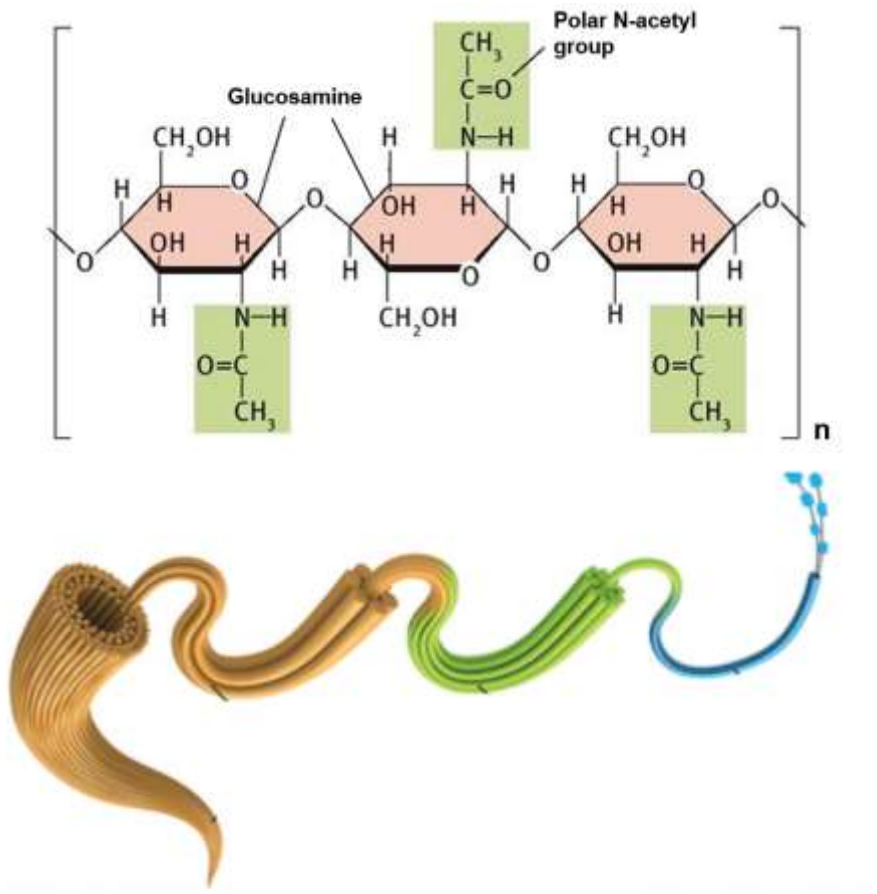

Fig. 1.1

(a) With reference to Fig. 1.1,

(i) name the covalent bond between two monomers in a chitin molecule and describe how this bond is formed.

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(ii) explain how the structure and property of chitin are related to its role as a structural polysaccharide in fungi and insects.

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(c) Chitinase is an enzyme found in plants. It degrades chitin in fungal cell walls and exoskeletons of insects, protecting the plants against a range of pathogens.

Describe the mode of action of chitinase.

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…… [3]

[Total: 10]

2 Fig. 2.1 is an electronmicrograph of a human cell during mitosis.

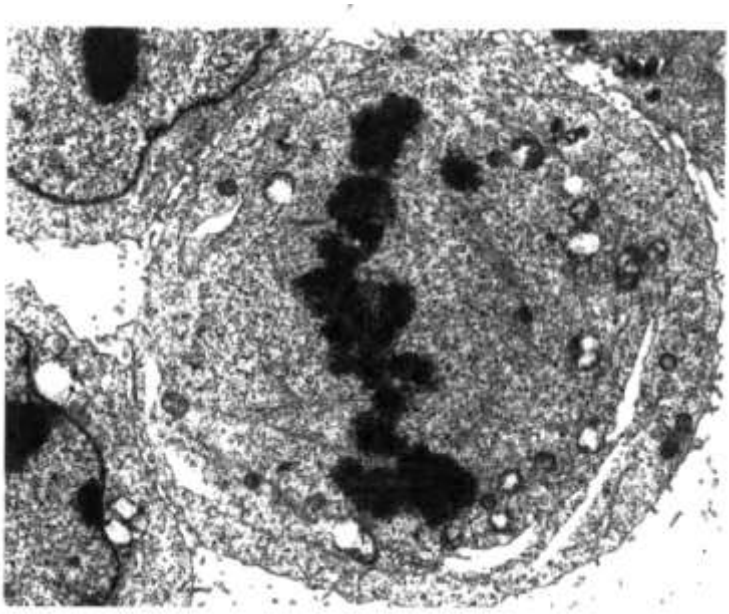

Fig. 2.1

(a) Describe the events that take place in the stage of mitosis **before** that seen in Fig. 2.1.

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…… [3]

(b) The normal diploid number of chromosomes for a human cell, such as that shown in Fig. 2.1, is 46.

The cell in Fig. 2.1 has 92 DNA molecules.

Explain the presence of 92 DNA molecules in this cell and why it is important to have this number.

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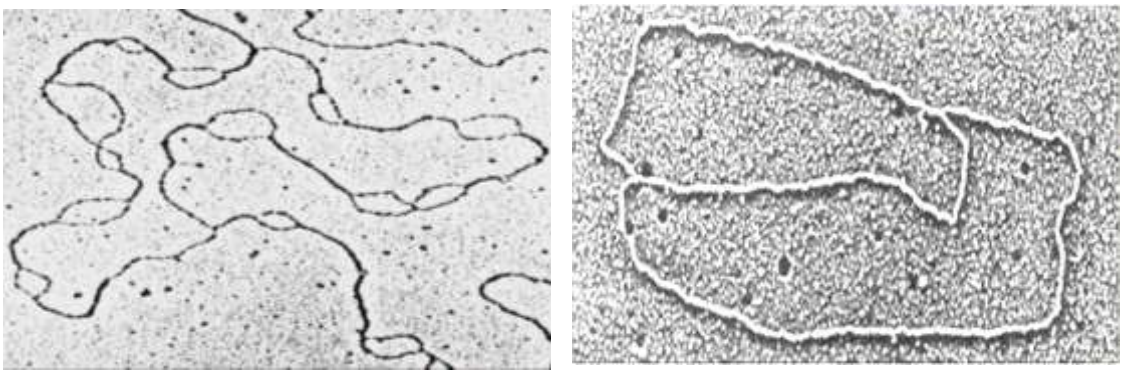
…… [4]

(c) Fig. 2.2 shows DNA replication occurring in a human cell (**A**) and in an *Escherichia coli* (**B**). Diagrams are not shown to scale.



A **B**

Fig. 2.2

(i) State **one** visible difference in the structure of these two DNA molecules during DNA replication and account for this difference.

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……... [2]

(ii) Explain why there is both continuous and discontinuous synthesis of daughter strands during DNA replication.

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[Total: 11]

Question 3 starts on page 8

3 Fig. 3.1 shows a diagram of protein synthesis.

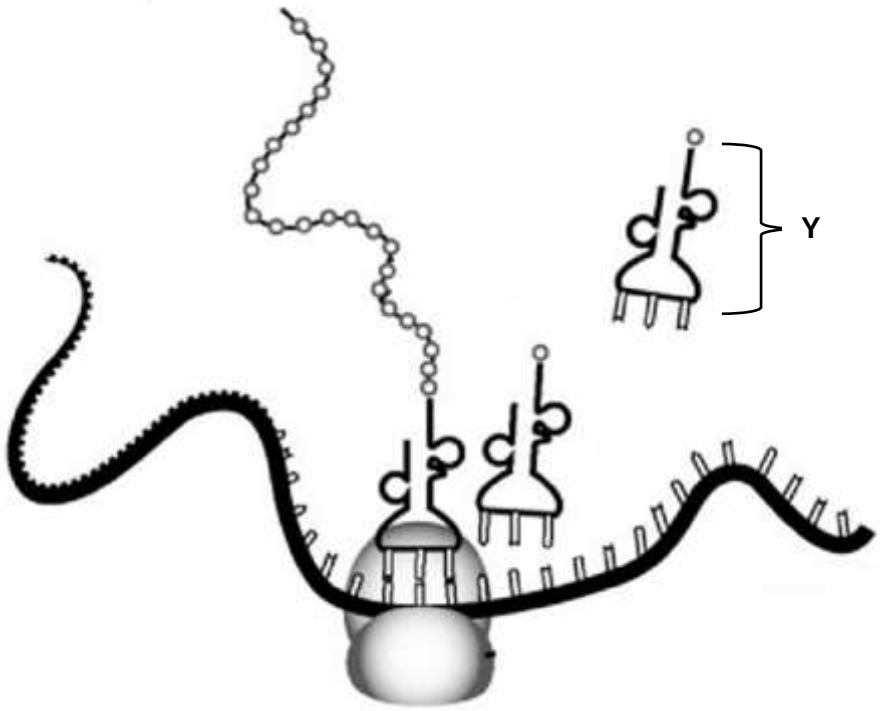

Fig. 3.1

(a) With reference to Fig. 3.1, outline the synthesis of the polypeptide chain from its mRNA.

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…… [4]

(b) During protein synthesis in cells of an embryo, all molecules **Y** in Fig. 3.1 are observed to be attached to the arginine amino acid instead of lysine.

(i) Suggest how the attachment of the wrong amino acid, arginine, to molecule **Y** may arise.

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…… [2]

(ii) Suggest and explain the effect of attachment of the wrong amino acid, arginine, to molecule **Y** on the embryo.

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…… [3]

[Total: 9]

4 The building blocks of anterior (head) – posterior (tail) axis patterning in *Drosophila* embryo (fertilised egg) are laid out during egg cell formation. Four genes (*hunchback, caudal, bicoid*, *nanos)* are responsible for the polarity of the egg cell and then of the subsequent embryo. mRNA molecules of these four genes were found to be distributed along the anterior-posterior axis of the developing egg cell as shown in Fig. 4.1.

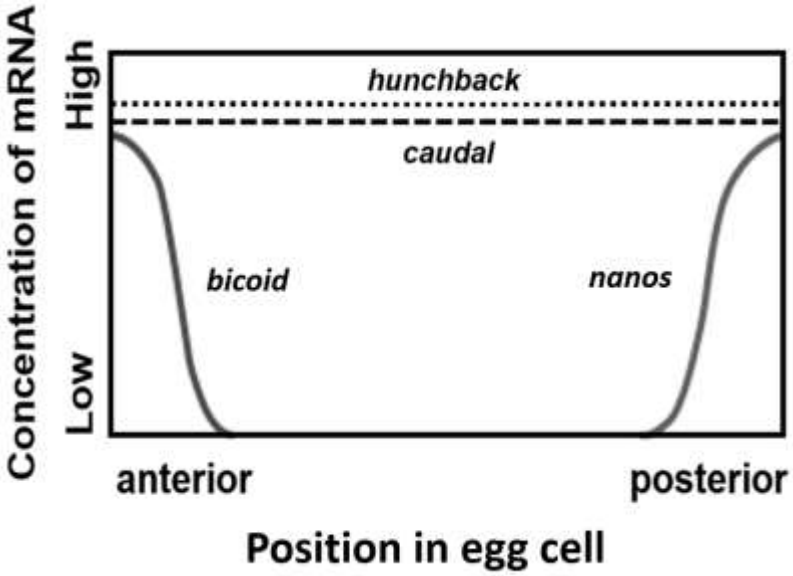

Fig. 4.1

(a) With reference to Fig 4.1,

(i) explain the types of chromatin modifications that may be carried out on the *hunchback* and *caudal* genes.

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(ii) The length of *hunchback* and *caudal* mRNA in the cytoplasm is shorter than the *hunchback* and *caudal* primary mRNA in the nucleus.

Describe what happen to the *hunchback* and *caudal* mRNA in the nucleus before they enter the cytoplasm.

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(iii) mRNAs in cells are very unstable, having short half-lives of not more than 30 minutes. Explain how the *hunchback* and *caudal* mRNA levels are maintained within the cell.

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……... [2]

(b) The corresponding protein concentrations of the four genes were measured in the early stages of development of the *Drosophila* embryo as shown in Fig. 4.2.

It was found that bicoid and nanos proteins act as repressors to block the translation of *caudal* and *hunchback* mRNA respectively.

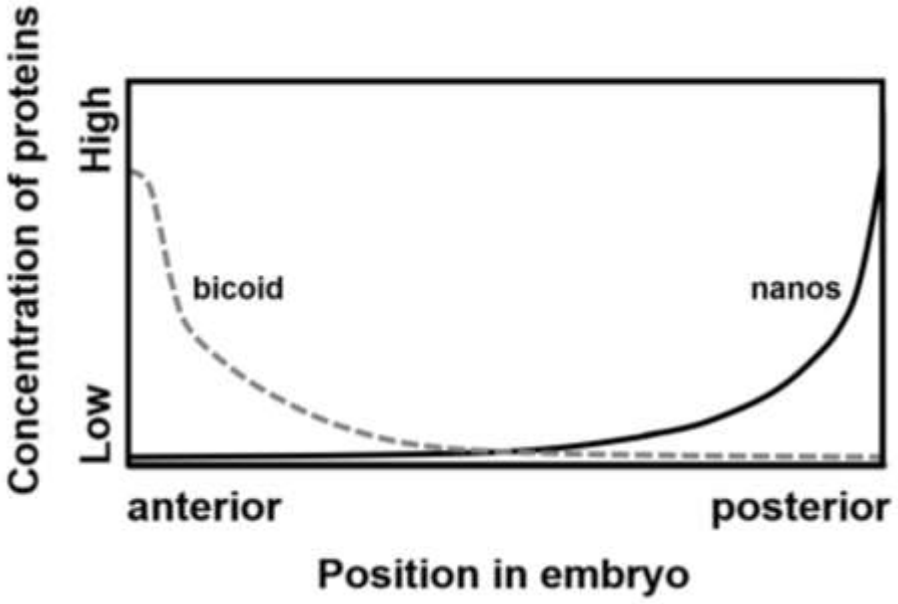

Fig. 4.2

Sketch **one** graph on Fig. 4.2, to represent the concentration of hunchback protein. [1]

[Total: 10]

5 Fig. 5.1 shows the main structural features of the influenza virus.

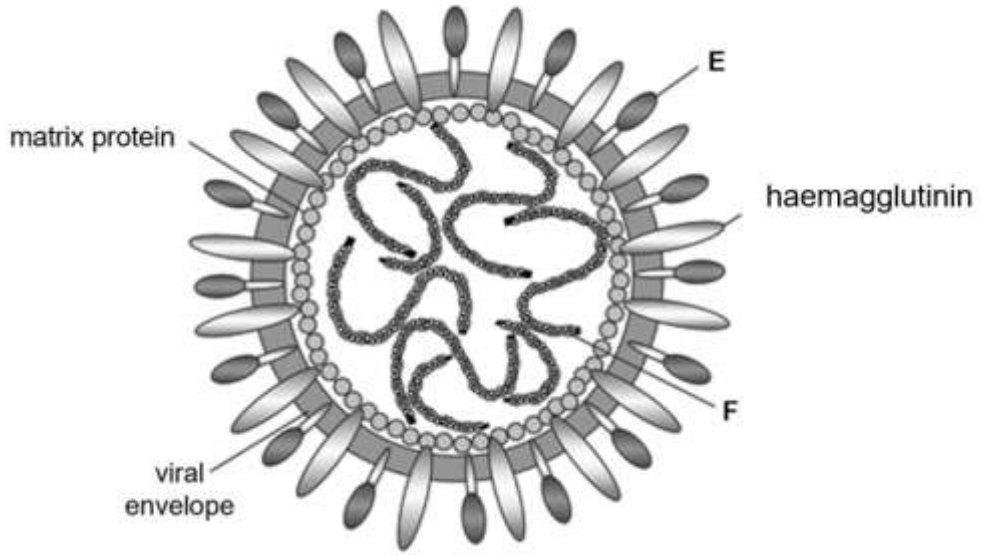

Fig. 5.1

(a) Explain the role of **E** and **F** in the influenza virus.

E ……..

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F ……..

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……... [4]

The sub-types of the influenza **A** virus that infect birds, human and pigs in one area of the world in recent times are shown in Table 5.1 below.

Table 5.1

time period	influenza A virus sub-types present		
	birds	humans	pigs
1918 – 1957	show any one of the H1 – H16 antigens combined with any one of the N1 – N9 antigens	H1N1	H1N1
1958 – 1970		H2N2	
1971 to present day		H3N2 H1N1	H3N2 H2N3

(b) Using the data in Table 5.1, two students, each has different claims that described how influenza **A** is a danger to human health in this area of the world.

(i) Student **X** claimed that "Antigenic drift of influenza human virus such as H3N2 would lead to vaccines that target hemagglutinin glycoprotein being less effective."

Put a tick (√) in one box to indicate whether or not this statement is true.

Give a reason for your answer.

true ☐ false ☐

Reason …..……..

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…… [3]

(ii) Student **Y** claimed that "Antigenic shift of influenza virus is happening within humans, by combining H2N2 from older people with H1N1 or H3N2."

Put a tick (√) in one box to indicate whether or not this statement is true.

Give a reason for your answer.

true ☐ false ☐

Reason …..……..

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…… [3]

[Total: 10]

6 Wing pattern in the butterfly species *Heliconius melpomene* is controlled by genes on autosomal chromosomes.

The gene for banding pattern on the upper wing has two alleles:

- a dominant allele coding for a full band
- a recessive allele coding for a broken band.

The gene for ray pattern on the lower wing has two alleles:

- a dominant allele coding for rays
- a recessive allele coding for no rays.

Scientists crossed a butterfly that was homozygous dominant for both genes with a butterfly that was homozygous recessive for both genes. The scientists wanted to check whether the phenotypic ratio for offspring in the F2 generation agreed with the expected phenotypic ratio of 9 : 3 : 3 : 1.

The results of these genetic crosses are shown in Fig. 6.1.

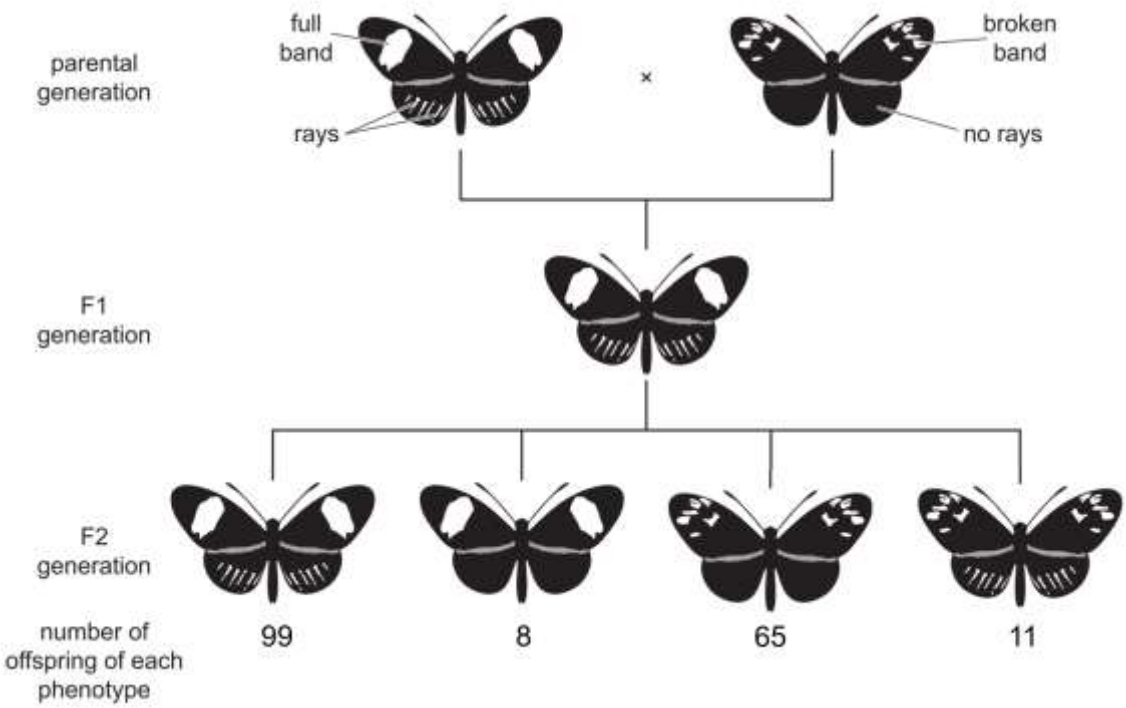

Fig. 6.1

(a) Draw a genetic diagram to explain the results of the genetic crosses.

[5]

(b) Two varieties of *Heliconius* butterflies, both pure-breeding for white wings, were crossed. All the F1 generation progeny produced orange wings.

The F1 butterflies were then crossed. In the F2 generation, 145 butterflies had orange wings and 111 butterflies had white wings. The control of wing colour is an example of epistasis resulting in a ratio that is close to 9:7.

Explain the term epistasis in this context.

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……... [3]

(c) The genus *Heliconius* contains more than 40 species of brightly patterned butterflies.

Researchers have investigated in the laboratory how one species, *Heliconius heurippa*, could have developed as a separate species. The phenotype of *H. heurippa* is intermediate between that of two other species, *H. cydno* and *H. melpomene* as it contains DNA from these two parent species as a result of hybridisation.

Laboratory breeding experiments showed that:

- matings between *H. cydno* and *H. melpomene* (parent species) produce fertile hybrid offspring
- controlled matings of the hybrids produces individuals identical in appearance to *H. heurippa* within three generations
- hybrid butterflies prefer to mate with each other, rather than with individuals of either of the parent species to produce fertile offspring.

In the wild,

- the genus *Heliconius* butterflies taste unpleasant to predators such as birds.
- the bright colours on the wings of the butterflies act as warnings so that birds avoid eating them. Therefore, this pattern provides a selective advantage.
- *Heliconius* hybrids occur in small numbers and have patterns that do not resemble the established warning pattern of either parent species. These hybrids have a selective disadvantage.

The researchers thought that, because the hybrid butterflies preferred to mate with each other, this could make speciation more likely to occur.

Suggest why *H. heurippa* is still **not** regarded as a separate species in the wild.

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……... [2]

[Total: 10]

7 Pancreatic cancer is an almost universally lethal disease.

Many genes are involved in the development of pancreatic cancer. Table 7.1 shows four of these genes.

Table 7.1

genes	genetic changes observed
P	homozygous deletion
Q	hypermethylation of the gene promoter
R	substitution in codon 56
S	amplification of gene

(a) Using the data in Table 7.1, identify an oncogene and a mutated tumour suppressor gene. Explain your answer.

(i) oncogene

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(ii) mutated tumour suppressor gene

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(b) Fig. 7.1 shows where the restriction enzyme *EcoRI* cuts within the two different alleles of gene **R**, the sizes of the fragments produced and the regions that bind to two probes, **Y** and **Z**.

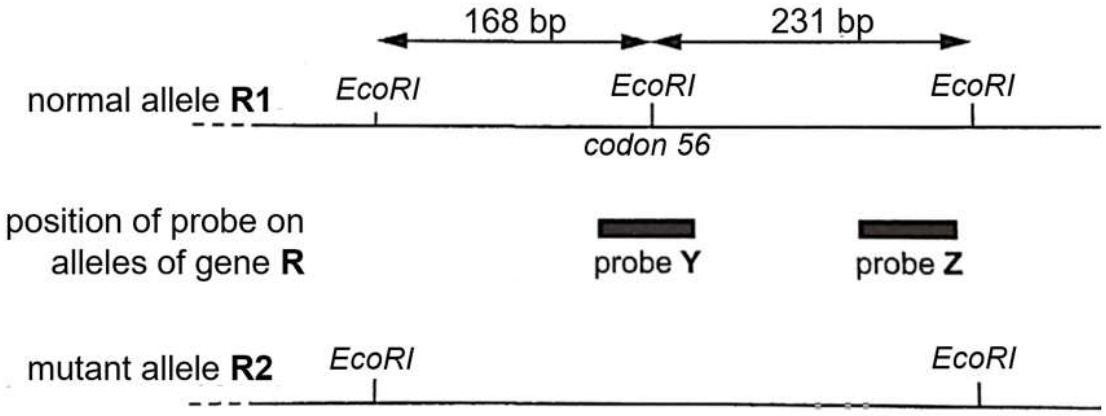

Fig. 7.1

(i) With reference to Fig. 7.1, explain how the two alleles of gene **R** can be distinguished using gel electrophoresis and detected by probe **Y**.

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……... [4]

(ii) On Fig. 7.2 below, draw the position(s) and label the size(s) of the DNA fragment(s) of a heterozygous individual if probe **Z** were to be used instead.

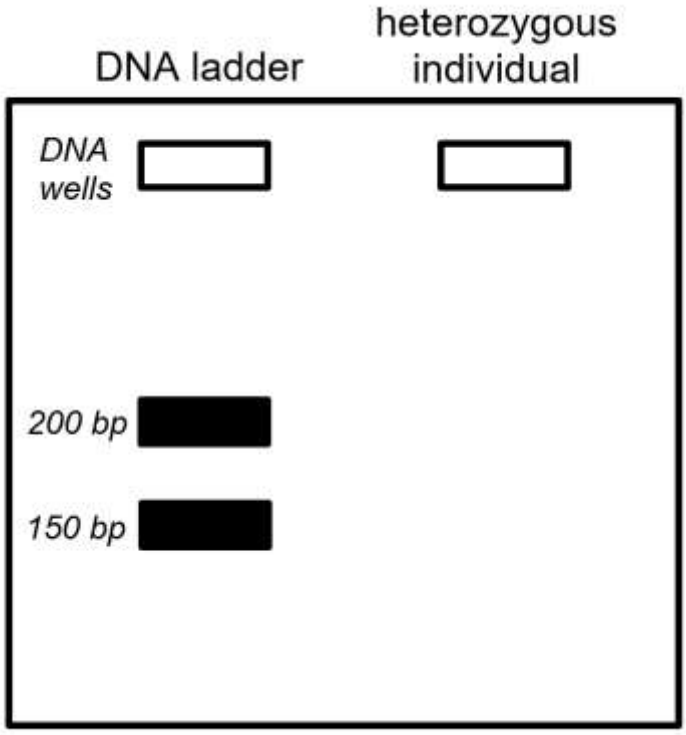

Fig. 7.2

[2]

[Total: 10]

8 Red algae are multicellular photosynthetic eukaryotes that contain phycoerythrin. Phycoerythrin is a photosynthetic pigment.

Fig. 8.1 shows:

- the absorption spectrum of phycoerythrin.
- the action spectrum of red algae.

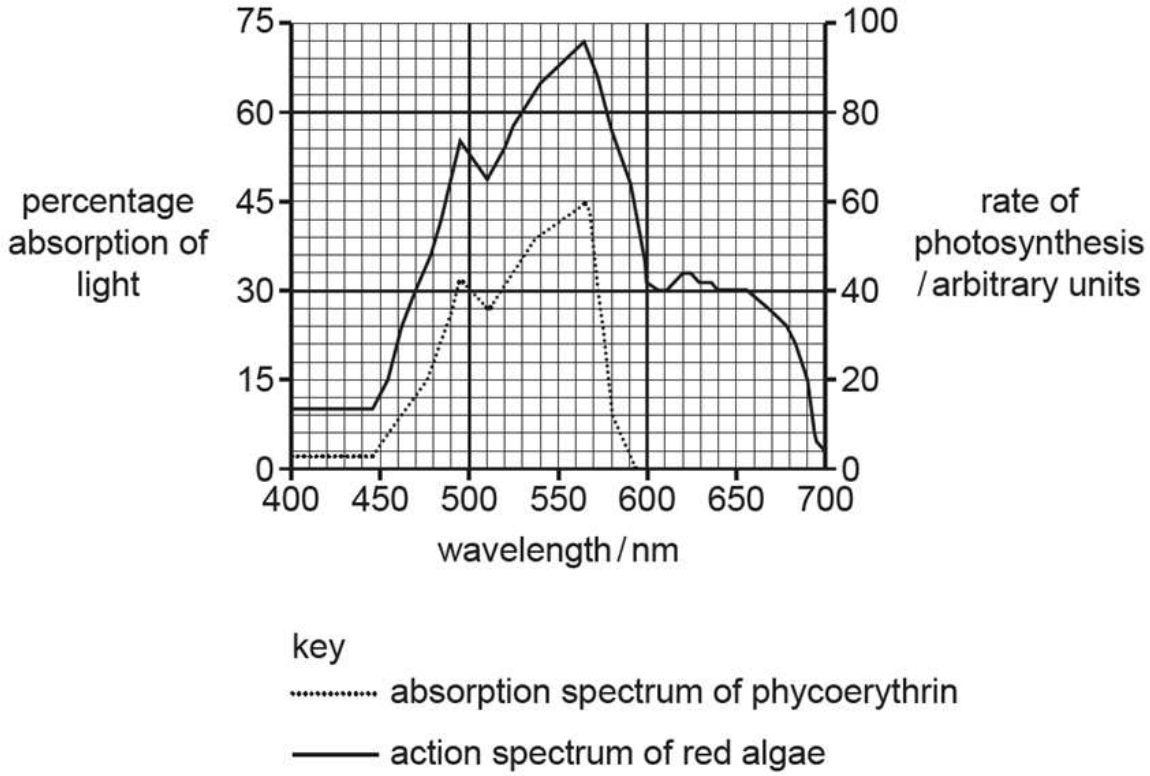

Fig. 8.1

(a) **(i)** With reference to Fig. 8.1, state the wavelength of peak absorption by phycoerythrin.

…….. [1]

(ii) Explain how the data in Fig. 8.1 show that phycoerythrin is **not** the only photosynthetic pigment in red algae.

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…….. [2]

(iii) Phycoerythrin is **not** the primary pigment (pigment in reaction centre) for photosynthesis in red algae.

Suggest the role of phycoerythrin in photosynthesis in red algae.

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……... [2]

(b) The rate of photosynthesis is affected by factors other than wavelength of light. These factors may act as limiting factors. A student investigated the effect of limiting factors on rate of photosynthesis by measuring the volume of oxygen released from a plant.

(i) Explain what is meant by the term limiting factor and state an example of a limiting factor in photosynthesis.

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(ii) Explain why the volume of oxygen released from a plant does **not** give a true rate of photosynthesis.

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…… [2]

[Total: 10]

9 Fig 9.1 shows the arrangement of bones in the pentadactyl forelimbs of four vertebrates. This is used by many people to provide evidence for evolution.

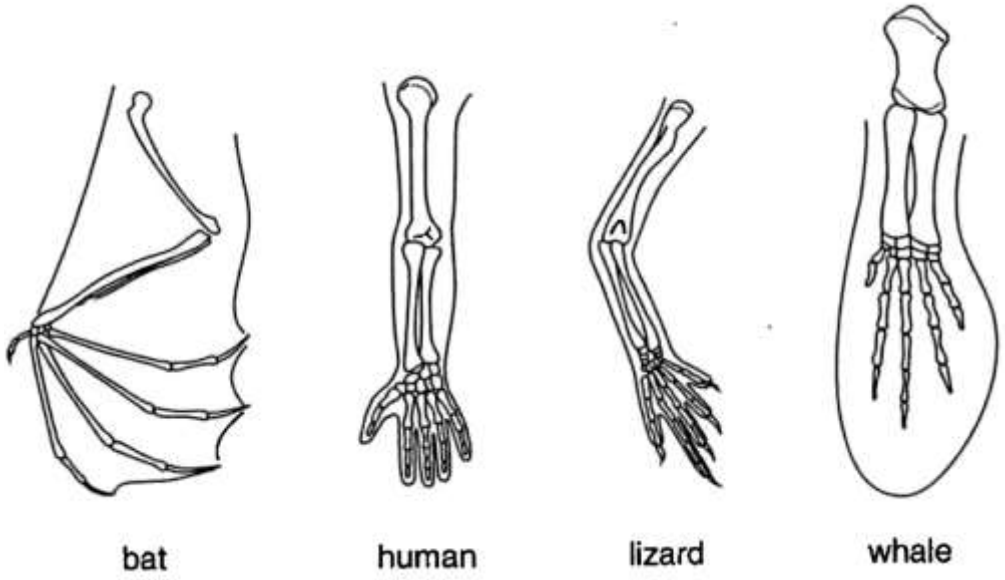

Fig. 9.1

(a) (i) State the term used to describe the relationship between structures such as those in Fig. 9.1.

…….. [1]

(ii) Explain how the relationship between the structures in Fig. 9.1 provides evidence to support the theory of evolution.

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(b) There are many different species of lizards. Three of these species, *Liolaemus fabiani, L. molinai* and *L. multicolor*, are thought to be closely related.

Samples of these three species were collected from the Andes range in Western South America. The base sequences of four regions of DNA of each species were sequenced.

The percentage difference in the base sequences in *L. molinai and L. multicolor,* compared to the sequences in *L. fabiani,* was calculated. The results are shown in Table 9.1.

Table 9.1

DNA region	Lizard species	Percentage difference in base sequence from that of *L. fabiani* / %
Non-coding region 1	*L. molinai*	4.8
	L. multicolor	4.4
Non-coding region 2	*L. molinai*	8.1
	L. multicolor	7.3
Coding region 1	*L. molinai*	2.1
	L. multicolor	2.0
Coding region 2	*L. molinai*	1.9
	L. multicolor	1.7

(i) Using the evidence from the non-coding regions in Table 9.1, explain why *L. fabiani* may be more closely related to *L. multicolor* than to *L. molinai*.

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…….. [2]

(ii) The coding regions 1 and 2 in Table 9.1 were measured by analysing the *cytochrome c* gene.

Suggest why the *cytochrome c* gene is used to measure changes in DNA sequences in closely related species.

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…….. [2]

(c) Explain the importance of variation in the coding regions for evolution to occur.

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…….. [2]

[Total: 10]

10 Fig 10.1 shows an antigen presenting cell (APC) presenting an antigen from a pathogen such as a virus, to a cytotoxic T cell.

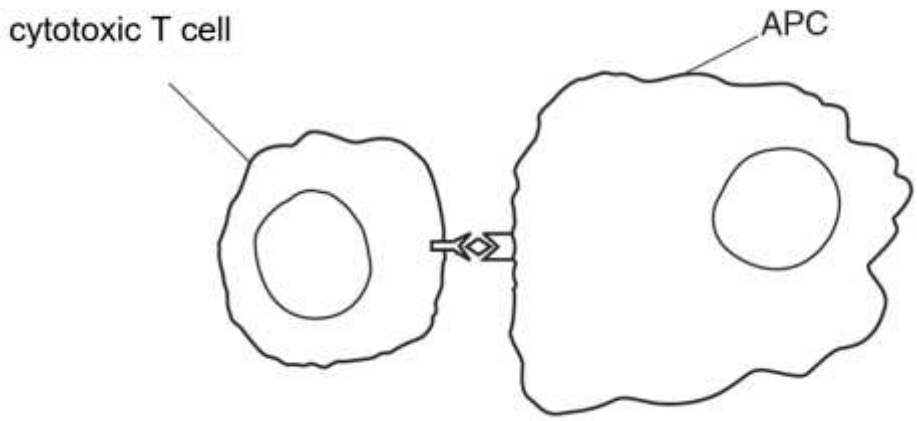

Fig. 10.1

(a) Using Fig. 10.1, describe how presentation of an antigen by APC will lead to the elimination of the pathogen.

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……. [3]

(b) State **two** differences between artificial active immunity and natural passive immunity.

Difference between artificial and natural immunity

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Difference between active and passive immunity

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[2]

[Total: 5]

11 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.

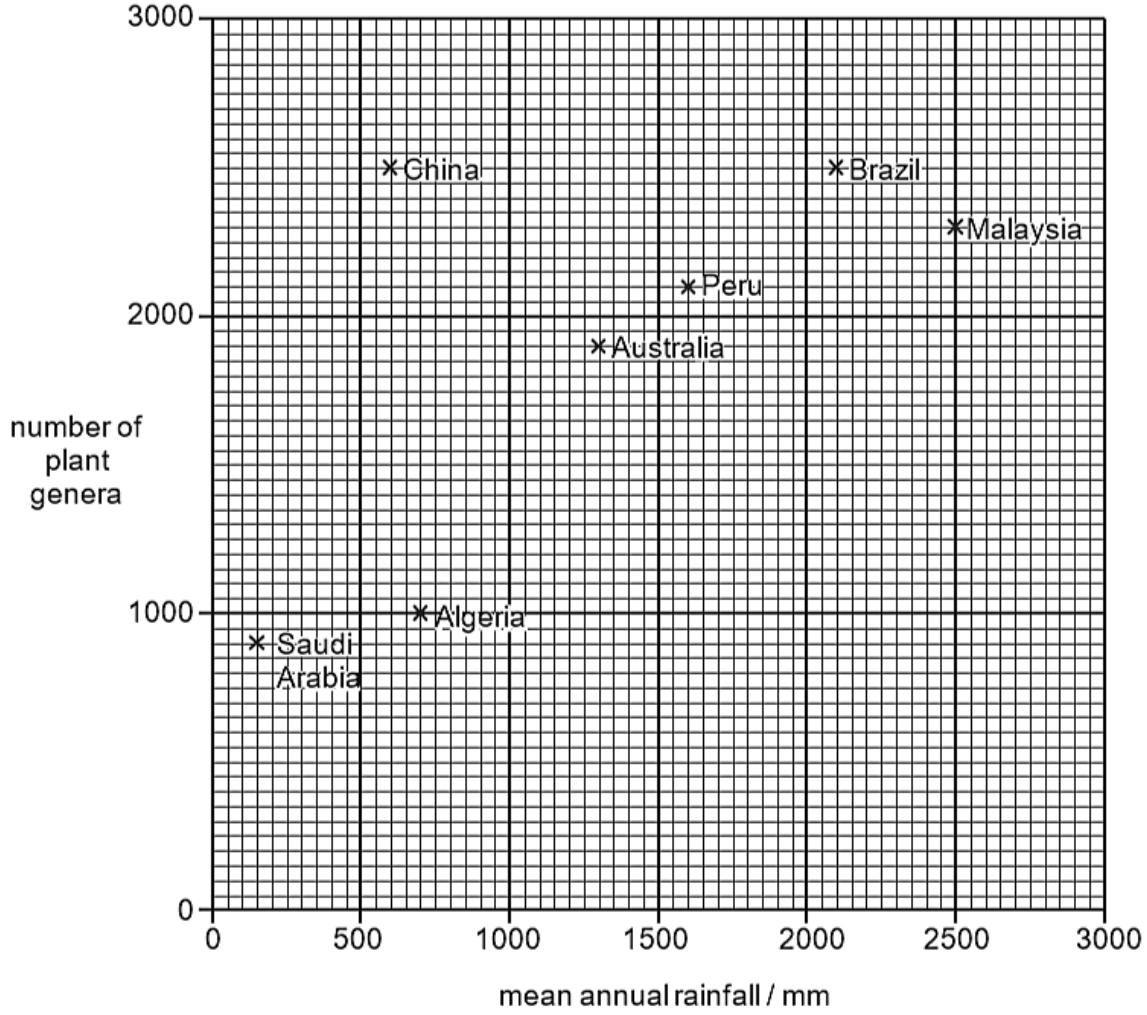

Fig. 11.1

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

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…… [2]

(ii) Global warming has led to changes in rainfall in many parts of the world**.**

Explain how changes in rainfall can decrease plant biodiversity.

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…….. [2]

(b) The Millennium Seed Bank is located in the United Kingdom. So far it has successfully stored seeds from 10% of the world's wild plant species.

Suggest **one** benefit to humans of conserving plant species.

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..…….. [1]

[Total: 5]

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