H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CLASS

BIOLOGY **9744/02**

Paper 2 Structured Questions **10 September 2024**

Candidates answer on the Question Paper.
No Additional Materials are required. **2 hours**

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do no use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

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 no 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	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
Total	

This document consists of **30** printed pages and **0** blank pages.

[Turn over

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

1 *Candida albicans* is a yeast-like fungus that lives in human lungs. It is the causative agent of
one of the opportunistic infections that may develop during AIDS.

C. albicans is eukaryotic. Fig. 1.1 shows its structure.

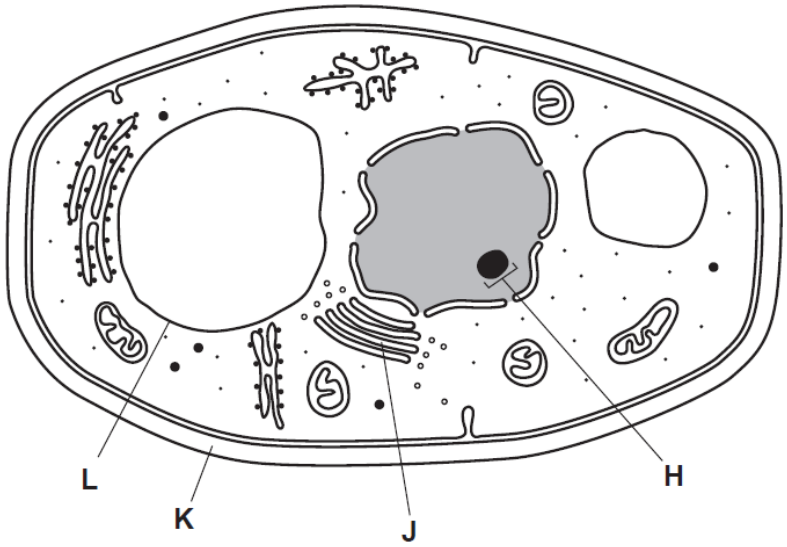


Fig. 1.1

(a)(i) Name **H** to **L**.

.....

.....

.....

.....
[2]

(ii) State two ways in which the **structure** of a prokaryotic cell differs from that shown in Fig. 1.1.

.....

.....

.....

.....
[2]

C. albicans uses a transport protein, TMP1, to absorb sugar molecules from the inside of the mouth. TMP1 is encoded by a gene within the nucleus and is produced when sugars are present in the surroundings.

(b) Explain how the structures within the cell shown in Fig. 1.1, are involved with the production of functioning TMP1.

.....

.....

.....

.....

.....

.....

.....

.....

[4]

[Total: 8]

2 Table 2.1 contains statements about four molecules.

(a) Complete the table by indicating with a tick (✓) or a cross (✗) whether the statements apply to haemoglobin, DNA, phospholipids or antibodies.

You should put a tick or a cross in each box of the table.

Table 2.1

statement	haemoglobin	DNA	phospholipids	antibodies
contains phosphate				
able to replicate				
hydrogen bonds stabilise the molecule				
Contains nitrogen				

[4]

(b) Haemoglobin is a globular protein that shows quaternary structure. It is composed of two types of polypeptide, known as α and β globin.

(i) Explain how a globular protein differs from a fibrous protein, such as collagen.

.....

.....

.....

.....

[2]

Fig. 2.1 shows part of the base sequence of the mRNA that codes for the first ten amino acids of β globin. Table 2.2 shows some of the codons and the amino acids for which they code for.

GUG	CAC	CUG	ACU	CCU	GAG	GAG	AAG	UCU	GCC

Fig. 2.1

Table 2.2

amino acid	abbreviation	codons					
alanine	ala	GCA	GCC	GCG	GCU		
glutamic acid	glu	GAA	GAG				
histidine	his	CAC	CAU				
leucine	leu	UUA	UUG	CUA	CUC	CUG	CUU
lysine	lys	AAA	AAG				
proline	pro	CCA	CCC	CCG	CCU		
serine	ser	UCA	UCC	UCG	UCU	AGC	AGU
threonine	thr	ACA	ACC	ACG	ACU		
valine	val	GUA	GUC	GUG	GUU		

(ii) Use the information in Table 2.2 to complete the sequence of amino acids at the beginning of β globin using the first three letters of each amino acid. Some of them have been done for you.

val	his				glu				ala

[2]

(iii) β globin has a tertiary structure that consists of eight helices arranged to give a precise three-dimensional shape.

Describe how the precise three-dimensional shape of a polypeptide is maintained.

.....

.....

.....

.....

.....

.....

[3]
[Total: 11]

3 Pepsin is an enzyme that hydrolyses proteins (protease). Some students used pepsin from the stomach of a mammal. The activity of the pepsin was investigated by placing a small quantity of the enzyme with a known concentration of the protein albumen.

Fig. 3.1 shows the progress of the enzyme-catalysed reaction that was carried out at 20 °C.

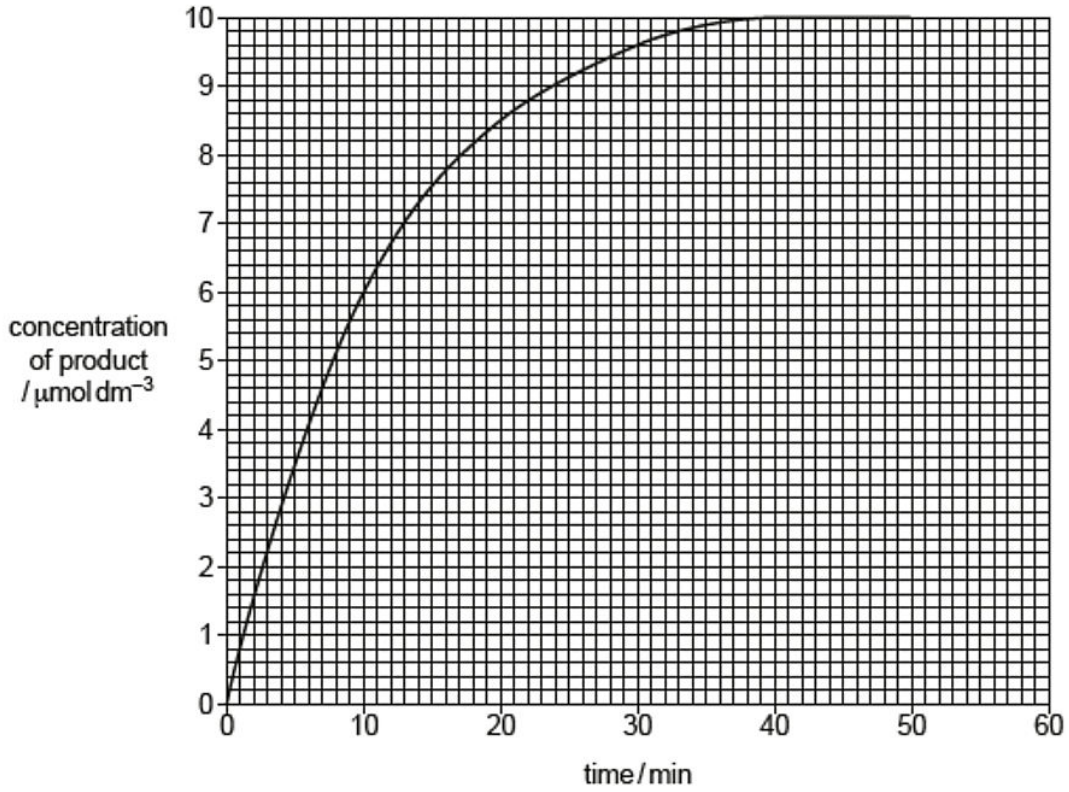


Fig. 3.1

(a) Calculate the initial rate of the reaction.

initial rate of reaction = ... [2]

(b) The procedure was repeated to find the effects on the activity of the pepsin using a N-acetyl-statine, a competitive inhibitor at the same temperature, 20 °C.

(i) Predict the results that will be obtained using the competitive inhibitor.

.....

.....

.....

.....

[2]

(ii) Explain how N-acetyl-statine inhibits the enzyme pepsin.

.....

.....

.....

.....

.....

.....

[3]

(c) Enzyme chymotrypsin is another protease synthesized by mammals. However chymotrypsin and pepsin are structurally different with different amino acid sequences.

Explain how two enzymes with different amino acid sequences can catalyse the same reaction.

.....

.....

.....

.....

[2]

[Total: 9]

4 Telomere length has been associated with cell division and cell cycle arrest. Fig 4.1 shows the telomere length over time in various cell types. If telomeres are shortened to a 'critical length', the cell will undergo permanent growth arrest or apoptosis.

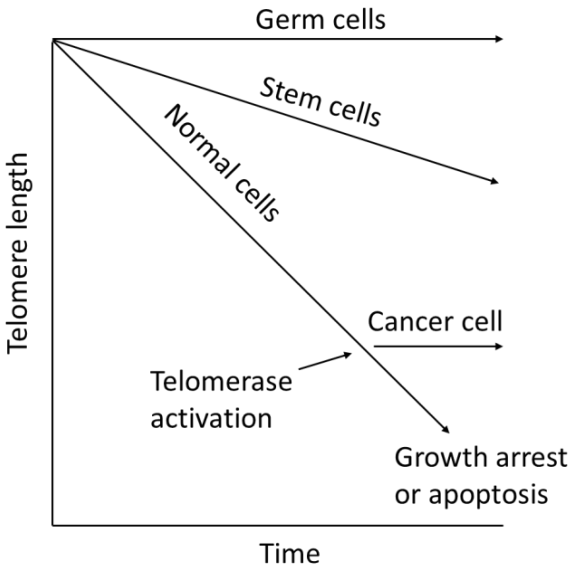


Fig. 4.1

(a) (i) With reference to Fig. 4.1, describe the difference in telomere length between normal cells and germ cells (cells that give rise to gametes) over time.

.....

.....

[1]

(ii) Telomerase results in the extension of the telomere length. Explain the significance of telomerase in germ cells.

.....

.....

.....

.....

.....

.....

[3]

(iii) Describe how telomerase extends telomere length.

.....

.....

.....

.....

.....

.....

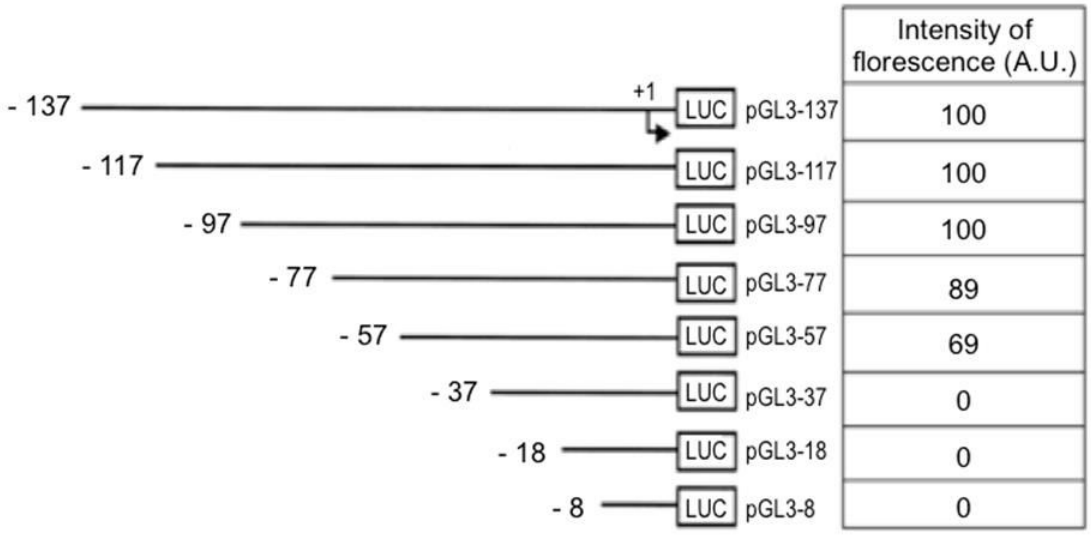
.....

.....

[4]

Transcriptional regulation of human telomerase (hTERT) gene is the major mechanism in regulating telomerase amount in human cells. The hTERT gene promoter is found to be inactive in normal cells but is activated in germline cells and stem cells.

The luciferase gene (*LUC*) is placed under the control of hTERT gene promoter of varying lengths as shown in Fig. 4.2. Luciferase produces a fluorescent green protein when luciferin is added. The intensity of the florescence was quantified and the results are shown below.



Intensity of florescence (A.U.)
100
100
100
89
69
0
0
0

Fig. 4.2

(b) With reference to Fig. 4.2, explain the decrease in intensity of fluorescence when the region between -97 to -37 in the promoter is deleted.

.....

.....

.....

.....

[2]

(c) Telomerase gene expression is silenced in most adult somatic cells. Methylation of histones results in the recruitment of chromatin remodeling complexes that cause formation of heterochromatin.

Suggest why histone methylation occurs over large areas of chromatin in a differentiated cell.

.....

.....

.....

.....

.....

.....

[3]

[Total: 13]

5 Scientists have produced structures known as virosomes, which are used in certain vaccines. Virosomes do not cause disease.

Fig. 5.1 is a diagram of a section through a virosome used in some vaccinations to protect against the virus which causes influenza.

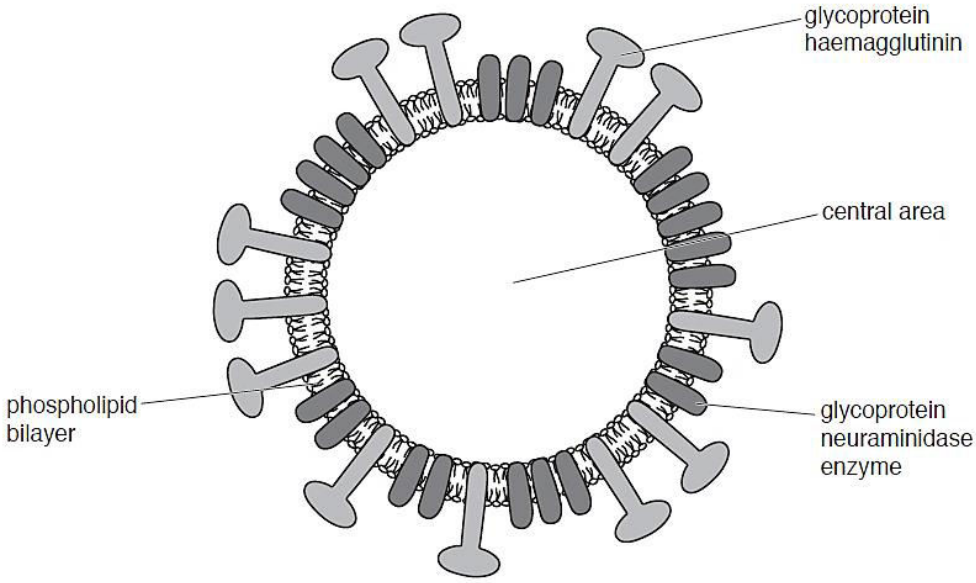


Fig. 5.1

(a) State the differences between the structure of a virosome and a virus.

.....

.....

.....

.....

[2]

(b) The glycoproteins haemagglutinin and neuraminidase are found in the influenza virus and the virosomes used in a vaccine against the influenza virus.
Haemagglutinin binds to a receptor in the cell surface membrane of phagocytes.
Suggest why haemagglutinin is present in virosomes used in the vaccine for influenza.

.....

.....

.....

.....

[2]

(c) Changes to the structure of the antigens on the surface of the influenza virus happen continually over time, as shown in Fig. 5.2 below. This results in the formation of different variants of influenza virus.

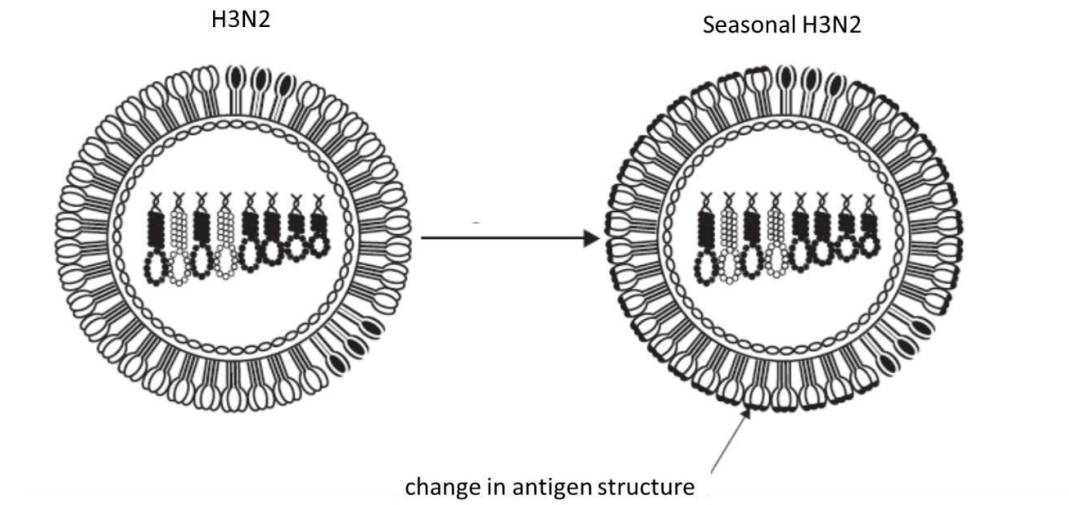


Fig. 5.2

(i) Identify the type of antigenic change that resulted in the new variant.

.....

[1]

(ii) Explain the characteristics of the influenza virus which contribute to these antigenic changes.

.....

.....

.....

.....

.....

.....

[3]

[Total: 8]

6 Extracellular growth factors are involved in the control of cell cycles in some mammalian cells. One of these growth factors is epidermal growth factor (EGF). Fig. 6.1 shows the events that occur when EGF is present at the surfaces of two cells, A and B.

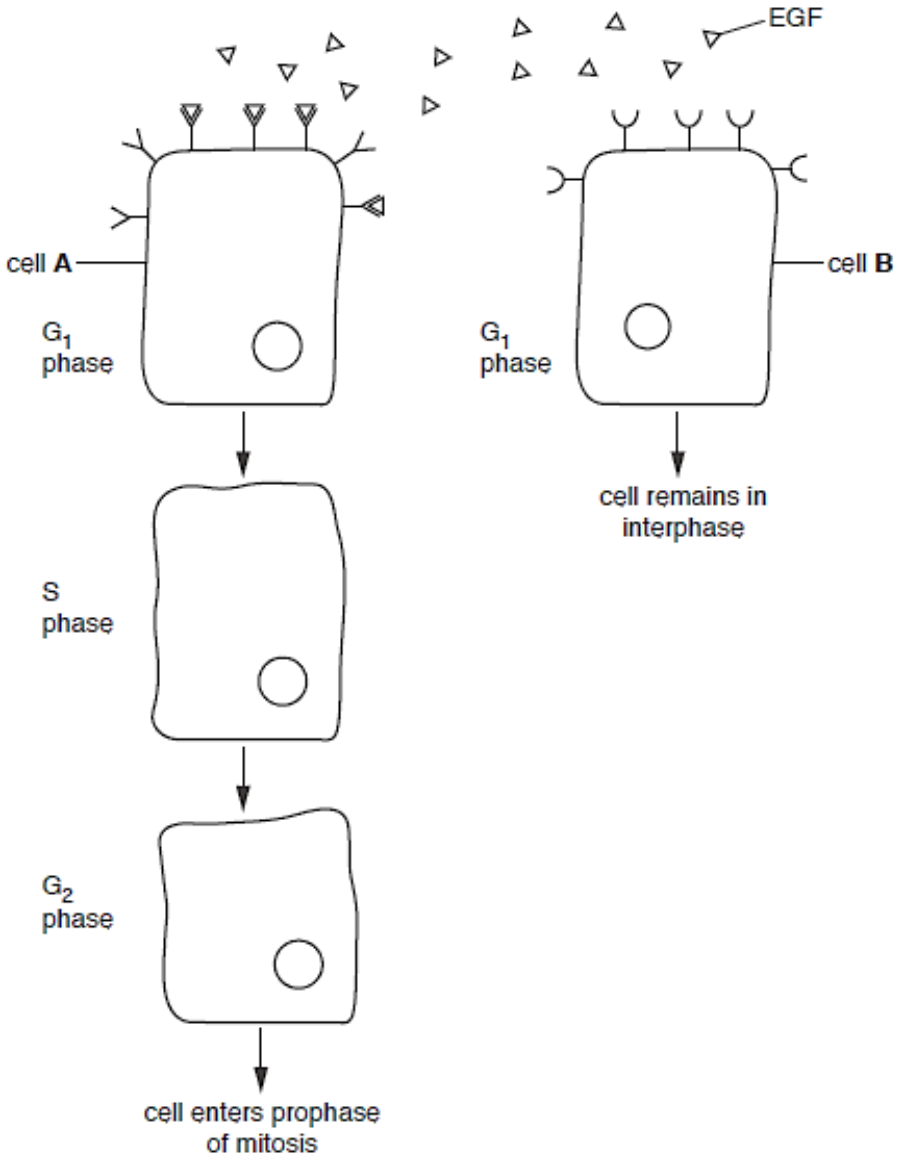


Fig. 6.1

(a) Explain why cell **A** in Fig. 6.1 responds to EGF, but cell **B** does not.

.....

.....

[1]

(b) In the cell cycle, more mRNA is produced in the G1 phase than during mitosis.

Suggest why this is so.

.....

.....
[1]

(c) DNA is replicated during the S phase of the cell cycle. EGF is one of many factors that stimulate the change from the G1 phase to the S phase.

State the molecules used to synthesise DNA during the S phase.

.....

.....

.....

.....
[2]

(d) Fig. 6.2 is a drawing of chromosome 1 from rice, *Oryza sativa*, during metaphase of mitosis.

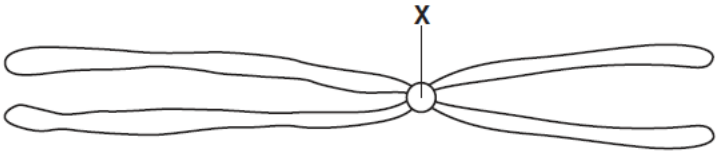


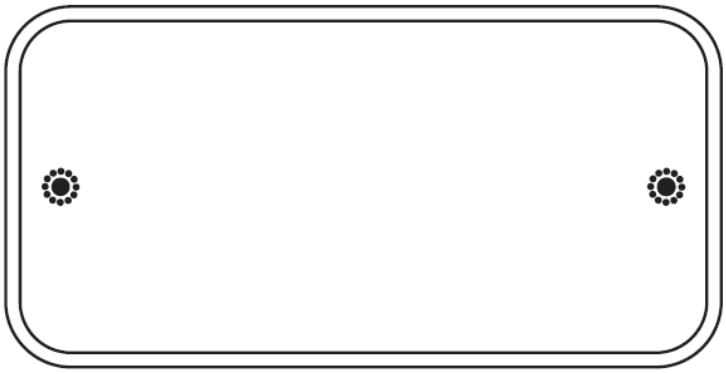
Fig. 6.2

(i) State the name and function of the region of the chromosome labelled **X**.

.....

.....
[2]

(ii) In the outline of the cell below, draw the chromosome from Fig. 6.2 as it would appear in anaphase of mitosis.

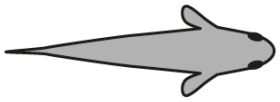
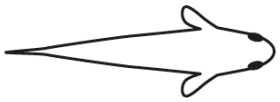


[2]

[Total: 8]

7 A freshwater fish species, *Oryzias latipes*, has individuals with four body colour patterns, as shown in Table 7.1.

Table 7.1

phenotype	body colour pattern
red	
white	
red with black spots	
white with black spots	

Two unlinked genes determine the body colour patterns shown in Table 7.1.

One gene controls whether the body colour is red or white:

- dominant allele **R** = red
- recessive allele **r** = white

The other gene controls whether black spots are present or **not** present:

- dominant allele **B** = with black spots
- recessive allele **b** = without black spots

A fish that is homozygous recessive at both loci is white.

Genetic crosses were carried out to investigate the inheritance of the four different body colour patterns.

Males that were red with black spots, and homozygous at both loci, were crossed with females that were white. The F1 offspring were all red with black spots.

These F1 offspring were then crossed to produce the F2 generation.

(a) Table 7.2 shows the observed numbers obtained of each of the four different phenotypes for the F2 generation.

Table 7.2

phenotype	observed	expected	$O–E$	$(O–E)^2$	$\frac{(O–E)^2}{E}$
red with black spots	279	281.25			
white with black spots	95	93.75	1.25	1.5625	0.017
red	96	93.75	2.25	5.0625	0.054
white	30	31.25			
				χ^2 = ...	

Table 7.2 compares the observed numbers with the numbers that would be expected in the F2 generation for a normal dihybrid ratio.

Calculate χ^2 for the F2 generation by completing Table 7.2.

The formula for χ^2 is:

$$\chi^2 = \sum \frac{(O–E)^2}{E}$$

[2]

(b) The critical value at p = 0.05 and 3 degrees of freedom is 7.815.

Comment on whether the null hypothesis should be accepted or rejected.

.....

.....

[2]

Further analysis of the results from the F2 generation in Table 7.2 showed that there were no white males or white males with black spots.

In *O. latipes*, females have two **X** chromosomes and males have an **X** and a **Y** chromosome.

It was deduced that, in *O. latipes*:

- the gene that controls body colour is not found on homologous autosomes but is located on both the **X** chromosome and the **Y** chromosome
- the gene that controls whether black spots are present or **not** is located on an autosome.

(c) To produce the F2 generation, red males with black spots, $\mathbf{X^rY^RBb}$, were crossed with red females with black spots, $\mathbf{X^RX^rBb}$.

Draw a genetic diagram in the space below to show the predicted genotypes and phenotypes of the F2 generation.

- Use the symbols $\mathbf{X^R}$, $\mathbf{X^r}$ and $\mathbf{Y^R}$ for the alleles of the gene that controls body colour.
- Use the symbols **B** and **b** for the alleles of the gene that controls whether black spots are present or **not**.

[4]

(d) Explain why there are no white males or males that are white with black spots in the F2 generation.

.....

.....

.....

.....

[2]

(e) In another cross, red males with the genotype $\mathbf{X^rY^Rbb}$ were mated with white females with the genotype $\mathbf{X^rX^rbb}$. All the male offspring were expected to be red and all the female offspring were expected to be white.

The observed results showed that the offspring included two red females out of 253 and one white male out of 198.

Suggest an explanation for this unexpected result.

.....

.....

.....

.....

[2]

[Total: 12]

8 The Krebs cycle was named after the biochemist Sir Hans Krebs, who worked out the sequence in 1937.

Fig. 8.1 is an outline of the Krebs cycle.

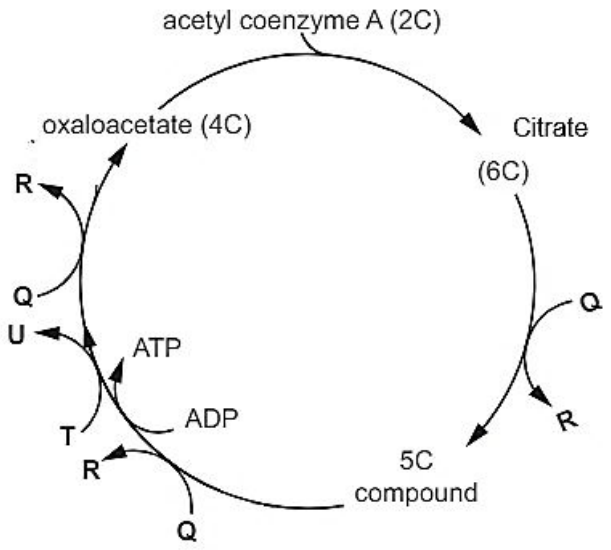


Fig. 8.1

(a) Explain the roles of the **Q, R, T** and **U** in aerobic respiration.

.....

.....

.....

.....

.....

.....

[3]

(b) State the process of the production of ATP in the Krebs cycle.

.....

.....

[1]

(c) Under anaerobic conditions, the production of ATP in mammals and yeast involves glycolysis and fermentation.

Describe the differences in the process of fermentation in mammals and in yeast.

.....

.....

.....

.....

[2]

(d) Describe the features of ATP that make it suitable as the universal energy currency.

.....

.....

.....

.....

[2]

(e) ATP is also used in cell signalling pathways. Explain the significance of ATP in signal transduction.

.....

.....

.....

.....

[2]

[Total: 10]

9 Green lacewings are a family of insects with more than 1300 species. The common green lacewing, *Chrysoperla carnea*, is shown in Fig. 9.1.

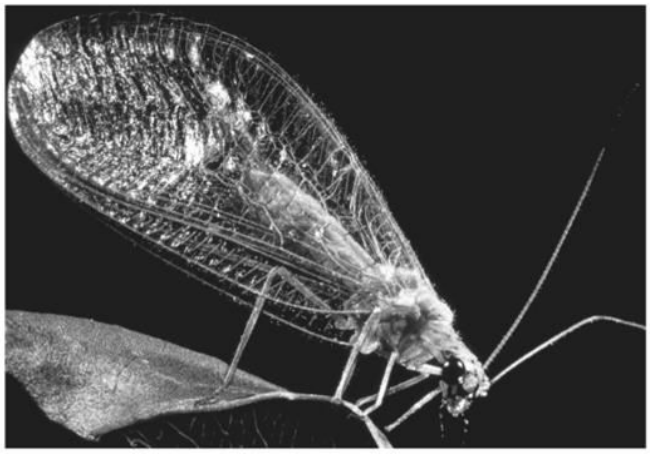


Fig. 9.1

Green lacewings have sense organs, known as tympanal organs, that detect sound. The tympanal organ of green lacewings has evolved to detect the high frequency sounds that bats make when they are hunting. Bats eat green lacewings.

When a green lacewing senses the presence of a bat, it moves away or closes its wings in flight to escape.

(a) Outline how the tympanal organ of green lacewings could have evolved by natural selection.

.....

.....

.....

.....

.....

.....

[3]

(b) Two species of green lacewing, *C. carnea* and *C. downesi*, evolved from a common ancestor.

The two species have populations with overlapping distributions in parts of North America.
Table 9.1 shows a comparison of the characteristics of overlapping populations of the two species.

Table 9.1

characteristic	*C. carnea*	*C. downesi*
breeding months	June to September	April to May
courtship song	song with regular rhythm	song with no regular rhythm
colour	light green	dark green

(i) Suggest how speciation occurred to produce the two different species of green lacewing.

.....

.....

.....

.....

[2]

(ii) Describe one advantage of using databases of nucleotide sequences to investigate evolutionary relationships between the two different species of green lacewing.

.....

.....

[1]

(c) Dominant advantageous alleles and recessive advantageous alleles both naturally occur in populations.

Explain why, when a new dominant advantageous allele occurs, its frequency increases more quickly in the population than when a new recessive advantageous allele occurs.

.....

.....

.....

.....

.....

.....

.....

.....

[4]

[Total: 10]

10 Blood plasma plays an important role in the transport of molecules such as antibodies.

Scientists discovered that some of the antibodies in the blood plasma of sharks have a different structure to the antibodies found in human blood plasma.

Fig.10.1 shows the structure of an antibody molecule found in the blood plasma of a shark.

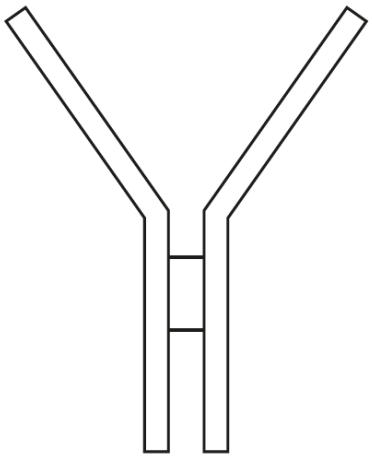


Fig. 10.1

(a) State how the quaternary structure of a human antibody molecule differs from the quaternary structure of the shark antibody molecule shown in Fig. 10.1.

.....

.....
[1]

(b) Human antibodies are used in the treatment of some forms of cancer. However, the antibodies injected into the bloodstream can only reach a small percentage of the cancer cells that form the cancerous tumour.

Shark antibodies are smaller than human antibodies. Scientists are researching the possibility of injecting shark antibodies into the bloodstream to treat cancerous tumours in humans.

Suggest how using the smaller shark antibodies may be more effective in treating cancer cells than human antibodies.

.....

.....
[1]

(c) Antibodies can also be used in the prevention of infectious diseases.

Explain how injection of antibodies into the bloodstream can protect a person from disease after infection by a pathogen.

.....

.....

.....

.....

.....

.....

[3]

[Total: 5]

11 Plant biodiversity varies throughout the world and is dependent on many factors, particularly climate. Global warming has led to changes in rainfall and increased temperature in many parts of the world.

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

Fig. 11.2 shows the mean elevation of the 83 plant species studied in Brazil, between the years of 1994 to 2024. Each point on the graph represents a single plant species.

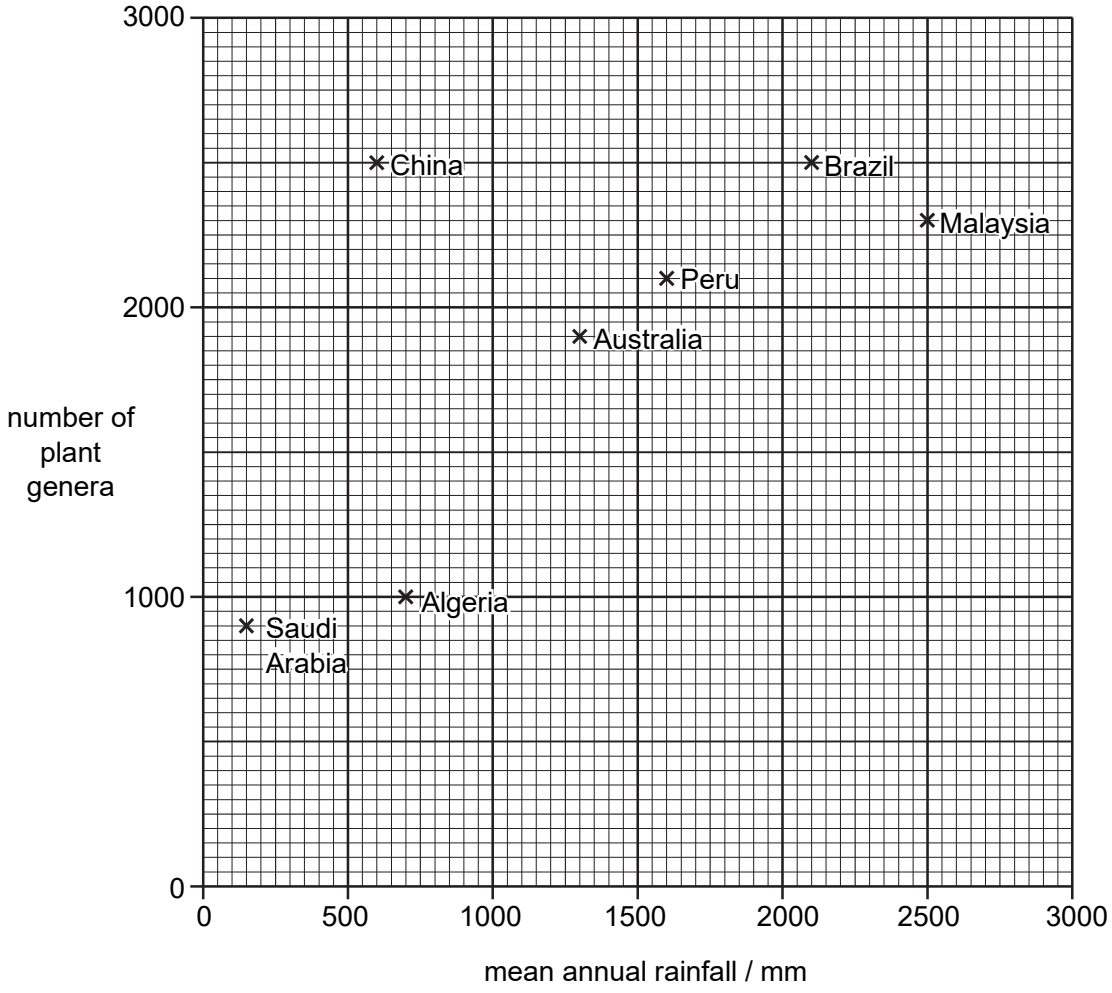


Fig. 11.1

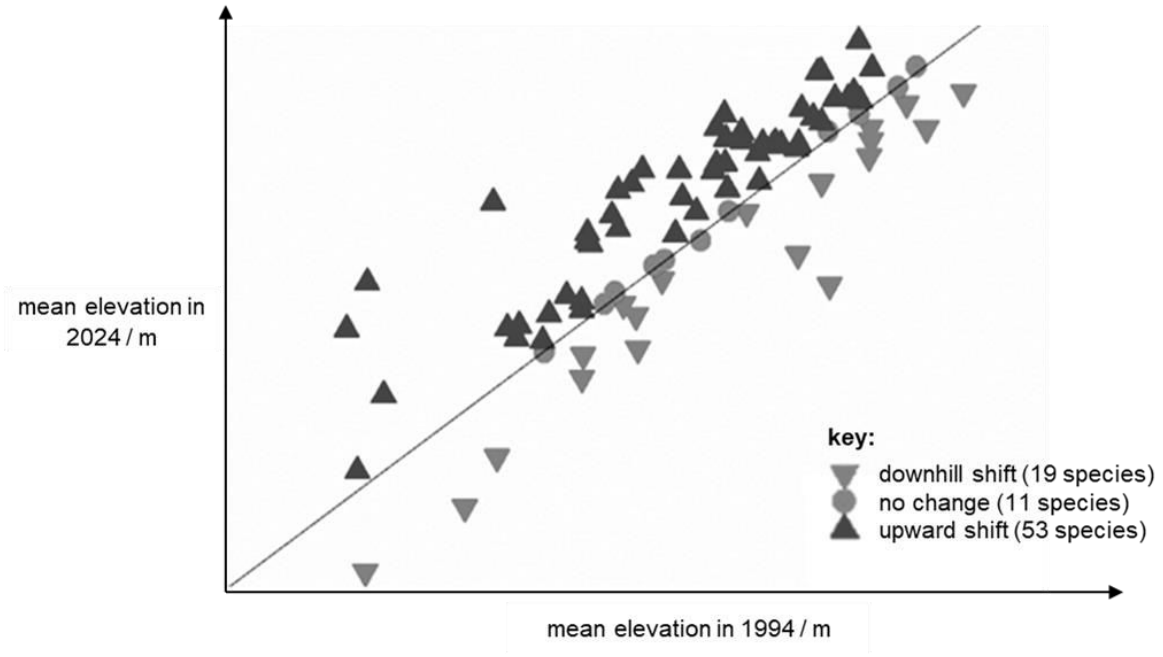


Fig. 11.2

(a) Using the data in both Fig. 11.1 and Fig. 11.2, explain how climate change affects plant distribution and biodiversity.

.....

.....

.....

.....

.....

.....

.....

.....

[4]

(b) Suggest why it would be difficult for the scientists to conclude that changes in rainfall can affect plant biodiversity.

.....

.....

[1]

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.

(c) Suggest the benefit to humans of conserving plant species.

.....

.....

[1]

[Total: 6]