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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	8
2	11
3	9
4	13
5	8
6	8
7	12
8	10
9	10
10	5
11	6
Total	100

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.

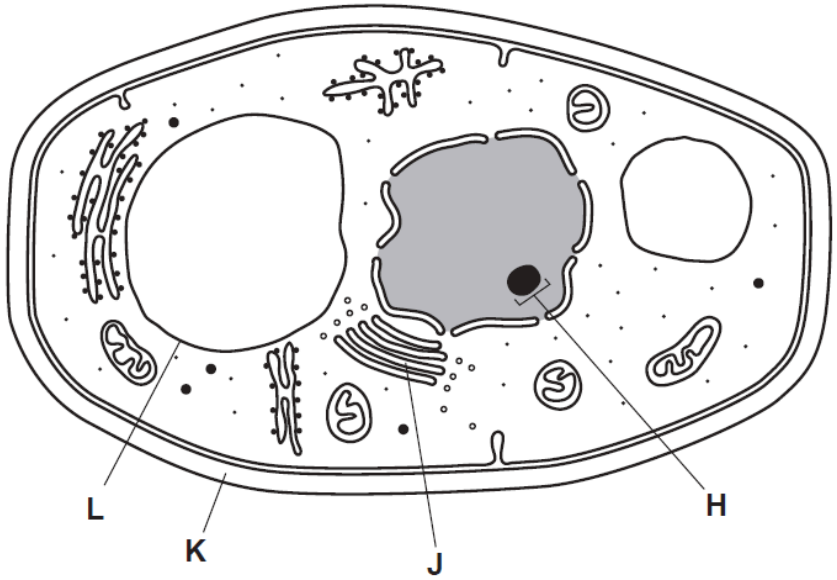


Fig. 1.1

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

H nucleolus ;
J Golgi (body / apparatus) ;
K cell wall ; R murein / peptidoglycan ignore cellulose or chitin
L vacuolar membrane / vacuole ; A tonoplast R cell sap;

Any two 1m;

[2]

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

1. Prokaryotic cell have no membrane-bound organelles but C.albicans has membrane bound organelle/ give example of membrane bound organelle (nucleus/mitochondria/Golgi apparatus/ER) that is absent in prokaryotes but present in C.albicans ;
2. Prokaryotes have plasmid(s) but C.albicans have no plasmids;
3. Prokaryotes has a peptidoglycan cell wall but C.albicans cell wall is made from other compounds (glucan and chitin) ;
4. Prokaryotes have 70S ribosomes but C.albicans has 80S ribosome ;
5. Prokaryotes have circular DNA but C.albicans have linear DNA

[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.

Any 4
1. Nucleus contains gene that is transcribed to pre-mRNA/mRNA sequence/AW ;
2. nuclear pore has protein complexes that facilitates exit of mature mRNA to, cytoplasm
3. ribosome on rER translates mRNA sequence to protein;
4. RER, transports protein to Golgi (apparatus / body) / modifies protein ;
5. Golgi apparatus further modifies protein by adding carbohydrates / sugars, to proteins ; A glycosylation/ any other example of post-translational modification

[max 1 of the following]
6. Golgi apparatus packages protein / makes vesicle(s) ;
7. Secretory vesicle fuses with cell surface membrane to embed TMP1 on CSM;
8. mitochondrion, provides / produces / synthesises, ATP in correct context ;

.....

.....

[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]

1m each row;

(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.

Any 2

1. *Globular proteins are s*oluble but fibrous proteins are *insoluble*;
2. Globular proteins have hydrophilic amino acids on the exterior and hydrophobic amino acids in the interior but fibrous protein hydrophobic amino acids on the exterior;
3. Globular proteins have spherical 3D conformation/compact conformation but fibrous proteins usually have linear/chain-like confomation;
4. Globular proteins such as haemoglobin has a primary, secondary, tertiary and quaternary structure but fibrous proteins such as collagen has a primary, secondary and quaternary structure/ haemoglobin has a tertiary structure but collagen has no tertiary structure;

.....

[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 2.1 shows some of the codons and the amino acids for which they code.

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 2.1 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	**leu**	**thr**	**pro**	glu	**glu**	**lys**	**ser**	ala

[2]

2 marks if all correct, 1 mark if one wrong, no marks if two or more wrong

(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.

1. **R group interactions** occur between the 8 helices which further folds into specific 3D shape;

Any 2

2. Hydrogen bond forms between polar groups;
3. ionic bond between positive and negative group;
4. Hydrophobic interactions between non-polar side chains;
5. (Idea of) no Disulphide/ covalent bonds present;

.....

[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.

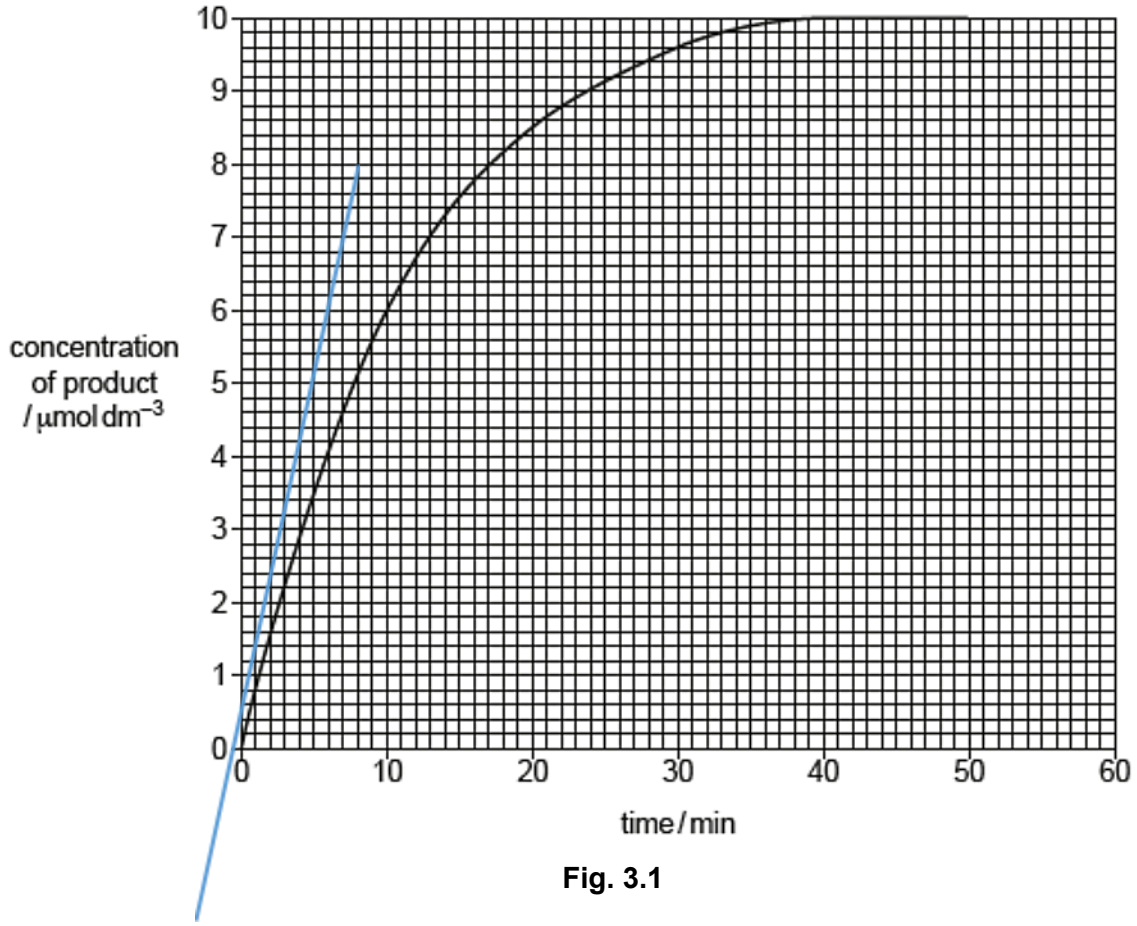


Fig. 3.1

(a) Calculate the initial rate of the reaction.

1. **anything within range 0.6 to 0.8 ;**
2. units of µmol dm^{-3} min^{-1} / µmol per dm^3 per min **; A** µmol per dm^3 / min *or* µmol dm^{-3} / min

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.

1 initial rate will be lower / slower **;**
2 takes longer to reach the plateau / end concentration of 10 μmol dm^{-3} **;**

.....

[2]

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

1. N-acetyl-statine has a similar shape as protein / substrate/ complementary in 3D shape to active site of pepsin;
2. **Binds to active site** of enzyme pepsin and **prevents protein from binding** to active site;
3. Frequency of effective collision between pepsin and protein is lower/none and hence **no/lesser pepsin-protein complexes formed per unit time;**

.....

.....

[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.

1. (Despite having different overall 3D conformation) 3D conformation of the active site of both enzymes are the same and **complementary in conformation to the same substrate**;
2. The catalytic and contact residues at the active site also have the same type of R-groups which can form the same bonds between substrate and active site;

.....

[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.

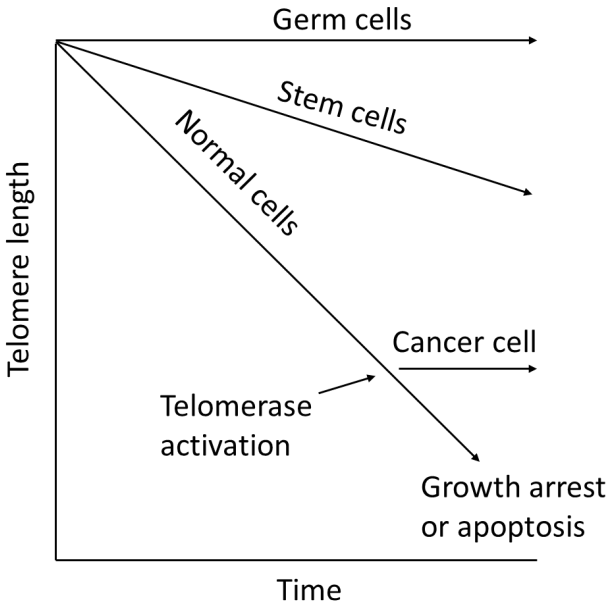


Fig. 4.1

(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.

In normal cells, the telomere length decreases linearly over time, but it remains the same/constant in germ line cells;

[1]

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

1. (Function of telomerase) Telomerase allows **telomere length to be maintained** at each cell division
2. **prevents telomeres from reaching critical length** thus **avoid cell death/ prevents the loss of vital genetic information** through **erosion at chromosomal ends**

[Compulsory point]

3. Germ cells can undergo continuous cell division to produce gametes/ ensure no genetic information is lost in daughter cells;

[3]

(iii) Describe how telomerase extends telomere length.

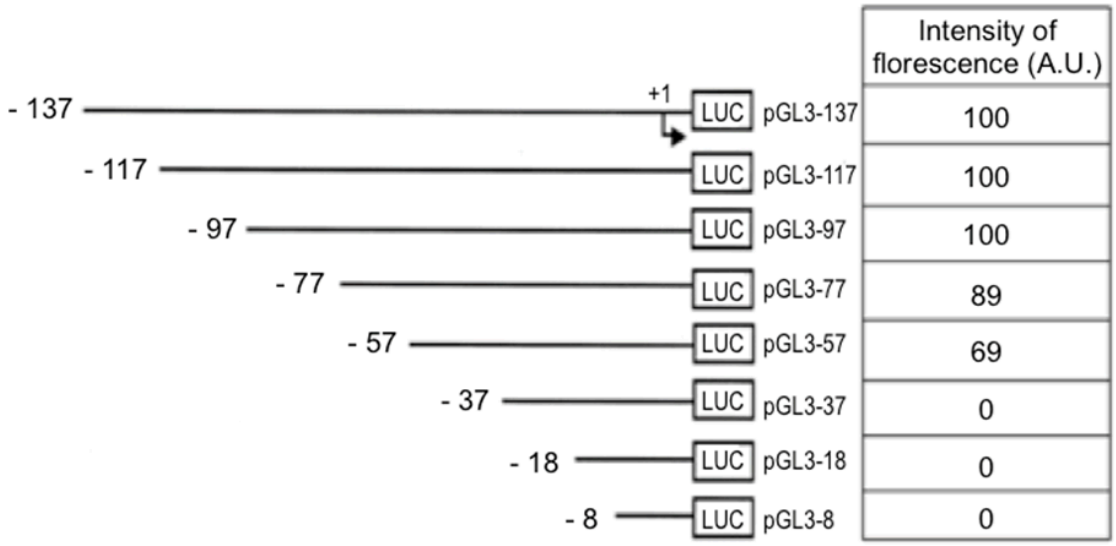
1. **RNA template in telomerase** anneals to **single-stranded overhang at 3' end of the telomere** via complementary base pairing;
2. 3' ends of telomere end is extended using RNA ***template*** in telomerase to add complementary **DNA nucleotides** via complementary base pairing;

3. Telomerase catalyzes the formation of phosphodiester bonds between deoxyribonuceotides;
4. Telomerase translocates to 3' end of telomeres to further elongate the 3' overhang to extend 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.

1. Deletion of -97 to -57 promoter region **reduces** the intensity of florescence from 100 a.u to 69 a.u and deletion of promoter sequence from -57 to -37 region decreased the intensity from 69 a.u. to 0 a.u;
2. As more of the promoter sequence is deleted, general transcription factors and RNA polymerase/transcription initiation complex unable to bind to promoter and hence **luciferase gene is not transcribed and translated** to produce florescence;

[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.

(any 3, max 3 marks)

1. **Genome is of a large size**, comprising both coding and non-coding regions;
2. A **large percentage** of the genome is non-coding regions such **as centromeres and telomeres** (at least 2 examples of non-coding DNA) and histone methylation occurs on these regions;
3. **Only specific genes required** in the differentiated cell are expressed;
4. **Expression of most genes are not required and undergoes histone methylation to condense DNA** at these regions, **prevents expression of these genes**

.....

[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.

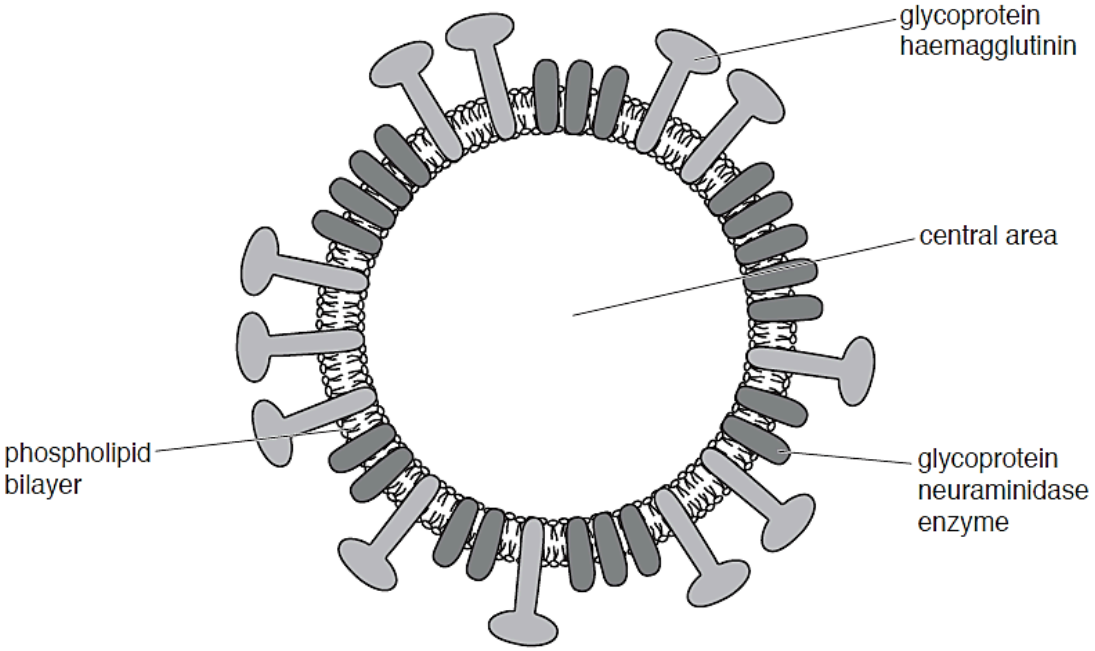


Fig. 5.1

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

Any 2

1. Virosome has no genetic material but virus has genetic material **;**

2. Virosome has no capsid / protein coat **but virus has a capsid/protein coat**

3. Virosome has no matrix proteins but virus has matrix proteins;

.....

[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.

*any **two** from:*

1. Haemagglutinin stimulates primary immune response / ref. to activation and differentiation of T cell and B cells;

2. resulting in formation of memory B and T cells;

.....

[2]

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.

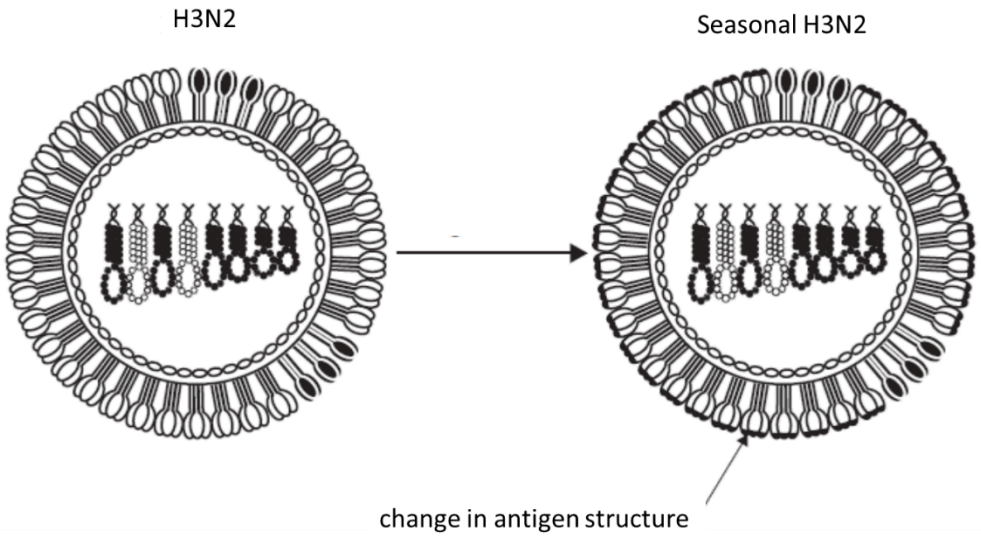


Fig. 5.2

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

Antigenic drift

[1]

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

[Any 2]
1. Single stranded RNA genome and hence no complementary strand to do correction or repair;
2. RNA-dependent RNA polymerase **lacks proof-reading ability** and hence **error in viral genome replication not repaired**/accumulation of mutation;
3. Fast/high rate of replication of the virus results in accumulation of more mutations;

[Compulsory point]
4. Result in **change in nucleotide sequence and thus change amino acid sequence which leads to change in R group interactions causing different 3D conformation** of glycoproteins;

[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.

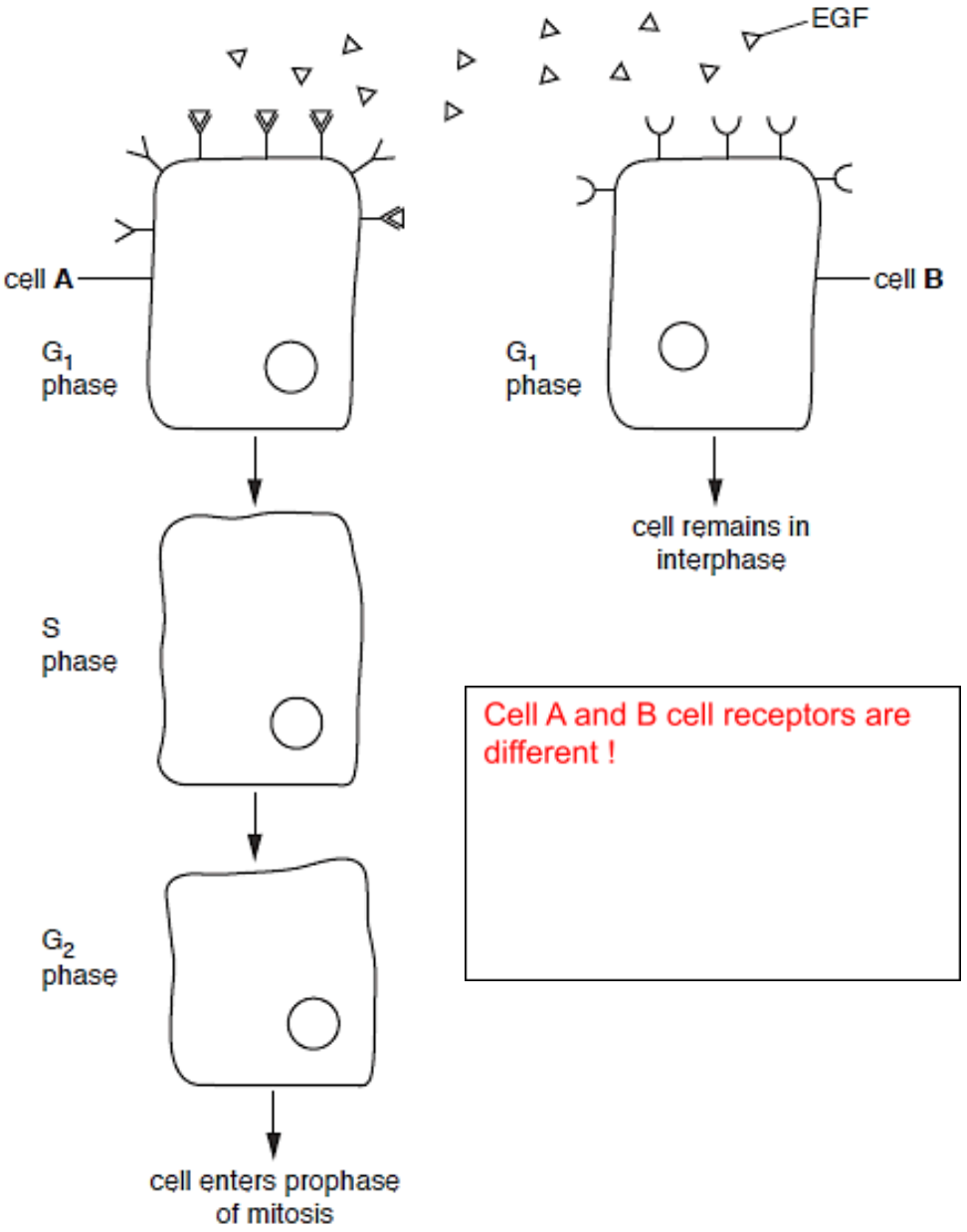


Fig. 6.1

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

1 EGF binds to receptor(s) on cell membrane of **A** but does not bind to receptor on **B as** EGF has complementary conformations/3d shape complementary to the **ligand-binding sites** present on **receptor on cell A not on cell B resulting in activation of cell to proceed to S-phase**

R antigen to antibody
I active site

- **Accept for reverse answer**

[1]

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

1. more proteins/polypeptides are synthesized using the **mRNA** template via **translation** in the G1 phase to provide **enzymes** like DNA polymerase/ helicase/ primase/microtubules (named protein) for **S phase of DNA synthesis/proteins are required for organelle synthesis in G1 phase** whereas during **mitosis DNA is highly condensed** (metaphase chromosome), **low transcription** to form mRNA (therefore mRNA formed during G1)**;**

.....

[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.

two from
1 ATP **;**
2 free deoxyribonucleotides**;**
3 DNA polymerase **;**
4 DNA ligase **;**

AVP **;** e.g. topoisomerase / gyrase helicase

R in context of transcription

.....

[2]

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

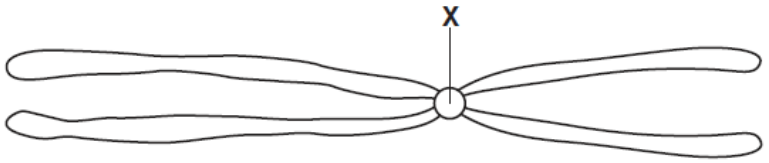


Fig. 6.2

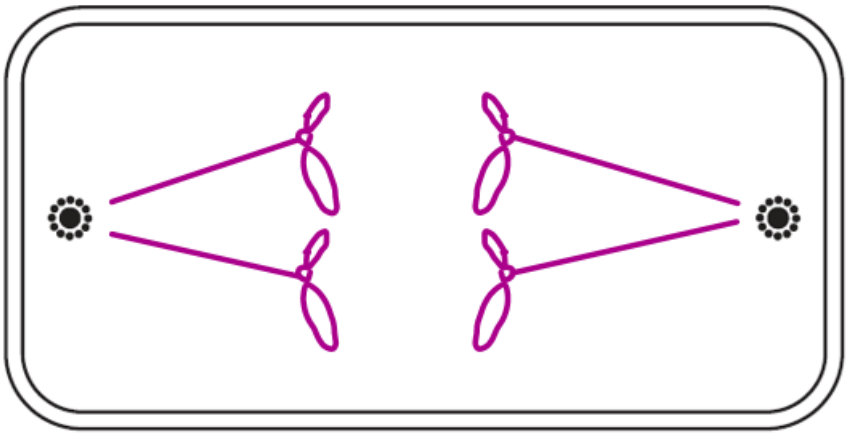
(i) State the name and function of the region of the chromosome labelled **X**.

centromere ; A kinetochore
one from
1. Required for the correct alignment and separation of sister chromatids in mitosis
OR
2. Kinetochore microtubules attach to kinetochore assembled on centromeres to pull the sister chromatids away from each other to opposite poles of the cell.

.....

[2]

(ii) In the outline of the cell below, draw the chromosome from Fig. 6.2 as it would appear in anaphase of mitosis. .[There are two copies of chromosome 1]



max 1 if more than one chromosome shown
two from
separate chromatids that are identical in shape ;

one arm larger than the other on both separate chromatids ;

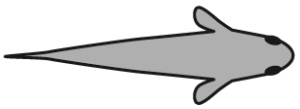
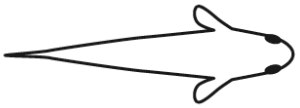
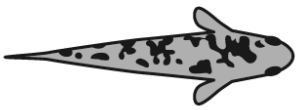
V-shaped chromatids with centromeres pointing towards the poles ;

[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	-2.25	5.0625	0.018
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	-1.25	1.5625	0.05(0)
				χ^2 = ...	0.139/ 0.14

1m last column
1m final answer;

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.

*any **two** from:*
accept null hypothesis (no mark)
1 1 ☐ Since the calculated χ^2 value 0.139 **</lower** than critical χ^2 value **7.815** at p = 0.05;
2 there is no significant difference between the observed and the expected values at the 5% level. Do not reject null hypothesis;
3 Any difference between observed and expected results is due to chance;
*allow ecf from **5(a)***

[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, **X^rY^RBb**, were crossed with red females with black spots, **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 **X^R**, **X^r** and **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**.

F_1 generation

F_1 phenotypes: Red, black spotted male x Red, black spotted female

F_1 genotypes: X^rY^RBb X^RX^rBb

After meiosis, gametes produced:

X^rB X^rb Y^RB Y^Rb ;

X^RB X^Rb X^rB X^rb

By random fertilisation,

	 X^RB	 X^Rb	 X^rB	 X^rb
 X^rB	X^RX^rBB Red female with black spots	X^RX^rBb Red female with black spots	X^rX^rBB White female with black spots	X^rX^rBb White female with black spots
 X^rb	X^RX^rBb Red female with black spots	X^RX^rbb Red female with no spots	X^rX^rBb White female with black spots	X^rX^rbb White female with no spots
 Y^RB	X^RY^RBB Red male with black spots	X^RY^RBb Red male with black spots	X^rY^RBB Red male with black spots	X^rY^RBb Red male with black spots

	X^RY^RBb Red male with black spots	X^RY^Rbb Red male with no spots	X^rY^RBb Red male with black spots	X^rY^Rbb Red male with no spots
Y^Rb				
F_2 genotypic ratio	1 X^RY^RBB, 2 X^RY^RBb, 1 X^rY^RBB, 2 X^rY^RBb	1 X^rY^Rbb 1 X^RY^Rbb	1 X^RX^rBB, 2 X^RX^rBb,	1 X^rX^rBB 2 X^rX^rBb
F_2 phenotypic ratio	6 red males with black spots	2 red male with no spots	3 red female with black spots	3 white female with black spots

	X^RX^rbb	X^rX^rbb
F_2 genotypic ratio	1 X^RX^rbb	1 X^rX^rbb
F_2 phenotypic ratio	1 red female with no spots	1 white female with no spots

[4]

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

Mark as pairs [1 & 2 or 3 & 4]
1 Dominant allele **R** is on **Y** chromosome **;**
2 <u>All males</u> will **inherit**, dominant allele **R coding for red body colour**
or
only $\mathbf{Y^R}$ is present in the gametes **;**
3 no, recessive allele **r** / recessive white allele, on **Y** chromosome
or
allele **r** only exists on the **X** chromosome **;**
4 (so) males never inherit, recessive white allele / allele **r ;**

.....

.....

[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.

*any **two** from:*
1 <u>Gene mutation</u> in the **R**/dominant red allele, on the **Y** chromosome to Y^r/ recessive allele;
2 non-functional protein or a protein with reduced functional activity resulting in the one white male offspring;
OR
3 <u>Crossing over</u> during <u>prophase 1</u> of meiosis in male gametes resulting in exchange of alleles ;
4 occurs between $\mathbf{Y^R}$ **and** $\mathbf{X^r}$ **resulting in** $\mathbf{Y^r}$ **and** $\mathbf{X^R}$ **forming red females and white males offspring** upon **fertilisation**

.....

.....

.....

.....

.....

[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.

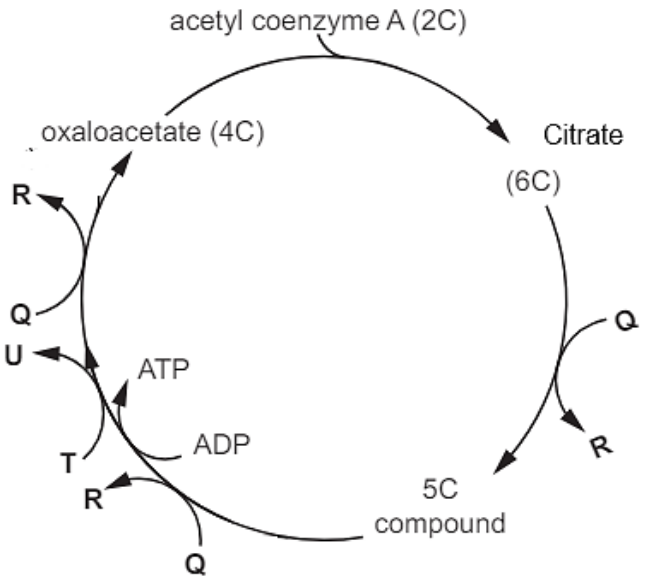


Fig. 8.1

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

1 NAD and FAD are coenzymes to dehydrogenase;
2 NAD and FAD remove hydrogen ions and electrons from the Krebs cycle to form reduced NAD and FAD;
3 Reduced NAD and FAD transfer high energy protons/hydrogen ions and electrons to ETC at inner mitochondrial membrane to be used for oxidative phosphorylation;
4 Resulting in regeneration of oxidized NAD and FAD for subsequent glycolysis, link reaction and KC to proceed;

[3]

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

Substrate level phosphorylation

[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]

(Ethanol fermentation in yeasts)	**(Lactate fermentation** in mammals)	
Carbon dioxide released	No carbon dioxide released	;
Involves the enzyme, decarboxylase & alcohol dehydrogenase	Involves only lactate dehydrogenase	;
Converted to ethanal then to ethanol/ two step process to form ethanol	Direct conversion to lactate/ One step process to form lactate	;
Ethanol cannot be used as energy source even when aerobic conditions return	Lactate transported to liver and reconverted to pyruvate when aerobic conditions return	;

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

[Any two]
1 soluble and can transport chemical energy to energy-consuming processes anywhere within the cell;
2 Hydrolysis of ATP releases energy
3 1 mole of ATP to ADP and inorganic phosphate (P_i) yields 30.6 kJ of energy

.....
[2]

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

1 conversion of ATP to cAMP, second messenger by adenylyl cyclase;
[Any two]
2 Phosphate from ATP used, in the **sequential phosphorylation and activation of kinases** leading to a phosphorylation cascade;resulting in signal amplification;
3 cAMP is used to **transduce the signal from the membrane-bound** receptors to the **effector molecules within the cell interior**

.....
[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.

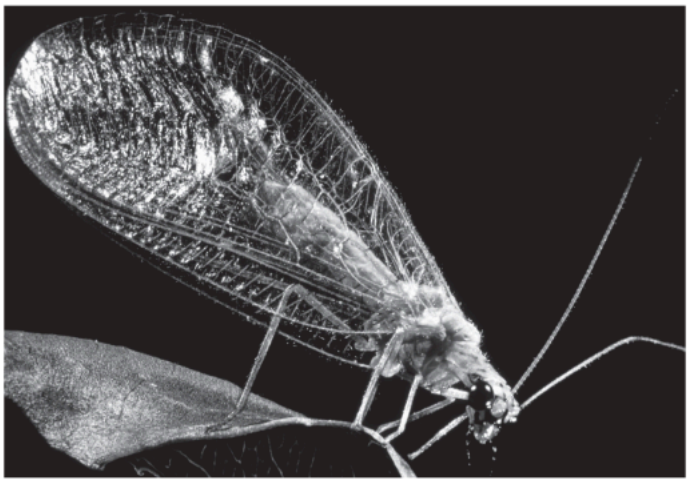


Fig. 9.1

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.

any three from:
1 Spontaneous mutation(s) allows for variation in the population of green lacewings for detection of high frequency;
2 selection pressure is bat which is the predation ;
3 those that can detect high frequencies from bats **survive / don't get eaten** / have selective advantage / are selected for ;
4 these reproduce and produce offspring and **pass on favourable (beneficial) allele(s)** to detect high sounds
5 increase in frequency of alleles in population;

.....

.....
[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.

1 sympatric speciation as C. carnea and C. downesi **breed in different months/different courtship song/are of different colour;**
2 a disruption of gene flow between **two populations arising from a common ancestor** and they develop their own unique characteristics become reproductively isolated;

.....
[2]

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

1 Protein, nucleic acid sequence data are precise and accurate and easy to quantify / convertible to numerical form, for mathematical and statistical analysis;
2 DNA/ RNA sequence is analysed and can be described in an unambiguous. This facilitates the objective assessment of evolutionary relationships.
3 Molecular data provides a clear model of evolution by comparing the nucleotide and amino acid sequence because the rate of molecular change in genes and proteins is regular like a molecular clock.

.....
[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.

1 allele initially found in heterozygotes ;

dominant advantageous allele:
2 (new) dominant allele is, expressed in heterozygote / always expressed ;
3 selection can act on individuals with dominant allele straight away / AW ;

recessive advantageous allele:
4 (new) recessive allele is not expressed, in heterozygote / due to dominant allele
or
recessive allele only expressed in homozygous recessive (genotype) ;
5 selection can only act on individuals who are homozygous recessive ;
6 it takes time for homozygous recessive (genotype) to occur / AW ;

.....

[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.

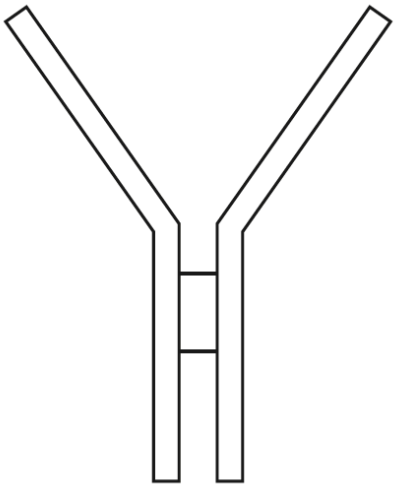


Fig. 10.1

(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 Human antibody is made of four polypeptides whereas shark antibody consist of two polypeptide chains;

OR

2 Human antibody contains two light chains and two heavy chains whereas shark antibody consist of two Heavy chains;

[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 more/easier to, pass through gaps in, capillary wall / endothelium ; OR

2 easier to, diffuse / move, through tumour to reach, more / all, cells

AVP ;

binds more tightly to antigens on (cancer) cell surface(s)

suggestion that makes macrophage response stronger

smaller overall size even when drugs attached

[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.

any three from:
1 gives (artificial) passive immunity ;
2 fast acting / quick response / time not needed for immune response **;**
3 antibody binds to (non-self / foreign) antigen (on surface of a pathogen) neutralizing/stoppingpreventing) the function of those surface proteins;
4 Results in agglutination of pathogens/antibodies bind to more than one of the same pathogen at multiple binding sites, thus clumping the pathogens together;
5 Opsonization/Binding of antibodies to antigens on the surface of pathogen promotes phagocytosis by phagocytes (e.g. macrophages and neutrophils).

AVP ;
antibodies bind to toxins, neutralising them / AW
or
antibodies act as antitoxins **;**

[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.

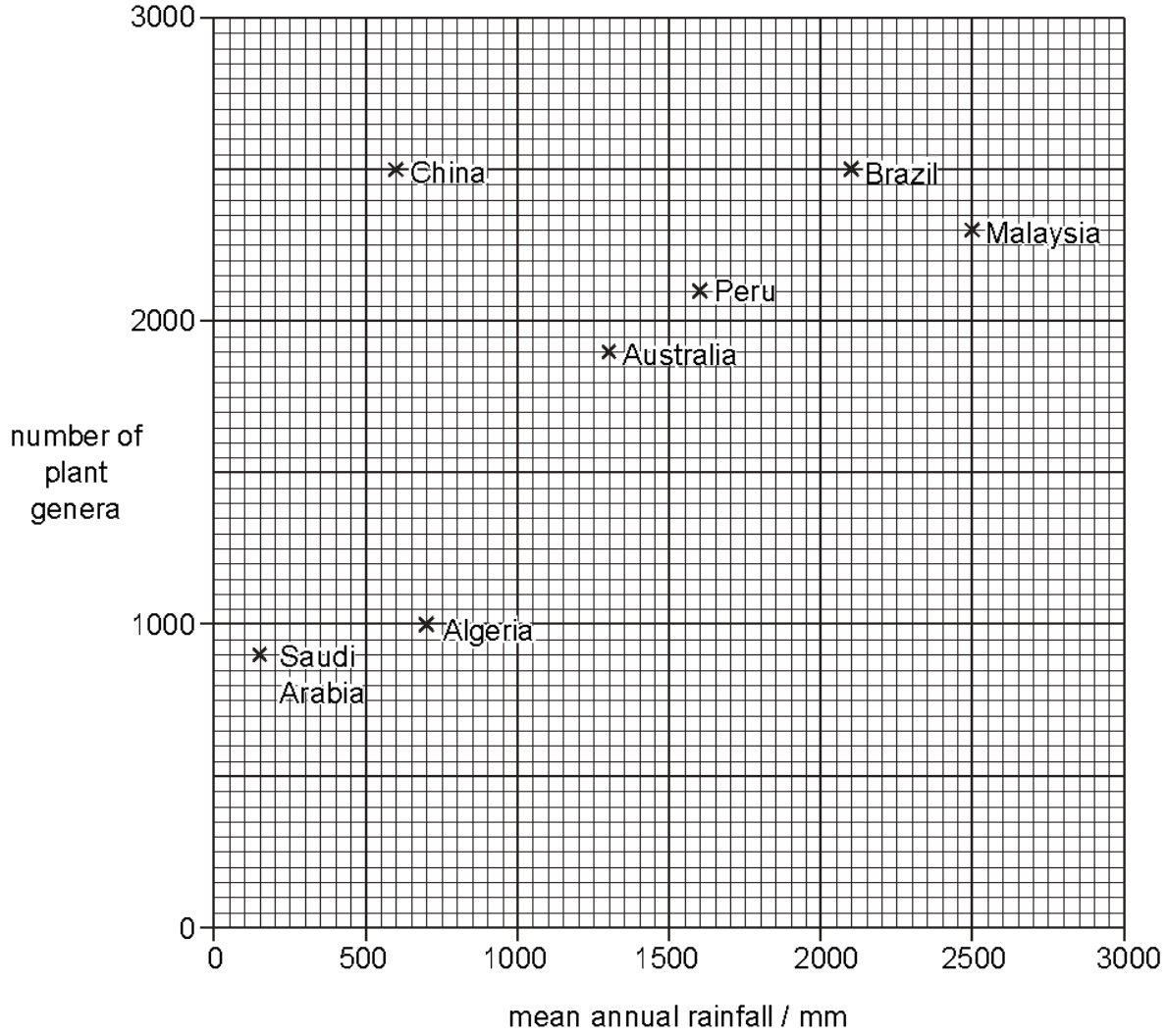


Fig. 11.1

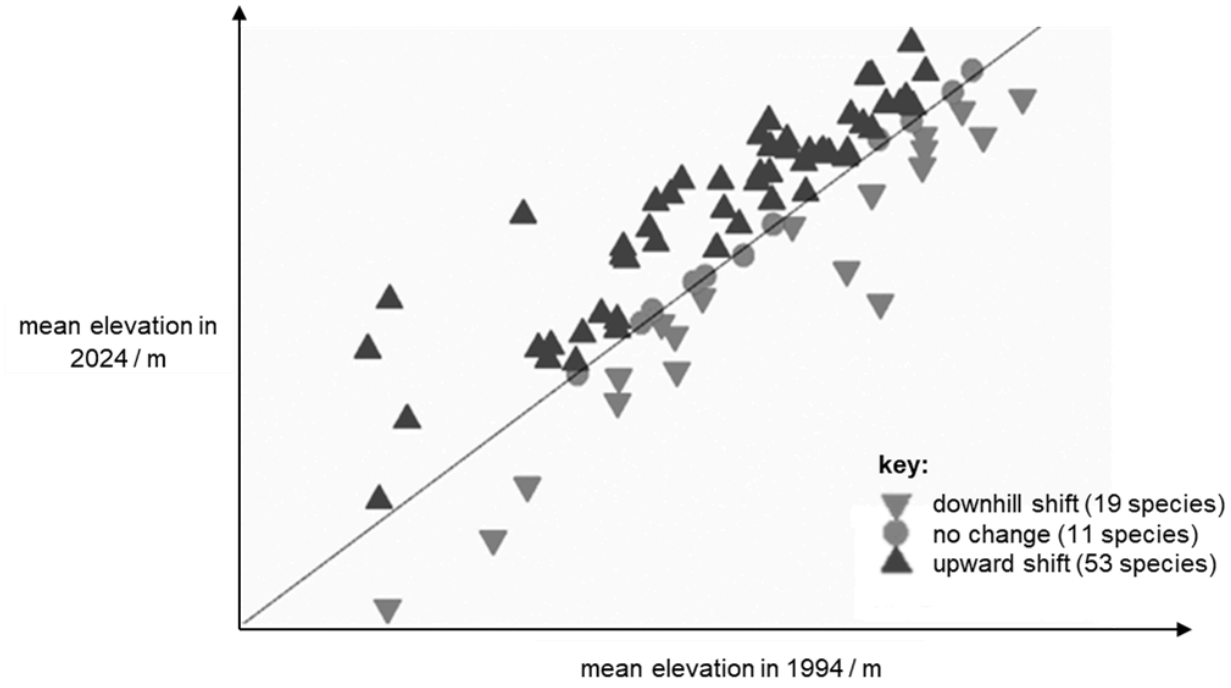


Fig. 11.2

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

Fig. 11.1:

1 [trend] There is an **overall** positive correlation/number of plant genera increases as mean annual rainfall increases as shown for Saudi Arabia which had a mean annual rainfall of 150 mm with 950 plant genera and Malaysia which had a greater/higher mean annual rainfall of 2500 mm with a greater/higher 2300 plant genera **+ to paired figures (i.e. genera number and mean annual rainfall in 2 named countries showing the trend) correctly quoted with units**

2 [reason] changes in rainfall/increase or decrease in rainfall and lead to **increased incidence of flooding / drought, shorter / longer rainy season can result in plant wilting from loss of water / plant rotting from waterlogged roots / plants infected by pests and pathogens**

3 [outcome] decrease in genetic diversity / species diversity

Fig. 11.2:

1 53 species of plant experience an upward shift in mean elevation which is greater compared 11 plant species experienced no change to mean elevation: changes and 19 plant species experienced a downhill shift in mean elevation

2 As temperature rises due to climate change, plant distributions may gradually shift upwards to a higher altitude where the once lower temperature has become **higher**.

3 Plant species at a particular zone are unable to disperse their seeds into suitable climate zones will completely die out when global warming shifts the plant zones up the altitude/Native plant species suffer from the potential increased

competition (for food and water or prey-predation) with invasive species and may face possible decrease/extinction of local populations.

[3 max for each section]

[4]

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

1 incomplete data/insufficient data as plant biodiversity can also be affected by change in phenology or pests infestations/pathogens which can happen due to changes in rainfall

[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.

[Any one]
1 may be of use in the future to increase plant diversity
2 (may produce) medicines / AW
3 maintain, gene pool / genetic diversity
4 to maintain stability in ecosystems
5 aesthetic reasons
6 (eco)tourism

[1]
[Total: 6]