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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.

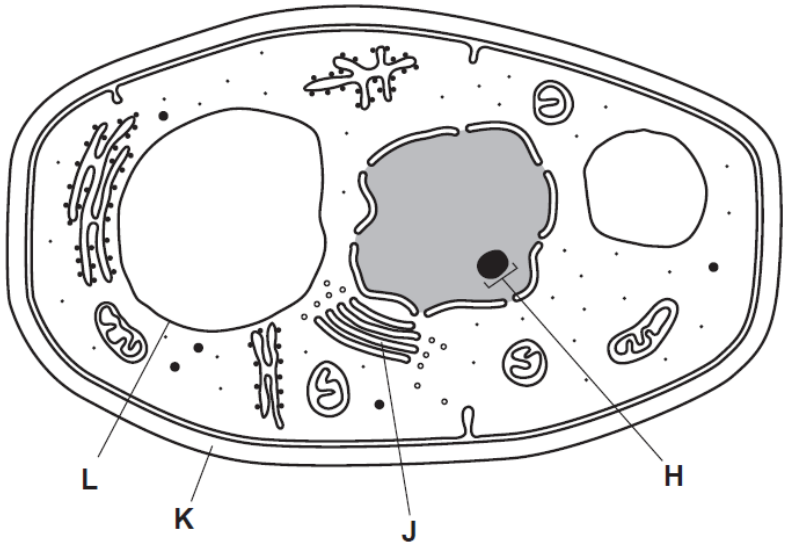


Fig. 1.1

(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.

no double membrane-bound organelles ;
no, nucleus / nuclear membrane / nuclear envelope / nucleolus ; A DNA lies free in the cytoplasm
no mitochondrion ;
no (large) vacuole ;
no, ER / RER / SER ;
no Golgi (body / apparatus) ;
smaller / 70S / 18nm, ribosomes ;
cell wall made of, murein / peptidoglycan / different compounds (from eukaryote) ;
circular DNA / plasmid(s) / no linear DNA ;
no histones / not complexed with proteins ; A naked DNA / no chromosomes
AVP ; e.g. mesosomes ; pili / no 9+2 microtubule pattern

[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.

nucleus, transcription / described as DNA to complementary RNA code / AW ;
nuclear pore, mRNA to, cytoplasm / ribosome / RER ;
RER / ribosome, assembly of amino acids / translation / polypeptide or protein synthesis ;
RER, transports protein to Golgi (apparatus / body) / modifies protein ;
Golgi adds, carbohydrates / sugars, to proteins ; A glycosylation
A post translational modification / other e.g.s

[max 1]:
Golgi, packages protein / makes vesicle(s) ;
(Golgi) vesicle fuses with cell (surface) membrane ;

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.

Assume answers are about globular proteins
Soluble *vs insoluble*;
Hydrophilic amino acids on the exterior and hydrophobic amino acids in the interior vs *hydrophobic amino acids on the exterior;*
Spherical *vs chain-like;*
Compact;
Ref 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.

(8 helices) further folds into (sp 3D structure);
Hydrogen bond between polar groups;
ionic bond between amino and carboxylic acid groups/ acidic/ basic / positive/negative group;
Hydrophobic interactions between non-polar side chains;
(Idea of) no Disulphide/ covalent bonds present;

[max 1] if H2I betw R groups;

.....

[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.

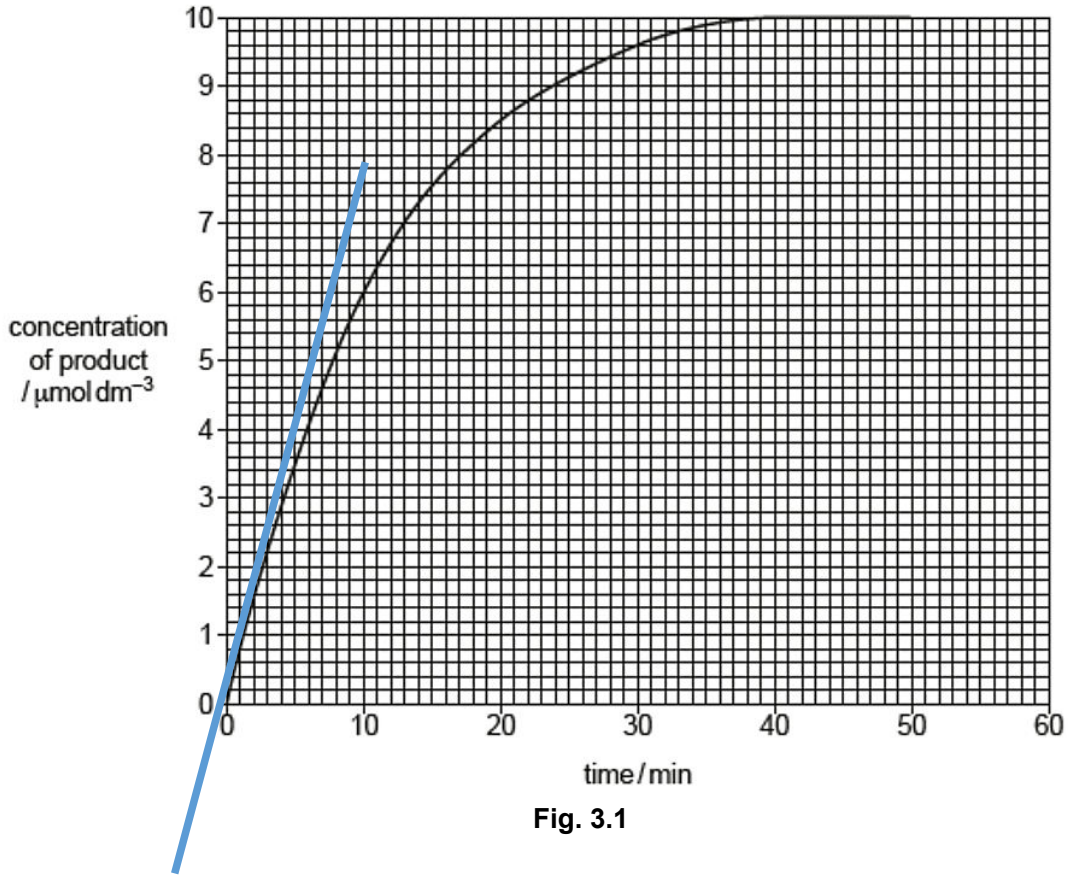


Fig. 3.1

(a) Calculate the initial rate of the reaction.

*any **two** from:*
anything within range 0.6 to 0.8 **;**
µmol dm–3 min–1 / µmol per dm3 per min **;**
A µmol per dm3 / 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.

ignore any explanation
*any **two** from:*
1 initial rate will be, lower / slower **;**
2 takes longer to reach the, plateau / end concentration / 10 µmol dm–3 **;**
A longer to complete the reaction / maximum concentration
3 *idea that* the final / end, concentration of product will be, the same / 10 µmol dm–3 **;**
I refs to the shape of the graph

[2]

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

N-acetyl-statine has a same / similar shape as protein / albumen;
complementary in shape to the active site of pepsin;
binds/ attaches / fits into active site of enzyme pepsin;
protein cannot bind to active site/ block substrate;
@no/few E-S complexes formed
~~amino acid production decreases / stops;~~

[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.

Same sequence of amino acids in active site means same R-groups which can form the same bonds between substrate and active site;

Also gives rise to active sites which are of the same shape and are complementary in terms of shape, size, charge and orientation to that of substrate / bond;

[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.

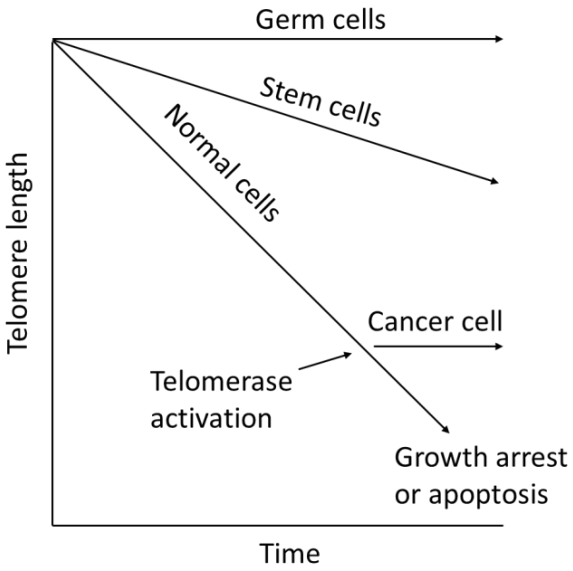


Fig. 4.1

(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. * Germ cells needs to undergo continuous cell division (both mitosis and meiosis) to allow many replication cycles to occur / prevents apoptosis;
2. Function of telomerase: Telomerase allows telomere length to be **maintained** from generation to generation
3. prevents telomeres from reaching critical length thus; wtte ;
4. prevents the loss of vital genetic information through erosion at chromosomal ends

[3]

(iii) Describe how telomerase extends telomere length.

Nucleotides of the telomerase RNA anneals and forms ***complementary base pairs**** with the single-stranded overhang at 3' end of the telomere;

Using telomerase RNA as a ***template**** (telomerase reverse transcriptase) forms a complementary *DNA** sequence through ***complementary base pairing****;

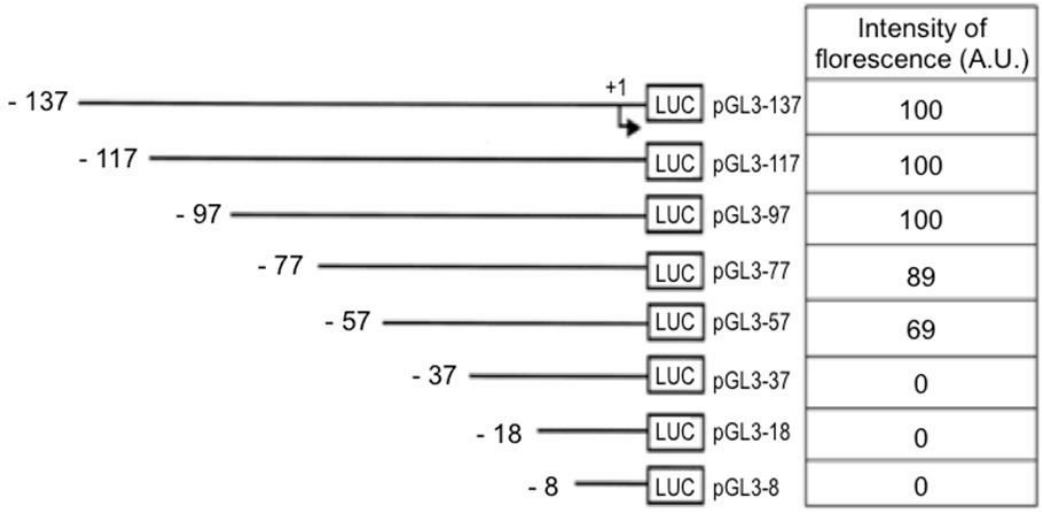
(where adenine base pair with uracil, thymine with adenine, cytosine with guanine, and guanine with cytosine)
Catalyzes the formation of ***phosphodiester bonds**** between deoxyribonuceotides elongating the 3'overhang by reverse transcriptase;
Idea of telomerase translocate to elongates the overhang / synthesize a series of tandem repeats;
Marker to note: only need to see "complementary base pairing" once

.....

.....
[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 this region in promoter region resulted in general ***transcription factors**** and ***RNA polymerase**** / ***transcription initiation complex**** unable to bind;
2. no transcription of luciferase gene / no synthesis of luciferase + quote data showing decrease from 100A.U to 0 A.U;

.....

.....
[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.

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 and histone methylation occurs on these regions;
3. Most of the chromatin comprises of many genes (that codes for proteins that are not required in specialized cells) that are not expressed/transcribed in differentiated cells;
4. condensation of DNA at these regions, prevents expression of these genes (Accept if student made ref to preventing RNA and transcription factor from binding to the promoter);

(any 3, max 3 marks)

.....

.....

[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.

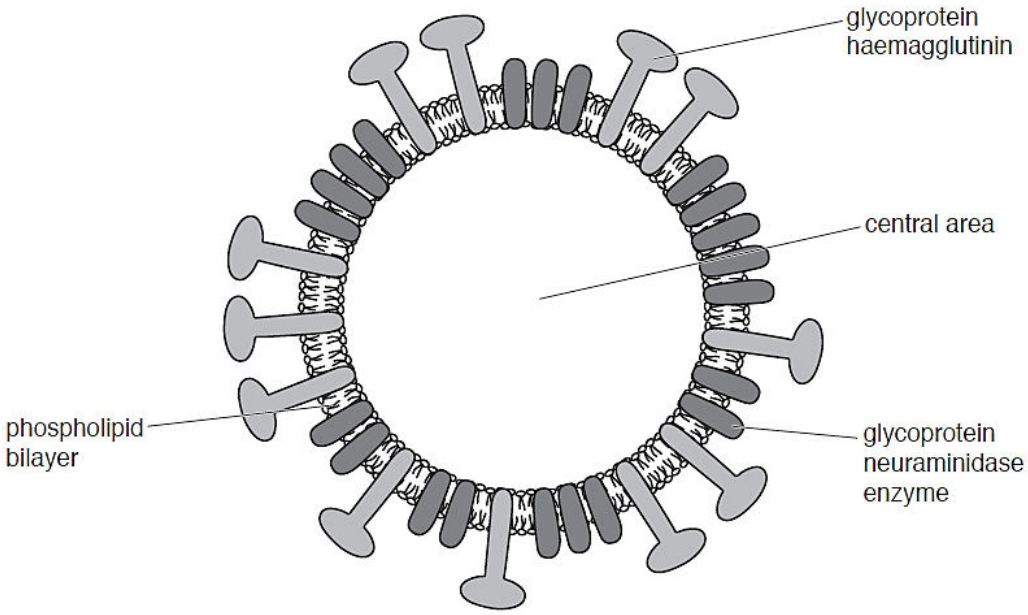


Fig. 5.1

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

no, nucleic acid / genetic material / DNA / RNA **;**
no, capsid / protein coat **;** **A** no capsomeres

only some viruses have envelopes **;**

.....

[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:*
acts as a non-self / foreign, antigen **;**
triggers / stimulates, primary immune response
or
provides (artificial) active immunity **;**
(leads to) formation of antigen presenting cell **;**
A endocytosis / phagocytosis, to present antigen (by, macrophage neutrophil)
activates, B lymphocytes / T lymphocytes **;**
A clonal selection

formation of memory cells **;**

.....

.....

[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.

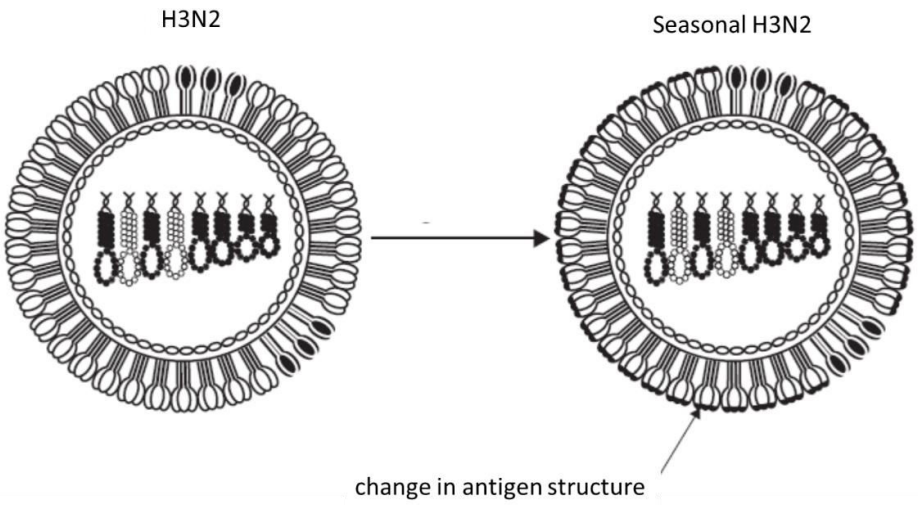


Fig. 5.2

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

Antigenic drift

.....

.....

[1]

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

1. Single stranded RNA genome;
2. No backup copy to do correction or repair;
   OR
3. (RNA-dependent) RNA polymerase lacks proof-reading abiilty;
4. Error in viral genome replication; (or with point 8)
   OR
5. RNA genome;
6. More reactive (due to the 2'OH group); R unstable
   OR
7. Fast/high rate of replication of the virus;
8. Accumulate more mutations;

9. *Result in change in nucleotide sequence and thus amino acid sequences of glycoproteins; (Compulsory point)

(must have, e.g. 1+2+9)

.....

[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.

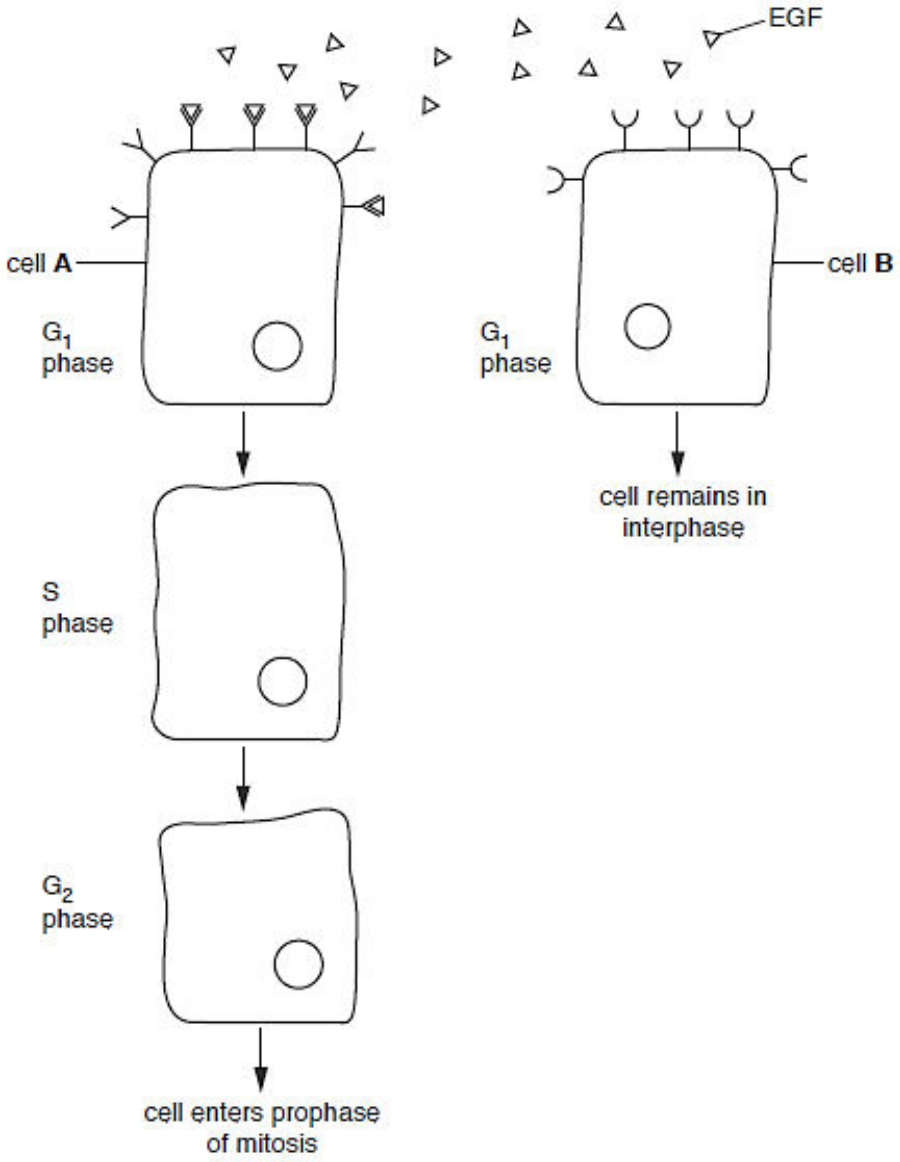


Fig. 6.1

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

EGF binds to receptor(s) on cell **A ; ora**
A has receptor for, EGF / cell signaling compound
A EGF does not bind to receptor on **B**
+
idea of complementary / specific **; ora**
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.

accept ***ora***
one from
more, proteins / polypeptides, for growth / to provide (named) protein for DNA synthesis / proteins are required for organelles / AW **;**
A S phase for DNA synthesis

during mitosis DNA is highly condensed, 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
ATP **;**

(activated / free / DNA) nucleotides **;**
R in context of transcription

DNA polymerase **;**

(DNA) ligase **;**

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

[2]

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

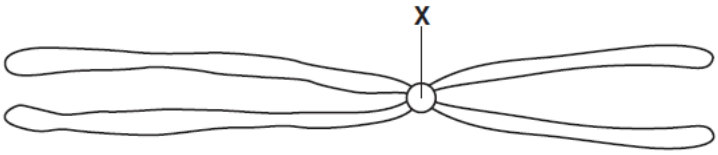


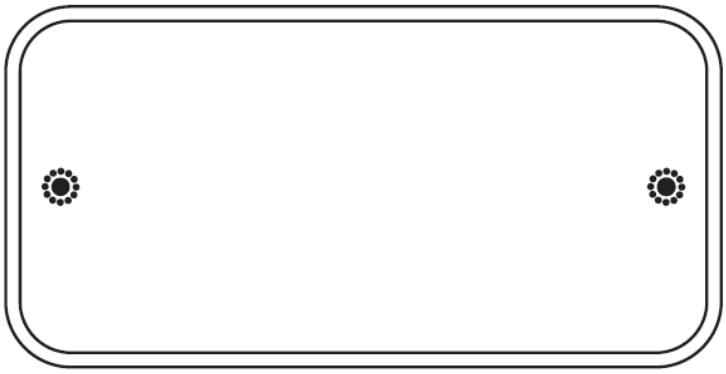
Fig. 6.2

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

centromere **;** **A** kinetochore
one from
holds / joins / AW, (sister) chromatids together **;**
attach to spindle

[2]

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



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 **;**

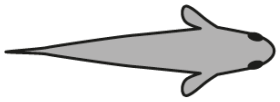
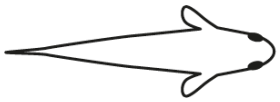
V-shaped chromatids with centromeres pointing towards the poles **;**

[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 ~~2 value~~ / 0.139 / 0.14, is lower than, the critical value / 7.815 **;**
2 the observed numbers are not significantly different to the expected numbers (at p = 0.05) **;**
3 any differences are 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, $\mathbf{X^rY^RBb}$, 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**.

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^R	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^R	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
Y^Rb	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 ;;

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	1 X^RX^rbb	1 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	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.

Male offspring inherits Y from male parent;
(in the male parent) only Y^R is present / or no Y^r;
r is carried on X chromosome;

Original answer: mark as pairs
*1 allele **R** / dominant red allele, is on **Y** chromosome **;***
*2 (so all) males **inherit**, dominant red allele / allele **R***
or
*only $\mathbf{Y^R}$ is present in the gametes **;***
*3 no, 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 mutation **;**
2 detail of mutation **;**
3 crossing over **;**
4 (of) the **R** allele / dominant red allele, from a **Y** chromosome to an **X** chromosome / in germ cell giving rise to male gamete**;**

.....

.....

.....

.....

[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.

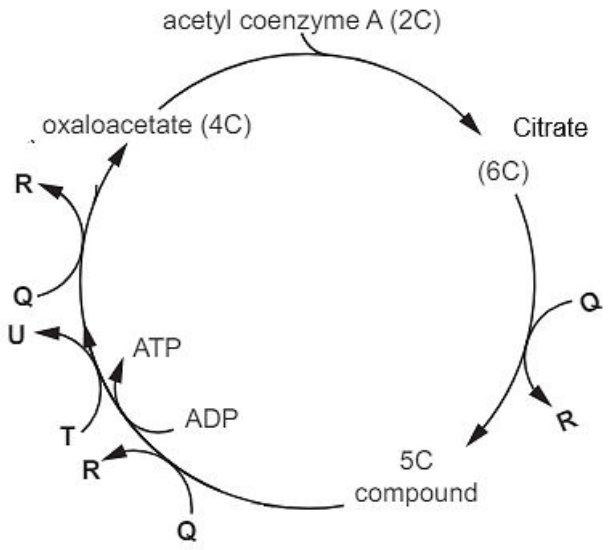


Fig. 8.1

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

[Identify QRTU in points below] (no mark).
Ref to QR being NAD, TU being FAD; [1 max if no other reference in answer]

NAD and FAD are coenzymes to dehydrogenase;
NAD and FAD remove protons and electrons from the Krebs cycle to form reduced NAD and FAD;
Reduced NAD and FAD transfer high energy protons and electrons to ETC at inner mitochondrial membrane to be used for oxidative phosphorylation;

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.

soluble and can transport chemical energy to energy-consuming processes anywhere within the cell;

Hydrolysis of ATP releases energy

.....

.....
[2]

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

conversion of ATP to cAMP second messenger by adenylyl cyclase;
(idea of) phosphate from ATP used, in the sequential phosphorylation and activation of kinases leading to a phosphorylation cascade;
Resulting in signal amplification;

.....

.....
[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.

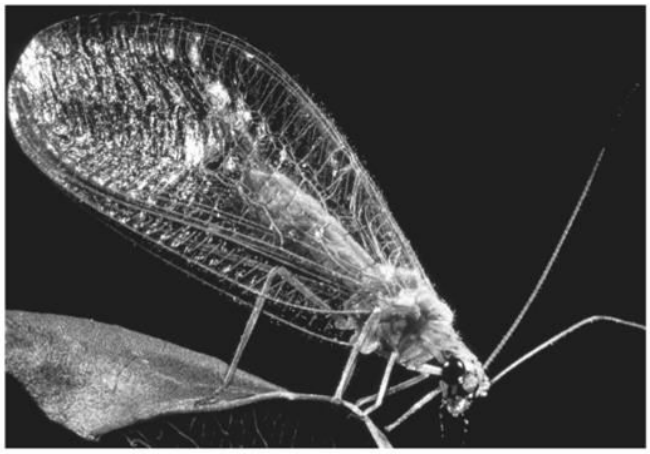


Fig. 9.1

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 (random) mutation(s) allows detection of high frequency ;
2 selection pressure is bat (predation) ;
3 those that can detect, high frequencies / bats, survive / don't get eaten / have selective advantage / are selected for ;
4 these, reproduce / pass on (beneficial) allele(s) ;
5 those that can detect high sounds / beneficial alleles, increase (in frequency / 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.

any two from:
sympatric (speciation) + behavioural, isolation / separation + (named) phenotypic / behavioural, differences (i.e. colour/ song) ;
(leading to) inability to reproduce together / reproductive isolation / genetic isolation / no/ disrupt gene flow between them ;
different mutations ;

.....

.....

[2]

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

(Ref to idea of a DNA/ RNA sequence), resulting to it being unambiguous;

Objective because morphological evidence can be confounded due to convergence/ analogous structures;

(whereby similarities in morphology is due to analogous structures and not common descent/ some morphological characteristics may be analogous / ref. convergent evolution)

protein, nucleic acid sequence data are precise and accurate and easy to quantify / convertible to numerical form, for mathematical and statistical analysis;

Molecular evidence can detect neutral mutations (for use in molecular clock); *avp*

.....

.....

.....

[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.

new 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.

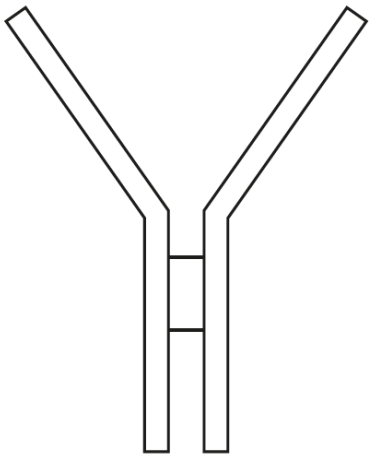


Fig. 10.1

(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.

human antibodies, are made of four polypeptides / contain two light chains and 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.

more / easier to, pass through gaps in, capillary wall / endothelium ;
easier to, diffuse / move, through tumour to reach, more / all, cells

(so) more enter tissue fluid (surrounding tumour cells) ;
idea of more cancer cells destroyed quickly ;
(smaller so) may not trigger an immune response ;
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:
gives (artificial) passive immunity ;
fast acting / quick response / time not needed for immune response **;**
antibody binds to (non-self / foreign) antigen (on surface of a pathogen) **;**
antibodies bind to toxins, neutralising them / AW
or
antibodies act as antitoxins **;**

ref phagocytosis ;
AVP ;
e.g. opsonisation
bind to flagella and immobilise pathogen
antibodies cause, agglutination / clumping / AW, of 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.

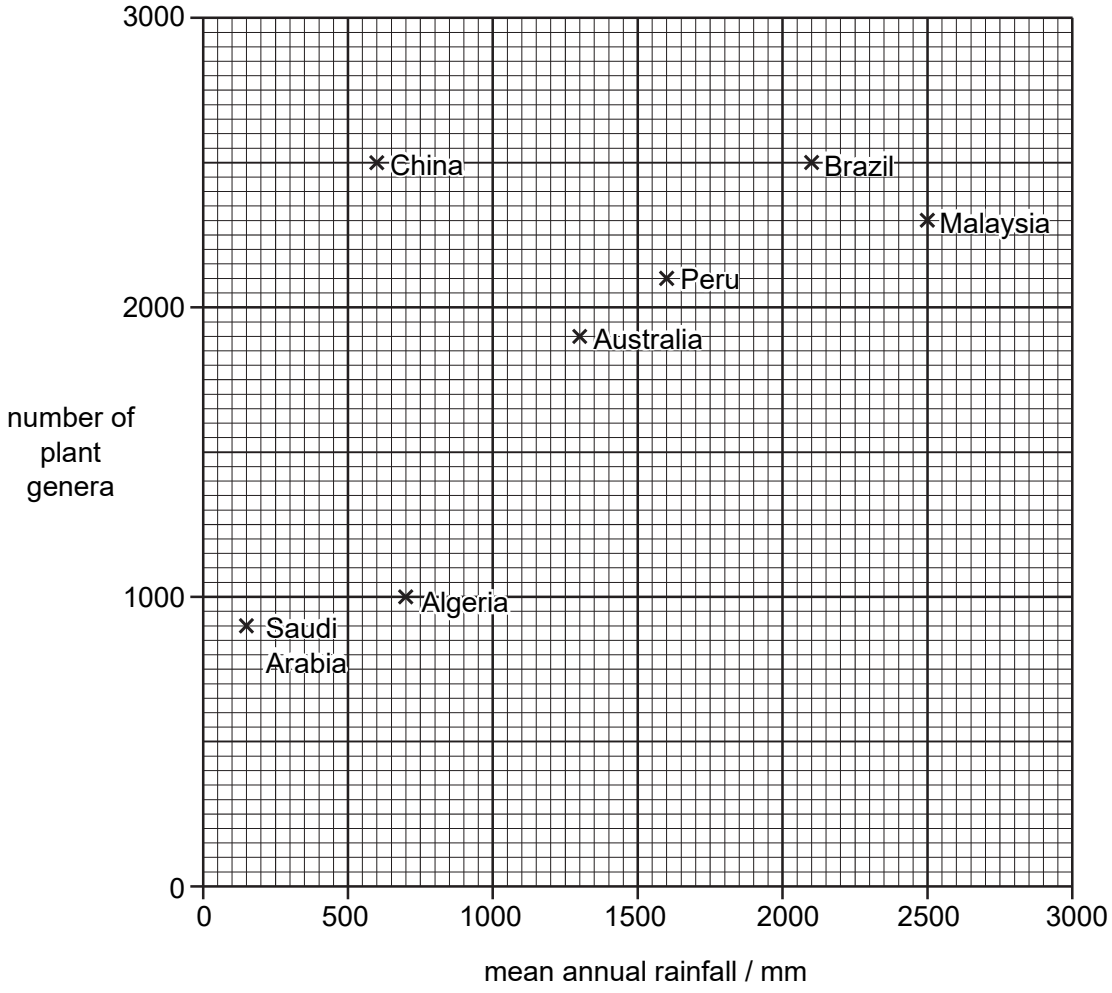


Fig. 11.1

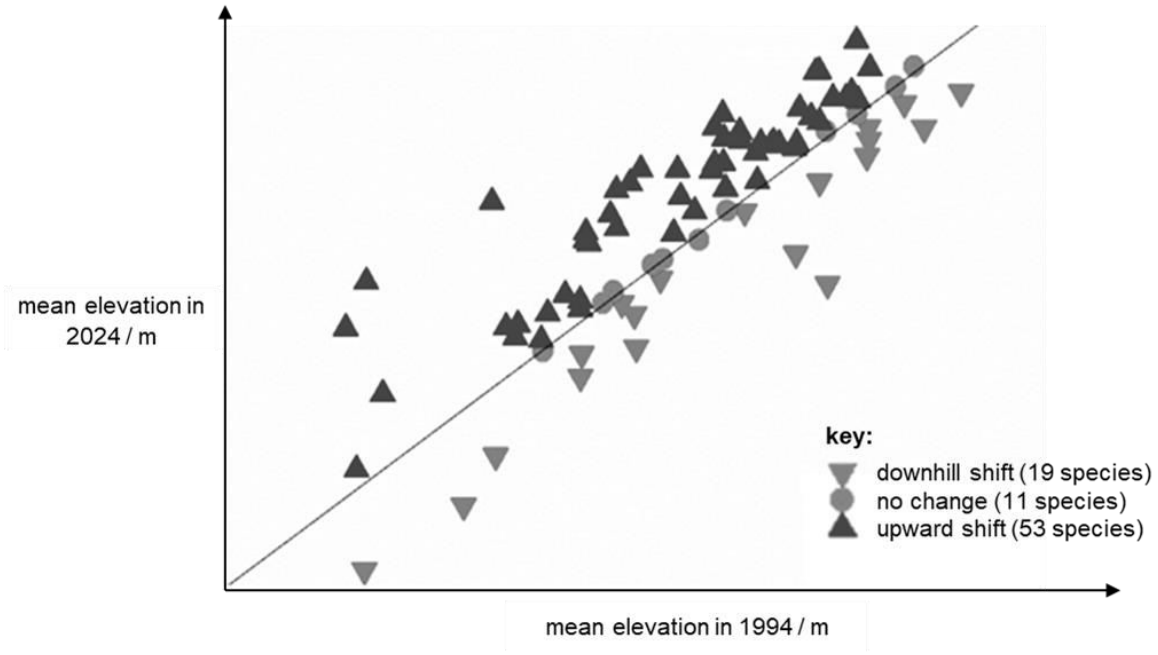


Fig. 11.2

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

Fig. 11.1:

- [trend] ref to **overall trend** (i.e. positive correlation) / number of plant genera increases as mean annual rainfall increases + to paired figures (i.e. genera number and mean annual rainfall in 2 named countries showing the trend) correctly quoted with units
- [reason] ref to increase / decrease in rainfall / increased incidence of flooding / drought, shorter / longer rainy season + relevant consequence on plants (e.g. plant wilting from loss of water / plant rotting from waterlogged roots / plants infected by pests and pathogens)
- [outcome] ref to idea of decrease / increase, in genetic diversity / species diversity

Fig. 11.2:

- Explain why 53 species of plant experience an upward shift in mean elevation: ref. to range shifts upwards where there is decreased temperature and increased precipitation which is now within tolerable limits
- Explain why 11 plant species experienced no change to mean elevation: changes are still within tolerable limits
- Explain why 19 plant species experienced a downhill shift in mean elevation: increased competition in the communities located at high altitudes
- Any correctly quoted trend;

.....

[3 max for each section]

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.....

.....

[4]

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

ref. to difficulties in determining cause-effect;
incomplete data;

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[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.

may be of use in the future
(may produce) medicines / AW
resources (for humans)e.g. wood for building / fibres for clothes / fuel / food / agriculture
maintain, gene pool / genetic diversity
to maintain stability in ecosystems
aesthetic reasons
(eco)tourism

.....

.....

[1]

[Total: 6]