



EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examination 2022
General Certificate of Education Advanced Level
Higher 2

H2 Biology

Paper 1 Multiple Choice

9744/01

21 September 2022

60 minutes

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use paper clips, glue or correction fluid.

Write your name, civics group and registration number on the Answer Sheet in the spaces provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **20** printed pages.

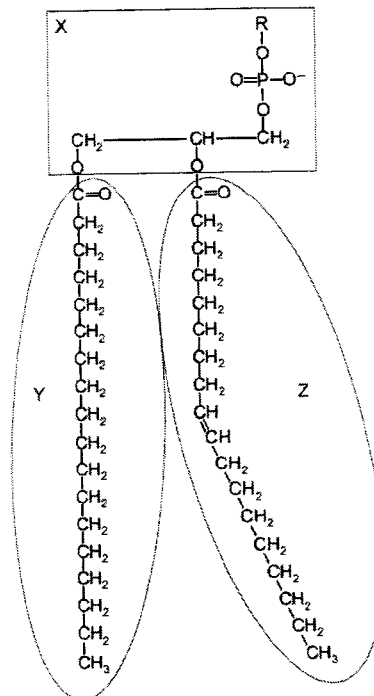
Answer all questions.

- 1 Tests on four samples from a mixture of biological molecules gave the results shown in the table.

test	boiled with excess Benedict's solution	boiled with excess Benedict's solution after acid hydrolysis and neutralisation	biuret reagent	iodine solution
result	blue	red	purple	yellow

Which biological molecules were in the mixture?

- A reducing sugar and protein
 B reducing sugar, non-reducing sugar and starch
 C non-reducing sugar and protein
 D non-reducing sugar and starch only
- 2 The diagram shows a phospholipid molecule divided into three regions, X, Y and Z. R, in region X, represents a range of possible chemical groups.



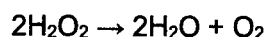
Regions X, Y and Z affect the properties of cell surface membranes in different ways.

Which row shows the effect of each region on the properties of a cell surface membrane?

	increases permeability of hydrophobic region	repels polar molecules	attracts water molecules
A	X	X	Y and Z
B	Y	Y and Z	X
C	Y and Z	X	Y and Z
D	Z	Y and Z	X

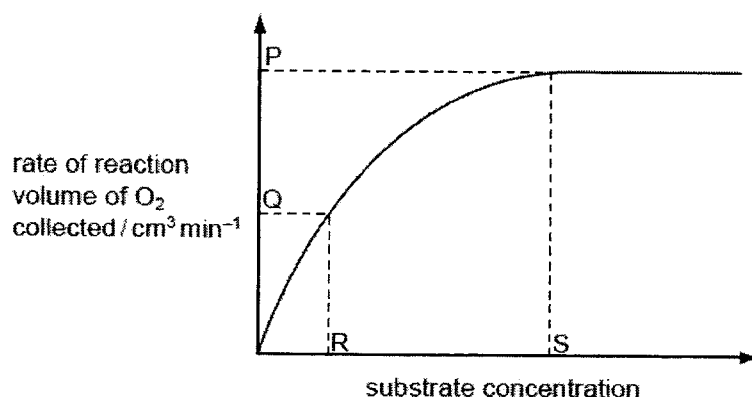
- 3 Which statements could be used to describe enzyme molecules **and** antibody molecules?
- 1 Hydrogen bonds stabilise the structure of the protein and are important for it to function efficiently.
 - 2 Hydrophilic R groups point in towards the centre of the molecule and cause it to curl into a spherical shape.
 - 3 The tertiary structure of the protein molecule plays an important role in the functioning of the protein.
- A 1 and 2 only
 B 1 and 3 only
 C 2 and 3 only
 D 1, 2 and 3

- 4 Liver tissue produces an enzyme called catalase which breaks down hydrogen peroxide into water and oxygen.



The rate of this reaction can be determined by measuring the volume of oxygen produced in a given length of time.

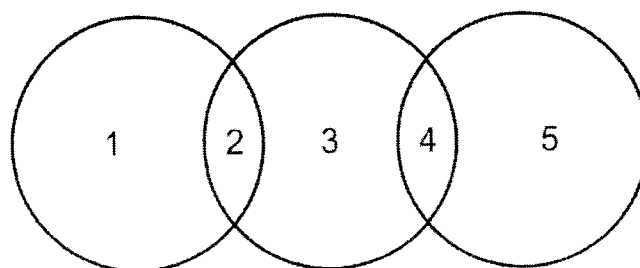
Students added small cubes of fresh liver tissue to a range of hydrogen peroxide solutions and measured the volumes of oxygen produced. Their data were used to produce the graph showing how changing the concentration of hydrogen peroxide affected the rate of oxygen production.



Which statement is correct?

- 1 At P, the rate of reaction is limited by the concentration of enzyme.
 - 2 At Q, all of the enzyme active sites are occupied by substrate molecules.
 - 3 At Q, the rate of reaction is limited by the concentration of the substrate.
 - 4 R represents K_m where the reaction rate = $V_{max}/2$.
 - 5 At S, all of the enzyme active sites are occupied by substrate molecules.
- A 2 and 3 only
 B 2 and 5 only
 C 1, 4 and 5 only
 D 1, 3, 4 and 5 only

- 5 The diagram shows the relationship between various cells and their components.



Which row is correct?

	1	2	3	4	5
A	80S ribosome	eukaryotic cell	mitochondrion	70S ribosome	prokaryotic cell
B	chloroplast	plant cell	cell wall	prokaryotic cell	80S ribosome
C	circular DNA	nucleus	eukaryotic cell	mitochondrion	70S ribosome
D	prokaryotic cell	circular DNA	chloroplast	membrane bound	70S ribosome

- 6 The eyepiece lens of a microscope can be fitted with an eyepiece graticule.

Which of these statements about eyepiece graticules are correct?

- 1 They measure the actual length of cells in micrometres.
- 2 They help biologists to draw cells with correct proportions.
- 3 They change in size when the objective lens is changed from x10 to x40.

- A 1 only
 B 2 only
 C 1 and 3 only
 D 1, 2 and 3

- 7 Liver cells contain vesicles that have proteins in their membranes which are specific for the transport of glucose.

When these cells need to take up glucose, the vesicles fuse with the cell surface membrane.

How does the uptake of glucose occur?

- A Exocytosis
 B Diffusion
 C Endocytosis
 D Facilitated diffusion

- 8 A piece of a DNA molecule contains 84 base pairs. The table shows the number of adenine and cytosine bases in one or both of the DNA strands in this piece of DNA molecule.

base	strand 1	strand 2
adenine	28	23
cytosine	15	

How many guanine bases are present in this piece of DNA molecule?

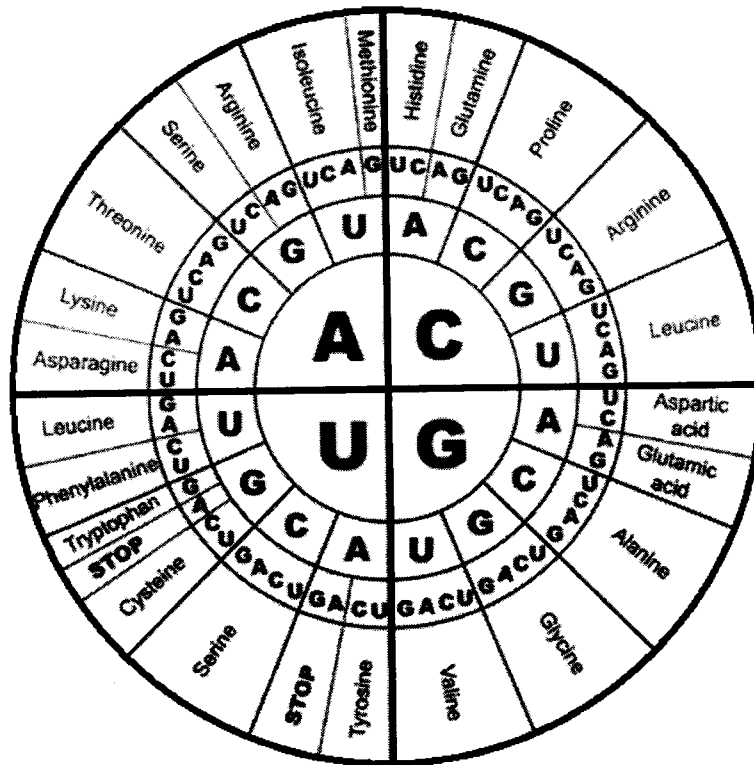
- A 18 B 33 C 36 D 41
- 9 A polypeptide has the amino acid sequence glycine – arginine – lysine – serine. The table below gives possible tRNA anticodons for each amino acid.

amino acid	possible tRNA anticodons	
Arginine	3' UCC 5'	3' GCG 5'
Glycine	3' CCA 5'	3' CCU 5'
Lysine	3' UUC 5'	3' UUU 5'
Serine	3' AGG 5'	3' UCG 5'

Which sequence of bases on DNA would code for the polypeptide?

- A 3' CGA CGC AAG AGC 5'
- B 3' CCT TCC TTC TCG 5'
- C 5' GGA AGG AAA AGC 3'
- D 5' GGT TGG TTG TGC 3'

10 The mRNA codons for amino acids are shown below.



A mutagen causes the adenine in DNA to pair with cytosine during transcription.

Which tripeptide will be synthesised when the template DNA sequence 5' TAACTGCCA 3' is used in protein synthesis in the presence of this mutagen?

- A proline-valine-proline
- B arginine-glutamine-proline
- C tryptophan-glutamine-leucine
- D threonine-valine-asparagine

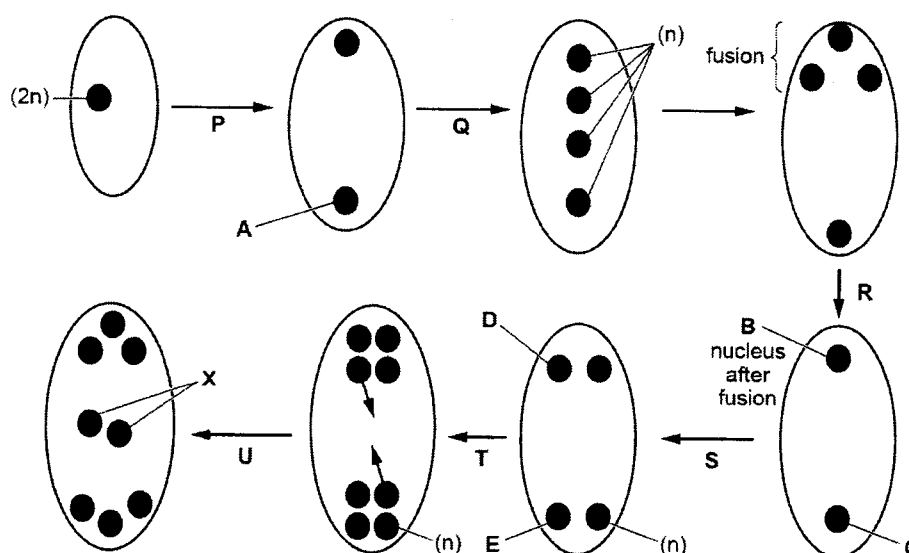
- 11 A student observed the cells in the growing region (meristem) of an onion root and obtained the data shown.

stage	number of cells
interphase	886
prophase	73
metaphase	16
anaphase	14
telophase	11

Which percentage of cells contains chromosomes that appear as two chromatids?

- A 7.3
 B 8.9
 C 95.9
 D 97.5
- 12 The development of the embryo sac in flowering plants involves both mitosis and meiosis. Details of this development can vary in different plants.

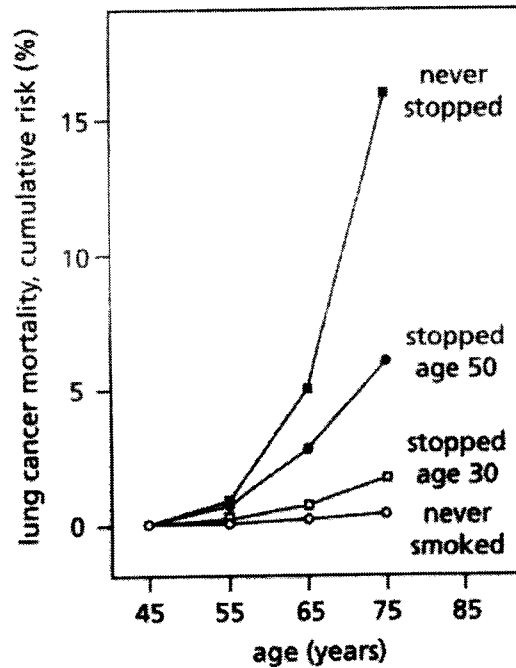
The diagrams summarise the development of the egg cell within the embryo sac of *Lilium* sp. Some of the nuclei have been labelled to indicate the ploidy: n = haploid; $2n$ = diploid.



Which stage, from P, Q, R, and T, represents meiosis II?

- A P B Q C R D T

- 13 Mortality due to lung cancer was followed in groups of males in the United Kingdom for 50 years. The cumulative risk of dying from lung cancer as a function of age and smoking habits for four groups of males is shown in the figure.

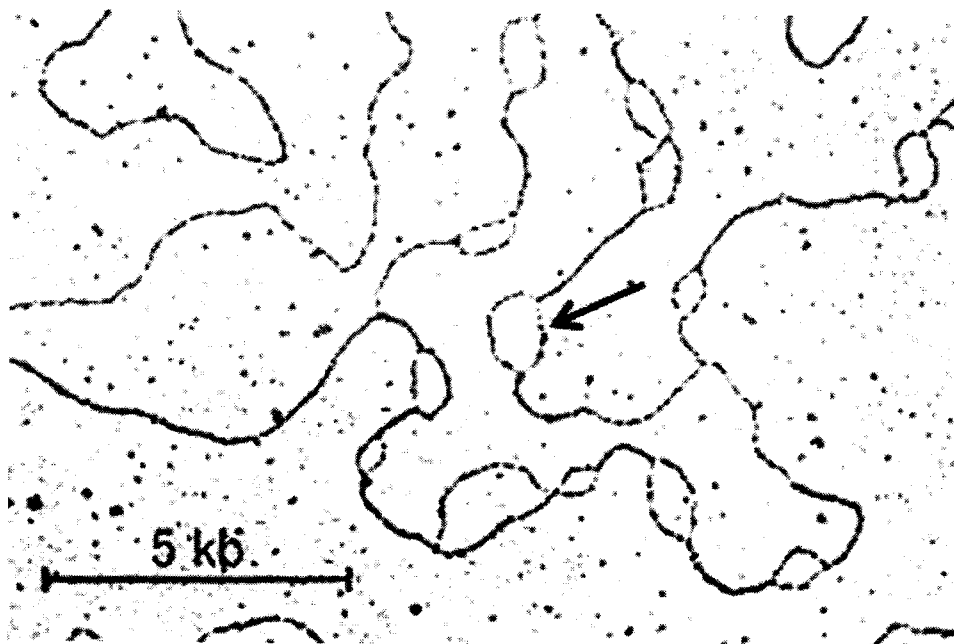


Which of the following best explains the trends observed in the graph?

I	The slower the rate of accumulation of mutations, the lower the cumulative risk.
II	When an individual stops smoking, he will undergo a decreased rate of mutation accumulation.
III	The presence of cigarette smoke will cause the accumulation of mutations to occur at an increased rate.
IV	There is little risk of a non-smoker dying of lung cancer.

- A I and IV only
 B II and III only
 C III and IV only
 D All of the above

- 14 The figure below shows structures that are formed along a DNA molecule of a eukaryotic cell during S phase of the cell cycle.

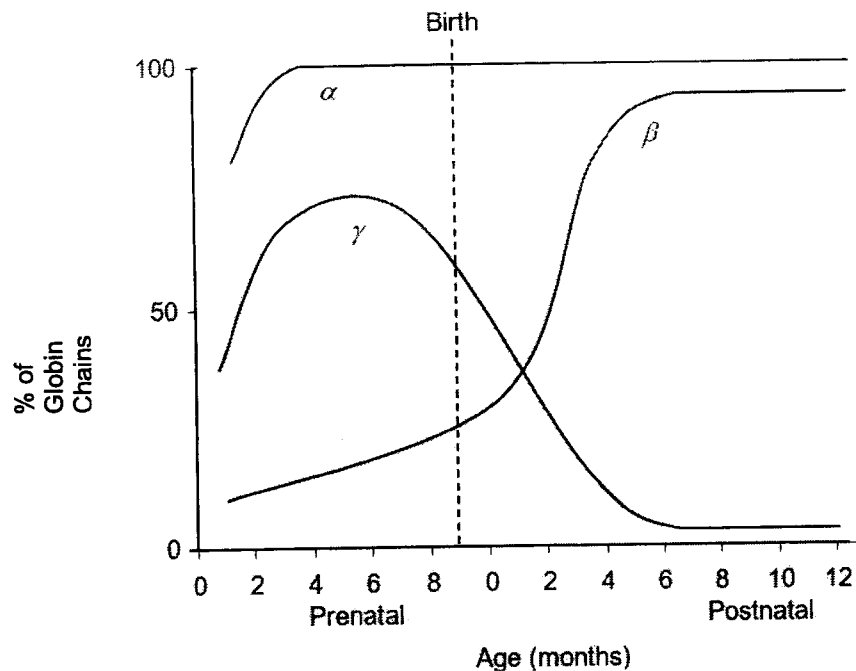


Which statement(s) correctly describe the labelled structure and the process that is taking place?

- 1 Many such structures can also be found in prokaryotic DNA.
 - 2 DNA replication requires primase to synthesize primers to provide free 3' OH for the elongation of daughter strands by RNA polymerase.
 - 3 Eukaryotic chromosomes face the end-replication problem as they are linear. Prokaryotic chromosomes do not have the end-replication problem as they are circular.
 - 4 The end-replication problem occurs only on the lagging strands.
- A** 1 and 2 only
B 1 and 3 only
C 3 only
D 3 and 4 only

- 15 The globin gene family in humans consists of the α , β and γ genes. These genes code for the globin chains that make up haemoglobin and are expressed at different levels during different developmental stages.

The graph shows the expression of the various globin chains during the prenatal (fetal) and postnatal (after birth) periods.



Which of the following cannot account for the differences in the levels of expression of globin chains?

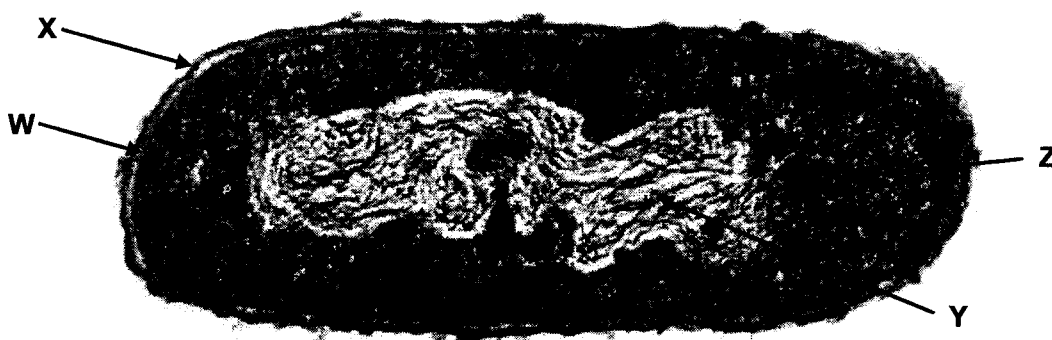
- A** Methyl groups are added to regulatory sequences of γ -globin genes during the postnatal period, allowing for some proteins to bind.
- B** Alternative splicing occurs in the mature mRNA of the α -globin and β -globin genes, resulting in differences in the rate of expression of globin chains during the prenatal period.
- C** A growth factor triggers the expression of a transcription factor that increases the rate of β -globin gene expression during the postnatal period.
- D** The shortening of poly(A) tail in the mRNA of γ -globin genes reduces its stability, resulting in a decrease in the rate of expression of γ -globin chains during the postnatal period.

- 16 One hypothesis about the origin of viruses is that they existed before cellular life forms, later evolving into parasites of cellular organisms. Groups with an ancient, common origin tend to share conserved sequences of DNA or RNA.

Which observation about virus genomes supports the view that viruses existed before cellular life forms and only much later evolved into parasites?

- A All viruses have genes that code for capsid components.
- B Introns of eukaryotic genes have common features with viral genomes.
- C Large virus genomes have genes that originate in host cells.
- D Viral genomes have conserved genes not found in any other genomes.

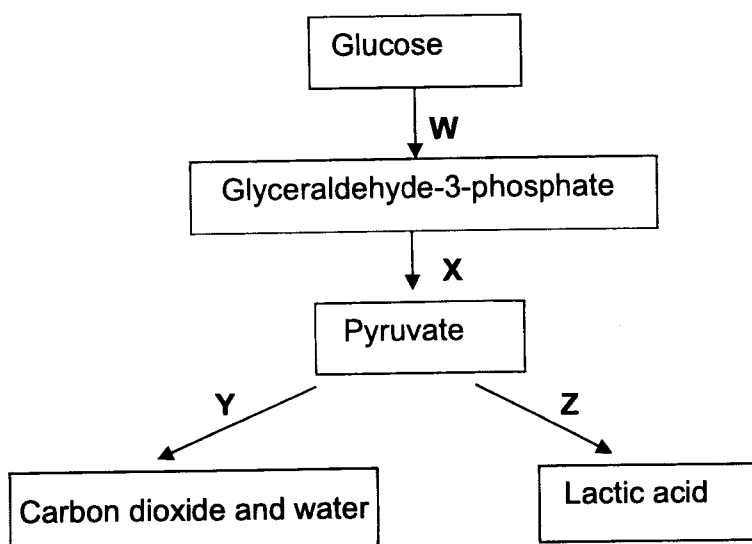
- 17 The diagram shows an electron micrograph of a bacterial cell.



Which of the following correctly identifies the functions of structures W, X, Y and Z?

	W	X	Y	Z
A	maintains shape of bacterial cell	protects bacterial cell against desiccation	contains antibiotic resistance genes which may be beneficial to the bacterial cell	serves as the site of protein synthesis
B	controls the passage of substances into and out of the cell	maintains shape of bacterial cell	contains genetic information which is essential to the survival of bacterial cell	serves as the site of translation of mRNA
C	controls the passage of substances into and out of the cell	maintains shape of bacterial cell	contains antibiotic resistance genes which may be beneficial to the bacterial cell	protects bacterial cell against desiccation
D	protects bacterial cell against desiccation	protects bacterial cell from the action of phagocytes	contains genetic information which is essential to the survival of bacterial cell	maintains shape of bacterial cell

- 18 Which option shows the correct matching of processes W, X, Y and Z to statements (1), (2) and (3)?



- (1) NAD is regenerated without the use of the electron transport system.
 (2) ATP is synthesised via substrate level phosphorylation.
 (3) It can take place under anaerobic conditions.

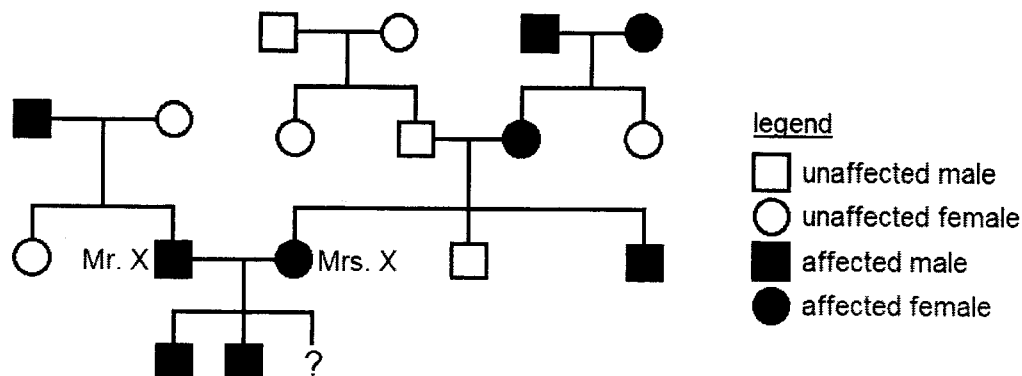
	(1)	(2)	(3)
A	Z only	X only	W, X, Z only
B	Z only	X, Y only	W, X, Z only
C	Y, Z only	X only	W, X, Y, Z
D	Y, Z only	X, Y only	W, X, Y, Z

- 19 Dinitrophenol is a compound that can lodge within the thylakoid membranes of chloroplasts. Its presence provides an alternative route for H^+ ions to diffuse across the thylakoid membranes.

In what way would the Calvin cycle be affected in chloroplasts poisoned with dinitrophenol?

- A No effect since Calvin cycle is an enzyme-controlled process.
 B The rate of Calvin cycle would increase as pH in the stroma decreases.
 C The rate of Calvin cycle would decrease with the accumulation of glycerate-3-phosphate.
 D The rate of Calvin cycle would decrease with the accumulation of glyceraldehyde-3-phosphate.

- 20 The family tree below shows the inheritance of a heart disease due to hypercholesterolaemia.



Mrs. X is expecting a third child. If the child is a son, what is the percentage probability that he will be unaffected?

- A 0 %
 B 12.5 %
 C 25 %
 D 50 %
- 21 Coat colour in horse has three possible phenotypes, grey, black and chestnut, which is due to the interaction of two genes.

Gene *G/g* has two alleles: *G* resulting in grey coat and *g* resulting in non-grey coat.

Gene *E/e* has two alleles: *E* resulting in black coat and *e* resulting in chestnut coat.

The following crosses were carried out.

cross	parental phenotypes	offspring phenotypes
1	grey x grey	grey, black, chestnut
2	black x black	black
3	grey x black	grey, black, chestnut

Which row shows the genotypes of the parents?

	1	2	3
A	GgEe x GgEE	ggEE x ggEE	GgEe x ggEe
B	GgEe x Ggee	ggEe x ggEe	GGEe x ggEe
C	GgEe x GgEe	ggEE x ggEE	GGEe x ggEE
D	GgEe x GgEe	ggEE x ggEe	GgEe x ggEe

- 22 Two pure-breeding varieties of plants, one producing short leaves and one producing long leaves, were crossed. The resultant seeds were planted in two different locations, and the lengths of the leaves were measured.

	Location A	Location B
Number of leaves measured	5	5
Mean length / cm	12.1	6.9
Standard deviation	1	1

The formula used for t -test is:

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

\bar{x} = mean of samples
 s = standard deviation
 n = number of samples

Degree of freedom	Probability				
	0.20	0.10	0.05	0.02	0.01
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169

Which conclusion is correct?

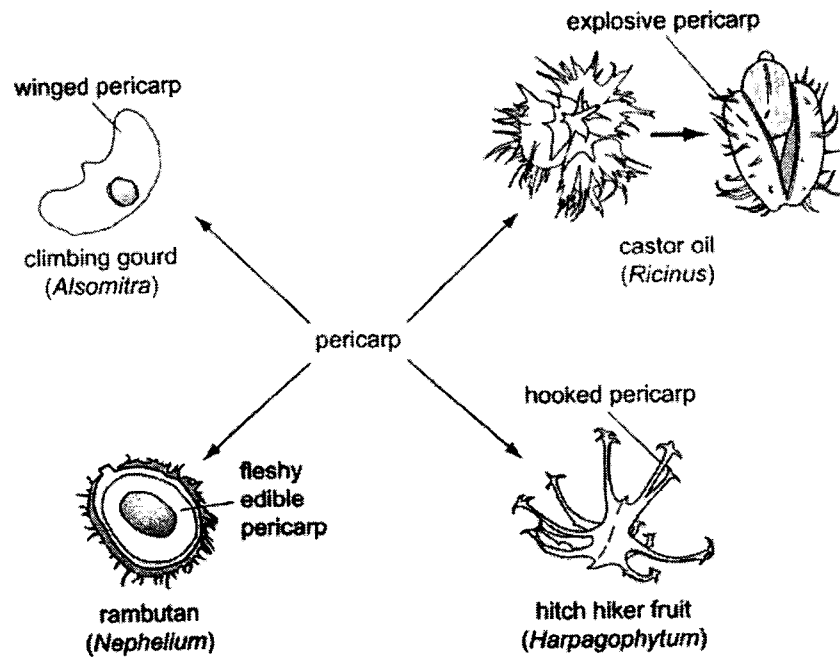
	t value	Conclusion
A	6.544	Differences in lengths of leaves due to different genotypes
B	8.222	Differences in lengths of leaves due to random chance
C	8.222	Differences in lengths of leaves due to effects of different environments
D	6.544	Differences in lengths of leaves due to effects of different environments

- 23 Which of the following correctly matches the step involved in gel electrophoresis to its purpose?

	Step	Purpose
A	Adding buffer solution into electrophoresis gel box	To separate the two complementary strands of double-stranded DNA fragments
B	Adding loading dye	To bind to all DNA fragments to monitor progress of electrophoresis
C	Electrophoresis	To separate DNA fragments based on the amount of negative charges they have
D	Soaking gel in ethidium bromide	To bind to all DNA fragments for visualisation of the DNA bands

- 24 *Dolly The Sheep* was the first mammal to be cloned from an adult cell. The success of this cloning experiment is consistent with the view that
- A differentiated cells retain all the genes of the zygote.
 - B genes are lost during differentiation.
 - C the differentiated state is normally very unstable.
 - D cells can be easily reprogrammed to differentiate and develop into another kind of cell.
- 25 Which of the following statements about insulin receptor are **false**?
1. It dimerises when insulin molecules bind to each of the 2 receptor subunits.
 2. It exhibits enzymatic activity.
 3. It has a 7-pass transmembrane domain.
 4. It is secreted by β -cells of islets of Langerhans.
- A 1 and 4
 - B 2 and 3
 - C 1, 3 and 4
 - D 2, 3 and 4

- 26 The diagram illustrates variation in the pericarp (fruit wall) for a variety of methods used in seed dispersal.



What do these examples illustrate?

- A The adaptive radiation of analogous structures showing convergent evolution.
- B The adaptive radiation of analogous structures showing divergent evolution.
- C The adaptive radiation of homologous structures showing convergent evolution.
- D The adaptive radiation of homologous structures showing divergent evolution.

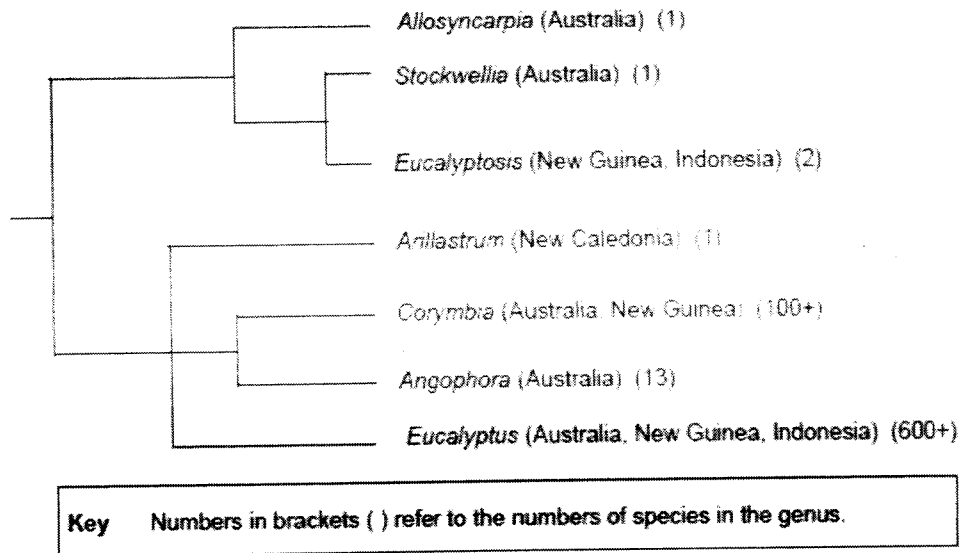
- 27 The α , β and γ globin chains of human, chimpanzee, gorilla and gibbon haemoglobin were analysed. The number of differences in the amino acid sequences in comparison with the human molecules is shown in the table.

species	number of differences in amino acid sequence from human molecules		
	α globin	β globin	γ globin
chimpanzee	0	0	1
gorilla	1	1	1
gibbon	3	3	2

What do the differences suggest?

- A Humans and gorillas shared a common ancestor more recently than humans and gibbons.
- B Humans and gibbons shared a common ancestor more recently than humans and chimpanzees.
- C Humans evolved from chimpanzees.
- D Humans and gorillas do not share a common ancestor.

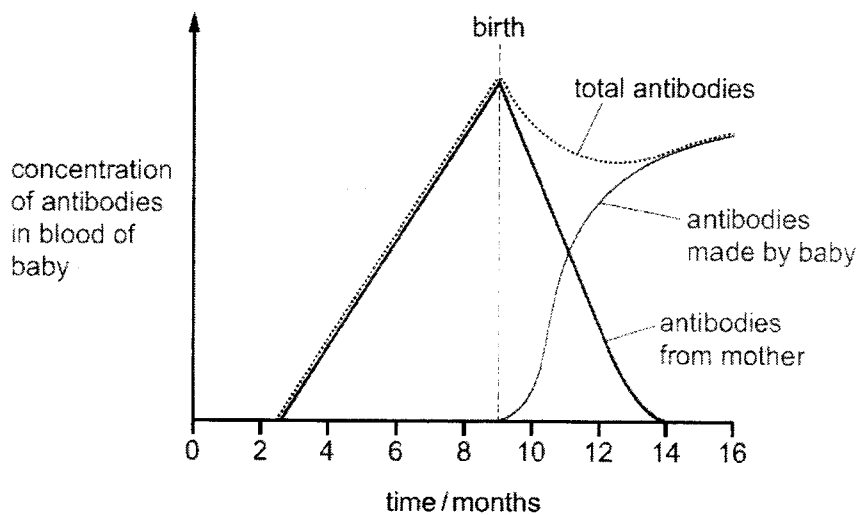
- 28 A proposed phylogeny for the seven genera of plants is shown in the diagram below, along with the countries in which they are found.



It would be reasonable to conclude that

- A** DNA sequences in *Eucalyptosis* would be more similar to those in *Allosyncarpia* than to those in *Stockwellia*.
- B** speciation in *Eucalyptus* was assisted by different selection pressures.
- C** the greater the number of species in a genus, the younger the genus.
- D** the genus that evolved most recently was *Angophora*.

- 29 The graph shows the changes that occur in the concentration of antibodies in the blood of a baby before birth and during the first few months after birth.

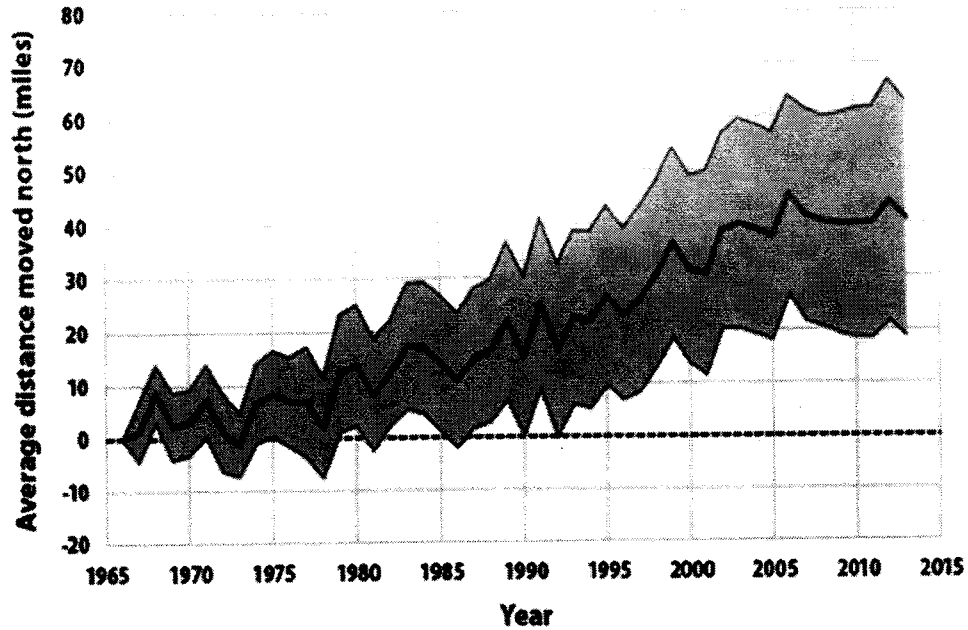


Which description about the changes in immunity during the first few months after birth is correct?

- A active artificial immunity decreases, active natural immunity increases
- B active natural immunity decreases, active artificial immunity increases
- C passive artificial immunity decreases, active natural immunity increases
- D passive natural immunity decreases, active natural immunity increases

- 30 Warmer temperatures are forcing birds in pine forests to breed farther north. Many species once found farther south are also expanding their ranges.

The graph below shows the average latitude occupied by 305 bird species in North America during the winters of 1966 to 2013. The shaded band shows the range of latitudes occupied by the birds.



What could explain the observation?

- 1 Seasonal birds begin their migration earlier, and lay eggs earlier, in response to warming forest climate.
- 2 Birds are mobile, thus do not need to adapt and can switch their home ranges and habitat to find more suitable breeding grounds.
- 3 As temperature rises, hardwood forests in the north lose their advantage, and pine forests found in the south now cover the northern region.
- 4 As temperature rises, birds experience warmer winters that increases their reproductivity, resulting in larger bird populations.

- A 2 only
 B 2 and 3 only
 C 1, 2 and 4 only
 D 1, 3 and 4 only



EUNOIA JUNIOR COLLEGE
 JC2 Preliminary Examination 2022
 General Certificate of Education Advanced Level
 Higher 2

CANDIDATE
 NAME

--

CIVICS
 GROUP

2	1	-		
---	---	---	--	--

REGISTRATION
 NUMBER

--	--

H2 Biology

9744/02

Paper 2 Structured Questions

14 September 2022

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [] at the end of each question or part question.

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

This document consists of **30** printed pages and **2** blank pages.

BLANK PAGE

Answer all questions.

- 1 The Golgi body, rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER) form part of the internal membrane system of a cell. The membranes have a fluid mosaic structure.

Fig. 1.1 is a transmission electron micrograph of one area of a liver cell showing a region with RER and a region with SER. Mitochondria are also visible in the image.

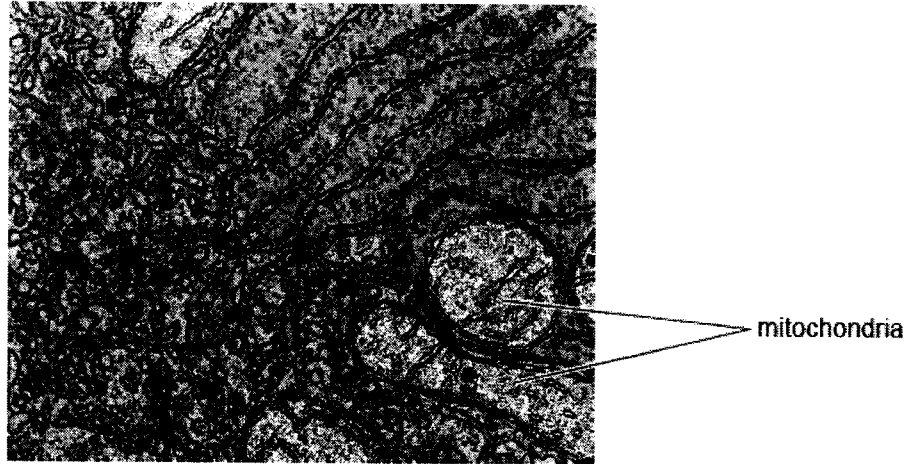


Fig. 1.1

- (a) Describe one difference between RER and SER.

structure

.....

function

..... [2]

- (b) Phospholipids are one of the main components of membranes.

Describe the structure of a phospholipid molecule.

.....

.....

.....

..... [2]

(c) One function of a Golgi body is to package molecules into Golgi vesicles.

(i) A Golgi body and Golgi vesicles are **not** visible in Fig. 1.1.

Describe the features, **other than** the presence of Golgi vesicles, that would help you identify a Golgi body in a transmission electron micrograph of another area of the same liver cell.

.....
.....
.....
.....[2]

(ii) Some Golgi vesicles contain secretory proteins for release from the cell.

Describe the sequence of events that occurs following the packaging of a secretory protein into a Golgi vesicle to its release from the cell.

.....
.....
.....
.....
.....
.....[3]

(iii) Some Golgi vesicles contain glycoproteins or glycolipids to be added to the cell surface membrane.

State a role of **glycolipids** in the cell surface membrane.

.....
.....[1]

[Total: 10]

- 2 Fig. 2.1A shows a polypeptide molecule during protein synthesis. A molecule of glycine is shown just before it is added to the polypeptide.

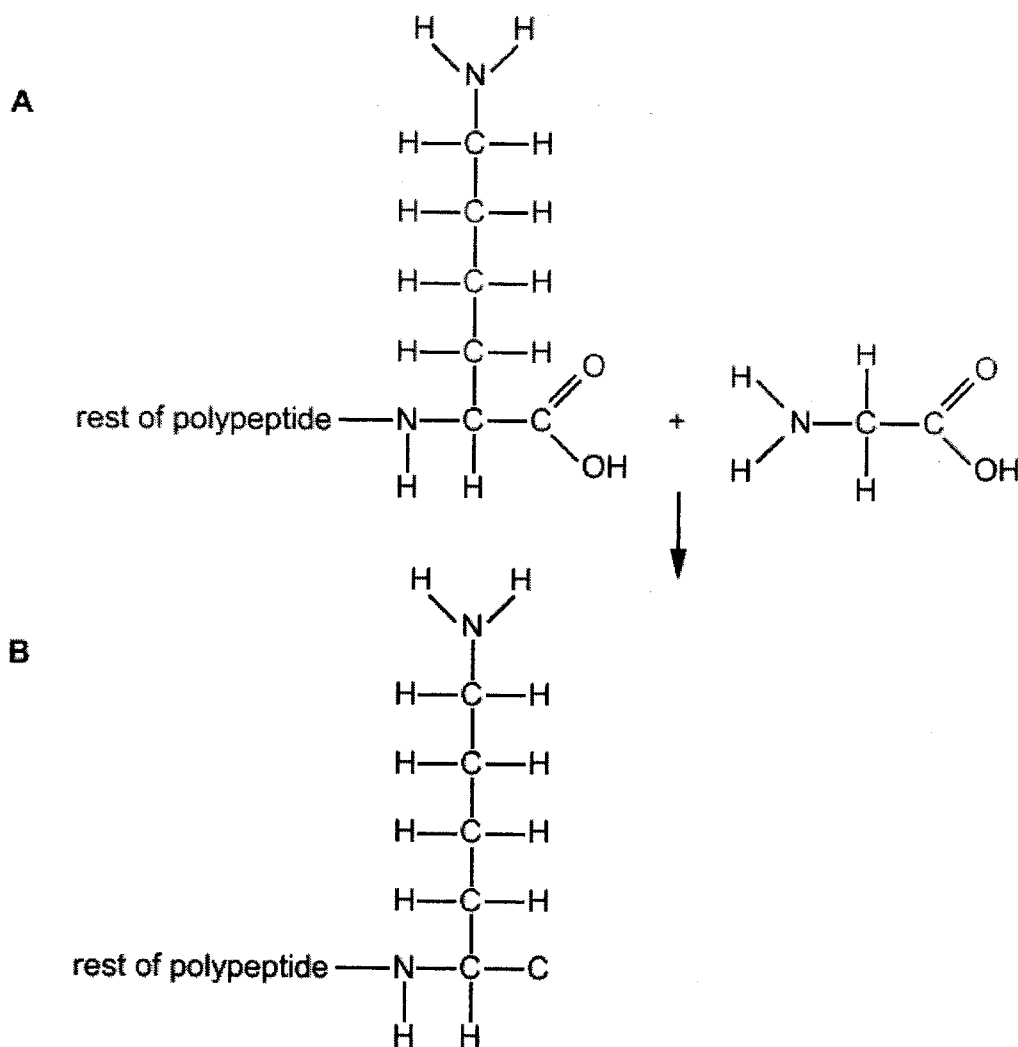


Fig. 2.1

- (a) Complete Fig. 2.1B to show the molecule of glycine added to the end of the polypeptide. [2]

- (ii) Osteogenesis imperfecta (OI), commonly known as "brittle bone disease", is a disorder characterized by bone fragility and abnormalities of connective tissue. Vast majority of affected individuals have mutations in the genes encoding the polypeptide chains of collagen, which result in substitution of amino acid residues.

Suggest the effect of such mutations on the structure of collagen fibre.

.....

.....

.....

.....

.....

.....[2]

Collagen is a water-insoluble fibrous protein that can be prone to swelling. Collagen swelling occurs when water fills up the gaps between collagen molecules.

Fig. 2.4 shows the effect of pH on swelling ratio of collagen. Swelling ratio is defined as the percentage increase in the weight of collagen due to water absorption.

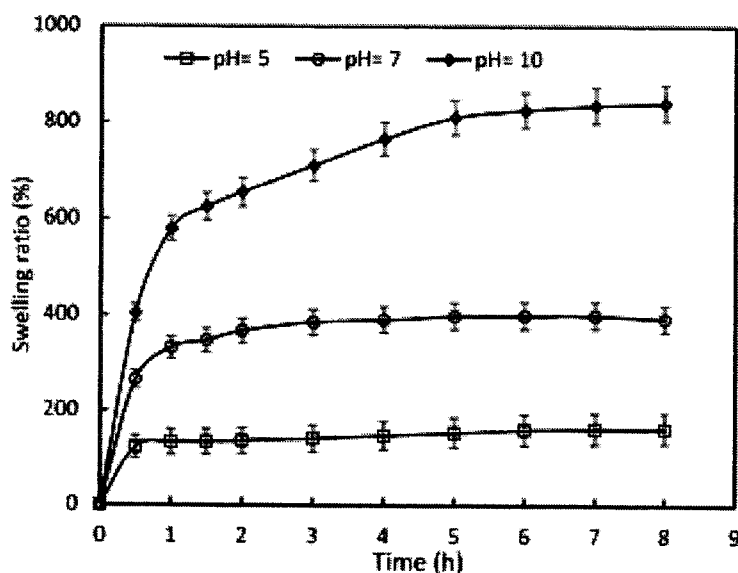


Fig. 2.4

- (c) With reference to Fig. 2.4, describe and explain the effect of pH on collagen.

.....

.....

.....

.....

..... [2]

[Total: 10]

[Turn over]

- 3 (a) Fig. 3.1 is a photomicrograph of root tip cells at different stages in the cell cycle. A cell cycle in interphase is labelled.

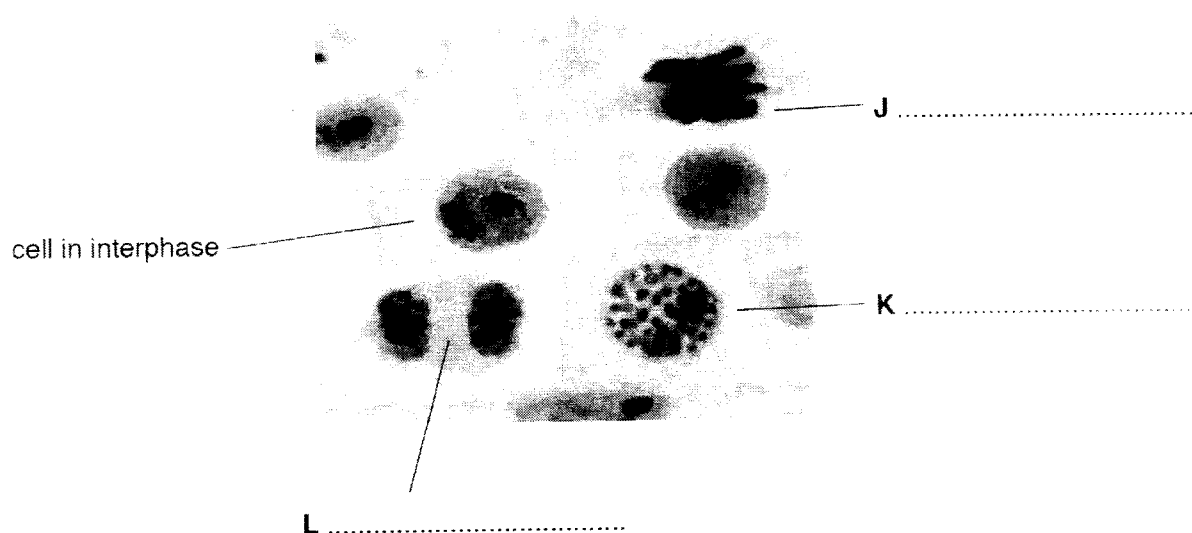


Fig. 3.1

- (i) Name the stage of mitosis shown in each of the cells J, K and L in Fig. 3.1.

Write your answer in the space next to each letter on Fig. 3.1.

[2]

- (ii) Explain how it is possible to deduce that the labelled cell in interphase shown in Fig. 3.1 is in late, rather than early, interphase.

.....
[1]

- (iii) Suggest one advantage of using a light microscope, rather than an electron microscope, to study cell division.

.....
[1]

(b) Mutations in human body cells can sometimes result in a tumour. Some tumours are cancerous.

(i) Outline how tumour development is a multistep process.

.....
.....
.....
.....
.....
.....
.....[3]

(ii) Tumour cells have antigens on their cell surface that are not present on non-tumour cells.

These antigens are the result of gene mutations and are known as tumour specific antigens (TSA).

One type of TSA differs in structure from the protein found on the cell surface of non-tumour cells by a single amino acid.

Explain how a gene mutation could result in the production of this TSA.

.....
.....
.....
.....[2]

(c) Immunotherapy is a form of treatment for cancer which aims to stimulate the immune system to destroy tumour cells.

One form of immunotherapy for cancer uses a vaccine which contains one specific type of TSA.

Suggest how vaccination with a specific type of TSA could lead to the destruction of tumour cells by T-lymphocytes in the body.

.....
.....
..... [1]

[Total: 10]

- 4 Lactate dehydrogenase (LDH) is an enzyme found in many organisms. Within the same organism, it can be found in different forms, called isoenzymes. The isoenzymes are structurally different but all catalyse the same reaction.

Lactate dehydrogenase isoenzymes are globular proteins, each consisting of four polypeptides.

Lactate dehydrogenase isoenzymes are made up of two types of polypeptide: polypeptide M, which is coded for by the LDH-A gene and polypeptide H, which is coded for by the LDH-B gene.

Table 4.1 shows the composition of different human lactate dehydrogenase isoenzymes and examples of tissues and organs where each can be found.

Table 4.1

isoenzyme	polypeptide composition of enzyme	example of isoenzyme location
LDH-1	HHHH	heart red blood cells
LDH-2	HHHM	heart red blood cells
LDH-3	HHMM	brain lungs
LDH-4	HMMM	kidneys placenta
LDH-5	MMMM	liver skeletal muscles

- (a) With reference to Table 4.1, suggest how different cells of the same individual can produce different isoenzymes.

.....

.....

.....

.....[2]

- (b) The base sequences of the LDH-A and LDH-B genes and the sequences of the amino acids encoded by these genes were determined.

Fig. 4.1 shows the first ten amino acids of polypeptides M and H and the corresponding base sequences of one of the DNA strands of each gene.

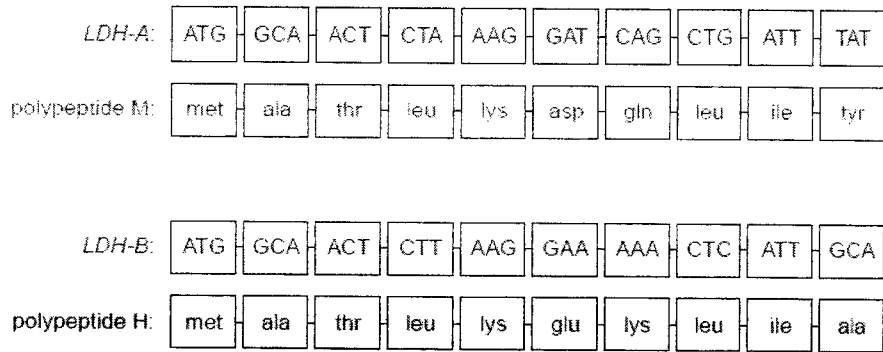


Fig. 4.1

Table 4.2 shows the genetic code (mRNA codons).

Table 4.2

first position	second position				third position
	U	C	A	G	
U	phe	ser	tyr	cys	U
	phe	ser	tyr	cys	C
	leu	ser	STOP	STOP	A
	leu	ser	STOP	trp	G
C	leu	pro	his	arg	U
	leu	pro	his	arg	C
	leu	pro	gln	arg	A
	leu	pro	gln	arg	G
A	ile	thr	asn	ser	U
	ile	thr	asn	ser	C
	ile	thr	lys	arg	A
	met	thr	lys	arg	G
G	val	ala	asp	gly	U
	val	ala	asp	gly	C
	val	ala	glu	gly	A
	val	ala	glu	gly	G

With reference to Fig. 4.1 and Table 4.2,

- (i) state if both the base sequences of LDH-A and LDH-B genes are the template strand or non-template strand of DNA.

..... [1]

(ii) explain your answer to (b)(i).

.....

.....

.....

..... [2]

(iii) Fig. 4.2 shows the process of polypeptide synthesis.

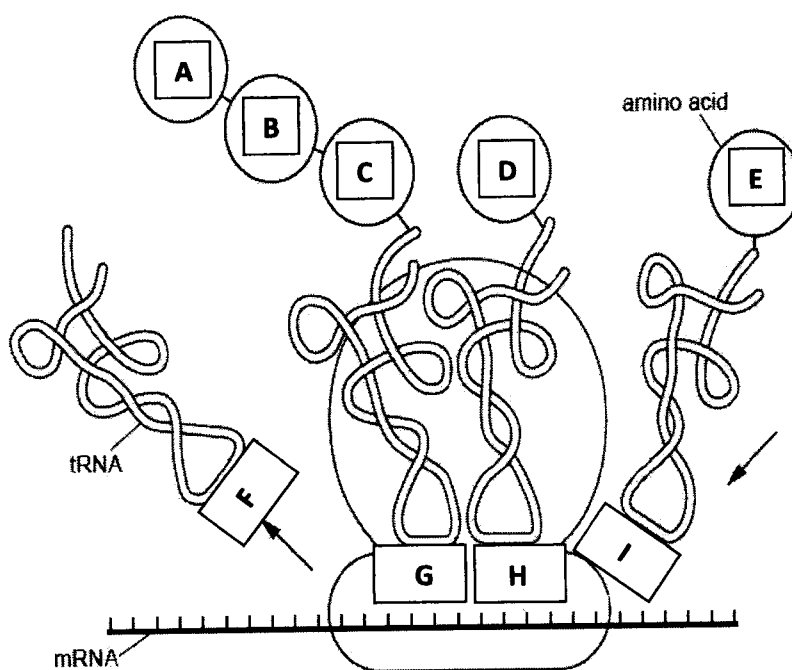


Fig. 4.2

Fill in the following spaces with the relevant information for the synthesis of the first five amino acids for the LDH-A polypeptide chain.

Amino acids: A B C D E

[1]

Anticodons: F G H I

[1]

(iv) Compare the structures of mRNA and tRNA.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

- 5 In multicellular eukaryotes, gene regulation is important in development. Different sets of genes need to be expressed in different cells, at the right times, and in the right sequence for organisms to develop correctly.

In eukaryotes, a specific transcription factor or activator binds to an enhancer to regulate the expression of genes coding for specific proteins in different tissues.

- (a) (i) Explain the meaning of the term 'enhancer'.

.....
.....[1]

- (ii) Using the information given, suggest a reason why activators are referred to as 'specific' transcription factors.

.....
.....[1]

- (b) The *PITX1* gene codes for a protein that plays a role in the development of pelvic spines of fishes like the three-spine stickleback, *Gasterosteus aculeatus*. *PITX1* also plays critical roles in controlling the development of the fish body like the formation of the jaws, pelvis and pituitary glands.

Fig. 5.1 shows a diagram of the *PITX1* gene and the associated regions.

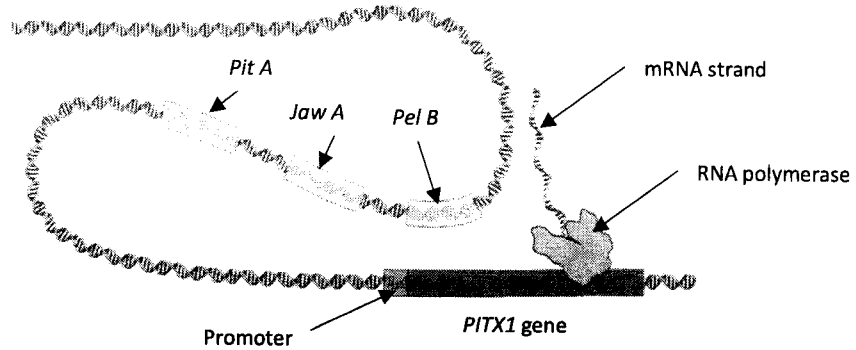


Fig. 5.1

- (i) The three regions, *Pel B*, *Jaw A*, *Pit A* are important for the expression of the *PITX1* gene.

Describe how the binding of an activator like *Pel B* at the *Pel B* region can affect gene expression.

.....

[2]

- (ii) Explain how the structure of the *Pel B* activator enables it to bind to the *Pel B* region.

.....
[1]

- (iii) Assuming that cells in the pelvis and eyes of the stickleback contain the same *PITX1* gene and the same three regions as shown in Fig. 5.1, explain why eyes of the stickleback do not have spines.

.....

[2]

- (c) Scientists researching on different species of sticklebacks living in the marine environments and in freshwater lakes found that they differed in the presence or absence of the pelvic spines as shown in Fig. 5.2.

Molecular genetic analysis found that these two groups of fishes exhibited very different levels of expression for the *PITX1* gene. Fig. 5.3 shows the level of expression (in arbitrary units or A.U.) of the *PITX1* gene in the pelvic regions for the fishes from both habitats.

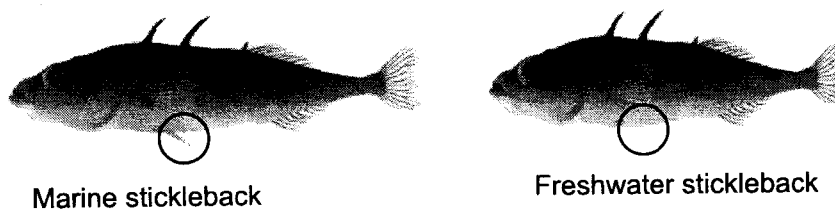


Fig. 5.2

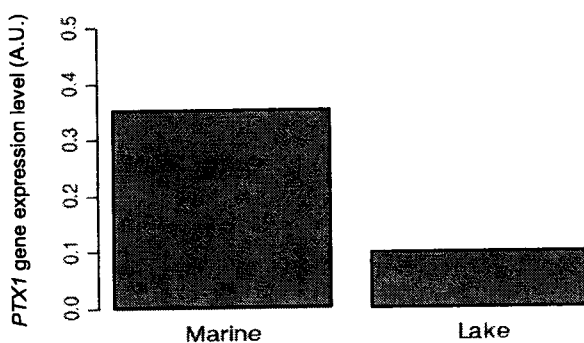


Fig. 5.3

- (i) With reference to Fig. 5.3, suggest a reason for the absence of pelvic spines in freshwater stickleback.

.....

.....

.....

.....[2]

- (ii) In freshwater habitats, dragonfly larva are much larger in size than young sticklebacks. They predate on the young sticklebacks by grabbing on to protruding parts of the fish.

Suggest how the absence of pelvic spines aids in the survival of the young sticklebacks.

.....

.....[1]

[Total: 10]

- 6 The patty pan squash plant, *Cucurbita pepo*, produces edible fruits that vary in colour.
- (a) The colour of the fruits is controlled by two genes, **A/a** and **B/b**, that occur on different chromosomes.
- Allele **A** produces a white fruit colour.
 - Allele **a** does not produce a colour by itself but allows the colours coded by gene **B/b** to show in the phenotype.
 - Allele **B** produces a yellow fruit colour.
 - Allele **b** produces a green fruit colour.

In a dihybrid cross, a pure-breeding white parent plant was crossed with another pure-breeding green parent plant. All the resulting F_1 plants produced white fruits.

The F_1 plants were then crossed with each other to obtain the F_2 generation.

- (i) State the name for this type of gene interaction.

.....[1]

- (ii) Draw a genetic diagram to show the cross of the F_1 plants to obtain the F_2 generation.

[4]

(b) Explain how different genotypes give rise to a white phenotype.

.....
.....
.....
.....
.....
.....[3]

(c) Explain how you would determine if the genotype of a white squash was homozygous dominant or homozygous recessive at gene locus **B**, assuming that it is heterozygous at gene locus **A**.

.....
.....
.....
.....[2]

[Total: 10]

7 (a) Chemiosmosis is the term used to describe the synthesis of ATP using a proton gradient across a membrane in a mitochondrion or chloroplast. It was first demonstrated by Peter Mitchell in 1961.

- In some of his experiments, Peter Mitchell used mitochondria that had been isolated from cells.
- The mitochondria were kept in liquid, in glass dishes, to which ADP, Pi and other substances were added.
- The outer mitochondrial membrane is freely permeable to proton entry.
- The temperature, pH and water potential were kept constant.
- After a period of time, he checked for the presence of ATP.

The contents of some of the dishes are shown in the table below.

Complete the table using a tick (✓) if ATP was produced, and a cross (×) if no ATP was produced. [2]

dish contents	ATP produced
mitochondria + ADP + Pi + acetyl CoA + oxygen	
mitochondria + ADP + Pi + acetyl CoA	
mitochondria + ADP + Pi + low concentration of protons (H ⁺)	
mitochondria + ADP + Pi + high concentration of protons (H ⁺)	

(b) Explain the consequences to a mitochondrion if the water potential of the liquid in the dishes is higher than the water potential of the mitochondrial matrix.

.....

.....

.....

.....[2]

(c) Fig. 7.1 is a transmission electron micrograph of a chloroplast.

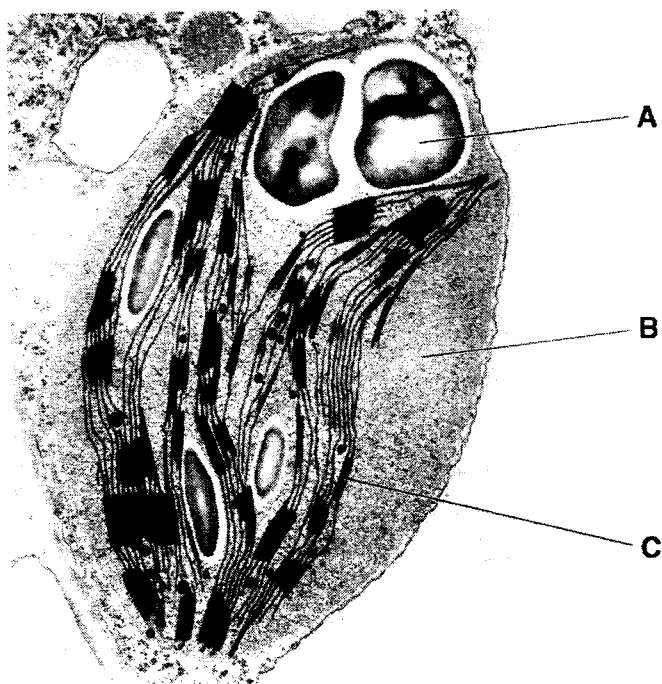


Fig. 7.1

Many compounds and structures involved in photosynthesis are located in a chloroplast.

Using the labels **A**, **B** or **C**, complete Table 7.1 to show the location of four of these compounds or structures.

You may use each of the letters **A**, **B** and **C** once, more than once, or not at all.

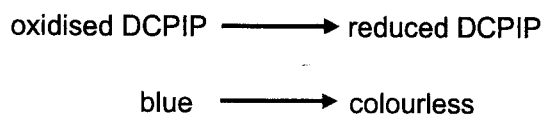
Table 7.1

compound or structure	location
ATP synthase
rubisco
starch grain
phospholipid bilayer

[2]

- (d) The light dependent stage of photosynthesis in a suspension of isolated chloroplasts can be investigated using the Hill reaction.

Dichlorophenolindophenol (DCPIP) can be used to follow the process. DCPIP is a blue dye which turns colourless when it is reduced by accepting hydrogen and electrons.



- (i) DCPIP is an artificial hydrogen acceptor that can be used in the Hill reaction.

Name the natural hydrogen acceptor found in chloroplasts that is replaced by DCPIP in the Hill reaction.

.....[1]

- (ii) Outline the way in which hydrogen is made available to reduce the hydrogen acceptor in the light dependent stage of photosynthesis.

.....

[2]

- (iii) Predict **and** explain the effect on the concentration of RuBP in the chloroplasts if DCPIP becomes reduced instead of the natural hydrogen acceptor.

.....
[1]

[Total: 10]

8 Sickle cell anaemia is an autosomal recessive inherited disorder.

- The Hb^A allele codes for the normal β -globin polypeptide of haemoglobin.
- The Hb^S allele, caused by a base substitution mutation, codes for an abnormal β -globin polypeptide.
- The base substitution results in the amino acid glutamate, which has a charged R group, to be replaced by valine, which has a non-polar R group, in the polypeptide.

The abnormal haemoglobin molecules (HbS) form fibres in low partial pressures of oxygen (pO_2). The fibres cause red blood cells to become sickle shaped and the cells can block blood capillaries.

Individuals with adult haemoglobin molecules that are all abnormal (HbS) have sickle cell anaemia. This is a painful chronic condition that can be life-threatening.

(a) Explain why this mutation causes the HbS to form fibres.

.....

.....

.....

..... [2]

(b) People who are heterozygous (Hb^A Hb^S) have sickle cell trait (SCT). For a child to inherit sickle cell anaemia (Hb^S Hb^S), both parents must have SCT. A genetic screening program is available for sickle cell anaemia and SCT.

(i) To test for the presence of Hb^S, DNA is extracted and the polymerase chain reaction (PCR) is carried out with two specific sets of primers. One set of primers (normal-specific primers) detects Hb^A allele while the other set of primers (mutant-specific primers) detects Hb^S allele.

Explain:

- why primers are used in PCR
- how the use of two specific sets of primers allows the amplification of the normal, sickle cell anaemia and SCT genotypes.

.....

.....

.....

.....

..... [2]

(ii) Gel electrophoresis is carried out on the products of the PCRs.

Fig. 8.1 includes the results for two individuals, **A** and **B**, tested for the sickle cell allele.

- Each lane has an 860 base pair (bp) band to indicate the test is valid.
- Lane 1 is a control lane with a 207bp band for an individual with known normal phenotype.
- Lane 2 is a control lane with a 207bp band for an individual with known sickle cell anaemia phenotype.
- Lanes 1, 3 and 5 contain DNA from the PCR that used normal-specific set of primers.
- Lanes 2, 4 and 6 contain DNA from the PCR that used mutant-specific set of primers.

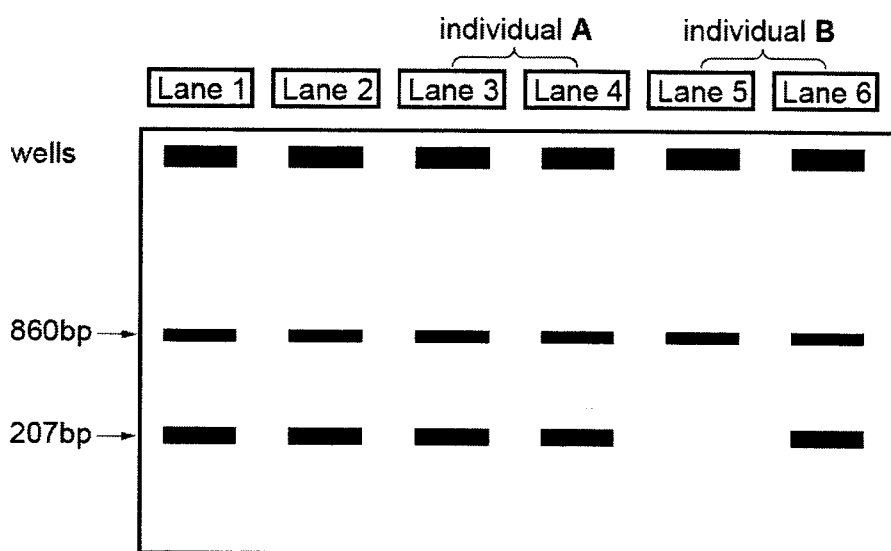


Fig. 8.1

Deduce the genotypes and phenotypes of individuals **A** and **B** in Fig. 4.1.

A:

.....

B:

.....[2]

- 9 Different signalling pathways generate calcium (Ca^{2+}) signals which regulate many cellular functions, e.g. smooth muscle contraction.

Fig. 9.1 shows the inositol triphosphate/calcium ($\text{IP}_3/\text{Ca}^{2+}$) signalling pathway. Phosphatidylinositol-bisphosphate (PIP_2) is hydrolysed into IP_3 and diacylglycerol (DAG) by phospholipase C.

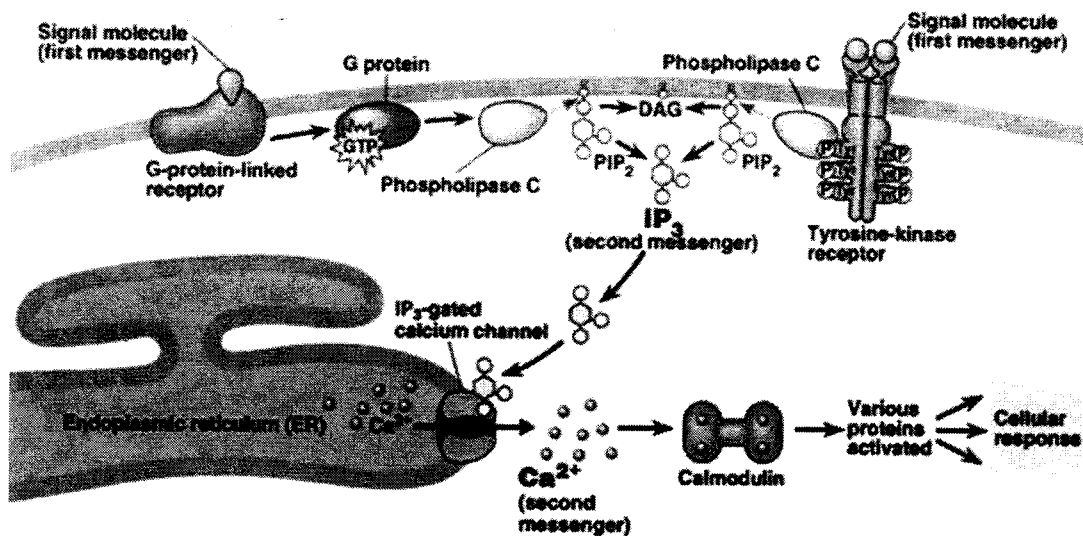


Fig. 9.1

(a) With reference to Fig. 9.1,

- (i) describe the structural differences of the two receptors.

.....

 [2]

- (ii) define second messengers and explain their role in signal transduction.

define

.....

role

.....
 [2]

(iii) outline two stages where signal amplification may occur.

.....
.....
.....
.....
.....[2]

(iv) Dysregulation of the IP_3/Ca^{2+} signalling pathway can lead to many different possible human diseases. Hypertension is caused by increased smooth muscle contraction due to enhanced IP_3/Ca^{2+} signalling.

Suggest the type of mutation in phospholipase C that could lead to hypertension.

.....
.....
.....
.....
.....[2]

- (b) Calcium binding by calmodulin exhibits considerable cooperativity, making calmodulin an unusual example of a monomeric (single-chain) cooperative-binding protein with four calcium-binding sites.

Fig. 9.2 shows calmodulin without calcium (left), and calmodulin with calcium (right). Sites that bind target proteins are indicated by the stars (*).

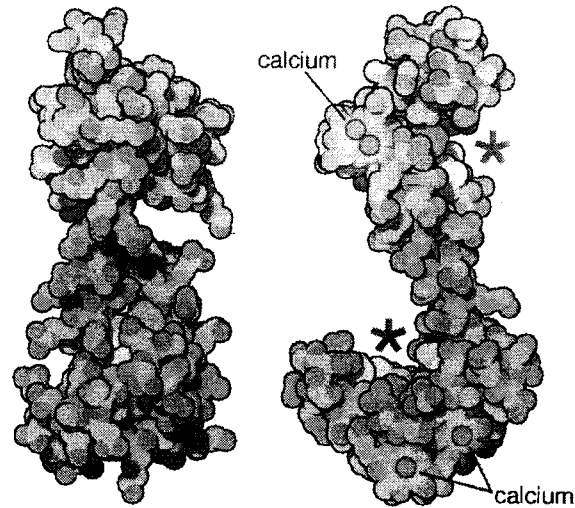


Fig. 9.2

With reference to Fig. 9.2, suggest how cooperative binding of Ca^{2+} ions to calmodulin is necessary for calmodulin activity.

.....

.....

.....

.....[2]

[Total: 10]

10 (a) Fig. 10.1 is a diagram that shows the structure of an antibody molecule.

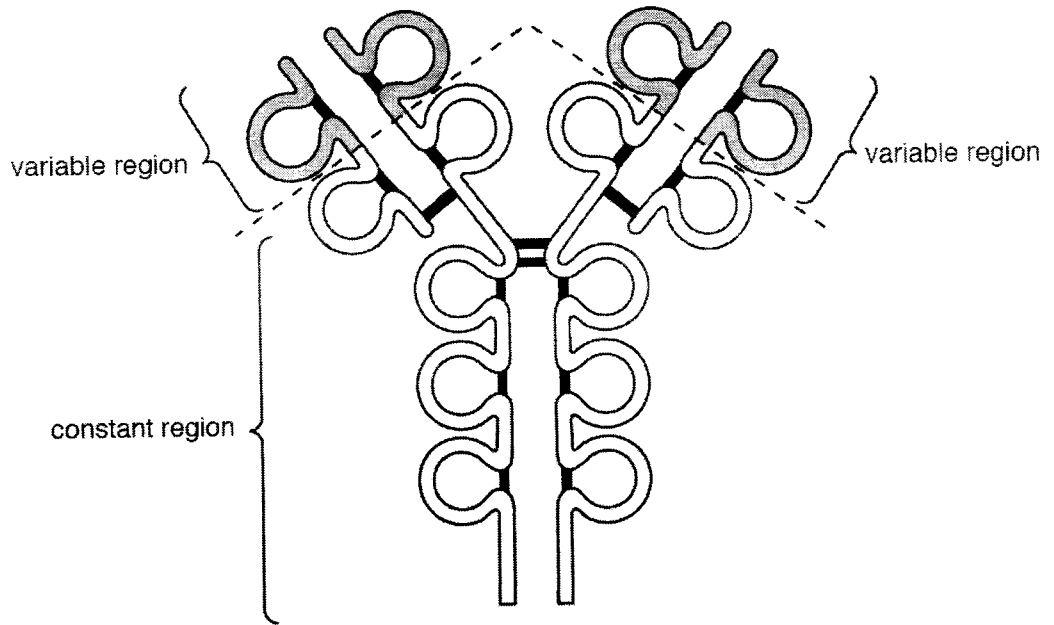


Fig. 10.1

Use Fig. 10.1 to explain how the structure of the variable region of an antibody molecule is related to its function.

.....

.....

.....

.....[2]

(b) Fig. 10.2 shows a process that occurs to heavy chain gene on human chromosome 14.

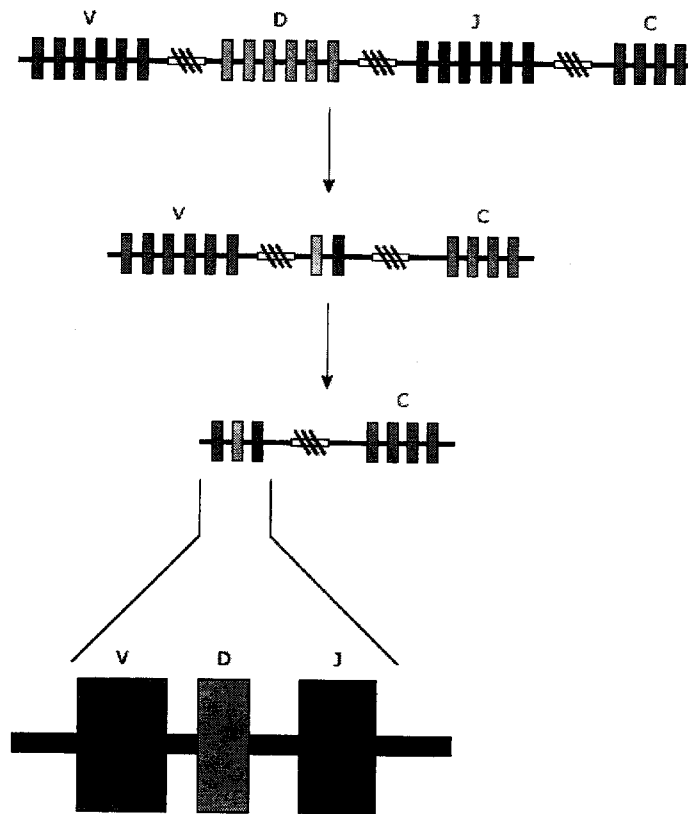


Fig. 10.2

(i) Outline the process shown in Fig. 10.2.

.....
.....
.....
.....[2]

(ii) Explain the significance of the above process.

.....
.....[1]

[Total: 5]

11 Fig. 11.1 shows the relationship between the density of coral skeletons and the rate of precipitation of key minerals for the coral skeleton. The different shapes represent coral samples obtained from different locations in the world.

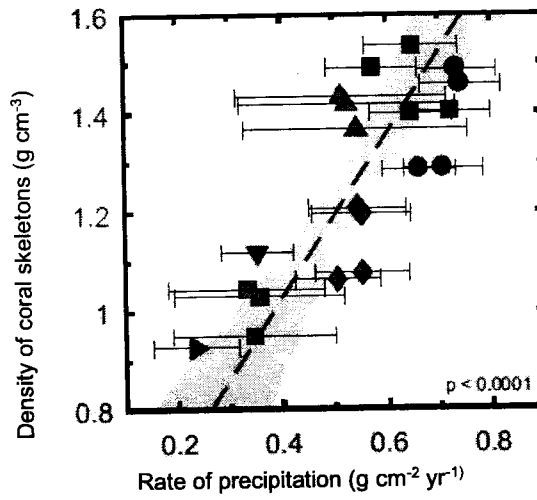


Fig. 11.1

(a) (i) Describe the general relationship between density of coral skeletons and rate of precipitation of key minerals for the coral skeleton.

.....
.....
.....[1]

(ii) An increase in carbon dioxide concentration in the atmosphere has resulted in higher concentrations of carbon dioxide in the ocean. This has caused a decrease in the pH of the ocean and has resulted in ocean acidification.

Explain how ocean acidification has affected corals.

.....
.....
.....[1]

BLANK PAGE



EUNOIA JUNIOR COLLEGE
 JC2 Preliminary Examination 2022
 General Certificate of Education Advanced Level
 Higher 2

CANDIDATE
 NAME

--

CIVICS
 GROUP

2	1	-	
---	---	---	--

REGISTRATION
 NUMBER

--	--

H2 Biology

9744/03

Paper 3 Structured & Free Response Questions

19 September 2022

2 hours

Candidates answer **Section A** on the Question Paper and **Section B** on the Answer Booklet.

Additional Materials: 12-page Answer Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
 Write in dark blue or black pen on both sides of the paper.
 You may use an HB pencil for any diagrams or graphs.
 Do not use paper clips, highlighters, glue or correction fluid/tape.

Section A

Answer **all** questions.

Section B

Answer **one** question on the **12-page Answer Booklet**.

Write your answer to each part of the question on a fresh sheet of paper.

The use of an approved scientific calculator is expected, where appropriate.

The number of marks is given in brackets [] at the end of each question or part question.

At the end of the examination, ensure that you submit both the question paper and answer booklets.

For Examiner's Use	
Section A	
1	
2	
3	
Section B	
4 OR 5	
Total	75

This document consists of **18** printed pages and **2** blank pages.

BLANK PAGE

Section A

1 (a) Influenza causes occasional pandemics that have claimed the lives of millions of people.

Different strains of influenza are named in terms of 'H' and 'N'. For example, avian influenza is named H5N1.

Fig. 1.1 shows the main structural features of the H5N1 influenza virus.

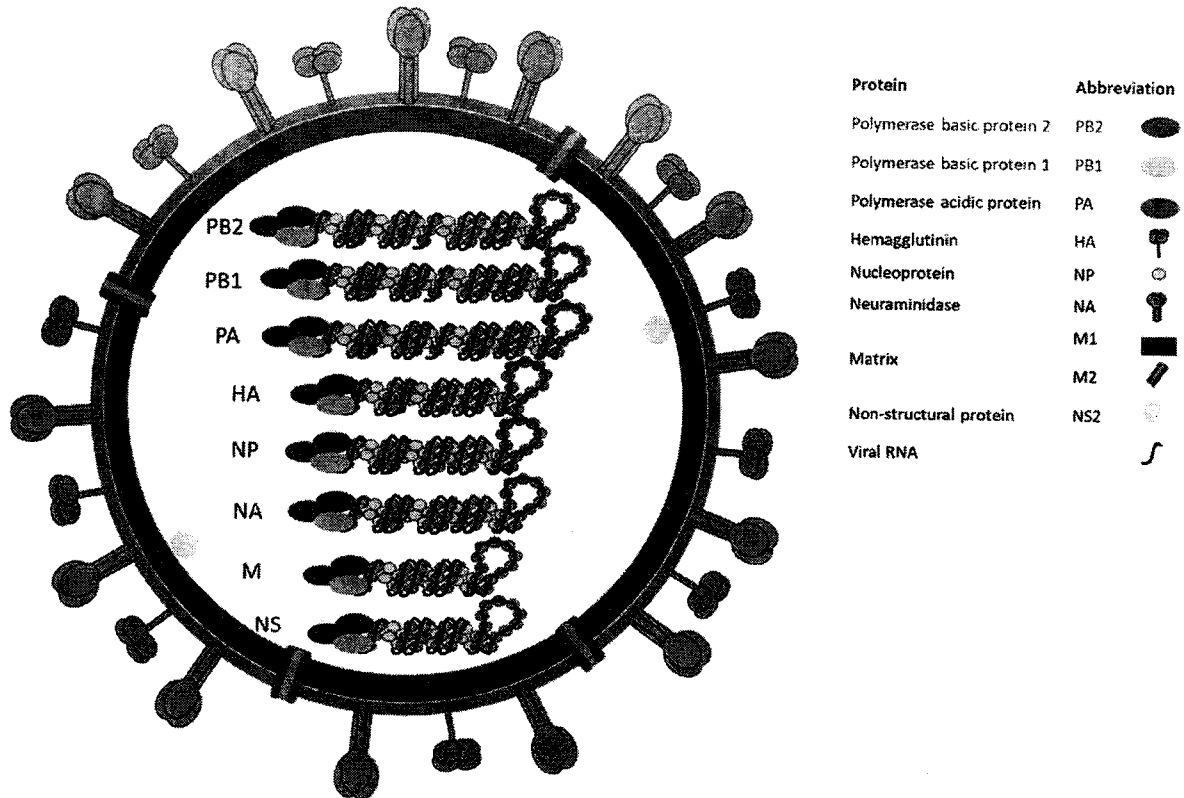


Fig. 1.1

(i) Explain the functions of haemagglutinin and neuraminidase in an enveloped virus, such as H5N1.

Haemagglutinin

.....
 [1]

Neuraminidase

.....
 [1]

- (ii) Other than components stated in Fig. 1.1, name two other components of the envelope of a virus, such as H5N1.

..... [1]

- (iii) The emergence of new strains of influenza continues to pose challenges to public health and the scientific communities.

Fig. 1.2 shows various ways that new strains of influenza, such as H5N1, may arise.

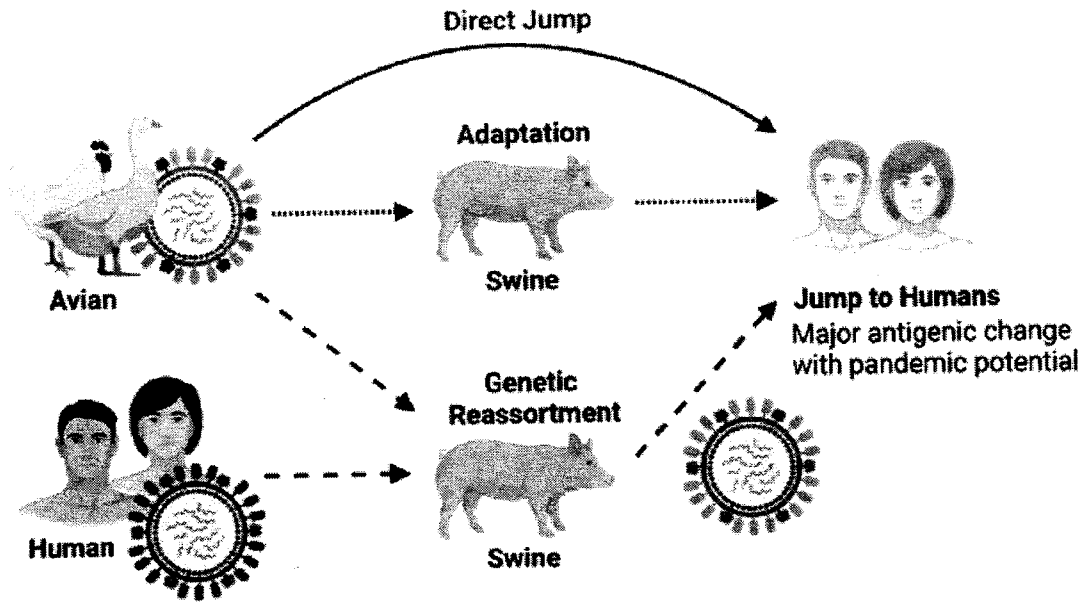


Fig. 1.2

Outline how a new strain may arise due to genetic reassortment.

.....

 [3]

- (iv) Suggest how adaptation of influenza virus in swine, as seen in Fig. 1.2, may have occur.

.....

 [2]

(v) An individual's immune responses can change throughout their lifetime.

Fig. 1.3 shows one person's immune response to the influenza virus when they were first infected and when they were infected two years later by a new, mutated strain of the virus.

The influenza virus has many antigens to which the immune system can respond. Fig. 1.3 shows the response to four of these antigens (A–D).

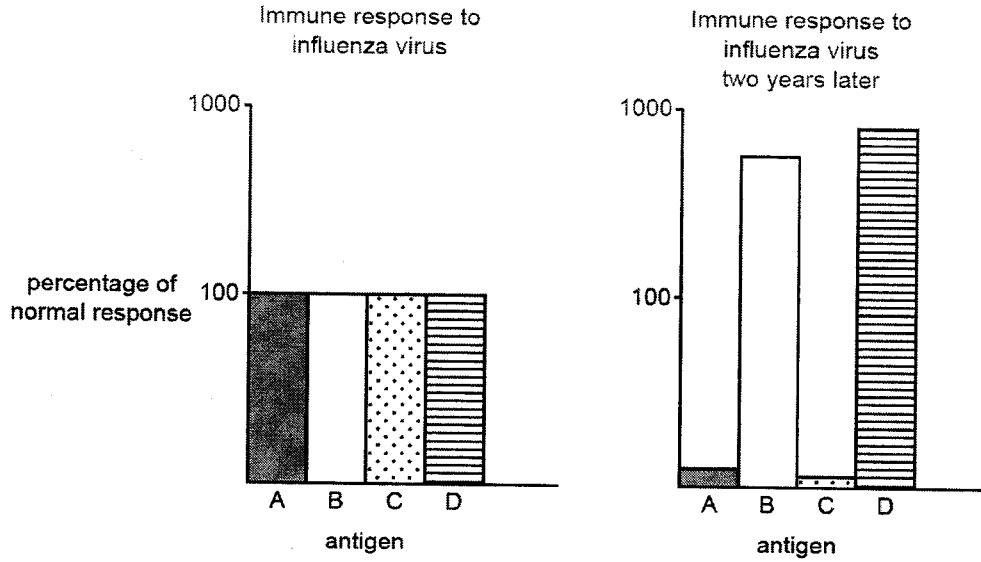


Fig. 1.3

Explain the differences in the person's initial immune response to the influenza virus with their immune response two years later.

.....

.....

.....

.....

[2]

(b) Tuberculosis (TB) is another respiratory infectious disease that affects humans.

The vaccine used to control TB is known as Bacillus Calmette-Guérin (BCG). The vaccine contains live bacteria that have been selected so that they do not cause disease in humans.

Fig. 1.4 shows a macrophage that is in the process of engulfing the bacteria in the vaccine.

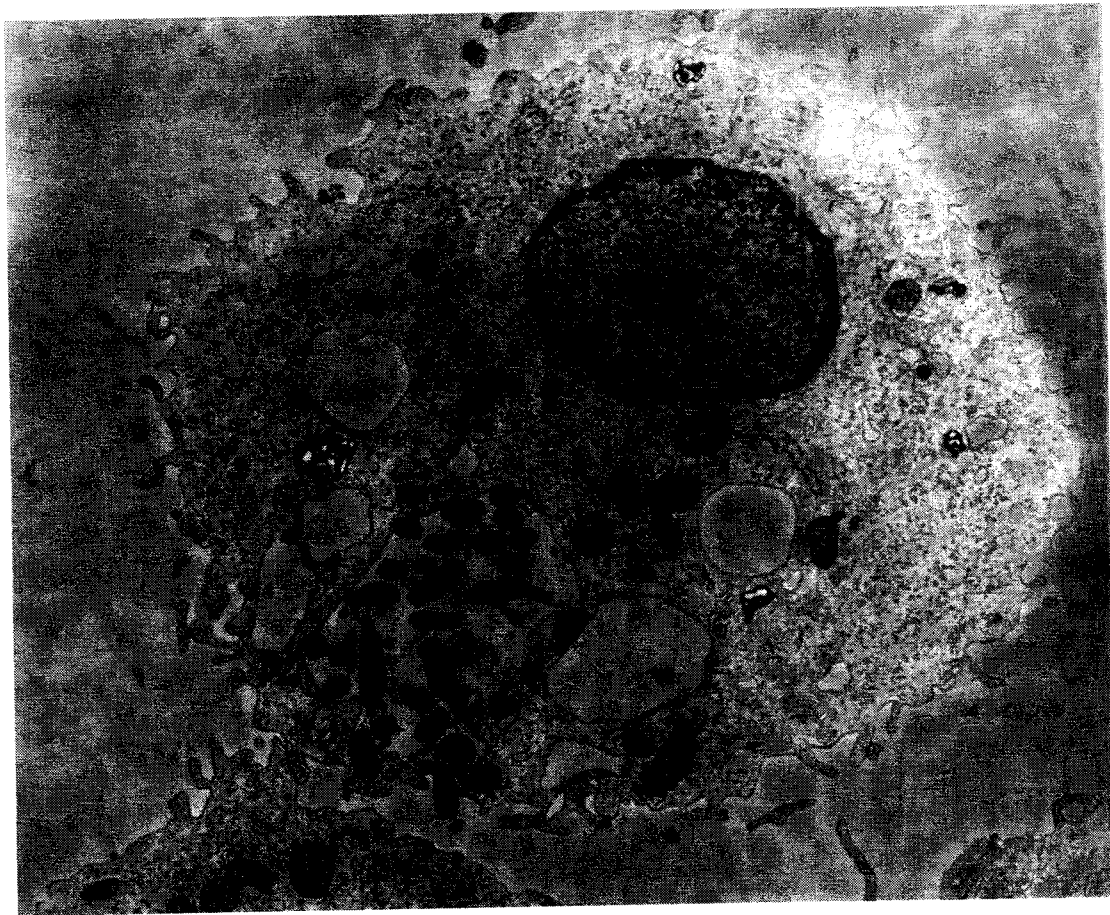


Fig. 1.4

(i) Name the pathogen that causes TB.

..... [1]

(ii) Describe how this pathogen is transmitted.

.....
.....
.....
..... [2]

- (v) Rifampicin binds tightly to an RNA polymerase molecule close to its active site. This affects the activity of the enzyme.

During the formation of RNA, a number of events occur that involve the action of RNA polymerase.

Suggest two ways in which rifampicin can affect the activity of RNA polymerase.

.....

.....

.....

..... [2]

- (vi) Countries are classified by the World Bank into one of four income groups.

Table 1.2 shows the estimated incidence of TB for 2012 to 2016 for these income groups.

The incidence represents the number of new cases of TB occurring per 100 000 people in one year. The new cases include the number of cases that have occurred again after a period of recovery (relapse TB).

Table 1.2

year income group	incidence per 100 000 people				
	2012	2013	2014	2015	2016
low	253	244	238	231	224
lower middle	244	240	236	232	227
upper middle	84	81	78	76	74
high	14	13	13	12	12

Describe the patterns and trends shown in Table 1.2.

.....

.....

.....

..... [2]

- (vii) In general, the countries that do not have a BCG vaccination programme are high-income countries that have a low number of cases of TB. In most of these countries, the vaccine is given only to babies and children at high risk of developing TB.

Suggest **one** reason why a child in a country with a low number of cases of the disease could be at a high risk of developing TB.

.....
 [1]

- (c) Sucrose phosphorylase is an enzyme found in some species of bacteria, including bacteria causing TB. One function of this enzyme is for the production of compounds that help to protect the cell from harmful osmotic changes in the external environment.

- (i) Fig. 1.5 shows the reversible reaction that takes place within the bacterial cell.

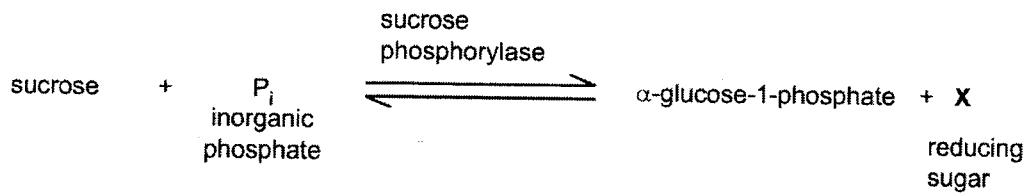


Fig. 1.5

Name reducing sugar **X** in Fig. 1.5.

..... [1]

- (ii) In the absence of sucrose phosphorylase as a catalyst, the reaction shown in Fig. 1.5 would take too long to occur to allow the bacterial cell to function efficiently.

Explain why the reaction shown in Fig. 1.5 proceeds at a much faster rate in the presence of the enzyme.

.....
 [1]

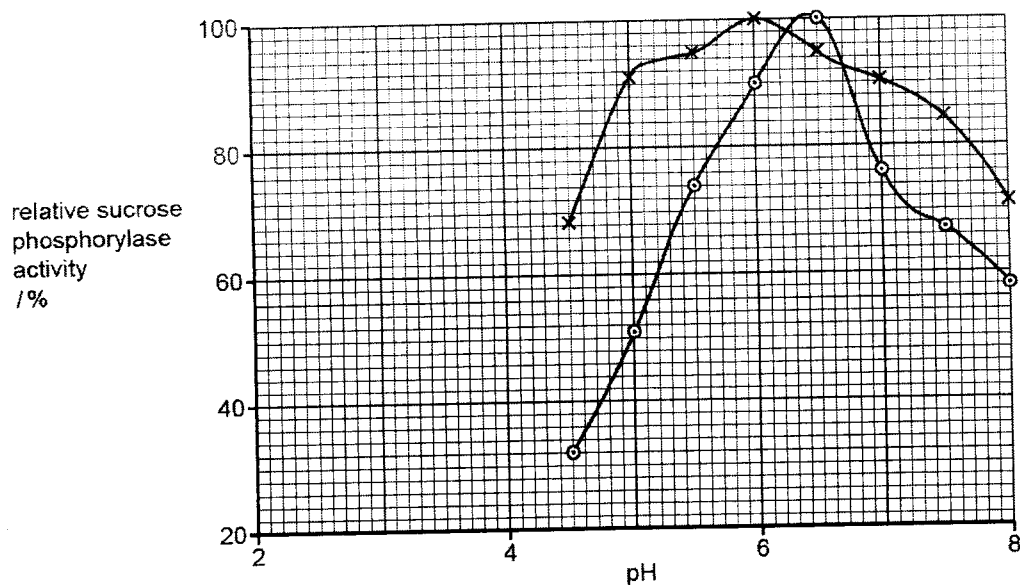
- (iii) An enzyme that catalyses a reaction of commercial interest needs to be investigated to see if it is suitable for use in industry.

For example:

- immobilised enzymes may be used as they have a longer shelf-life than the enzyme free in solution
- many industrial reactions are carried out at higher temperatures to minimize contamination of products by microorganisms.

Fig. 1.6 shows the results of an investigation to compare the activity of sucrose phosphorylase free in solution (free enzyme) with immobilised sucrose phosphorylase (immobilised enzyme) at different pHs.

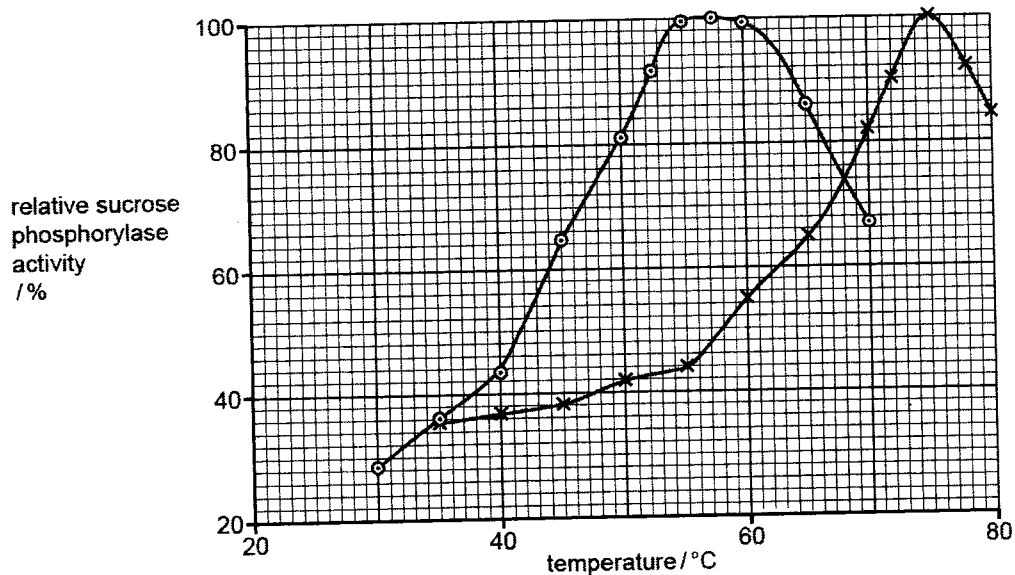
Fig. 1.7 shows the activity of the free enzyme and immobilised enzyme at different temperatures.



Key

- free enzyme
- × immobilised enzyme

Fig. 1.6



Key

- free enzyme
- × immobilised enzyme

Fig. 1.7

With reference to the results shown in Fig. 1.6 and Fig. 1.7, discuss why **immobilised** sucrose phosphorylase enzyme could be better for use in industrial reactions.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 30]

- 2 Researchers investigated the extent to which the founder effect and natural selection affected evolutionary change.

Fig. 2.1 shows the brown anole lizard, *Anolis sagrei*. These lizards live on a number of Caribbean islands and feed on a variety of invertebrates and other small animals.



Fig. 2.1

A. sagrei spends a lot of time perching (resting) on, or moving along, branches of shrubs and trees. The width of the branch that *A. sagrei* perches on is known as the perch diameter, as labelled in Fig. 2.1.

There is a positive correlation between perch diameter and hind limb length of *A. sagrei*.

- Longer hind limbs allow *A. sagrei* to run faster on vegetation with a larger diameter.
- Shorter hind limbs are needed to provide stability on vegetation of a smaller diameter.

In 2004, a hurricane caused the death of all the *A. sagrei* lizards on seven islands.

In 2005, the researchers randomly collected seven male and seven female lizards from a source population on a nearby island. For each of the seven islands affected by the hurricane, a male and female lizard were mated and placed on each island. These islands formed the experimental founder islands where new populations of *A. sagrei* were successfully established from each founding pair.

Fig. 2.2 shows the difference in vegetation between the source island and the seven experimental founder islands.

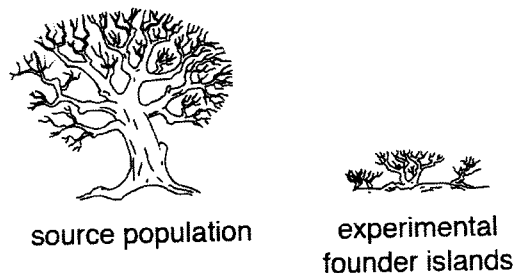


Fig. 2.2

(a) (i) Predict the effect of natural selection on mean hind limb length of *A. sagrei* on the seven experimental founder islands.

.....
 [1]

(ii) Predict how collecting individuals at random for the seven founding pairs affects the mean hind limb length of *A. sagrei* on the different islands.

.....
 [1]

(b) Many generations of *A. sagrei* were produced over the four years after the introduction of the founding pairs.

Fig. 2.3 shows how the mean hind limb length of *A. sagrei* changed on the seven experimental islands and on the source island.

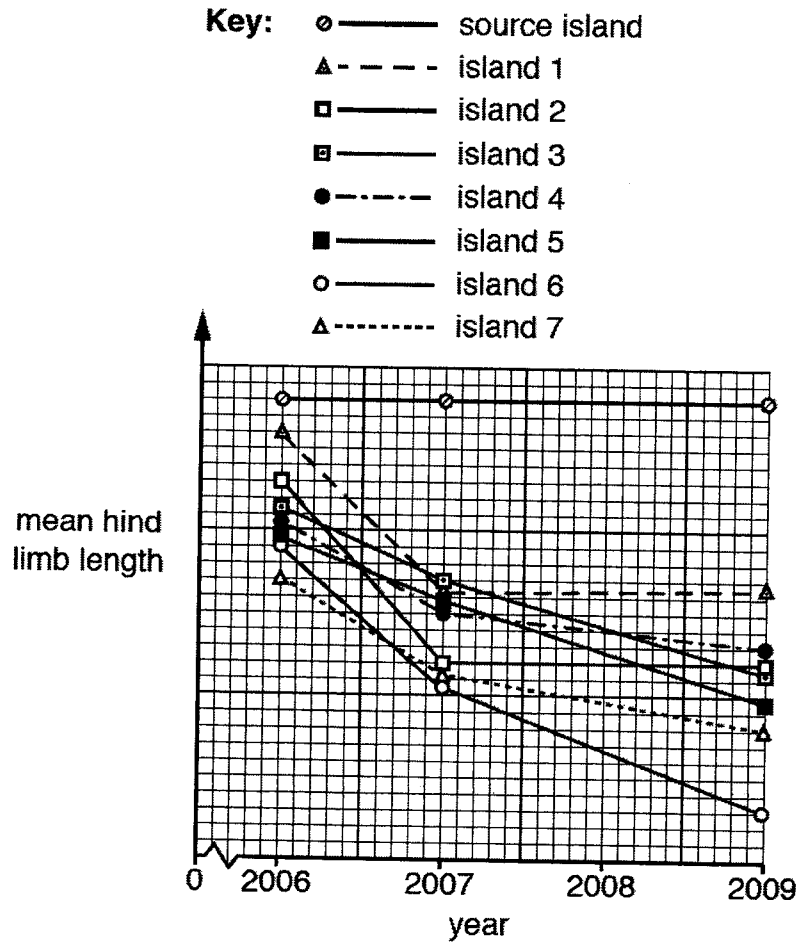


Fig. 2.3

3 (a) Fig. 3.1 shows the structure of a prokaryotic cell.

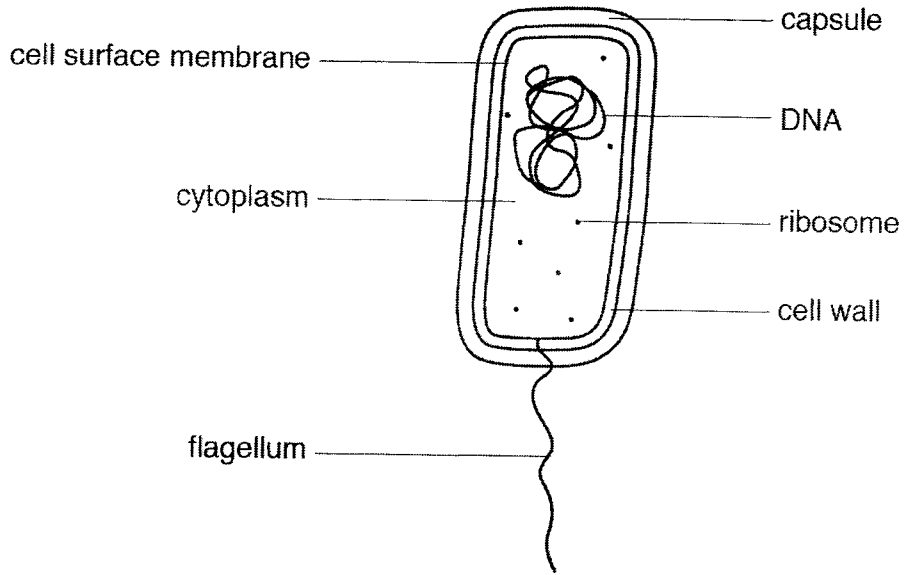


Fig. 3.1

Fig. 3.1 has not been fully labelled to confirm that the cell is prokaryotic.

State what other information could be added to two of the labels to confirm that this cell is prokaryotic and not eukaryotic.

.....

.....

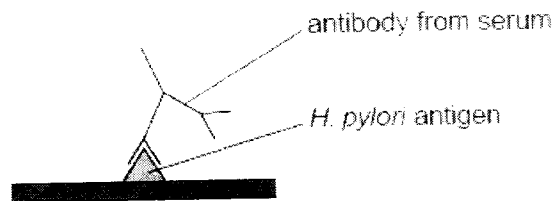
..... [1]

- (b) The bacterium *Helicobacter pylori* has been associated with diseases such as gastric ulcers and stomach cancer.

An infection with *H. pylori* can be diagnosed by testing for the antibodies produced in response to *H. pylori* antigens, as shown in Fig. 3.2.

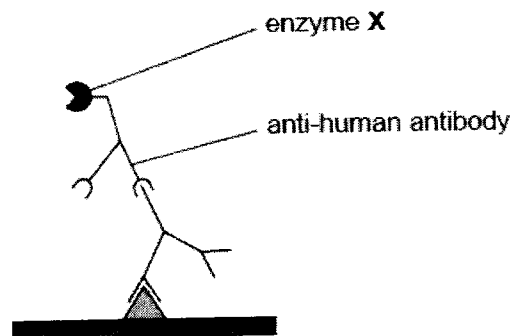
step 1

add blood serum samples to antigens of *H. pylori* attached to wells in a testing plate



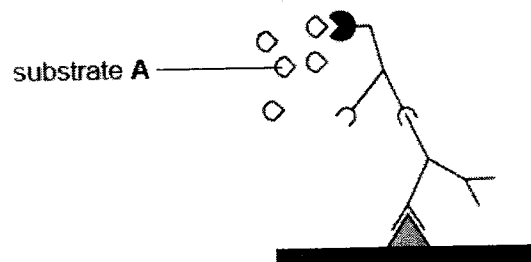
step 2

rinse the testing plate and add anti-human (secondary) antibody linked to enzyme X



step 3

rinse the testing plate and add substrate A, which is converted to a coloured product by enzyme X



step 4

reaction stopped and colour noted

Fig. 3.2

With reference to Fig. 3.2, explain the importance of the following in this test:

(i) the *H. pylori* antigen.

.....
..... [1]

(ii) the use of enzyme X

.....
..... [1]

(c) Amoxicillin is an antibiotic that is commonly used to treat *H. pylori*, it is similar to penicillin.

Suggest the mode of action of amoxicillin.

.....
.....
.....
..... [2]

(d) In some people, *H. pylori* infection can be difficult to treat because, over time, new strains of bacteria arise that have resistance to commonly used antibiotics. The resistance to antibiotics has been found to spread without the need of a vector or bacterium.

Explain how resistance to antibiotics is spread in a population of *H. pylori*.

.....
.....
.....
.....
.....
..... [3]

(e) *H. pylori* has an operon that is involved in synthesis of an amino acid, X. Fig 3.3 shows the operon and how it is being regulated.

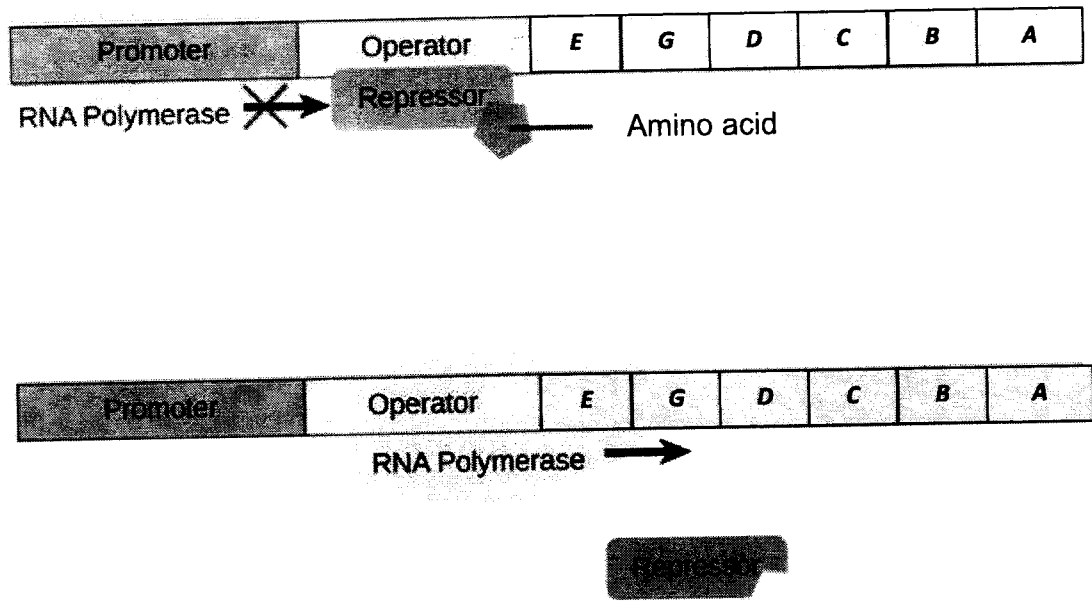


Fig. 3.3

(i) identify the type of operon.

..... [1]

(ii) predict the effect of an insertional mutation in the regulatory gene that codes for the repressor.

.....
..... [1]

[Total: 10]

Section B

Answer **one** question in this section.

Write your answers in the **12-page Answer Booklet** provided.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in section **(a)** and **(b)**, as indicated in the question.

- 4 (a)** Molecular biology techniques are common methods used in molecular biology, biochemistry, and genetics which generally involve manipulation and analysis of DNA.

Outline the principles of techniques used to analyse DNA. [10]

- (b)** Cycles play important roles in both natural and man-made biological processes.

Write an essay about cycles in biology. [15]

- 5 (a)** Explain how anatomical and molecular homology support Darwin's theory of evolution on descent with modification. [10]

- (b)** Explain the significance of different biomolecular composition in membranes of different cells and different organelles. [15]

BLANK PAGE