JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME

CLASS

BIOLOGY 9744/01

Paper 1 Multiple Choice **14 September 2018**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
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This document consists of **22** printed pages.

1 A severe inherited condition arises from the failure to produce an enzyme that breaks down glycoproteins in cells. The condition can be diagnosed from an electron micrograph of a patient's cells.

Which abnormality would be observed in these cells?

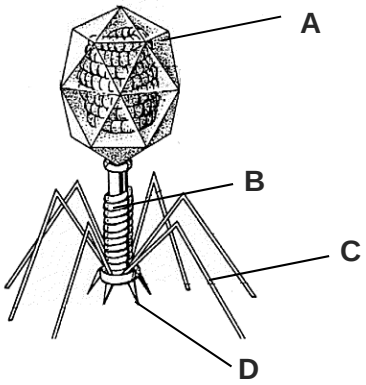
A an incomplete chromosome due to lack of a gene

B larger lysosomes due to accumulation of glycoprotein

C less endoplasmic reticulum due to a reduction in protein synthesis

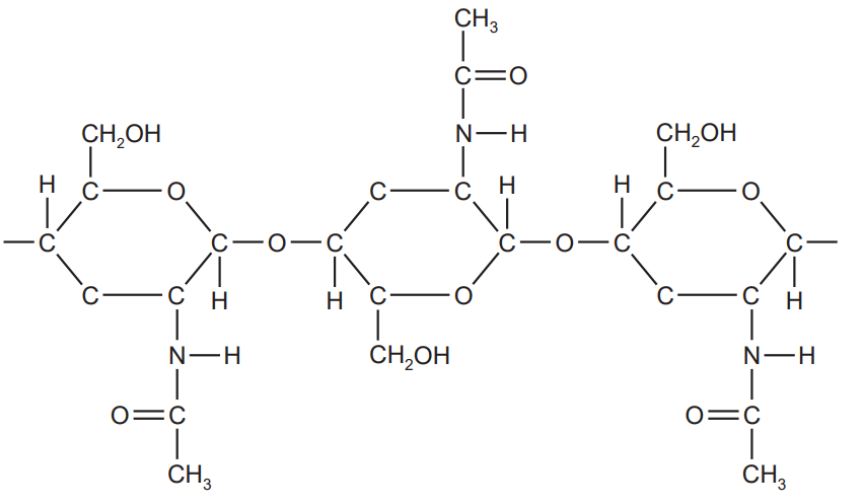
D thinner cell surface membrane due to lack of glycoprotein

2 The diagram shows a bacteriophage.



Which structure plays the most important role in host recognition?

3 The diagram shows the structure of the polysaccharide chitin which is found in the cell wall of fungi.



Which statements are correct for chitin and for cellulose?

1 The monomers are joined by 1, 4 glycosidic bonds.

2 Every second monosaccharide in the polysaccharide chain is rotated by 180°.

3 The polysaccharide contains the elements carbon, hydrogen, oxygen and nitrogen.

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 only

4 The cells in the roots of beetroot plants contain a red pigment.

When pieces of root tissue are soaked in cold water, some of the red pigment leaks out of the cells into the water.

An experiment was carried out to investigate the effect of temperature on the loss of red pigment from the root cells. It was found that the higher the temperature of the water, the higher the rate of loss of red pigment from the root cells.

Which of these statements could explain this trend?

1 Enzymes in the cells denature as the temperature increases, so the pigment can no longer be used for reactions inside the cells and diffuses out.

2 As the temperature increases, the tertiary structure of protein molecules in the cell surface membrane changes, increasing the permeability of the membrane.

3 Phospholipid molecules gain kinetic energy as temperature rises, increasing the fluidity of the phospholipid bilayer and allowing pigment molecules to diffuse out more easily.

A 1 and 2

B 2 and 3

C 2 only

D 3 only

5 The R group of the amino acid serine is $-CH_2-OH$. The R group of the amino acid alanine is $-CH_3$. Where would you expect to find these amino acids in a globular protein soluble in aqueous solution?

A Serine would be in the interior, and alanine would be on the exterior of the globular protein.

B Alanine would be in the interior, and serine would be on the exterior of the globular protein.

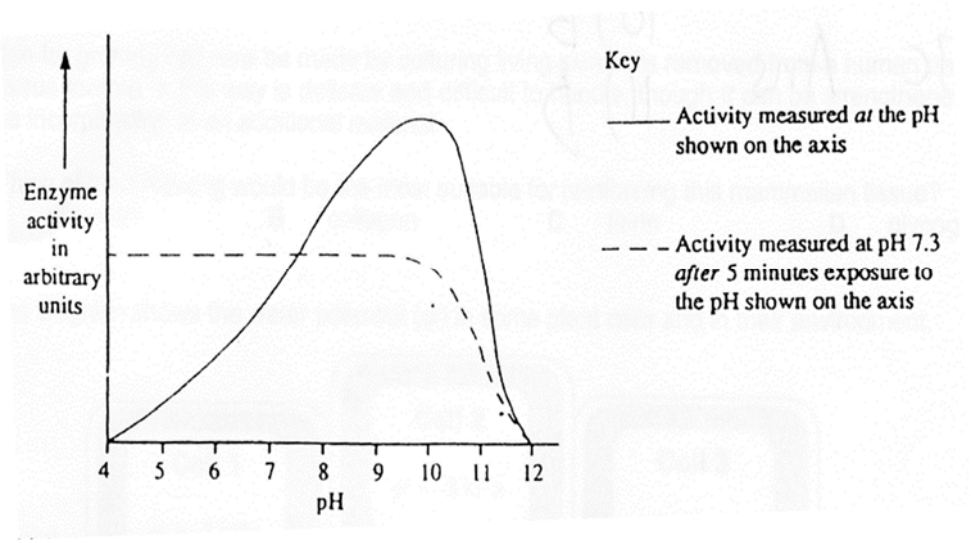
C Both serine and alanine would be in the interior of the globular protein.

D Both serine and alanine would be in the interior and on the exterior of the globular protein.

6 Which row correctly describes the structure of collagen?

A	covalent bonds hold the polypeptides within the triple helices together	about one third of the amino acids in a molecule are glycine	collagen does not have a quaternary structure
B	each of the three polypeptide strands forms a right-handed helix	there is a high proportion of the amino acids proline and glycine	the triple helices are insoluble in water
C	the polypeptides in a triple helix are held together by hydrogen bonds	the triple helices are cross bonded to one another by hydrogen bonds	the glycine side chains are always on the outside of the helix
D	three polypeptide helices are twisted together into a right-handed triple helix	triple helices cross bond to one another with staggered ends	every third amino acid in a polypeptide is usually glycine

7 The graph shows the effects of pH on the activity of the enzyme monoamine oxidase, as measured by two different methods.



Which hypothesis is not supported by these results?

A Both acid and strong alkali denature the enzyme.

B The optimum pH is alkaline.

C Strong alkali causes a reversible change in the tertiary structure of the enzyme.

D The change in the catalytic properties of the enzyme caused by acid is reversible.

8 Following a heart attack, the enzyme lactate dehydrogenase leaks into the blood plasma from damaged heart muscle.

Which steps are required to obtain the best estimate of lactate dehydrogenase activity in a sample of blood plasma?

	sterilise blood plasma by heating	incubate with substrate for lactate dehydrogenase	incubate with lactate dehydrogenase inhibitor
A	×	✓	×
B	✓	×	✓
C	×	✓	✓
D	✓	✓	✓

key

✓ = step required

× = step not required

9 Stem cells are found in many tissues that require frequent cell replacement such as the skin, the intestine or the blood.

However, within their own environments, a bone marrow cell cannot be induced to produce a skin cell and a skin cell cannot be induced to produce a bone marrow cell.

Which statement explains this?

A Different stem cells have only the genes required for their particular cell line.

B Genes not required for a particular cell line are methylated.

C Genes not required for a particular cell line are removed using restriction enzymes.

D mRNA that is not required for a particular cell line is destroyed.

10 Which statements concerning DNA and RNA are correct?

1 Adenine and guanine are bases that have a double ring structure; cytosine, thymine and uracil are bases with a single ring structure.

2 An adenine nucleotide from DNA is the same as an adenine nucleotide from RNA; DNA adenine pairs with thymine and RNA adenine pairs with uracil.

3 The base pairing that occurs in a double DNA helix and when RNA is synthesised during transcription is always according to the rule that a purine pairs with a pyrimidine.

4 The two polynucleotides on a DNA molecule run in opposite directions so that the double helix formed has two strands that are parallel to each other.

A 1, 2 and 3

B 1, 2 and 4

C 1, 3 and 4

D 2, 3 and 4

11 The table compares the structure and function of some elements involved in transcription.

	made of protein	interacts with protein	codes for protein
RNA polymerase	1	2	3
promoter	4	5	6
terminator	7	8	9
gene	10	11	12

Which combination of numbers link the four elements listed to their structures and functions?

A 1, 5, 6, 9 and 12

B 1, 5, 8, 11 and 12

C 2, 6, 7, 8 and 11

D 3, 4, 8, 10 and 12

12 Which statements about bacterial genetic transfer are incorrect?

1 In transformation, bacterial cells which possess competence factors can take up only plasmids from the surroundings.

2 Homologous recombination is always involved in bacterial genetic transfer.

3 After conjugation, the donor and recipient cells always contain the same genetic information.

4 Binary fission will not contribute to genetic variation in bacterial chromosomes.

A 1, 2 and 3

B 1, 2 and 4

C 1 and 3 only

D 2 and 3 only

13 In which process do nucleosomes play a role in eukaryotes?

1 tRNA activation

2 transcription regulation

3 DNA supercoiling

A 1, 2 and 3

B 2 and 3 only

C 2 only

D 3 only

14 A mutation occurred in an *Escherichia coli* cell. Given that glucose and lactose are both absent from the growth medium, and the structural genes of the *lac* operon are expressed efficiently, where could the mutation have taken place in the *E. coli* cell?

1 in the operator of the *lac* operon

2 in the *lacI* regulatory gene

3 in the promoter of the *lac* structural genes

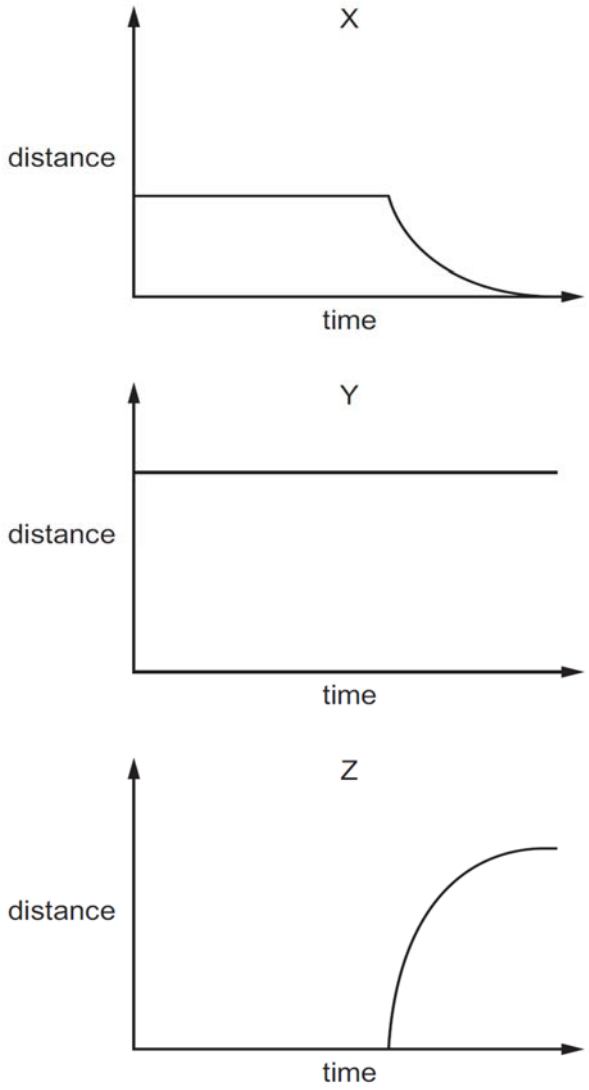
A 1, 2 and 3

B 1 and 2 only

C 2 and 3 only

D 1 only

15 The graphs show various distance measurements taken from metaphase of mitosis onwards. The graphs are to scale when compared to one another.



Which row correctly identifies the distance measurement for each graph?

	X	Y	Z
A	distance between poles of spindle	distance between sister chromatids	distance of centromeres from poles of spindle
B	distance between poles of spindle	distance of centromeres from poles of spindle	distance between sister chromatids
C	distance of centromeres from poles of spindle	distance between poles of spindle	distance between sister chromatids
D	distance of centromeres from poles of spindle	distance between sister chromatids	distance between poles of spindle

16 Which feature of the life cycle of some viruses may result in the development of cancer?

A Viral RNA can integrate into the chromosomes of host cells.

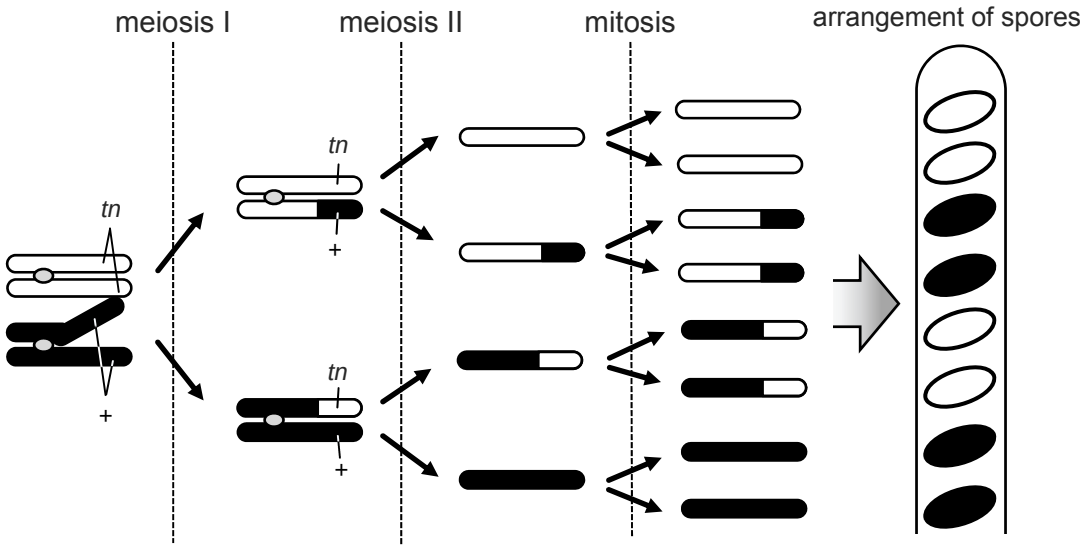
B Viruses can cause cell lysis and spread to other host cells.

C Viruses can cause loss of function mutations in proto-oncogenes.

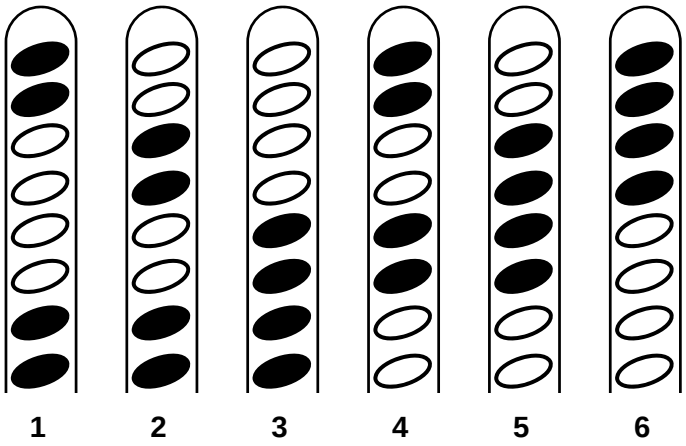
D Viruses can increase the rate of the cell cycle of host cells.

17 Two strains of a certain mould, one that produced black spores (+) and the other that produced white spores (*tn*) were crossed.

After fertilisation, the resulting hybrid mould formed four spores by meiosis. Each of these spores then divided once by mitosis so that eight spores were formed in a row. The relative arrangements of the black and white spores made it possible to identify the positions of the planes of the first and second meiotic divisions.



Random examination of the rows of spores formed revealed six possible patterns as shown below.



In which two of these did crossing over not occur?

A 1 and 4

B 2 and 4

C 3 and 5

D 3 and 6

18 In a monohybrid, sex-linked genetic cross involving dominant and recessive alleles, different phenotypes are observed.

Which statement correctly explains these different phenotypes?

A Expression of the recessive allele only occurs in males, because the Y chromosome lacks the relevant gene.

B The nucleotide sequences of the two alleles each produces a different mRNA molecule, only one of which is translated into a functional protein.

C The recessive allele present in the male is unlikely to be transcribed and translated, as the male does not have a corresponding nucleotide sequence on the shorter Y chromosome.

D Transcription of alleles at different loci leads to transcription and translation of active and inactive enzymes.

19 The genetic determination of dogs' coats can be quite complex, with many different genes acting at the same time.

- The dominant allele E gives brown tones. The recessive allele e results in red tones.
- The colour intensity is due to another gene. The dominant allele B gives a dark colour, whereas the recessive allele b results in a light colour.

What would be the genotype of a light brown dog produced from a cross between a dark brown dog and a light red dog?

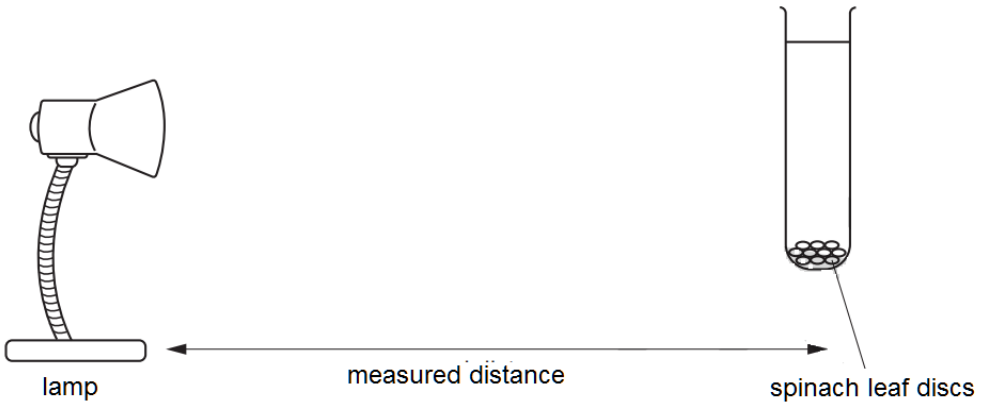
A EEbb

B EeBb

C eeBb

D Eebb

20 A student carried out an investigation into the effect of light intensity on photosynthesis. Several groups of spinach leaf discs were placed in test tubes of water. The discs all sank to the bottoms of the tubes. Each tube was placed at a measured distance from a lamp.



As photosynthesis occurs, the build-up of oxygen gas in the leaf discs causes them to rise from the bottom of the tube upwards. The results are shown in the table below.

tube number	distance from lamp / mm	time taken for five discs to float / s
1	50	125
2	100	210
3	150	360
4	200	600
5	250	none floated in the time available

Which of these statements are true?

1 The compensation point occurs between 200 and 250 mm.

2 A variable which is controlled is the distance of the tube from the light source.

3 The time taken for the discs to rise is directly proportional to the distance from the lamp.

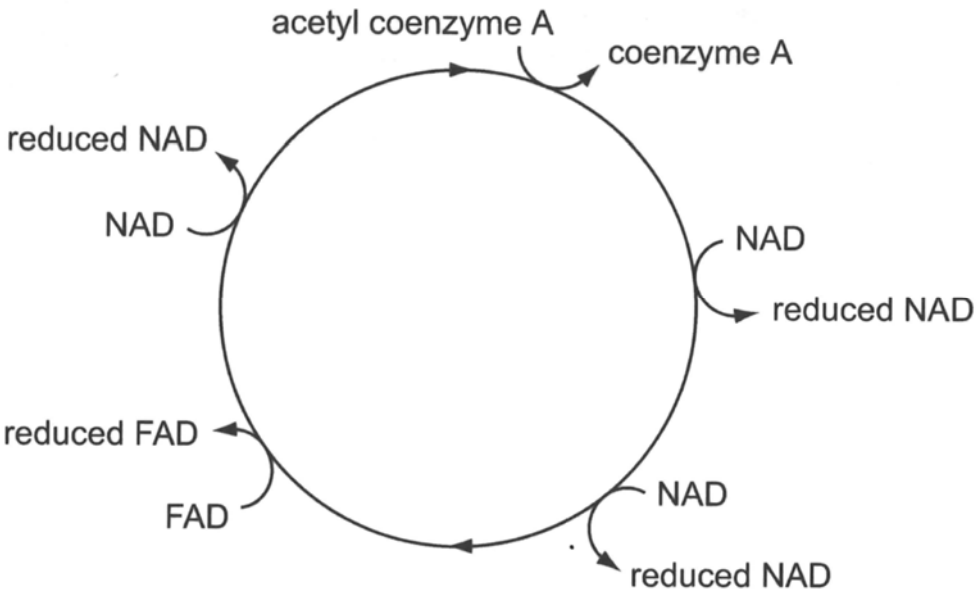
A 1, 2 and 3

B 1 and 3 only

C 1 only

D 2 and 3 only

21 The diagram shows the reactions of the hydrogen carriers in the Krebs cycle.



The average yield of ATP, in oxidative phosphorylation, is 2.5 molecules from each molecule of reduced NAD and 1.5 molecules from each molecule of reduced FAD.

What is the average yield of ATP from the hydrogen carriers reduced in the Krebs cycle from one molecule of glucose?

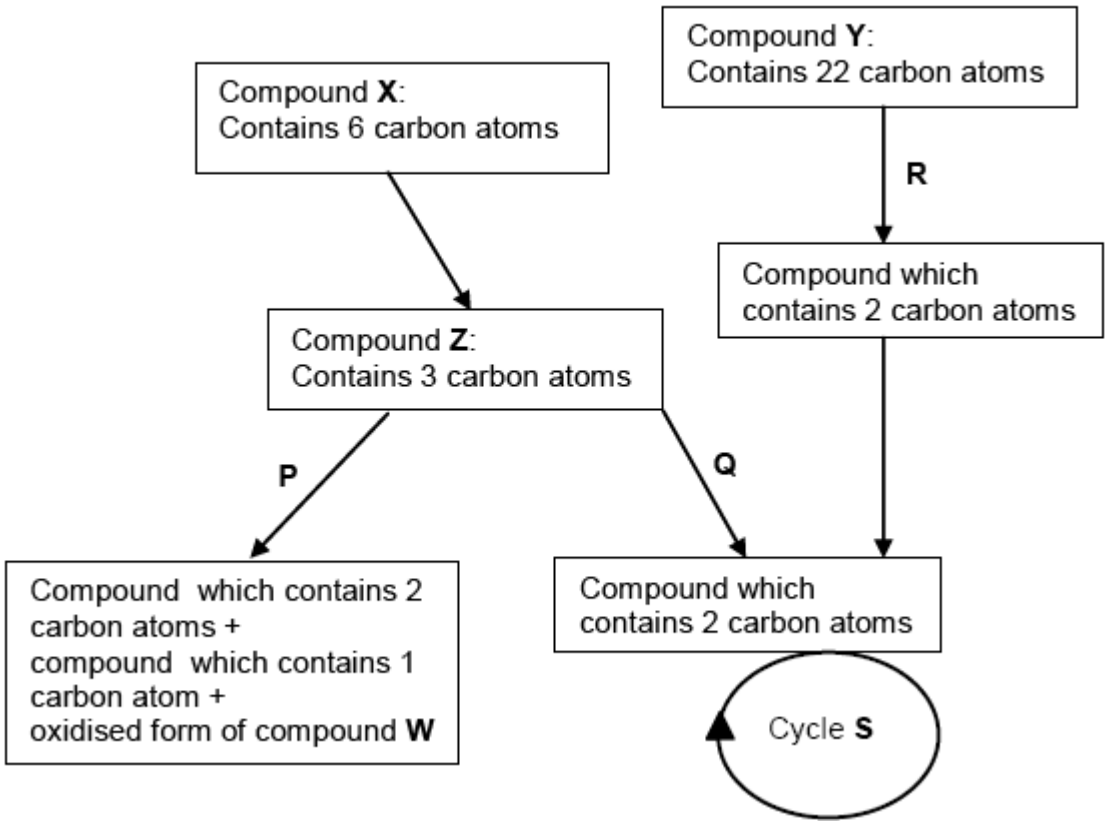
A 9

B 18

C 28

D 32

22 The diagram shows the flow of carbon atoms in cellular respiration in a plant cell, where processes **P**, **Q** and **R** are key stages.



Which statements are correct?

1 Process P involves the formation of lactic acid and regeneration of the oxidised form of compound W.

2 Compound Y is starch which hydrolyses into acetyl-CoA.

3 In process Q, compound Z undergoes oxidative decarboxylation.

4 Cycle S produces large amounts of reduced coenzymes for oxidative phosphorylation.

5 One molecule of compound X yields 36-38 ATP molecules when completely oxidised.

A 1, 2 and 4

B 1 and 3

C 2 and 5

D 3, 4 and 5

23 What is the correct sequence of events in a cell in response to insulin?

A Hormone binding to receptor → dimerisation of polypeptides → cross phosphorylation → activation of insulin response protein → activation of glycogen phosphorylase

B Hormone binding to receptor → dimerisation of polypeptides → cross phosphorylation → activation of insulin response protein → activation of glycogen synthase

C Hormone binding to receptor → cross phosphorylation → dimerisation of polypeptides → activation of protein kinases → activation of glycogen phosphorylase

D Hormone binding to receptor → cross phosphorylation → dimerisation of polypeptides → activation of insulin response protein → activation of glycogen synthase

24 Animals with horizontal stripes are bitten less frequently by tsetse flies. The flies carry diseases that infect zebras.

Which explains how zebras might evolve to have more horizontal stripes?

A Bites from tsetse flies cause mutations. If a zebra has a mutation it will die and not pass its genes to its offspring which will not have more horizontal stripes.

B If two zebras with horizontal stripes mate, their offspring will have more horizontal stripes. Horizontal stripes will become dominant. This is natural selection.

C Tsetse flies are a selection pressure. The zebras would gradually develop more horizontal stripes and pass them on to their offspring so they are not bitten by flies.

D Zebras with more horizontal stripes get fewer diseases from tsetse flies. These zebras live longer and breed more, passing the allele for more horizontal stripes to their offspring.

25 Two areas of molecular biology that have received considerable attention in evolutionary studies are the genetic code and cytochrome *c*. Cytochrome *c* is an essential component of all respiratory electron transport chains.

Which statements lend evidence to the ideas that

- all living organisms are related
- there is a single, rather than a multiple, origin of life?

1 The almost universal nature of the genetic code is a result of evolutionary convergence from multiple lineages.

2 The sequence of the amino acids in cytochrome *c* is similar in organisms that are from similar environments or with similar metabolic demands.

3 The majority of organisms have the same, or similar, amino acid sequences for cytochrome *c*.

4 When transferred into a very dissimilar organism, a gene coding for cytochrome *c* will lead to the expression of a protein that will function in the other organism.

A 1 and 2

B 1, 3 and 4

C 2 and 3

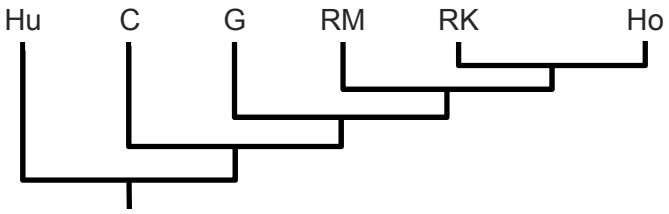
D 3 and 4

26 The table below shows the amino acid sequence of part of the β-haemoglobin molecule found in six different vertebrates. The β-globin chain has a total of 146 amino acids. Only the amino acids found in positions 101 to 116 are represented.

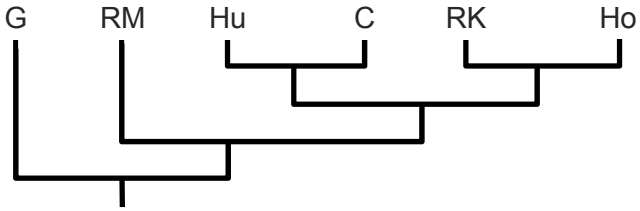
vertebrate	amino acid position															
	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
human (Hu)	glu	asn	phe	arg	leu	leu	gly	asn	val	leu	val	cys	val	leu	ala	his
red kangaroo (RK)	glu	asn	phe	lys	leu	leu	gly	asn	ile	ile	val	Ile	cys	leu	ala	glu
rhesus monkey (RM)	glu	asn	phe	lys	leu	leu	gly	asn	val	leu	val	cys	val	leu	ala	his
gorilla (G)	glu	asn	phe	lys	leu	leu	gly	asn	val	leu	val	cys	val	leu	ala	his
chimpanzee (C)	glu	asn	phe	arg	leu	leu	gly	asn	val	leu	val	cys	val	leu	ala	his
horse (Ho)	glu	asn	phe	arg	leu	leu	gly	asn	val	leu	ala	leu	val	val	ala	arg

Using the information above, a suitable phylogenetic diagram would be

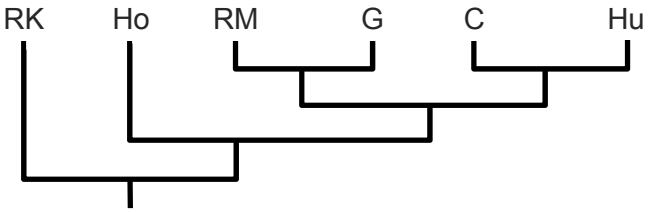
A



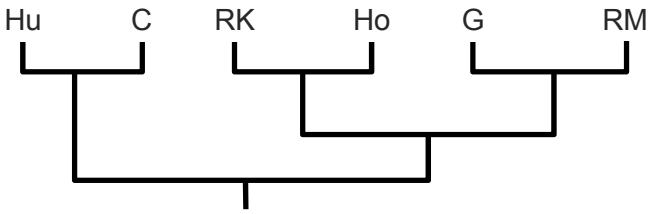
B



C



D



27 Which statement regarding a B cell expressing both IgM and IgD on its membrane is incorrect?

A The L chains of the IgM and IgD have identical amino acid sequences.

B The constant parts of the H chains of the IgM and IgD have different amino acid sequences.

C The IgM and IgD have different antigenic specificities.

D If it is triggered by antigen and T-cell signals to proliferate and differentiate, it may differentiate into a plasma cell that may secrete IgG, IgE, or IgA antibodies.

28 After contact with the polio virus a child developed polio and recovered. Twelve months later the child came in contact with the polio virus again but did not show any symptoms of the disease.

This happened because, shortly after the first infection, the child

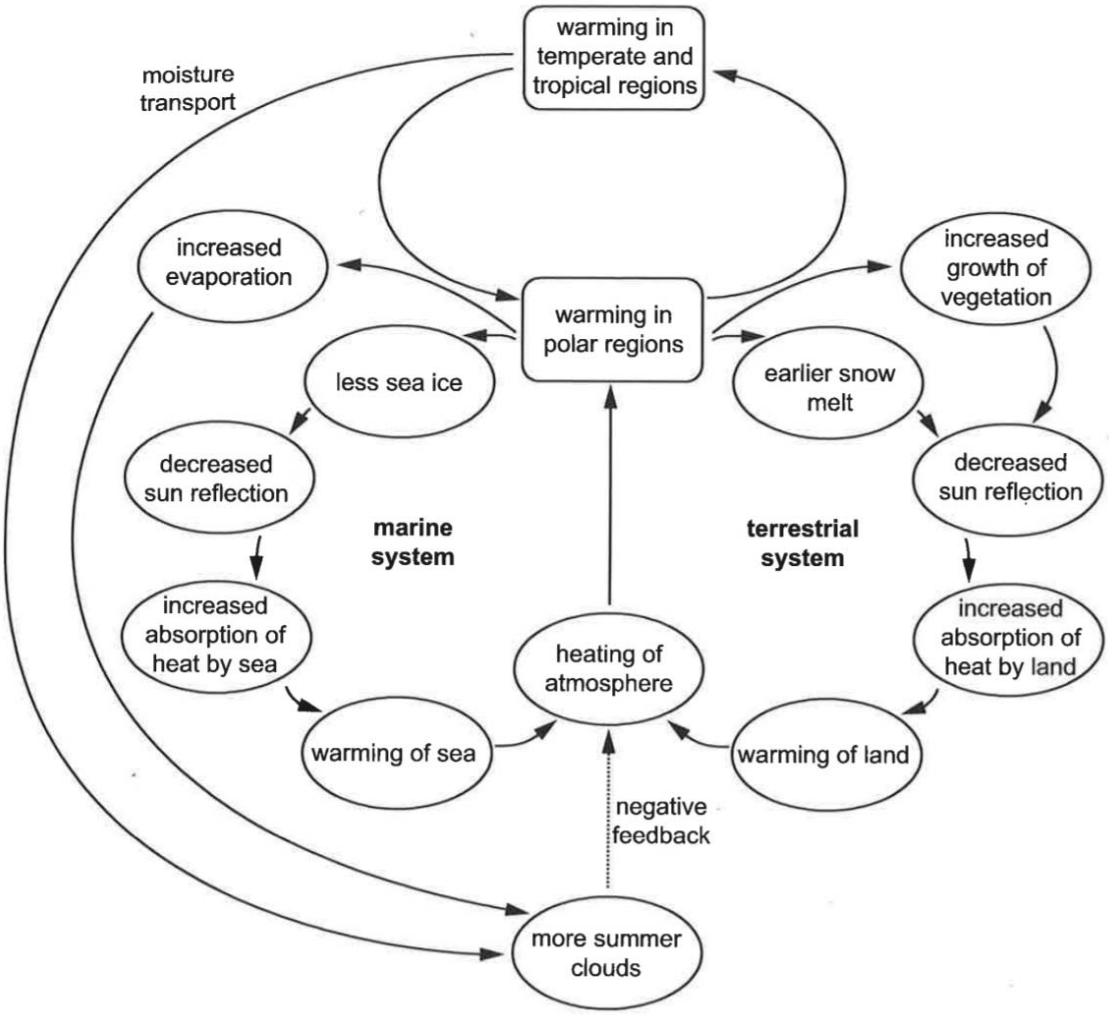
A had an injection of polio antibodies.

B grew B memory cells specific to polio.

C grew B memory cells that could respond to any virus.

D developed T cells that consumed the new polio particles.

29 The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.



Which effect of higher temperatures in the polar regions could increase global warming?

A Increased evaporation leads to more rainfall, which absorbs heat from the land and the sea.

B Melting of ice and snow results in less reflection of sunlight and more heat absorption by the Earth.

C Melting of sea ice caused more cloud formation, which increases absorption of heat in the atmosphere.

D Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.

30 Rice crops in Japan are damaged by the green rice leafhopper (*Nephotettix cincticeps*), a pest that reduces crop yield.

In a study of the effect of climate change on crop damage by the green rice leafhopper, it was found that an increase in winter temperatures caused an increase in crop damage, while an increase in summer temperatures caused a decrease in crop damage.

Which of the following are possible explanations for these findings?

1 Increased temperatures in the summer cause a rise in metabolic rate that results in the pests reproducing more rapidly.

2 Increased temperatures in the summer raise the metabolic rate above the range that the pests can tolerate.

3 Increased temperatures in the winter disrupt the pests' life cycle and result in fewer being able to reproduce.

4 Increased temperatures in the winter allow more pests to survive and results in an increase in the pest population.

A 1 and 3

B 1 and 4

C 2 and 3

D 2 and 4

JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME	**Answers**
CLASS	

BIOLOGY

9744/01

Paper 1 Multiple Choice

14 September 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

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

This document consists of **22** printed pages and **2** blank pages.

Qn	Ans
1	B
2	C
3	B
4	B
5	B
6	D
7	C
8	A
9	B
10	C

Qn	Ans
11	B
12	A
13	B
14	B
15	C
16	D
17	D
18	B
19	D
20	C

Qn	Ans
21	B
22	D
23	B
24	D
25	D
26	C
27	C
28	B
29	B
30	D

JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME						
CLASS		INDEX NUMBER				

BIOLOGY 9744/02

Paper 2 Structured Questions **23 August 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name 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, glue or correction fluid.

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.

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	
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9	
10	
11	
Total	

This document consists of **27** printed pages and **1** blank page.

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

1 Fig. 1.1 shows an electron micrograph of mitochondria cross-sections.

Fig. 1.1

(a) With reference to Fig. 1.1, state one visible feature of the mitochondrion and explain how this feature is adapted for the mitochondrion's function. [3]

_____

_____

_____

_____

_____

_____

Fig. 1.2 shows the molecular structure of carbonyl cyanide-4-(trifluoromethoxy) phenylhydrazone (FCCP). FCCP is a respiratory poison that binds protons and transports them across the phospholipid bilayer of the inner mitochondrial membrane. Protons alone are unable to diffuse freely in this manner.

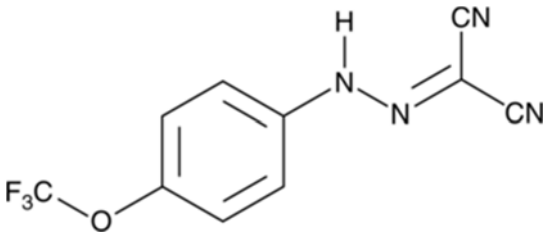

Fig. 1.2

(b) Explain, in relation to their properties, why FCCP readily diffuses across the phospholipid bilayer while protons do not. [2]

_____

_____

_____

_____

In the presence of FCCP, the rate of ATP synthesis during respiration is significantly diminished. The rate is further reduced if oxygen becomes unavailable. In such conditions where oxygen is depleted, cells continue to oxidise glucose to form pyruvate and sustain ATP synthesis.

(c) (i) Identify the key stages of aerobic respiration where the release of carbon dioxide occurs. [1]

_____

_____

(ii) State the location where the biochemical pathway enabling the continual oxidation of glucose to form pyruvate occurs. [1]

_____

(iii) Explain how ATP synthesis can be sustained in the absence of oxygen in yeast cells. [3]

_____

_____

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_____

[Total: 10]

2 Fig. 2.1 shows a triglyceride molecule.

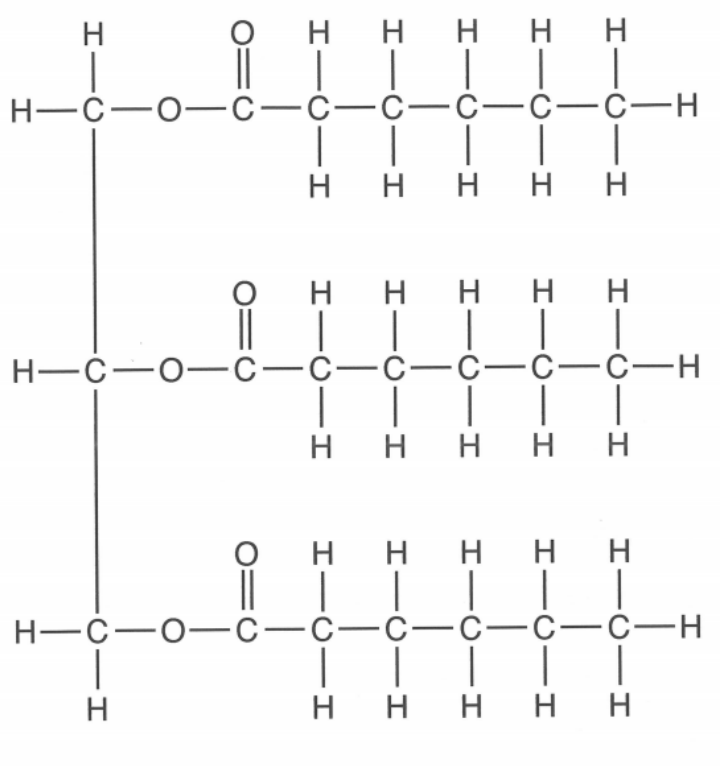

Fig. 2.1

(a) (i) State the names of the two types of molecules that undergo condensation reactions to form a triglyceride. [2]

_____

_____

(ii) Describe what is meant by a condensation reaction. [2]

_____

_____

_____

_____

(iii) The triglyceride in Fig. 2.1 is saturated.

Explain how the structure would be different for an unsaturated triglyceride. [3]

(b) The eukaryotic cell surface membrane contains phospholipids, cholesterol and proteins.

(i) Describe how a phospholipid molecule differs from a triglyceride molecule. [2]

(ii) Describe the roles of cholesterol in eukaryotic cell surface membranes. [2]

(c) The respiratory quotient, RQ, is used to show which substrate is being metabolised by cells. It can be determined using the equation below.

$$RQ = \frac{\text{molecules of carbon dioxide released}}{\text{molecules of oxygen taken in}}$$

Lauric acid is a saturated fatty acid found in coconuts and has a chain of 12 carbon atoms.

(i) Complete the equation below which outlines the aerobic respiration of lauric acid. [1]

$C_{12}H_{24}O_2$ + ……. O_2 ➔ $12CO_2 + 12H_2O$

(ii) Calculate the RQ value for lauric acid.

Give your answer to 2 decimal places.

RQ value = ……. [1]

[Total: 13]

3 Lysosomes are important membrane-bound organelles within animal cells.

They contain many different types of enzymes that hydrolyse lipids, nucleic acids, polysaccharides or proteins. When phagocytic vesicles containing these food substances fuse with lysosomes, the internal pH of lysosomes will be lowered to a range of pH 4.5 to pH 5.0 resulting in the activation of the lysosome enzymes.

(a) Describe how proteins are hydrolysed.

You may use annotated diagrams to illustrate your answer. [4]

(b) Explain how the lysosome enzymes can be activated by the change in pH. [3]

_____

_____

_____

_____

_____

_____

(c) Suggest why the lysosome membrane is not destroyed by the enzymes in the lysosome. [3]

_____

_____

_____

_____

_____

_____

[Total: 10]

4 Fig. 4.1 shows the elongation phase of translation.

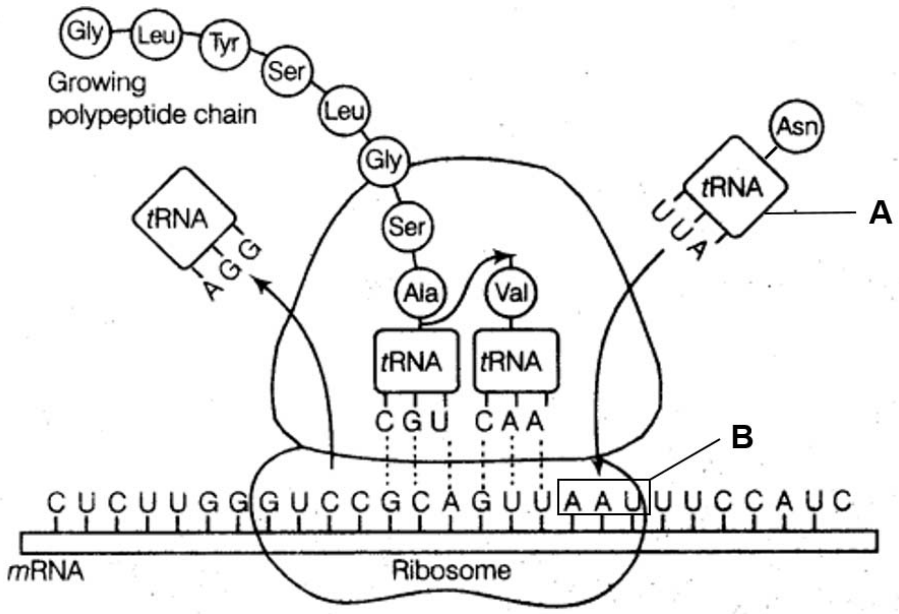

Fig. 4.1

(a) On Fig. 4.1, draw an arrow to show the direction of translocation of the ribosome. [1]

(b) Name the structures **A** and **B** in Fig. 4.1. [2]

A _____

B _____

(c) Explain how the molecular structure of **A** is related to its functions. [2]

_____

_____

_____

_____

(d) Describe the phase of translation that occurs before elongation. [3]

_____

_____

_____

_____

_____

_____

(e) State two differences between translation in prokaryotes and translation in eukaryotes. [2]

_____

_____

_____

_____

[Total: 10]

5 Viruses such as bacteriophages have been described as being “organisms at the edge of life”.

(a) State one reason why viruses may be classified as:

(i) living [1]

_____

_____

(ii) non-living. [1]

_____

_____

(b) Fig. 5.1 is an electron micrograph of a T4 bacteriophage.

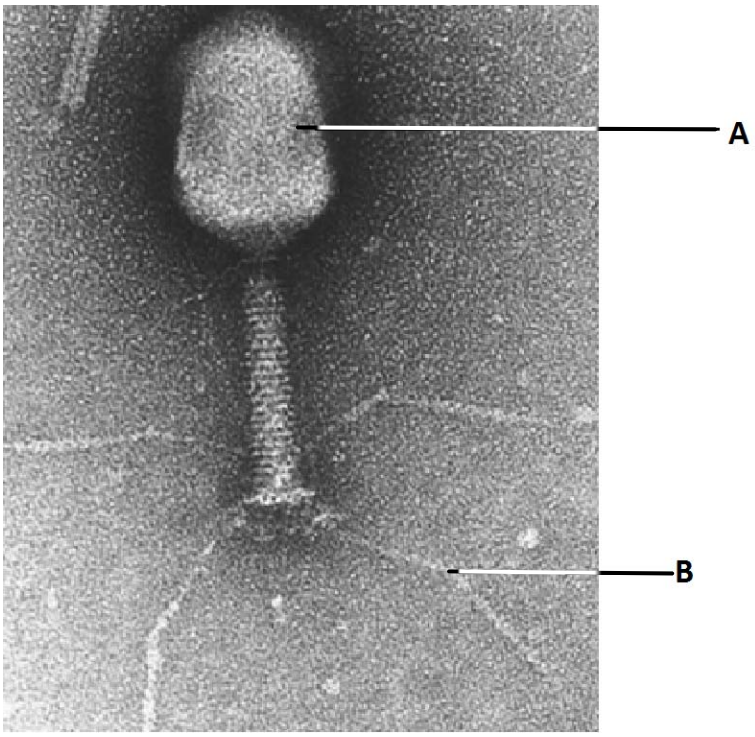

Fig. 5.1

(i) Explain what is meant by the term *bacteriophage*. [1]

_____

_____

(ii) Identify the structures labelled **A** and **B**. [2]

A _____

B _____

Fig. 5.2 shows a scanning electron micrograph of numerous T4 bacteriophages infecting *Escherichia coli*.

Fig. 5.2

(c) With reference to Fig. 5.2, outline the process which allows for *E.coli* DNA to be transferred to another bacterial cell after infection. [4]

_____

_____

_____

_____

_____

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_____

_____

[Total: 9]

6 In *Escherichia coli*, the level of transcription for most genes varies widely according to the nutrient growth condition. The cause of these differences may be due to the presence of many operon-specific activators or repressors, which vary with the composition of the growth medium.

Fig. 6.1 shows the interaction between a lac repressor, coded by a regulatory gene, and the *lac* operon.

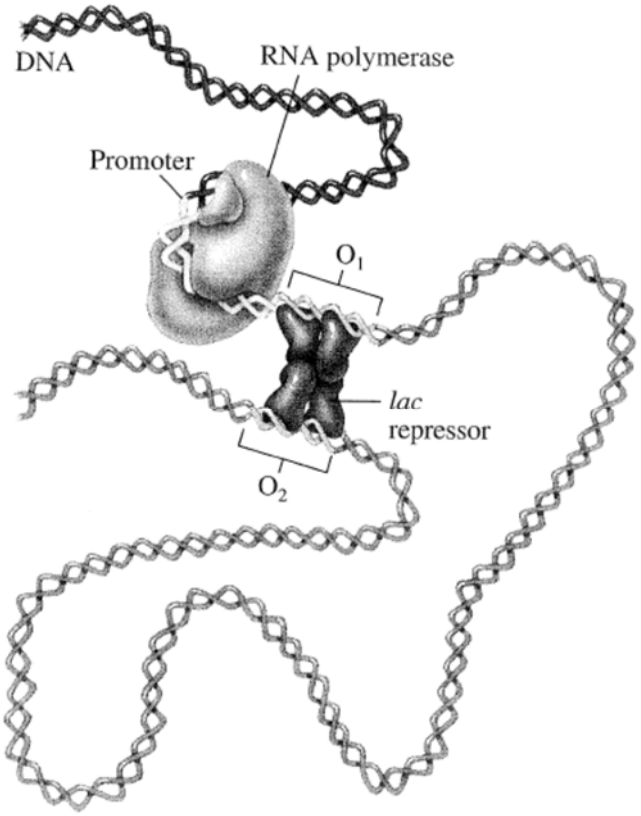

Fig. 6.1

(a) Explain what is meant by *regulatory gene*. [1]

_____

_____

(b) Name two enzymes coded by structural genes of the *lac* operon. [2]

_____

_____

(c) With reference to Fig. 6.1,

(i) suggest the nutrient growth condition of the *E. coli* [1]

_____

_____

(ii) outline how the lac repressor interacts with the *lac* operon. [2]

_____

_____

_____

_____

Fig. 6.2 shows the *trp* operon of *E. coli* with five genes *trpA, trpB, trpC, trpD* and *trpE* that code for enzymes responsible for the biosynthesis of the amino acid tryptophan (Trp).

This operon is transcriptionally regulated by trp repressor, encoded by the *trpR* gene, which is located upstream of *trp* operon.

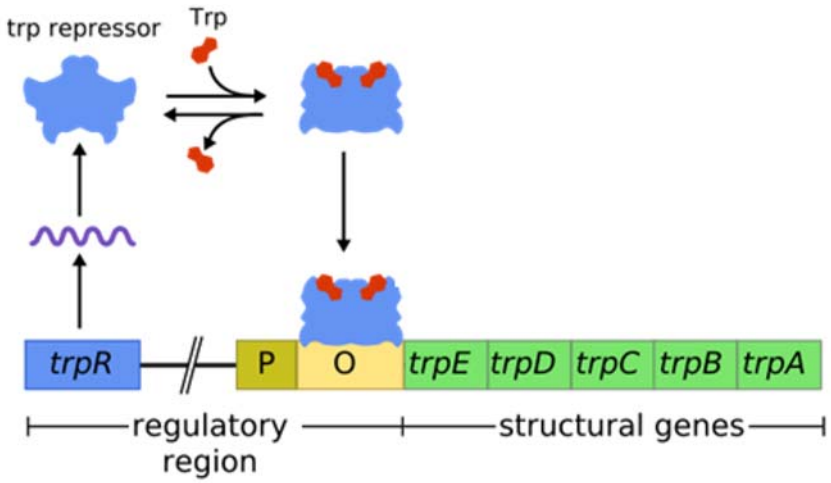

Fig. 6.2

(d) *trp* operon is an example of repressible operon while *lac* operon is an example of inducible operon.

State two other differences between *trp* operon and *lac* operon. [2]

_____

_____

_____

_____

[Total: 8]

7 Fig. 7.1 shows an electron micrograph of a chromosome in prophase II.

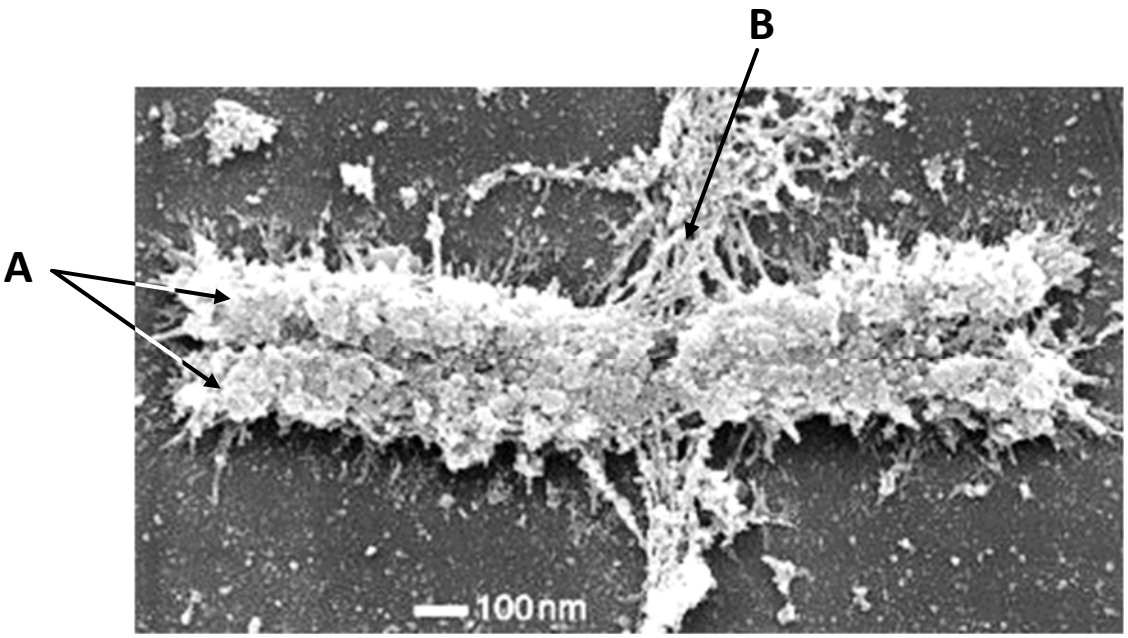

Fig. 7.1

(a) Name the structures **A** and **B**. [2]

A _____

B _____

(b) Explain why the chromosome occurs as a double structure. [2]

_____

_____

_____

_____

The risk of mis-segregation of chromosomes increases with age among women. This can lead to aneuploid embryos. Fig. 7.2 shows an oocyte undergoing nuclear division with mis-segregated and lagging chromosomes.

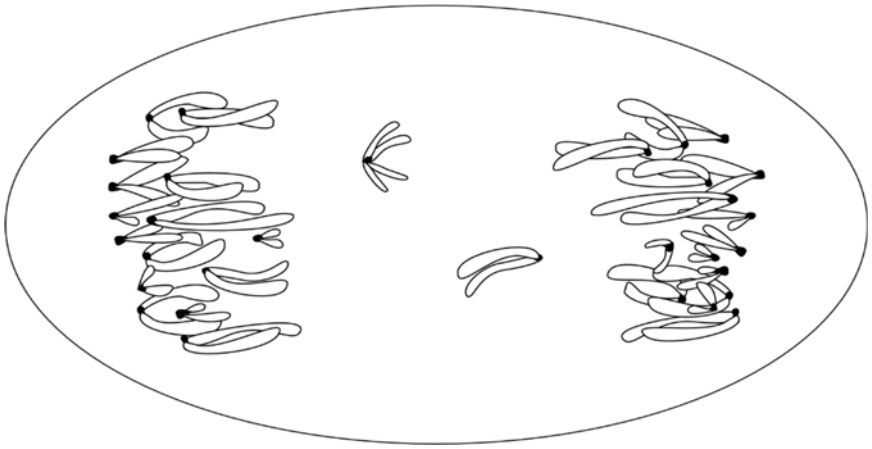

Fig. 7.2

(c) Identify the stage in meiosis as shown in Fig. 7.2. [1]

_____

(d) With reference to Fig. 7.2, suggest how aneuploid embryos are formed. [3]

_____

_____

_____

_____

_____

_____

[Total: 8]

8 The sweet pea, *Lathyrus odoratus*, is a flowering plant that grows in many parts of Europe. The inheritance of flower colour and shape of pollen grains is controlled by genes that display autosomal linkage.

(a) Explain what is meant by *autosomal linkage*. [2]

_____

_____

_____

_____

(b) In sweet peas, the allele for purple flowers is dominant to the allele for red flowers and the allele for long pollen grains is dominant to the allele for round pollen grains.

A sweet pea plant that is heterozygous for both purple flowers and long pollen grains is crossed with a sweet pea plant with red flowers and round pollen grains. The results of this cross are shown in Table 8.1.

Table 8.1

offspring phenotype	number of offspring
purple flowers, long pollen grains	44
red flowers, round pollen grains	44
purple flowers, round pollen grains	6
red flowers, long pollen grains	6

Describe and explain the results shown in Table 8.1. [3]

_____

_____

_____

_____

_____

_____

(c) Draw a genetic diagram to explain the results shown in Table 8.1. [3]

Use the following symbols to represent the different alleles involved:

R - purple flower **r** - red flower
L - long pollen grain **l** - round pollen grain

A horticulturist suggested the hypothesis that the phenotypic ratio of the offspring from the cross was 1:1:1:1. A chi-squared test was carried out on the results of the cross.

phenotype	observed number (*O*)	expected number (*E*)	$\frac{(O-E)^2}{E}$
purple flowers, long pollen grains	44	25	14.44
red flowers, round pollen grains	44	25	14.44
purple flowers, round pollen grains	6	25	14.44
red flowers, long pollen grains	6	25	14.44
			χ^2 = 57.8

Table 8.2 shows part of the critical values of the chi-squared distribution.

Table 8.2

	Probability								
df	0.995	0.975	0.9	0.5	0.1	0.05	0.025	0.01	0.005
1	.000	.000	0.016	0.455	2.706	3.841	5.024	6.635	7.879
2	0.010	0.051	0.211	1.386	4.605	5.991	7.378	9.210	10.597
3	0.072	0.216	0.584	2.366	6.251	7.815	9.348	11.345	12.838
4	0.207	0.484	1.064	3.357	7.779	9.488	11.143	13.277	14.860
5	0.412	0.831	1.610	4.351	9.236	11.070	12.832	15.086	16.750

(d) Explain the significance of the chi-squared value for these results. [3]

_____

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_____

[Total: 11]

Question 9 starts on page 22

9 On the volcanic, equatorial island of São Tomé found off the coast of western Africa, two species of vinegar flies *Drosophila yakuba* and *Drosophila santomea* live in co-existence. While *D. santomea* is found only in the moist forests at higher elevations, its close relative, *D. yakuba* resides mostly in the drier lowlands disturbed by human activities. *D. santomea* is also found exclusively on São Tomé while *D. yakuba* can also be found on the neighbouring islands of Príncipe and Bioko and on continental Africa.

Fig. 9.1 shows the distribution patterns of the two species of vinegar flies on São Tomé.

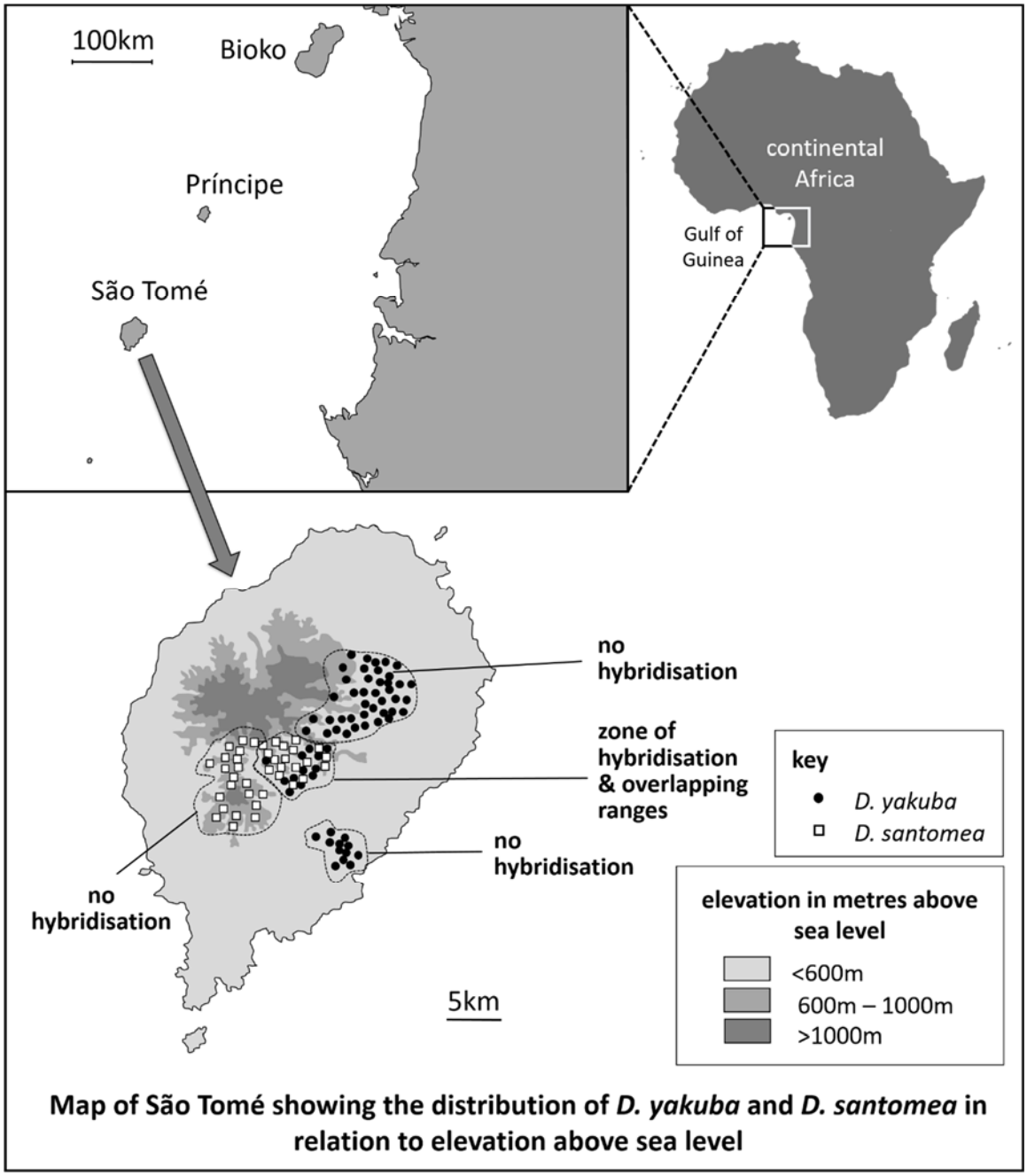

Fig. 9.1

(a) Give one reason why *D. yakuba* found on São Tomé and continental Africa might be considered as the same species. [1]

_____

_____

(b) With reference to Fig. 9.1, explain how island species like *D. santomea* could have arisen from an ancestral population of vinegar flies. [5]

_____

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It was observed that *D. yakuba* and *D. santomea* can hybridise in a well-delineated zone of hybridisation. Hybrids possess intermediate traits of their parents. A population count revealed that hybrids were outnumbered by both *D. yakuba* and *D. santomea* in this zone.

(c) Suggest why the hybrid population is smaller than *D. yakuba* and *D. santomea* populations in this zone. [1]

_____

_____

Studies of the nuclear genome suggested that *D. yakuba* on São Tomé is more closely related to *D. yakuba* from continental Africa than to *D. santomea*. Fig. 9.2 shows the evolutionary relationships among these populations and their sister species *D. teissieri*.

Fig. 9.2

Based on this data, biologists argued that there were two occasions where ancestral populations of vinegar flies arrived on São Tomé from continental Africa and rapidly colonised parts of the island.

(d) Using Fig. 9.2, explain how biologists came to the conclusion that two colonisation events had taken place on São Tomé. [2]

_____

_____

_____

_____

[Total: 9]

10 Phagocytes and lymphocytes are both involved in defence against infectious diseases.

Active B lymphocytes are known as plasma cells.

Fig. 10.1 shows drawings made from electron micrographs of a phagocyte, **A**, and a plasma cell, **B**.

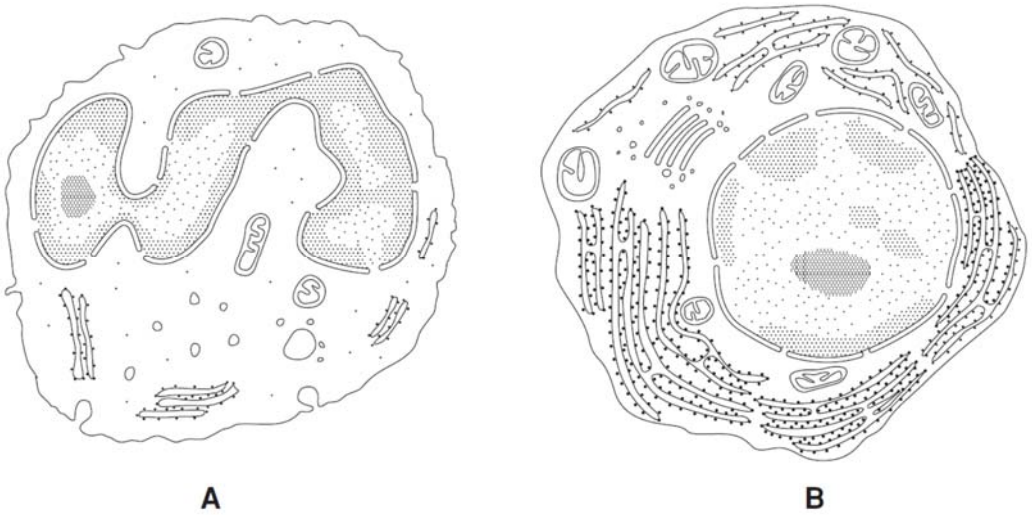

Fig. 10.1

(a) State two visible structural differences between the cells **A** and **B**. [2]

_____

_____

_____

_____

(b) With reference to Fig. 10.1, describe the modes of action of the two cells in defence against infectious diseases. [4]

_____

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_____

[Total: 6]

11 An analysis of ice cores from the Arctic and Antarctic can provide information about the composition of the Earth's atmosphere over thousands of years.

Fig. 11.1 shows the concentrations of carbon dioxide measured in ice cores, dated between 1000 and 2000 AD.

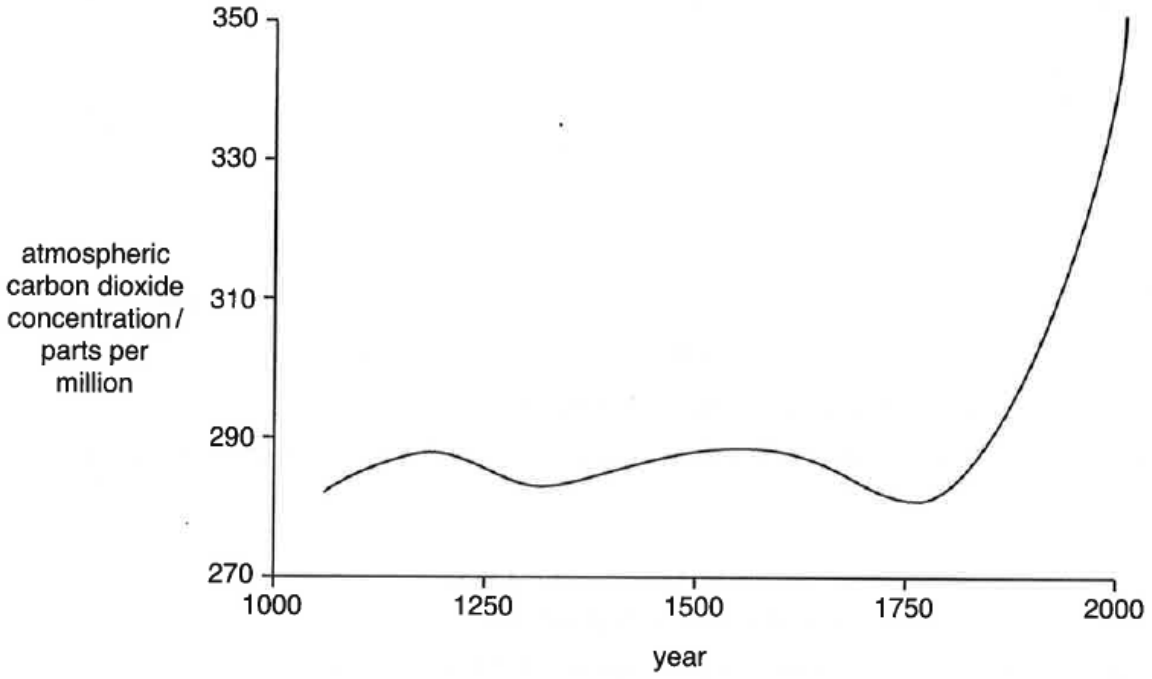

Fig. 11.1

(a) Describe the trend in Fig. 11.1. [2]

_____

_____

_____

_____

(b) Atmospheric carbon dioxide concentrations show regular annual variations. Suggest one reason for this. [1]

_____

_____

(c) Fig. 11.2 shows that, over the same period of time, the average surface temperature of the Earth has shown a similar pattern of change. The increasing concentrations of carbon dioxide is thought to be responsible for the increase in temperature over the last 100 years. This is referred to as the enhanced greenhouse effect.

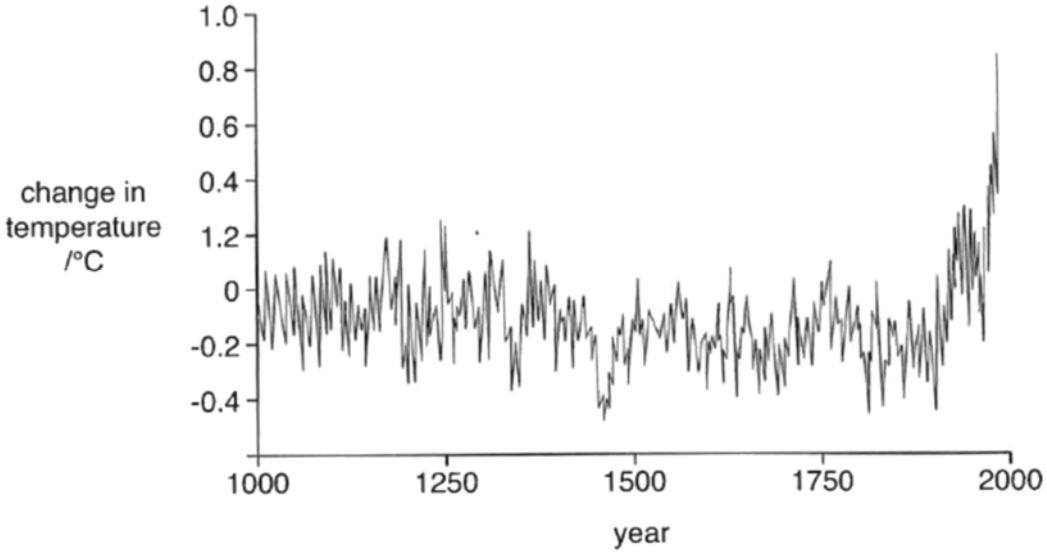

Fig. 11.2

(i) Describe one way in which the data in Fig. 11.2 resembles the data in Fig. 11.1 and one way in which it is different. [2]

Similarity _____

_____

Difference _____

_____

(ii) Describe one human activity that has contributed to the enhanced greenhouse effect. [1]

_____

_____

[Total: 6]

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JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME	**Tr's Copy**					
CLASS		INDEX NUMBER				

BIOLOGY 9744/02

Paper 2 Structured Questions **23 August 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name 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, glue or correction fluid.

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.

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

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

This document consists of **21** printed pages and **1** blank page.

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

1 Fig. 1.1 shows an electron micrograph of mitochondria cross-sections.

Fig. 1.1

(a) With reference to Fig. 1.1, state one visible feature of the mitochondrion and explain how this feature is adapted for the mitochondrion's function. [3]

Visible feature:

1. **The mitochondrion has a highly folded inner mitochondrial membrane / has numerous infoldings/cristae ;**

Adaptation:

2. **which provides a (large) surface (area) for the attachment of enzymes / electron transport chains / electron carriers / ATP synthase ; [R: for H^+ diffusion]**
3. **involved in oxidative phosphorylation for ATP synthesis. ;**

OR

Visible feature:

4. **The mitochondrion has a narrow intermembrane space / Compartmentalisation of the mitochondrion by the inner mitochondrial membrane into regions like the intermembrane space ;**

Adaptation:

5. **facilitates the accumulation / concentration of H^+ leading to the (rapid) establishing of a (steep) electrochemical / proton gradient required to ;**
6. **drive ATP synthesis. ;**

[must make correct match between Visible Feature and Adaptation]

Fig. 1.2 shows the molecular structure of carbonyl cyanide-4-(trifluoromethoxy) phenylhydrazone (FCCP). FCCP is a respiratory poison that binds protons and transports them across the phospholipid bilayer of the inner mitochondrial membrane. Protons alone are unable to diffuse freely in this manner.

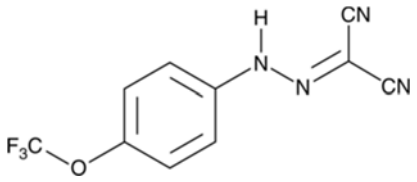


Fig. 1.2

(b) Explain, in relation to their properties, why FCCP readily diffuses across the phospholipid bilayer while protons do not. [2]

1. **FCCP is a small, hydrophobic <u>non-polar</u> molecule and readily <u>diffuses across</u> the <u>hydrophobic core</u> of the phospholipids bilayer. FCCP is hence soluble in lipids. ;**
2. **Protons are <u>charged (ions)</u> and are <u>repelled by</u> the <u>hydrophobic core</u> of the phospholipid bilayer of the inner mitochondrial membrane. Thus, protons cannot diffuse readily. ;**
   [Mark once for *"hydrophobic core"*]

In the presence of FCCP, the rate of ATP synthesis during respiration is significantly diminished. The rate is further reduced if oxygen becomes unavailable. In such conditions where oxygen is depleted, cells continue to oxidise glucose to form pyruvate and sustain ATP synthesis.

(c) (i) Identify the key stages of aerobic respiration where the release of carbon dioxide occurs. [1]

- **Link reaction and Krebs cycle. ;**

(ii) State the location where the biochemical pathway enabling the continual oxidation of glucose to form pyruvate occurs. [1]

Cytosol / cytoplasm ;

(iii) Explain how ATP synthesis can be sustained in the absence of oxygen in yeast cells. [3]

1. **ATP in yeast can be sustained through anaerobic respiration, where <u>glycolysis</u> occurs followed by <u>alcoholic fermentation</u>. ;**
2. **<u>Regeneration of NAD</u> (during alcoholic fermentation) / <u>Oxidation of NADH to NAD</u> <u>allows glycolysis to continue</u> ;**
3. **resulting in a <u>(net gain) of 2 ATP per molecule of glucose</u> via <u>substrate level phosphorylation</u>. ;**

[Total: 10]

2 Fig. 2.1 shows a triglyceride molecule.

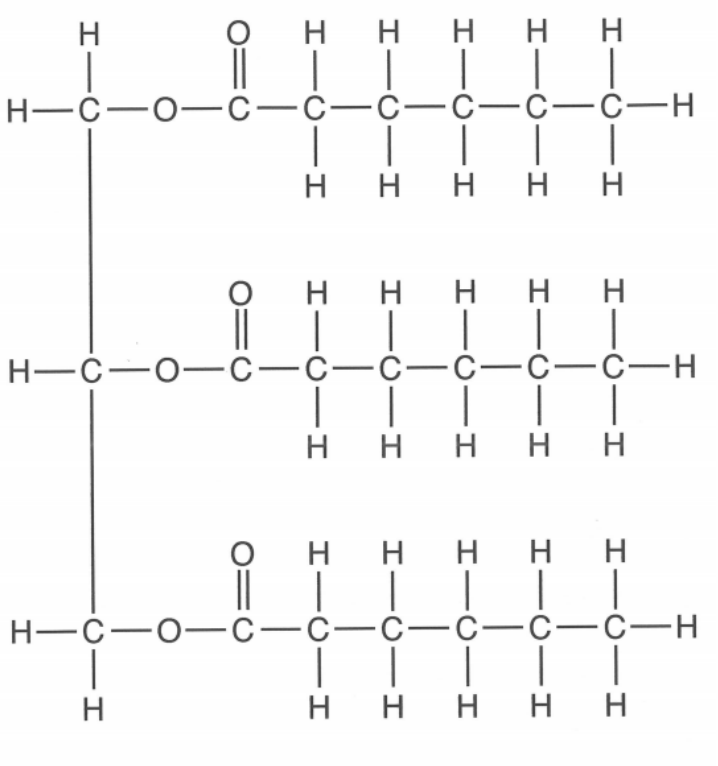


Fig. 2.1

(a) (i) State the names of the two types of molecules that undergo condensation reactions to form a triglyceride. [2]

1. **glycerol ;**
2. **fatty acid ;**

(ii) Describe what is meant by a condensation reaction. [2]

1. **A condensation reaction takes place between the <u>–OH group</u> <u>and –COOH group</u> ;**
2. **involves the <u>removal of (one) water molecule</u> ;**
   A: Three condensation reaction and removal of three water molecules

(iii) The triglyceride in Fig. 2.1 is saturated.

Explain how the structure would be different for an unsaturated triglyceride. [3]

1. **contains the lesser number of hydrogen atoms ;**
2. **presence of carbon-carbon double covalent bond (C = C) ;**
3. **presence of kinks in the hydrocarbon chain ;**

(b) The eukaryotic cell surface membrane contains phospholipids, cholesterol and proteins.

(i) Describe how a phospholipid molecule differs from a triglyceride molecule. [2]

	Phospholipids	**Triglycerides**	
1.	**1 glycerol, 2 fatty acids and 1 (-vely charged) phosphate group**	**1 glycerol and 3 fatty acids**	**;**
2.	**2 ester bonds and a phosphoester bond**	**3 ester bonds**	**;**
3.	**Phospholipid diversity is based on differences in the two fatty acids and in the groups attached to the phosphate group of the head.**	**Triglyceride diversity is based on differences in the three fatty acids.**	**;**
4.	**Phospholipids are amphipathic in nature.**	**Triglycerides are non-polar in nature.**	**;**
5.	**Phospholipids may associate covalently with carbohydrates to form glycolipids.**	**Triglycerides do not associate covalently with carbohydrates.**	**;**

* **A: fatty acid tails / hydrocarbon chains.**

(ii) Describe the roles of cholesterol in eukaryotic cell surface membranes. [2]

1. **increases the stability of membranes/decrease membrane fluidity, by restraining the movement of phospholipids, at (relatively) warm temperatures ;**
   or
2. **increases the flexibility of membranes/increase membrane fluidity, by hindering the close packing of phospholipids, at low temperatures ;**
   I: helps to reduce the tendency of membrane to 'freeze'/solidfy/breaking up (consequence)
3. **acts like a plug, reducing the escape / entry of charged ions/small polar molecules through the membrane ;**

(c) The respiratory quotient, RQ, is used to show which substrate is being metabolised by cells. It can be determined using the equation below.

$$RQ = \frac{\text{molecules of carbon dioxide released}}{\text{molecules of oxygen taken in}}$$

Lauric acid is a saturated fatty acid found in coconuts and has a chain of 12 carbon atoms.

(i) Complete the equation below which outlines the aerobic respiration of lauric acid. [1]

$C_{12}H_{24}O_2$ + ……. O_2 ➔ $12CO_2 + 12H_2O$

- **17 ;**

(ii) Calculate the RQ value for lauric acid.

Give your answer to 2 decimal places.

- **allow ecf from (i) for one mark**

RQ value = **0.71** [1]

[Total: 13]

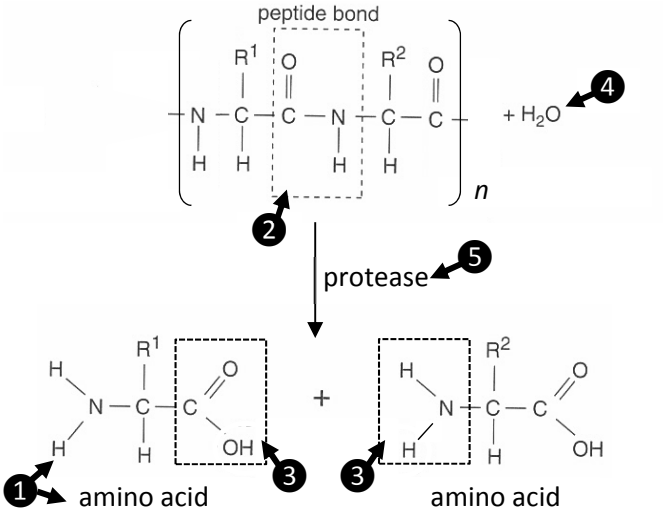
3 Lysosomes are important membrane-bound organelles within animal cells.

They contain many different types of enzymes that hydrolyse lipids, nucleic acids, polysaccharides or proteins. When phagocytic vesicles containing these food substances fuse with lysosomes, the internal pH of lysosomes will be lowered to a range of pH 4.5 to pH 5.0 resulting in the activation of the lysosome enzymes.

(a) Describe how proteins are hydrolysed.

You may use annotated diagrams to illustrate your answer. [4]

1. **Hydrolysis of <u>proteins</u> / <u>polypeptides</u> to form <u>dipeptides</u> / <u>amino acids</u> / <u>short peptides</u> ;**
2. **involves the <u>breaking of peptide bonds</u> along a polypeptide chain ;**
3. **to <u>form amino ($-NH_2$) groups and carboxyl ($-COOH$) groups</u> on adjacent amino acid residues. ;**
4. **The reaction involves the <u>addition of water</u> / <u>hydrolysis</u> ;**
5. **and is catalysed by <u>proteases</u> / <u>peptidases</u>. ;**
   [max 4m]



Award for corresponding points in diagram:

1. **Structure of amino acid drawn correctly along with label for "amino acid". Ignore errors for carboxyl and amino group (penalise in Pt 3).**
2. **Peptide bond drawn correctly + to show conversion of polypeptide (A: if dipeptide is shown) to smaller molecules (amino acids)**
3. ***Both* carboxyl group and amino group drawn correctly for *both* molecules of amino acids.**
4. **Addition of water [Ignore number of water molecules]**
5. **Example of valid type of enzyme (i.e. must be a protease)**

(b) Explain how the lysosome enzymes can be activated by the change in pH. [3]

1. **Changes in pH alters the ionic charges on acidic and basic R-groups of amino acid residues present in inactive lysosome enzymes. ;**

2. **This results in the rearrangement of ionic bonds and hydrogen bonds in lysosome enzymes and ;**
   A: *break AND form new ionic bonds*

3. **alters the 3D conformation of the active sites of these enzymes such that these active sites are now complementary to the shape of their substrates / substrates can enter and bind to the active site / AW. ;**

(c) Suggest why the lysosome membrane is not destroyed by the enzymes in the lysosome. [3]

1. **The lysosome membrane contains glycoproteins / glycolipids / phospholipids.;**
2. **Lysosomes contains only enzymes that can breakdown lipids / nucleic acids / proteins / polysaccharides ;**
3. **The enzymes in the lysosome are specific (to the lipids / nucleic acids / proteins / polysaccharides in the phagocytic vesicle). ;**
   OR
4. **This is because the shape of these enzymes' active sites are not complementary to the membrane glycoproteins / glycolipids / phospholipids. Hence, membrane glycoproteins / glycolipids / phospholipids are unable to enter and bind to the active sites of the enzymes to form substrate-enzyme complexes for hydrolysis to occur / AW (ref. to lack of fit between substrate and active site of enzyme) ;**
5. **and hence are unable to digest the glycoproteins / glycolipids / phospholipids in the lysosome membrane. ;**
   Hence the integrity of the lysosome membrane is preserved.

[Total: 10]

4 Fig. 4.1 shows the elongation phase of translation.

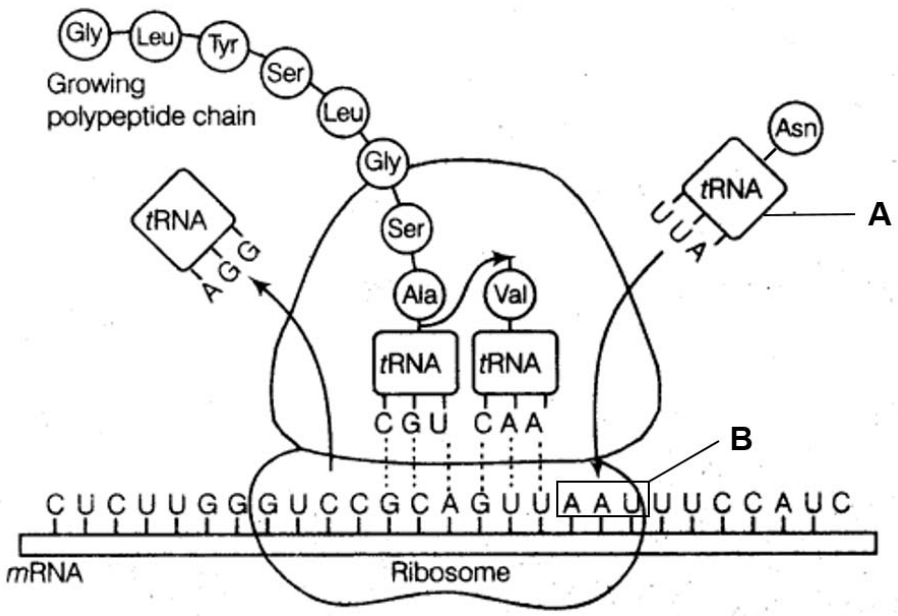


Fig. 4.1

(a) On Fig. 4.1, draw an arrow to show the direction of translocation of the ribosome. [1]

(b) Name the structures **A** and **B** in Fig. 4.1. [2]

A: aminoacyl-tRNA ;
B: codon ;

(c) Explain how the molecular structure of **A** is related to its functions. [2]

Structure

1. **Has <u>anticodon (loop)</u> that <u>complementary base pairs</u> with a particular <u>codon</u> on the <u>mRNA</u>**
2. **Attached covalently to its <u>specific amino acid</u> coded for by the anticodon of the tRNA at the <u>CCA stem</u>**

Function (OWTTE)

3. **To transfer amino acids present in the cytoplasm to the ribosome ;**
4. **To act as an intermediate molecule between the codon of mRNA and the amino acid sequence of the polypeptide strand ;**

1+4 / 2+3 / 2+4

(d) Describe the phase of translation that occurs before elongation. [3]

1. **A <u>small ribosomal subunit</u> recognises and <u>binds to the 5' end of the mRNA</u> and travels along the mRNA until it <u>reaches the first AUG</u> / <u>start codon</u> ;**
2. **A special <u>initiator tRNA</u> carrying the <u>amino acid methionine (Met)</u> / <u>anticodon UAC</u>, binds to the start codon AUG on the mRNA ;**
3. **The union of mRNA, initiator tRNA, and a small ribosomal subunit is followed by the attachment of a <u>large ribosomal subunit</u>, completing a <u>translation initiation complex</u> ;**
4. **Proteins called <u>initiation factors</u> and <u>GTP</u> are required to bring all these components together ;**

(e) State two differences between translation in prokaryotes and translation in eukaryotes. [2]

	Features	prokaryotes	eukaryotes	
1.	Ribosomes involved	Involves 70S ribosomes	Involves 80S ribosomes	;
2.	Continuous/ simultaneous transcription and translation	Translation is continuous/ simultaneous with transcription	Translation is separated/ not simultaneous with transcription	;
3.	mRNA involved in translation	mRNA used is usually polycistronic/code for many proteins/ act as template for the synthesis of many polypeptides	mRNA used is monocistronic/code for one protein/ act as template for the synthesis of one polypeptide;	;
4.	Location	Translation occurs on free ribosomes only	Translation occurs on free ribosomes or ribosomes attached to endoplasmic reticulum	;

[Total: 10]

5 Viruses such as bacteriophages have been described as being "organisms at the edge of life".

(a) State one reason why viruses may be classified as:

(i) living [1]

1. **They are capable of reproduction only in living host cells ;**
2. **They are capable of transmitting/passing on genetic characteristics from one generation of viruses to the next generation of viruses ;**
3. **Genomes of viruses are capable of mutating ;**

(ii) non-living. [1]

1. **They are acellular ;**
2. **They cannot carry out metabolism on their own and must replicate using the host cell's metabolic machinery/enzymes and ribosomes ;**
3. **They do not grow or divide/ new viral components are synthesised and assembled within the infected host cell ;**
4. **They contain only one type of hereditary material i.e. either DNA or RNA but never both ;**
5. **They survive within a host cell but crystallise when outside of host cell ;**
6. **They are not capable of movement as they have no flagella or other means to propel themselves ;**

AVP: unable to obtain own source of nutrients through diet or photosynthesis etc.

(b) Fig. 5.1 is an electron micrograph of a T4 bacteriophage.

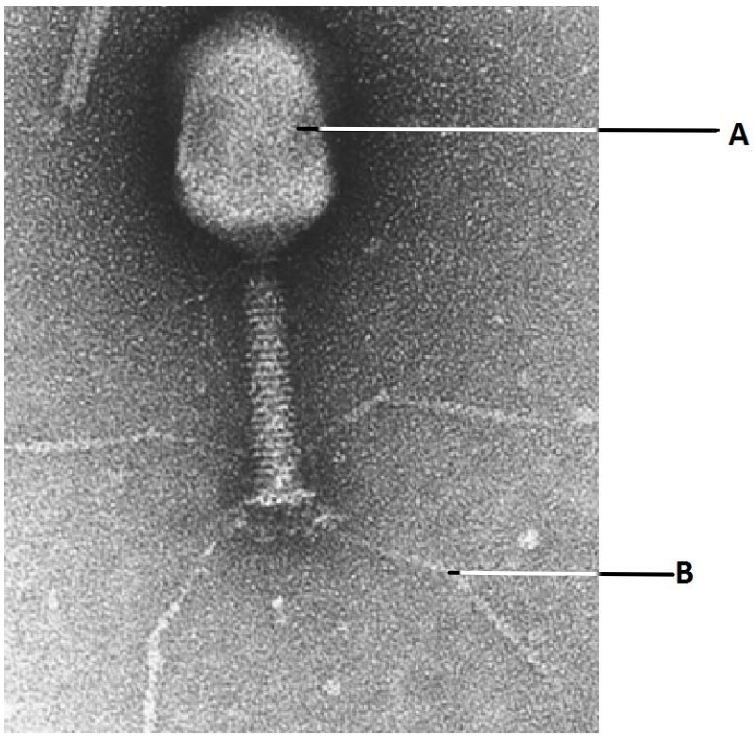


Fig. 5.1

(i) Explain what is meant by the term bacteriophage. [1]

1. Viruses that only infect bacteria ;

(ii) Identify the structures labelled **A** and **B**. [2]

A: capsid ;
B: tail fibre ;

Fig. 5.2 shows a scanning electron micrograph of numerous T4 bacteriophages infecting *Escherichia coli*.

Fig. 5.2

(c) With reference to Fig. 5.2, outline the process which allows for *E.coli* DNA to be transferred to another bacterial cell after infection. [4]

1. **<u>Generalised transduction</u> ;**
2. **T4 bacteriophages undergo <u>lytic cycle</u> /phage enzymes (nucleases) hydrolyse the bacterial chromosome into fragments ;**
3. **A fragment of the <u>bacterial/host cell's degraded DNA</u> (instead of phage genome) gets <u>mistakenly packaged into the capsid</u> during assembly of the phage ;**
4. **The <u>defective phage attaches to another bacterium</u> and injects the piece of bacterial DNA acquired from the lysed bacterial cell ;**
5. **Foreign bacterial DNA incorporated into new host cell's DNA via homologous recombination (i.e. crossing over with a homologous region found on the recipient bacterial chromosome) ;**

[Total: 9]

6 In *Escherichia coli*, the level of transcription for most genes varies widely according to the nutrient growth condition. The cause of these differences may be due to the presence of many operon-specific activators or repressors, which vary with the composition of the growth medium.

Fig. 6.1 shows the interaction between a lac repressor, coded by a regulatory gene, and the *lac* operon.

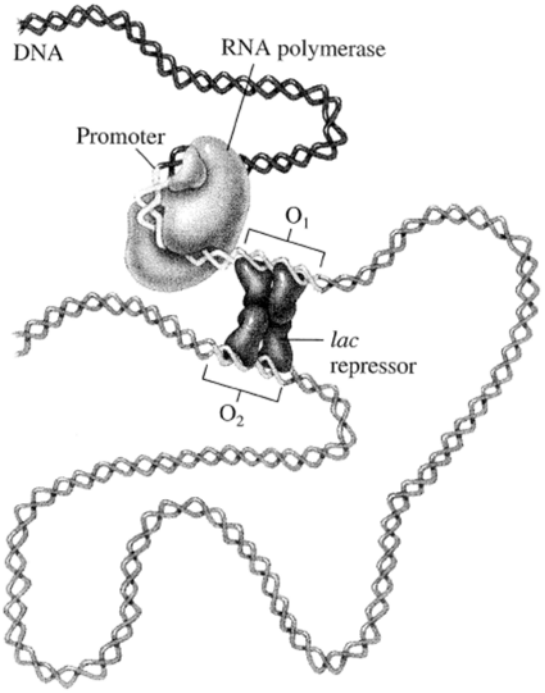


Fig. 6.1

(a) Explain what is meant by *regulatory gene*. [1]

1. **A regulatory gene codes for a specific protein product that regulates the expression of the structural genes ;**

(b) Name two enzymes coded by structural genes of the *lac* operon. [2]

1. **β-galactosidase ;**
2. **lac permease ;**
3. **β-galactoside transacetylase ;**
   (any 2)

(c) With reference to Fig. 6.1,

(i) suggest the nutrient growth condition of the *E. coli* [1]

1. **Absence of lactose in the growth media/environment ;**

(ii) outline how the lac repressor interacts with the *lac* operon. [2]

1. **lac repressor is synthesised in its active conformation and recognises and binds to the operator ;**
2. **No allolactose binds to the allosteric site of *lac* repressor, *lac* repressor remains in its active 3D conformation and remains bound to the operator ;**

Fig. 6.2 shows the *trp* operon of *E. coli* with five genes *trpA, trpB, trpC, trpD* and *trpE* that code for enzymes responsible for the biosynthesis of the amino acid tryptophan (Trp).

This operon is transcriptionally regulated by trp repressor, encoded by the *trpR* gene, which is located upstream of *trp* operon.

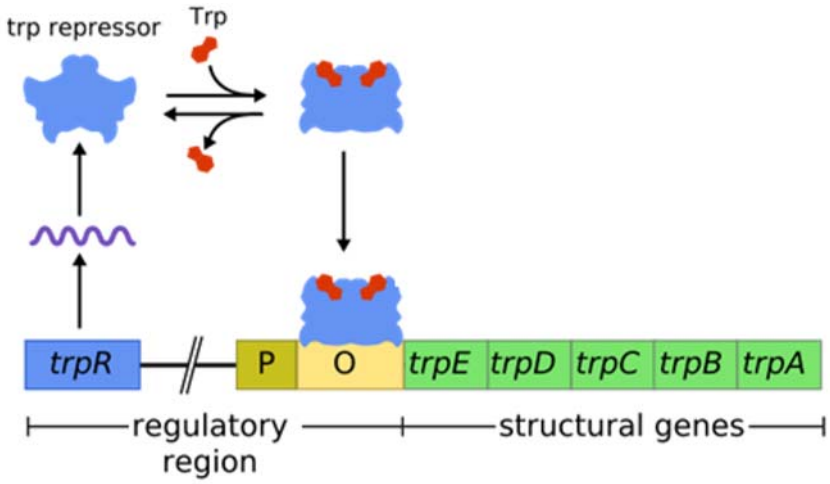


Fig. 6.2

(d) *trp* operon is an example of repressible operon while *lac* operon is an example of inducible operon.

State two other differences between *trp* operon and *lac* operon. [2]

	features	*trp* operon	*lac* operon	
1.	Effector molecule	tryptophan acts as a co-repressor	Allolactose acts as an inducer	;
2.	Effect of effector molecule on operon	In the presence of co-repressor/tryptophan, operon is turned off	In the presence of inducer/allolactose, operon is turned on	;
3.	Conformation of newly synthesized repressor	Repressor is synthesized in the inactive form	Repressor is synthesized in the active form	;
4.	Nature of pathway involved	*trp* operon is involved in anabolic pathway	*lac* operon is involved in catabolic pathway	;
5.	By default, operon are switched on/off	operon are switched on	operon are switched off	;
6.	When does repressor bind operator	When co-repressor binds to allosteric site, repressor can recognize and bind the operator	Repressor in its active form, and recognize and bind to the operator	;
7.	When does repressor not bind to operator	Repressor in its inactive form, and does not bind to the operator	When inducer binds to allosteric site, repressor does not bind to the operator	

[Total: 8]

7 Fig. 7.1 shows an electron micrograph of a chromosome in prophase II.

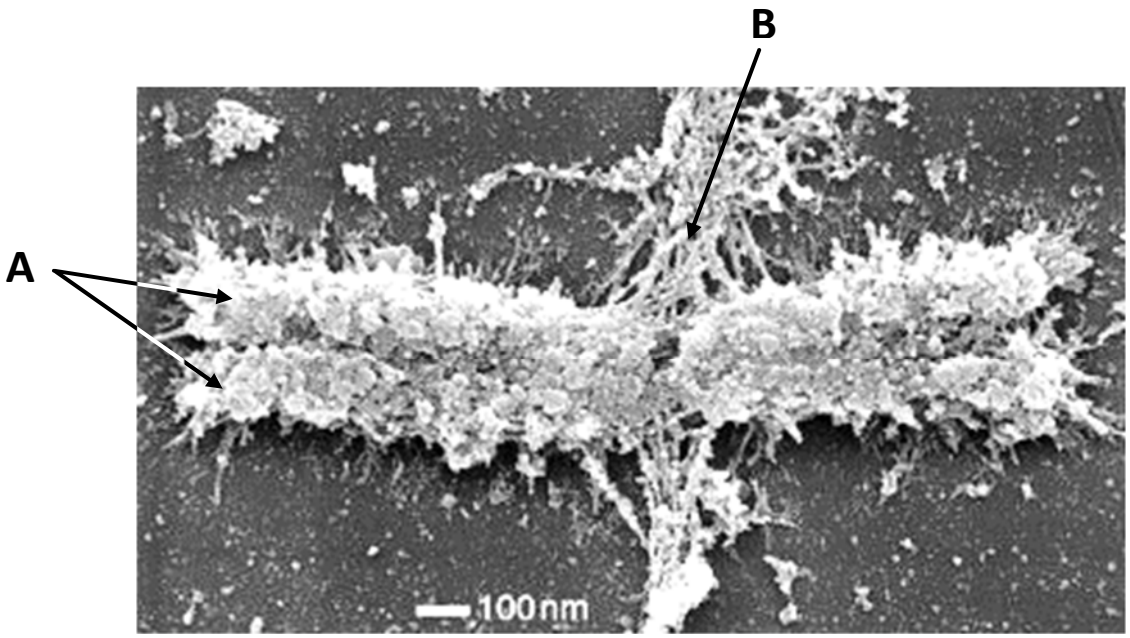


Fig. 7.1

(a) Name the structures **A** and **B**. [2]

A: (a pair of recombinant) chromatids ; [R: sister chromatids / chromosomes]
B: (kinetochore) spindle fibre ;

(b) Explain why the chromosome occurs as a double structure. [2]

1. **<u>Semi-conservative DNA replication</u> occurred during S phase of interphase, producing <u>two identical DNA molecules</u> ;**
2. **which coil and <u>condense</u> during prophase I of meiosis I to form a chromosome consisting of <u>2 (identical) sister chromatids</u> <u>held together at the centromere</u> before crossing over occurred. ;**

The risk of mis-segregation of chromosomes increases with age among women. This can lead to aneuploid embryos. Fig. 7.2 shows an oocyte undergoing nuclear division with mis-segregated and lagging chromosomes.

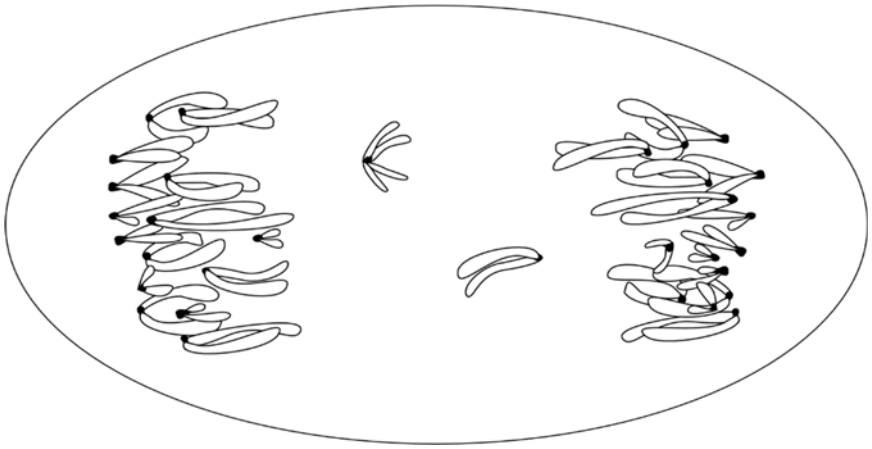


Fig. 7.2

(c) Identify the stage in meiosis as shown in Fig. 7.2. [1]

Anaphase II ;

(d) With reference to Fig. 7.2, suggest how aneuploid embryos are formed. [3]

1. **Mis-segregation of chromosomes arose when <u>centromeres did not divide properly</u> / <u>recombinant chromatids did not separate at their centromeres</u>. ;**
   OR
2. **Lagging chromosomes arose when the kinetochore <u>spindle fibres</u> attached to the centromeres <u>failed to shorten and contract</u> to pull the daughter recombinant chromosomes to opposite poles of the cell. ;**

3. **These processes may (lead to chromosomal/numerical aberrations) resulting in oocytes with <u>extra / less / n + 1 / n - 1 chromosomes</u>. [No credit for mentioning "*chromosomal/numerical aberrations*" alone];**
4. **<u>Fusion of these oocytes with a normal haploid sperm</u>, results in aneuploid embryos. ;**

[Total: 8]

8 The sweet pea, *Lathyrus odoratus*, is a flowering plant that grows in many parts of Europe. The inheritance of flower colour and shape of pollen grains is controlled by genes that display autosomal linkage.

(a) Explain what is meant by autosomal linkage. [2]

1. two or more genes on same chromosome will be inherited together;
AND
2. not sex chromosome/non-sex chromosome;

(b) In sweet peas, the allele for purple flowers is dominant to the allele for red flowers and the allele for long pollen grains is dominant to the allele for round pollen grains.

A sweet pea plant that is heterozygous for both purple flowers and long pollen grains is crossed with a sweet pea plant with red flowers and round pollen grains. The results of this cross are shown in Table 8.1.

Table 8.1

offspring phenotype	number of offspring
purple flowers, long pollen grains	44
red flowers, round pollen grains	44
purple flowers, round pollen grains	6
red flowers, long pollen grains	6

Describe and explain the results shown in Table 8.1. [3]

1. **The observed offspring of the cross are minority of recombinants combination/phenotype ;**
2. **and majority of parental combinations/phenotype / The 2 genes for flower colour and shape of pollen grains are linked and the alleles of the two genes will be inherited together as one linkage group, resulting in a higher proportion of gametes/ higher chances of getting gametes carrying the parental types/parental gametes ;**
3. **Crossing over between the two linked genes on non-sister chromatids of homologous chromosomes may occur, (as crossing over is a chance event,) resulting in a lower proportion of recombinant gametes/lower chances of getting recombinant gametes ;**

(c) Draw a genetic diagram to explain the results shown in Table 8.1. [3]

Use the following symbols to represent the different alleles involved:

R - purple flower **r** - red flower
L - long pollen grain **l** - round pollen grain

Parental phenotypes:	**purple flowers and long pollen grains**	**X**	**red flowers and round pollen grains**	
Parental genotypes:	$\frac{RL}{rl}$	**X**	$\frac{rl}{rl}$	**;**
Gametes	(RL) (rL) (Rl) (rl)		(rl)	

Fertilisation:

	(RL)	(rl)	(Rl)	(rL)
(rl)	$\frac{RL}{rl}$	$\frac{rl}{rl}$	$\frac{Rl}{rl}$	$\frac{rL}{rl}$

Offspring genotype :	$\frac{RL}{rl}$	**:**	$\frac{rl}{rl}$	**:**	$\frac{Rl}{rl}$	**:**	$\frac{rL}{rl}$ **;**
Offspring phenotype :	**purple flowers, long pollen grains**	**:**	**red flowers, round pollen grains**	**:**	**purple flowers, round pollen grains**	**:**	**red flowers, long pollen grains** **;**
Offspring phenotypic ratio :	**7**	**:**	**7**	**:**	**1**	**:**	**1**

A horticulturist suggested the hypothesis that the phenotypic ratio of the offspring from the cross was 1:1:1:1. A chi-squared test was carried out on the results of the cross.

phenotype	observed number (*O*)	expected number (*E*)	$\frac{(O-E)^2}{E}$
purple flowers, long pollen grains	44	25	14.44
red flowers, round pollen grains	44	25	14.44
purple flowers, round pollen grains	6	25	14.44
red flowers, long pollen grains	6	25	14.44
			χ^2 = 57.8

Table 8.2 shows part of the critical values of the chi-squared distribution.

Table 8.2

	Probability								
df	0.995	0.975	0.9	0.5	0.1	0.05	0.025	0.01	0.005
1	.000	.000	0.016	0.455	2.706	3.841	5.024	6.635	7.879
2	0.010	0.051	0.211	1.386	4.605	5.991	7.378	9.210	10.597
3	0.072	0.216	0.584	2.366	6.251	7.815	9.348	11.345	12.838
4	0.207	0.484	1.064	3.357	7.779	9.488	11.143	13.277	14.860
5	0.412	0.831	1.610	4.351	9.236	11.070	12.832	15.086	16.750

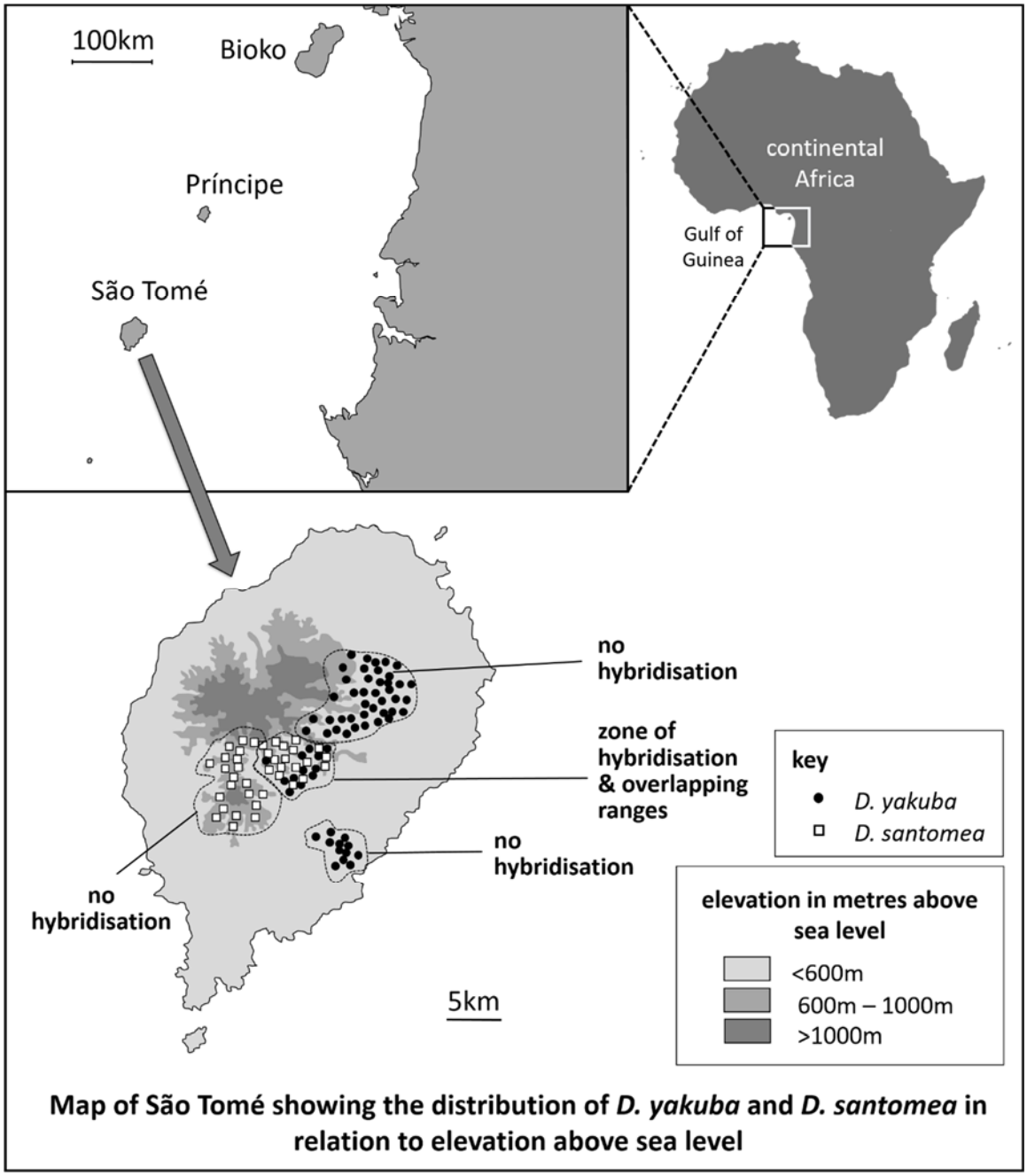
(d) Explain the significance of the chi-squared value for these results. [3]

1. **The calculated χ2 value is 57.8, more than the critical χ2 value of 7.815 at p= 0.05, Value of p is less than 0.005, less than p = 0.05 ;**
2. **Reject the null hypothesis, there is significant difference between the observed and the expected ratio ;**
   A: results/data
3. **The phenotypic ratio of the offspring from the cross was not 1:1:1:1, any deviation from the expected is not due to chance but due to other factors eg. Linkage ;**

[Total: 11]

9 On the volcanic, equatorial island of São Tomé found off the coast of western Africa, two species of vinegar flies *Drosophila yakuba* and *Drosophila santomea* live in co-existence. While *D. santomea* is found only in the moist forests at higher elevations, its close relative, *D. yakuba* resides mostly in the drier lowlands disturbed by human activities. *D. santomea* is also found exclusively on São Tomé while *D. yakuba* can also be found on the neighbouring islands of Príncipe and Bioko and on continental Africa.

Fig. 9.1 shows the distribution patterns of the two species of vinegar flies on São Tomé.



Map of São Tomé showing the distribution of *D. yakuba* and *D. santomea* in relation to elevation above sea level

Fig. 9.1

(a) Give one reason why *D. yakuba* found on São Tomé and continental Africa might be considered as the same species. [1]

1. **These populations of *D. yakuba* are capable of <u>interbreeding</u> to produce <u>viable and fertile offspring</u> ;**
2. **And share the <u>same ecological niche</u> ; [R: same environment]**
3. **And share <u>similar body shape</u> and/or other <u>structural features</u> / <u>morphology</u> ; [max 1m]**

(b) With reference to Fig. 9.1, explain how island species like *D. santomea* could have arisen from an ancestral population of vinegar flies. [5]

1. **<u>Founder effect</u> occurs when some members of an ancestral vinegar fly population from continental Africa colonised the islands along the coast to form sub-populations ; [Reject if wrong reference to migration from lower elevation to higher elevation on same island was mentioned]**
2. **The sub-populations become <u>geographically isolated leading to allopatric speciation</u> (and are also physiologically / behaviourally isolated leading to sympatric speciation) ;**
3. **The sub-populations <u>did not interbreed</u> (when isolated) and thus <u>gene flow was disrupted</u> ;**
4. **The sub-populations were exposed to <u>different environments</u> on each island and were thus subjected to <u>different selection pressures</u> e.g. availability of food, predators etc. ;**
5. **Since there was <u>variation within the sub-populations</u>, <u>individuals with favourable characteristics were at a selective advantage (or vice versa)</u> and**
6. **can <u>survive to maturity, reproduce and passed on their favourable alleles</u> / genes (R: traits) <u>to their offspring</u> (vice versa) ;**
7. **Over successive generations, <u>evolutionary changes</u> occurred <u>independently</u> in each subpopulation / <u>changes in allele frequencies</u> in <u>each</u> sub-populations lead to divergence, giving rise to a new species such as *D. santomea*. ;**

It was observed that *D. yakuba* and *D. santomea* can hybridise in a well-delineated zone of hybridisation. Hybrids possess intermediate traits of their parents. A population count revealed that hybrids were outnumbered by both *D. yakuba* and *D. santomea* in this zone.

(c) Suggest why the hybrid population is smaller than *D. yakuba* and *D. santomea* populations in this zone. [1]

1. **Hybrids have lower fitness / are selectively less advantageous than *D. yakuba* and *D. santomea* / disruptive selection against (the intermediate traits of) hybrids / ORA. ; [A: "hybrids are less adapted to the environment / have less favourable traits (R: alleles) compared to pure breds"]**
2. **Interspecific breeding (breeding between *D. yakuba* and *D. santomea*) occurs less frequently than intraspecific breeding (within each species). ;**
3. **Hybrids have lower reproductive potential compared to *D. yakuba* and *D. santomea* pure breeds. ; [R: hybrids are infertile and cannot produce viable and fertile offspring]**

R:

- ***D. yakuba* and *D. santomea* have low chance of encountering each other.**
- **Behavioural and physiological isolation occurs between *D. yakuba* and *D. santomea*.**

Studies of the nuclear genome suggested that *D. yakuba* on São Tomé is more closely related to *D. yakuba* from continental Africa than to *D. santomea*. Fig. 9.2 shows the evolutionary relationships among these populations and their sister species *D. teissieri*.

Fig. 9.2

Based on this data, biologists argued that there were two occasions where ancestral populations of vinegar flies arrived on São Tomé from continental Africa and rapidly colonised parts of the island.

(d) Using Fig. 9.2, explain how biologists came to the conclusion that two colonisation events had taken place on São Tomé. [2]

1. **Based on the phylogenetic tree, São Tomé *D. yakuba* population shared a most recent common ancestor with the *D. yakuba* population from continental Africa, ;**

2. **suggesting that the São Tomé *D. yakuba* population had only recently arrived on the island from continental Africa ;**
   [idea of second *recent* dispersal and colonisation of *D. yakuba*; must match correct colonisation event to correct species]
   OR
3. **where an existing *D. santomea* population had descended from an ancestral population from an initial colonisation event. ;**
   [idea of first dispersal and colonisation of *D. santomea*; must match correct colonisation event to correct species]

   [Pt 1, 2 and 3 must identify correct clades: e.g. Pt 1 must mention the clade that *only includes* São Tomé *D. yakuba*, continental African *D. yakuba* and their common ancestor *and excludes* *D. santomea*]

[Total: 9]

10 Phagocytes and lymphocytes are both involved in defence against infectious diseases.

Active B lymphocytes are known as plasma cells.

Fig. 10.1 shows drawings made from electron micrographs of a phagocyte, **A**, and a plasma cell, **B**.

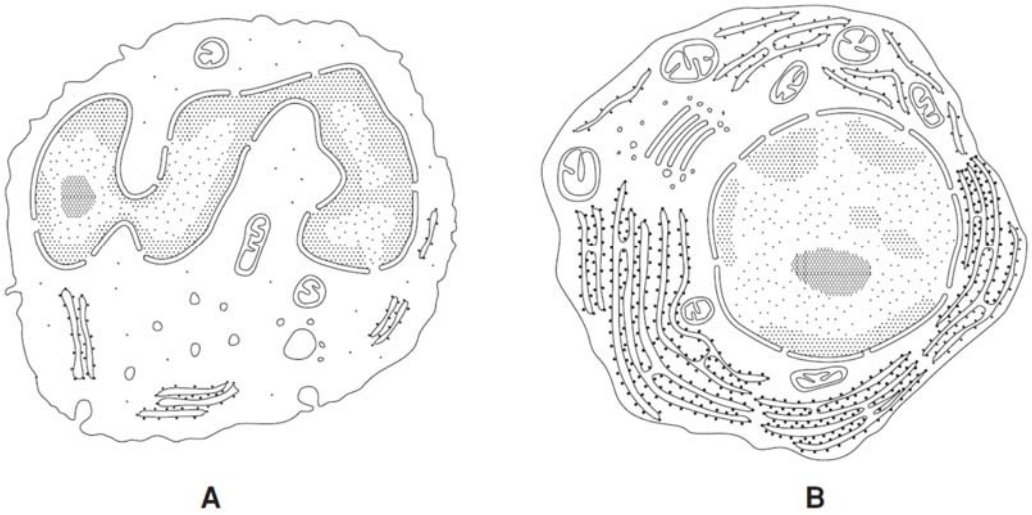


Fig. 10.1

(a) State two visible structural differences between the cells **A** and **B**. [2]

Structural feature	Phagocyte (A)	Plasma cell (B)
1. Rough endoplasmic reticulum (RER)	**Small quantity**	**Large quantity**
2. Ribosomes	**Few OR Free ribosomes**	**Many OR RER bound ribosomes**
3. Lysosomes/vacuoles	**Present**	**Absent**
4. Nucleus	**Lobed/irregular/not round**	**Round/not lobed/regular/ circular**
5. Golgi body	**Absent**	**Present**
6. Mitochondria	**Few**	**Many**
7. Presence of endocytotic/pinocytotic/ phagocytic/exocytotic vesicles	**Present**	**Absent**

(b) With reference to Fig. 10.1, describe the modes of action of the two cells in defence against infectious diseases. [4]

phagocyte

1. **ingest/engulf/phagocytosis of / endocytosis of, bacteria/microbes/pathogens ; R: antigens, virus**
2. **(form) phagocytic / endocytotic, vacuoles/vesicles/phagosomes ;**
3. **lysosomes contains hydrolytic enzymes to digest / hydrolyse, (bacteria / AW) ;**
4. **antigen presentation;**

max 2

plasma cell

5. **produce / secrete / release / synthesise , antibodies ;**
6. **antibodies are proteins synthesized by ribosomes on RER ;**
7. **Golgi (body) packages antibodies ;**
8. **each type of plasma cell produces one type of antibody ;**
9. **antibody effects agglutination/opsonisation/neutralisation ;**

max 2

[Total: 6]

11 An analysis of ice cores from the Arctic and Antarctic can provide information about the composition of the Earth's atmosphere over thousands of years.

Fig. 11.1 shows the concentrations of carbon dioxide measured in ice cores, dated between 1000 and 2000 AD.

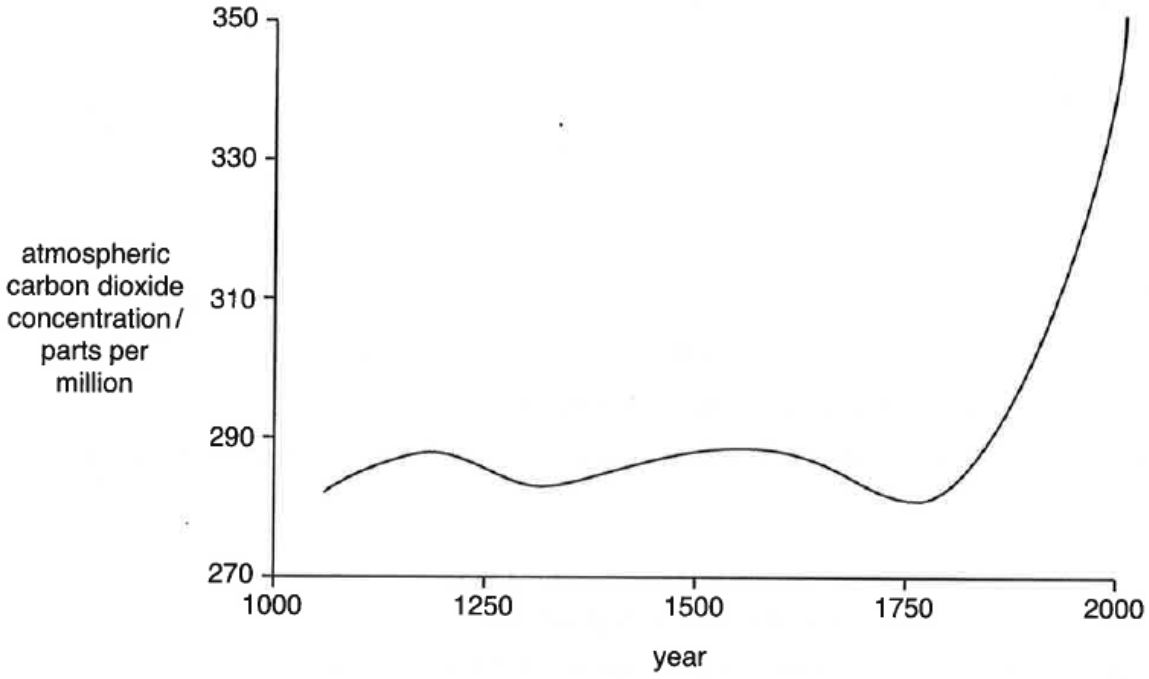


Fig. 11.1

(a) Describe the trend in Fig. 11.1. [2]

1. The atmospheric carbon dioxide concentration stayed relatively <u>constant</u> at around 285 parts per million in year 1060 and <u>increased exponentially/sharply</u> in year 1750 to reach 350 parts per million in year 2000 ;

1m for constant, increased sharply
1m for pair of figures

(b) Atmospheric carbon dioxide concentrations show regular annual variations. Suggest one reason for this. [1]

1. There are (four) seasons/seasonal changes in a year, atmospheric carbon dioxide concentrations is lower in summer and higher in winter ;

(c) Fig. 11.2 shows that, over the same period of time, the average surface temperature of the Earth has shown a similar pattern of change. The increasing concentrations of carbon dioxide is thought to be responsible for the increase in temperature over the last 100 years. This is referred to as the enhanced greenhouse effect.

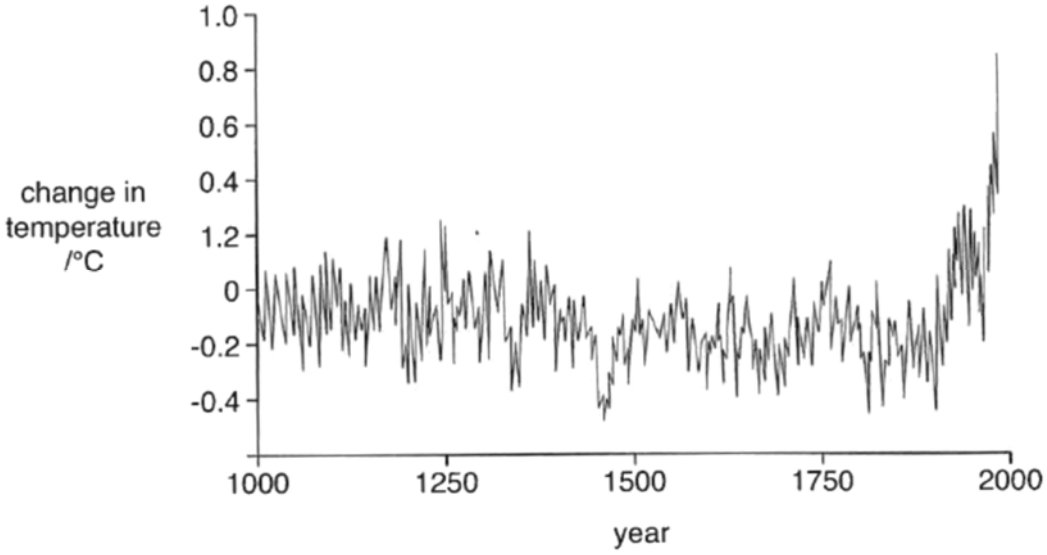


Fig. 11.2

(i) Describe one way in which the data in Fig. 11.2 resembles the data in Fig. 11.1 and one way in which it is different. [2]

Similarity:
The change in temperature stayed relatively constant before increasing exponentially/sharply ;

Difference:
there are more variations/fluctuations in the changes in temperature and less variations/fluctuations in atmospheric carbon dioxide concentrations ;

(ii) Describe one human activity that has contributed to the enhanced greenhouse effect. [1]

1. **<u>Burning of fossil fuels due to increasing energy usage releases large amounts of stored carbon into the atmosphere</u> as carbon dioxide (CO_2) and is the major source of CO_2 emission ;**
2. **<u>Deforestation</u> causes a net <u>reduction in carbon storage</u> as forested areas act as carbon sinks and results in <u>CO_2 emission when forests are burnt</u>, increasing the level of CO_2 in the atmosphere ;**

[Total: 6]

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JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME					
CLASS		INDEX NUMBER			

BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions **10 September 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name 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, glue or correction fluid.

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

Section B
Answer any **one** question 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.

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

For Examiner's Use	
1	
2	
3	
Section B	
Total	

This document consists of **19** printed pages and **1** blank page.

Section A

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

1 Over thousands and millions of years, there have been natural cycles in the Earth's climate. There have been ice ages (e.g. the Quaternary Ice Age) and warmer interglacial periods. Climatic changes can be investigated using evidence left in tree rings, layers of ice in glaciers, ocean sediments and layers of sedimentary rocks. For example, bubbles of air in glacial ice trap tiny samples of Earth's atmosphere, giving scientists a history of greenhouse gases that stretches back more than 800,000 years.

These changes in climate affect plant distribution and physiology. Fig. 1.1 is a diagram showing the topographical profile of two mountains in the tropics during a warm phase and a cool phase in the Earth's climate. The shape of the lines corresponds to a vertical section through the mountains to show their height and shape. The distribution of rain forest vegetation is also shown.

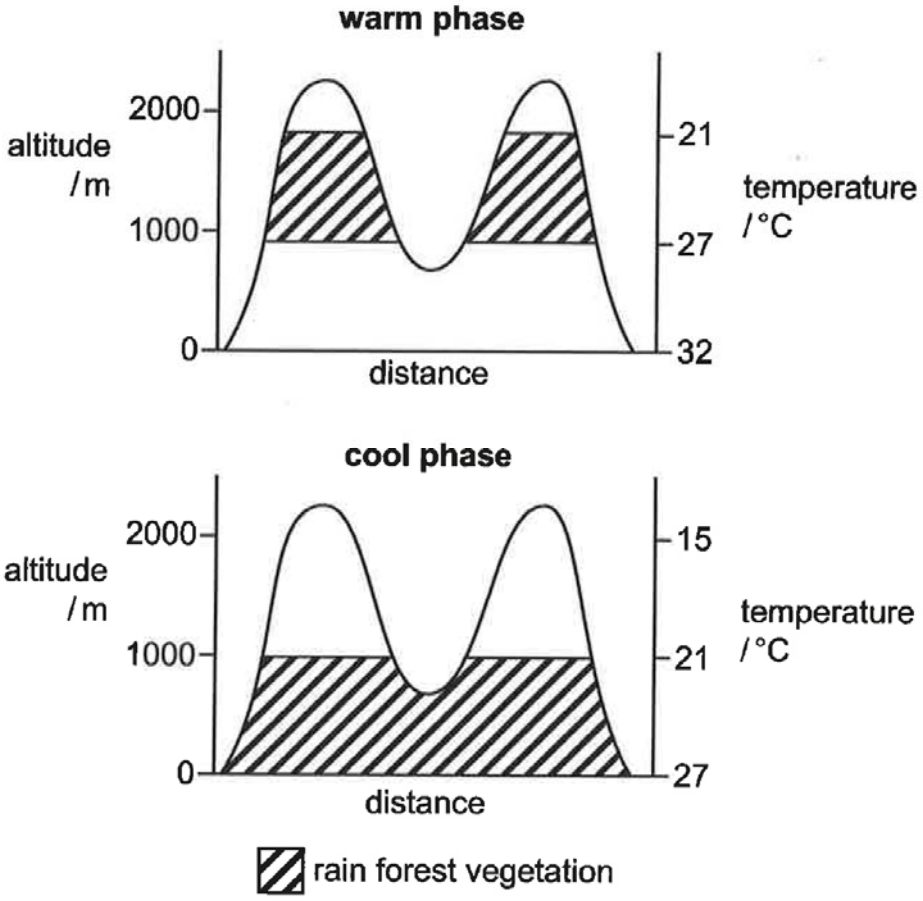

Fig. 1.1

(a) (i) Describe and explain the effect of climate change on the distribution of rain forest vegetation in the tropics, as shown in Fig. 1.1. [4]

(ii) Over millions of years there are repetitive cycles of climate change resulting in a pattern of alternating warm and cool phases in the Earth's climate.

Suggest how repeated changes in climate between the two phases shown in Fig. 1.1 may lead to evolution of new species and greater species diversity. [4]

(iii) As the atmosphere is thin at the top of the mountains, the plants growing at this region absorb high amounts of light energy from the sun since the sun rays are not scattered or reflected by the air molecules.

Explain how photosynthesis may be affected. [3]

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(b) Changes in the Earth's climate are also expected to have an impact on insects such as the *Aedes aegypti* mosquitoes which are commonly found in the tropics and sub-tropics. As the mosquitoes are the vectors carrying dengue virus and causes dengue in humans, their life-cycles have been studied in detail to manage their population size.

Describe the life-cycle of *Aedes aegypti*. [4]

(c) Another mosquito-borne disease of concern worldwide is malaria. Malaria was common in Italy, a European country situated in the Northern Hemisphere. Widespread land drainage together with the use of the insecticide DDT and the drug chloroquine eradicated both the mosquito vectors and the malaria parasites, *Plasmodium*, in the 1950s. Due to the success of these measures, they were later discontinued.

Articles in the scientific literature more recently show that malarial mosquitoes are returning to Italy and increasing their numbers and their northerly range, with some cases of malaria being reported. In general, winters are milder and summers hotter in the south of the country, with temperatures decreasing in the north, especially in winter.

Discuss whether the return of malaria to Italy can be attributed to climate change. [4]

(d) In many parts of the world, the malaria parasites, *Plasmodium*, have become resistant to chloroquine. In these areas, one of the most effective anti-malarial drugs currently in use is artemisinin. Artemisinin works by binding to an enzyme in *Plasmodium* called PfATP6, acting as an inhibitor.

A substance called curcumin, which has long been used as a spice and yellow food colouring in India and other countries, is also known to act against chloroquine-resistant *Plasmodium*. A group of researchers predicted that curcumin acts by binding to the same enzyme as artemisinin.

In order to test this hypothesis, and to try to find other similar substances that might work better than curcumin, the researchers used theoretical modelling to:

- look at the chemical structures of various molecules with a similar structure to curcumin (curcumin analogues)
- generate a three-dimensional model of the structure of the enzyme PfATP6
- investigate whether each curcumin analogue could bind to PfATP6.

The researchers predicted that several of the curcumin analogues would bind more strongly than curcumin to PfATP6.

(i) Suggest advantages of using theoretical models in this research, rather than testing possible drugs in the laboratory. [2]

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(ii) Suggest why theoretical modelling cannot completely replace laboratory trials in the search for new drugs. [2]

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(e) In places such as Africa where malaria is endemic, sickle cell anaemia — an inherited blood disorder — is prevalent in the populations. Sickle cell anaemia is caused by a single base pair substitution.

(i) Describe the effects of the mutation of the gene involved in sickle cell anaemia. [4]

(ii) Only those individuals that inherit two copies of the recessive allele which causes sickle cell anaemia develop the disease. If left untreated, these individuals have a shorter than normal life expectancy. As such, it would be expected that this mutation would be rare in human populations. However, observations made during the mid-20th century revealed that there are sometimes 10-40% of the population carrying this recessive allele.

Explain how there can be a high proportion of the population carrying the recessive allele even when it is disadvantageous. [3]

[Total: 30]

2 Fig. 2.1 shows stem cells in bone marrow dividing by mitosis to form blood cells. Each time a stem cell divides, it forms a replacement stem cell and a cell that develops into a blood cell.

Stem cells in the bone marrow give rise to reticulocytes, phagocytes, B-cells and T-cells.

Reticulocytes will differentiate into red blood cells.

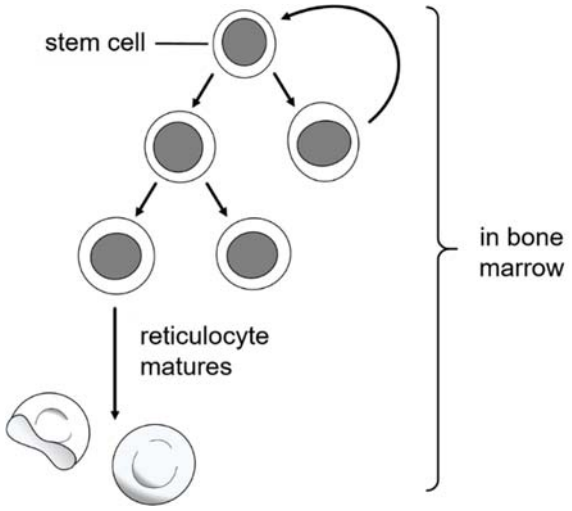

Fig. 2.1

(a) Describe how a functional red blood cell develops from a stem cell. [3]

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(b) Stem cells share some features of cancer cells, such as having long life span and ability to replicate for extended periods of time.

In some cases, the use of stem cells in medical treatment of genetic diseases appears to increase the risk of cancer.

Suggest why there might be a connection between the medical use of stem cells in treatment and increased cancer risk. [2]

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Stem cells can also differentiate to form T cells. T cells are arguably the most important cells in adaptive immunity, as they are required for almost all adaptive immune responses.

A person infected with the HIV virus was monitored for several years for the level of T cells and HIV particles.

The results are summarised in Fig. 2.2.

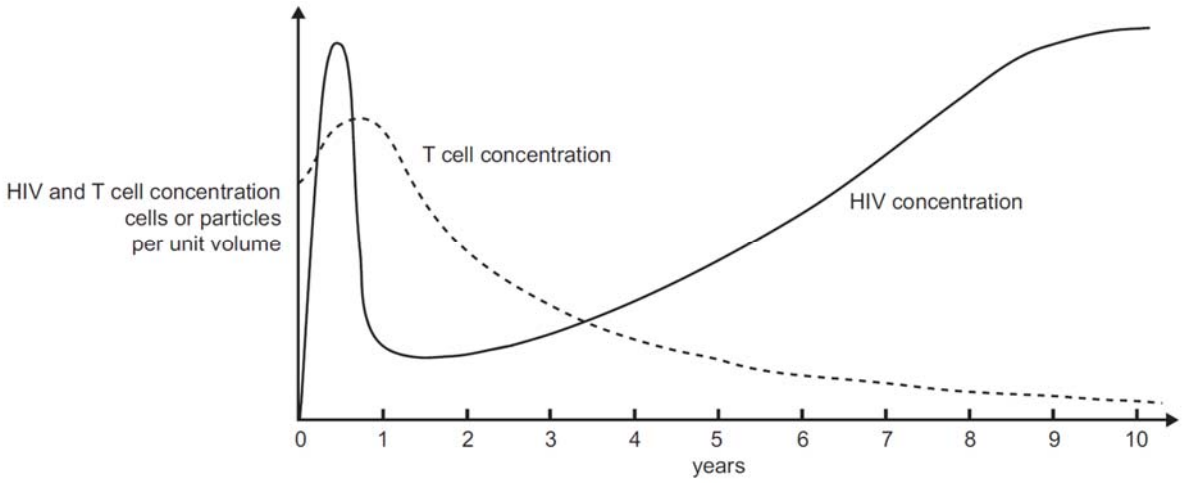

Fig. 2.2

(c) Explain the trend observed from 0.5 to 10 years. [4]

Enzymes essential in the life cycle of human immunodeficiency virus (HIV) have been at the focus of research. HIV-1 protease is one such enzyme.

HIV-1 protease is formed from two identical polypeptides, each of which is made up of 99 amino acids. The polypeptides both have α helices and β strands. The active site of the enzyme is formed by three amino acids from each polypeptide. Fig. 2.3 shows HIV-1 protease.

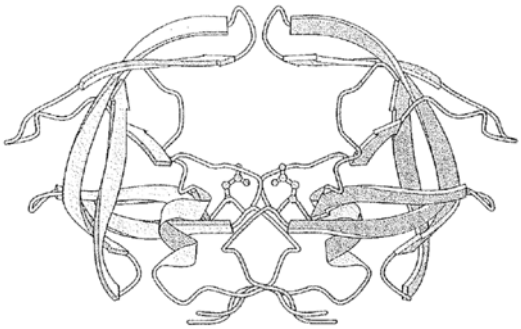

Fig. 2.3

Over the years, knowledge of the structure led to designs of HIV protease inhibiting drugs with improved antiviral properties. Despite the qualified success of these inhibitors, the high mutation rate associated with RNA viruses continues to hamper the long-term clinical efficacy of HIV protease inhibitors.

(d) Suggest why this means that researchers may need to continue to develop new drugs in order to prevent the action of HIV-1 protease. [2]

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[Total: 11]

3 G protein-coupled receptors (GPCRs) constitute a large protein family of receptors that detect molecules outside the cell and activate internal signal transduction pathways and, ultimately, cellular responses in mammals.

(a) Describe two ways in which GPCRs are similar in structure and explain why these features are important for their function. [4]

The glucagon receptor is a Class B GPCR that plays a central role in the regulation of blood glucose levels and glucose homeostasis. The actions of glucagon are transduced via activation of the glucagon receptor.

(b) Describe how binding of glucagon aids in the maintenance of a constant blood glucose level. [4]

(c) The following findings were concluded from studies on the expression of the glucagon receptor mRNA in liver, adipose tissues and pancreatic islets.

- The promoter of the glucagon receptor gene contain regulatory elements for glucose and cyclic AMP.
- The expression of the glucagon receptor mRNA is stimulated by glucose and inhibited by cyclic AMP in liver.
- The number of glucagon receptors expressed in the liver can be regulated by glucagon.

Comment how the above features are advantageous to mammals. [1]

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_____

[Total: 9]

Section B starts on page 14

Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

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 parts **(a)** and **(b)**, as indicated in the question.

4 **(a)** The organelles of the endomembrane system in eukaryotic cells are related through direct contact or by the transfer of membrane segments as vesicles.

Outline the functions of the organelles of the endomembrane system and state the structural similarities between these organelles. [15]

(b) Binary fission is a process where a single bacterial cell divides into two genetically identical daughter cells. Discuss if human cells are genetically identical and contrast the organisation of bacterial and human genome. [10]

[Total: 25]

5 **(a)** Variation exists in individuals of the same species in a population due to a number of different reasons. Describe what causes variation and why it is important in natural selection. [15]

(b) Discuss, using known examples, how limiting factors can influence the rate of various biological processes. [10]

[Total: 25]

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JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME	**Tr's Copy**				
CLASS		INDEX NUMBER			

BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions **10 September 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name 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, glue or correction fluid.

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

Section B
Answer any **one** question 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.

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

For Examiner's Use	
1	
2	
3	
Section B	
Total	

This document consists of **23** printed pages.

Section A

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

1 Over thousands and millions of years, there have been natural cycles in the Earth's climate. There have been ice ages (e.g. the Quaternary Ice Age) and warmer interglacial periods. Climatic changes can be investigated using evidence left in tree rings, layers of ice in glaciers, ocean sediments and layers of sedimentary rocks. For example, bubbles of air in glacial ice trap tiny samples of Earth's atmosphere, giving scientists a history of greenhouse gases that stretches back more than 800,000 years.

These changes in climate affect plant distribution and physiology. Fig. 1.1 is a diagram showing the topographical profile of two mountains in the tropics during a warm phase and a cool phase in the Earth's climate. The shape of the lines corresponds to a vertical section through the mountains to show their height and shape. The distribution of rain forest vegetation is also shown.

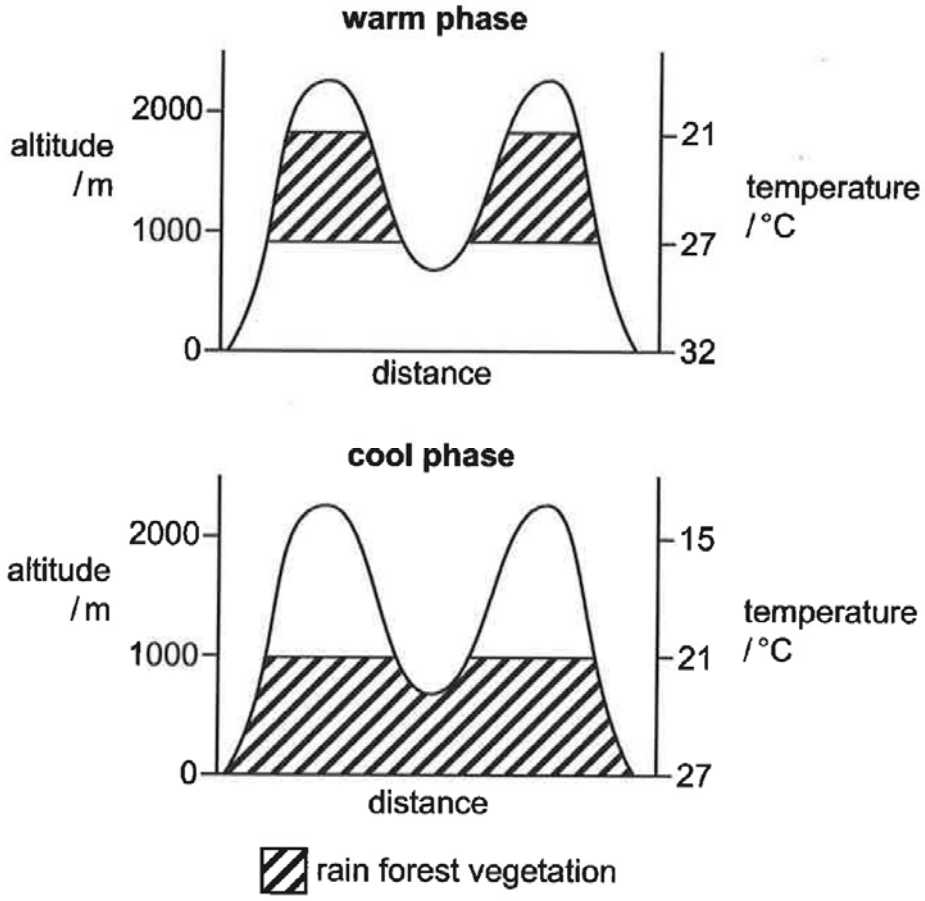

Fig. 1.1

(a) (i) Describe and explain the effect of climate change on the distribution of rain forest vegetation in the tropics, as shown in Fig. 1.1. [4]

Describe

1. **Warm phase 900—1800 m, cold phase 0—1000 m ;**
2. **Distribution continuous in cool phase, discontinuous/patchy/forming islands in warm phase ;**

Explain

3. **Rain forest vegetation will only grow in temperature range of 21—27 °C ;**
4. **Lower temperatures at higher altitude/ORA ;**
5. **As temperature increases, the distribution of rain forest vegetation shifts towards higher altitudes/ORA ;**

(ii) Over millions of years there are repetitive cycles of climate change resulting in a pattern of alternating warm and cool phases in the Earth's climate.

Suggest how repeated changes in climate between the two phases shown in Fig. 1.1 may lead to evolution of new species and greater species diversity. [4]

Warm phase (max 2)

1. **Geographical isolation leading to allopatric speciation ;**
2. **Reduced/no gene flow/interbreeding ;**
3. **Different conditions/different selection pressures ;**

Cool phase

4. **Ref. to spread of new species (to places that they were not prev found in) ;**
5. **previously isolated populations come back into contact but can no longer interbreed ;**

6. **ref. to effect of repeated rounds of speciation/fragmentation ;**

(iii) As the atmosphere is thin at the top of the mountains, the plants growing at this region absorb high amounts of light energy from the sun since the sun rays are not scattered or reflected by the air molecules.

Explain how photosynthesis may be affected. [3]

1. **At higher light intensities/with more light, there will be higher rate of photosynthesis/light dependent reaction/photophosphorylation/light independent reaction/Calvin cycle ;**
2. **more electrons of special chlorophyll a in the reaction centre of the photosystems are excited and boosted to a higher energy level/more photoactivation ;**
3. **increasing movement of electrons down both ETCs ;**
4. **There is more photolysis of water ;**
5. **resulting in more ATP and NADPH synthesis ;**
6. **more triose phosphate and glucose formed ;**

any 4 discussion points from MP 2-6 for max 2m

(b) Changes in the Earth's climate are also expected to have an impact on insects such as the *Aedes aegypti* mosquitoes which are commonly found in the tropics and sub-tropics. As the mosquitoes are the vectors carrying dengue virus and causes dengue in humans, their life-cycles have been studied in detail to manage their population size.

Describe the life-cycle of *Aedes aegypti*. [4]

1. **Female Aedes aegypti lay their eggs above the water line in areas likely to temporarily flood such as tree holes and containers (e.g. buckets, discarded bottles and flower pots) ;**
2. **Mosquito larvae hatch from the submerged eggs 2 days after the containers are filled with water and feed on microorganisms found in the water ;**
3. **Larvae go through developmental stages in which they moult four times over 5 days / moult to become fourth instar ;**
4. **When a larva is a fully grown fourth instar, it undergoes metamorphosis into a new form called a pupa ;**
5. **After two days, the fully developed adult mosquito forms and breaks through/emerge from the pupal case ;**

1m for 4 correct stages (egg, larva, pupa and adult)
3m for elaborations
l number of days

(c) Another mosquito-borne disease of concern worldwide is malaria. Malaria was common in Italy, a European country situated in the Northern Hemisphere. Widespread land drainage together with the use of the insecticide DDT and the drug chloroquine eradicated both the mosquito vectors and the malaria parasites, *Plasmodium*, in the 1950s. Due to the success of these measures, they were later discontinued.

Articles in the scientific literature more recently show that malarial mosquitoes are returning to Italy and increasing their numbers and their northerly range, with some cases of malaria being reported. In general, winters are milder and summers hotter in the south of the country, with temperatures decreasing in the north, especially in winter.

Discuss whether the return of malaria to Italy can be attributed to climate change. [4]

YES

1. **Range extending further north may relate to warmer temperatures ;**
2. **Change/increase, in rainfall may result in more flooded areas for mosquitoes to breed ;**
3. **Rate of malaria parasite replication within host/vector increases and extrinsic incubation period shortens due to warmer temperatures ;**

NO

Any 3 from

4. **Mosquitoes, migrate/are introduced, from surrounding countries ;**
5. **(thrive because they) historically lived in Italy/Italy provides suitable, habitat/conditions, for them ;**
6. **(thrive because) use of, DDT/some insecticides, was discontinued/banned (after 1950s/eradication ;**
7. **Survival and reproduction of malaria parasite in, host/vector, not/hardly, affected by ambient temperature ;**

Max 3 if no stand stated (need at least 1) /not balanced

(d) In many parts of the world, the malaria parasites, *Plasmodium*, have become resistant to chloroquine. In these areas, one of the most effective anti-malarial drugs currently in use is artemisinin. Artemisinin works by binding to an enzyme in *Plasmodium* called PfATP6, acting as an inhibitor.

A substance called curcumin, which has long been used as a spice and yellow food colouring in India and other countries, is also known to act against chloroquine-resistant *Plasmodium*. A group of researchers predicted that curcumin acts by binding to the same enzyme as artemisinin.

In order to test this hypothesis, and to try to find other similar substances that might work better than curcumin, the researchers used theoretical modelling to:

- look at the chemical structures of various molecules with a similar structure to curcumin (curcumin analogues)
- generate a three-dimensional model of the structure of the enzyme PfATP6
- investigate whether each curcumin analogue could bind to PfATP6.

The researchers predicted that several of the curcumin analogues would bind more strongly than curcumin to PfATP6.

(i) Suggest advantages of using theoretical models in this research, rather than testing possible drugs in the laboratory. [2]

1. **cheaper / more economical / more cost-effective / less wastage leading to cost savings ;**
2. **faster / can try many different drugs in a short time / time-saving / greater ease / theoretical models can reproduce the structure of the analogues that are rare or hard to acquire or produce ; [R: less effort]**
3. **can try out <u>changes</u> to <u>model/drug structure</u> to see if more <u>effective</u> ;**
4. **<u>no need for laboratories/equipment</u> ; IGNORE: uses less labour**
   R: resources [Must specifically state what *type* of resources]
5. **(initially) <u>no need for tests</u> on <u>animals/humans</u> / <u>fewer ethical issues</u> ;**

REJECT:

- **ORA [i.e. why lab methods more disadvantageous]**
- **"*can be quantified and statistical analysis can be done*"**
- **"*prevent the development of drug-resistant pathogens*"**
- **"*does not involve use of actual malaria parasite and thus reduce risk of disease outbreak from the laboratory*"**

(ii) Suggest why theoretical modelling cannot completely replace laboratory trials in the search for new drugs. [2]

1. **functionality/to test that drug, actually works/is effective / to test whether drugs are interfered by other molecules *in vivo* or in the parasite / if drug indeed inhibits *Plasmodium* ;**
2. **A cannot assume predictions are correct ; [I: efficiency, R: based on theory]**
3. **safety ; A ref. to clinical trials/side effects**
4. **dosage ; A theoretical modelling will not give information on doses**

REJECT:

- **Theoretical models only takes into account the spatial fit of the inhibitor in the binding site of PfATP6 and not the chemical fit. [Reason: theory should consider all aspects of fit already]**
- **Owing to selection for drug resistance, the structure of the allosteric site of PfATP6 had mutated with time and the analogues are no longer complementary to the allosteric site. Thus, theoretical models are unable to keep current or keep up with these new mutations. [Reason: neither can laboratory trials keep up! In fact it is harder]**

(e) In places such as Africa where malaria is endemic, sickle cell anaemia — an inherited blood disorder — is prevalent in the populations. Sickle cell anaemia is caused by a single base pair substitution.

(i) Describe the effects of the mutation of the gene involved in sickle cell anaemia. [4]

1. **In sickle cell anaemia, a single base pair substitution of the gene coding for ß chain causes adenine to replace thymine / DNA triplet to be changed from CTC to CAC in the gene/DNA ;**
2. **In the mRNA formed, GUG is coded for instead of GAG / resulting in hydrophobic valine replacing hydrophilic glutamic acid (at the 6th amino acid position of β chain) ;**
3. **This results in a change in the 3D conformation of haemoglobin to produce haemoglobin S (HbS) instead of HbA ;**
4. **This decreases the solubility of deoxygenated HbS and at low oxygen concentration, hydrophobic areas of different HbS would stick together / HbS molecules will polymerise and precipitate out of solution to form rigid fibres;**
5. **red blood cells becomes sickle shape and may block capillaries, impeding blood flow / deprives multiple organs of oxygen resulting in organ damage / have shorter lifespan and haemolyse readily, resulting in anaemia ;**

(ii) Only those individuals that inherit two copies of the recessive allele which causes sickle cell anaemia develop the disease. If left untreated, these individuals have a shorter than normal life expectancy. As such, it would be expected that this mutation would be rare in human populations. However, observations made during the mid-20th century revealed that there are sometimes 10-40% of the population carrying this recessive allele.

Explain how there can be a high proportion of the population carrying the recessive allele even when it is disadvantageous. [3]

1. **Due to <u>heterozygote advantage</u> ;**

2. **Individuals who are <u>heterozygous</u> for the recessive allele which causes sickle cell anaemia/sickle cell allele have <u>greater fitness / at selective advantage</u> as compared to individuals who are <u>homozygous</u> ;**
   [Must demonstrate *relative* advantage *over* homozygotes (including both Hb^SHb^S and Hb^AHb^A)]

3. **As <u>heterozygotes are protected</u> against a type of <u>severe malaria</u> [R: diseases], hence maintaining genetic variation in the population/ both alleles in the population/ a high frequency of the recessive allele ;**

[Total: 30]

2 Fig. 2.1 shows stem cells in bone marrow dividing by mitosis to form blood cells. Each time a stem cell divides, it forms a replacement stem cell and a cell that develops into a blood cell.

Stem cells in the bone marrow give rise to reticulocytes, phagocytes, B-cells and T-cells.

Reticulocytes will differentiate into red blood cells.

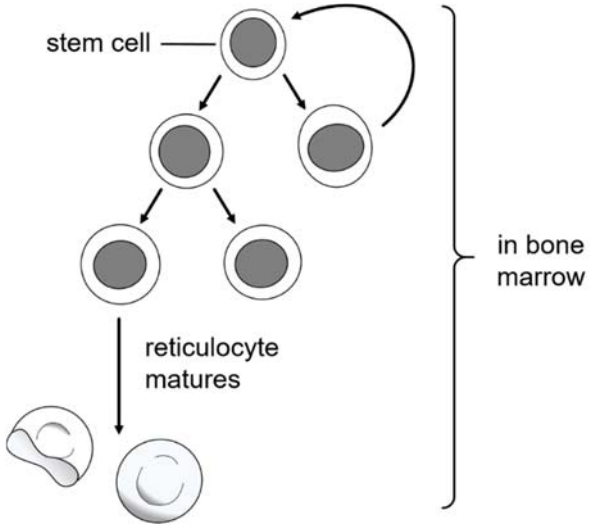

Fig. 2.1

(a) Describe how a functional red blood cell develops from a stem cell. [3]

1. **transcription (of specific genes) ; A: reference to differential gene expression**
2. **protein / polypeptide, synthesis ; A: translation**
3. **production of haemoglobin ;**
4. **further detail of haemoglobin formation ; e.g. assembly of quaternary structure**
5. **loss of, mitochondria / nucleus ;**
6. **adopts biconcave disc shape ;**
7. **increase in membrane elasticity of rbc to move through capillaries ;**

(b) Stem cells share some features of cancer cells, such as having long life span and ability to replicate for extended periods of time.

In some cases, the use of stem cells in medical treatment of genetic diseases appears to increase the risk of cancer.

Suggest why there might be a connection between the medical use of stem cells in treatment and increased cancer risk. [2]

1. **Stem cells and cancer cells share similarity of having <u>active telomerase</u> which a)<u>prevents the progressive shortening of telomeres</u> with each round of DNA replication OR b) have <u>limitless replicative potential/divide indefinitely</u> ;**

any 1:

2. **When exposed to carcinogens, spontaneous mutations occurs within stem cells resulting in uncontrolled cell division ;**
3. **Ref to one featur of cancer hallmark accumulated which heightens the risk of of cancer ;**

Stem cells can also differentiate to form T cells. T cells are arguably the most important cells in adaptive immunity, as they are required for almost all adaptive immune responses.

A person infected with the HIV virus was monitored for several years for the level of T cells and HIV particles.

The results are summarised in Fig. 2.2.

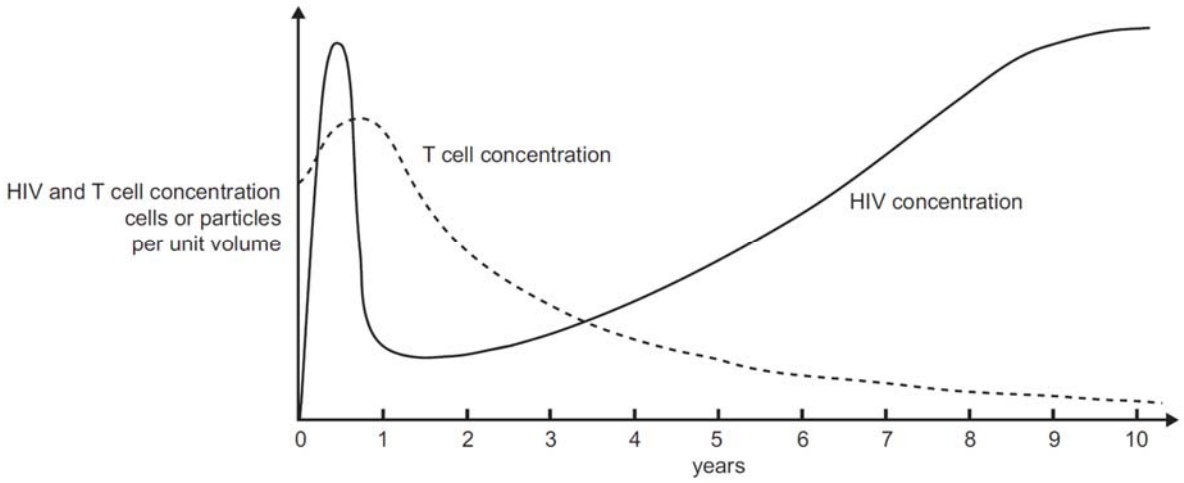

Fig. 2.2

(c) Explain the trend observed from 0.5 to 10 years. [4]

1. **<u>Sharp decrease</u> in HIV concentration 0.5 to 1 year post-infection ;**

2. **Concentration of T cells increased to remove HIV at the initial stage of infection OR**
3. **No active replication of HIV upon first half year post-infection OR**
4. **HIV infects T_H cells with some provirus integrating into the chromosome of T_H cells and remain dormant/ latent stage ;**

5. **HIV concentration <u>increases gradually</u> while T cells concentration <u>decreases gradually</u> from 1 to 10 years ;**

6. **Untreated HIV infection led to the replication of new virus that triggers the destruction of T_H cells ;**

Enzymes essential in the life cycle of human immunodeficiency virus (HIV) have been at the focus of research. HIV-1 protease is one such enzyme.

HIV-1 protease is formed from two identical polypeptides, each of which is made up of 99 amino acids. The polypeptides both have α helices and β strands. The active site of the enzyme is formed by three amino acids from each polypeptide. Fig. 2.3 shows HIV-1 protease.

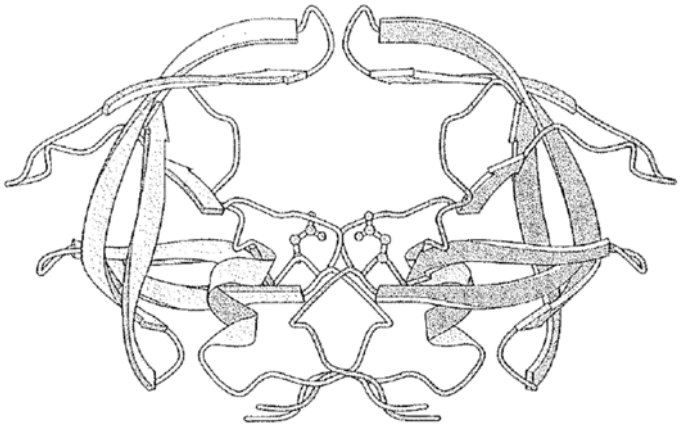

Fig. 2.3

Over the years, knowledge of the structure led to designs of HIV protease-inhibiting drugs with improved antiviral properties. Despite the qualified success of these inhibitors, the high mutation rate associated with RNA viruses continues to hamper the long-term clinical efficacy of HIV protease inhibitors.

(d) Suggest why this means that researchers may need to continue to develop new drugs in order to prevent the action of HIV-1 protease. [2]

1. mutations to the viral genome could alter the <u>genes coding for HIV-1 protease</u> ; OR
2. change in 3-D conformation of HIV-1 protease's active site ;

any 1:
3. drugs that are previously complementary to the active site may not be complementary to the new active site that resulted ;
4. ref to new strains of HIV that are resistant to drugs ;

[Total: 11]

3 G protein-coupled receptors (GPCRs) constitute a large protein family of receptors that detect molecules outside the cell and activate internal signal transduction pathways and, ultimately, cellular responses in mammals.

(a) Describe two ways in which GPCRs are similar in structure and explain why these features are important for their function. [4]

1. **(S) has (extracellular) <u>binding site for the (specific) signal molecule/ligand</u> ;**
   AND
2. **(F) <u>recognised and bound by (hydrophilic,) polar ligands</u> (which are unable to pass freely across the membrane) ;**

3. **(S) the extracellular parts of G-protein linked receptors may be <u>glycosylated</u> ;**
   AND
4. **(F) <u>serve as the binding site for (specific/ complementary) signal molecule/ ligand</u> ;**

5. **(S) has (intracellular) <u>binding site for G-protein</u> ;**
   AND
6. **(F) the G-protein linked receptor undergoes a conformational change upon the binding of a signal molecule/ligand that causes it to <u>bind and activate a specific G-protein</u> (which activates other signal transduction proteins inside the cell, leading to a specific cellular response) ;**

7. **(S) non-polar R groups of amino acid residues on the receptor form hydrophobic interactions with non-polar hydrocarbon tails of the membrane phospholipid molecules ;**
   AND
8. **(F) G-protein linked receptors are embedded in (and span) the plasma membrane, (held by weak hydrophobic interactions) ;**

A MP 1+4

The glucagon receptor is a Class B GPCR that plays a central role in the regulation of blood glucose levels and glucose homeostasis. The actions of glucagon are transduced via activation of the glucagon receptor.

(b) Describe how binding of glucagon aids in the maintenance of a constant blood glucose level. [4]

1. **binding of glucagon to specific binding site of GPCR induces a conformational change in the receptor ;**
2. **The receptor now binds to G protein and activates it ;**
3. **A molecule of GTP replaces the GDP on the G protein ;**
4. **The activated G-protein dissociates from the receptor and activates adenyl cyclase ;**
5. **Adenyl cyclase catalyses the conversion of ATP to / synthesis of cyclic AMP (cAMP) ;**
6. **The cAMP acts as a second messenger and triggers downstream signalling events such that glycogen phosphorylase is activated ;**
7. **Glycogen phosphorylase will catalyse the breakdown of glycogen to glucose (glycogenolysis) so that the blood glucose concentration <u>increases and return back to constant/normal levels</u> ;**

max 3 for MP 1-6

(c) The following findings were concluded from studies on the expression of the glucagon receptor mRNA in liver, adipose tissues and pancreatic islets.

- The promoter of the glucagon receptor gene contain regulatory elements for glucose and cyclic AMP.
- The expression of the glucagon receptor mRNA is stimulated by glucose and inhibited by cyclic AMP in liver.
- The number of glucagon receptors expressed in the liver can be regulated by glucagon.

Comment how the above features are advantageous to mammals. [1]

1. **allow/enable the expression of glucagon receptor gene <u>in response to the presence/absence of glucose and cyclic AMP;</u>**
2. **glucagon receptors are only expressed when required to <u>increase efficiency / conserve/prevent the waste of energy and resources</u>;**

[Total: 9]

Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

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 parts **(a)** and **(b)**, as indicated in the question.

4 **(a)** The organelles of the endomembrane system in eukaryotic cells are related through direct contact or by the transfer of membrane segments as vesicles.

Outline the functions of the organelles of the endomembrane system and state the structural similarities between these organelles. [15]

(Max 12 from pt 1 – 17)

Functions of the rough ER

1. **<u>sites of protein synthesis</u> ;**
2. **<u>biochemical modification</u> takes place in cisternal space / proteins may be modified by enzymes in the cisternal space of ER that add carbohydrate chains (or lipids) to them – <u>glycosylation</u> ;**
3. **serves as the <u>intracellular transport system</u> which transports the synthesised/modified proteins to other compartments within the cell by transport vesicles budding off from the ER membrane ;**
4. **The membrane of transport vesicles (formed from rough ER membrane) also replenishes the membrane of Golgi body ;**

Functions of the smooth ER

5. **responsible for the synthesis of lipids (e.g. phospholipids and steroid hormones) ;**
6. **involved in carbohydrate metabolism in the liver (glycogenolysis) ;**
7. **detoxification of drugs and other toxic substances in the liver ;**
8. **storage of calcium ions necessary for muscle contraction ;**

Function of Golgi body

9. **Further modify, sort and package proteins / products of ER into vesicles before transporting to other parts of the cell and/or out of the cell / targeted for other destinations ;**
10. **Formation of secretory vesicles containing matured proteins which move to the cell surface and fuse with the plasma membrane, releasing their contents out of the cell via the process of exocytosis ;**
11. **Formation of lysosomes containing hydrolytic enzymes/proteases/nucleases/ lipases ;**

(In plant cells)

12. **Packaging of polysaccharides destined for secretion, e.g. mucus ;**
13. **Formation of secretory vesicles containing polysaccharide which move to the cell surface and fuse with the plasma membrane, releasing their contents out of the cell via the process of exocytosis ;**
14. **During the synthesis of new plant cell walls, transport vesicles containing cell wall materials/pectins/certain non-cellulose polysaccharides fuse to form the cell plate ;**

MP 10&s13: award once

Function of Lysosomes

15. **Intracellular digestion - to digest material which the cell consumes from the environment through phagocytosis ;**
16. **Autophagy - to digest parts of the cell such as damaged or worn-out organelles;**
17. **Autolysis - self-destruction of a cell by releasing the hydrolytic enzymes of all lysosomes within the cell ;**

Structural similarities

18. **Presence of (single) membrane / phospholipids bilayer ;**
19. **Presence of proteins/enzymes within organelles ;**
20. **Presence of fluid-filled space ;**
21. **Association with cytoskeleton ;**

QWC:
Good spread of knowledge communicated without ambiguity to include:
At least 2 organelles' functions and at least 1 MP on the structural similarities.

(b) Binary fission is a process where a single bacterial cell divides into two genetically identical daughter cells. Discuss if human cells are genetically identical and contrast the organisation of bacterial and human genome. [10]

Definition of genetically identical ;

1. **daughter cells which contain exact copies/same genetic material or information/same number and type of chromosomes/same amount and type of DNA, as the parent cell**

Human/eukaryotic cells can be considered genetically identical because:

2. **(idea of) following fertilisation, single-cell zygote can undergo <u>mitosis</u> and divide into two genetically-identical cells ;**
3. **during S phase of interphase ; DNA replication takes place (with an identical copy of the DNA molecule synthesized) ;**
4. **most <u>somatic cells</u> of human are genetically identical ;**

Not all cells of a human are genetically identical because:

5. **Human is a <u>multicellular</u> organism with many different cell types ;**
6. **number of chromosomes are different in gametes/sperm/egg compared to most somatic cells ;**
7. **somatic hypermutation occurs in T and B cells ;**
8. **cells with specialised function such as red blood cells do not have nucleus ;**
9. **<u>telomeres shortening</u> takes place with repeated rounds of cell division, changing the DNA sequences ;**
10. **ref to virally infected cells where the viral DNA has been integrated into the chromosome of human host cell ;**
11. **ref to cancer cells with altered genes ;**

	Feature of comparison	Bacterial genome	Human genome
12.	**No. of chromosomes/ bases ;**	**Smaller number of chromosomes/bases**	**Greater number of chromosomes/bases**
13.	**No. of chromosomal set ;**	**Single chromosome/haploid/1 set**	**Multiple chromosomes/ diploid**
14.	**Clustering of genes ;**	**Polycistronic genes / operons**	**Monocistronic genes**
15.	**Presence of distal control elements/ enhancer/silencer ;**	**Absence of enhancer/silencer** **Presence of operator**	**Presence of enhancers / silencers**
16.	**Introns ;**	**Absent**	**Present**
17.	**Association with histones and other proteins ;**	**No association with histones/association with H-NS proteins**	**Association with histones / scaffolding proteins**

QWC:
clearly expressed and well structured, using correct terminology to address both parts of the question ;

5 (a) Variation exists in individuals of the same species in a population due to a number of different reasons. Describe what causes variation and why it is important in natural selection. [15]

Causes of Variation (Max 12)

1. **Variation is due to mutation, meiosis and sexual reproduction ;**

Gene Mutation

2. **Gene mutations are defined as changes in the sequence of DNA nucleotides in the gene;**
3. **Due to exposure to chemical carcinogens such as tobacco in cigarette smoke / ionising radiation such as UV-rays, X-ray / viruses / errors during DNA replication or repair etc.;**
4. **Base pair substitution / addition / deletion may occur, resulting in nonsense / silent / missense / frameshift mutation; (max 1)**

5. **Base-pair substitution – replacement of one nucleotide base pair with another base-pair in a gene, resulting in missense mutation/nonsense mutation/significant change in the encoded protein OR silent mutation/no/little effect on the encoded protein;**

6. **Base-pair addition – insertion of one or more nucleotide base pairs in a gene, resulting in frameshift mutation, whereby the reading frame is altered / nucleotides downstream from the mutation are improperly grouped into incorrect codons and read in different sets of threes;**
   OR
7. **Base-pair deletion – loss of one or more nucleotide base pairs in a gene, resulting in frameshift mutation, whereby the reading frame is altered / nucleotides downstream from the mutation are improperly grouped into incorrect codons and read in different sets of threes;**

Max 2 for MP 4-7

Chromosomal aberration

8. **Chromosomal aberration can be categorised as numerical aberration (the change in chromosome number) or structural aberration to chromosomes;**

9. **Translocation – a section of chromosome breaks off from one chromosome and becomes attached to another chromosome;**
10. **Duplication – a section of a chromosome replicates such that a set of gene loci is repeated;**
11. **Deletion – a chromosome breaks at two points, the middle portion is displaced with the two ends joining together;**
12. **Inversion – a chromosome breaks at two locations and the middle portion flips through 180° before rejoining;**

13. **Aneuploidy is a condition in the nucleus where there are one or several chromosomes more than or less than the diploid number of chromosomes;**
14. **Aneuploidy can result from non-disjunction during anaphase / when a haploid gamete fuses with a gamete carrying n-2, n-1, n+1 or n+2 chromosomes;**
15. **Polyploidy is a condition of the nucleus where there are three or more times the haploid number of chromosomes, e.g. 3n, 4n and 5n;**
16. **It can result from non-disjunction, the fusion of a diploid gamete with a normal haploid gamete giving a triploid nucleus;**

Meiosis

17. **In meiosis, crossing over between non-sister chromatids of homologous chromosomes occurs during prophase I;**
18. **Independent assortment of homologous chromosomes during metaphase I and chromatids during metaphase II;**
19. **Results in new combination of alleles;**

Sexual reproduction

20. **Random fusion of gametes during sexual reproduction;**
21. **Results in new combination of alleles (award once);**

Genetic variation in prokaryotes (max 2 per mechanism)

22. **Transformation is the uptake of naked, foreign DNA by competent cells from the surrounding environment resulting in the alteration of a bacterial cell's genotype and phenotype;**
23. **A (competent) bacterium takes up foreign DNA;**
24. **The foreign DNA is incorporated into bacterium's own DNA via homologous recombination/through crossing over with a homologous region found on the bacterial chromosome;**

25. **Transduction is the process by which bacterial DNA/genes is transferred from one bacterium (host cell) to another (recipient cell) via a bacteriophage;**
26. **When a (virulent) bacteriophage undergoes lytic cycle, a small piece of the host bacterial cell's degraded DNA is packaged within the capsid (of a defective phage); OR**
27. **When a (temperate) bacteriophage enters into lytic cycle from lysogenic cycle, a small region of the host bacterial DNA that was adjacent to the prophage is excised and the phage-host hybrid DNA is packaged within the capsid (of a defective phage);**
28. **The defective phage infects another bacterial cell and inject the piece of host bacterial DNA/ phage-host hybrid DNA into the newly infected bacterial cell cytoplasm, the host bacterial DNA/ phage-host hybrid DNA is incorporated into bacterium's DNA via homologous recombination/through crossing over;**

29. **Conjugation is the direct transfer of genetic material from one bacterial cell to another, through a temporary link between two cells (requires cell to cell contact);**
30. **F^+ cell/donor bacterial cell with F factor produces sex pilus to attach itself to F^- cell/recipient cell;**
31. **A temporary cytoplasmic mating bridge is formed between the two bacterial cells which allows F^+ cell to transfer its F plasmid to the F^- cell (by rolling circle mechanism);**

Importance in Natural Selection

32. **Variation describes the differences in characteristics / means the presence of different characteristics;**
33. **due to presence of different alleles in the different individuals;**
34. **resulting in differential reproductive success / different survival rates;**
35. **Variations in characteristics are subjected to selection pressure from the environment;**
36. **There can be continuous / discontinuous variation;**
37. **Due to interaction of genotype and environment;**
38. **variants with favourable characteristics will survive to maturity, reproduce and pass down their favourable alleles to their offspring;**
39. **Those with unfavourable characteristics die and fail to do so;**

QWC:
Good spread of knowledge communicated without ambiguity to include:
At least 2 causes of variation and at least 1 MP on the importance.

(b) Discuss, using known examples, how limiting factors can influence the rate of various biological processes. [10]

Definition

1. **A limiting factor is that factor which directly affects/determines the rate of reaction/process if its quantity is changed / when the factor is in lowest/shortest/scarcest supply. ;**
   [Reject "*in short / shorter / low / lower supply*"; MUST be "*short<u>est</u>*" or "*low<u>est</u>*"]

Biological Processes

2. **Biological Process: Enzyme-catalysed Reactions ;**

Factor	How Factor Influences Rate	
3. Substrate concentration	+ illustrate how factor influence rate	;
4. Enzyme concentration		;
5. Temperature		;
6. pH		;

REJECT: Concentration of competitive or non-competitive inhibitors as limiting factors.

7. **Biological Process: Facilitated Diffusion ;**

Factor	How Factor Influences Rate	
8. (Steepness of) concentration gradient / difference in concentrations of transported substance across a cell / biological membrane	+ illustrate how factor influence rate	;
9. Density of channel/carrier proteins on the membrane		;

10. **Biological Process: Photosynthesis ;**

Factor	How Factor Influences Rate	
11. Light intensity	+ illustrate how factor influence rate	;
12. Temperature		;
13. Carbon dioxide concentration		;

14. **Biological Process: Aerobic Respiration ;**

Factor	How Factor Influences Rate	
15. Glucose / hexose sugars concentration	+ illustrate how factor influence rate	;
16. Oxygen availability		;
17. Temperature		;
18. NAD^+ / FAD^+ / mobile electron carriers availability		;

19. Biological Process: Population Growth / Bacteria Colony Growth ;

Factor	How Factor Influences Rate	
20. Nutrient availability	**+ illustrate how factor influence rate**	**;**
21. Water availability		**;**
22. Temperature		**;**
23. Competition for resources / Predation / AVP		**;**

REJECT: Signal Reception / Ligand-Receptor Interactions as a form of biological process that is influenced by limiting factors. Any limits on rates of signal propagation and hence response efficacy is overcome by signal amplification.

QWC:
Clearly communicates limiting factors of 2 different biological processes