H

JC 2 PRELIMINARY
EXAMINATIONS Higher 2

CANDIDATE NAME

CLASS

BIOLOGY **9648/01**

Paper 1 Multiple Choice **28 September 2016**

1 hour 15 min

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

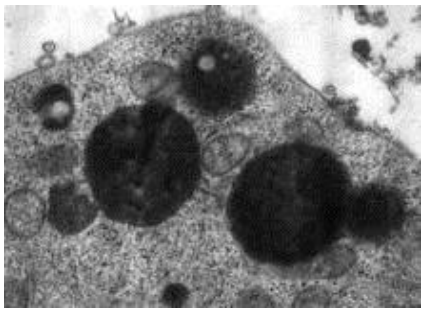
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Calculators may be used.

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

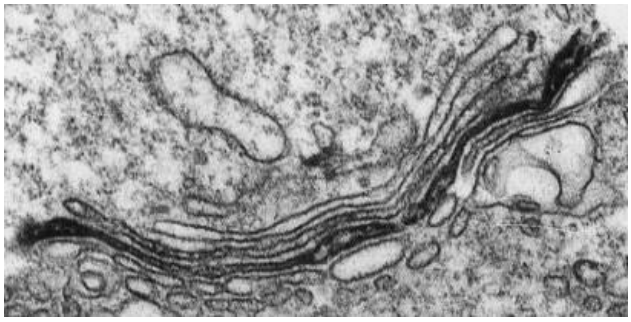
[Turn over

1 In an active cell, the pathway of a protein synthesis to maturation involves the endomembrane system.

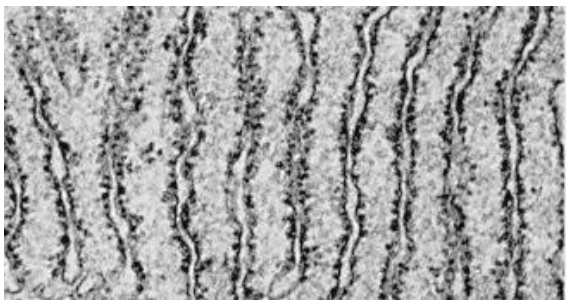
(I)



(II)



(III)



(IV)

The following are several processes that occur in an active cell.

w. modification of carbohydrates on protein

x. folding of protein into its 3 dimensional conformation

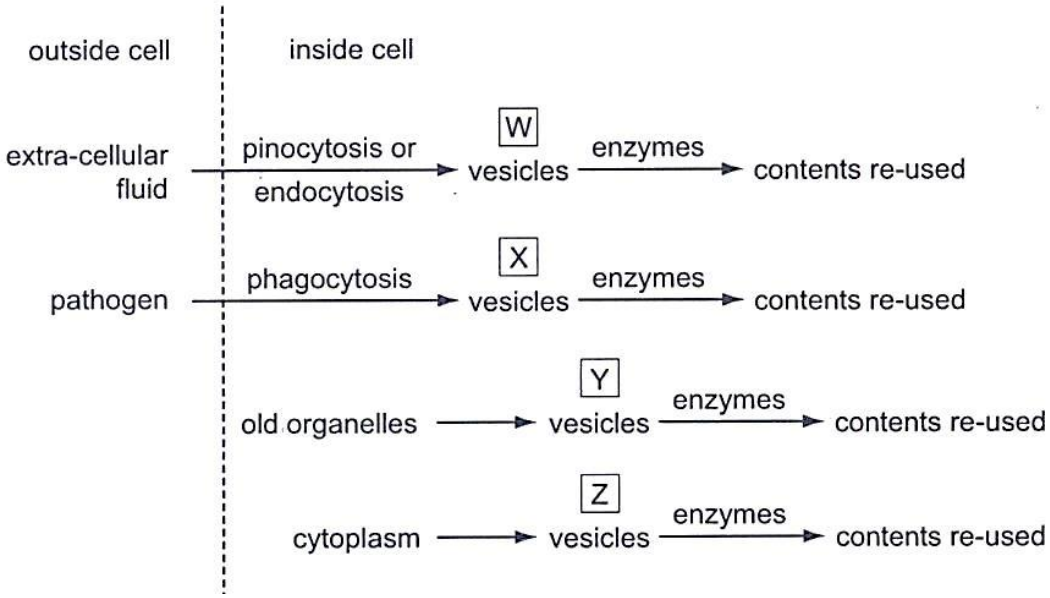
y. synthesis of steroids

z. storage of synthesized proteins

Where in the above diagrams do these processes take place?

	(I)	(II)	(III)	(IV)
A	z	w	y	x
B	z	w	x	y
C	y	w	x	z
D	z	y	x	w

2 The flow chart shows processes which takes place inside animal cells.



Which processes require the activity of lysosomes?

A **W, X, Y** and **Z**
B **W** and **X** only
C **X** and **Y** only
D **Y** and **Z** only

3 Which of the following lists of processes matches the type of movement across membrane correctly?

	Passive diffusion	**Facilitated diffusion**	**Active transport**	**Endocytosis**	**Exocytosis**
A	Exit of CO_2 from mitochondria	Chemiosmosis of H^+ through ATP synthase	Exit of Ca^{2+} from synaptic knob	Entry of HIV	Budding of influenza virus
B	Exit of CO_2 from mitochondria	Exit of K^+ from neuron	Entry of Na^+ into neuron	Entry of HIV	Budding of influenza virus
C	Entry of O_2 into mitochondria	Exit of K^+ from neuron	Exit of Ca^{2+} from synaptic knob	Entry of influenza virus	Release of insulin from β cells
D	Entry of O_2 into mitochondria	Chemiosmosis of H^+ through ATP synthase	Entry of Na^+ into neuron	Entry of influenza virus	Release of insulin from β cells

4 Raffinose is a trisaccharide which can be degraded by enzymes. The results of two different enzymatic incubations are shown in the table below:

Enzyme used	**Products**
Sucrase	Melibiose and fructose
Galactosidase	Galactose and sucrose

Which of following statements are consistent with the results shown above?

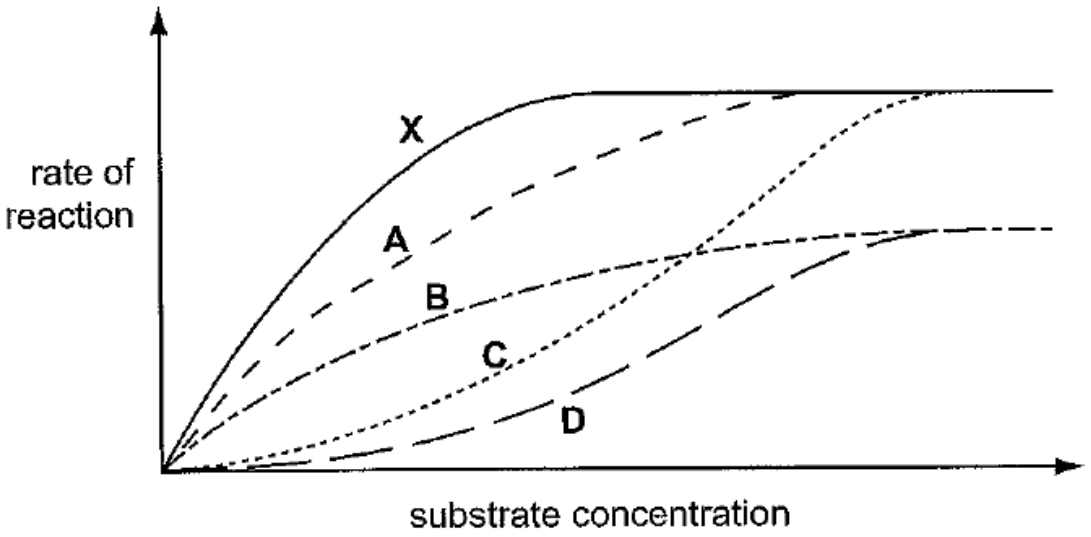
I Raffinose is composed of three different monosacchardies.
II Melibiose is a dissacharide.
III One of the products of acid hydrolysis of raffinose is glucose.
IV The products of raffinose digestion by sucrase and galactosidase respectively will yield a brick-red precipitate when heated with Benedict's reagent.

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

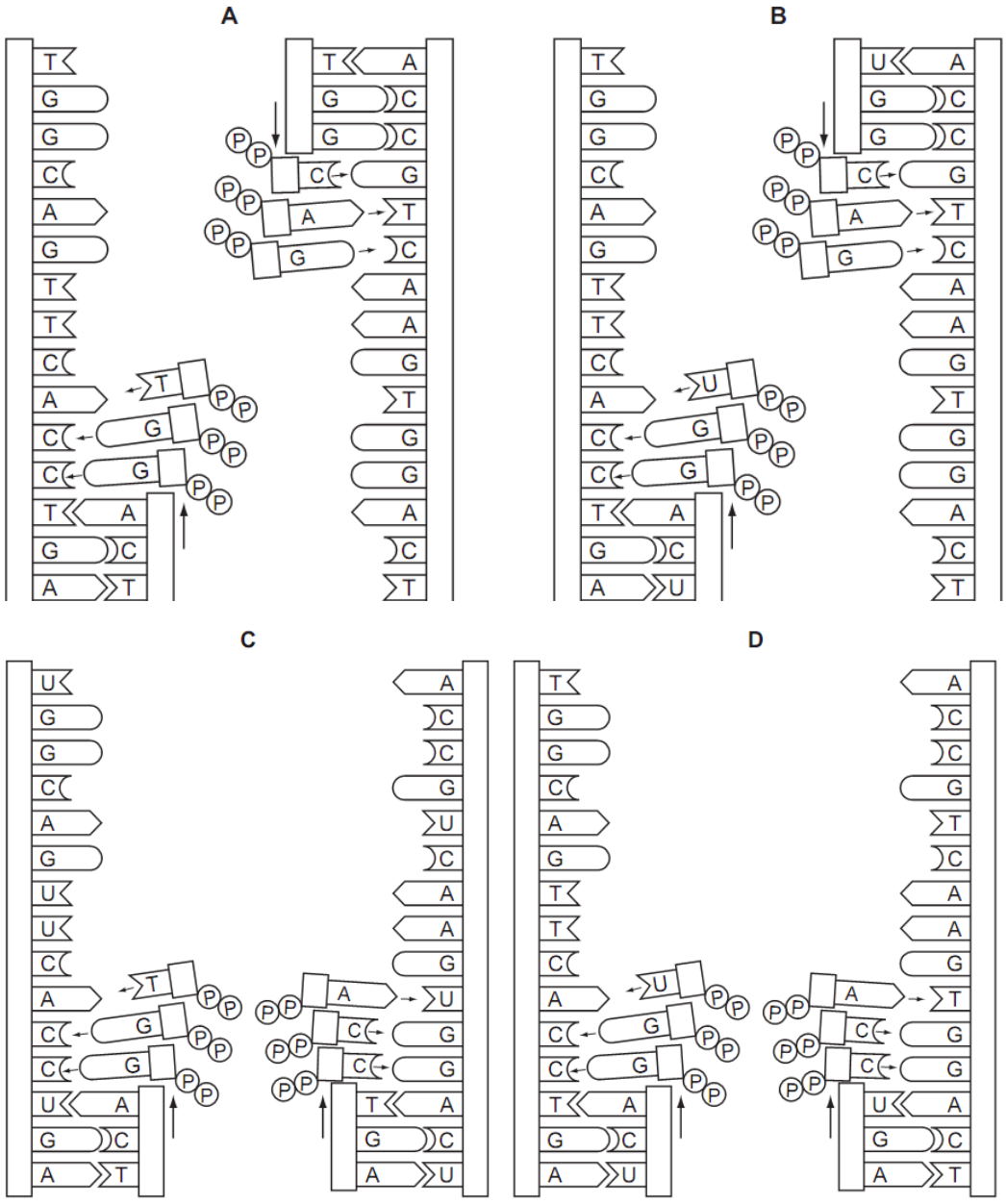
5 The reaction rate of salivary amylase on starch decreases as the concentration of chloride ions is reduced. Which of the following describes the role of the chloride ions?

A Allosteric inhibitors
B Co-enzymes
C Co-factors
D Competitive inhibitors

6 In the graph, X represents the initial rate of reaction of an enzyme in increasing substrate concentrations under optimum temperature and pH, in the absence of an inhibitor. Which curve represents the result when the same experiment is carried out under a lower temperature?



7 Which diagram shows the semi-conservative replication of a section of a molecule of DNA?



8 The diagram represents part of a DNA molecule.

Mutation	Name
from purine to other purine	transition
from pyrimidine to other pyrimidine	transition
from purine to pyrimidine	transversion
from pyrimidine to purine	transversion

Which diagram shows the DNA molecule with only transversion(s)?

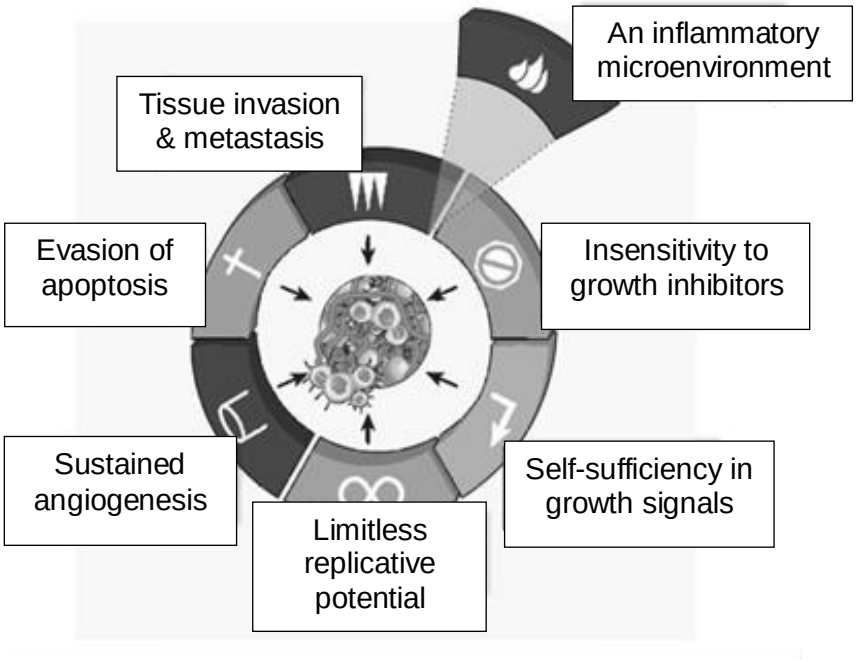
A

B

C

D

9 The diagram illustrates the hallmarks of cancer.



Which of the following statements correctly describe the changes in cancer cells?

I	Limitless replicative potential often results in the accumulation of chromosomal mutations in many cancer cells.
II	Cancer cells could overproduce signal molecules so that they become self-sufficient in growth signals.
III	Angiogenesis is the result of expression of oncogenes in a cell line that produces blood vessels.
IV	Loss-of-function mutations in tumour suppressor genes contribute to tissue invasion and metastasis.

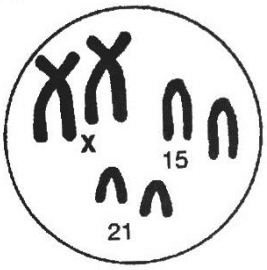
A **I** and **IV** only

B **II** and **III** only

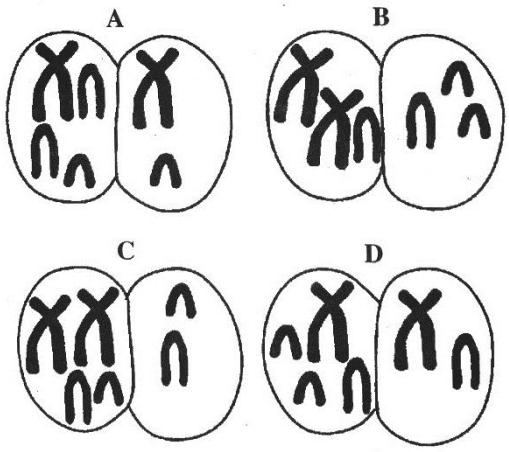
C **I, II** and **IV** only

D **II, III** and **IV** only

10 The diagram shows three of the 23 pairs of chromosomes found in a human cell.



Which diagram shows an example of non-disjunction in the formation of an egg, that could lead to the formation of a Down's syndrome zygote?



11 A toxic chemical causes malfunction of the centrioles in animal cells.

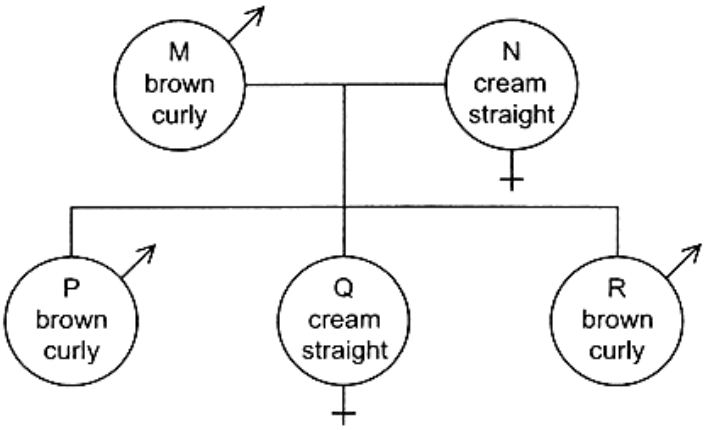
Which process in mitosis is likely to be directly affected by the chemical?

1 migration of the chromosomes
2 replication of centromeres
3 chromosome shortening
4 alignment of chromosomes

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

12 Assume that in goats a pair of alleles is responsible for the inheritance of hair colour and that another pair controls hair texture. These pairs are located on different autosomes. The allele for brown hair (B) is dominant to the allele for cream hair (b), and the allele for curly hair (C) is dominant to the allele for straight hair (c).

The diagram shows a cross between two goats.



If R is mated with a female goat of the same genotype as M, what are the chances of the first offspring being a male with cream coloured, straight hair?

A 0
B 1 in 32
C 1 in 16
D 1 in 4

13 A cross between a round-leafed, tall plant and round-leafed, dwarf plant produced the following offspring:

121 round-leafed, tall plants	R – round leaf
121 round-leafed, dwarf plants	r – oval leaf
42 oval-leafed, tall plants	T – tall
37 oval-leafed, dwarf plants	t – dwarf

What were the genotypes of the parents?

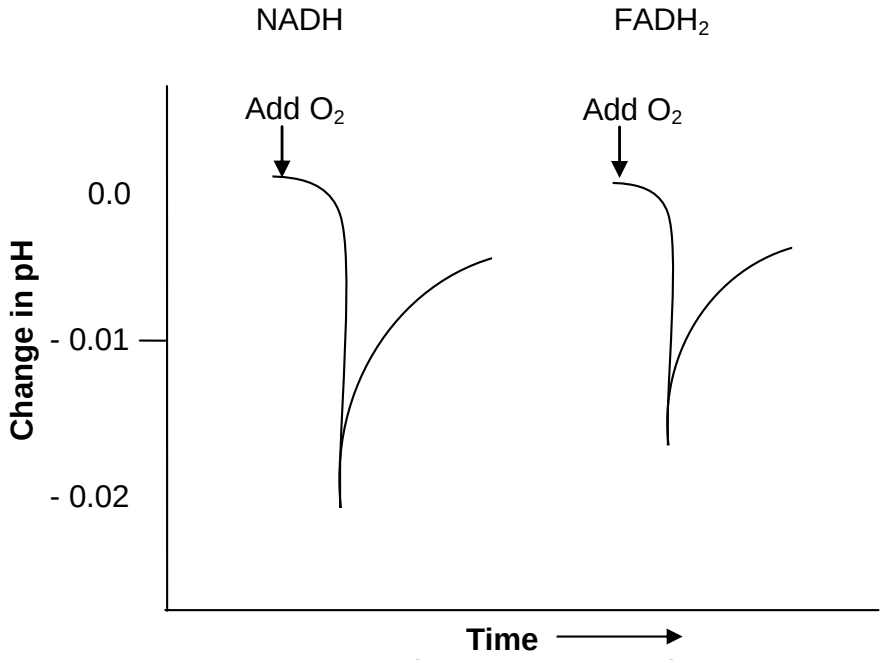
A RrTt x Rrtt
B RrTt x RRtt
C RrTT x Rrtt
D RrTT x RRtt

14 Black, chestnut and bay (reddish brown with black mane, tail, eartips and lower legs) coat colour in horses is determined by two genes. The dominant E allele codes for black and red pigment, while the recessive e allele codes only for red pigment. At a separate gene, the dominant A allele restricts any black pigment produced to the horse's mane, tail, eartips and lower legs, while the recessive allele allows any black pigment produced to show up throughout.

Two black horses were mated. Which of the following coat colours will definitely **not** show up in their offspring?

A Bay
B Black
C Chestnut
D All three colours are possible

15 Isolated mitochondria were incubated with NADH in one experiment and an equal amount of $FADH_2$ in another experiment. The mitochondria were initially deprived of oxygen. The pH of the intermembrane space was then monitored as a known quantity of oxygen was added. The results are shown in the graph.

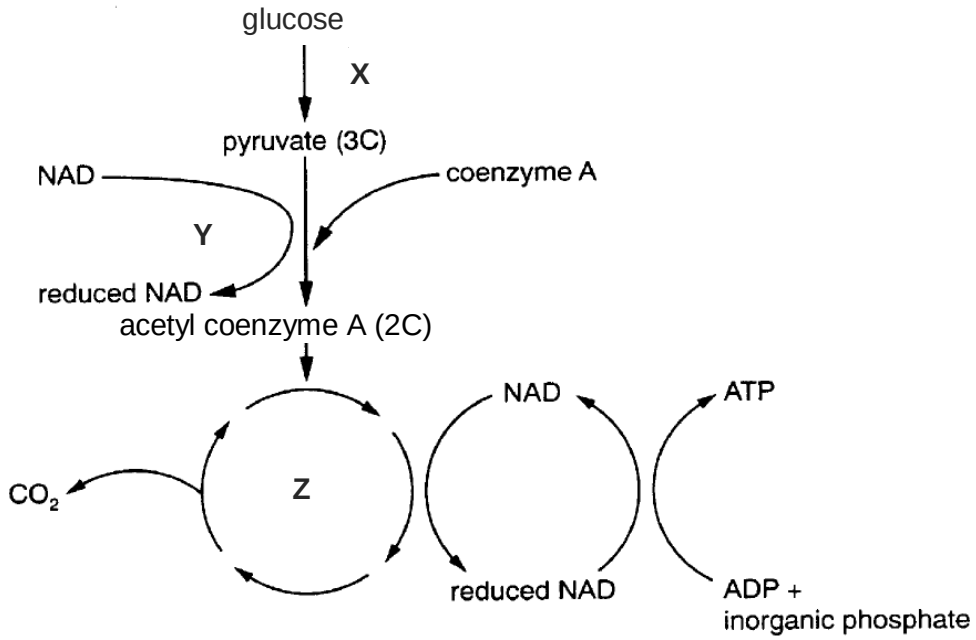


Which of the following can be concluded based on the results?

I	Upon the addition of oxygen, glycolysis and subsequently, link reaction, Krebs cycle and oxidative phosphorylation occurred.
II	Electron transfer was initiated by the addition of oxygen.
III	The pH drop was greater with NADH than with $FADH_2$, which is consistent with the greater ATP yield that accompanies the oxidation of NADH.
IV	The rapid decline in pH indicates that protons were pumped into the intermembrane space when oxygen was available.

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

16 The flow chart shows a series of reactions occurring in an animal cell.



Which of the following statements correctly describes the flow chart?

A Reaction **X**, which occurs in the cytosol, is an anabolic reaction.
B Reaction **Y** involves the process of substrate-level phosphorylation, whereby pyruvate is first converted to a compound called acetyl coenzyme A.
C Reaction **Y** occurs in the cytoplasm whereas reaction **Z** occurs in the mitochondria.
D Reaction **Z** is a catabolic pathway which occurs twice for every glucose molecule to be completely oxidised.

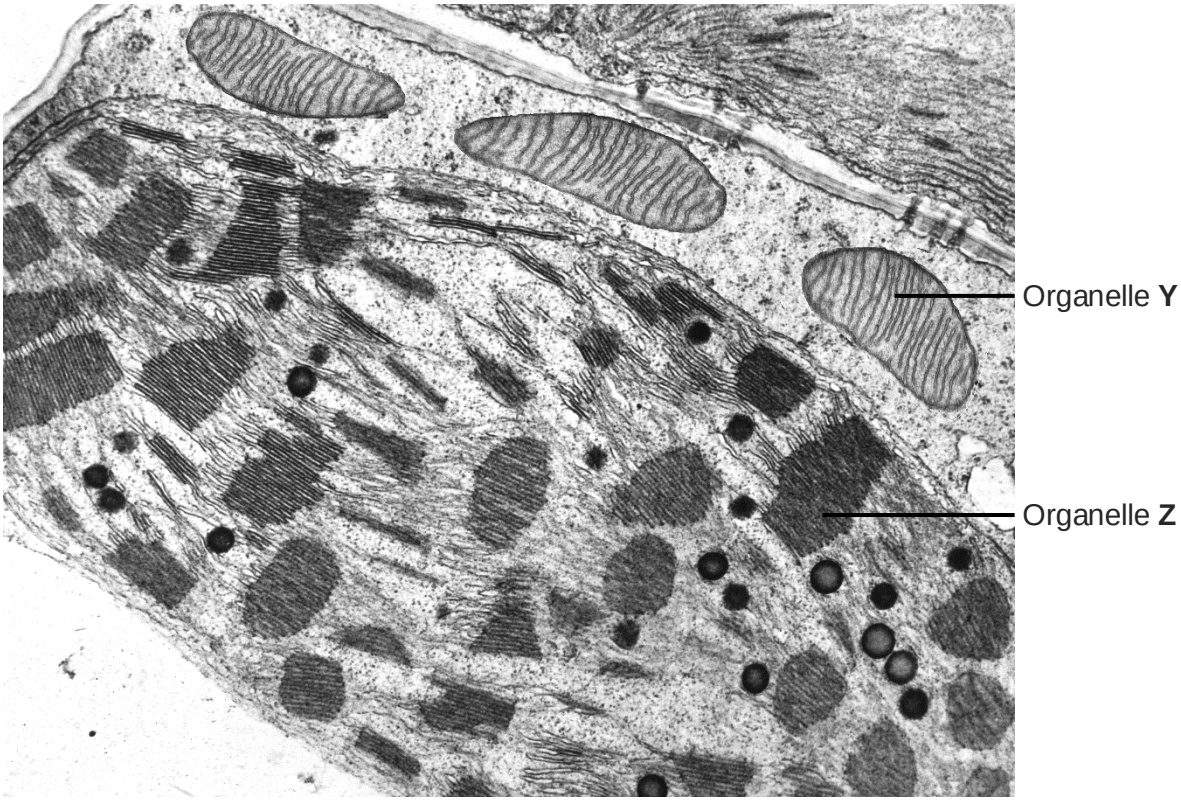
17 In a laboratory, a plant with variegated leaves (containing orange and green pigments) was supplied with radioactive carbon dioxide, $^{14}CO_2$. The plant was kept in the dark for 12 hours and then illuminated for the next 12 hours. A leaf from the plant was obtained and its level of radioactivity was measured both in the absence and presence of light. The results are shown in the table.

	Level of radioactivity in leaf (Arbitrary units)	
	Orange region of leaf	**Green region of leaf**
Absence of light	225	225
Presence of light	410	9271

Which of the following could be the most likely explanation for the level of radioactivity found in the orange region of the leaf in the presence of light?

A Some photosynthesis occurs in the orange region but due to the absence of chlorophyll in that region, the rate of photosynthesis is low.
B Photosynthesis occurs in the orange region but no storage of starch occurs.
C Photosynthetic products diffuse into the orange region.
D Radioactive $^{14}CO_2$ diffuses into the orange region and accumulates in that region.

18 A new species of plant was recently discovered in the Amazon forest. The electron micrograph shows two organelles **Y** and **Z** in a leaf mesophyll cell of the plant.

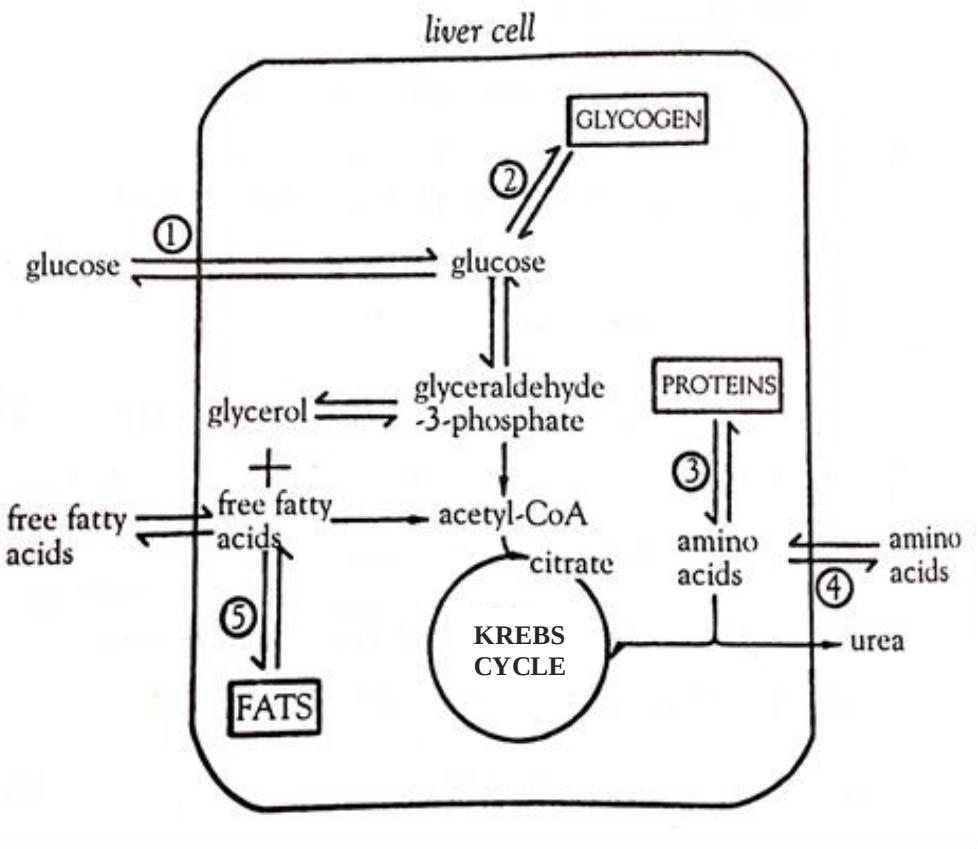


Which of the following statements are **not** true about organelles **Y** and **Z**?

I	Organelle **Z** utilises transporters to export ATP to organelle **Y** to drive cellular activities.
II	Oxygen released by organelle **Z** is used in organelle **Y** during Krebs cycle.
III	Phosphate ions in organelle **Y** is used for the production of ATP during Calvin cycle.
IV	NADPH molecules produced in organelle **Z** are used in organelle **Y** for the production of triose phosphate.

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

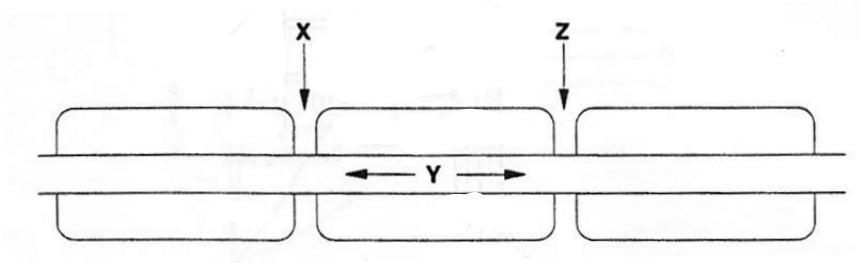
19 The diagram shows some biochemical pathways in a liver cell. Some of the points where hormones affect the pathways are labelled 1 to 5.



At which numbered points would the hormone insulin accelerate the pathway in the directions indicated?

A 1, 2 and 3
B 1, 2 and 5
C 1, 3 and 4
D 3, 4 and 5

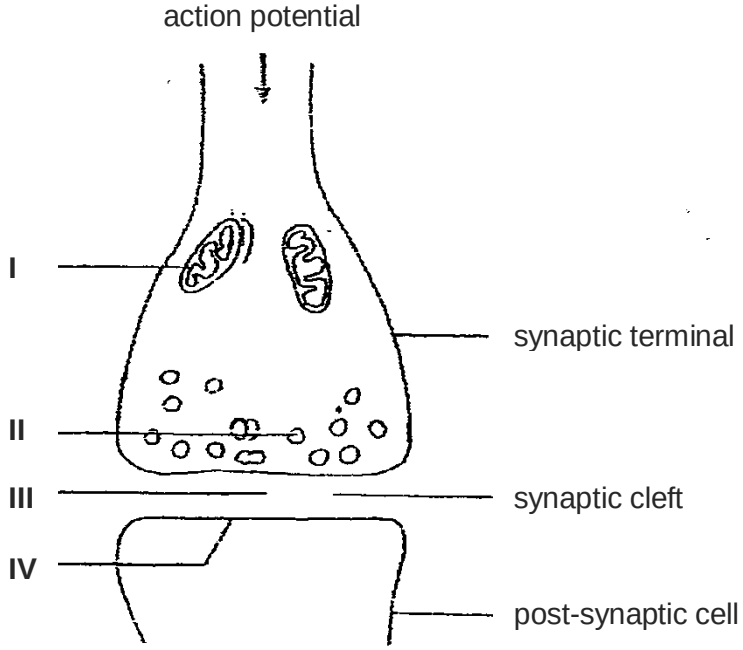
20 The diagram below shows a myelinated axon



How does the myelin sheath increase the speed of impulse transmission along the axon?

A It ensures that the ions are kept close to the axon membrane in region Y.
B It insulates the axon, so increasing the potential at regions X and Z.
C It restricts the change in potential difference to regions X and Z.
D It promotes a change in potential difference in region Y.

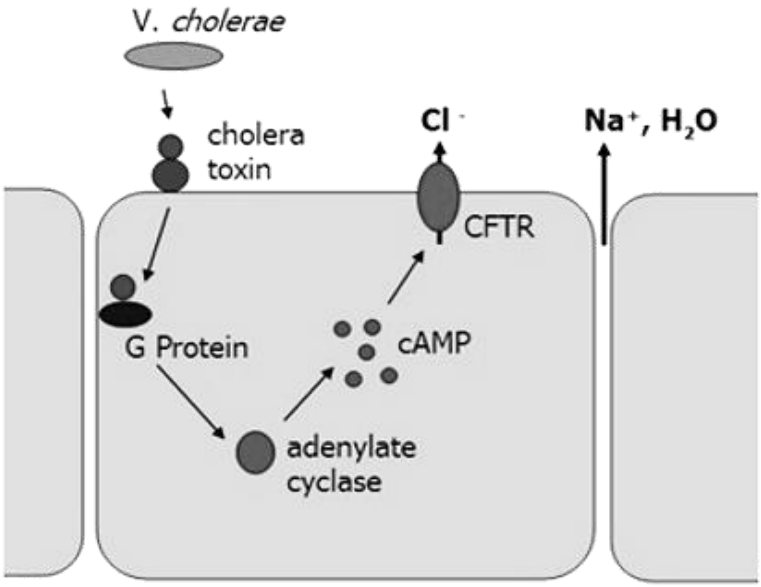
21 Snake venom contains a neurotoxin that affects synaptic transmission. The toxin can cause paralysis and death.



Which of the following is **NOT** a possible way for the toxin to act?

A The toxin reduces enzyme activity in structure **I**.
B The toxin diffuses into structure **II** and binds to its contents.
C The toxin binds with the contents of structure **II** after they are released into site **III**.
D The toxin lodges itself in between the phospholipids found on site **IV**.

22 Cholera is a disease caused by infection of the intestine with the bacterium *Vibrio cholera*. This disease is characterised by profuse diarrhoea, leading to excessive loss of fluids and dehydration. Cholera toxin binds to receptor, resulting in the activation of G protein involved in regulating salt and water secretion.



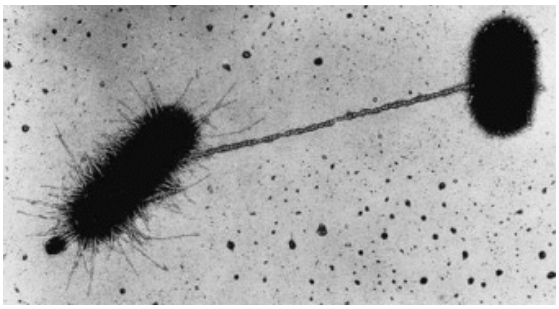
The toxin of *Vibrio cholera* causes profuse diarrhoea because

A cytosolic concentration of ions is decreased, making the cells hypotonic to the lumen of intestine
B phosphodiesterase is permanently activated
C G protein is modified such that it is unable to hydrolyse GTP to GDP
D cystic fibrosis transmembrane conductance regulator (CFTR) Cl^- channel is permanently activated due to binding of cAMP

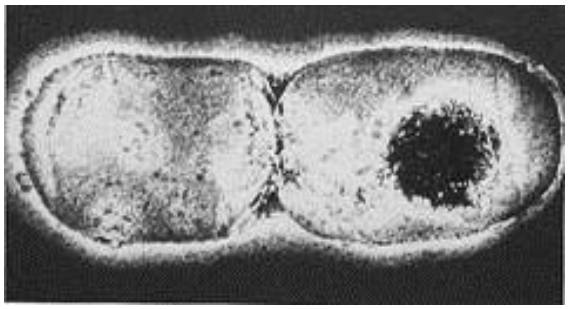
23 What is an example of a step that amplifies the signal during its transduction in a cell?

A the action of adenylyl cyclase in converting ATP to ADP
B the activation of protein kinase A by cAMP
C the binding of a steroid hormone to its intracellular receptor
D the phosphorylation of many mitogen-activated protein (MAP) kinase by an activated MAP kinase kinase

24 The photomicrographs below show two different processes occurring in two different species of bacteria.



Process 1



Process 2

Which of the following statements is/are true of both processes?

(i) For both processes, only bacteria with genes that code for cytoplasmic bridge are involved.

(ii) Process 1 requires direct contact between 2 different bacteria whereas process 2 can occur with 1 bacterium.

(iii) Process 1 will result in an increase in the number of identical bacteria whereas process 2 will result in an increase in the number of different bacteria.

(iv) Both processes involve DNA replication.

A (i) and (iii) only
B (ii) and (iv) only
C (i), (ii) and (iv) only
D (i), (ii), (iii) and (iv)

25 Which of the following statements could explain why a combination of different drugs rather than a single drug is being used to treat HIV patients?

(i) HIV has a short generation span (eg. 2 days).

(ii) In an AIDS patient, the HIV infection produces many new viruses per day (eg. 10^{10} new viruses per day or more).

(iii) HIV has an RNA genome which has a higher mutation rate than DNA as it is single stranded.

(iv) The RNA genome allows the HIV to mutate rapidly to acquire the resistance to the drug being used.

(v) Insertion of the HIV genome into the host cells will result in the host cells mutations that will confer resistance to the drug.

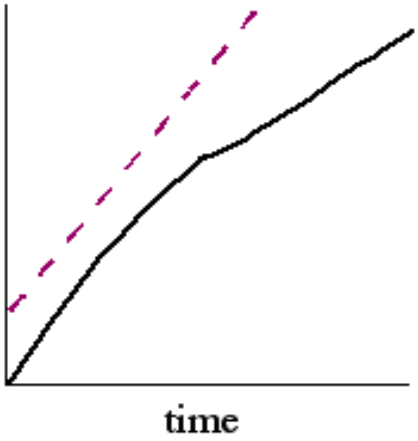
A (i) and (ii) only
B (iii) and (v) only
C (i), (ii) and (iii) only
D (iii), (iv) and (v) only

26 Which combination is true about bacteria?

	presence of methylated DNA	interaction of DNA with histone proteins	transcription initiation at promoter site
A	√	√	√
B	√	x	√
C	x	√	√
D	x	x	x

27 The graph shows the bacterial growth and β-galactosidase production of mutant *Escherichia coli* cells (unable to produce *lacI* protein) with time.

- *Bacterial growth is represented by solid line (——).*
- *β-galactosidase production is represented by dashed line (- - -).*



Which of the following best explains the graph?

A high level of cAMP due to high concentration of glucose
B high level of cAMP due to low concentration of glucose
C low level of cAMP due to high concentration of glucose
D low level of cAMP due to low concentration of glucose

28 Four different genes are regulated in different ways.

Gene C: regulatory gene whose product binds to an operator site

Gene D: product undergoes tissue-specific patterns of alternative splicing

Gene E: acetylation and deacetylation occurs to histones binding to the gene

Gene F: part of a group of structural gene controlled by the same regulatory sequence

Which combination correctly identifies which genes are prokaryotic and which are eukaryotic?

	Prokaryotic	**Eukaryotic**
A	C and F	D and E
B	C and D	E and F
C	D and E	C and F
D	D and F	C and E

29 Which of the following is a feature of eukaryotic gene expression?

A Genes are organized in operons.
B Polycistronic mRNA is common.
C Transcription and translation are spatially separated.
D Translation initiation occurs with a molecule of formyl-methionine.

30 How is translation controlled in eukaryotes?

A By differential removal of introns enabling a gene to code for more than one protein.
B By activation of the protein by folding or cleavage after it is formed.
C By the production of RNA from the non-coding strand of the DNA.
D By protein factors that bind to specific sequences in the mRNA.

31 DNA methylation is known to silence genes because it prevents transcription factors from binding. Which of the following best explains this phenomenon?

A DNA methylation modifies the shape of the transcription factor.
B DNA methylation prevents dimerization of DNA binding proteins.
C DNA methylation modifies the shape of the DNA element where the transcription factor binds.
D DNA methylation causes acetylation of histone proteins which causes heterochromatin to be formed.

32 Some statements concerning evolution are listed:

1 Offspring tend to resemble their parents.

2 Individuals in a sexually reproducing population are different.

3 The fossil record shows that many species have become extinct.

4 More offspring are produced than can possibly survive to sexual maturity.

5 Characteristics acquired during an organism's lifetime are passed to its offspring.

Which of these statements form the basis of Darwin's theory of evolution by natural selection?

A 1, 2 and 3
B 1, 2 and 4
C 1, 3 and 5
D 1, 4 and 5

33 Which of the following pairs is *least* likely to represent homology?

A the haemoglobin of a baboon and that of a gorilla
B the mitochondria of a plant and those of an animal
C the wings of a bird and those of an insect
D the wings of a bat and the arms of a human

34 Which of the following statements does not correctly compare the neutral theory of molecular evolution and natural selection?

A Neutral theory of molecular evolution accounts for most of the differences that we observe at the phenotypic level as compared to natural selection.

B Neutral theory of molecular evolution accounts for most of the differences that we observe at the genotypic level as compared to natural selection.

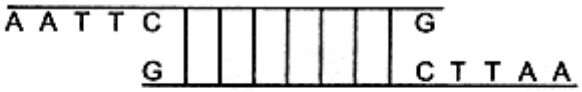
C The rate of change in the nucleotide sequence brought about by neutral theory of molecular evolution occurs at a constant rate due to random chance events while the rate of change brought about by natural selection can be fast or slow depending on the strength of the selection pressure.

D Neutral theory of molecular evolution is largely responsible for the RFLP that we observe between species as compared to natural selection.

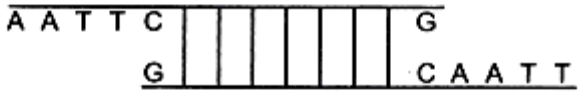
35 In genetic engineering, a restriction enzyme is used to cut plasmid DNA at a specific target site. The enzyme recognises a sequence of six bases and forms sticky ends.

Which diagram of such a cut section of DNA is correct?

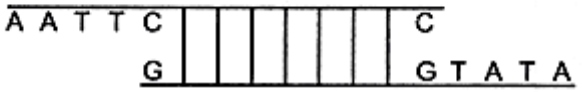
A



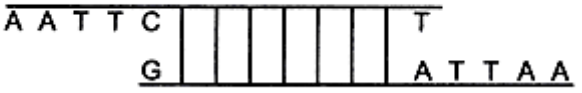
B



C



D



36 The human genome project has identified and mapped the genes on human chromosomes. This is allowing scientists to identify specific, faulty genes which contribute to inherited conditions.

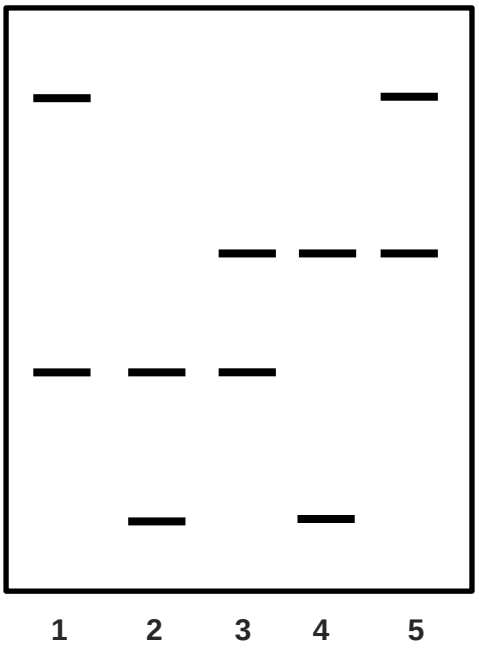
This is useful in many ways, for example

1 carriers of faulty genes can be advised about changes in lifestyle to minimise risks.
2 carriers of faulty genes can be identified and informed of their risk status.
3 diagnostic tests can be developed to identify carriers of faulty genes.
4 drugs can be developed to block the action of problem genes.
5 embryos can be screened to avoid the birth of affected children.
6 employers can take account of the genetic predisposition of employees.

Which two uses arise **directly** from the information provided by the project?

A 1 and 2
B 2 and 5
C 3 and 4
D 5 and 6

37 Results from the DNA fingerprint analysis of a single VNTR locus for a man and his 4 different children are shown in the autoradiograph.



Which lane contains the DNA of the father?

A Lane **1**
B Lane 2
C Lane **3**
D Lane **4**

38 The common gene delivery system for in vivo gene therapy is

I microinjection

II liposome mediated gene transfer (lipofection)

III electroporation

IV adenoviruses

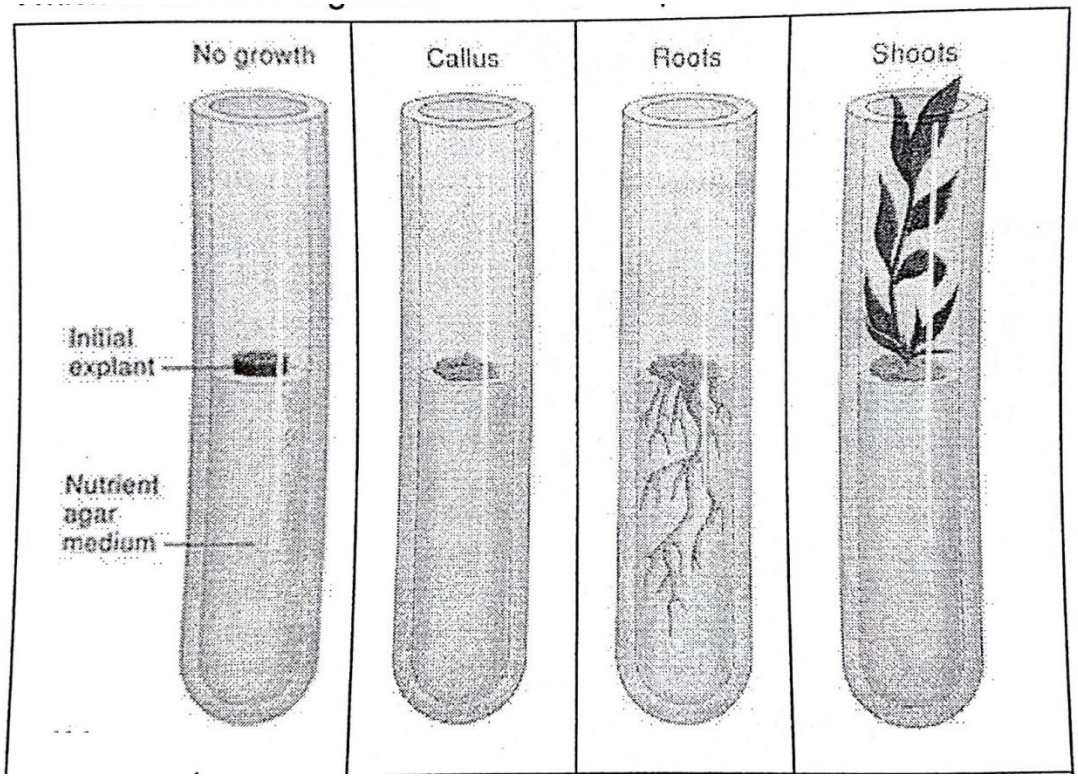
A **I** only
B **I, II** and **III** only
C **II** and **IV** only
D All of the above

39 A student wanted to investigate the response of an explant to various concentrations of IAA (auxin) and kinetin (cytokinin). He labelled and prepared the test tubes as follows:

Test tubes	**1**	**2**	**3**	**4**
IAA (mg/L)	0.02	0.00	1.00	2.00
Kinetin (mg/L)	1.00	0.20	0.20	0.02

After preparation, he handled the test tubes while his gloves were still wet with ethanol. Hence all labels were wiped off. After 2 weeks, his results were shown below.

Which of the following observations correspond to the correct test tube?



A	Tube 3	Tube 2	Tube 1	Tube 4
B	Tube 2	Tube 3	Tube 4	Tube 1
C	Tube 1	Tube 4	Tube 3	Tube 2
D	Tube 4	Tube 1	Tube 2	Tube 3

40 Which of the following statements best support the view that genetically modified crops could help resolve world food shortages?

I Genetic engineering enables production of drought resistant crops more quickly than selective breeding.

II Genetically modified crops are produced by adding single genes.

III Genetically modified crops can cross-fertilise with non-modified related plants.

IV Genetically modified crops can be adapted to their environment when crossed with local varieties of the crop.

A **I** only
B **II** and **III** only
C **II** and **IV** only
D **I** and **IV** only

H

JC 2 PRELIMINARY
EXAMINATIONS Higher 2

CANDIDATE NAME

MARK SCHEME

CLASS

BIOLOGY **9648/01**

Paper 1 Multiple Choice **28 September 2016**

1 hour 15 min

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

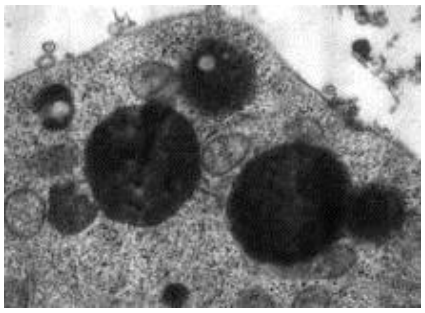
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Calculators may be used.

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

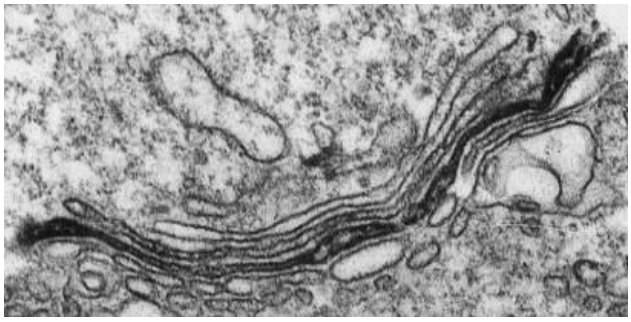
[Turn over

1 In an active cell, the pathway of a protein synthesis to maturation involves the endomembrane system.

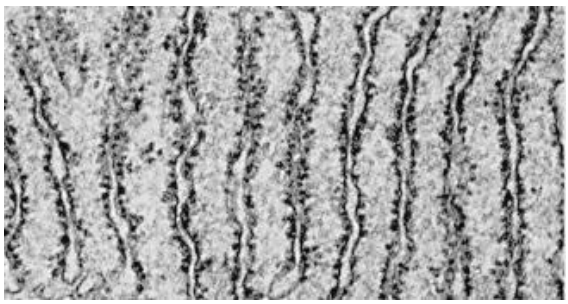
(I)



(II)



(III)



(IV)

The following are several processes that occur in an active cell.

w. modification of carbohydrates on protein

x. folding of protein into its 3 dimensional conformation

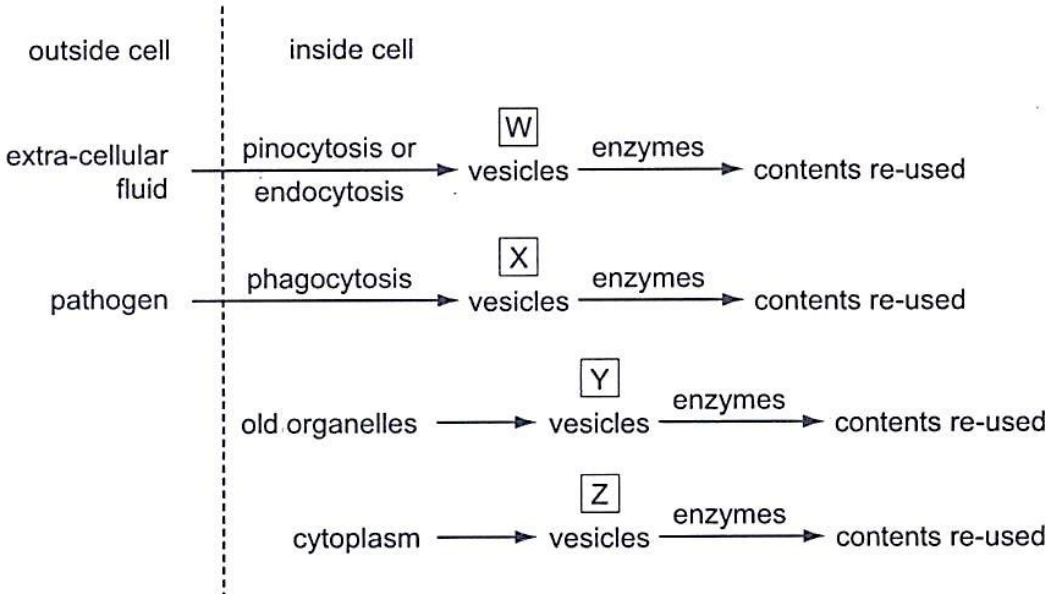
y. synthesis of steroids

z. storage of synthesized proteins

Where in the above diagrams do these processes take place?

	(I)	(II)	(III)	(IV)
A	z	w	y	x
B	z	w	x	y
C	y	w	x	z
D	z	y	x	w

2 The flow chart shows processes which takes place inside animal cells.



Which processes require the activity of lysosomes?

A **W, X, Y** and **Z**
B **W** and **X** only
C **X** and **Y** only
D **Y** and **Z** only

3 Which of the following lists of processes matches the type of movement across membrane correctly?

	Passive diffusion	Facilitated diffusion	Active transport	Endocytosis	Exocytosis
A	Exit of CO_2 from mitochondria	Chemiosmosis of H^+ through ATP synthase	Exit of Ca^{2+} from synaptic knob	Entry of HIV	Budding of influenza virus
B	Exit of CO_2 from mitochondria	Exit of K^+ from neuron	Entry of Na^+ into neuron	Entry of HIV	Budding of influenza virus
C	Entry of O_2 into mitochondria	Exit of K^+ from neuron	Exit of Ca^{2+} from synaptic knob	Entry of influenza virus	Release of insulin from β cells
D	Entry of O_2 into mitochondria	Chemiosmosis of H^+ through ATP synthase	Entry of Na^+ into neuron	Entry of influenza virus	Release of insulin from β cells

4 Raffinose is a trisaccharide which can be degraded by enzymes. The results of two different enzymatic incubations are shown in the table below:

Enzyme used	Products
Sucrase	Melibiose and fructose
Galactosidase	Galactose and sucrose

Which of following statements are consistent with the results shown above?

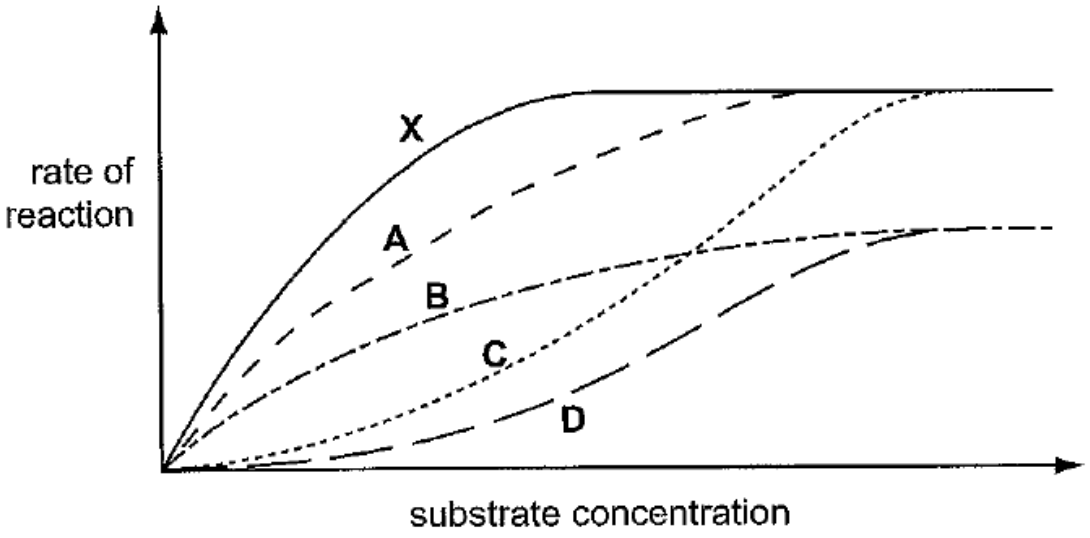
I Raffinose is composed of three different monosacchardies.
II Melibiose is a dissacharide.
III One of the products of acid hydrolysis of raffinose is glucose.
IV The products of raffinose digestion by sucrase and galactosidase respectively will yield a brick-red precipitate when heated with Benedict's reagent.

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

5 The reaction rate of salivary amylase on starch decreases as the concentration of chloride ions is reduced. Which of the following describes the role of the chloride ions?

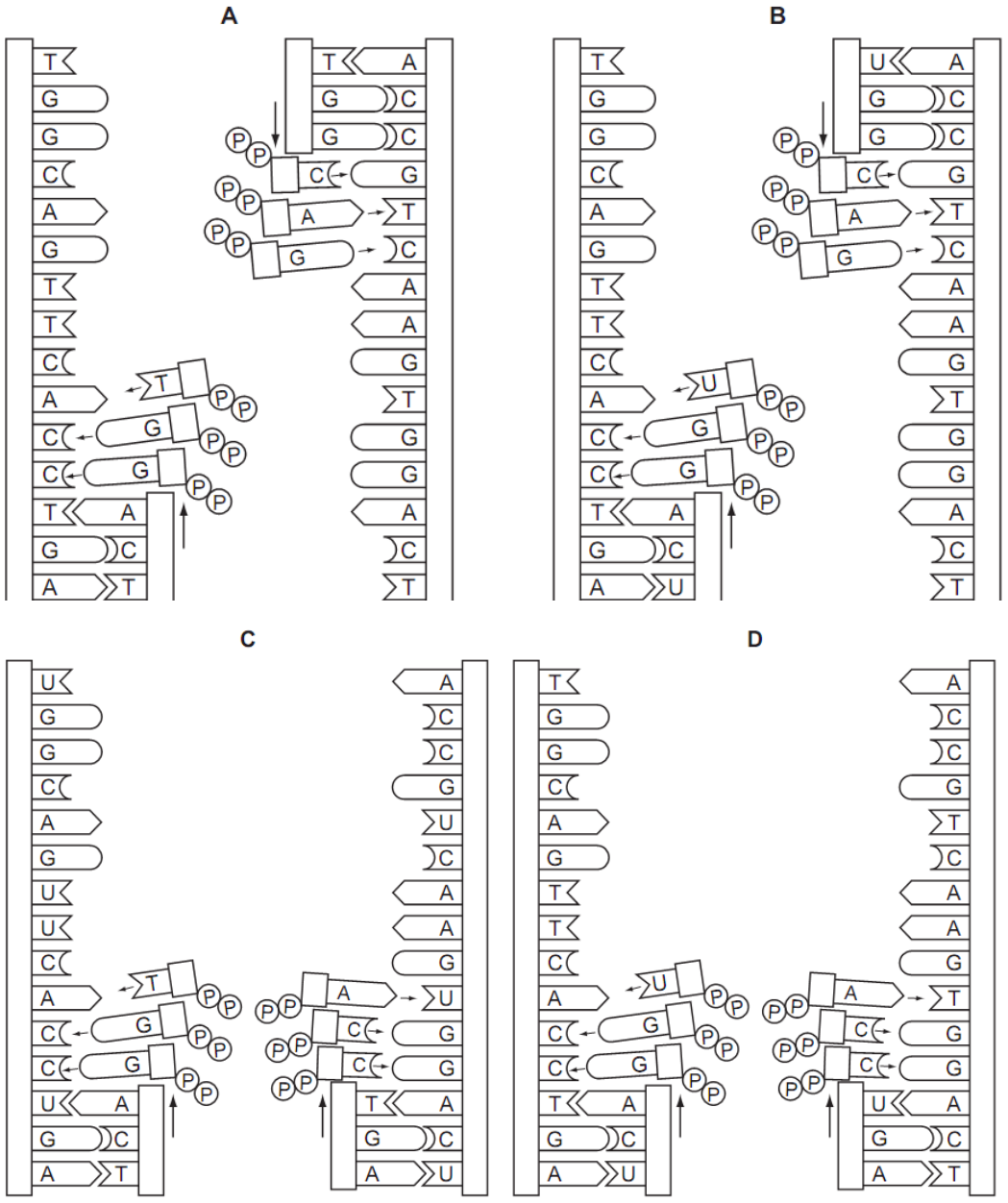
A Allosteric inhibitors
B Co-enzymes
C Co-factors
D Competitive inhibitors

6 In the graph, X represents the initial rate of reaction of an enzyme in increasing substrate concentrations under optimum temperature and pH, in the absence of an inhibitor. Which curve represents the result when the same experiment is carried out under a lower temperature? BBBBBBBBBBB



7 Which diagram shows the semi-conservative replication of a section of a molecule of DNA?

AAAAAAAAAAAAAAAAA



8 The diagram represents part of a DNA molecule.

G A T A C C A
C T A T G G T

Mutation	Name
from purine to other purine	transition
from pyrimidine to other pyrimidine	transition
from purine to pyrimidine	transversion
from pyrimidine to purine	transversion

Which diagram shows the DNA molecule with only transversion(s)?

A

G T T A T C A
C A A T A G T

B

G A A A C A A
C T T T G T T

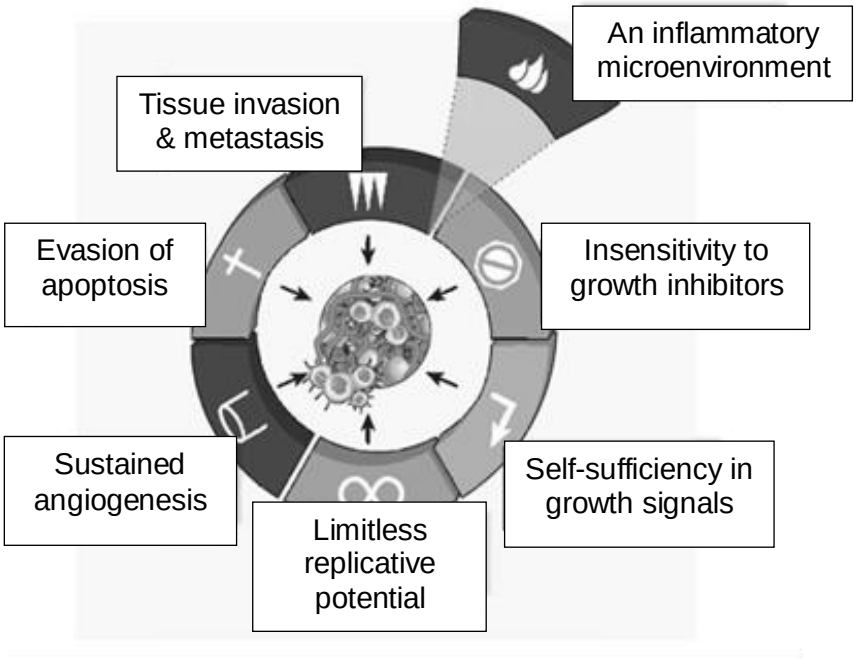
C

A A T A C C A
T T A T G G T

D

G A T A T C A
C T A T A G T

9 The diagram illustrates the hallmarks of cancer.



Which of the following statements correctly describe the changes in cancer cells?

I	Limitless replicative potential often results in the accumulation of chromosomal mutations in many cancer cells.
II	Cancer cells could overproduce signal molecules so that they become self-sufficient in growth signals.
III	Angiogenesis is the result of expression of oncogenes in a cell line that produces blood vessels.
IV	Loss-of-function mutations in tumour suppressor genes contribute to tissue invasion and metastasis.

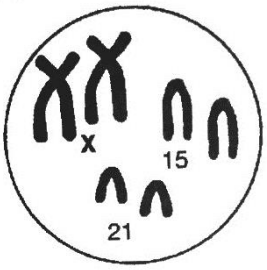
A **I** and **IV** only

B **II** and **III** only

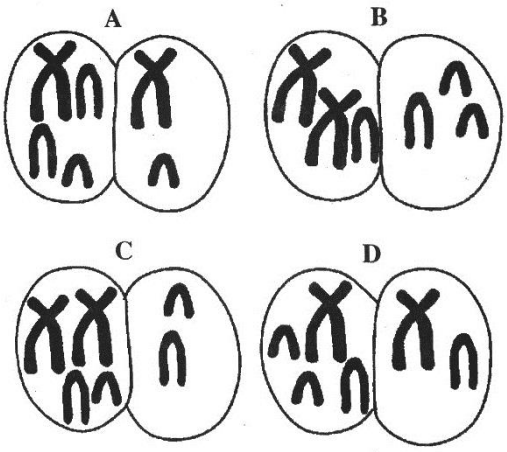
C **I, II** and **IV** only

D **II, III** and **IV** only

10 The diagram shows three of the 23 pairs of chromosomes found in a human cell.



Which diagram shows an example of non-disjunction in the formation of an egg, that could lead to the formation of a Down's syndrome zygote? DDDDDDDD



11 A toxic chemical causes malfunction of the centrioles in animal cells.

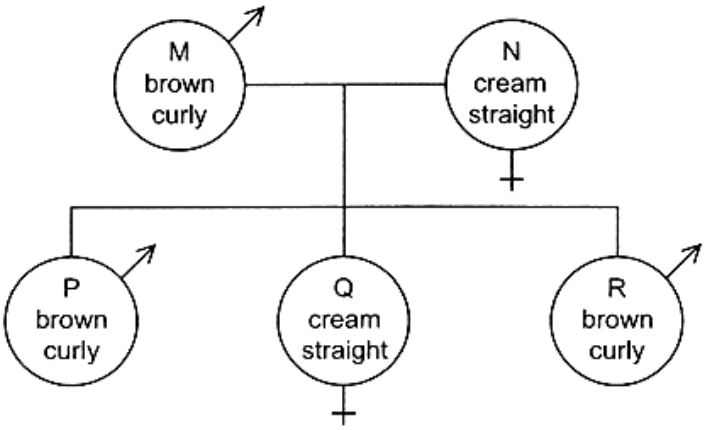
Which process in mitosis is likely to be directly affected by the chemical?

1 migration of the chromosomes
2 replication of centromeres
3 chromosome shortening
4 alignment of chromosomes

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

12 Assume that in goats a pair of alleles is responsible for the inheritance of hair colour and that another pair controls hair texture. These pairs are located on different autosomes. The allele for brown hair (B) is dominant to the allele for cream hair (b), and the allele for curly hair (C) is dominant to the allele for straight hair (c).

The diagram shows a cross between two goats.



If R is mated with a female goat of the same genotype as M, what are the chances of the first offspring being a male with cream coloured, straight hair?

A 0
B 1 in 32
C 1 in 16
D 1 in 4

13 A cross between a round-leafed, tall plant and round-leafed, dwarf plant produced the following offspring:

121 round-leafed, tall plants	R – round leaf
121 round-leafed, dwarf plants	r – oval leaf
42 oval-leafed, tall plants	T – tall
37 oval-leafed, dwarf plants	t – dwarf

What were the genotypes of the parents?

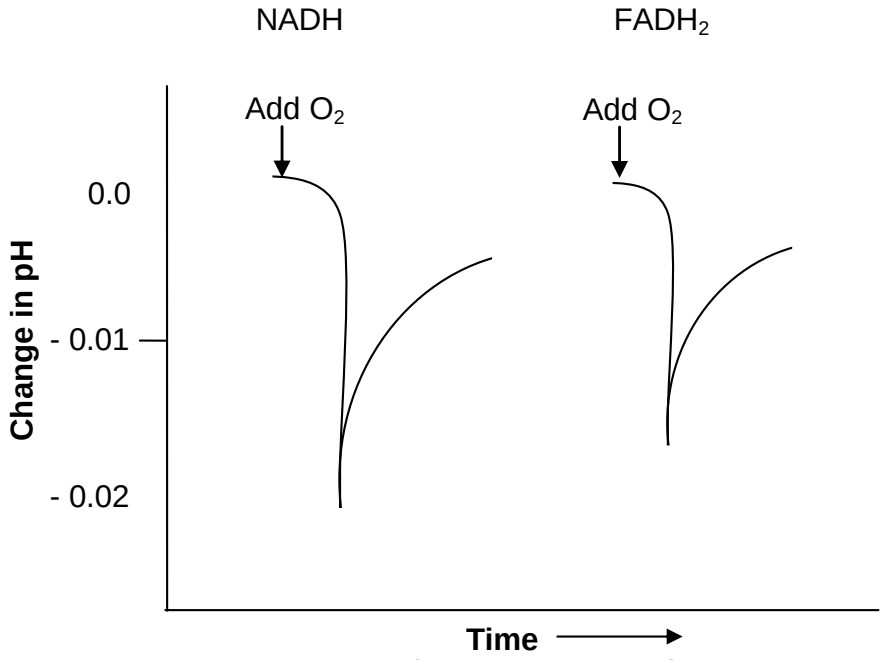
A RrTt x Rrtt
B RrTt x RRtt
C RrTT x Rrtt
D RrTT x RRtt

14 Black, chestnut and bay (reddish brown with black mane, tail, eartips and lower legs) coat colour in horses is determined by two genes. The dominant E allele codes for black and red pigment, while the recessive e allele codes only for red pigment. At a separate gene, the dominant A allele restricts any black pigment produced to the horse's mane, tail, eartips and lower legs, while the recessive allele allows any black pigment produced to show up throughout.

Two black horses were mated. Which of the following coat colours will definitely **not** show up in their offspring?

A Bay
B Black
C Chestnut
D All three colours are possible

15 Isolated mitochondria were incubated with NADH in one experiment and an equal amount of $FADH_2$ in another experiment. The mitochondria were initially deprived of oxygen. The pH of the intermembrane space was then monitored as a known quantity of oxygen was added. The results are shown in the graph.

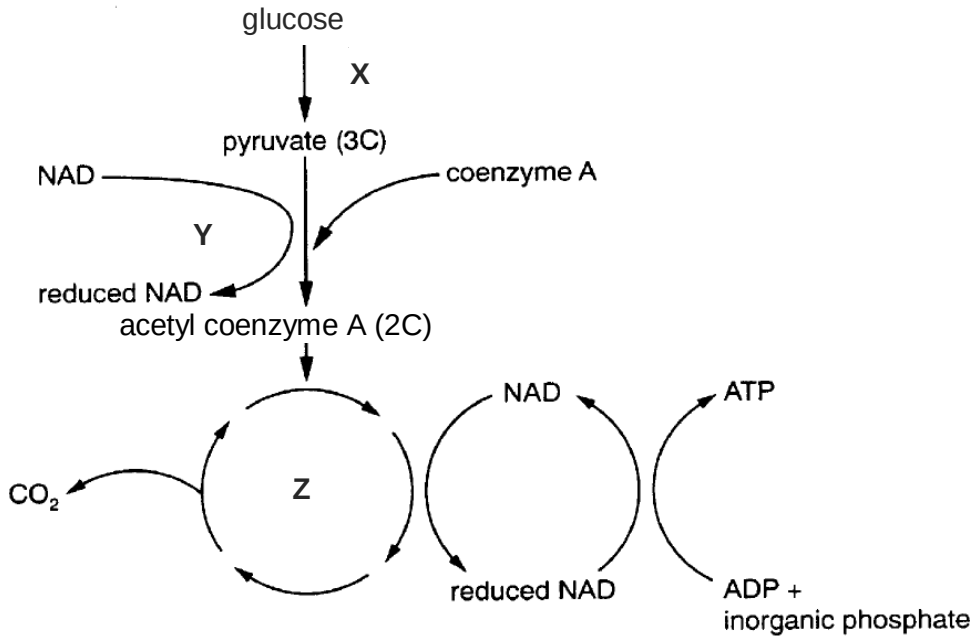


Which of the following can be concluded based on the results?

I	Upon the addition of oxygen, glycolysis and subsequently, link reaction, Krebs cycle and oxidative phosphorylation occurred.
II	Electron transfer was initiated by the addition of oxygen.
III	The pH drop was greater with NADH than with $FADH_2$, which is consistent with the greater ATP yield that accompanies the oxidation of NADH.
IV	The rapid decline in pH indicates that protons were pumped into the intermembrane space when oxygen was available.

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

16 The flow chart shows a series of reactions occurring in an animal cell.



Which of the following statements correctly describes the flow chart?

A Reaction **X**, which occurs in the cytosol, is an anabolic reaction.
B Reaction **Y** involves the process of substrate-level phosphorylation, whereby pyruvate is first converted to a compound called acetyl coenzyme A.
C Reaction **Y** occurs in the cytoplasm whereas reaction **Z** occurs in the mitochondria.
D Reaction **Z** is a catabolic pathway which occurs twice for every glucose molecule to be completely oxidised.

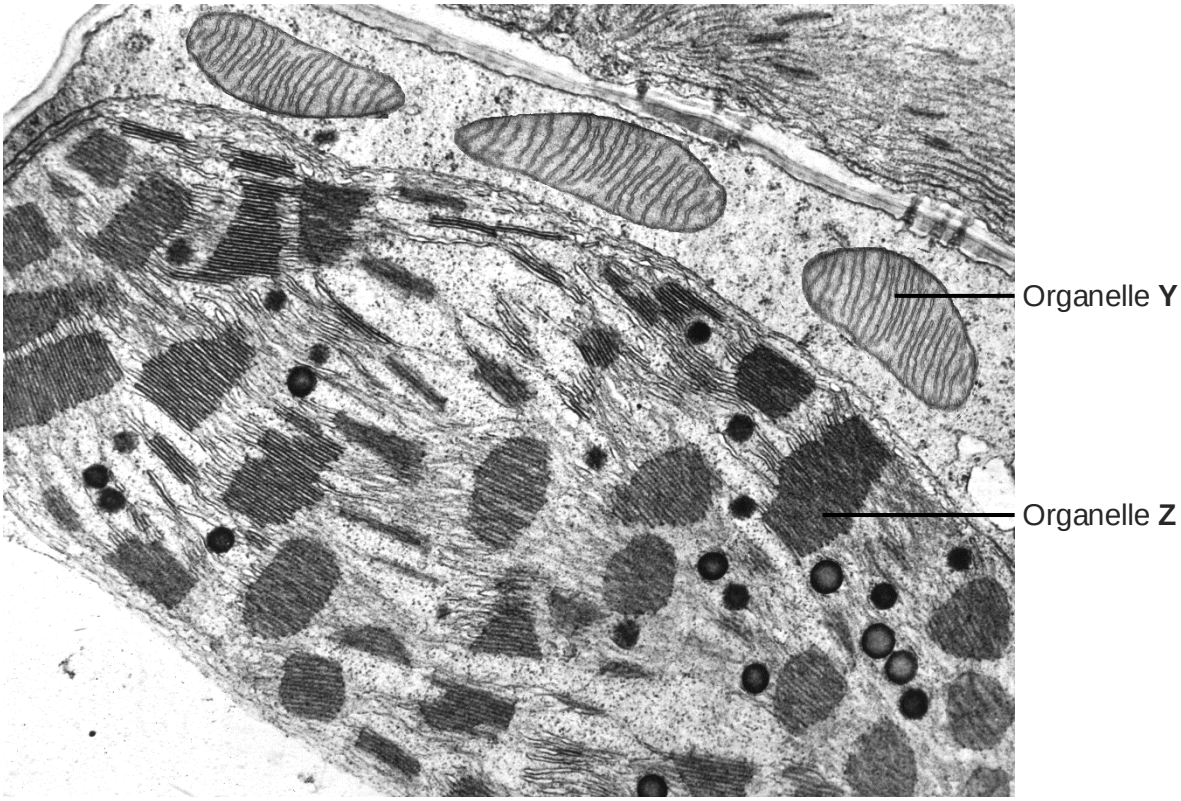
17 In a laboratory, a plant with variegated leaves (containing orange and green pigments) was supplied with radioactive carbon dioxide, $^{14}CO_2$. The plant was kept in the dark for 12 hours and then illuminated for the next 12 hours. A leaf from the plant was obtained and its level of radioactivity was measured both in the absence and presence of light. The results are shown in the table.

	Level of radioactivity in leaf (Arbitrary units)	
	Orange region of leaf	**Green region of leaf**
Absence of light	225	225
Presence of light	410	9271

Which of the following could be the most likely explanation for the level of radioactivity found in the orange region of the leaf in the presence of light?

A Some photosynthesis occurs in the orange region but due to the absence of chlorophyll in that region, the rate of photosynthesis is low.
B Photosynthesis occurs in the orange region but no storage of starch occurs.
C Photosynthetic products diffuse into the orange region.
D Radioactive $^{14}CO_2$ diffuses into the orange region and accumulates in that region.

18 A new species of plant was recently discovered in the Amazon forest. The electron micrograph shows two organelles **Y** and **Z** in a leaf mesophyll cell of the plant.

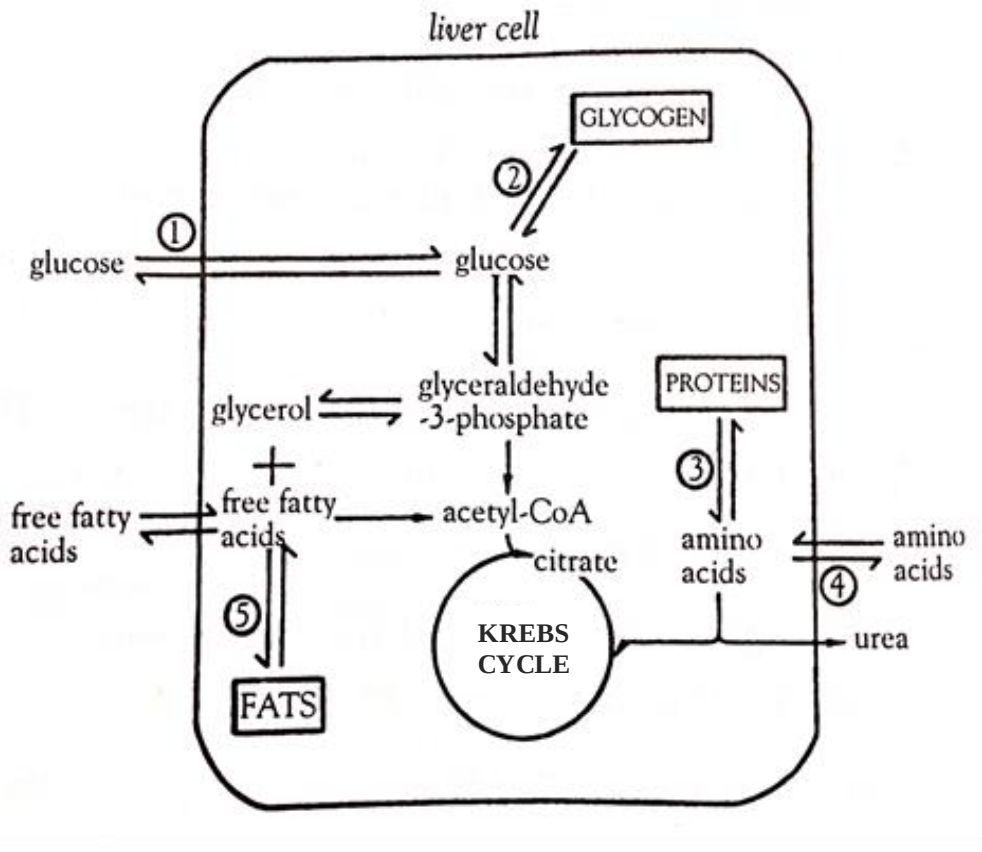


Which of the following statements are **not** true about organelles **Y** and **Z**?

I	Organelle **Z** utilises transporters to export ATP to organelle **Y** to drive cellular activities.
II	Oxygen released by organelle **Z** is used in organelle **Y** during Krebs cycle.
III	Phosphate ions in organelle **Y** is used for the production of ATP during Calvin cycle.
IV	NADPH molecules produced in organelle **Z** are used in organelle **Y** for the production of triose phosphate.

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

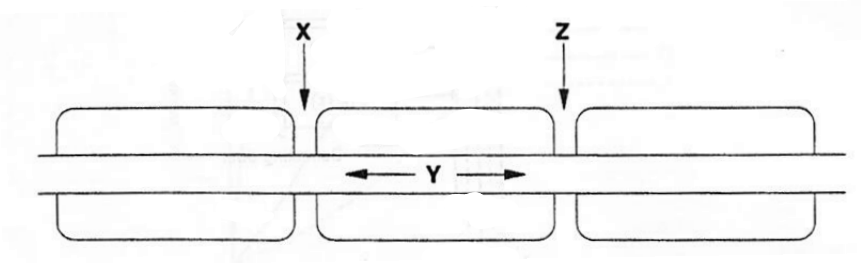
19 The diagram shows some biochemical pathways in a liver cell. Some of the points where hormones affect the pathways are labelled 1 to 5.



At which numbered points would the hormone insulin accelerate the pathway in the directions indicated?

A 1, 2 and 3
B 1, 2 and 5
C 1, 3 and 4
D 3, 4 and 5

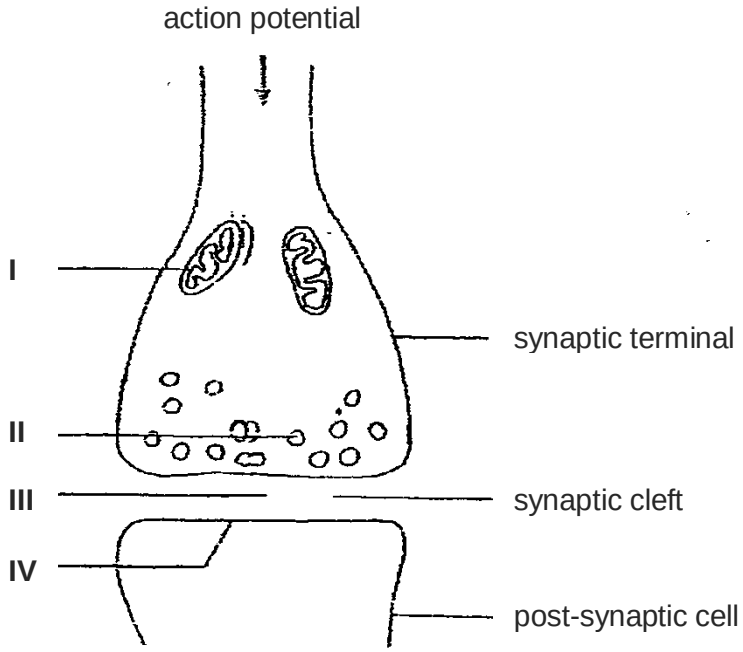
20 The diagram below shows a myelinated axon



How does the myelin sheath increase the speed of impulse transmission along the axon?

A It ensures that the ions are kept close to the axon membrane in region Y.
B It insulates the axon, so increasing the potential at regions X and Z.
C It restricts the change in potential difference to regions X and Z.
D It promotes a change in potential difference in region Y.

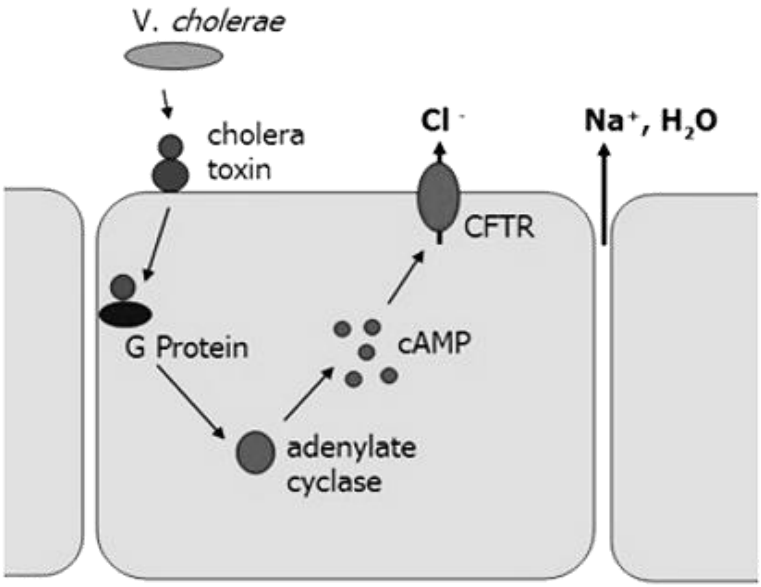
21 Snake venom contains a neurotoxin that affects synaptic transmission. The toxin can cause paralysis and death.



Which of the following is **NOT** a possible way for the toxin to act?

A The toxin reduces enzyme activity in structure **I**.
B The toxin diffuses into structure **II** and binds to its contents.
C The toxin binds with the contents of structure **II** after they are released into site **III**.
D The toxin lodges itself in between the phospholipids found on site **IV**.

22 Cholera is a disease caused by infection of the intestine with the bacterium *Vibrio cholera*. This disease is characterised by profuse diarrhoea, leading to excessive loss of fluids and dehydration. Cholera toxin binds to receptor, resulting in the activation of G protein involved in regulating salt and water secretion.



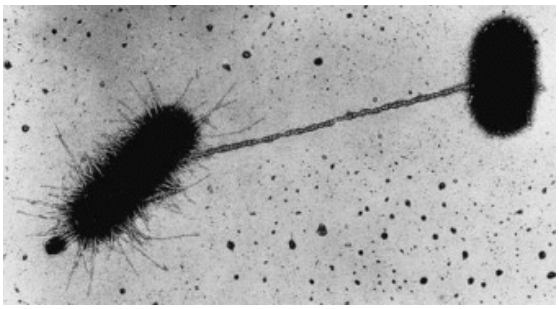
The toxin of *Vibrio cholera* causes profuse diarrhoea because

A cytosolic concentration of ions is decreased, making the cells hypotonic to the lumen of intestine
B phosphodiesterase is permanently activated
C G protein is modified such that it is unable to hydrolyse GTP to GDP
D cystic fibrosis transmembrane conductance regulator (CFTR) Cl^- channel is permanently activated due to binding of cAMP

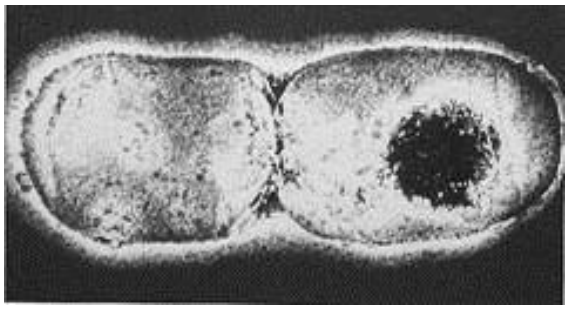
23 What is an example of a step that amplifies the signal during its transduction in a cell?

A the action of adenylyl cyclase in converting ATP to ADP
B the activation of protein kinase A by cAMP
C the binding of a steroid hormone to its intracellular receptor
D the phosphorylation of many mitogen-activated protein (MAP) kinase by an activated MAP kinase kinase

24 The photomicrographs below show two different processes occurring in two different species of bacteria.



Process 1



Process 2

Which of the following statements is/are true of both processes?

(i) For both processes, only bacteria with genes that code for cytoplasmic bridge are involved.

(ii) Process 1 requires direct contact between 2 different bacteria whereas process 2 can occur with 1 bacterium.

(iii) Process 1 will result in an increase in the number of identical bacteria whereas process 2 will result in an increase in the number of different bacteria.

(iv) Both processes involve DNA replication.

A (i) and (iii) only
B (ii) and (iv) only
C (i), (ii) and (iv) only
D (i), (ii), (iii) and (iv)

25 Which of the following statements could explain why a combination of different drugs rather than a single drug is being used to treat HIV patients?

(i) HIV has a short generation span (eg. 2 days).

(ii) In an AIDS patient, the HIV infection produces many new viruses per day (eg. 10^{10} new viruses per day or more).

(iii) HIV has an RNA genome which has a higher mutation rate than DNA as it is single stranded.

(iv) The RNA genome allows the HIV to mutate rapidly to acquire the resistance to the drug being used.

(v) Insertion of the HIV genome into the host cells will result in the host cells mutations that will confer resistance to the drug.

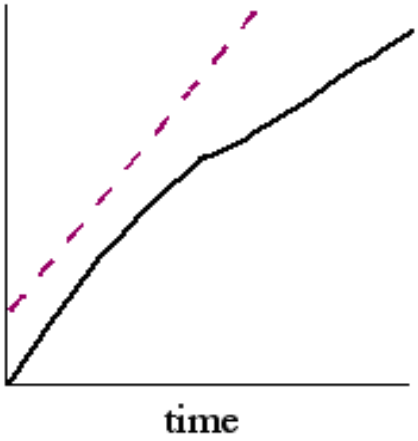
A (i) and (ii) only
B (iii) and (v) only
C (i), (ii) and (iii) only
D (iii), (iv) and (v) only

26 Which combination is true about bacteria?

	presence of methylated DNA	interaction of DNA with histone proteins	transcription initiation at promoter site
A	√	√	√
B	√	x	√
C	x	√	√
D	x	x	x

27 The graph shows the bacterial growth and β-galactosidase production of mutant *Escherichia coli* cells (unable to produce *lacI* protein) with time.

- *Bacterial growth is represented by solid line (——).*
- *β-galactosidase production is represented by dashed line (- - -).*



Which of the following best explains the graph?

A high level of cAMP due to high concentration of glucose
B high level of cAMP due to low concentration of glucose
C low level of cAMP due to high concentration of glucose
D low level of cAMP due to low concentration of glucose

28 Four different genes are regulated in different ways.

Gene C: regulatory gene whose product binds to an operator site

Gene D: product undergoes tissue-specific patterns of alternative splicing

Gene E: acetylation and deacetylation occurs to histones binding to the gene

Gene F: part of a group of structural gene controlled by the same regulatory sequence

Which combination correctly identifies which genes are prokaryotic and which are eukaryotic?

	Prokaryotic	**Eukaryotic**
A	C and F	D and E
B	C and D	E and F
C	D and E	C and F
D	D and F	C and E

29 Which of the following is a feature of eukaryotic gene expression?

A Genes are organized in operons.
B Polycistronic mRNA is common.
C Transcription and translation are spatially separated.
D Translation initiation occurs with a molecule of formyl-methionine.

30 How is translation controlled in eukaryotes?

A By differential removal of introns enabling a gene to code for more than one protein.
B By activation of the protein by folding or cleavage after it is formed.
C By the production of RNA from the non-coding strand of the DNA.
D By protein factors that bind to specific sequences in the mRNA.

31 DNA methylation is known to silence genes because it prevents transcription factors from binding. Which of the following best explains this phenomenon?

A DNA methylation modifies the shape of the transcription factor.
B DNA methylation prevents dimerization of DNA binding proteins.
C DNA methylation modifies the shape of the DNA element where the transcription factor binds.
D DNA methylation causes acetylation of histone proteins which causes heterochromatin to be formed.

32 Some statements concerning evolution are listed:

1 Offspring tend to resemble their parents.

2 Individuals in a sexually reproducing population are different.

3 The fossil record shows that many species have become extinct.

4 More offspring are produced than can possibly survive to sexual maturity.

5 Characteristics acquired during an organism's lifetime are passed to its offspring.

Which of these statements form the basis of Darwin's theory of evolution by natural selection?

A 1, 2 and 3
B 1, 2 and 4
C 1, 3 and 5
D 1, 4 and 5

33 Which of the following pairs is *least* likely to represent homology?

A the haemoglobin of a baboon and that of a gorilla
B the mitochondria of a plant and those of an animal
C the wings of a bird and those of an insect
D the wings of a bat and the arms of a human

34 Which of the following statements does not correctly compare the neutral theory of molecular evolution and natural selection?

A Neutral theory of molecular evolution accounts for most of the differences that we observe at the phenotypic level as compared to natural selection.

B Neutral theory of molecular evolution accounts for most of the differences that we observe at the genotypic level as compared to natural selection.

C The rate of change in the nucleotide sequence brought about by neutral theory of molecular evolution occurs at a constant rate due to random chance events while the rate of change brought about by natural selection can be fast or slow depending on the strength of the selection pressure.

D Neutral theory of molecular evolution is largely responsible for the RFLP that we observe between species as compared to natural selection.

35 In genetic engineering, a restriction enzyme is used to cut plasmid DNA at a specific target site. The enzyme recognises a sequence of six bases and forms sticky ends.

Which diagram of such a cut section of DNA is correct?
AAAAAAAAAAAAAAAAAAAAAA

36 The human genome project has identified and mapped the genes on human chromosomes. This is allowing scientists to identify specific, faulty genes which contribute to inherited conditions.

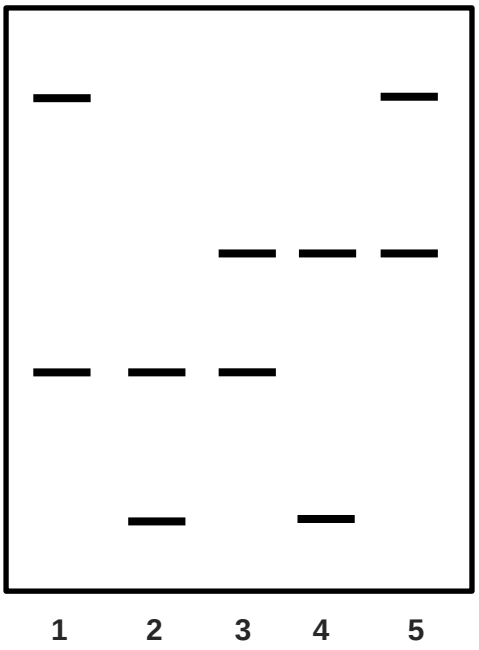
This is useful in many ways, for example

1 carriers of faulty genes can be advised about changes in lifestyle to minimise risks.
2 carriers of faulty genes can be identified and informed of their risk status.
3 diagnostic tests can be developed to identify carriers of faulty genes.
4 drugs can be developed to block the action of problem genes.
5 embryos can be screened to avoid the birth of affected children.
6 employers can take account of the genetic predisposition of employees.

Which two uses arise **directly** from the information provided by the project?

A 1 and 2
B 2 and 5
C 3 and 4
D 5 and 6

37 Results from the DNA fingerprint analysis of a single VNTR locus for a man and his 4 different children are shown in the autoradiograph.



Which lane contains the DNA of the father?

A Lane **1**
B Lane **2**
C Lane **3**
D Lane **4**

38 The common gene delivery system for in vivo gene therapy is

I microinjection

II liposome mediated gene transfer (lipofection)

III electroporation

IV adenoviruses

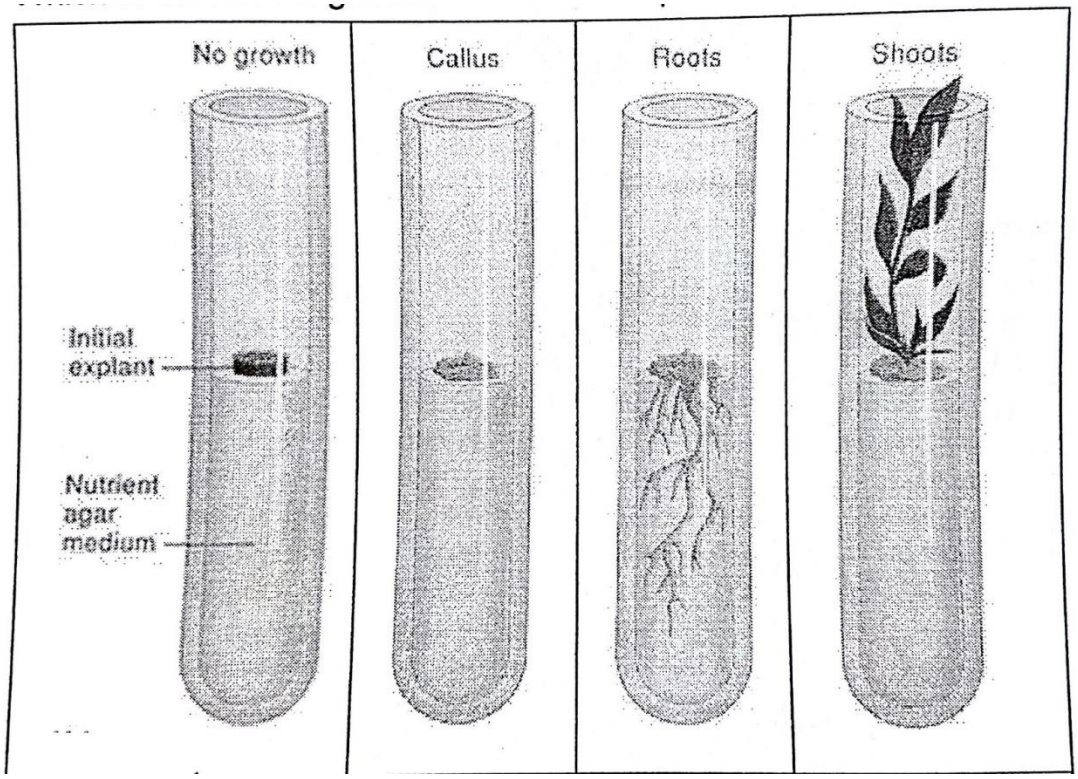
A **I** only
B **I, II** and **III** only
C **II** and **IV** only
D All of the above

39 A student wanted to investigate the response of an explant to various concentrations of IAA (auxin) and kinetin (cytokinin). He labelled and prepared the test tubes as follows:

Test tubes	**1**	**2**	**3**	**4**
IAA (mg/L)	0.02	0.00	1.00	2.00
Kinetin (mg/L)	1.00	0.20	0.20	0.02

After preparation, he handled the test tubes while his gloves were still wet with ethanol. Hence all labels were wiped off. After 2 weeks, his results were shown below.

Which of the following observations correspond to the correct test tube?



A	Tube 3	Tube 2	Tube 1	Tube 4
B	Tube 2	Tube 3	Tube 4	Tube 1
C	Tube 1	Tube 4	Tube 3	Tube 2
D	Tube 4	Tube 1	Tube 2	Tube 3

40 Which of the following statements best support the view that genetically modified crops could help resolve world food shortages?

I Genetic engineering enables production of drought resistant crops more quickly than selective breeding.

II Genetically modified crops are produced by adding single genes.

III Genetically modified crops can cross-fertilise with non-modified related plants.

IV Genetically modified crops can be adapted to their environment when crossed with local varieties of the crop.

A **I** only
B **II** and **III** only
C **II** and **IV** only
D **I** and **IV** only

H

JC 2 PRELIMINARY
EXAMINATIONS Higher 2

CANDIDATE NAME

CLASS

BIOLOGY

9648/02

Paper 2 Core Paper

19 September 2016

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use soft pencil for any diagrams, graphs or rough working.
Do no use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** questions.

Section B

Answer any **one** question.

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	
Section A	
1	
2	
3	
4	
5	
6	
7	
Section B	
Total	

This document consists of **22** printed pages and **0** blank page.

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Section A

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

1 Fig 1.1 shows a molecule of tRNA and the enzyme that attaches the correct amino acid to it

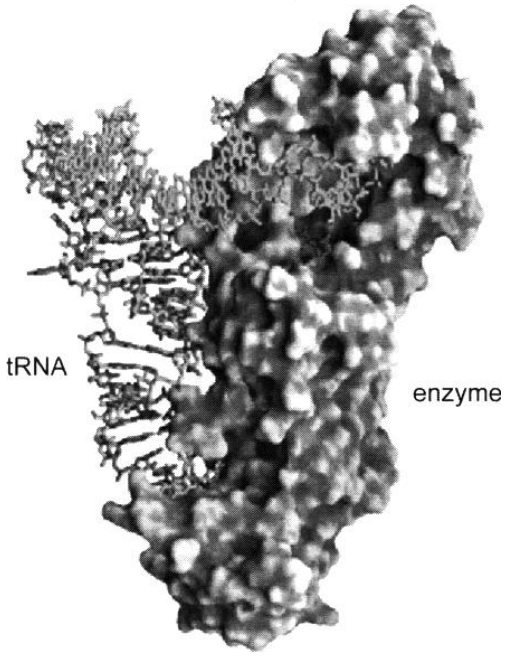

Fig. 1.1

(a) With reference to **Fig. 1.1**, explain how the enzyme is suited to its function.

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[3]

(b) The average molecular weight of proteins encoded in the human genome is about 50,000 daltons. Given the average molecular mass of an amino acid is about 110 daltons and 5% of the initial transcript is converted to mature mRNA, estimate how long it will take a muscle cell to transcribe a gene for an average protein. Assume that the transcription rate is 20 nucleotides per second.

Show your working and express your answer to the nearest whole number (in minutes).

Answer: …… minutes [2]

(c) Edeine is an antibiotic that inhibits protein synthesis but has no effect on either DNA synthesis or RNA synthesis. When added to the cell extract of an immature red blood cell, edeine stops protein synthesis after a short lag, as shown in **Fig. 1.2.** By contrast, cycloheximide, which is also an inhibitor, stops protein synthesis immediately. Protein synthesis is measured via radioactivity in haemoglobin.

Analysis of the edeine-inhibited cell extract showed that no polyribosomes remained at the time protein synthesis had stopped. Instead, all the globin mRNA were found associated with small ribosomal subunit and initiator tRNA.

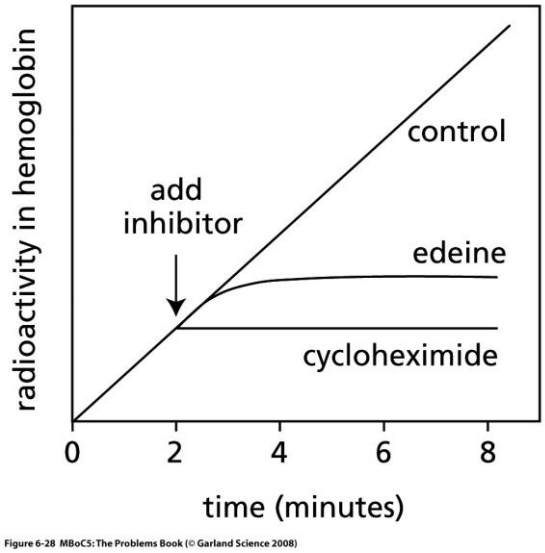

Figure 6-28 MBoC5: The Problems Book (© Garland Science 2008)

Fig. 1.2

(i) Explain how protein synthesis is measured via radioactivity in haemoglobin.

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[1]

(ii) Describe how edeine inhibits protein synthesis.

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[2]

(iii) Explain why there is a lag between the addition of edeine and cessation of protein synthesis.

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[2]

Protein synthesis in an organism is illustrated in **Fig 1.3.**

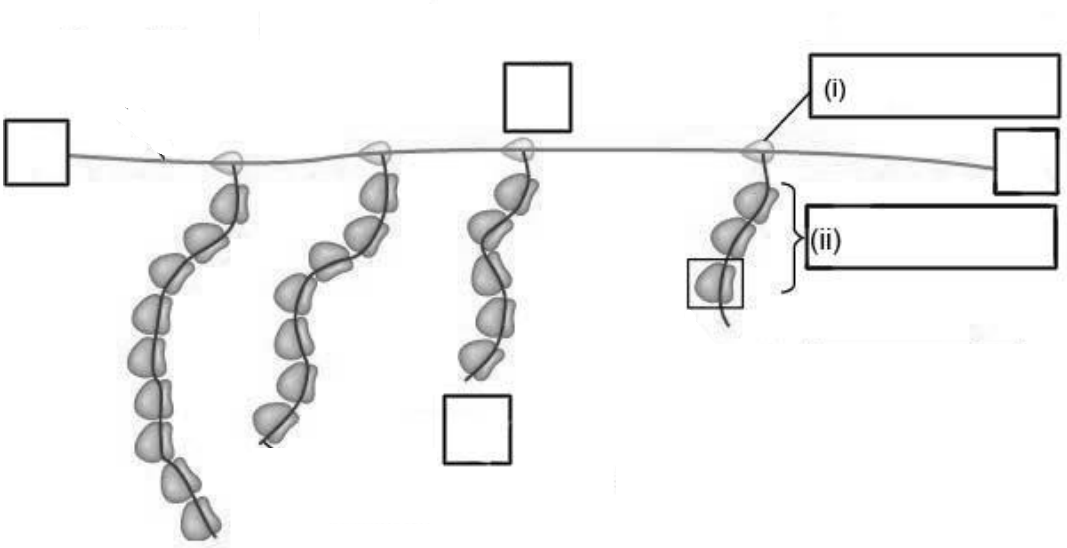

Fig. 1.3

(d) Label the 5' and 3' ends of the mRNA and DNA template strand in the boxes provided and structures (i) and (ii) on **Figure 1.3.** [2]

[Total: 12]

2 A gene for feather colour in chickens is carried on an autosome. This gene has two alleles, black (C^B) and splashed-white (C^W). When a male chicken with black feathers is mated with a female chicken with splashed-white feathers, all the offspring have blue feathers. This also occurs when a male chicken with splashed-white feathers is crossed with a female with black feathers.

Black feathers

Splashed-white feathers

Barred feathers

Another gene may cause stripes on feathers (barred feathers). The gene is carried on the X chromosome. The allele for barred feathers (X^A) is dominant to the allele for non-barred feathers (X^a). In chickens the male is homogametic, while the female is heterogametic.

(a) A male chicken with black, non-barred feathers was crossed with a female chicken with splashed-white, barred feathers. All the offspring had blue feathers, but the males were barred and the females were non-barred.

(i) Using the symbols given, draw a genetic diagram to show this cross.

Parental phenotype	Male, black, non-barred feathers	Female, splashed-white, barred feathers
Genotype		
Gametes		
Offspring genotypes		
Phenotypes		

[2]

(ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

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[3]

(b) The table below shows the genotypes and wool length in two breeds of sheep, **X** and **Y,** and their F1 hybrids.

	Genotype	***Mean wool length/cm***
Breed **X**	**DDEEff**	**18**
Breed **Y**	**ddeeFF**	**14**
F1 (breed **X** x Breed **Y**)	**DdEeFf**	**16**

When the F1 were crossed among themselves, the F2 offspring had a mean wool length ranging from 10cm to 22cm.

Assume that the inheritance of wool length in sheep depends upon alleles at three loci acting additively and that all variation in wool length in the F2 population is due to the segregation of alleles at these three loci.

(i) How many different types of gametes would be produced by an organism of genotype DdEeFF, if all of the genes assort independently?

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[1]

(ii) What proportion of the F2 offspring are expected to have a mean wool length of 22 cm? Explain your reasoning.

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[4]

[Total: 10]

3 Phosphofructokinase (PFK) is a tetrameric enzyme that plays a central role in controlling the rate of glycolysis. In many organisms, the activity of PFK is enhanced allosterically by several substances, including ADP, and is inhibited allosterically by several other substances, including ATP and citrate. **Fig. 3.1** shows part of the glycolysis reactions.

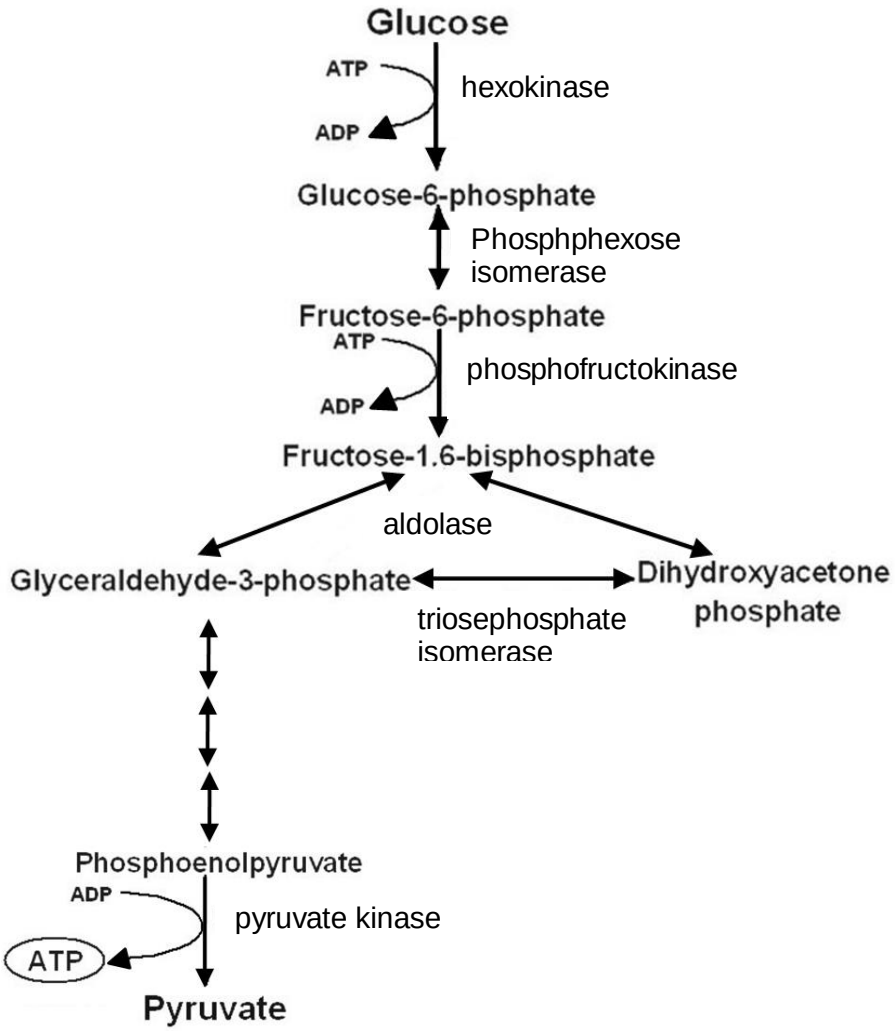

Fig. 3.1

(a) Explain why phosphofructokinase is a quaternary protein.

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[1]

(b) Besides PFK, hexokinase and pyruvate kinase also play a role in determining the overall rate of glycolysis.

With reference to **Fig. 3.1**, suggest why reactions catalyzed by these three enzymes determine the rate of glycolysis.

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[2]

(c) Explain the importance of inhibition of PFK by citrate when citrate concentration in the cell is high.

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[2]

(d) Describe how citrate inhibits PFK.

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[3]

(e) In mammals, under anaerobic condition, both Krebs cycle and oxidative phosphorylation do not occur. Instead, lactate fermentation occurs.

Explain the significance of lactate fermentation.

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[2]

(f) Hexokinase, the enzyme involved in the first step of glycolysis, is able to utilize various hexoses such as glucose, fructose and mannose.

Suggest how hexokinase is able to utilize different substrates.

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[2]

[Total: 12]

4 Norepinephrine is a stress hormone secreted during fight-or-flight response. **Fig. 4.1** shows an example of a G-protein signalling pathway.

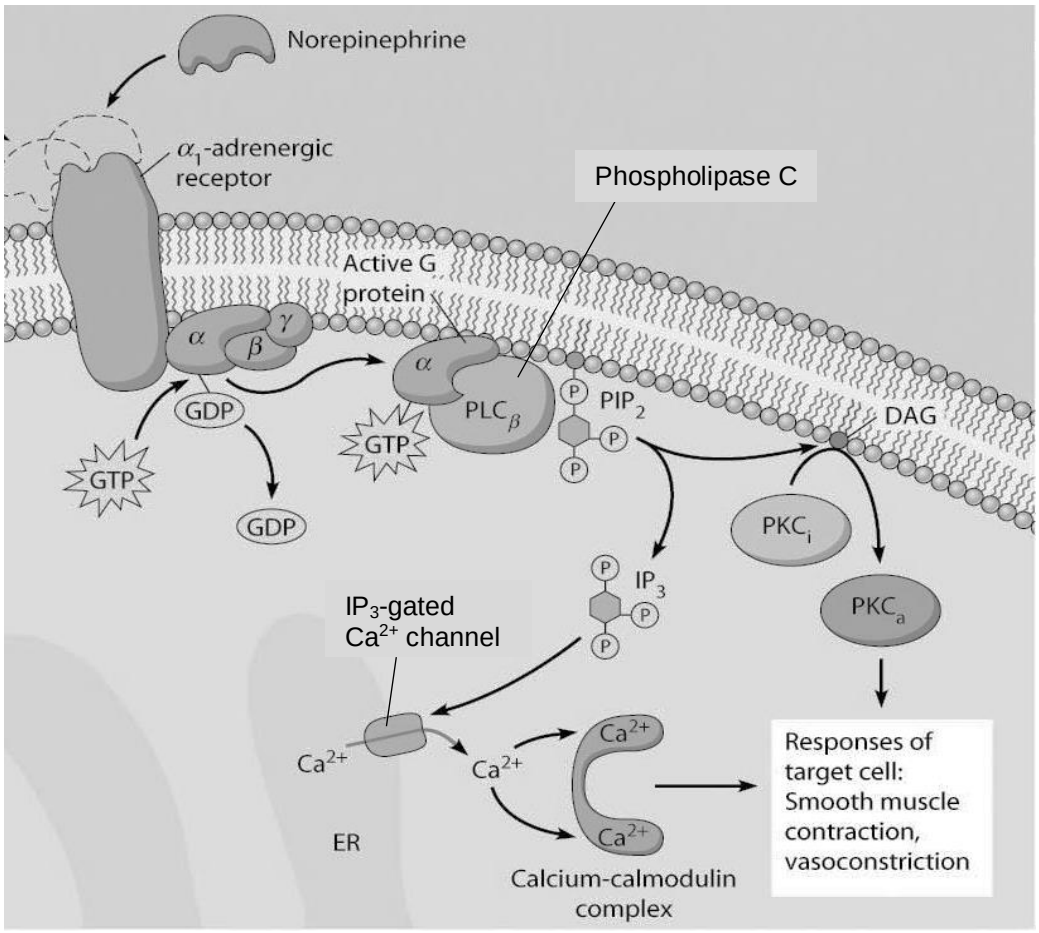

Fig. 4.1

(a) With reference to **Fig. 4.1**, describe explain how the presence of norepinephrine leads to the opening of IP_3-gated Ca^{2+} channels.

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[4]

(b) With reference to **Fig. 4.1**, explain the significance of IP_3 and Ca^{2+} in the cell signalling pathway.

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[2]

(c) The same signalling molecule norepinephrine usually targets more than one cell type. For e.g. muscle, heart and liver cells.

Explain how the same norepinephrine molecule can have different effects on different cells.

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[2]

(d) Suggest how signal termination can occur.

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[1]

Most people with type I diabetes inject insulin. A recent product contains insulin that can be administered using a nasal spray. The spray is inhaled and the insulin is taken up through the lungs.

Fig. 4.2 shows the concentration of insulin in the blood plasma in the 480 minutes after injecting or inhaling insulin. In both cases, the insulin was of the same type, obtained from genetically engineered *Escherichia coli*.

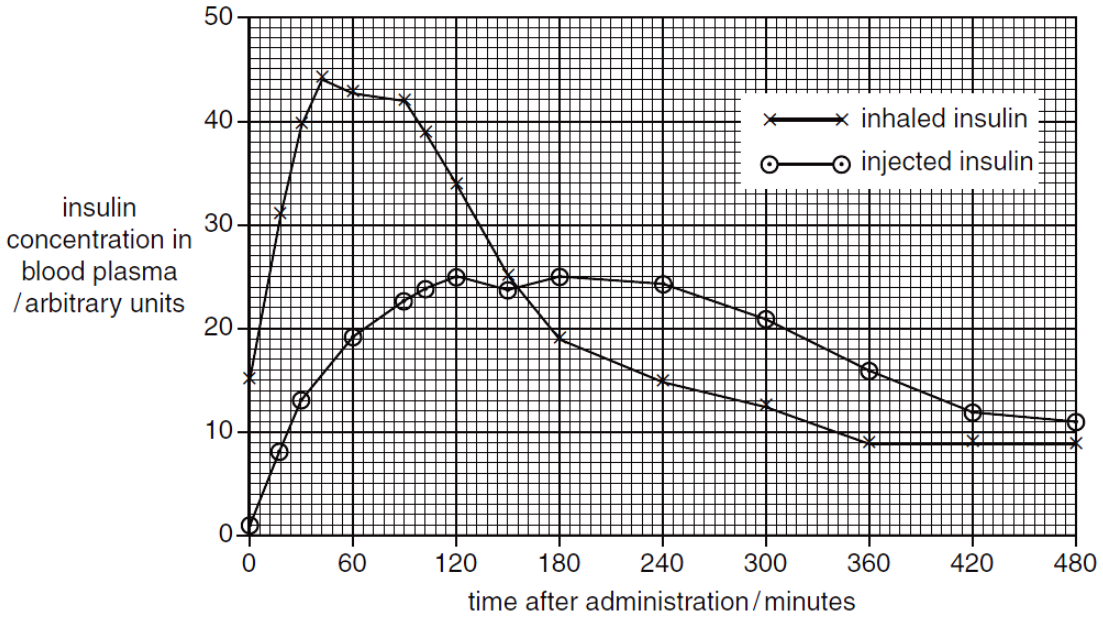

Fig 4.2

Fig. 4.3 shows the concentration of glucose in the blood plasma in the 480 minutes after injecting or inhaling insulin.

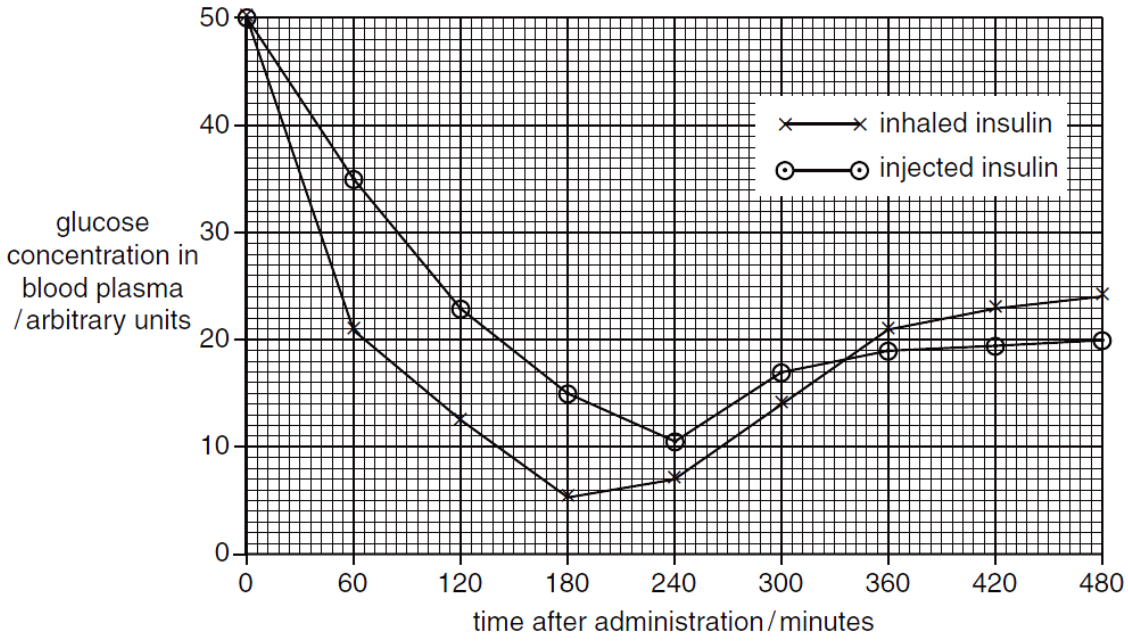

Fig 4.3

(e) Compare the results for injected insulin and inhaled insulin shown in **Fig. 4.2**.

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[2]

(f) With reference to **Fig. 4.2**, explain the differences in the blood glucose levels after injecting or inhaling insulin shown in **Fig. 4.3**.

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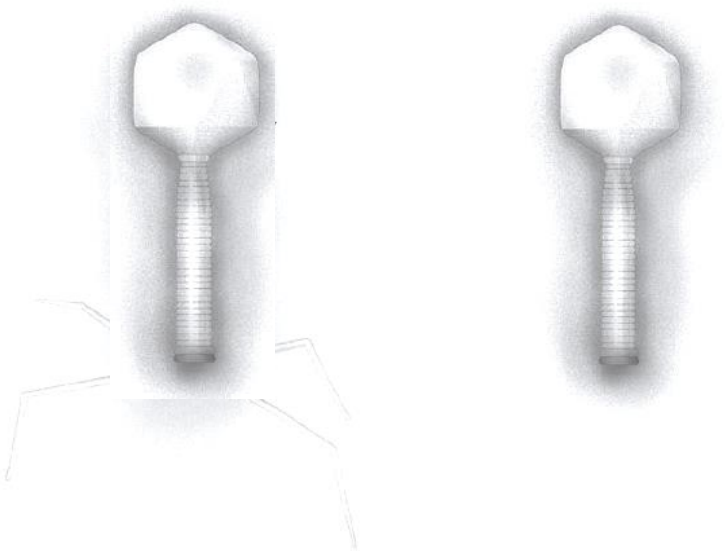
[3]

[Total: 14]

5 Lambda is a bacteriophage that uses *Escherichia coli* as its host cell. **Fig. 5.1 A** is an electron micrograph (EM) of a wild-type bacteriophage lambda while **Fig. 5.1 B** is an EM of a laboratory-cultured lambda.



A B

(a) State one main difference between the two bacteriophages.

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[1]

(b) Suggest how the laboratory-cultured bacteriophage binds to the host cell, *Escherichia coli*.

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[1]

(c) Explain how lambda phage enters the host cell.

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[2]

(d) Suggest why it is sometimes difficult to distinguish between a plasmid and the DNA of the bacteriophage lambda inside an *Escherichia coli*, when viewed under the electron microscope.

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[1]

Some of the *Escherichia coli* are infected with the laboratory-cultured lambda phage. It is observed that no new phages are produced. The bacteria are initially cultured in a nutrient medium without X-gal. The bacteria colonies produced are replica plated onto two agar plates, one containing X-gal and lactose and the other containing X-gal without lactose.

There is no glucose in either plates. **Fig. 5.2.** shows the results of this experiment.

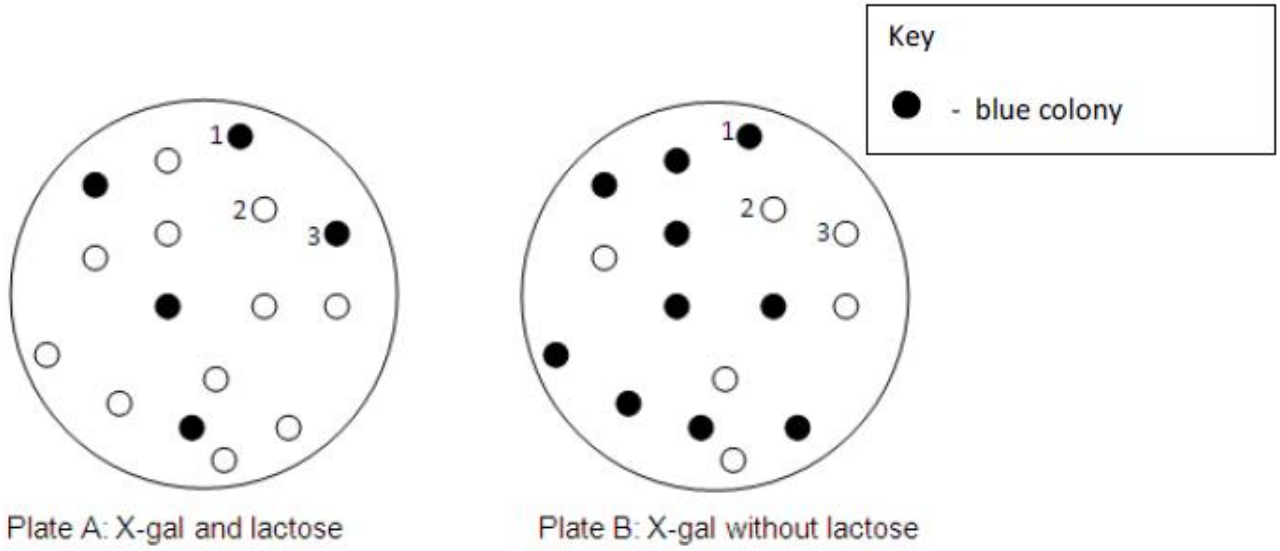

Fig. 5.2

(e) Suggest why no new phages were formed.

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[1]

(f) Account for the observations seen in:

(i) Colony 1

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[2]

(ii) Colony 2

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[2]

(iii) Colony 3

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[2]

[Total: 12]

6 **Fig. 6.1** below is an electron micrograph of a microorganism that is isolated from the stools of cholera patients.

Fig. 6.1

(a) With reference to Fig. 6.1, state **two** structural differences between the chromosome of this type of microorganism and a human cell.

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[2]

(b) The enzyme lactase is responsible for lactose metabolism in humans and is encoded by a gene on chromosome 2.

Based on your understanding of eukaryotic and prokaryotic genomes, describe how the genes in humans and *Escherichia coli* that are responsible for lactose metabolism differ in terms of:

(i) their organisation;

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[1]

(ii) the control of gene expression.

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[2]

(c) Streptomycin is an antibiotic that binds to bacterial ribosomes.

(i) Explain how this effect of streptomycin prevents the growth of bacteria.

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[2]

(ii) Suggest why streptomycin does not affect the growth of human cells.

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[1]

[Total: 8]

7 **Fig. 7.1** shows the distribution of the giant tortoises across the various islands of the Galápagos archipelago. Some sub-species are distributed across the southern part of the largest island named Isabela. In addition, three other species, *G. chilensis*, *G. carbonaria*, and *G. denticulate* are also found on the west coast of Ecuador, a country in the South America continent.

The giant tortoises had been previously classified based on morphological differences, primarily using carapace (shell) shape, which varies from domed to saddleback with intermediate forms also occurring.

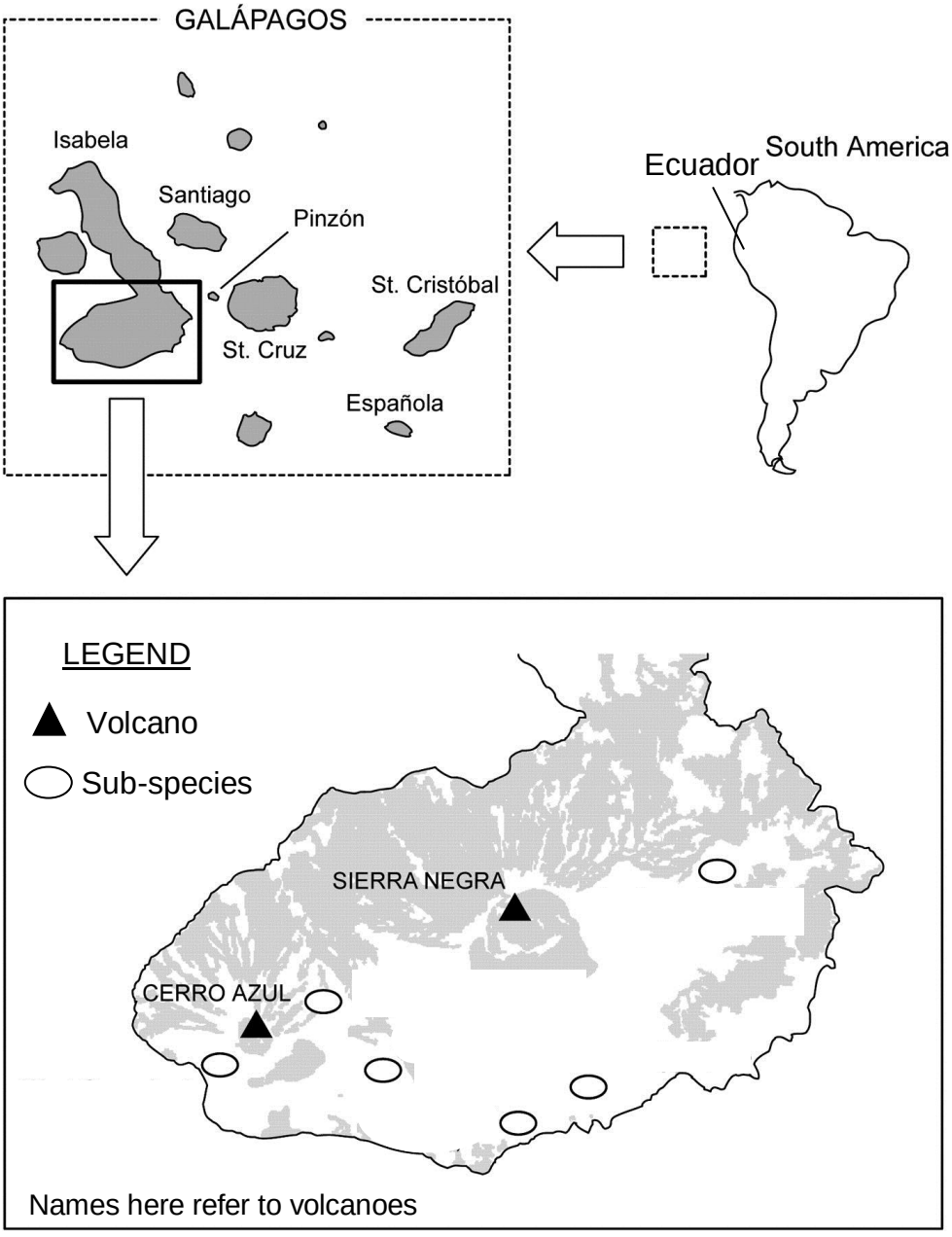

Fig. 7.1

(a) With reference to **Fig. 7.1**, explain how biogeography supports the evolutionary deductions that the tortoises are all evolutionally related.

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[2]

(b) Suggest why the previous classification using carapace shape may not be an accurate way of determining the evolutionary relationships accurately.

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[2]

(c) Suggest why the sub-species found on the southern part of Isabela island did not evolve to become distinct species.

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[2]

In another separate experiment, scientist were investigating on the Red Queen hypothesis which state that sexual reproduction persists because it enables many species to rapidly evolve new genetic defenses against parasites that attempt to live off them.

Scientists have tested this idea by observing different groups of small fish *Poecilopsis* species (Gila topminnow) in Mexico. Some populations of the topminnow reproduce sexually, while others practice parthenogenesis. Parthenogenesis occurs when females produce offspring without any male contribution and the female's gametes develop directly into female offspring.

Topminnows are constantly parasitized by ‘black spot disease’ caused by black spot worms that encyst in the skin. Parasitized topminnows rarely survive. The researchers found that identical populations of the asexually reproducing topminnows harbored many more black-spot worms than did those producing sexually, a finding that fit the Red Queen hypothesis: the sexual topminnows could devise new defenses faster by recombination than the asexually producing clones.

However, it was observed that after a drought, the sexually reproducing topminnows were more heavily parasitized than the cloned topminnows. This process of whereby chance events cause the allele frequency to change unpredictably is known as genetic drift.

(d) Name the evolutionary event that resulted in this genetic drift.

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[1]

(e) Explain why there was an increase in the number of parasitized sexually reproducing topminnows after the drought.

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[2]

The Neutral Theory of Molecular Evolution proposed that frequencies of alleles are not affected by natural selection but may increase or decrease as a result of genetic drift.

(f) Briefly describe the Neutral Theory of Molecular Evolution.

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[3]

[Total: 12]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

8 **(a)** Describe the changes involving homologous chromosomes during meiosis, and explain how these changes ensure genetic variation and genetic stability. [10]

(b) Describe the development of cancer as a multi-step process. [6]

(c) Describe the structure and function(s) of the centrioles in the cell. [4]

9 **(a)** Explain the role of control elements in regulating gene expression in eukaryotes. [8]

(b) Using named examples, describe the process and significance of gene amplification in eukaryotes. [8]

(c) Explain why the ability to rapidly degrade mRNA can be an adaptive advantage for prokaryotes. [4]

H

JC 2 PRELIMINARY
EXAMINATIONS Higher 2

CANDIDATE NAME

CLASS

BIOLOGY

9648/02

Paper 2 Core Paper

September 2016

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use soft pencil for any diagrams, graphs or rough working.
Do no use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** questions.

Section B

Answer any **one** question.

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	
Section A	
1	
2	
3	
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5	
6	
7	
Section B	
Total	

This document consists of **20** printed pages and **no** blank page.

[Turn over

Section A

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

1 Fig 1.1 shows a molecule of tRNA and the enzyme that attaches the correct amino acid to it

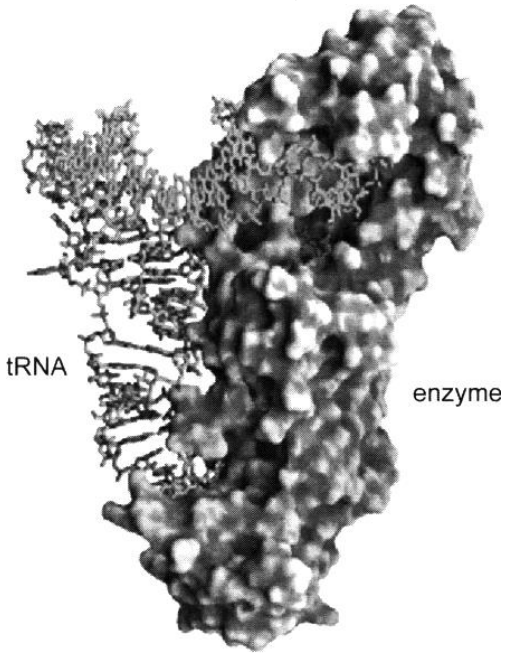

Fig. 1.1

(a) With reference to **Fig. 1.1**, explain how the enzyme is suited to its function **[AJC 2011]**

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[3]

(b) The average molecular weight of proteins encoded in the human genome is about 50,000 daltons. Given the average molecular mass of an amino acid is about 110 daltons and 5% of the initial transcript is converted to mature mRNA, estimate how long it will take a muscle cell to transcribe a gene for an average protein. Assume that the transcription rate is 20 nucleotides per second.

Show your working and express your answer to the nearest whole number (in minutes).

Answer: …… minutes [2]

(c) Edeine is an antibiotic that inhibits protein synthesis but has no effect on either DNA synthesis or RNA synthesis. When added to the cell extract of an immature red blood cell, edeine stops protein synthesis after a short lag, as shown in Fig. 1.2. By contrast, cycloheximide, which is also an inhibitor, stops protein synthesis immediately. Protein synthesis is measured via radioactivity in haemoglobin.

Analysis of the edeine-inhibited cell extract showed that no polyribosomes remained at the time protein synthesis had stopped. Instead, all the globin mRNA were found associated with small ribosomal subunit and initiator tRNA.

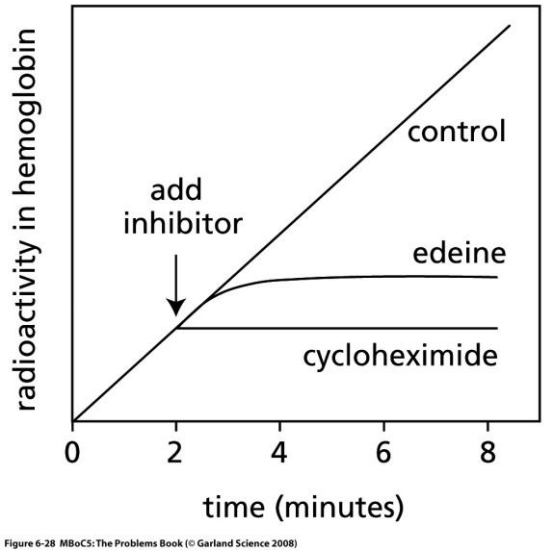

Fig. 1.2

(i) Explain how protein synthesis is measured via radioactivity in haemoglobin.

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[1]

(ii) Describe how edeine inhibits protein synthesis.

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[2]

(iii) Explain why there is a lag between the addition of edeine and cessation of protein synthesis.

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[2]

Protein synthesis in an organism is illustrated in Fig 1.3. (MJC 2011)

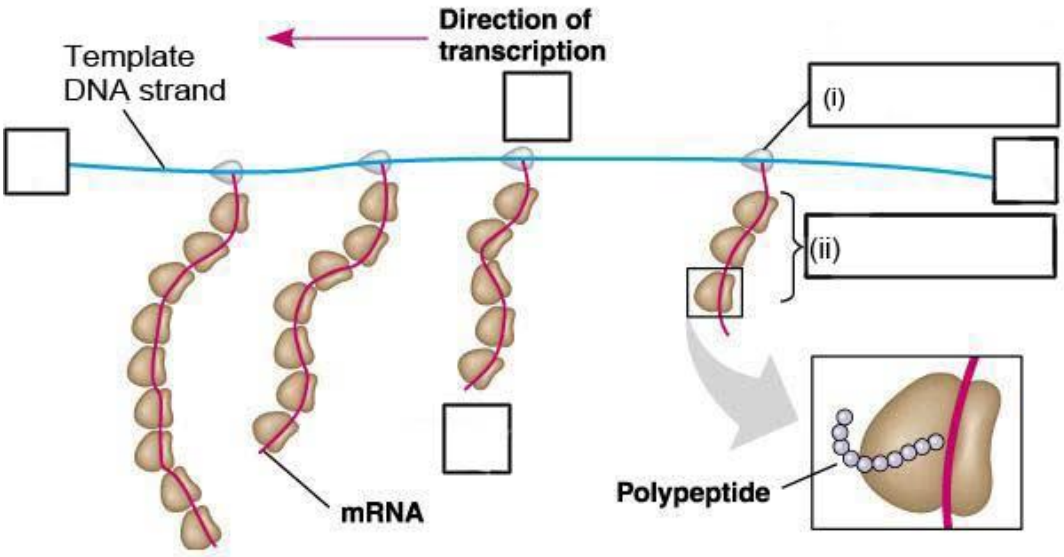

Fig. 1.3

(a) Label the 5' and 3' ends of the mRNA and DNA template strand and structures (i) and (ii) on Figure 1.2. [2]

[Total: 12]

2 A gene for feather colour in chickens is carried on an autosome. This gene has two alleles, black (C^B) and splashed-white (C^W). When a male chicken with black feathers is mated with a female chicken with splashed-white feathers, all the offspring have blue feathers. This also occurs when a male chicken with splashed-white feathers is crossed with a female with black feathers.

Black feathers

Splashed-white feathers

Barred feathers

Another gene may cause stripes on feathers (barred feathers). The gene is carried on the X chromosome. The allele for barred feathers (X^A) is dominant to the allele for non-barred feathers (X^a). In chickens the male is homogametic, while the female is heterogametic.

(a) A male chicken with black, non-barred feathers was crossed with a female chicken with splashed-white, barred feathers. All the offspring had blue feathers, but the males were barred and the females were non-barred.

(i) Using the symbols given on the previous page draw a genetic diagram to show this cross.

Parental phenotype	Male, black, non-barred feathers	Female, splashed-white, barred feathers
Genotype		
Gametes		
Offspring genotypes		
Phenotypes		

[4]

(ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

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[3]

(b) The table below shows the genotypes and wool length in two breeds of sheep, **X** and **Y,** and their F1 hybrids.

	Genotype	***Mean wool length/cm***
Breed **X**	**DDEEff**	**18**
Breed **Y**	**ddeeFF**	**14**
F1 (breed **X** x Breed **Y**)	**DdEeFf**	**16**

When the F1 were crossed among themselves, the F2 offspring had a mean wool length ranging from 10cm to 22cm.

Assume that the inheritance of wool length in sheep depends upon alleles at three loci acting additively and that all variation in wool length in the F2 population is due to the segregation of alleles at these three loci.

How many different types of gametes would be produced by an organism of genotype DdEeFF, if all of the genes assort independently?

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[1]

What proportion of the F2 offspring are expected to have a mean wool length of 2 cm? Explain your reasoning.

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[4]

[Total: 12]

3 Phosphofructokinase (PFK) is a tetrameric enzyme that plays a central role in controlling the rate of glycolysis. In many organisms, the activity of PFK is enhanced allosterically by several substances, including ADP, and is inhibited allosterically by several other substances, including ATP and citrate. Fig. 3.1 shows part of the glycolysis reactions.

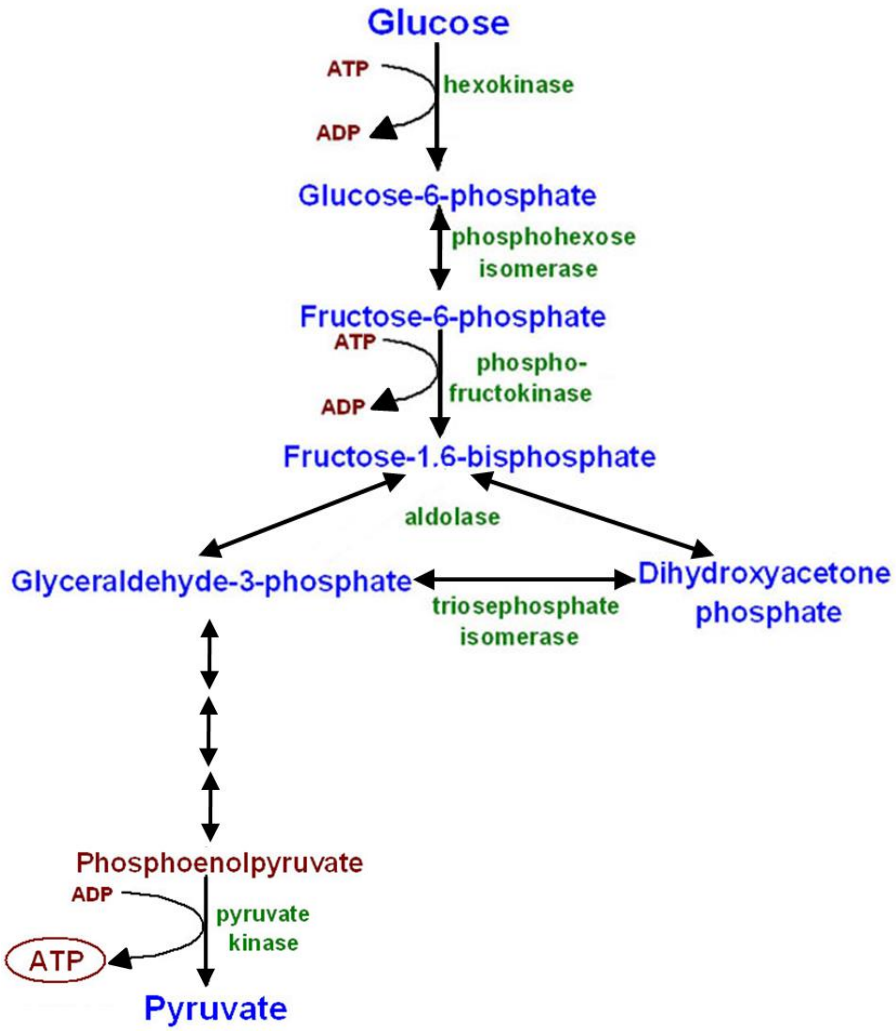

Fig. 3.1

(a) Explain why phosphofructokinase is a quaternary protein. MJC 2011

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[1]

(b) Besides PFK, hexokinase and pyruvate kinase also play a role in determining the overall rate of glycolysis.

With reference to Fig. 3.1, suggest why reactions catalyzed by these three enzymes determine the rate of glycolysis.

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[1]

(c) Explain the importance of inhibition of PFK by citrate when citrate concentration in the cell is high.

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[2]

(d) Describe how citrate inhibits PFK.

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[3]

(e) In mammals, under anaerobic condition, both Krebs cycle and oxidative phosphorylation do not occur. Instead, lactate fermentation occurs.

Explain the significance of lactate fermentation.

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[2]

(f) Hexokinase, the enzyme involved in the first step of glycolysis, is able to utilize various hexoses such as glucose, fructose and mannose.

Suggest how hexokinase is able to utilize different substrates.

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[2]

[Total: 12]

4 Norepinephrine is a stress hormone secreted during fight-or-flight response. Fig. 6.1 shows an example of a G-protein signalling pathway.

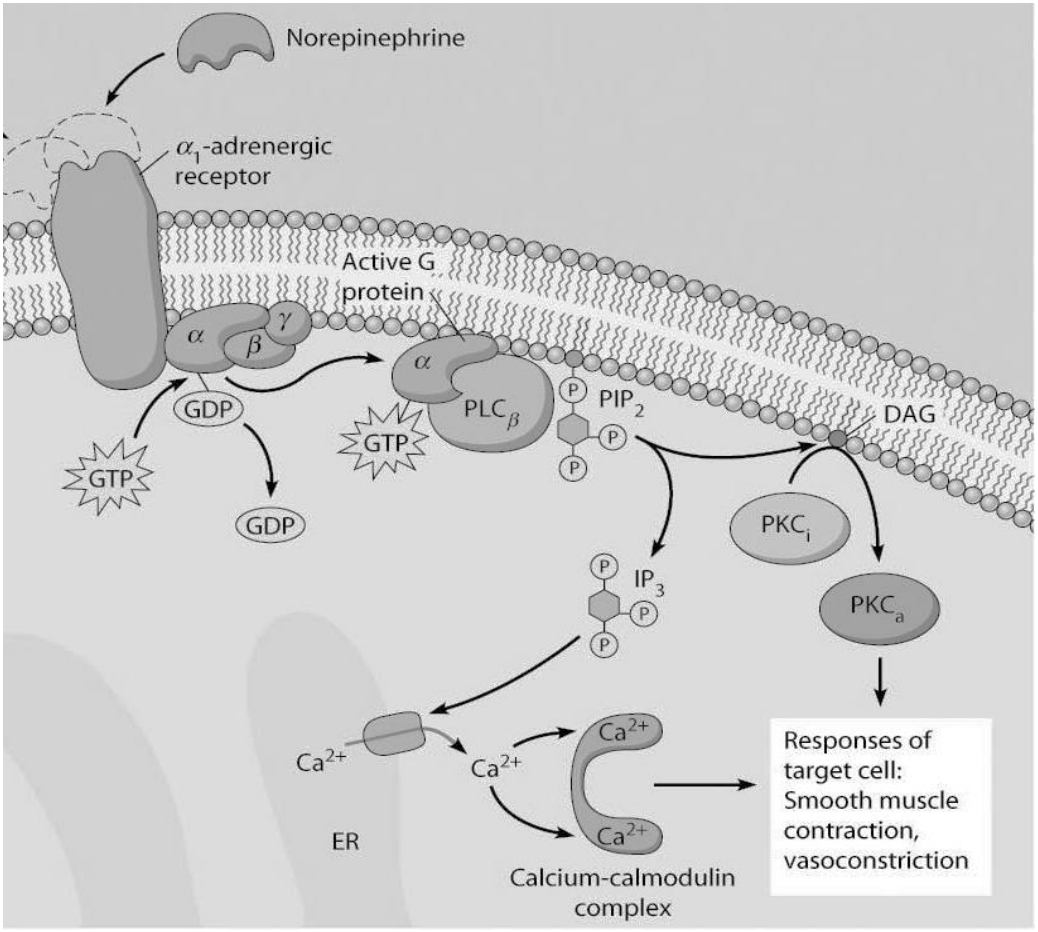

Fig. 4.1

(a) With reference to Fig. 6.1, describe explain how the presence of norepinephrine leads to the opening of IP_3-gated Ca^{2+} channels.

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[4]

(b) With reference to Fig. 6.1, explain the significance of IP_3 and Ca^{2+} in the cell signalling pathway.

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[2]

(c) The same signalling molecule norepinephrine usually targets more than one cell type. For e.g. muscle, heart and liver cells.

Explain how the same norepinephrine molecule can have different effects on different cells.

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[2]

(d) Suggest how signal termination can occur.

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[1]

Most people with type I diabetes inject insulin. A recent product contains insulin that can be administered using a nasal spray. The spray is inhaled and the insulin is taken up through the lungs.

Fig. 6.2 shows the concentration of insulin in the blood plasma in the 480 minutes after injecting or inhaling insulin. In both cases, the insulin was of the same type, obtained from genetically engineered *Escherichia coli*.

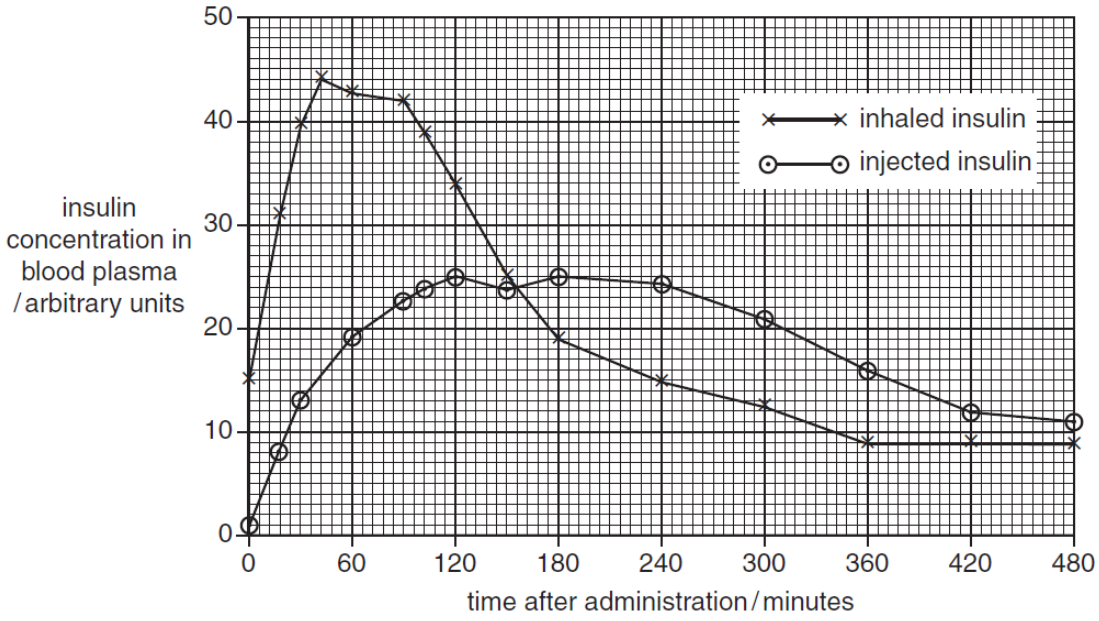

Fig 6.2

Fig. 6.3 shows the concentration of glucose in the blood plasma in the 480 minutes after injecting or inhaling insulin.

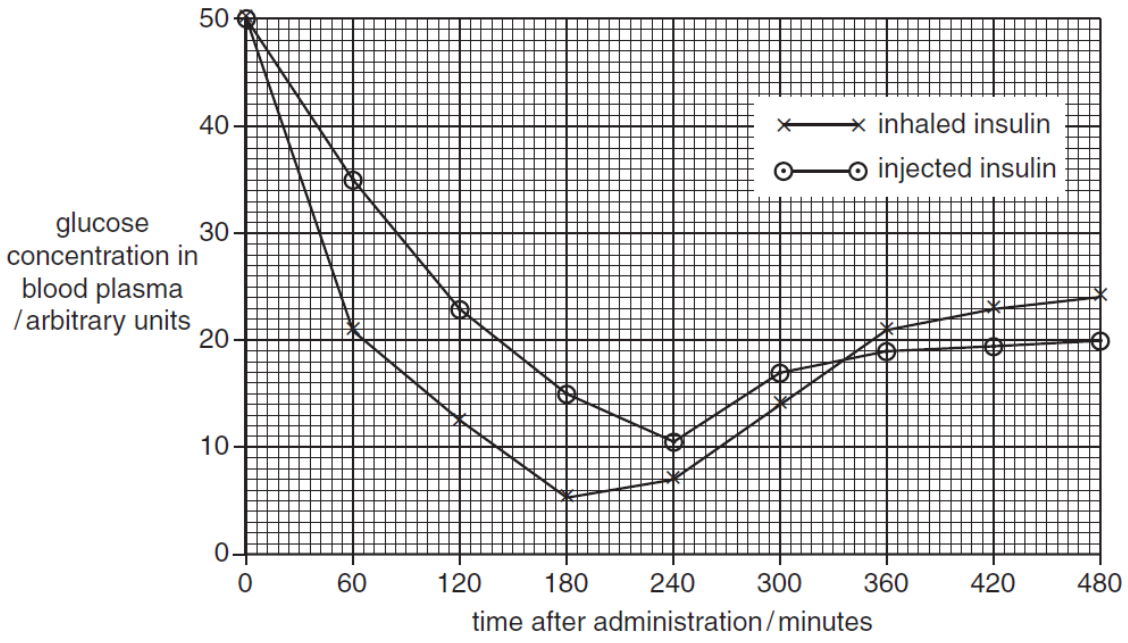

Fig 6.3

(e) Compare the results for injected insulin and inhaled insulin shown in Fig. 6.2.

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[2]

(f) With reference to Fig. 6.2, explain the differences in the blood glucose levels after injecting or inhaling insulin shown in Fig. 6.3.

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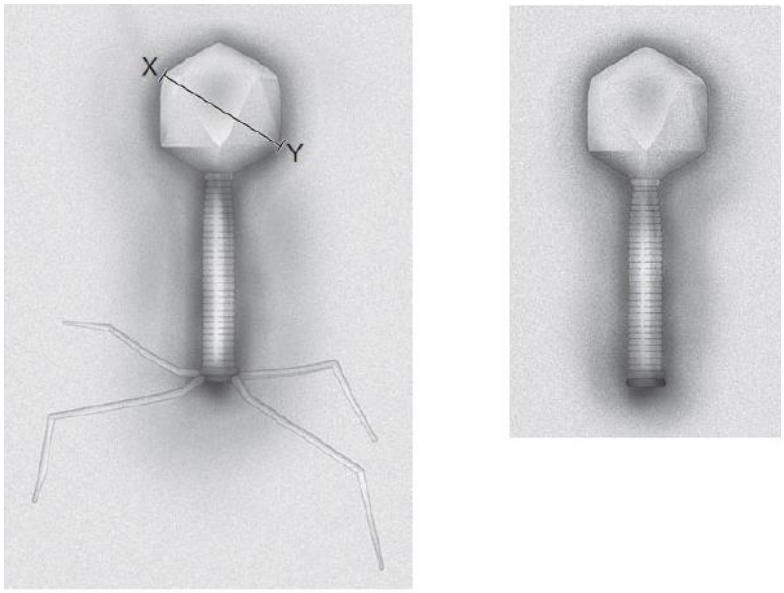
[3]

[Total: 14]

5 Lambda is a bacteriophage that uses *Escherichia coli* as its host cell. Fig. 5.1 A is an electron micrograph (EM) of a wild-type bacteriophage lambda while Fig. 5.1 B is an EM of a laboratory-cultured lambda. MJC 2010



A B

(a) State one main difference between the two bacteriophages.

Presence or tail fibres in phage A

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[1]

(b) Studies have shown that laboratory-cultured bacteriophage can bind to the host cell, *Escherichia coli*. But no new phages are formed.

Suggest how the laboratory-cultured bacteriophage binds to the host cell, *Escherichia coli*.

Binding to host cell via base plate

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[1]

(c) Suggest why no new phages were formed.

Phage DNA integrates into bacterial genome as prophage ; undergoing lysogenic cycle

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[1]

(d) Explain how lambda phage enters the host cell.

Lambda phage recognises and binds / attaches to specific receptor sites on host cells' surface (attachment phase)

Penetrates into host by injecting its DNA into the cytosol of the host bacteria

[2]

(e) Suggest why it is sometimes difficult to distinguish between a plasmid and the DNA of the bacteriophage lambda inside an *Escherichia coli*, when viewed under the electron microscope.

Both may be similar in size / circular in shape

[1]

Some of the *Escherichia coli.* are infected with the laboratory-cultured lambda phage. The bacteria are initially cultured in a nutrient medium without X-gal. The bacteria colonies produced are replica plated onto two agar plates, one containing X-gal and lactose and the other containing X-gal without lactose.

There is no glucose in either plates. Fig. 5.2. shows the results of this experiment.

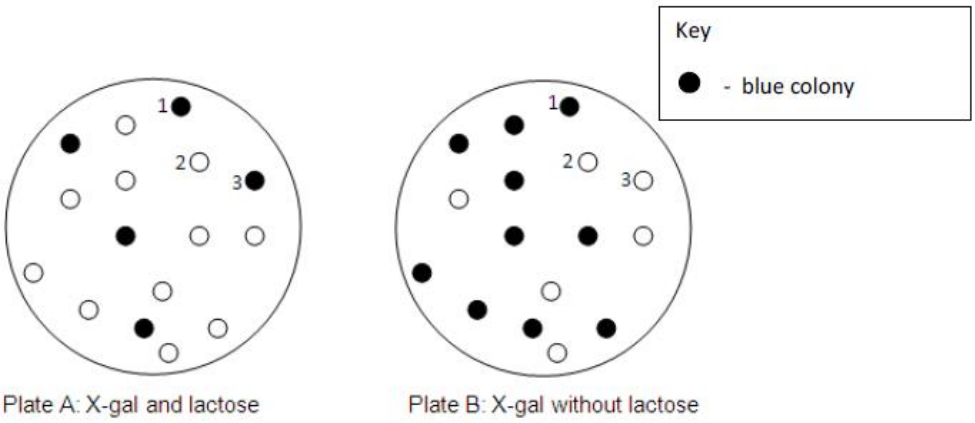

Fig. 5.2

(f) Account for the observations seen in:

(i) Colony 1

Colony 1 is blue in both plates because transcription of Lac Z gene is turned on all the time so β galactosidase is continuously translated to break dwon X-gal into a blue compound

Phage DNA is integrated into the operator by transduction and repressor cannot find to operator OR phage DNA is integrated inot lacI gene and no repressor is produced;

[2]

(ii) Colony 2

Colony 2 is white in both plates because transcription of lac Z gene cannot take place and β galactosidase is not translated ;

Viral DNA is integrated into the promoter and RNA polymerase cannot bind to promoter OR viral DNA is integrated into lac Z gene and lac Z gene is disrupted leading to insertional inactivation ;

[2]

(iii) Colony 3

Observation for colony 3 is as expected. Blue when lactose is present and white when lactose is absent / regulation of lac operon is normal ;

Viral genome is not integrated into the lac operon / no transduction occurs ;

[1]

[Total: 11]

6 **(a)** With reference to the *lac* operon, explain what is meant by : CJC 2011 Q3

(i) regulatory genes;

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[2]

(ii) structural genes

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[2]

(b) Fig. 6.1 below is an electron micrograph of a microorganism that is isolated from the stools of cholera patients.

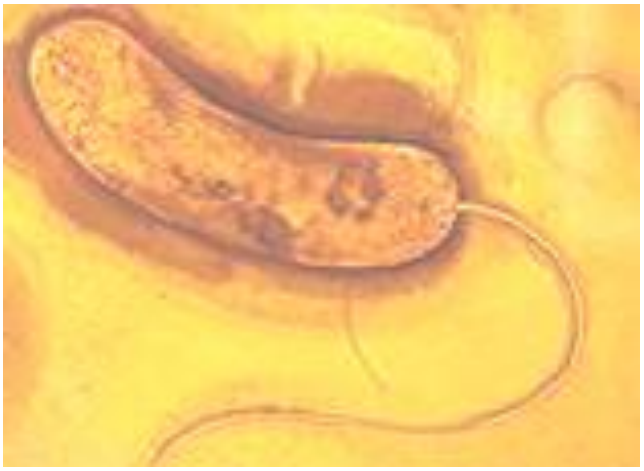

Fig. 6.1

With reference to Fig. 6.1, state **two** structural differences between the chromosome of this type of microorganism and a human cell.

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[2]

(c) The enzyme lactase is responsible for lactose metabolism in humans and is encoded by a gene on chromosome 2.

Based on your understanding of eukaryotic and prokaryotic genomes, describe how the genes in humans and *Escherichia coli* that are responsible for lactose metabolism differ in terms of:

(i) their organisation;

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[1]

(ii) the control of gene expression.

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[2]

(d) Streptomycin is an antibiotic that binds to bacterial ribosomes.

(i) Explain how this effect of streptomycin prevents the growth of bacteria.

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[2]

(ii) Suggest why streptomycin does not affect the growth of human cells.

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[1]

[Total: 12]

7 **Fig. 7.1** shows the distribution of the giant tortoises across the various islands of the Galápagos archipelago. Some sub-species are distributed across the southern part of the largest island named Isabela. In addition, three other species, *G. chilensis*, *G. carbonaria*, and *G. denticulate* are also found on the west coast of Ecuador, a country in the South America continent.

The giant tortoises had been previously classified based on morphological differences, primarily using carapace (shell) shape, which varies from domed to saddleback with intermediate forms also occurring. [AJC 2011]

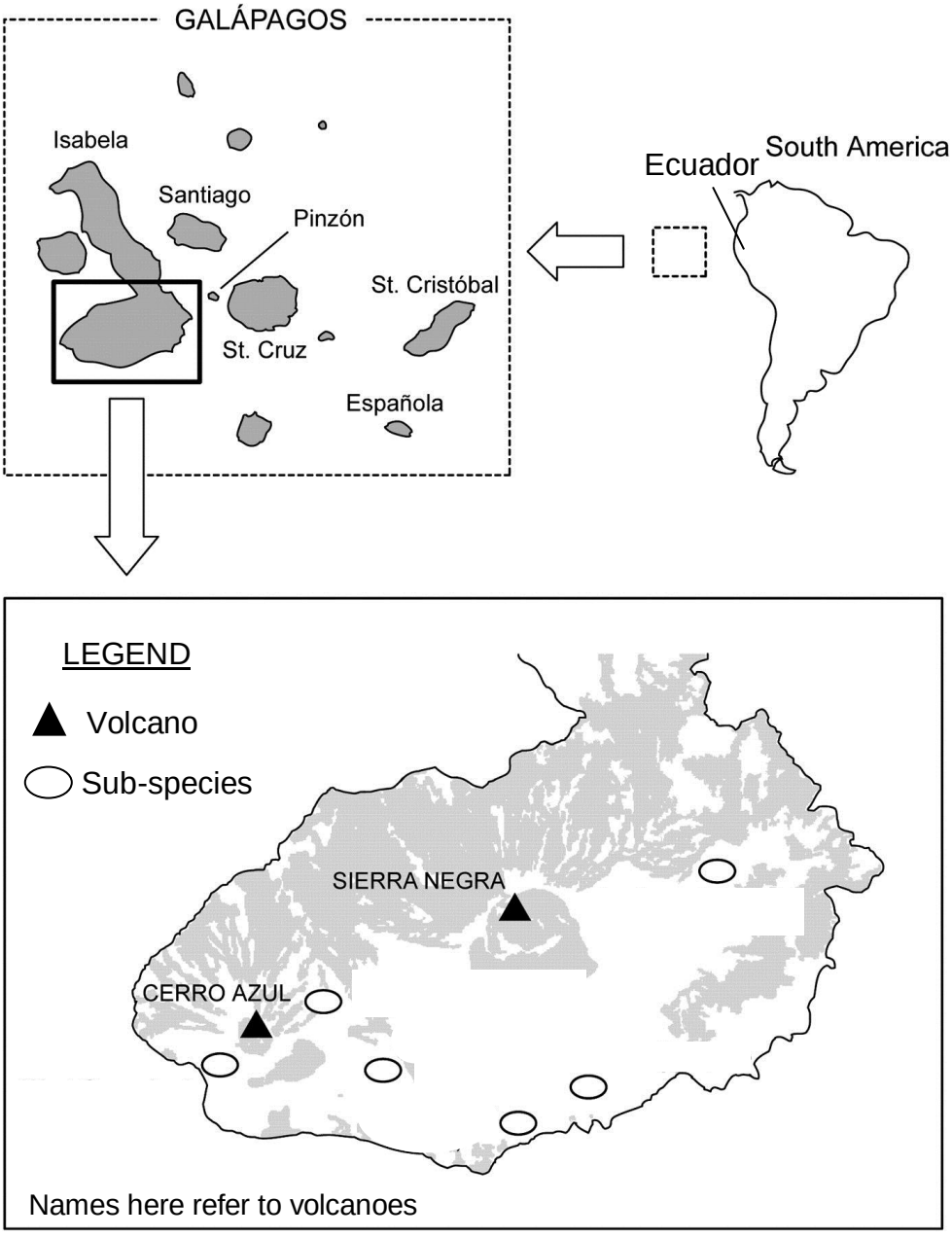

Fig. 7.1

(a) With reference to Fig. 7.1, explain how biogeography supports the evolutionary deductions that the tortoises are all evolutionally related.

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[2]

(b) Suggest why the previous classification using carapace shape may not be an accurate way of determining the evolutionary relationships accurately.

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[2]

(c) Suggest why the sub-species found on the southern part of Isabela island did not evolve to become distinct species.

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[2]

In another separate experiment, scientist were investigating on the Red Queen hypothesis which state that sexual reproduction persists because it enables many species to rapidly evolve new genetic defenses against parasites that attempt to live off them.

Scientists have tested this idea by observing different groups of small fish *Poecilopsis* species (Gila topminnow) in Mexico. Some populations of the topminnow reproduce sexually, while others practice parthenogenesis. Parthenogenesis occurs when females produce offspring without any male contribution and the female's gametes develop directly into female offspring.

Topminnows are constantly parasitized by ‘black spot disease’ caused by black spot worms that encyst in the skin. Parasitized topminnows rarely survive. The researchers found that identical populations of the asexually reproducing topminnows harbored many more black-spot worms than did those producing sexually, a finding that fit the Red Queen hypothesis: the sexual topminnows could devise new defenses faster by recombination than the asexually producing clones.

However, it was observed that after a drought, the sexually reproducing topminnows were more heavily parasitized than the cloned topminnows. This process of whereby chance events cause the allele frequency to change unpredictably is known as genetic drift.

(i) Name the evolutionary event that resulted in this genetic drift.

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[1]

(ii) Explain why there was an increase in the number of parasitized sexually reproducing topminnows after the drought.

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[2]

The Neutral Theory of Molecular Evolution proposed that frequencies of alleles are not affected by natural selection but may increase or decrease as a result of genetic drift.

(iii) Briefly describe the Neutral Theory of Molecular Evolution.

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[3]

[Total: 12]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

8 **(a)** Describe the changes involving homologous chromosomes during meiosis, and explain how these changes ensure genetic variation and genetic stability. [10]

(b) Describe the development of cancer as a multi-step process. [6]

(c) Describe the structure and functions of the centrioles in the cell. [4]

9 **(a)** Explain the role of control elements in regulating gene expression in eukaryotes. [8]

(b) Using named examples, describe the process and significance of gene amplification in eukaryotes. [8]

(c) Explain why the ability to rapidly degrade mRNA can be an adaptive advantage for prokaryotes. [4]

H

JC 2 PRELIMINARY
EXAMINATIONS Higher 2

CANDIDATE NAME

CLASS

BIOLOGY

9648/03

Paper 3 Applications and Planning

26 September 2016

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use soft pencil for any diagrams, graphs or rough working.
Do no use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

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.

Answer questions **1** to **4** in the spaces provided on the question paper.

Answer question **5** on the separate answer paper provided.

For Examiner's Use	
1	
2	
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5	
Total	60
For Examiner's Use	
4	12

This document consists of **12** printed pages and **0** blank page.

[Turn over

Section A

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

1 Insulin deficiency is one of the causes of diabetes. There are a few methods to synthesize recombinant insulin using genetic engineering, one of the methods involve cloning the human insulin cDNA.

(a) Compare the differences on how a genomic library and a cDNA library are produced.

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[2]

(b) Explain the advantages of obtaining human insulin gene from a cDNA library instead of a genomic DNA library.

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[3]

Fig. 1.1 shows the bacteria plasmid containing the positions of the restriction sites of the restriction enzymes available at its multiple cloning site. These restriction sites do not occur elsewhere within the plasmid.

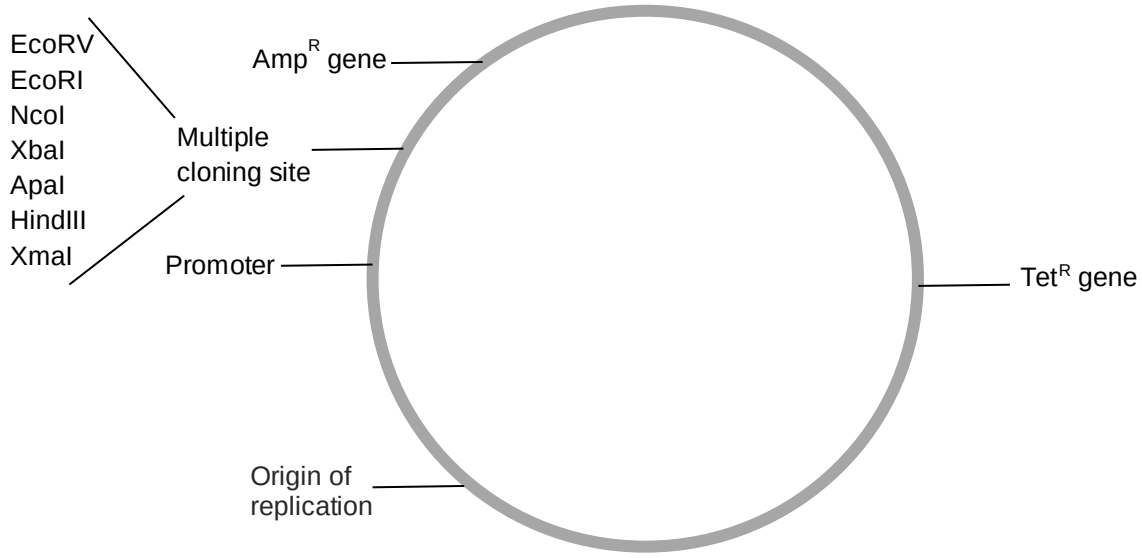

Fig. 1.1

Fig. 1.2 shows the restriction enzymes and their corresponding specific recognition sequences with respect to human insulin cDNA sequence. With the exception of *EcoRV*, all the restriction sites (*Apa I*, *Nco I*) generate sticky ends when cut.

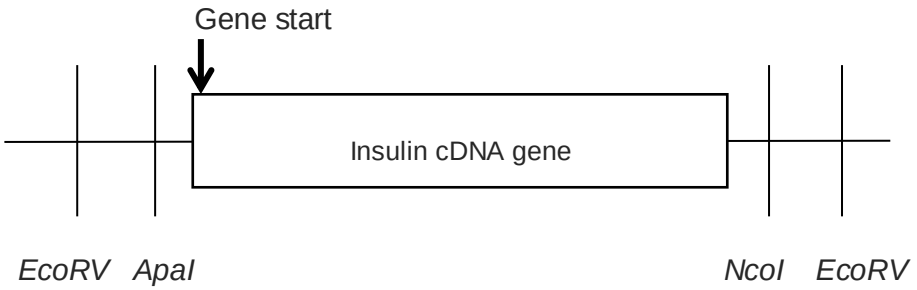

Fig. 1.2

(c) In order to obtain a recombinant plasmid containing the human insulin gene, the human insulin cDNA and vector needs to be digested with restriction enzymes prior to annealing them together.

(i) State the restriction enzymes used in order to obtain **efficient** gene expression.

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[1]

(ii) Explain your choice of restriction enzymes.

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[2]

(iii) With reference to **Fig. 1.1** and **1.2**, explain how recombinant bacteria (formed using the recombinant plasmids) can be selected using antibiotics.

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[4]

(d) Suggest a reason why functional insulin was not expressed in the recombinant E.coli cells.

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[2]

(e) Bacteriophages can be used to transfer foreign DNA into bacteria cells. Suggest **one** advantage of the use of phage vectors over plasmid vectors in transferring DNA into bacteria.

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[1]

[Total: 15]

2 A violent air crash resulted in the death of 150 passengers. The poor condition of the crash victims made physical identification impossible. Forensic scientists were tasked to confirm the identities of victims by using molecular techniques for families who have come forward to claim the correct remains of their relatives.

DNA samples of human remains and surviving relatives were subjected to restriction enzyme digest and Southern blot analysis to analyse VNTR band patterns. Single locus VNTR probes will yield DNA patterns of seven individuals at a single locus, as shown in **Fig. 2.1**. On the other hand, multi-locus VNTR probes can yield more information about each individual since 10 to 30 loci can be simultaneously analysed. This is illustrated in five different individuals in **Fig. 2.2**.

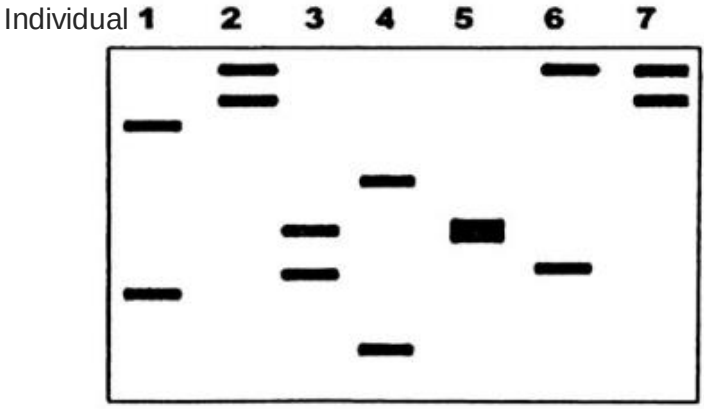

Fig. 2.1

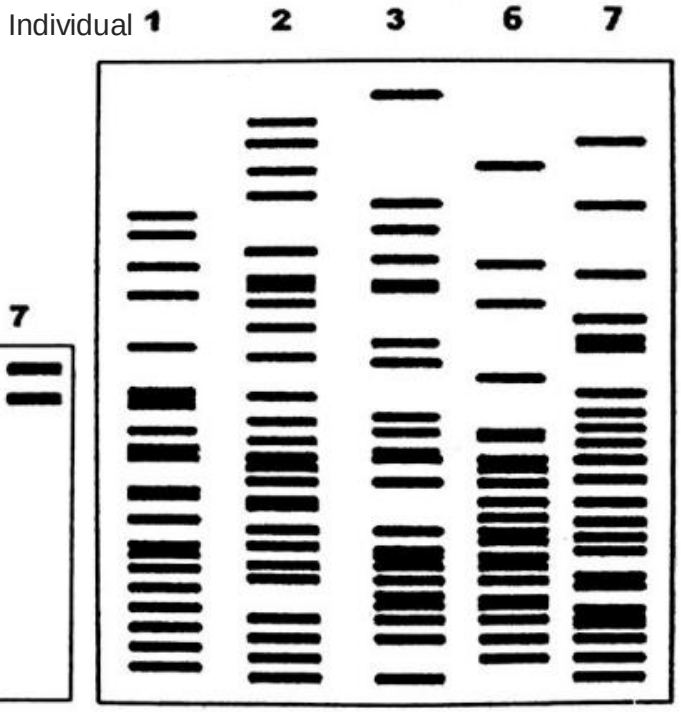

Fig. 2.2

(a) (i) Explain the basis of application of VNTR in DNA profiling.

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[3]

(ii) With reference to **Fig. 2.1**, explain the different numbers of fragments seen in different individuals.

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[2]

(iii) With reference to **Fig. 2.1** and **Fig. 2.2**, suggest why using multi-locus probes is preferred.

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[2]

(b) VNTRs can be analysed by Southern blotting or by PCR analysis.

Describe **two** differences between Southern blotting and PCR analysis in the analysis of the single locus VNTR shown in **Fig. 2.1.**

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[2]

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(c) The fully sequenced human genome contains many unknown genes. Suggest how RFLP analysis can help to identify **unknown** genes that are responsible for heritable diseases.

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[2]

[Total: 12]

3 Plant tissue culture is a method used to propagate plants. **Fig. 3.1** shows one method of plant tissue culture.

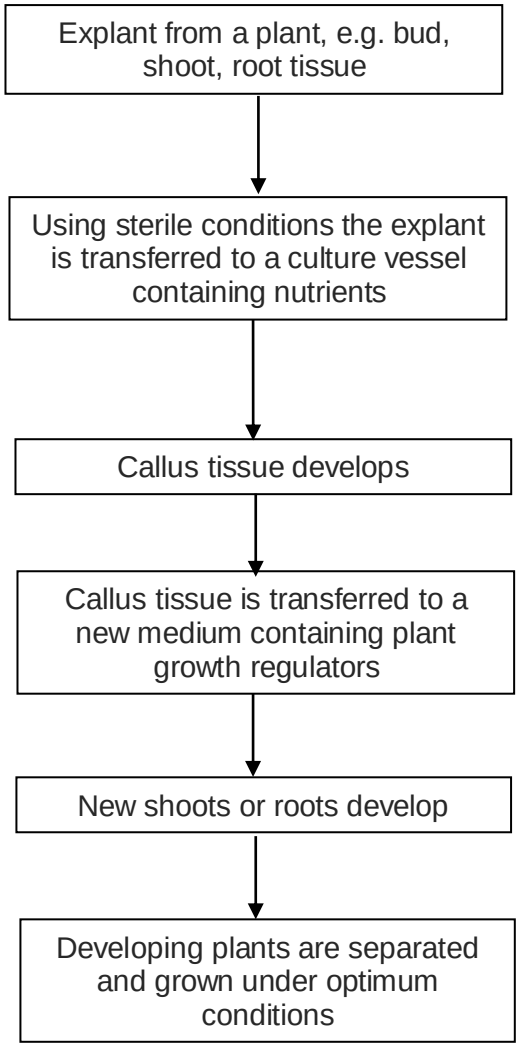

Fig. 3.1

(a) Suggest why explants are used in tissue culture.

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[1]

(b) Suggest why the explant is initially grown in sterile conditions.

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[2]

After the callus tissue develops, equal masses of the plant callus were cultured for four weeks on media containing different concentrations of two plant growth regulators: auxin and cytokinin. The results are shown in **Fig. 3.2.**

Treatment	Concentration of plant growth regulators/ mg dm^{-3}		Effect of plant growth regulators on callus growth
	auxin	cytokinin	
A	2.00	0.00	little or no growth
B	2.00	0.02	growth of roots
C	2.00	0.20	increased growth of callus with no differentiation
D	2.00	0.50	growth of shoots
E	0.00	0.20	little or no growth

Fig. 3.2

(c) Explain why growing plantlets from a callus in tissue culture results in a clone.

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[3]

(d) With reference to **Fig. 3.2**, describe the effects of auxin and cytokinin on callus growth.

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[3]

(e) Outline using **one** named example, the process of genetic engineering that could increase crop yield.

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[4]

(f) Suggest one possible risks to the environment of growing genetically engineered crops.

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[1]

[Total: 14]

Planning Question

4 Amylases are naturally found in wheat flour. During bread-making when water is added to flour, amylases are activated and break down starch in flour into maltose. Maltose is a reducing sugar and its presence can be tested with Benedict's solution.

Amylase activity can be inhibited by heavy metals ions such as iron (Fe^{2+}). Using this information and your knowledge, design an experiment to determine if Fe^{2+} functions as a competitive inhibitor or a non-competitive inhibitor and its effect on the rate of amylase activity.

You must use:

- 1.0% stock α-amylase solution
- 0.3% iron sulfate solution
- 5.0% starch solution
- distilled water
- Benedict's solution
- 10.0% maltose solution

You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods etc. ,
- syringes,
- white card,
- white tile,
- blunt forceps,
- Bunsen burner with tripod, gauze and bench mat,
- thermometer.
- water bath
- timer e.g. stopwatch or stop clock

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagrams, if necessary,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 12]

Write your answers on the separate answer paper provided.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

5 **(a)** Explain how a disease such as cystic fibrosis can be treated by gene therapy, using **non-viral** delivery systems. [6]

(b) Explain, with specific examples, how genetic engineering can improve the quality and yield of crop plants and animals in solving the demand for food in the world. [7]

(c) Discuss the ethical and social implications of genetically modified organisms. [7]

[Total: 20]

H

JC 2 PRELIMINARY
EXAMINATIONS Higher 2

CANDIDATE NAME **Mark Scheme**

CLASS

BIOLOGY

9648/03

Paper 3 Applications and Planning

September 2016

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
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Total	60
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4	12

This document consists of **15** printed pages and **1** blank page.

[Turn over

Section A

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

1 Insulin deficiency is one of the causes of diabetes. There are a few methods to synthesize recombinant insulin using genetic engineering, one of the methods involve cloning the human insulin cDNA.

(a) Compare the differences on how a genomic library and a cDNA library are produced.

Source: Genomic DNA, which is the complete set of genetic material of an organism VS mature messenger RNA, which is present in a specific cell type at a specific stage;

Obtaining the DNA/ mRNA to be inserted: Digestion by restriction enzymes VS no need, use reverse transcriptase and DNA polymerase instead

Vectors used: Plasmids, BAC, YAC VS Plasmids, phage.

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[2]

(b) Explain the advantages of obtaining human insulin gene from a cDNA library instead of a genomic DNA library.

Insulin gene isolated from cDNA library contains only coding regions/ does not contain introns but gene isolated from genomic DNA library contains both coding and non-coding sequence;

Bacterial cells used for cloning cannot undergo RNA processing/remove introns/RNA splicing;

Insulin gene isolated from cDNA library is intact but gene isolated from genomic DNA library may be fragmented;

Easier to find the Insulin gene from cDNA library since it smaller;

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[3]

Fig. 1.1 shows the bacteria plasmid containing the positions of the restriction sites of the restriction enzymes available at its multiple cloning site. These restriction sites do not occur elsewhere within the plasmid.

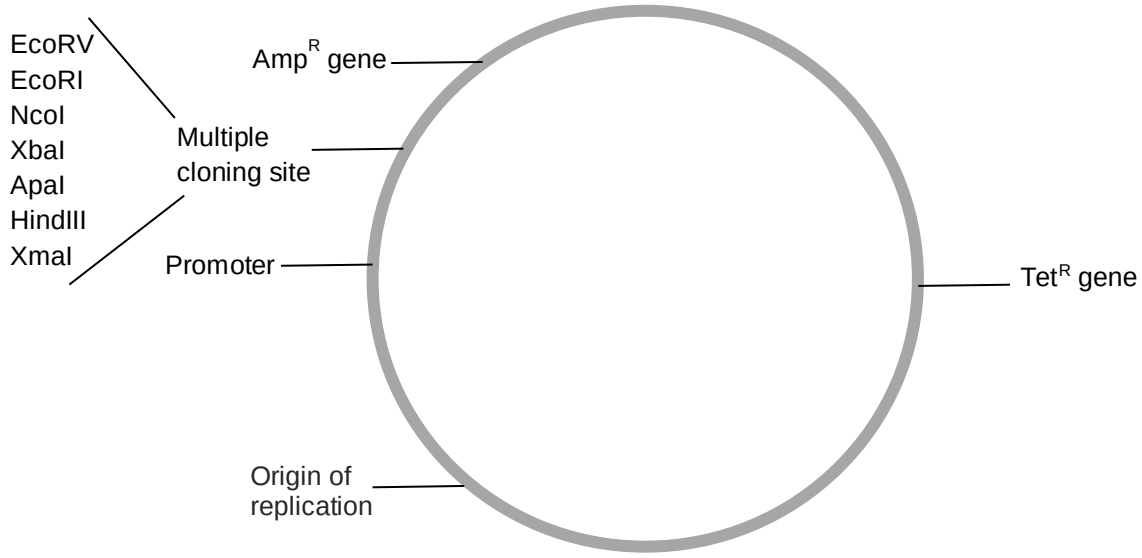


Fig. 1.1

Fig. 1.2 shows the restriction enzymes and their corresponding specific recognition sequences with respect to human insulin cDNA sequence. With the exception of *EcoRV*, all the restriction sites (*Apa I*, *Nco I*) generate sticky ends when cut.

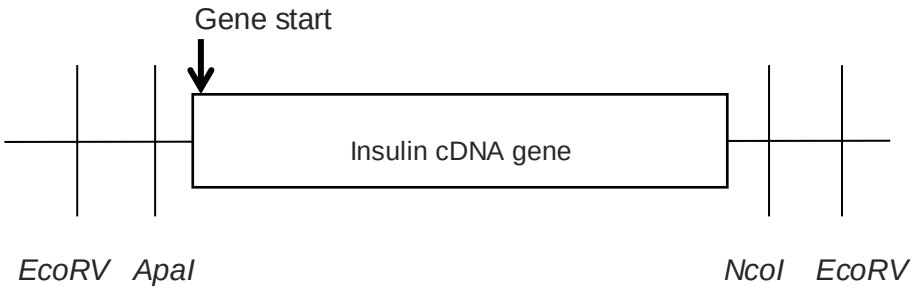


Fig. 1.2

(c) In order to obtain a recombinant plasmid containing the human insulin gene, the human insulin cDNA and vector needs to be digested with restriction enzymes prior to annealing them together.

(i) State the restriction enzymes used in order to obtain **efficient** gene expression.

ApaI and NcoI ;

[1]

(ii) Explain your choice of restriction enzymes.

Create two different **sticky ends**, ***Apa*I** near to the gene start site and **NcoI** at the gene end;
Ensure only **1 correct orientation** of inserting the gene (Transcription can occur in the correct direction);
Prevent self-annealing of gene/plasmid;

[2]

(iii) With reference to **Fig. 1.1** and **1.2**, explain how recombinant bacteria (formed using the recombinant plasmids) can be selected using antibiotics.

Two antibiotic resistance genes (Ampicillin and tetracycline resistance genes) on the plasmid are used as selection markers;

Transformed cells are grown on tetracycline plate and tetracycline selects for bacterial cells that are successfully transformed and contains the plasmid as untransformed bacterial cells without tetracycline gene dies;

Replica plating is carried out with transfer of bacterial colonies onto ampicillin plate. Transformed bacterial cells with recombinant plasmid has inserted gene of interest and thus disrupting ampicillin resistance gene, resulting in insertional inactivation thus these cells are susceptible to ampicillin and dies;

Comparison between the plates allows identification of bacterial colonies with recombinant plasmid. Those bacteria colonies that survive on Tet plate and died on Amp plate contain recombinant plasmids and the corresponding bacteria colonies are isolated from the Tet plate;

[4]

(d) Suggest a reason why functional insulin was not expressed in the recombinant E.coli cells.

Euk post-translational modifications not present in prok cells;

Signal peptide cannot be removed from preproinsulin to form proinsulin, which usually happens in rER in euk cells;

Proinsulin cannot undergo modification whereby A chain and B chain are joined via disulfide bonds and the C chain removed, so as to form functional insulin.

® no post transcriptional modification

[2]

(e) Bacteriophages can be used to transfer foreign DNA into bacteria cells. Suggest **one** advantage of the use of phage vectors over plasmid vectors in transferring DNA into bacteria.

Higher transformation efficiency as bacteriophages specifically target bacteria cells (must have reference to specificity);

(Temperate) phages can integrate their genomes together with the gene of interest into the bacterial chromosome, hence the gene of interest is replicated together with the bacterial chromosome during DNA replication;

Phage vectors can accommodate large DNA inserts/ longer DNA fragments;

[1]

[Total: 15]

2 A violent air crash resulted in the death of 150 passengers. The poor condition of the crash victims made physical identification impossible. Forensic scientists were tasked to confirm the identities of victims by using molecular techniques for families who have come forward to claim the correct remains of their relatives.

DNA samples of human remains and surviving relatives were subjected to restriction enzyme digest and Southern blot analysis to analyse VNTR band patterns. Single locus VNTR probes will yield DNA patterns of seven individuals at a single locus, as shown in **Fig. 2.1**. On the other hand, multi-locus VNTR probes can yield more information about each individual since 10 to 30 loci can be simultaneously analysed. This is illustrated in five different individuals in **Fig. 2.2**.

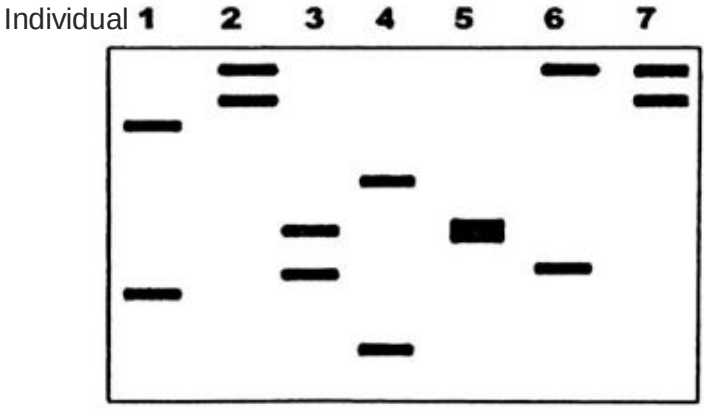


Fig. 2.1

Fig. 2.2

(a) (i) Explain the basis of application of VNTR in DNA profiling.

Each individual has a different number of tandem repeats;

As such, their DNA fragments which are cut from the genome will be of different sizes;

Which will affect their position on the agarose gel during gel electrophoresis, and subsequently nitrocellulose membrane during Southern Blotting;

[3]

(ii) With reference to **Fig. 2.1**, explain the different numbers of fragments seen in different individuals.

For individuals with 2 fragments, they are heterozygous for that gene and each allele will be a different VNTR. Therefore, different sized fragments are produced, resulting in 2 bands;

Individuals who have singe band are homozygous for that gene. Therefore, both alleles have the same VNTR, and only 1 sized DNA fragment is produced;

[2]

(iii) With reference to **Fig. 2.1** and **Fig. 2.2**, suggest why using multi-locus probes is preferred.

They provide more points of comparison as when using a single locus, the victim would have a different VNTR for that locus from his relative.

However, it is more likely to identify the correct human remains with multi-locus as there are higher chances of finding similarities in DNA banding patterns of multiple locus.

[2]

(b) VNTRs can be analysed by Southern blotting or by PCR analysis.

Describe **two** differences between Southern blotting and PCR analysis in the analysis of the single locus VNTR shown in **Fig. 2.1.**

DNA probes are used in Southern blotting, whereas DNA primers are used in PCR.

Autoradiography is used in Southern blotting but not in PCR analysis.

[2]

(c) The fully sequenced human genome contains many unknown genes. Suggest how RFLP analysis can help to identify **unknown** genes that are responsible for heritable diseases.

RFLP markers are linked to the genes and so, even if the genes are unknown;

probing for the presence of the specific RFLP restriction site would indicate a high probability of the presence of the disease allele;

[2]

[Total: 12]

3 Plant tissue culture is a method used to propagate plants. **Fig. 3.1** shows one method of plant tissue culture.

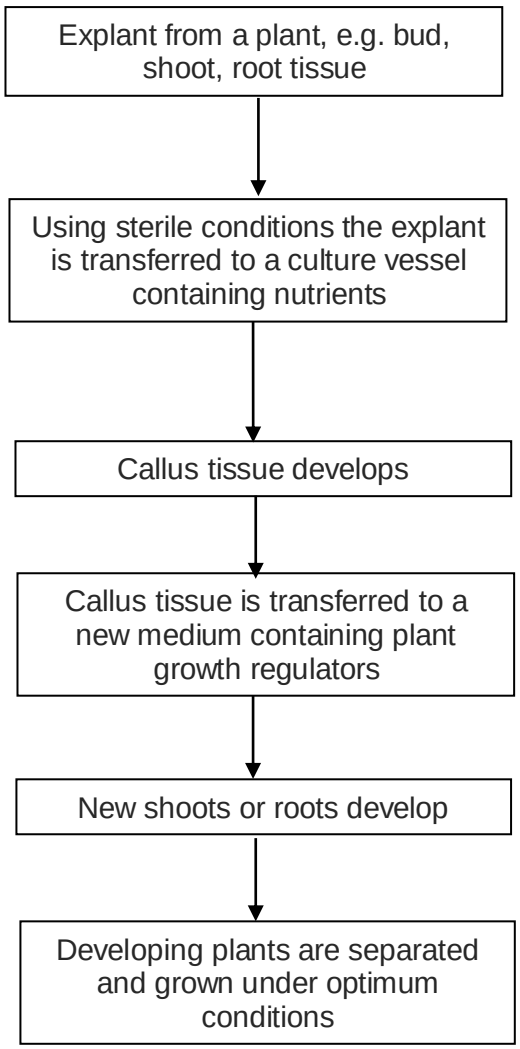


Fig. 3.1

(a) Suggest why explants are used in tissue culture.

Contain meristematic cells which are able to **divide** and **differentiate** into any cell type / **regenerate** the whole plant / are **totipotent;**

[1]

(b) Suggest why the explant is initially grown in sterile conditions.

To prevent **contamination** by bacteria / fungi / micro-organisms (® pathogens);
which can (grow very rapidly on the media and) compete with explant for nutrients;

OR

To prevent infection by bacteria / fungi / micro-organisms / pathogens;

Which can spread very rapidly to other cells as they are genetically identical; (®

because they do not have any defense mechanism)

[2]

After the callus tissue develops, equal masses of the plant callus were cultured for four weeks on media containing different concentrations of two plant growth regulators: auxin and cytokinin. The results are shown in **Fig. 3.2.**

Treatment	Concentration of plant growth regulators/ mg dm^{-3}		Effect of plant growth regulators on callus growth
	auxin	cytokinin	
A	2.00	0.00	little or no growth
B	2.00	0.02	growth of roots
C	2.00	0.20	increased growth of callus with no differentiation
D	2.00	0.50	growth of shoots
E	0.00	0.20	little or no growth

Fig. 3.2

(c) Explain why growing plantlets from a callus in tissue culture results in a clone.

This is a type of **asexual** reproduction / derived from a single parent;

All the plantlets are **genetically identical** (® genetically similar) / have the same genotype; (® same genome)

Due to **semi-conservative replication** of the parental DNA;

Examiner's Comments

Students might fail to identify the last point.

[3]

(d) With reference to **Fig. 3.2**, describe the effects of auxin and cytokinin on callus growth.

Both hormones need to be present for any growth to occur / The type of growth depends on the relative concentrations of the auxin and cytokinin;

A low level of cytokinin, i.e. 0.02 mg dm to auxin, triggers root growth

Increasing the relative level of cytokinin, i.e. 0.50 mg dm to auxin, i.e. 2.00 mg dm triggers shoot growth;

[3]

(e) Outline using **one** named example, the process of genetic engineering that could increase crop yield.

Example: Pest-resistant (NOT pesticide-resistant / insect-resistant);

The gene of interest is inserted into a tumour-inducing / Ti plasmid, using same restriction enzyme;

Selection for *Agrobacterium* cells that have successfully taken up recombinant plasmid, which are then cultured with leaf discs / callus tissue;

Transgenic plants containing the Bt gene are protected against damage by insect pests;

[4]

(f) Suggest one possible risks to the environment of growing genetically engineered crops.

Gene transfer to other plants/crops due to cross pollination;
Contamination of other crop (e.g. ref to organic crop);
Gene transfer to wild relative;
Gene transfer from crop to crop via bacteria or viruses with unknown effect;;
Recipient plant (plant that receives the gene) outcompetes others / ref to 'superweed';
Toxic to non pests;

[1]

[Total: 14]

Planning Question

4 Amylases are naturally found in wheat flour. During bread-making when water is added to flour, amylases are activated and break down starch in flour into maltose, which is a reducing sugar. Maltose is a reducing sugar therefore its presence can be tested with Benedict's solution.

Amylase activity can be inhibited by heavy metals ions such as iron (Fe^{2+}). Plan an investigation to determine if Fe^{2+} functions as a competitive inhibitor or a non-competitive inhibitor of amylase.

You must use:

- 1.0% stock α-amylase solution
- 0.3% iron sulfate solution
- 5.0% starch solution
- distilled water
- Benedict's solution
- 10.0% maltose solution

You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods etc. ,
- syringes,
- white card,
- white tile,
- blunt forceps,
- Bunsen burner with tripod, gauze and bench mat,
- thermometer.
- water bath
- timer e.g. stopwatch or stop clock

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagrams, if necessary,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 12]

Theoretical Background (2M max)

- Heavy metals are positively charged and form strong bonds with negatively-charged carboxyl R-groups of proteins, disrupting ionic bonds.
- With less negative charges on the protein, the solubility of protein is reduced, as there is less interaction with polar water molecules.
- Protein denaturation
    - loss of specific 3D conformation → loss of enzymatic function, amylase unable to catalyse the breakdown of starch to form maltose
    - enzyme inhibitors affect enzyme activity resulting in a decrease in the rate of enzyme catalyzed reactions
    - **Competitive inhibitor** is structurally similar to the substrate
    - Binds reversibly to the active site of the enzyme and competes for the substrate for active site
    - Effect of inhibition overcome by increasing substrate concentration
    - **Non-competitive inhibitor** does not bind to active site of the enzyme
    - Binds to site away from the active site
    - Inhibition cannot be overcome by increasing substrate concentration
    - active site distorted, fewer E-S complex formed per unit time
- Maltose is produced when amylase digests starch, which can be detected using the reducing sugar test.
- Maltose reacts with Benedict's solution to give precipitate. The colour and the cloudiness of the mixture reflect the amount of maltose present.
- As the amount of maltose increases, the colour of the mixture changes from green to yellow to orange-red and the degree of cloudiness increases.
- The concentration of the maltose can thus be estimated by comparing the colour and the degree of cloudiness against the mixture obtained from Benedict's test conducted on maltose solutions of known concentration.

Hypothesis (1M)

- If Iron ion functions as a non-competitive inhibitor, it prevents the rate of reaction from reaching Vmax.
- When concentration of starch solution increases, the rate of amylase activity does not reach the maximum rate.
- The lesser the number of functional amylases, the lesser the number of E-S complexes formed per unit time, amount of reducing sugar produced decreases.
- The colour of the precipitate will be less orange-red when inhibitor is used, as compared to the absence of inhibitor.

Variables (2M)

Dependent

- Rate of enzyme amylase activity
- Measure by concentration of reducing sugars produced per unit time (% min^{-1})

Independent

- Concentration of starch solution (at least 5, with regular spacing between intervals)

Constant

- Time taken for reaction, temperature, pH, vol of inhibitor solution, vol of starch solution, vol of amylase, volume of Benedict's solution, vol of sample of Benedict's solution + *Explain how to keep them constant*

Procedure (*Apparatus and Quantity) (4M)

Preparation of maltose standards

1. Prepare 20 cm3 of various concentrations of maltose solutions as shown in the table below. Perform dilutions of 10.0% reducing sugar solution to produce 5.0%, 4.5%, 4.0%, 3.5%, 3.0%, 2.5%, 2.0%, 1.5%, 1.0%, 0.5%, using 10cm3-syringes and place the solution into 10 separate boiling tubes.

Concentration of maltose solution to be prepared /%	Volume of 10% maltose solution /cm3	Volume of distilled water / cm3
0.5	1	19
1.0	2	18
1.5	3	17
2.0	4	16
2.5	5	15
3.0	6	14
3.5	7	13
4.0	8	12
4.5	9	11

3. Label 10 test-tubes 0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%, 3.5%, 4.0%, 4.5% and 5.0%.
4. Using a 5-cm3 syringe, add 2 cm^3 of each concentration of maltose solution into their respective test-tubes.
5. Using a 5-cm3 syringe, add 2 cm^3 of Benedict's solution. Shake gently to mix the contents of the tube
6. Place all the test tubes in the boiling / (between 80-100°C) water bath for two minutes. Start the stopwatch.
7. After two minutes, stop the stopwatch. Remove the tubes from the boiling water and place them on the rack.
8. Shake gently to mix the contents of the tube and observe the contents of the test-tubes immediately after mixing. Record the observations in a table, noting any differences in terms of colour and cloudiness.

Preparation for different concentrations of starch

Concentration of starch solution to be prepared /%	Volume of 5% starch solution /cm3	Volume of distilled water / cm3
1.0	10	10
2.0	12	8

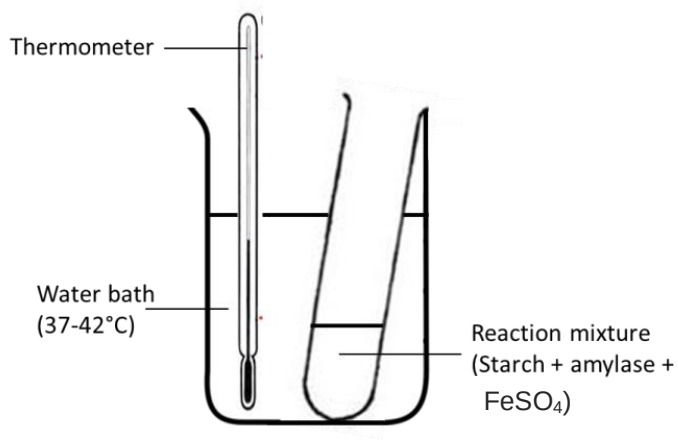
3.0	14	6
4.0	16	4
5.0	18	2

3. Prepare 20cm^3 of 5 different concentrations of starch according to the dilution table. Perform dilutions of 5.0% starch solution to produce 1.0%, 2.0% 3.0%, 4.0%, 5.0% using 10cm^3-syringes and place the solution into 5 separate boiling tubes.
4. Using a 10-cm^3 syringe, add 5 cm^3 of each concentration of starch solution into their respective test-tubes.
5. Label 5 test tubes separately and add 1cm^3 of the amylase solutions into each test tube.
6. Equilibrate the amylase solutions and starch suspension in the constant 38-42°C water bath for 2 min.
7. After 2 min, add 1cm^3 of the 0.3% $FeSO_4$ solution and 1cm^3 amylase solution to 5cm^3 starch solution.
8. Mix well by stirring with a glass rod and start time. Allow the reaction to take place for 2 minute.
9. Immediately after 2 minutes, remove the reaction mixture.
10. To 2cm^3 of the reaction mixture, add equal volume of Benedict's solution. Shake gently to mix the contents of the tube
11. Place the test tube in the boiling / (between 80-100°C) water bath for two minutes. Start the stopwatch.
12. After two minutes, stop the stopwatch. Remove the tube from the boiling water and place them on the rack.
13. Shake gently to mix the contents of the tube and observe the contents of the test-tubes immediately after mixing. Record the observations in a table, noting any differences in terms of colour and cloudiness.
14. Place the tubes containing the reaction mixture after Benedict's test and the glucose standards against a white card. Compare with the glucose standards (from Part I, Step 8) to determine the amount of maltose present. Shake the tube gently to mix the contents before comparison.
15. Record the amount of maltose present (%) in a table.
16. To ensure reliability of results, **repeat steps 4 to 14** to obtain a total of three readings (triplicates**)** at this starch concentration using fresh samples
17. Repeat steps 4 to 15 using the other starch concentrations as prepared.
18. To show that the inhibitor affects the function of amylase, a control is set up with 0% $FeSO_4$ solution. Steps 4 to 14 are performed with equivalent volume of distilled water in place of $FeSO_4$ solution. This is to obtain results of the effect of starch concentration on the rate of starch hydrolysis / enzyme activity on starch hydrolysis in the absence of inhibitor.
19. To ensure reproducibility of data, **repeat the entire experiment** twice using freshly prepared reagents and solutions and maltose standards.

Standards – known concentrations of maltose solution

Controls – absence of iron sulfate (0%)

Annotated diagram

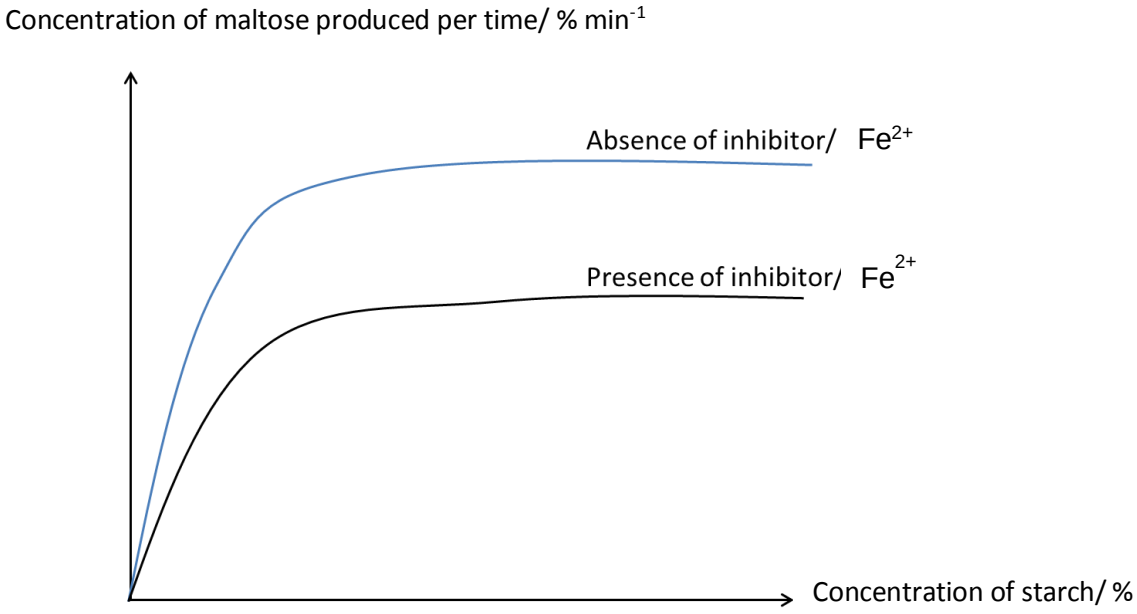


Data recording & processing (2M max)

Table

Concentration of starch / gdm^{-3}	• Concentration of maltose produced in the **presence** of Cu^{2+} / %				• Rate of production of maltose in the **presence** of Cu^{2+} / % min^{-1}	• Concentration of maltose produced in the **absence** of Cu^{2+} / %				• Rate of production of maltose in the **absence** of Cu^{2+} / % min^{-1}
	R1	R2	R3	Average		R1	R2	R3	Average	
5.0										
4.0										
3.0										
2.0										
1.0										
0.0										

Graph



Risks and precautions (1M)

- Iron sulfate / amylase /starch/ Benedict's solution is an irritant to the skin → Wear gloves and safety goggles when handling / Wash hands thoroughly if hands come into contact with solution.
- Boiling water may scald/burn skin → Use a test-tube holder to hold test-tube. Care must be taken when handling the boiling water.

Write your answers on the separate answer paper provided.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

5 **(a)** Explain how a disease such as cystic fibrosis can be treated by gene therapy, using **non-viral** delivery systems. [6]

(b) Explain, with specific examples, how genetic engineering can improve the quality and yield of crop plants and animals in solving the demand for food in the world. [7]

(c) Discuss the ethical and social implications of genetically modified organisms. [7]

[Total: 20]

5 **(a)** Explain how a disease such as cystic fibrosis can be treated by gene therapy, using **non-viral** delivery systems. [6]

1. Preparing sterile media containing nutrients and hormones needed for plant growth / antibiotics / herbicides for selection of successfully transformed cells;
2. Insertion of transgene via microprojectile bombardment / electroporation / *Agrobacterium tumefaciens*-mediated transformation;
3. Explant containing meristematic cells is selected and surface sterilized before growing on medium;
4. As callus increases in size, pieces of callus is sliced off and grown on new medium composition;
5. By adjusting concentration of plant hormones in growth medium, cells in callus can be induced to differentiate into roots and shoots;
6. Plantlets are removed from agar medium and transplanted to sterile soil for further growth;

(b) Explain, with specific examples, how genetic engineering can improve the quality and yield of crop plants in solving the demand for food in the world. [7]

Candidate must elaborate on at least 3 specific e.g. which must cover both improvements in 'quality' and 'yield'. If candidate only elaborated in one aspect, maximum of 6 marks will be awarded.

Examples for improvement in yield of crop plants (any 2 e.g.)

Pest-resistant transgenic plants

1. Trangenic plants containing the Bt gene will produce the protoxin which is ingested by the insect; Protoxin is cleaved in the insect gut and the active Bt toxin is released;
2. Protein binds to cell membranes and causes them to be permeable causing gut cells of insect to lyse, eventually killing insects;

Herbicide-resistant transgenic plants

3. Glyphosate is a herbicide used to get rid of weeds which compete with crops for soil nutrients;
4. Inhibits 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase needed for biosynthesis of essential amino acids;
5. Transgenic plants contain mutated gene which codes for mutant EPSP synthase that is not inhibited by glyphosate;

Extension of shelf life of produce

6. Transgenic plants contain antisense polygalacturonase mRNA;
7. Results in the formation of mRNA-antisense RNA hybrid, which prevents the polygalacturonase mRNA from being translated;
8. Enzyme will not be synthesized, thus ensures fruits are not damaged / too ripe / soft when it reaches consumer in market place;

Examples for improvement in quality of crop plants (must have this e.g.)

Improving nutritional value of crops

9. Golden rice is a transgenic plant that three beta-carotene biosynthesis genes;
10. Produces yellow rice grains containing beta-carotene, which is a precursor to vitamin A;
11. Prevent vitamin A deficiency in world's population that depends on rice as a staple food;

(c) Discuss the ethical and social implications of genetically modified organisms. [7]

Social implications (maximum 4 marks)

1. Transfer of antibiotic resistance markers to pathogenic microorganisms which may result in increase in resistance to clinically important antibiotics;
2. Probability of introducing novel allergens as GM foods may contain proteins introduced from sources people are allergic to;
3. Possibility of GM food being toxic or carcinogenic as they may cause over-expression of other proteins;
4. Monopolistic behaviour of biotechnology companies as terminator gene is likely to be inserted into many GMO seeds, causing second generation seeds to be sterile;
5. Scientists have raised concerns about innovations in research that are not shared, raising fears that world food production may be dominated by a few large biotechnology companies;
6. Increasing dependence of developing nations on industrialized nations;
7. Impact on international trade as Europe has been much more hesitant than the United States in accepting GM products in processed food;

Ethical issues (maximum 3 marks)

8. Tampering with nature as it is going against the natural way of life;
9. Lack of mandatory food labelling in some countries;
10. Religious groups are concerned that GM foods might contain genes from animals prohibited by their religion;