NAME: _____ CLASS: _____ INDEX: _____

H

JC2 PRELIMINARY EXAMINATION
Higher 2

BIOLOGY

9648/01

Paper 1 Multiple Choice

29th August 2016
1 hour 15 minutes

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

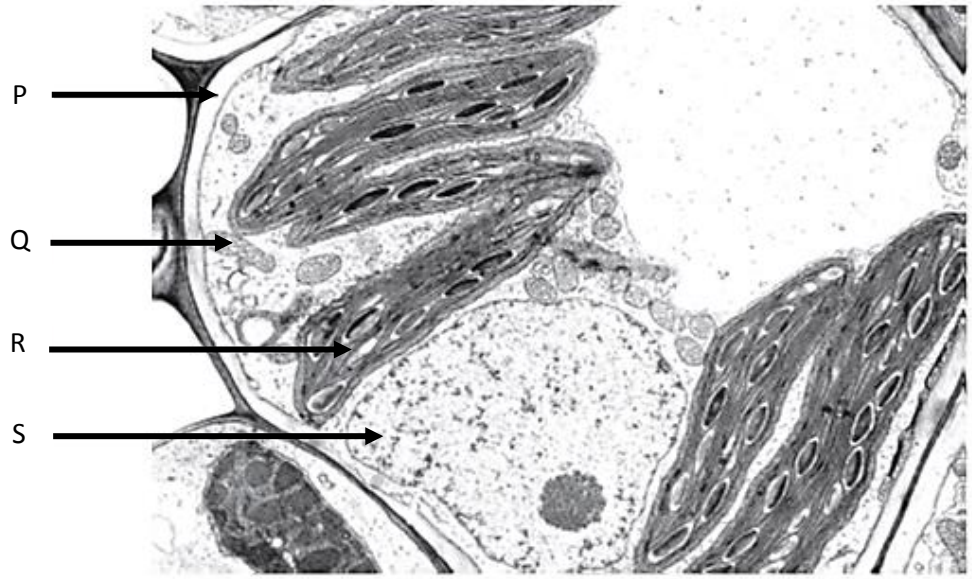
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write and/or shade your name, NRIC / FIN number and HT group on the Answer Sheet in the spaces provided unless this has been done for you.

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 2B pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

1 The electron micrograph of a cell is shown below.



The electron micrograph of a cell is shown below.

Which of the following statements are true?

1 Structure P is found in all eukaryotic cells.
2 Organelle Q contains hydrolytic enzymes.
3 Organelle R contains starch.
4 Organelle S contains heterochromatin but not euchromatin.
5 Organelles Q, R and S contain RNA polymerase.

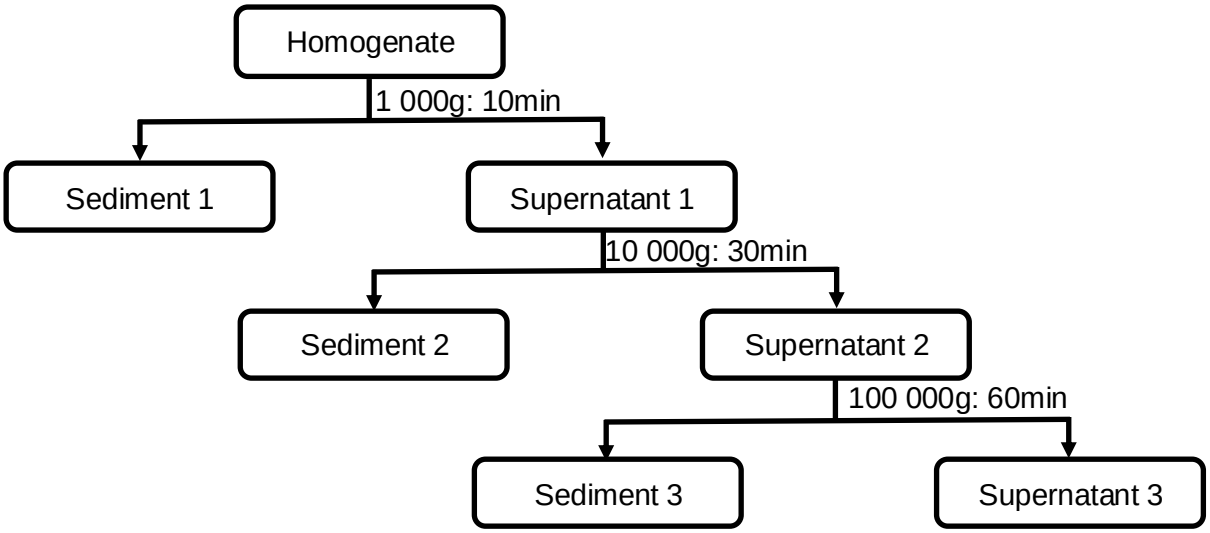
A 1 and 3 only

B 3 and 5 only

C 1, 3 and 5 only

D 2, 3 and 5 only

2 The figure below shows a centrifugation schematic of a rat liver cell.



Which of the following statements is incorrect?

A Sediment 1 contains organelles which are nucleic acid rich.

B Sediment 2 contains organelles with carbohydrate and nucleic acid.

C Supernatant 2 contains organelles that are the most dense amongst all other organelles.

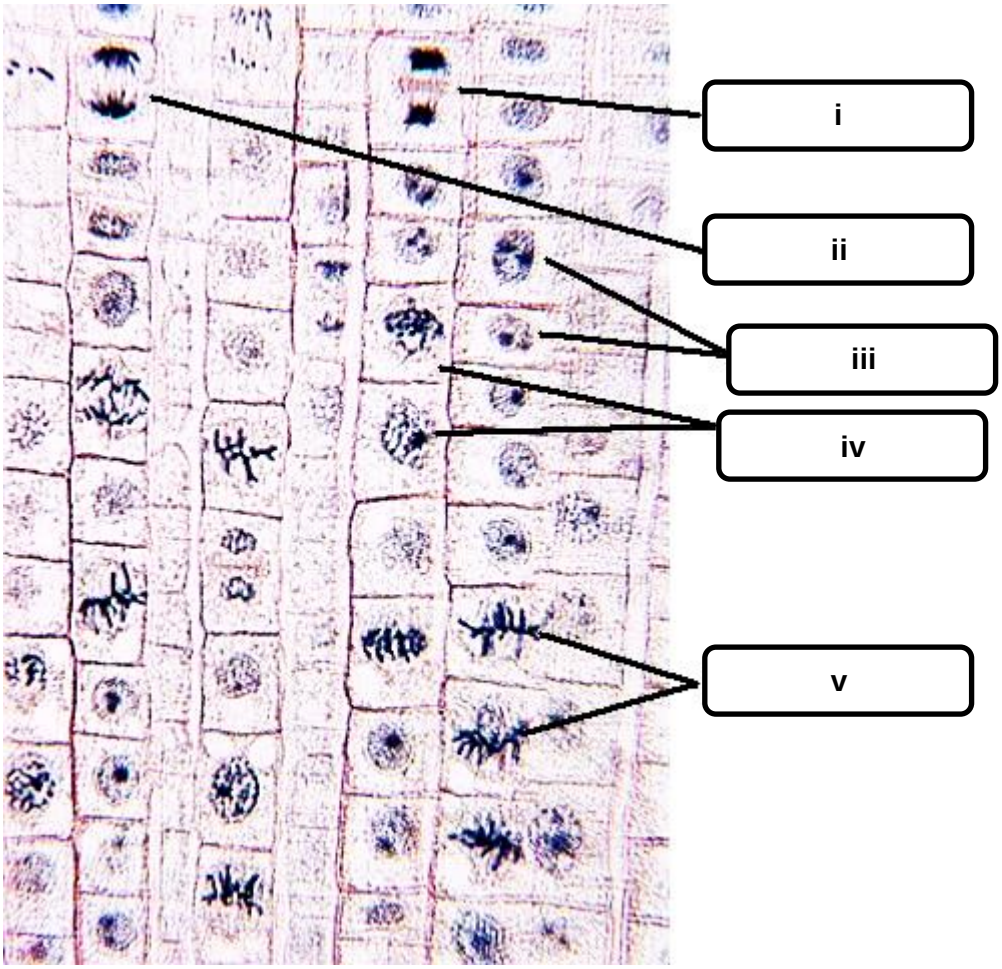
D Supernatant 3 contains organelles that are involved in protein synthesis.

3 Which features of collagen result in it having high tensile strength?

1 covalent bonds form between adjacent molecules
2 each three-stranded molecule is held together by intramolecular hydrogen bonds
3 every third amino acid in the polypeptide is small
4 the primary structure is held together by peptide bonds

A 1 and 2
B 1, 2 and 3
C 1, 3 and 4
D All of the above

4 The diagram below shows the longitudinal section of a root tip.



Which of the following correctly outlines the sequence in the stages of cell division in the root tip

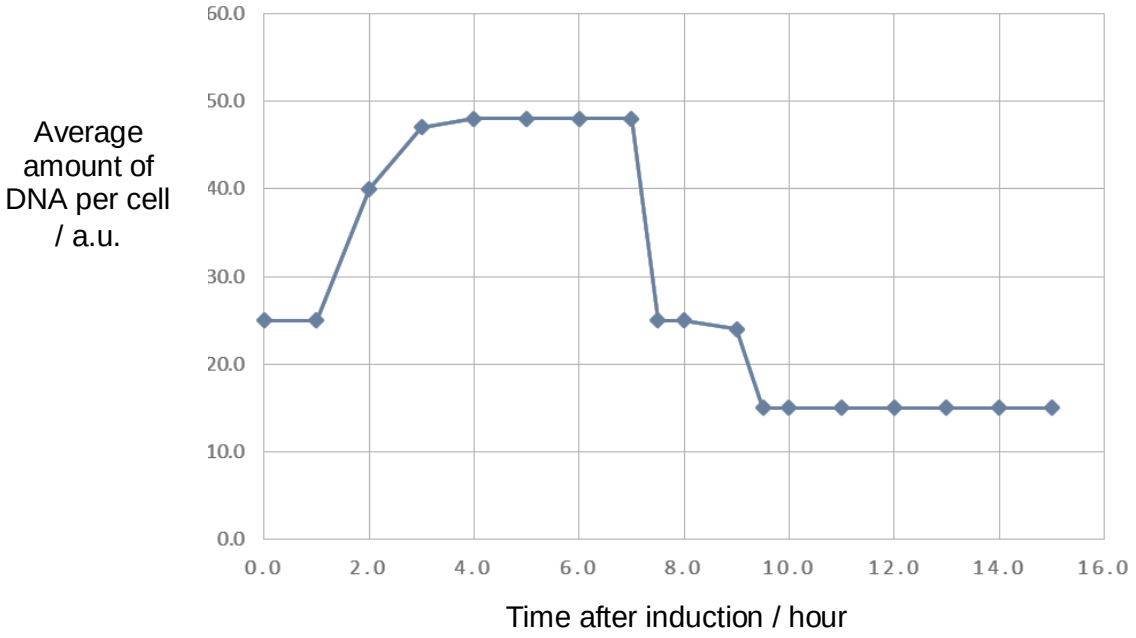
A iii > iv > v > ii > i

B iii > iv > i > v > ii

C iv > iii > v > ii > i

D iv > v > iii > i > ii

5 The figure below shows the average amount of DNA in a cell after induction.



Which of the following correctly accounts for the trends seen?

	Time Frame after induction / hours	Ploidy level at the end of timeframe	Stage in Cell growth
A	0.0 to 1.0	2n	G2
B	1.0 to 3.0	4n	S
C	3.0 to 8.0	n	G2-Meiosis I
D	8.0 to 9.0	2n	Meiosis II

6 Which of the following is not required for transcription?

A Ribonucleoside triphosphates

B RNA polymerase

C RNA primer

D TATA box

7 A mutation had occurred on the template DNA strand which resulted in the polypeptide having the following sequence:

Met – Ser – Cys – Gly – Glu – Gln – His – Phe – Arg – Gly – Stop

The mRNA codon table is shown below.

First Letter	Second Letter				Third Letter
	U	C	A	G	
U	phenylalanine	serine	tyrosine	cysteine	U
	phenylalanine	serine	tyrosine	cysteine	C
	leucine	serine	stop	stop	A
	leucine	serine	stop	tryptophan	G
C	leucine	proline	histidine	arginine	U
	leucine	proline	histidine	arginine	C
	leucine	proline	glutamine	arginine	A
	leucine	proline	glutamine	arginine	G
A	isoleucine	threonine	asparagine	serine	U
	isoleucine	threonine	asparagine	serine	C
	isoleucine	threonine	lysine	arginine	A
	methionine	threonine	lysine	arginine	G
G	valine	alanine	aspartate	glycine	U
	valine	alanine	aspartate	glycine	C
	valine	alanine	glutamate	glycine	A
	valine	alanine	glutamate	glycine	G

If the normal non-mutated template DNA strand has the following sequence,

3’ – TAC – TCA – ACA – ACC – TCT – TGT – CGT – GAA – GGC – CCA – ACT – 5’

Identify the mutation(s) that had occurred.

A Single base pair substitution

B Deletion

C Addition

D Deletion and addition

8 The bacterium, Pneumococcus pneumoniae, forms two types of colonies whose cells are structurally different. Smooth (S) cells have thick outer capsules, but rough (R) cells lack this capsule. S cells cause the disease pneumonia.

In 1928, Frederick Griffith found that:

- when R cells were mixed with heat-killed S cells and the mixture injected into mice, some of the mice became infected and died.
- living S cells with capsules could be isolated from these dead mice.
- injection of heat-killed S cells alone or of living R cells alone did not cause disease in mice.

What can be concluded from these three observations to explain what happened when R cells were mixed with heat-killed S cells?

A A heritable genetic change occurred in the R cells.

B R and S cells conjugated when mixed.

C R cells were changed into S cells by transduction.

D R cells were transformed by DNA from heat-killed S cells.

9 Which statements about bacterial conjugation are correct?

1. The F-plasmid is transferred to the recipient bacterial cell via the rolling circle mechanism.

2. An F plasmid carries genes controlling the process of conjugation.

3. Only one DNA strands of an F plasmid in the donor cell break at the origin of replication.

4. An F plasmid DNA strand enters the recipient cell beginning at its 5' end.

5. After transfer of F plasmid DNA, complementary strands of F plasmid DNA are synthesised in both donor and recipient cells.

6. Exonucleases cleave the donor DNA to create a nick.

A 1, 2, 3 and 5 only

B 1, 2, 3, 5 and 6 only

C 1, 2, 3, 4 and 5 only

D All of the above

10 Which of the following is not part of the Trp operon?

A Structural genes (*trp A* to *E*)

B *trp R*

C *trp* operator

D *trp* promoter

11 Which statements about inducible and repressible systems are correct?

1. Repressible systems code for the synthesis of enzymes involved in anabolic pathways.
2. An inducible system is one where the operon is switched on under normal conditions.
3. An repressible system is one where the operon is switched off under normal conditions.
4. Inducible systems functions in catabolic pathways, digesting nutrients to simpler molecules.
5. An example of a inducible system is the Trp operon.

A All of the above

B 1 and 4 only

C 2, 3 and 4 only

D 1, 2, 3 and 4 only

12 Viruses are considered obligate parasites because

A they reproduce using host cell DNA polymerase.

B they lack RNA-dependent RNA polymerases and ribosomes hence must depend on the host cell to carry out gene expression.

C they are unable to generate or store energy in the form of ATP and thus derive their energy for all metabolic functions from the host cell.

D they make use of the host cell's inorganic molecules such as amino acids, nucleotide and tRNA.

13 Which of the following proposed methods would be most viable in treating influenza?

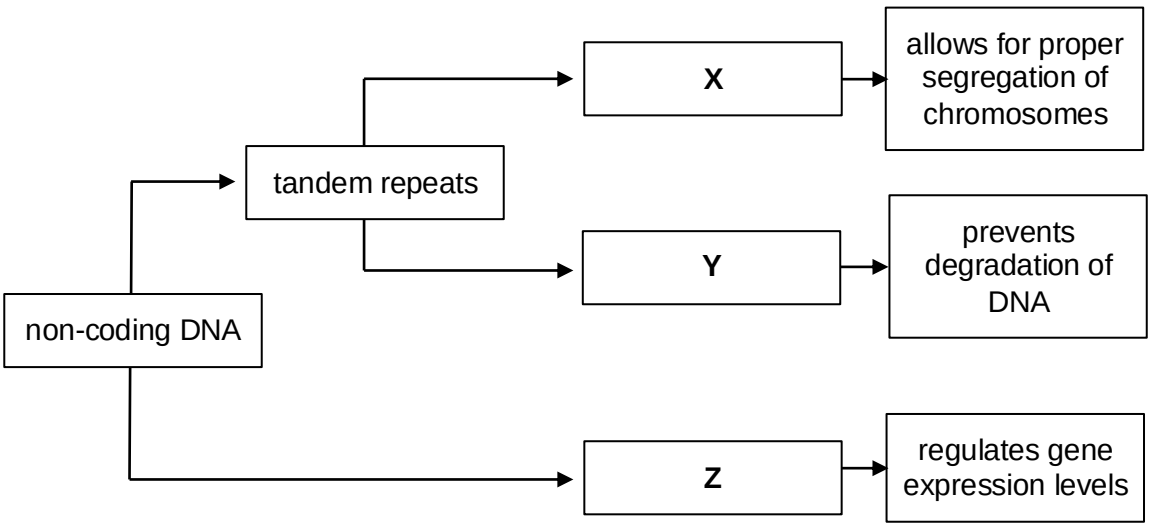
A Introducing a ribosome inhibitor so that translation of viral proteins cannot take place.

B Introducing a ribonucleotide analog that would cause chain termination upon addition to an RNA polymer.

C Inhibit the attachment and thereby entry of the virus into its host cell by developing inhibitors that bind to the sialic acid on host cells.

D Inhibit the attachment and thereby entry of the virus into its host cell by developing antibodies that bind to the haemagglutinin on the viruses.

14 The flowchart shows the classification of several regions of non-coding eukaryotic DNA, **X**, **Y** and **Z**.



Which statement(s) correctly describes **X**, **Y** and **Z**?

1 Regions **X** and **Y** are made up of transcriptionally active tandem repeats.

2 Regions **X** and **Y** are always associated with proteins, but DNA at region **Z** is only associated with proteins during gene expression.

3 Region **Z** may involve DNA bending but region **Y** shortens during DNA replication.

4 Regions **X**, **Y** and **Z** are conserved throughout the life of the organism.

A 2 only

B 3 only

C 1 and 4 only

D 2 and 3 only

15 Which one of the following statements correctly describes the role of enhancers.

A DNA sequences that are bound by general transcription factors.

B DNA sequences that directly induces the bending of DNA.

C DNA sequences that are involved in stabilisation of the transcriptional initiation complex.

D DNA sequences are proximal control elements that are non-coding.

16 The electron micrograph below shows several labelled structures present in a mitochondrion.

Which of the statements below correctly describe the labelled structures?

1 The structure labelled **A** is the polypeptide chain.

2 The structures labelled **B** are polyribosomes which consist of many 70S ribosomes.

3 The structure labelled **C** is the 3' end of template DNA strand.

4 The structure labelled **C** is the 5' end of the mRNA strand.

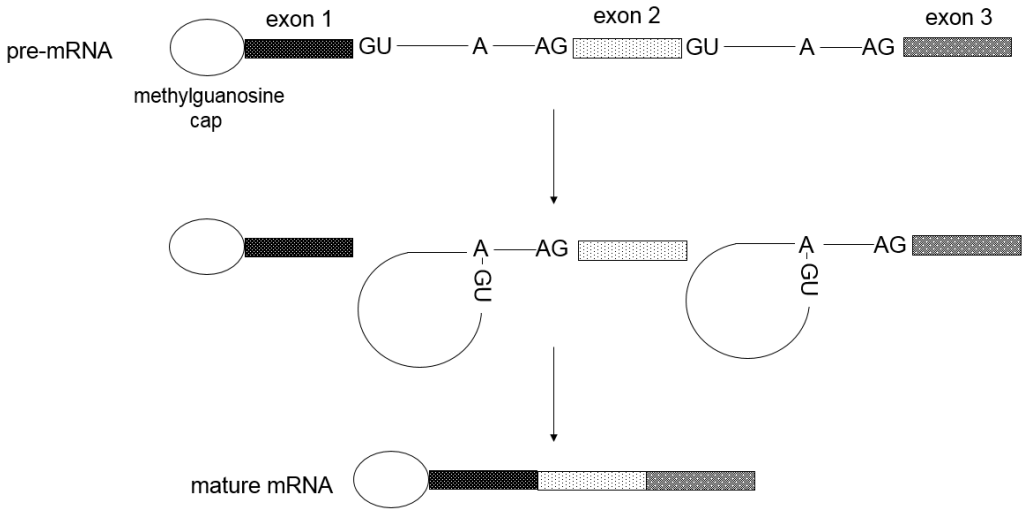
A 1 and 2 only

B 1 and 4 only

C 2 and 3 only

D 1, 2 and 4 only

17 The diagram shows part of an mRNA undergoing the process of splicing.



With reference to the diagram above, which statement(s) is / are related to the process shown?

1 RNA splicing occurs after the release of pre-mRNA from RNA polymerase.

2 Spliceosome binds to the 3' splice site GU and the 5' splice site AG on the pre-mRNA.

3 A RNA loop is formed on the pre-mRNA where the intron is excised.

4 There can be more than one type of product formed from a single pre-mRNA.

A 1 and 2

B 3 and 4

C 2, 3 and 4

D 1, 3 and 4

18 Gene expression is similar in prokaryotes and eukaryotes in that both:

A have post-transcriptional modifications.

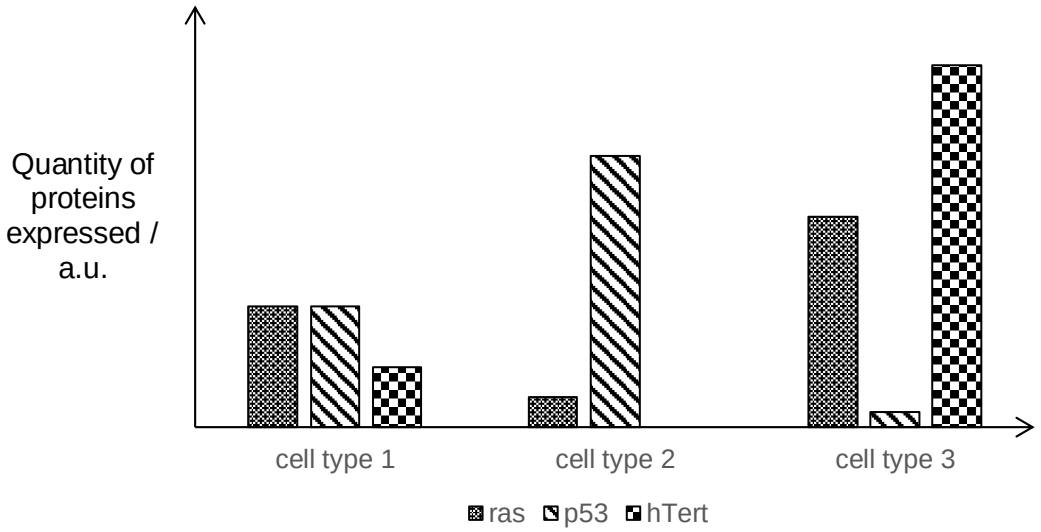
B require helicase to separate the DNA so that transcription can take place.

C have spliceosomes to intron splicing.

D involve attachment of proteins to DNA adjacent to the gene being transcribed.

19 Cancer critical genes include ras, p53 and hTert. hTert codes for human telomerase.

The levels of proteins expressed by each gene in three different cell types of a patient are shown in the graph. Only one cell type was taken from a malignant tumour.



Which statement is true?

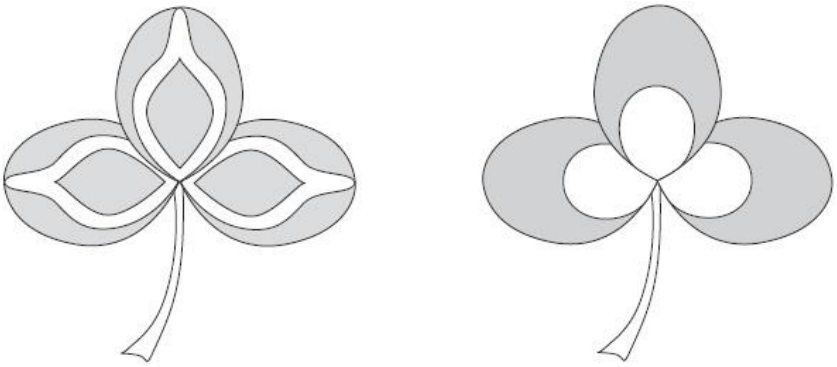
A Cell type 1 is not from the malignant tumour since balanced expression of *ras* and *p53* halts cell cycle progression.

B Activation of telomerase will result in cell type 2 gaining immortality and becoming cancerous.

C Cell type 3 is obtained from the malignant tumour as the cells will divide uncontrollably.

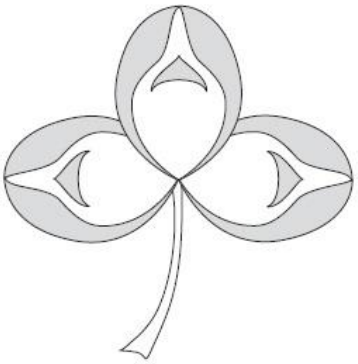
D Gain-of-function mutation of *hTert* in cell type 1 will result in malignant tumour formation.

20 The white clover, *Trifolium repens*, is one of the plants found growing as a weed in many lawns. Leaves of the white clover are divided into three leaflets, which often have characteristic white patterns visible on their surface. The two basic forms of the pattern are a chevron and patch. The diagram below shows these two patterns.



chevron pattern patch pattern

If a pure-breeding clover plant with the chevron pattern is crossed with a pure-breeding plant with the patch pattern, the offspring have leaflets with a mixed chevron and patch pattern, as shown in the diagram below.



mixed pattern

Which row correctly describes the inheritance of leaflet patterns in white clover?

	number of alleles that determines the white patterns in the leaflets	mode of inheritance
A	2	codominance
B	2	epistasis
C	> 2	codominance
D	> 2	epistasis

21 In a cross involving polygenic inheritance, 3 genes control the height of a tulip plant. The shortest and tallest plants are 12 cm and 24 cm respectively.

Assuming all other environmental factors are kept constant, what is the height of the F1 offspring obtained from a cross between a homozygous 12 cm and a homozygous 24 cm plant?

A 6 cm

B 12 cm

C 14 cm

D 18 cm

22 A plant with orange-spotted flowers was grown in a greenhouse from a seed collected in the wild. The plant was self-pollinated and gave rise to the following progeny: 129 plants with orange-spotted flowers, 22 plants with yellow-spotted flowers, 26 plants with solid orange flowers, and 15 plants with solid yellow flowers.

The formula for the chi-squared (χ^2) test is given as follows:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

degrees of freedom	probability			
	0.10	0.05	0.01	0.001
1	2.71	3.84	6.64	10.83
2	4.69	5.99	9.21	13.82
3	6.25	7.82	11.35	16.27
4	7.78	9.49	13.28	18.47

Which statement is true about the inheritance of flower colour and flower pattern at 99% confidence level?

A Since p < 0.05, the difference between the observed and expected results is not significant. The inheritance of flower colour and flower pattern is following Mendel's law of independent assortment.

B Since p > 0.05, the difference between the observed and expected results is not significant. The inheritance of flower colour and flower pattern is not following Mendel's law of independent assortment.

C Since p > 0.01, the difference between the observed and expected results is not significant. The inheritance of flower colour and flower pattern is following Mendel's law of independent assortment.

D Since p < 0.01, the difference between the observed and expected results is significant. The inheritance of flower colour and flower pattern is not following Mendel's law of independent assortment.

23 Which of the following statements about transport in the cell is incorrect?

A Active transport is the movement of substances across the cell membrane against a concentration gradient.
B Diffusion is the mechanism by which movement of hydrophobic particles through a cell membrane down a concentration gradient.
C Receptor mediated endocytosis involves the binding of the substance to specific receptors and their subsequent passive entry into the cell.
D Bulk transport is a process which requires energy.

24 Which of the following statements is false about cell signalling involving tyrosine kinase receptors.

A Ligand molecules are mostly hydrophilic in nature.

B Different activated relay proteins serve to directly amplify the effects of the ligand.

C Dimerisation serves to initiate auto-phosphorylation.

D Receptors are transmembrane proteins that are anchored within the cell surface membrane.

25 Phosphorylation cascade is an important component in cell signaling, which of the following statements is incorrect about this cell signaling mechanism.

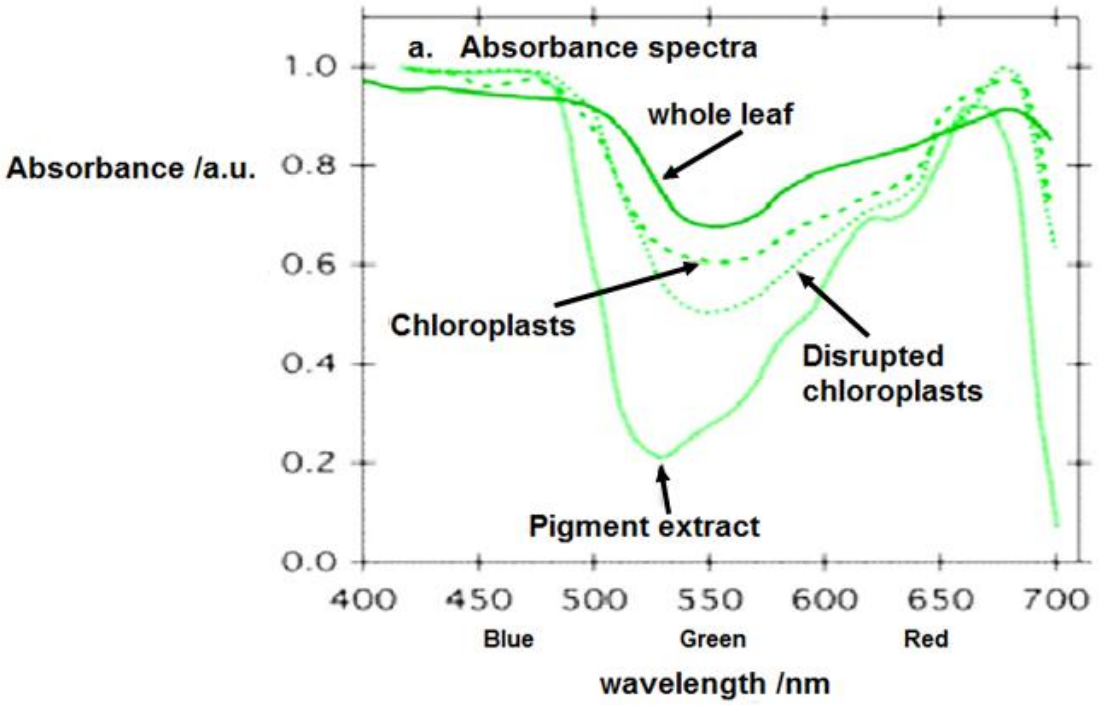
A The signal is passed via a series of phosphorylation involving protein kinases.

B The mechanism allows for greater control and speed in transmission of the signal.

C Phosphorylation cascade mechanism is initiated by a second messenger.

D Inactivation of the signal mechanism involves phosphatases which deactivate protein kinases.

26 The figure shows the absorptance spectra of various components of a leaf.



What can be inferred from the data shown?

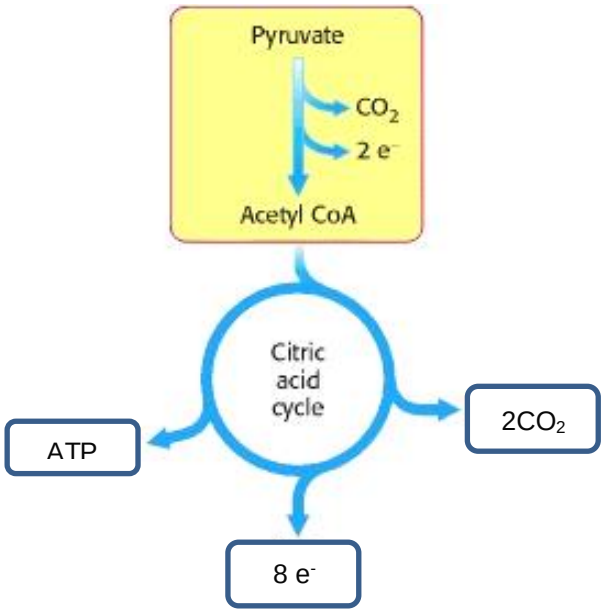
A Absorptance is highest in 650-700 nm in all leaf components due to light harvesting complexes.

B Whole leaf samples experience the least absorptance at 550 nm due to all green light being reflected.

C Disrupted chloroplast samples have higher absorptance compared to chloroplasts due to a larger surface area for light capture.

D Pigment extracts are the main agents of light harvesting due to the presence of carotenoids.

27 The figure below shows the part of the process of aerobic respiration.



Which of the following statements is true of the significance of acetyl CoA?

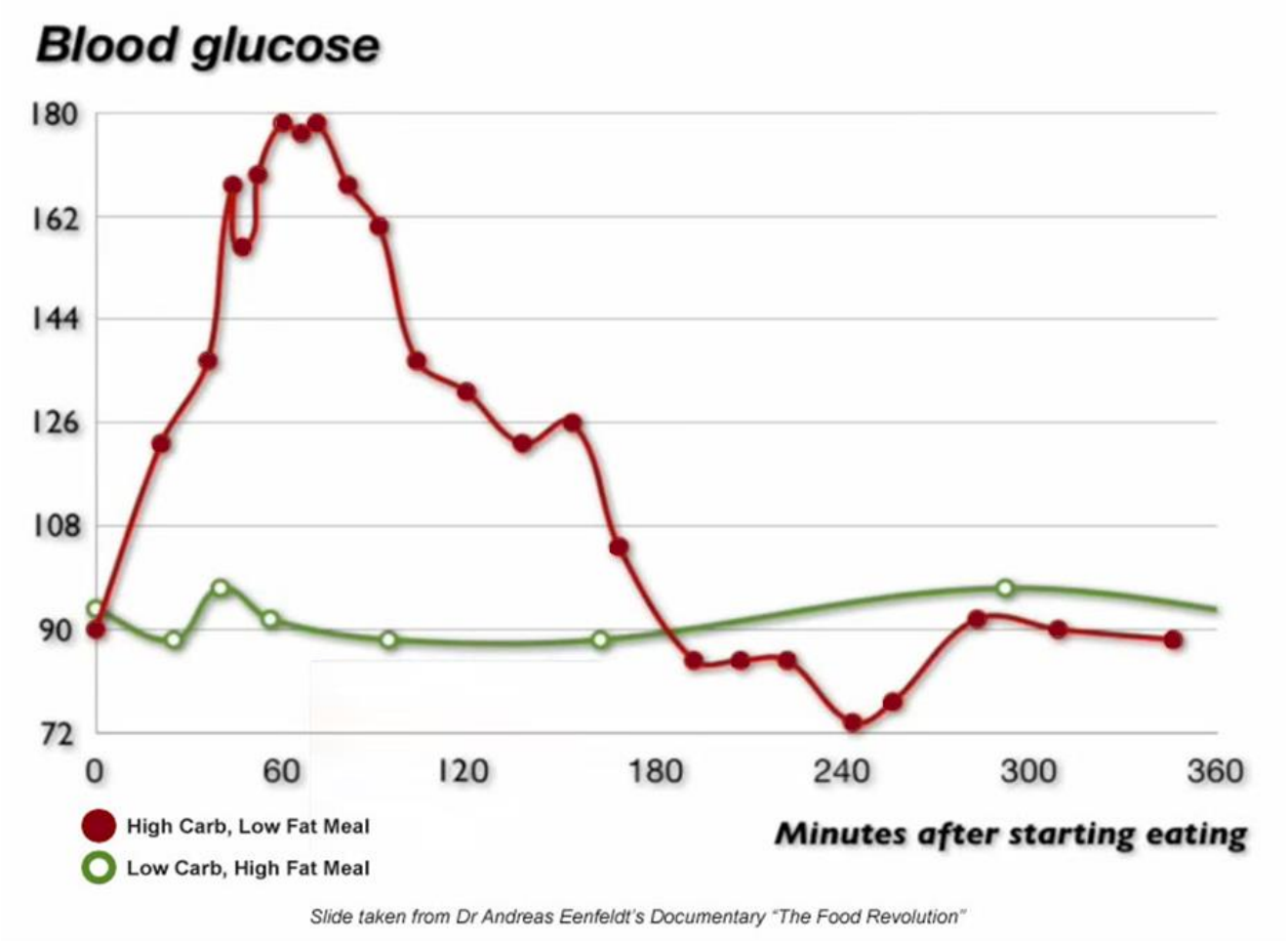
A Acetyl CoA is the product of the link reaction and is subsequently brought into the mitochondria to enter the Krebs cycle

B Acetyl CoA is the entry point into the metabolic pathway of both carbohydrates and fats.

C Acetyl CoA is an energised molecule combined with Oxaloacetate, to yield 4 molecules of citric acid per molecule of Glucose.

D Electrons released in the formation of Acetyl CoA are used in the production of NADPH.

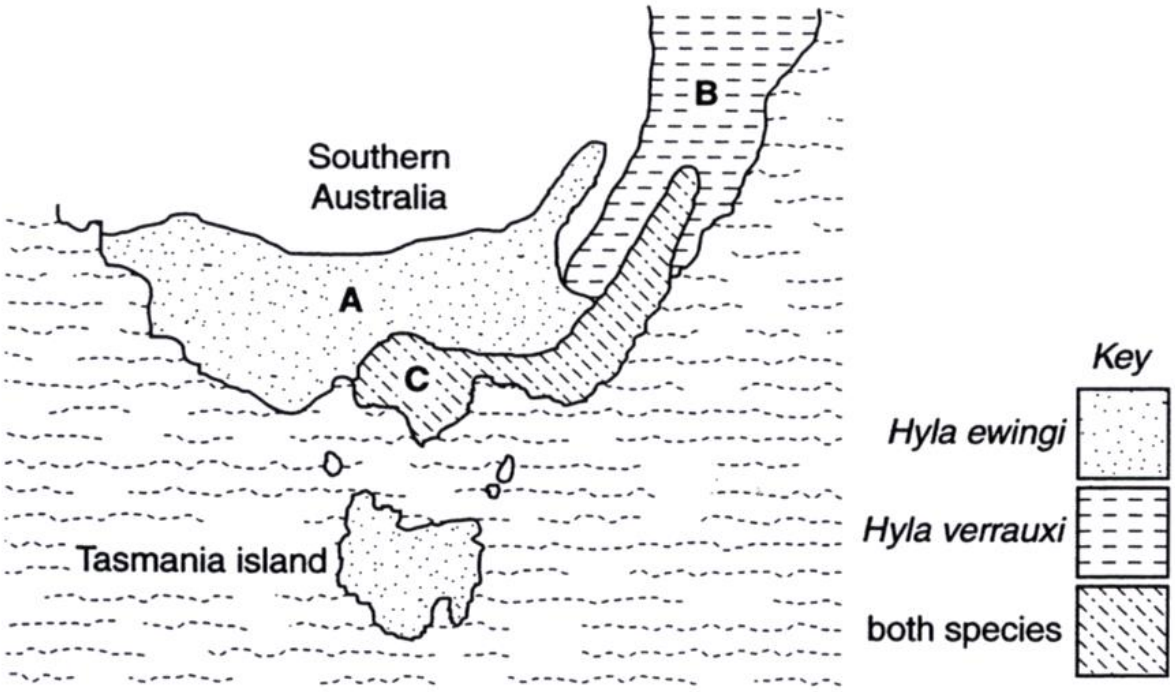
28 The figure below represents the blood glucose levels of a normal person after a meal.



At which time do the beta cells of the islets of Langerhans detect and effect the secretion of insulin to manage blood glucose levels?

	Detection by beta cells	Secretion of insulin
A	0 to 5 minutes	61 to 180 minutes
B	0 to 5 minutes	0 to 10 minutes
C	180 to 200 minutes	240 to 300 minutes
D	180 to 200 minutes	180 to 200 minutes

29 Two closely related species of frog, *Hyla ewingi* and *Hyla verrauxi* live in South Australia. The figure below shows the distribution of the tree frogs in Southern Australia.



Hyla ewingi and *Hyla verrauxi* are two closely related species of tree frogs from southern Australia. Research from breeding studies and DNA sequence data has shown that they have weak genetic incompatibility.

Male frogs attract females of the same species for mating by their pulsing call. The pulse rate of the male calls of the two species is almost identical. However, when both species coexist within the same region, the calls of *H. ewingi* are quite different than those of *H. verrauxi*.

Which of the following can be correctly inferred from the data given?

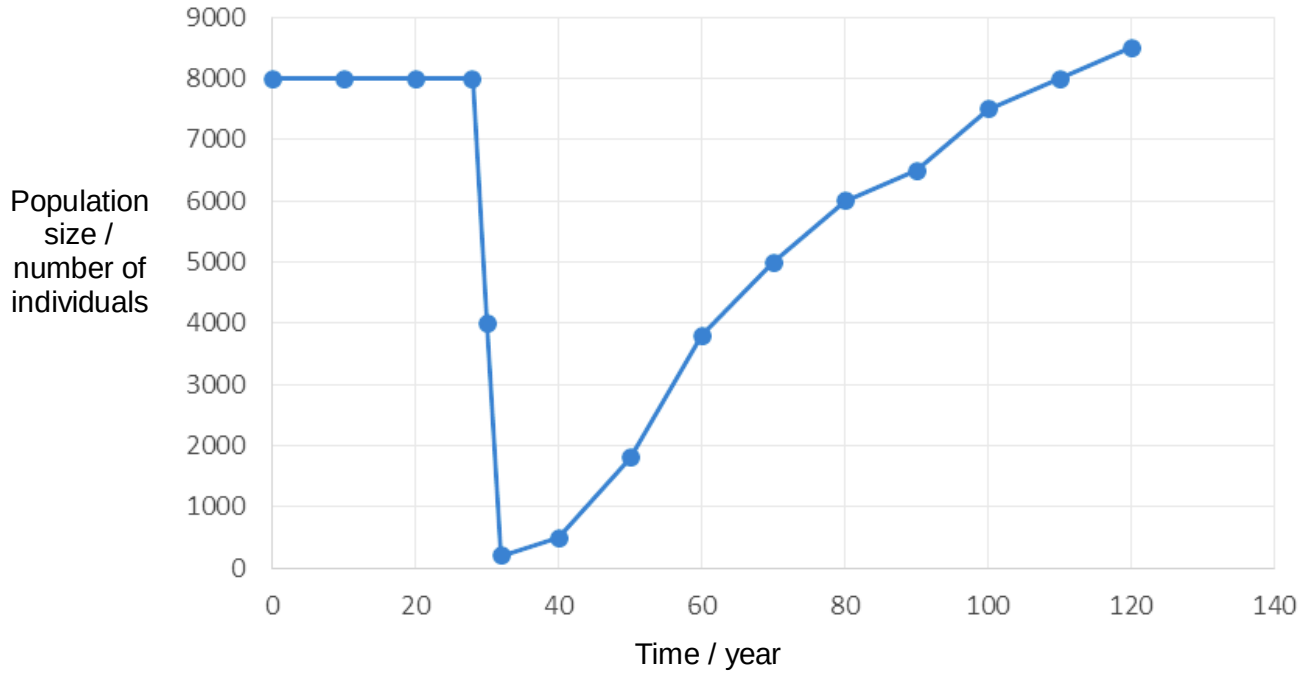
A Complete speciation has taken place between the two groups of frogs.

B Allopatric speciation was probably the evolutionary mechanism at work.

C Convergent evolution has seen the frogs in Tasmania similar to those in region A in Australia.

D Sympatric speciation was probably the evolutionary mechanism at work.

30 The figure shows the population of a group of organisms in a fixed region over time.



The following statements are derived from the data shown.

i. Bottleneck event has taken place Year 30 to 35
ii. Genetic variation has been fully restored by Year 110
iii. Allele frequency steadily increases due to genetic drift
iv. Founder effect has taken place from Year 28 onward

Which statements can be concluded as true?

A i only

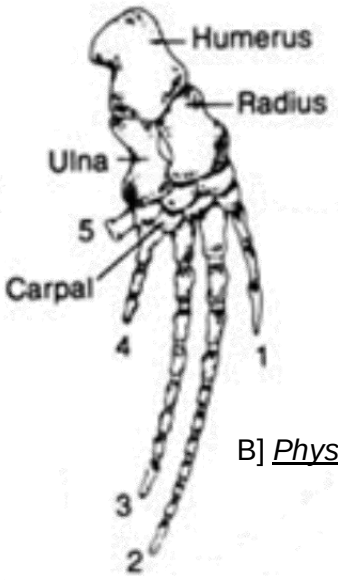
B ii only

C i, ii & iii only

D i, iii & iv only

31 The following figure shows the anatomy of the left front appendages of the two vertebrates.

A] *Javan surili*



B] *Physeter macrocephalus*

Which one of the following correctly describes the type of structures seen and their evolutionary connection?

	Type of structures	Ancestry	Type of evolution
A	Homologous	Different ancestor	Convergent Evolution
B	Homologous	Common ancestor	Divergent Evolution
C	Analogous	Different ancestor	Convergent Evolution
D	Analogous	Common ancestor	Divergent Evolution

32 All the characteristics below support the use of plasmids in cloning and expression in bacteria **except**

A More than one plasmid can be taken up by each bacterium.

B Plasmids are able to control their own replication through their origin of replication

C Plasmids contain a wide range of restriction sites for various restriction enzymes.

D Linker DNA / artificial sticky ends are not required to express eukaryotic genes of interest derived from cDNA.

33 *lacZ* gene is a genetic marker found in the plasmid which can be used in genetic engineering.

What is the function of *lacZ* gene in a cloning vector?

A Express *lac* repressor

B Distinguish between introns and exons

C Break down lactose to galactose and glucose

D Screen for cells with the recombinant plasmid

34 Which correctly describe the difference between genomic and cDNA libraries and the corresponding reason for the difference?

	Difference	Reason
A	Genomic library may contain distant control elements and centromere while cDNA library contains only expressed genes.	Due to mRNA splicing which removes exons and splice introns together.
B	Genomic library is larger in size than cDNA library.	Due to genomic library containing total DNA extract from a cell while cDNA library containing the total mRNA extract from a particular cell type.
C	Genomic library from an individual is always the same, while cDNA library may differ, depending on the cell type from which it is constructed.	Due to differential gene expression in the different cell types.
D	Genes from genomic library are more suited than those from cDNA library for expression in bacterial cells.	Due to the action of restriction endonucleases in the construction of genomic library and that of reverse transcriptase in the construction of cDNA library.

35 Genes P, Q, R and S occur on the same chromosome. The table shows the recombination frequencies.

	recombination frequency (%)
between P and Q	46
between P and R	8
between R and Q	54
between Q and S	13
between R and S	41

Which of the following represents the correct order of genes on the chromosome?

A P – Q – R – S

B P – R – S – Q

C R – P – S – Q

D R – S – Q – P .

36 The Human Genome Project facilitated genetic testing of individuals and renewed emphasis on ethical and social implications.

Which of the following statements correctly describe unintended consequences of genetic testing?

1 discovery of wrongly attributed paternity

2 unauthorised publication of genetic test results

3 psychological stress after receiving genetic test results

4 social stigmatisation of genetically predisposed individuals

A 1 and 2

B 3 and 4

C 1, 2 and 3

D All of the above .

37 Which of the following shows the correct developmental potency of the following stem cells.

	Haematopoietic stem cells	Zygotic stem cells	Embryonic stem cells	Neural stem cells
A	Multipotent	Pluripotent	Totipotent	Unipotent
B	Multipotent	Totipotent	Pluripotent	Unipotent
C	Multipotent	Pluripotent	Totipotent	Multipotent
D	Multipotent	Totipotent	Pluripotent	Multipotent

.

38 Which problem is associated with gene therapy?

A Target cells do not have suitable receptors on their cell surface membranes.

B The nuclear pores do not allow the vector into the nucleus.

C The viral vector cannot trigger cyclic AMP to activate appropriate genes.

D Viral vectors insert therapeutic genes at random points in the genome. .

39 Some plant tissue culture techniques involve the production of protoplasts using leaf tissue. Preparation of protoplasts involves incubation in a solution that contains enzymes such as cellulase and pectinase.

Which statement about protoplast is not correct?

A Protoplasts are pluripotent and regenerate into whole plants when provided with the correct growth factors.

B Protoplasts are more susceptible to microbial contamination.

C Protoplasts are used for the production of genetically engineered plants as they take up naked DNA easily.

D Protoplasts need to be maintained in the solution of the same water potential to prevent lysis. .

40 Which statement supports the view that genetically engineered animals could help to solve the demand for food in the world?

A Transgenic pigs and sheep are produced to express higher levels of growth hormone.

B Biomedical applications of genetically engineered animals have also become routine within the pharmaceutical industry, for drug discovery, drug development and risk assessment.

C Cloning of either extinct or endangered species such as thylacine and woolly mammoth helps to retain genetic diversity in small populations.

D By inserting genes from sea anemone and jellyfish, zebrafish have been genetically engineered to express fluorescent proteins.

END OF PAPER

NAME: _____ CLASS: _____ INDEX: _____

H

JC2 PRELIMINARY EXAMINATION
Higher 2

Answers

BIOLOGY

9648/01

Paper 1 Multiple Choice

29th August 2016
1 hour 15 minutes

Additional Materials: Multiple Choice Answer Sheet

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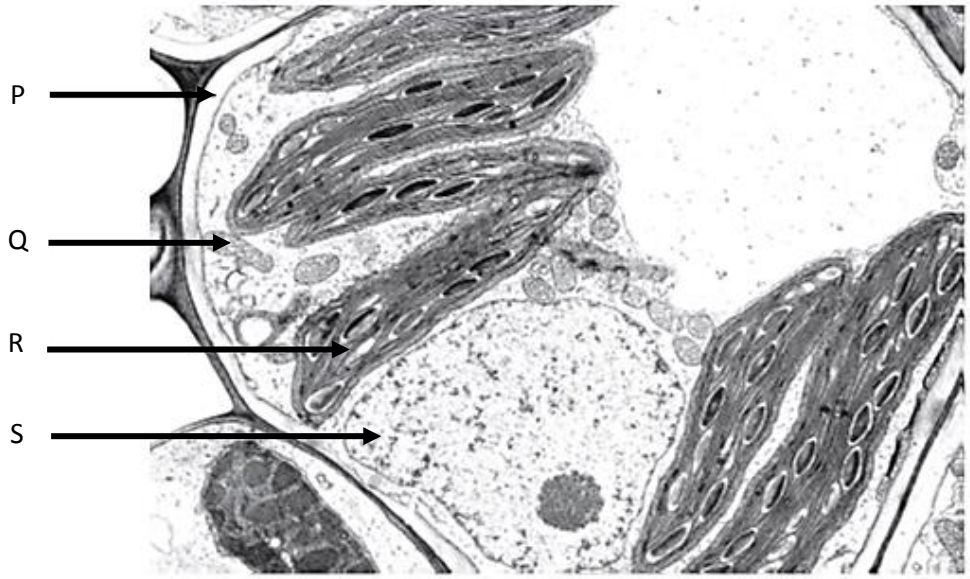
The use of an approved scientific calculator is expected, where appropriate.

1	B	2	C	3	C	4	A	5	C
6	C	7	D	8	A	9	C	10	B
11	B	12	C	13	D	14	B	15	C
16	C	17	D	18	D	19	C	20	A
21	D	22	C	23	C	24	B	25	B
26	D	27	B	28	B	29	D	30	A
31	B	32	D	33	D	34	C	35	C
36	D	37	D	38	D	39	A	40	A

This document consists of 27 printed pages and **0** blank page.

[Turn over

1 The electron micrograph of a cell is shown below.



The electron micrograph of a cell is shown below.

Which of the following statements are true?

1 Structure P is found in all eukaryotic cells.
2 Organelle Q contains hydrolytic enzymes.
3 Organelle R contains starch.
4 Organelle S contains heterochromatin but not euchromatin.
5 Organelles Q, R and S contain RNA polymerase.

A 1 and 3 only

B 3 and 5 only

C 1, 3 and 5 only

D 2, 3 and 5 only

Ans: B

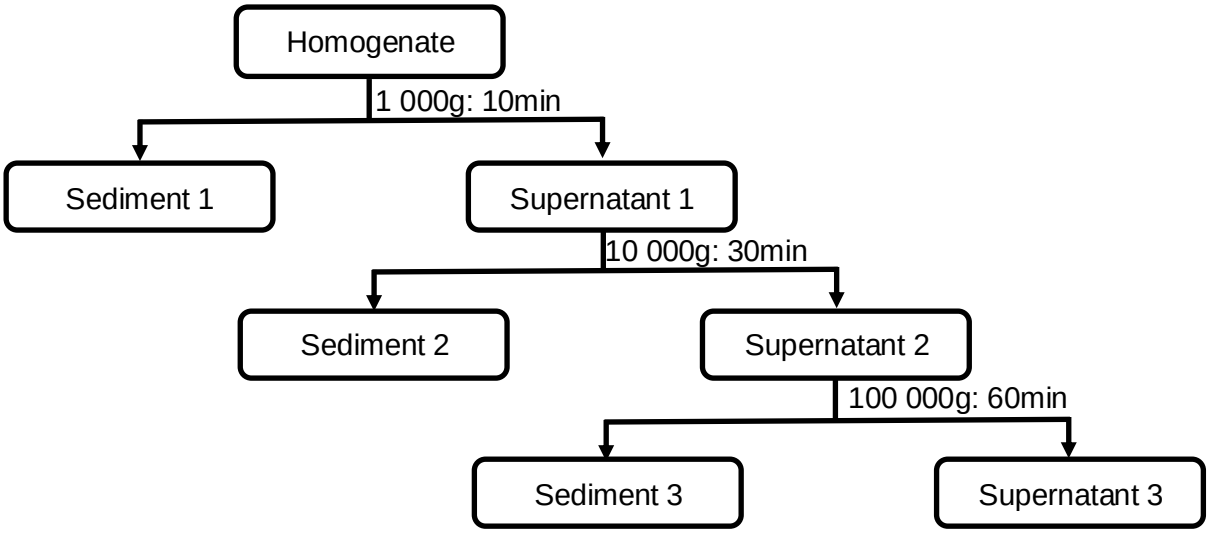
1.1] Cell structure and Organisation – EM

SC: P- Cell Wall Q-Mitochondria R- Chloroplast S- Nucleus

OR:
1 Structure P is found in all eukaryotic cells. × Only Plant Cells
2 Organelle Q contains hydrolytic enzymes. × Q is not a lysosome
3 Organelle R contains starch. ✓
4 Organelle S contains heterochromatin but not euchromatin. × Contains both
5 Organelles Q, R and S contain RNA polymerase. ✓

[L1] (ACJC H1 PRELIM 2015 P1.Q1)

2 The figure below shows a centrifugation schematic of a rat liver cell.



Which of the following statements is incorrect?

A Sediment 1 contains organelles which are nucleic acid rich.

B Sediment 2 contains organelles with carbohydrate and nucleic acid.

C Supernatant 2 contains organelles that are the most dense amongst all other organelles.

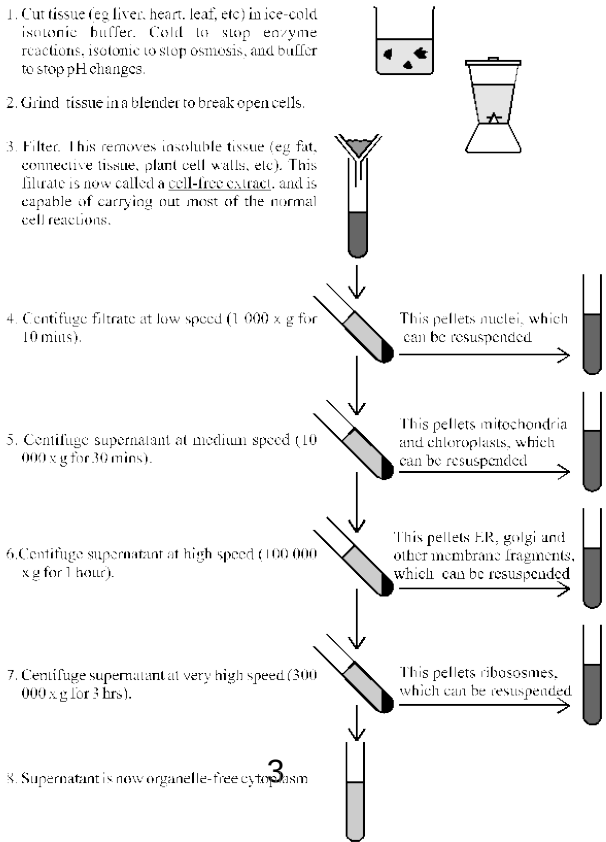
D Supernatant 3 contains organelles that are involved in protein synthesis.

SC: Sed1: Nucleus Sed2: Mitochondria and Chloroplast Sed3: ER, Golgi
OR: A Sediment 1 contains organelles which are nucleic acid rich True

B Sediment 2 contains organelles which produce carbohydrate and nucleic acid True
ATP is a nucleic acid
C Supernatant 2 contains organelles that are the most dense amongst all other organelles. False
nuclei are in Sediment 1
D Supernatant 3 contains organelles that are involved in protein synthesis - True-
ribosomes

Ans: C

[L2] Novel



3 Which features of collagen result in it having high tensile strength?

1 covalent bonds form between adjacent molecules
2 each three-stranded molecule is held together by intramolecular hydrogen bonds
3 every third amino acid in the polypeptide is small
4 the primary structure is held together by peptide bonds

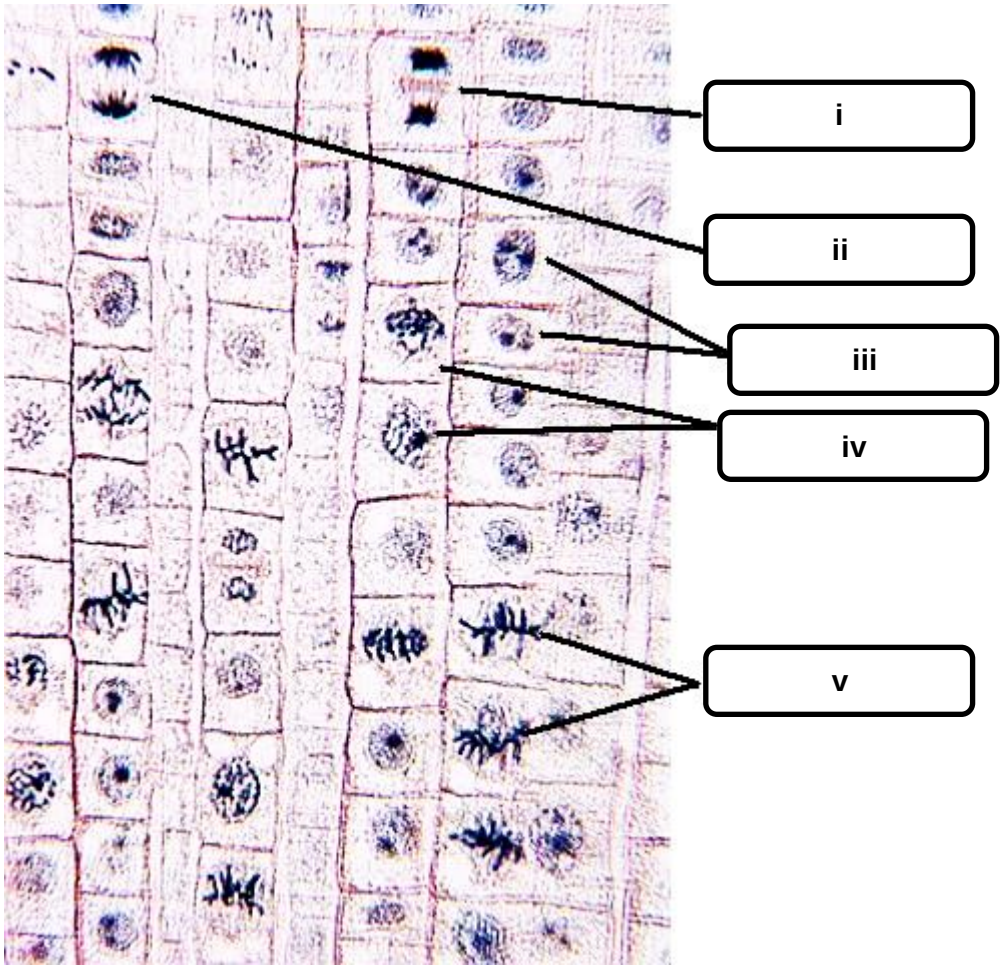
A 1 and 2
B 1, 2 and 3
C 1, 3 and 4
D All of the above

SC: features / collagen / high tensile strength
OR: Option 1 ✓ parallel strands bring cyctine groups together forming Disulphide cross bridges
Option 2 × No hydrogen bonds across molecules
(where present will more likely be intramolecular)
Option 3✓ X,Y,Glycine the third being small allows a tight coil in each fibril
Option 4✓ Primary structure is a polypeptide chain comprising of peptide bonds.

Ans: **C**

[L2] (2015 IJC Prelim P1Q5)

4 The diagram below shows the longitudinal section of a root tip.



Which of the following correctly outlines the sequence in the stages of cell division in the root tip

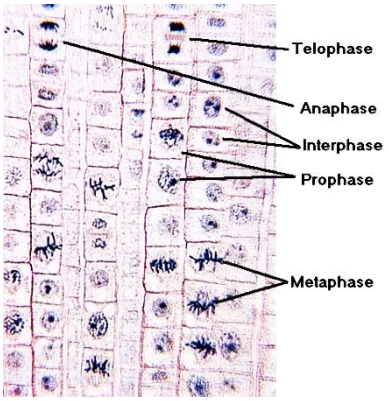
A iii > iv > v > ii > i

B iii > iv > i > v > ii

C iv > iii > v > ii > i

D iv > v > iii > i > ii

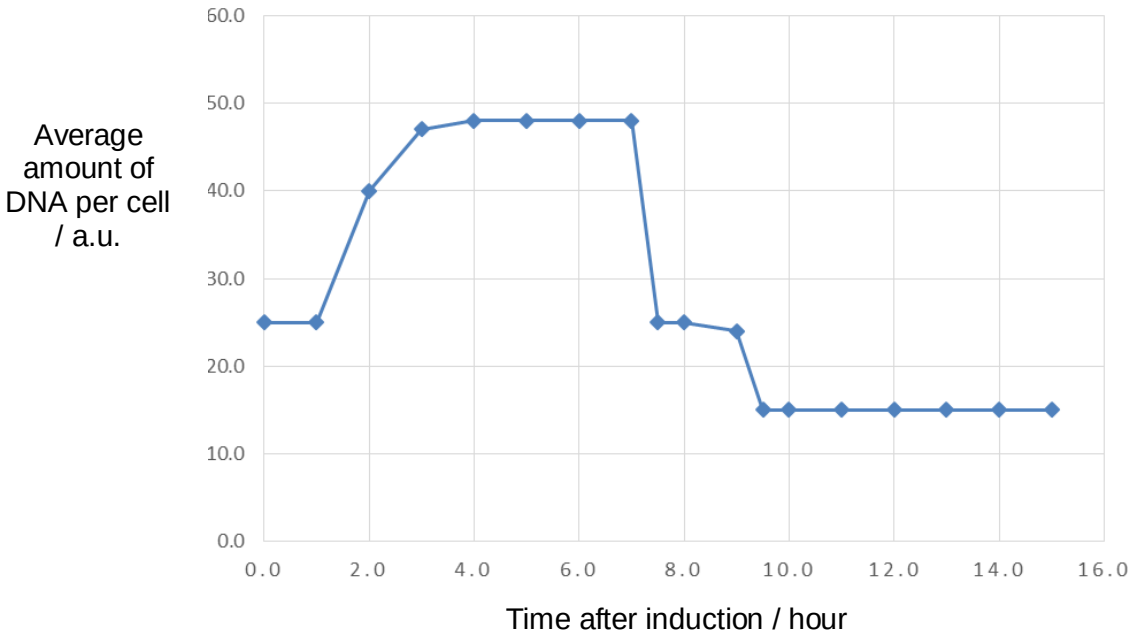
SC: correctly outlines seq in cell division
OR: Interphase (iii) >> Prophase (iv) >> Metaphase (v) >> Anaphase (ii) >> Telomerase (i)



Ans: **A**

[L2] Novel

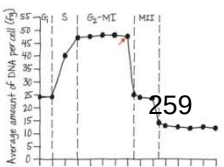
5 The figure below shows the average amount of DNA in a cell after induction.



Which of the following correctly accounts for the trends seen?

	Time Frame after induction / hours	Ploidy level at the end of timeframe	Stage in Cell growth
A	0.0 to 1.0	2n	G2
B	1.0 to 3.0	4n	S
C	3.0 to 8.0	n	G2-Meiosis I
D	8.0 to 9.0	2n	Meiosis II

SC: cell after induction / correctly accounts
OR: A ✗ Ploidy 2n ✓ stage is G1 not G2
B ✗ Ploidy 4n ✗ stage S ✓ slow rise in DNA as replication increases DNA 2 fold
C✓ Ploidy n✓ since after cytokinesis time 7 hrs Stage G2-MI✓



D✗ Ploidy 2n✗ sice it is after cytokinesis time 7 hrs Stage MII. ✓

Ans: C
[L2] Novel

6 Which of the following is not required for transcription?

A Ribonucleoside triphosphates

B RNA polymerase

C RNA primer

D TATA box

SC: Need to know which factors play a role in transcription and which does not.
OR:
- ✓ A: Ribonucleoside triphosphates are the incoming monomers of transcription.
- ✓ B: RNA polymerase catalyses the process of transcription.
- ✗ C: RNA primer is not required. It is required only for DNA replication.
- ✓ D: TATA box is where RNA polymerase and general transcription factors will bind to during initiation of transcription.

Ans: C

[L1] Novel

7 A mutation had occurred on the template DNA strand which resulted in the polypeptide having the following sequence:

Met – Ser – Cys – Gly – Glu – Gln – His – Phe – Arg – Gly – Stop

The mRNA codon table is shown below.

First Letter	Second Letter				Third Letter
	U	C	A	G	
U	phenylalanine	serine	tyrosine	cysteine	U
	phenylalanine	serine	tyrosine	cysteine	C
	leucine	serine	stop	stop	A
	leucine	serine	stop	tryptophan	G
C	leucine	proline	histidine	arginine	U
	leucine	proline	histidine	arginine	C
	leucine	proline	glutamine	arginine	A
	leucine	proline	glutamine	arginine	G
A	isoleucine	threonine	asparagine	serine	U
	isoleucine	threonine	asparagine	serine	C
	isoleucine	threonine	lysine	arginine	A
	methionine	threonine	lysine	arginine	G
G	valine	alanine	aspartate	glycine	U
	valine	alanine	aspartate	glycine	C
	valine	alanine	glutamate	glycine	A
	valine	alanine	glutamate	glycine	G

If the normal non-mutated template DNA strand has the following sequence,

3' – TAC – TCA – ACA – ACC – TCT – TGT – CGT – GAA – GGC – CCA – ACT – 5'

Identify the mutation(s) that had occurred.

A Single base pair substitution

B Deletion

C Addition

D Deletion and addition

SC:
Template: 3' –TAC–TCA–ACA–ACC–TCT–TGT–CGT–GAA–GGC–CCA--ACT–5'
mRNA: 5'- AUG--AGU-UGU-UGG-AGA-ACA-GCA-CUU-CCG-GGU -UGA-3'
Protein: Met – Ser – Cys -Trp-Arg-Thr-Ala-Leu-Pro-Gly-Stop
Mutated protein: Met– Ser– Cys– Gly– Glu– Gln– His– Phe– Arg– Gly– Stop

OR:
- A: If it is a single base pair substitution, there will only be one amino acid changing.
- B & C: If is is addition of deletion the frame will not be reinstated at the back.
- D: Most likely an addition occurred which caused a frameshift mutation. This is followed by a deletion which caused a resotring of the frame towards the end of the amino acid sequence.

Ans: D

[L3] Novel

8 The bacterium, Pneumococcus pneumoniae, forms two types of colonies whose cells are structurally different. Smooth (S) cells have thick outer capsules, but rough (R) cells lack this capsule. S cells cause the disease pneumonia.

In 1928, Frederick Griffith found that:

- when R cells were mixed with heat-killed S cells and the mixture injected into mice, some of the mice became infected and died.
- living S cells with capsules could be isolated from these dead mice.
- injection of heat-killed S cells alone or of living R cells alone did not cause disease in mice.

What can be concluded from these three observations to explain what happened when R cells were mixed with heat-killed S cells?

A A heritable genetic change occurred in the R cells.

B R and S cells conjugated when mixed.

C R cells were changed into S cells by transduction.

D R cells were transformed by DNA from heat-killed S cells.

SC: Process here is transformation.
OR:
- A: It is not mutation here and furthermore this does not explain what happened to the R cells.
- B: S cells were heat killed so it is not alive and conjugation requires sex pillus to form between two live bacterial cels.
- C: No virues were cited in the preamble and therefore transduction is possible.
- D: R cells underwent genetic recombination when it was transformed by a naked DNA that came from heat-killed S cells.

Ans: D

[L2] ('13 A-level/P1/Q13)

9 Which statements about bacterial conjugation are correct?

1 The F-plasmid is transferred to the recipient bacterial cell via the rolling circle mechanism.

2 An F plasmid carries genes controlling the process of conjugation.

3 Only one DNA strands of an F plasmid in the donor cell break at the origin of replication.

4 An F plasmid DNA strand enters the recipient cell beginning at its 5' end.

5 After transfer of F plasmid DNA, complementary strands of F plasmid DNA are synthesised in both donor and recipient cells.

6 Exonucleases cleave the donor DNA to create a nick.

A 1, 2, 3 and 5 only

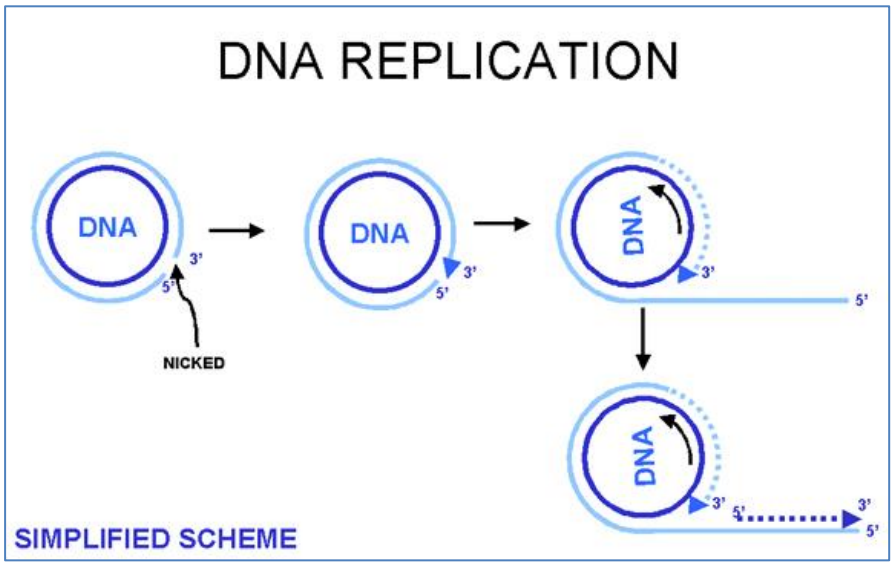
B 1, 2, 3, 5 and 6 only

C 1, 2, 3, 4 and 5 only

D All of the above

SC: Process here is conjugation. (Question was scaffolded in MYE & June holiday assignment)
OR:
- ✓1: Yes, the F-plasmid is transferred to recipient bacterial cell via rolling circle mechanism.

- ✓2: Yes, the F-plasmid carries the genes responsible for conjugation to take place.
- ✓3: Yes, only 1 strand break.
- ✓4: Yes, the F-plasmid enters the recipient cells from the 5' end onward.



- ✓5: Yes, the single-stranded DNA serves as a template for the second strand to be complementarily synthesized for the molecule to become double-stranded.
- ✓6: Yes, that is correct.
- ✗7: No. It is supposed to be endonucleases.
-

Ans: C

[L2] (Adapted from '14 A-level/P1/Q13)

10 Which of the following is not part of the Trp operon?

A Structural genes (*trp A* to *E*)

B *trp R*

C *trp* operator

D *trp* promoter

SC: *Trp* operon knowledge.
OR:
- *trp R* codes for the regulatory protein (Trp repressor) and it is not part of the Trp operon.

Ans: B

[L1] (novel)

11 Which statements about inducible and repressible systems are correct?

1. Repressible systems code for the synthesis of enzymes involved in anabolic pathways.
2. An inducible system is one where the operon is switched on under normal conditions.
3. An repressible system is one where the operon is switched off under normal conditions.
4. Inducible systems functions in catabolic pathways, digesting nutrients to simpler molecules.
5. An example of a inducible system is the Trp operon.

A All of the above

B 1 and 4 only

C 2, 3 and 4 only

D 1, 2, 3 and 4 only

SC: Inducible and repressible systems
OR:
- ✓1. Repressible genes code for the synthesis of enzymes involved in anabolic pathways.
- ✗2: An inducible system is one where the operon is switched off under normal conditions.
- ✗3: An repressible system is one where the operon is switched on under normal conditions.
- ✓4: True.
- ✗5: An example of a inducible system is the Lac operon.

Ans: B

[L2] (novel)

12 Viruses are considered obligate parasites because

A they reproduce using host cell DNA polymerase.

B they lack RNA-dependent RNA polymerases and ribosomes hence must depend on the host cell to carry out gene expression.

C they are unable to generate or store energy in the form of ATP and thus derive their energy for all metabolic functions from the host cell.

D they make use of the host cell's inorganic molecules such as amino acids, nucleotide and tRNA.

SC: Inducible and repressible systems
OR:
- ✗A. Reproduction does not occur on host cell ribosome.
- ✗B: Should be DNA-dependent RNA polymerases.
- ✓C: Correct.
- ✗D: Should be organic instead of inorganic.

Ans: C

[L1] (novel)

13 Which of the following proposed methods would be most viable in treating influenza?

A Introducing a ribosome inhibitor so that translation of viral proteins cannot take place.

B Introducing a ribonucleotide analog that would cause chain termination upon addition to an RNA polymer.

C Inhibit the attachment and thereby entry of the virus into its host cell by developing inhibitors that bind to the sialic acid on host cells.

D Inhibit the attachment and thereby entry of the virus into its host cell by developing antibodies

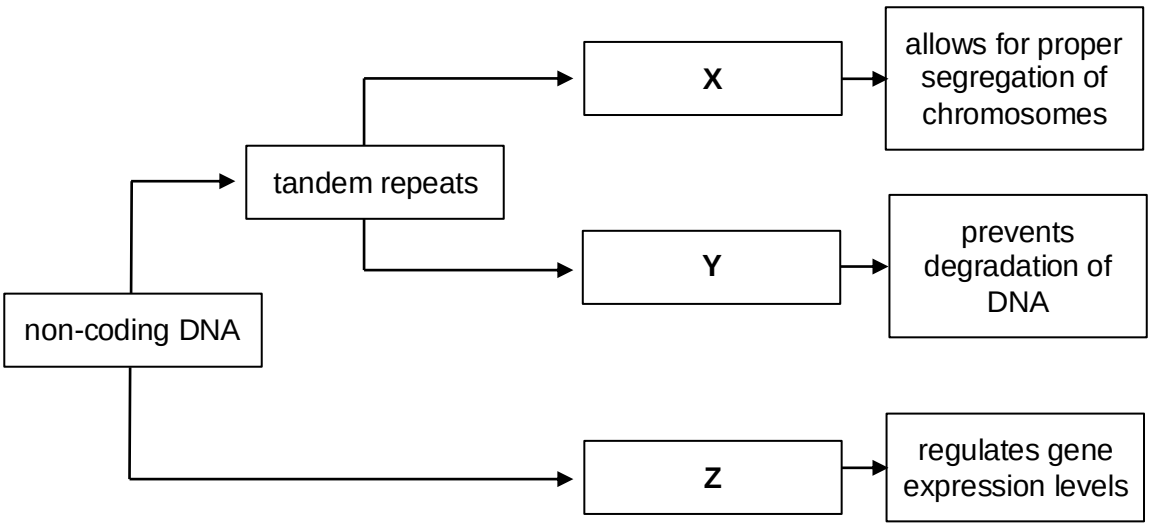
that bind to the haemagglutinin on the viruses.

SC: Influenza viral reproductive cycle
OR:
- ✗A.Translation to produce normal host cell proteins will also be affected.
- ✗B: Transcription to produce normal host cell RNA will also be affected.
- ✗C: By binding to host cell sialic acid is not an option as sialic acid is ubiquitous and blocking all sialic acid is not practical.
- ✓D: Yes, by targeting HA, virus cannot adsorb on host cell and thus cannot enter host cell.

Ans: D

[L3] (novel)

14 The flowchart shows the classification of several regions of non-coding eukaryotic DNA, **X**, **Y** and **Z**.



Which statement(s) correctly describes **X**, **Y** and **Z**?

1 Regions **X** and **Y** are made up of transcriptionally active tandem repeats.

2 Regions **X** and **Y** are always associated with proteins, but DNA at region **Z** is only associated with proteins during gene expression.

3 Region **Z** may involve DNA bending but region **Y** shortens during DNA replication.

4 Regions **X**, **Y** and **Z** are conserved throughout the life of the organism.

A 2 only

B 3 only

C 1 and 4 only

D 2 and 3 only

SC: X - centromeres, Y – telomeres and Z – control elements (non-coding)
OR: Statement 1 False (all non-coding), Statement 2 False (all associated with protein, Z is associated with proteins during chromatin packaging), Statement 3 True, Statement 4 False (not all conserved).

Ans: **B**

[L3] (HCI 2015 Prelim P1 Q14 modified)

15 Which one of the following statements correctly describes the role of enhancers.

A DNA sequences that are bound by general transcription factors.

B DNA sequences that directly induces the bending of DNA.

C DNA sequences that are involved in stabilisation of the transcriptional initiation complex.

D DNA sequences are proximal control elements that are non-coding.

SC: Factual recall
OR:
- A is wrong because it should not be general transcription factors.
- B is wrong because it does not directly induce bending but bending occurs only after an activator binds to it.
- C is correct.
- D is wrong because it is not a proximal control element.

Ans: **C**

[L1]

16 The electron micrograph below shows several labelled structures present in a mitochondrion.

Which of the statements below correctly describe the labelled structures?

1 The structure labelled **A** is the polypeptide chain.

2 The structures labelled **B** are polyribosomes which consist of many 70S ribosomes.

3 The structure labelled **C** is the 3' end of template DNA strand.

4 The structure labelled **C** is the 5' end of the mRNA strand.

A 1 and 2 only

B 1 and 4 only

C 2 and 3 only

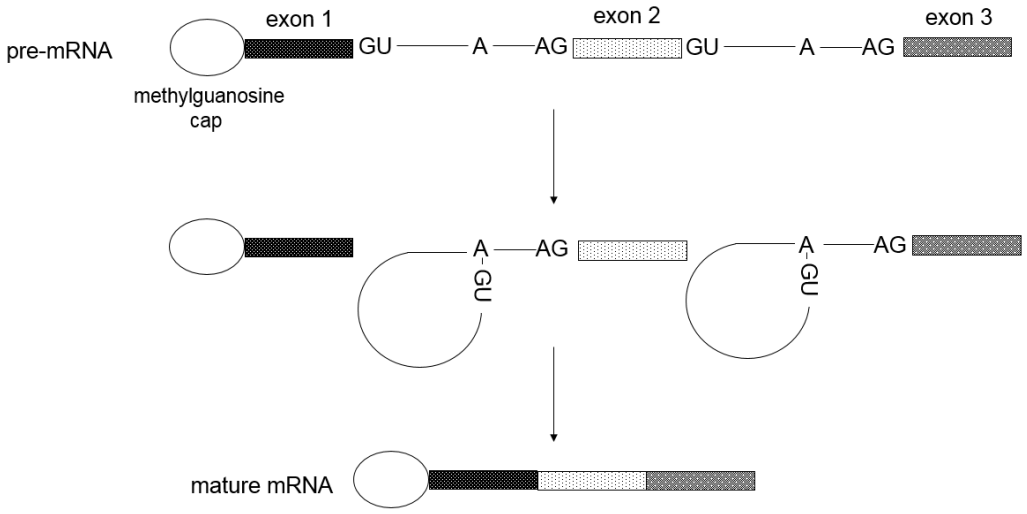
D 1, 2 and 4 only

SC: Labelled structure in EM is polyribosomes (structure B), ribosomes binds to mRNA template for translation (hence structure A is mRNA), Structure C must be DNA template strand. 70S ribosome because context is mitochondrion.
OR: Statement 1 false; Statement 2 true; Statement 3 true; Statement 4 false → accept Option C

Ans: **C**

[L3] AJC 2015 Prelim P1 Q16

17 The diagram shows part of an mRNA undergoing the process of splicing.



With reference to the diagram above, which statement(s) is / are related to the process shown?

1 RNA splicing occurs after the release of pre-mRNA from RNA polymerase.

2 Spliceosome binds to the 3' splice site GU and the 5' splice site AG on the pre-mRNA.

3 A RNA loop is formed on the pre-mRNA where the intron is excised.

4 There can be more than one type of product formed from a single pre-mRNA.

A 1 and 2

B 3 and 4

C 2, 3 and 4

D 1, 3 and 4

SC: Diagram shows RNA looping, splicing (alternative splicing possible)
OR: Statement 1, 3 and 4 possible (even if not shown explicitly as qns ask for related process)
Statement 2 is wrong (should be 5'GU and 3'AG)

Ans: D

[L3] (HCI 2015 Prelim P1 Q15)

18 Gene expression is similar in prokaryotes and eukaryotes in that both:

A have post-transcriptional modifications.

B require helicase to separate the DNA so that transcription can take place.

C have spliceosomes to intron splicing.

D involve attachment of proteins to DNA adjacent to the gene being transcribed.

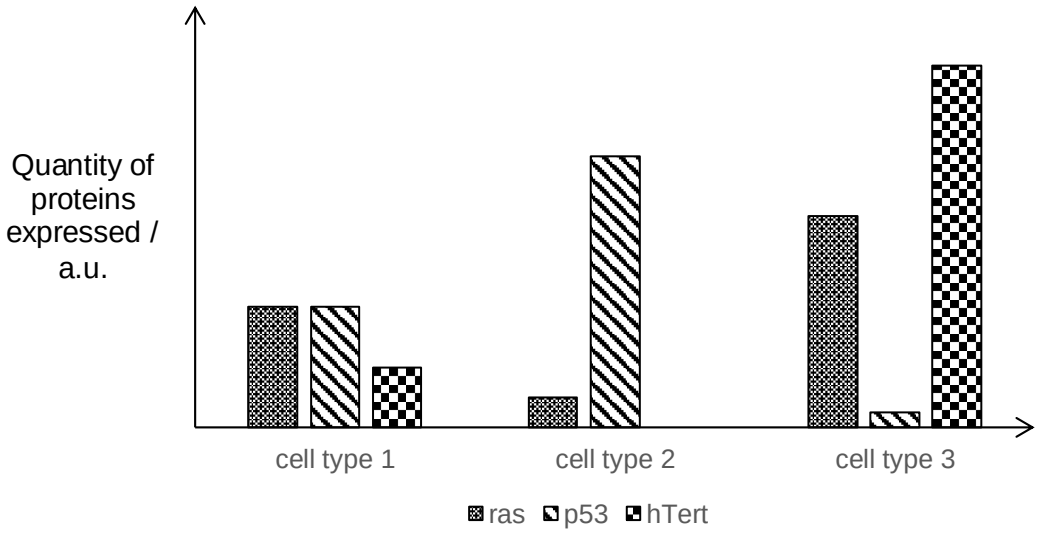
SC: Transcription and translation are common to both prokaryotes and eukaryotes. Among options given, points on transcription are given.
OR: Statement A false (prokaryotes do not have), Statement B false (RNA polymerase not helicase), Statement C (Prokaryotes do not utilise spliceosome). Accept D.

Ans: **D**

[L2]

19 Cancer critical genes include ras, p53 and hTert. hTert codes for human telomerase.

The levels of proteins expressed by each gene in three different cell types of a patient are shown in the graph. Only one cell type was taken from a malignant tumour.



Which statement is true?

A Cell type 1 is not from the malignant tumour since balanced expression of *ras* and *p53* halts cell cycle progression.

B Activation of telomerase will result in cell type 2 gaining immortality and becoming cancerous.

C Cell type 3 is obtained from the malignant tumour as the cells will divide uncontrollably.

D Gain-of-function mutation of *hTert* in cell type 1 will result in malignant tumour formation.

SC: ras – oncogene, p53 – Tumour suppressor gene, hTert – Telomerase gene (activated in cancer)

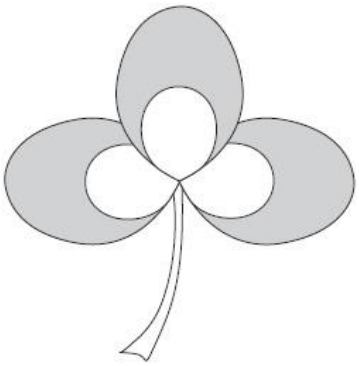
OR: Statement A false (insufficient info from data), Statement B false (no expression of telomerase), Statement D false (insufficient info from data to conclude gain-of-function mutation). State C true as it fulfils 3 conditions for cancer development (overexpression of ras oncogene, underexpression of p53 tumour suppressor gene and high expression of telomerase).

Ans: **C**

[L2] (HCI 2015 Prelim P1 Q17 modified)

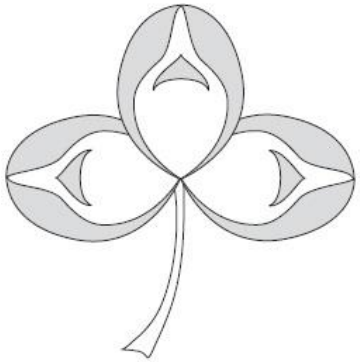
20 The white clover, *Trifolium repens*, is one of the plants found growing as a weed in many lawns. Leaves of the white clover are divided into three leaflets, which often have characteristic white patterns visible on their surface. The two basic forms of the pattern are a chevron and patch. The diagram below shows these two patterns.

chevron pattern



patch pattern

If a pure-breeding clover plant with the chevron pattern is crossed with a pure-breeding plant with the patch pattern, the offspring have leaflets with a mixed chevron and patch pattern, as shown in the diagram below.



mixed pattern

Which row correctly describes the inheritance of leaflet patterns in white clover?

	number of alleles that determines the white patterns in the leaflets	mode of inheritance
A	2	codominance
B	2	epistasis
C	> 2	codominance
D	> 2	epistasis

SC: only 2 alleles (one for chevron and other for patch). Offspring shows mixed pattern (both expressed hence codominace)

OR: Accept A, Reject B (not epistasis), C (not sufficient information provided to infer 3 or more alleles) and D (not epistasis)

Ans: **A**

[L2] (HCI 2015 Prelim P1 Q19)

21 In a cross involving polygenic inheritance, 3 genes control the height of a tulip plant. The shortest and tallest plants are 12 cm and 24 cm respectively.

Assuming all other environmental factors are kept constant, what is the height of the F1 offspring obtained from a cross between a homozygous 12 cm and a homozygous 24 cm plant?

A 6 cm

B 12 cm

C 14 cm

D 18 cm

SC: polgenic inheritance involving 3 gene A,B,C. shortest homozygous (aabbcc – 12cm → every recessive allele contribute 2 cm) tallest homozygous (AABBCC - 24cm → every dominant allele contribute 4 cm)

OR: Cross between homozygous recessive (aabbcc) and homozygous dominant (AABBCC) result in heterozygous (AaBbCc) which will result in 18 cm tall plants.

Ans: D

[L3] (VJC 2015 Prelim P1 Q20 modified)

22 A plant with orange-spotted flowers was grown in a greenhouse from a seed collected in the wild. The plant was self-pollinated and gave rise to the following progeny: 129 plants with orange-spotted flowers, 22 plants with yellow-spotted flowers, 26 plants with solid orange flowers, and 15 plants with solid yellow flowers.

The formula for the chi-squared (χ^2) test is given as follows:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

degrees of freedom	probability			
	0.10	0.05	0.01	0.001
1	2.71	3.84	6.64	10.83
2	4.69	5.99	9.21	13.82
3	6.25	7.82	11.35	16.27
4	7.78	9.49	13.28	18.47

Which statement is true about the inheritance of flower colour and flower pattern at 99% confidence level?

A Since p < 0.05, the difference between the observed and expected results is not significant. The inheritance of flower colour and flower pattern is following Mendel's law of independent assortment.

B Since p > 0.05, the difference between the observed and expected results is not significant. The inheritance of flower colour and flower pattern is not following Mendel's law of independent assortment.

C Since p > 0.01, the difference between the observed and expected results is not significant. The inheritance of flower colour and flower pattern is following Mendel's law of independent assortment.

D Since p < 0.01, the difference between the observed and expected results is significant. The inheritance of flower colour and flower pattern is not following Mendel's law of independent assortment.

SC: Observed no. compared against dihybrid ratio of 9:3:3:1, chi square calculated for df=3 is 6.91.

OR: p>0.05 (random chance of difference high), not statistically significant, inheritance follows Mendel's law of independent assortment.

Ans: C

[L2] (HCI 2015 Prelim P1 Q 23 modified)

23 Which of the following statements about transport in the cell is incorrect?

A Active transport is the movement of substances across the cell membrane against a concentration gradient.

B Diffusion is the mechanism by which movement of hydrophobic particles through a cell membrane down a concentration gradient.

C Receptor mediated endocytosis involves the binding of the substance to specific receptors and their subsequent passive entry into the cell.

D Bulk transport is a process which requires energy.

SC: transport / false / transport / correct
OR: A True

B True

C False (Receptor mediated endocytosis is an active process.)

D True

Ans: C

[L1]

24 Which of the following statements is false about cell signalling involving tyrosine kinase receptors.

A Ligand molecules are mostly hydrophilic in nature.

B Different activated relay proteins serve to directly amplify the effects of the ligand.

C Dimerisation serves to initiate auto-phosphorylation.

D Receptors are transmembrane proteins that are anchored within the cell surface membrane.

SC: statement / false / TKR
OR: A True (are extracellular within an aqueous medium) True

B Different activated relay protein affect different processes and therefore are not seen to directly amplify
(ie there is more of the same effect) False

C Correct True

D both hydrophobic tails and hydrophilic head form anchor points with the respective portions of the receptor True

Ans: B

[L2] Novel

25 Phosphorylation cascade is an important component in cell signaling, which of the following statements is incorrect about this cell signaling mechanism.

A The signal is passed via a series of phosphorylation involving protein kinases.

B The mechanism allows for greater control and speed in transmission of the signal.

C Phosphorylation cascade mechanism is initiated by a second messenger.

D Inactivation of the signal mechanism involves phosphatases which deactivate protein kinases.

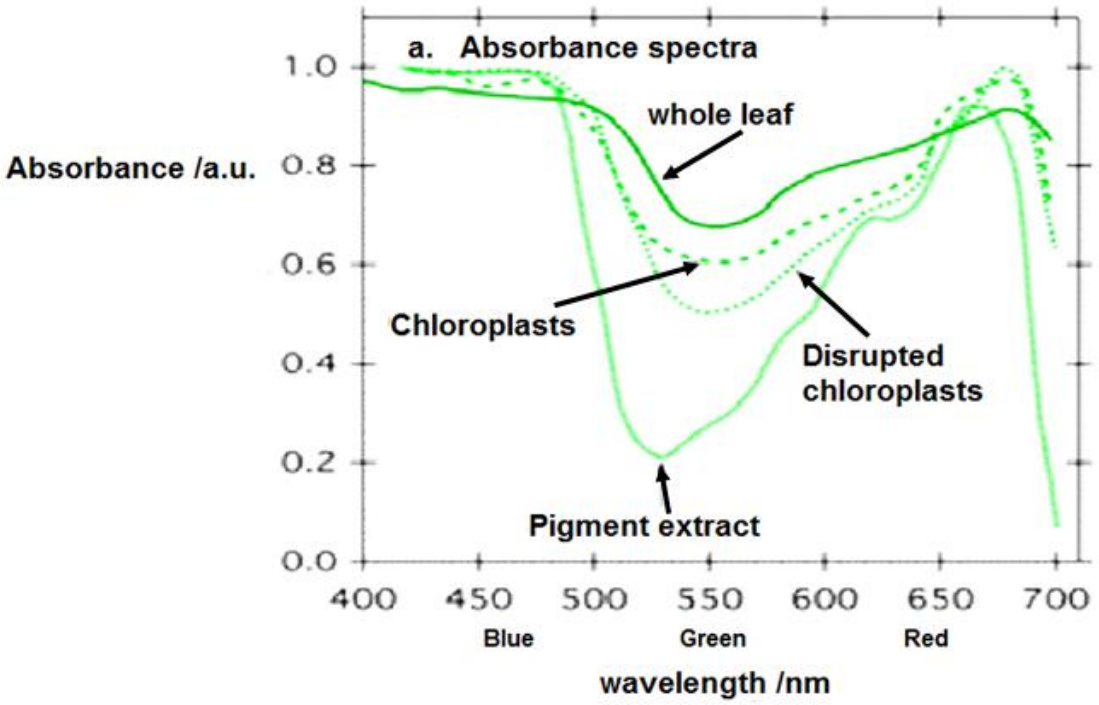
SC: statement / false / phosphorylation cascade
OR: A True
B False -Phosphorylation cascade does not speed up the transmission of the signal.
C True
D True

Ans: **B**

[L1]

21

26 The figure shows the absorptance spectra of various components of a leaf.



What can be inferred from the data shown?

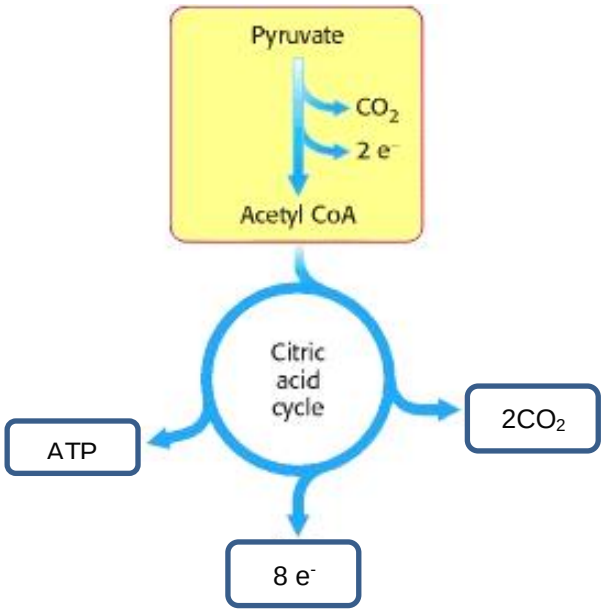
A Absorptance is highest in 650-700 nm in all leaf components due to light harvesting complexes.
B Whole leaf samples experience the least absorptance at 550 nm due to all green light being reflected.
C Disrupted chloroplast samples have higher absorptance compared to chloroplasts due to a larger surface area for light capture.
D Pigment extracts are the main agents of light harvesting due to the presence of carotenoids.

SC: inferred from data
OR: A × except in whole leaf where at 475nm, absorption is higher compared to 650-700nm.
B × not all green light is reflected, there is still absorption of 0.2 a.u.
C × Disrupted chloroplasts lack the organization compared to chlorophyll.
D ✓ Carotenoids make up the main light harvesting components of the leaf.

Ans: **D**

[L3]

27 The figure below shows the part of the process of aerobic respiration.



Which of the following statements is true of the significance of acetyl CoA?

A Acetyl CoA is the product of the link reaction and is subsequently brought into the mitochondria to enter the Krebs cycle

B Acetyl CoA is the entry point into the metabolic pathway of both carbohydrates and fats.

C Acetyl CoA is an energised molecule combined with Oxaloacetate, to yield 4 molecules of citric acid per molecule of Glucose.

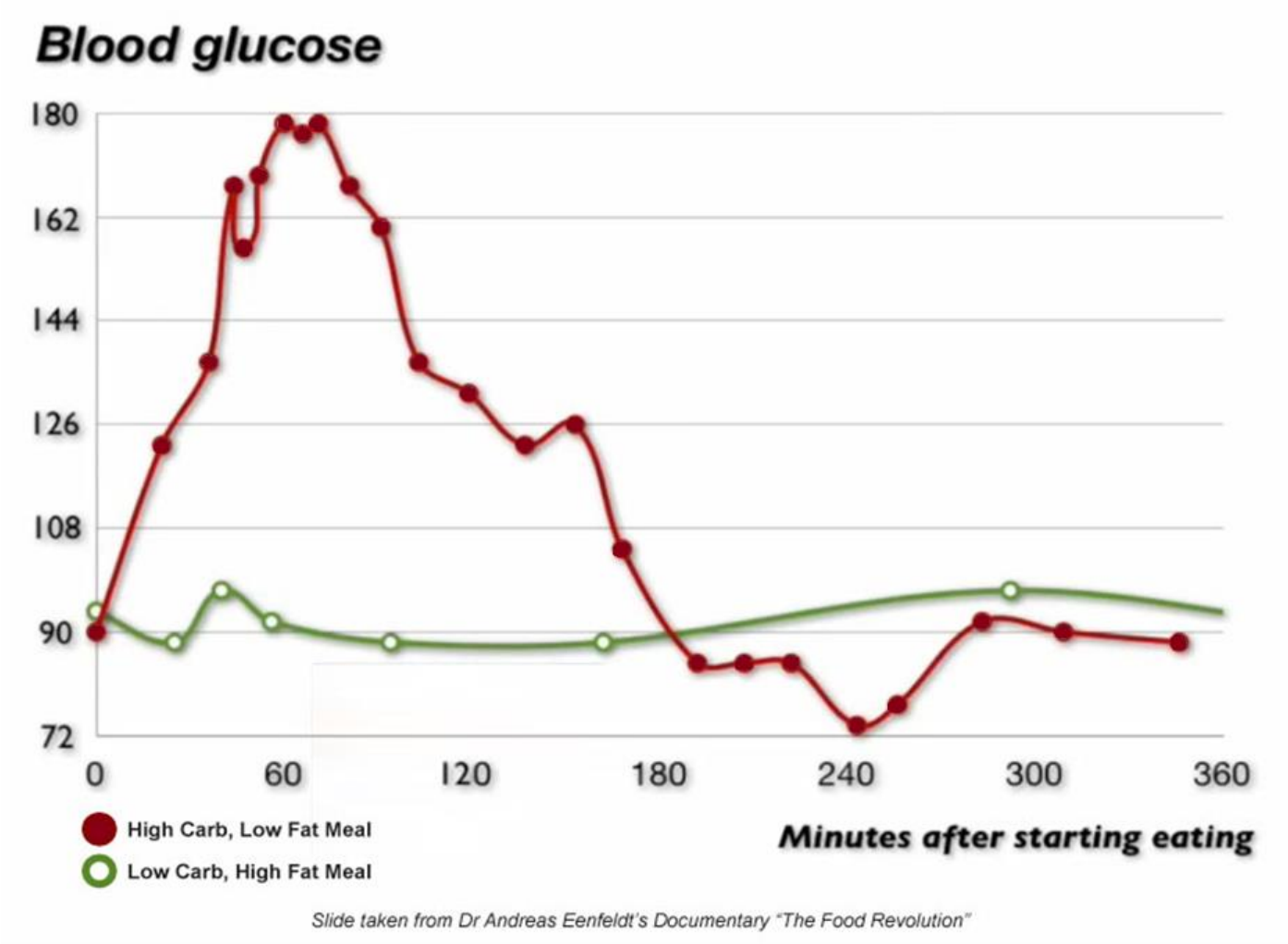
D Electrons released in the formation of Acetyl CoA are used in the production of NADPH.

SC: true significance / acetyl CoA
OR: A × link reaction occurs in the mitochondrial matrix.
B ✓ lipid metabolism enters here.
C × only 2 molecules of citric acid are produced for every 1 molecule of glucose.
D × electrons released is used in the production of NADH not NADPH.

Ans: **B**

[L2]

28 The figure below represents the blood glucose levels of a normal person after a meal.



At which time do the beta cells of the islets of Langerhans detect and effect the secretion of insulin to manage blood glucose levels?

	Detection by beta cells	Secretion of insulin
A	0 to 5 minutes	61 to 180 minutes
B	0 to 5 minutes	0 to 10 minutes
C	180 to 200 minutes	240 to 300 minutes
D	180 to 200 minutes	180 to 200 minutes

SC: time / beta cells Islets Langerhans / detect and secrete insulin

OR: A × detection and secretion are close together –detection immediately followed by secretion of insulin

B ✓ as explained in A.

C × detection is by Alpha cells of islets of Langerhans and for hypoglycaemic conditions..

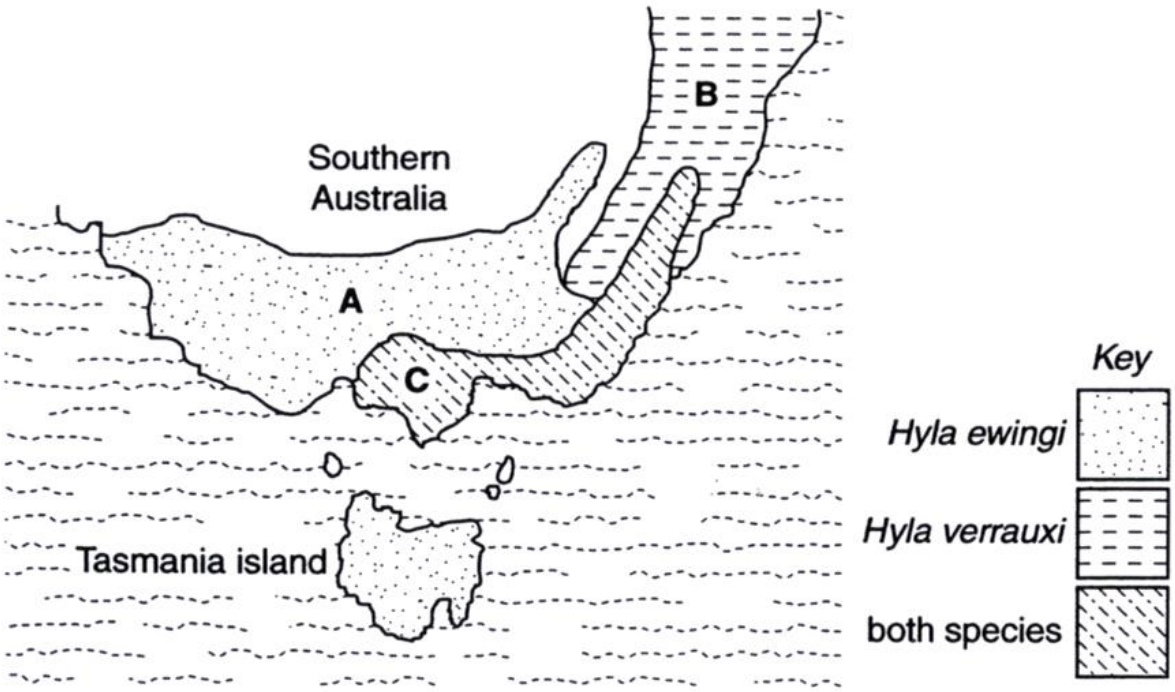
D × detection and secretion are close together- detection immediately followed by secretion of glucagon.

Ans: **B**

[L1 high/ L2]

23

29 Two closely related species of frog, *Hyla ewingi* and *Hyla verrauxi* live in South Australia. The figure below shows the distribution of the tree frogs in Southern Australia.



Hyla ewingi and *Hyla verrauxi* are two closely related species of tree frogs from southern Australia. Research from breeding studies and DNA sequence data has shown that they have weak genetic incompatibility.

Male frogs attract females of the same species for mating by their pulsing call. The pulse rate of the male calls of the two species is almost identical. However, when both species coexist within the same region, the calls of *H. ewingi* are quite different than those of *H. verrauxi*.

Which of the following can be correctly inferred from the data given?

A Complete speciation has taken place between the two groups of frogs.

B Allopatric speciation was probably the evolutionary mechanism at work.

C Convergent evolution has seen the frogs in Tasmania similar to those in region A in Australia.

D Sympatric speciation was probably the evolutionary mechanism at work.

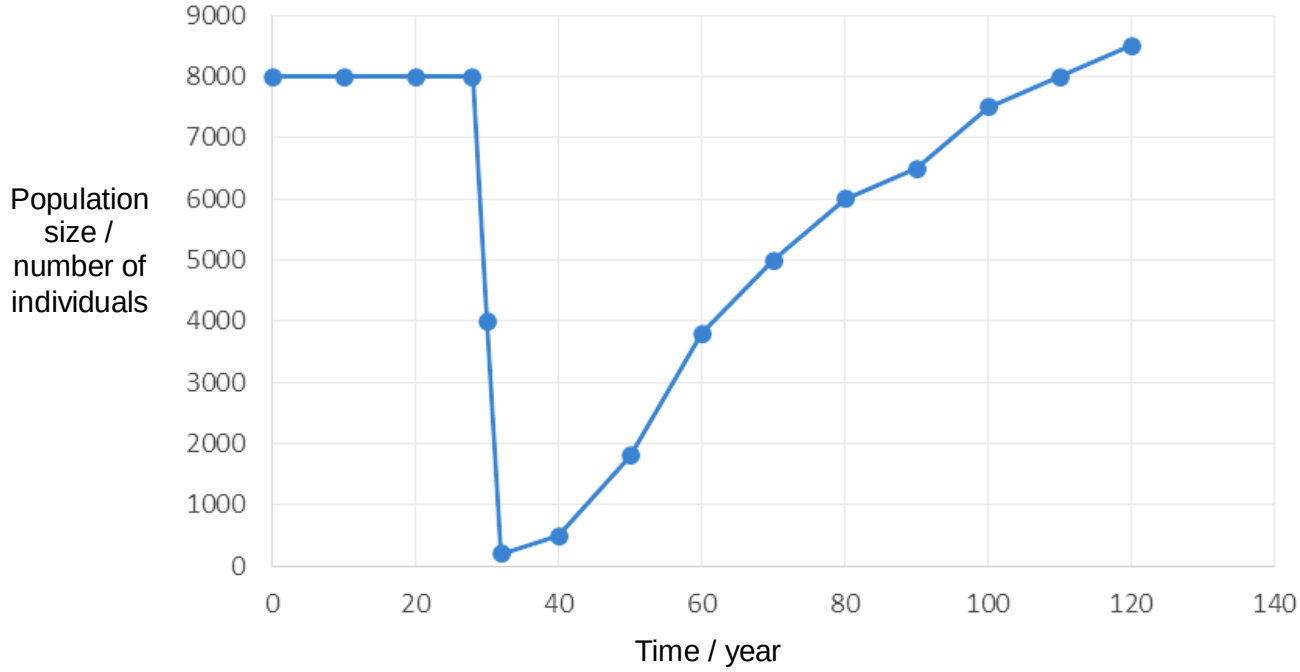
SC: 1. P2L1 weak genetic incompatibility – ie genetically similar
2. P3L1 Male attract females for mating – ie are not reproductively isolated- same species
3. P3L1 different behaviours- behavioural isolation beginning but not led yet to reproductive isolation.
4. P3L2 coexist in same region, no geographical isolation- Sympatric speciation occurring over time.
-correctly inferred / data given

OR: A × reasons from point 2.
B × reasons from point 4.
C × plate tectonics in biogeography would explain H. ewingi present in both regions not convergent evolution. Besides they are exactly the same species so cannot be Convergent evolution.
D ✓reasons from point 4.

Ans: **D**

[L2]

30 The figure shows the population of a group of organisms in a fixed region over time.



The following statements are derived from the data shown.

i. Bottleneck event has taken place Year 30 to 35
ii. Genetic variation has been fully restored by Year 110
iii. Allele frequency steadily increases due to genetic drift
iv. Founder effect has taken place from Year 28 onward

Which statements can be concluded as true?

A i only

B ii only

C i, ii & iii only

D i, iii & iv only

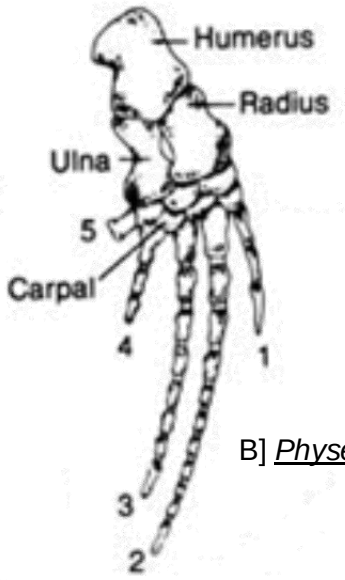
SC: 1. P1L1 Populatio .. fixed region ie no founder effect
OR: 2. i ✓ Bottle neck possible drastic reduction in population
3. ii × genetic variation is reduced after bottleneck and is only increased by mutation over time but would not have been regained by year 150.
4. iii × Not conclusive from the table.
5. iv × Founder Effect is not considered in the original population see point 1.

Ans: **A**

[L2 high]

31 The following figure shows the anatomy of the left front appendages of the two vertebrates.

A] *Javan surili*



B] *Physeter macrocephalus*

Which one of the following correctly describes the type of structures seen and their evolutionary connection?

	Type of structures	Ancestry	Type of evolution
A	Homologous	Different ancestor	Convergent Evolution
B	Homologous	Common ancestor	Divergent Evolution
C	Analogous	Different ancestor	Convergent Evolution
D	Analogous	Common ancestor	Divergent Evolution

SC: correct type structure / evo connection
OR: Homologous (same pentadactyle plan) / divergent evo / common ancester
A × same ancestor / not convergent
B ✓ correct.
C × not analogous / same ancestor / not convergent.
D × not analogous / not divergent evo.
Ans: **B**

[L2]

32 All the characteristics below support the use of plasmids in cloning and expression in bacteria **except**

A More than one plasmid can be taken up by each bacterium.

B Plasmids are able to control their own replication through their origin of replication

C Plasmids contain a wide range of restriction sites for various restriction enzymes.

D Linker DNA / artificial sticky ends are not required to express eukaryotic genes of interest derived from cDNA.

SC: factual recall
OR: Statement A, B and C are true. Only Statement D false. Accept option D.

Ans: **D**

[L1] (VJC 2015 Prelim P1 Q33 modified)

33 *lacZ* gene is a genetic marker found in the plasmid which can be used in genetic engineering.

What is the function of *lacZ* gene in a cloning vector?

A Express *lac* repressor

B Distinguish between introns and exons

C Break down lactose to galactose and glucose

D Screen for cells with the recombinant plasmid .

SC: factual recall
OR: Statement A wrong, B (wrong) and C (true but not align to qn context. Also, the gene does not do the breakdown of lactose, it is the enzyme that is encoded for). Only Statement D relevant. Accept option D.

Ans: **D**

[L1] (TJC 2015 Prelim P1 Q33)

34 Which correctly describe the difference between genomic and cDNA libraries and the corresponding reason for the difference?

	Difference	Reason
A	Genomic library may contain distant control elements and centromere while cDNA library contains only expressed genes.	Due to mRNA splicing which removes exons and splice introns together.
B	Genomic library is larger in size than cDNA library.	Due to genomic library containing total DNA extract from a cell while cDNA library containing the total mRNA extract from a particular cell type.
C	Genomic library from an individual is always the same, while cDNA library may differ, depending on the cell type from which it is constructed.	Due to differential gene expression in the different cell types.
D	Genes from genomic library are more suited than those from cDNA library for expression in bacterial cells.	Due to the action of restriction endonucleases in the construction of genomic library and that of reverse transcriptase in the construction of cDNA library.

SC: Statement Evaluation of DNA libraries

OR: Statement A wrong (introns are excised and exons spliced), B (cDNA library does not contain total mRNA extract) and D (genes from genomic library are not more suitable for expression in bacterial cells due to presence of introns). Only Statement C True. Accept option C.

Ans: **C**

[L2] (MJC 2015 Prelim P1 Q37)

35 Genes P, Q, R and S occur on the same chromosome. The table shows the recombination frequencies.

	recombination frequency (%)
between P and Q	46
between P and R	8
between R and Q	54
between Q and S	13
between R and S	41

Which of the following represents the correct order of genes on the chromosome?

A P – Q – R – S

B P – R – S – Q

C R – P – S – Q

D R – S – Q – P .

SC: Distance between gene loci can be inferred from recombination frequencies; the closer the gene loci → smaller recombination frequency, the more distant gene loci → higher recombination frequency.
OR: R and Q has the highest recombination frequency so should be furthest from each other → Option C

Ans: **C**

[L2] (IJC 2015 Prelim P1 Q35)

36 The Human Genome Project facilitated genetic testing of individuals and renewed emphasis on ethical and social implications.

Which of the following statements correctly describe unintended consequences of genetic testing?

1 discovery of wrongly attributed paternity

2 unauthorised publication of genetic test results

3 psychological stress after receiving genetic test results

4 social stigmatisation of genetically predisposed individuals

A 1 and 2

B 3 and 4

C 1, 2 and 3

D All of the above .

SC: For HGP genetic testing, all are unintended.
OR: Statement 1, 2, 3 and 4 are unintended consequences. Accept Option C.

Ans: **D**

[Low L2]

37 Which of the following shows the correct developmental potency of the following stem cells.

	Haematopoietic stem cells	Zygotic stem cells	Embryonic stem cells	Neural stem cells
A	Multipotent	Pluripotent	Totipotent	Unipotent
B	Multipotent	Totipotent	Pluripotent	Unipotent
C	Multipotent	Pluripotent	Totipotent	Multipotent
D	Multipotent	Totipotent	Pluripotent	Multipotent

SC: Stem cells' developmental potency
OR:
- HSCs & NSCs are multipotent
- Zygotic stem cells are totipotent
- ESCs are pluripotent

Ans: D

[L1] (novel)

38 Which problem is associated with gene therapy?

A Target cells do not have suitable receptors on their cell surface membranes.

B The nuclear pores do not allow the vector into the nucleus.

C The viral vector cannot trigger cyclic AMP to activate appropriate genes.

D Viral vectors insert therapeutic genes at random points in the genome.

SC: Stem cells' developmental potency
OR:
- A: Receptors are not necessarily required. Non-viral methods do not require receptors.
- B: They usually do.
- C: cAMP not necessarily triggered.
- D: Yes, this will cause insertional mutagenesis and hence cancer.

Ans: D

[L2] ('13 A-level/P1/Q39)

39 Some plant tissue culture techniques involve the production of protoplasts using leaf tissue. Preparation of protoplasts involves incubation in a solution that contains enzymes such as cellulase and pectinase.

Which statement about protoplast is not correct?

A Protoplasts are pluripotent and regenerate into whole plants when provided with the correct growth factors.

B Protoplasts are more susceptible to microbial contamination.

C Protoplasts are used for the production of genetically engineered plants as they take up naked DNA easily.

D Protoplasts need to be maintained in the solution of the same water potential to prevent lysis.

SC: Plant cloning
OR:
- A: They are not pluripotent. They can be totipotent.
- B: Yes they are.
- C: Yes they take up naked DNA easily as they lack cell wall.
- D: Yes.

Ans: A

[L2] ('15 HCI/P1/Q40)

40 Which statement supports the view that genetically engineered animals could help to solve the demand for food in the world?

A Transgenic pigs and sheep are produced to express higher levels of growth hormone.

B Biomedical applications of genetically engineered animals have also become routine within the pharmaceutical industry, for drug discovery, drug development and risk assessment.

C Cloning of either extinct or endangered species such as thylacine and woolly mammoth helps to retain genetic diversity in small populations.

D By inserting genes from sea anemone and jellyfish, zebrafish have been genetically engineered to express fluorescent proteins.

SC: GMO animals
OR:
- A: Correct.
- B: Does not solve the demand for food.
- C: Does not solve the demand for food.
- D: Does not solve the demand for food.

Ans: A

[L2] ('15 HCI/P1/Q40)

END OF PAPER

JC2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME					
CLASS	**2T**	**INDEX NUMBER**			

BIOLOGY

9648/02
23rd August 2016
2 hours

Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are two sections in this paper.

Section A]
Answer all questions

Section B]
Answer all questions. Answer each part on a **separate** piece of paper.

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

For Examiner's Use	
Section A	**80**
1 [10]	
2 [10]	
3 [10]	
4 [10]	
5 [10]	
6 [10]	
7 [10]	
8 [10]	
Section B	**20**
9a/10a	
9b/10b	
9c/10c	
TOTAL	**100**

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

[Turn over

Section A

Answer **all** questions in this section.

1 The figure below shows three structural components of the membrane system in a pancreatic cell.

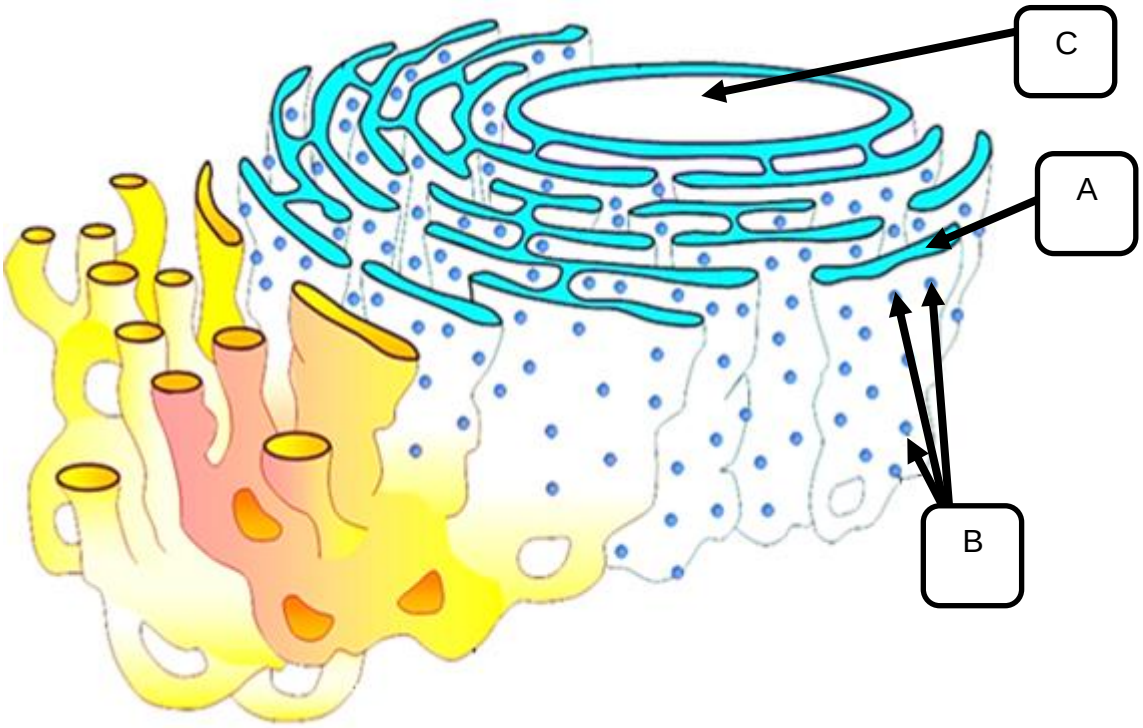


Fig. 1.1

(a) State the name and function of the structures in Fig. 1.1.

Structure A

Name: ……

Function: …… [1]

Structure B

Name: ……

Function: …… [1]

(b) State what is **structure C** and explain how **structure A** remains in close proximity to **C.**

……

……[2]

Fig. 1.2 shows a hormone essential for regulation of high blood glucose levels.

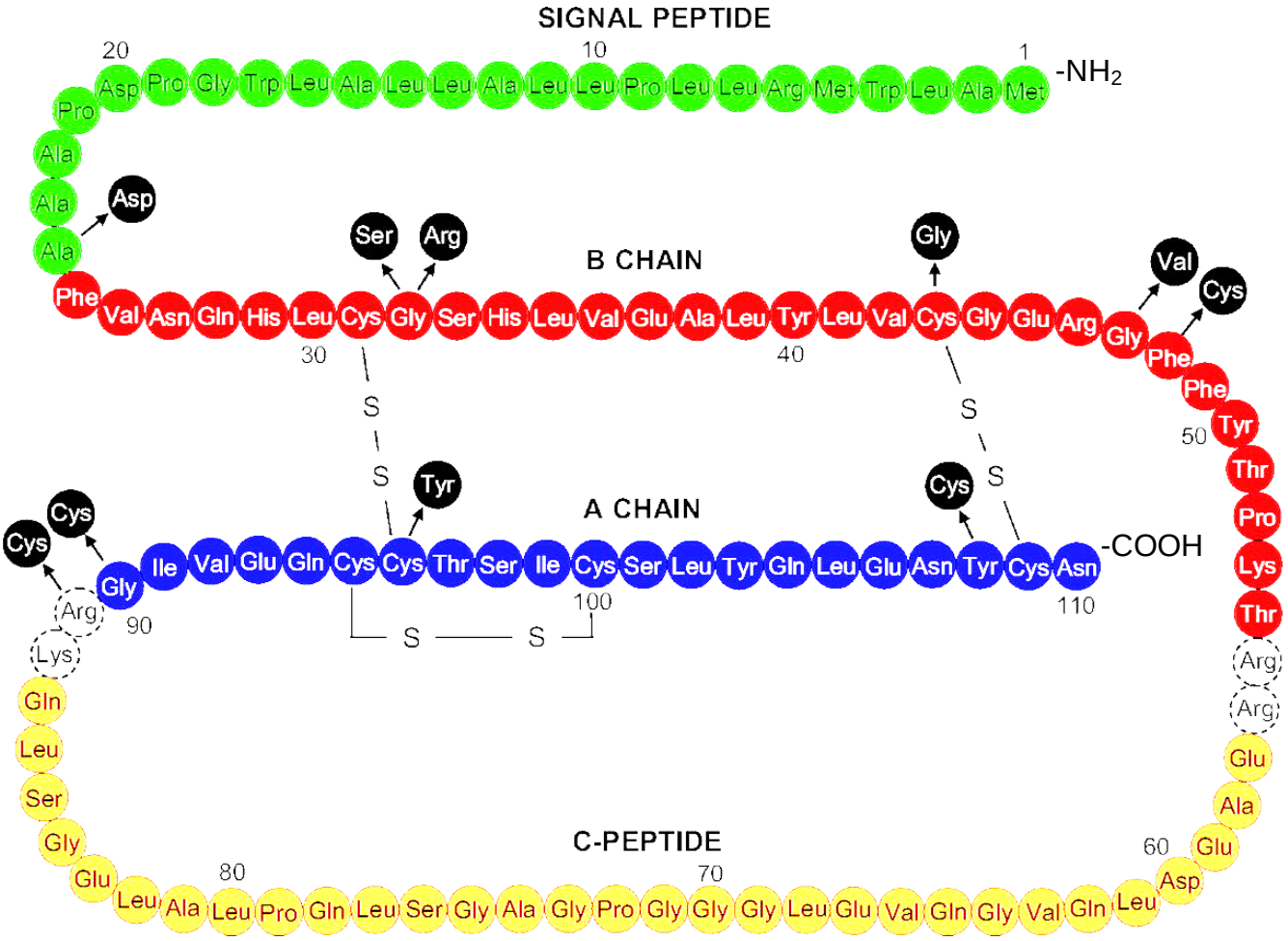


Fig. 1.2 Unit sequences of wild type (WT) and the mutant hormone. The mutations are noted in black circles together with location in the B (25 to 5) or A chain (90-110). The dashed circles indicate the basic residues that are activation cleavage sites.

(c) With reference to Fig. 1.2, draw out the bond (ensure correct orientation) formed between units 109 and 110 of the A-chain.

[2]

(d) With reference to Fig 1.2, suggest how amino acid substitutions between 90 and 109 could occur and what would be the corresponding effect on the resultant mutant hormone.

……

……

……

……[4]

[Total: 10]

2 The figure shows the molecular configuration of chymotrypsin. Chymotrypsin is one of the major proteases in the human digestive tract, in which its role is to hydrolyse large protein molecules into smaller peptides that are then further processed by peptidases. Fig. 2.1a shows a blown up representation of a portion of chymotrypsin shown in Fig. 2.1b.

Fig. 2.1a

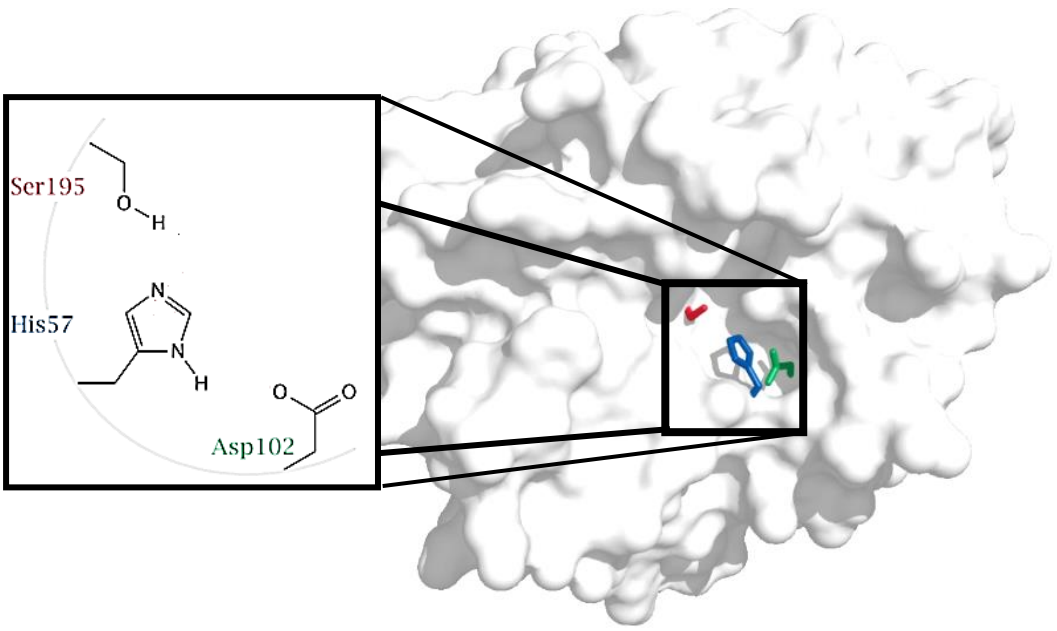


Fig. 2.1b

(a) Using the 'induced-fit hypothesis', explain the mechanism in which chymotrypsin carries out its function.

……

……[2]

Fig. 2.2 shows the energy exchange in a chemical reaction without the enzyme present.

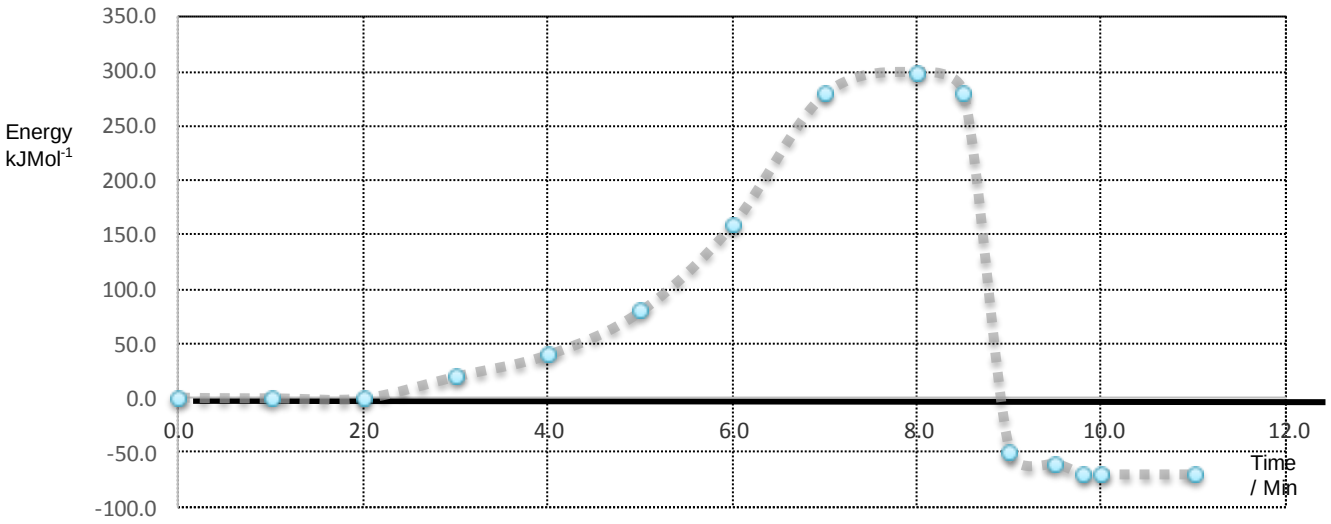


Fig. 2.2

(b) On the graph above draw out the plot tracing the effect of enzyme action and label the effect of enzyme on activation energy. [2]

Fig. 2.3 shows the effects of substrate on enzyme reaction.

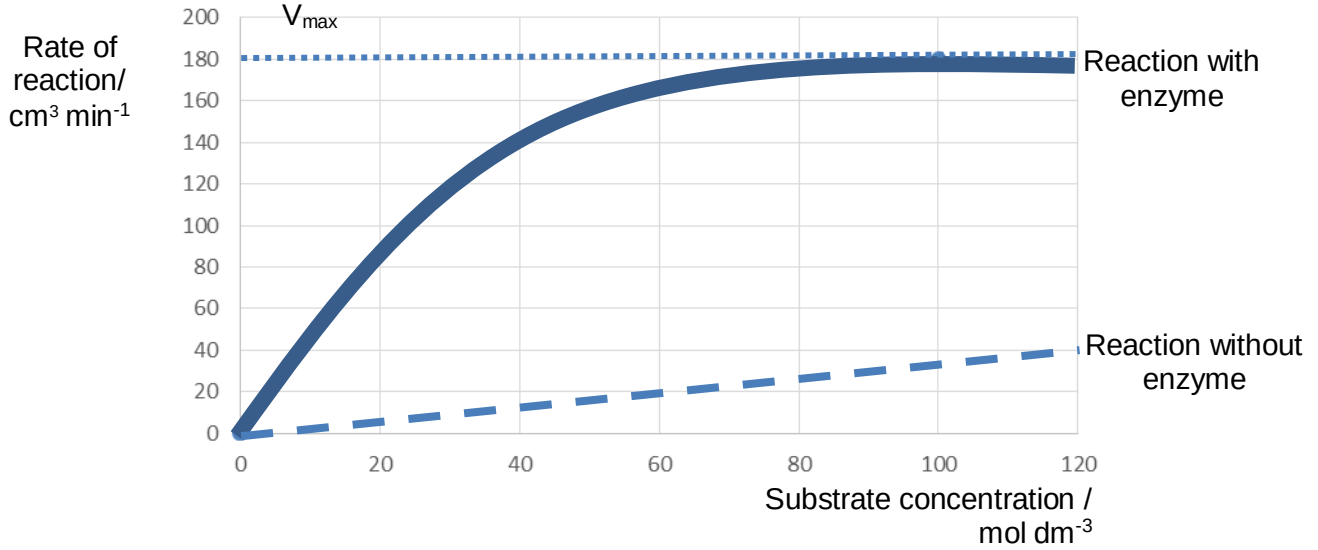


Fig. 2.3

(c) Explain what can be inferred from the graph in Fig. 2.3, with reference to substrate concentration and limiting factors.

……

……

……[2]

(d) On Fig. 2.3 draw a curve representing the effect of a non-competitive inhibitor on rate of reaction with no change in the affinity of the enzyme.

[2]

(e) Account for why the Michaelis constant for both the non-competitive inhibitor and the reaction without inhibitor is the same.

……

……

……[2]

[Total: 10]

3 Cells were transferred and grown in ^{15}N medium for many generations before they were transferred to ^{14}N medium again and allowed to divide.

DNA was extracted periodically from the culture and subjected to density gradient centrifugation using caesium chloride.

Fig. 3.1 shows the density gradient results across three generations.

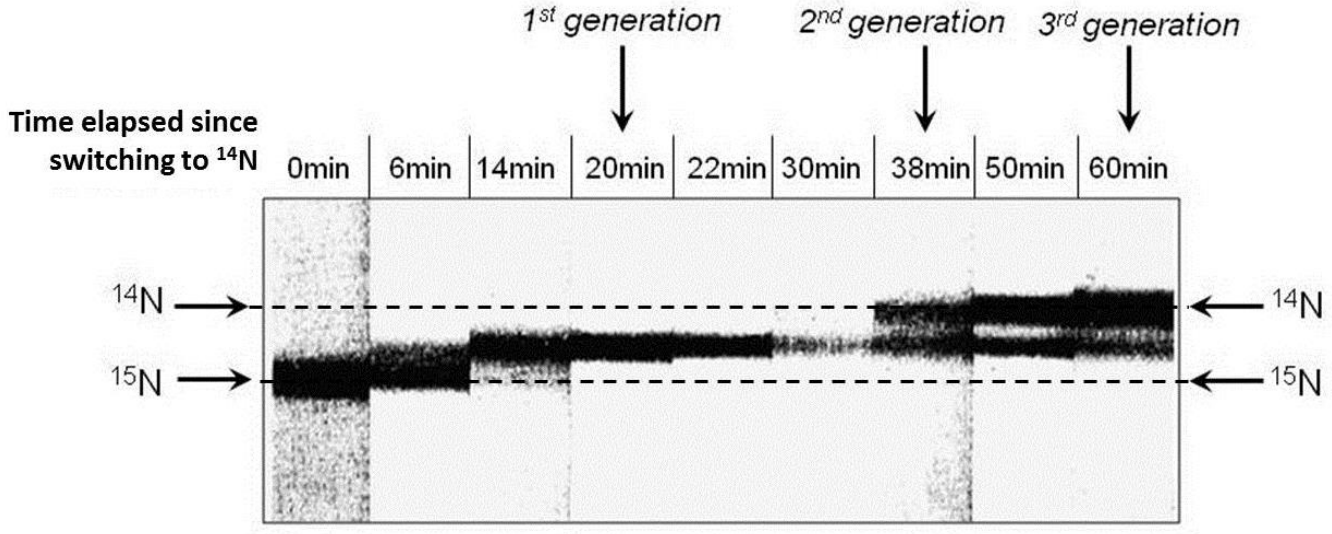


Fig. 3.1

(a) With reference to Fig. 3.1, account for the model of DNA replication which these cells undergo.

……

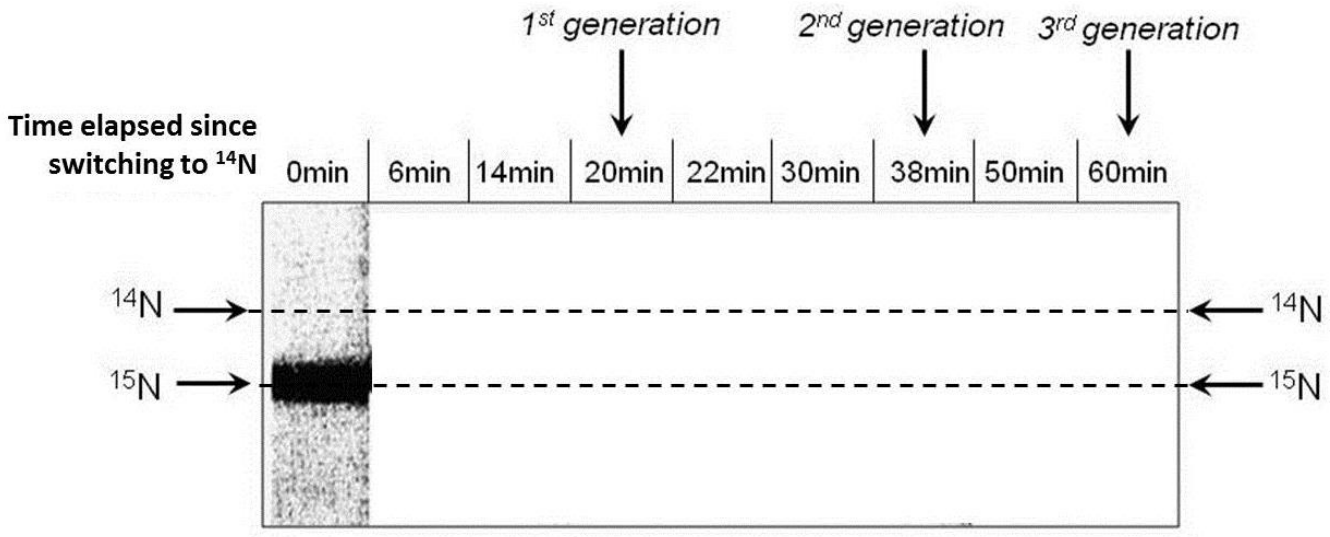
……

……

……[3]

(b) State another model of DNA replication not shown in Fig. 3.1 draw only its band patterns for the 1st, 2nd and 3rd generations in the Figure below.

Model of DNA replication: ……



[2]

Fig. 3.2 shows a simplified representation of DNA replication occurring on a linear chromosome.

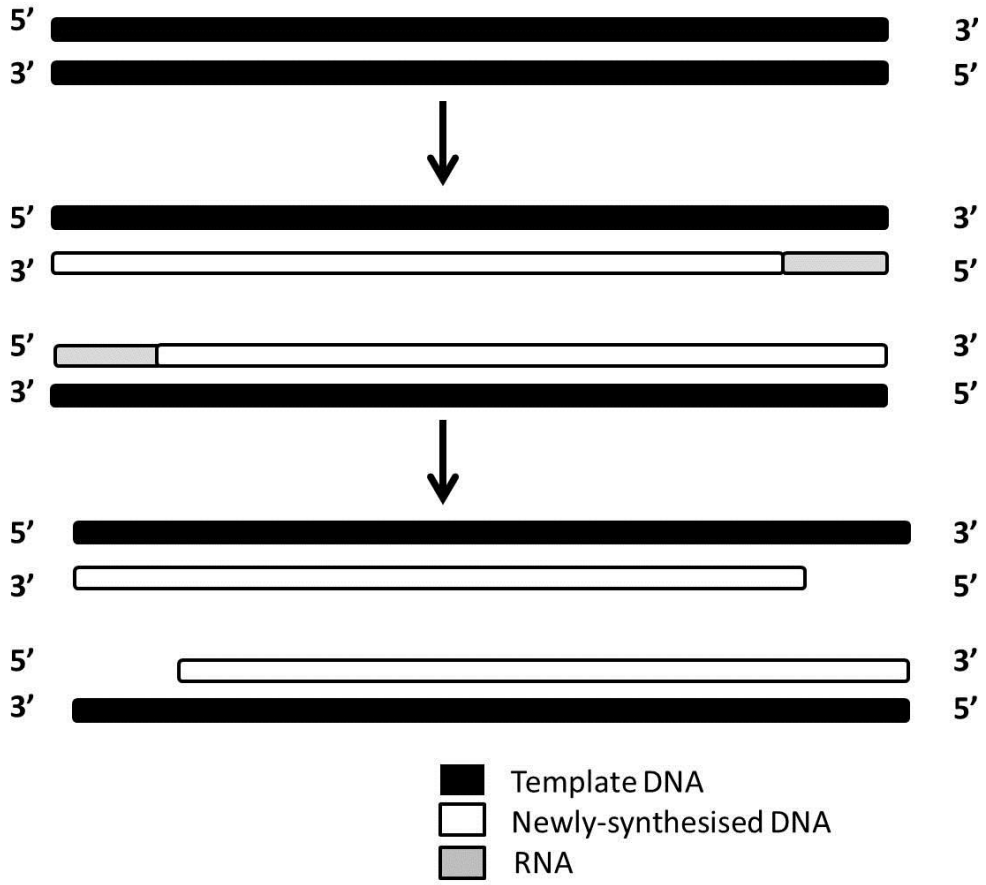


Fig. 3.2

(c) Explain how certain cells address the molecular issue reflected in Fig. 3.2.

……

……

……[2]

The cellular process shown in Fig. 3.2 has many similarities with translation even though the products formed are different. Some of the similarities are that they both take place in 3 different stages (initiation, elongation, termination), both require energy, monomers for extension, a template for product synthesis as well as bond formation involving the removal of a water molecule.

(d) State three other similarities between the cellular process shown in Fig. 3.2 and translation.

……

……

……

…… [3]

[Total: 10]

4 Fig. 4.1 shows two different stages, A and B (as shown by arrow) of the HIV reproductive cycle.

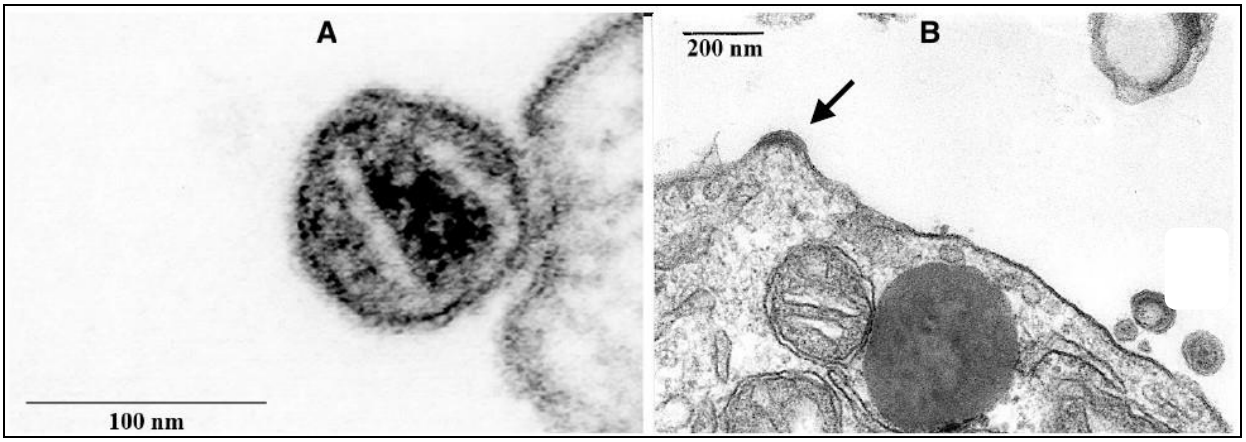


Fig. 4.1

(a) Describe the events occurring in stage A of the HIV reproductive cycle.

……

……

……[2]

(b) Compare the stage immediately following stage A with stage B.

……

……

……[2]

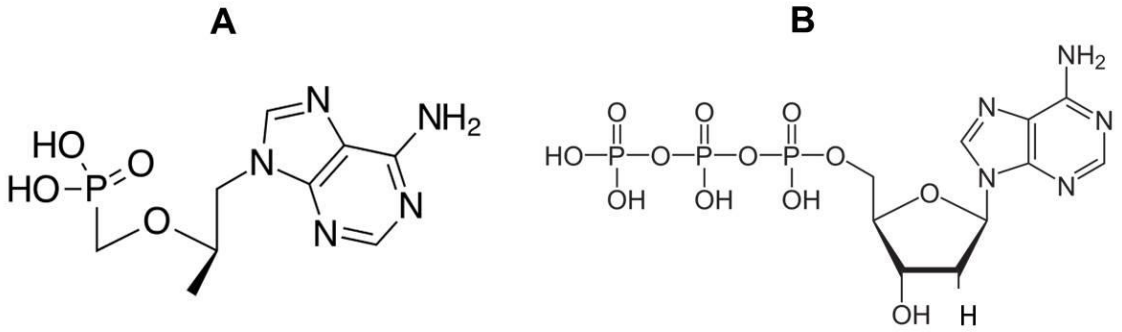
(c) Contrast the final stage of the reproductive cycle of HIV and T4 phage.

……

……[1]

For treatment, HIV-infected patients can receive HIV antiviral drugs such as Tenofovir (Fig. 4.2A).

Fig 4.1B shows an adenosine triphosphate (dATP) molecule, which shares similar chemical groups to Tenofovir.



Tenofovir **dATP**

Fig. 4.2

(d) With reference to Fig. 4.2, suggest how Tenofovir acts as a drug that interferes with the HIV reproductive cycle.

……

……

……[2]

HIV entry into cells requires involvement of at least one type of co-receptor. CCR5 is required for HIV virus entry. CCR5 Δ32 is a 32-base-pair deletion that introduces a premature stop codon into the CCR5 receptor locus, resulting in a non-functional receptor.

Timothy Ray Brown was an AIDS patient who received a hematopoietic stem cell transplant from a donor with homozygous CCR5 Δ32 on the CCR5 gene. After the transplant, he stopped his antiretroviral treatment. Following that, it was found that Timothy's HIV viral levels steadily decreased and his CD4 T- cell count increased. Eventually, he was found to be cured from HIV.

(e) Suggest why not all HIV-infected patients can be cured with this therapeutic method.

……

……[1]

(f) Explain how HIV infection may result in the death of infected CD4 cells.

……

……

……[2]

[Total: 10]

5 Fig. 5.1 shows the formation of a eukaryotic transcription initiation complex.

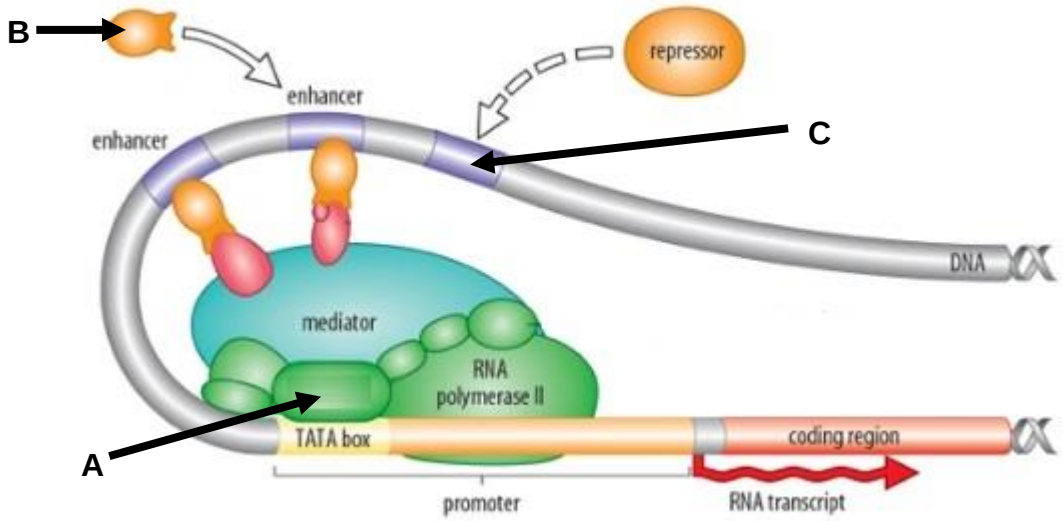


Fig. 5.1

(a) Identify the following proteins.

A: _____

B: _____

C: _____

[3]

(b) Explain how the eukaryotic transcription initiation complex for high rate of transcription can be formed.

……

……

……

……

……[4]

High rate of transcription caused by mutations in cancer critical genes may result in dysregulation of cell cycle control and subsequently lead to uncontrolled cell division.

c-myc is a regulator gene that codes for a transcription factor. A mutated version of c-myc that is highly expressed is found in many cancers. Fig 5.2 shows the relative level of expression of c-myc in normal and cancer prostate tissue.

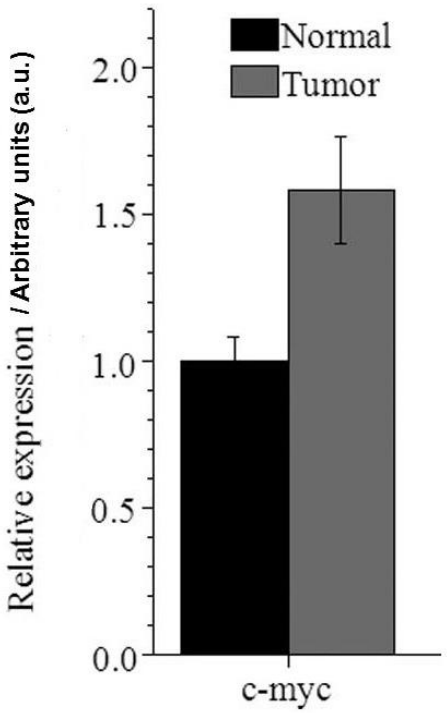


Fig 5.2

(c) With reference to Fig.5.2, explain how mutation in the c-myc gene led to increased expression in cancer prostate tissue.

……

……

……

……[3]

[Total: 10]

6 Fig. 6.1 shows a Calico cat with a mosaic coat with patches of orange and black. It is known that fur coat colour in cats is determined by a single gene. Only female cats can develop calico fur coat. Male cats usually have only orange or black fur coat.

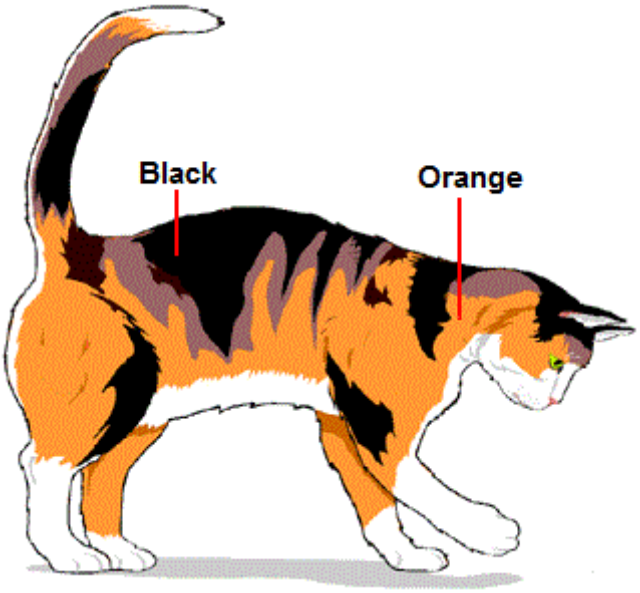


Fig. 6.1

(a) Identify the type(s) of inheritance determining Calico fur coat colour in cats.

……

……[1]

(b) Using B to represent allele for black coat and R to represent allele for orange coat, draw a genetic diagram to show how a cat-breeder can obtain Calico cat from a cross between a pure-breeding black male and an orange female cat.

[4]

Coat colour inheritance in horses is different from cats. Two unlinked genes *E* and *G* control coloured coat in horses. The two genes are thought to be involved in the same metabolic pathway for pigment formation.

- Horses may be bay, black or chestnut in colour.
- Horses may be bay / black when at least one dominant allele *E* is present.
- Chestnut coat colour is always produced in the presence of two copies of the e allele.

Horses coat colour goes through a natural graying process. Horses born with bay, black or chestnut coat colour will steadily turn gray. This process is mediated by a single copy of the dominant allele G regardless of the genotype of the gene E controlling coat colour.

(c) Draw a genetic diagram in the space below to show the result of the cross between two gray horses that were heterozygous at both gene loci G/g and E/e and the resultant phenotypic ratio of the offspring.

[5]

[Total: 10]

7 Fig. 7.1 shows the different modes of signal conduction in a non-myelinated neuron.

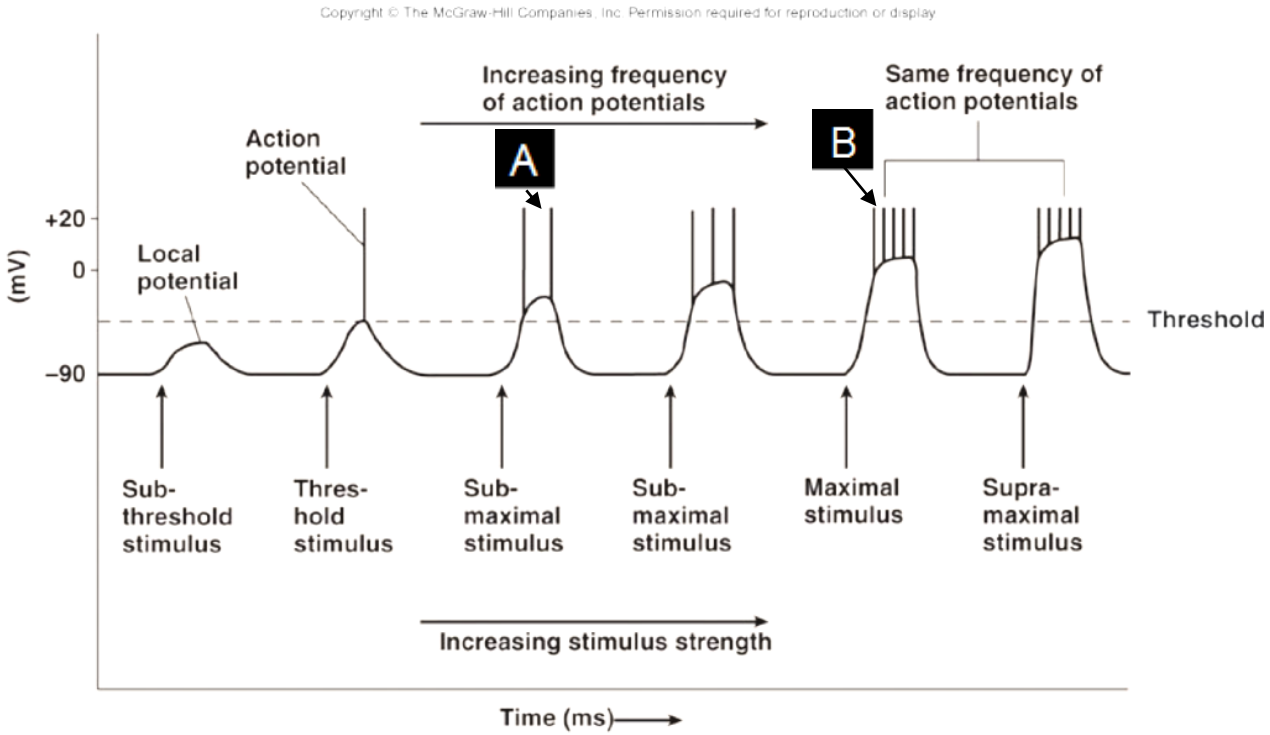


Fig. 7.1

(a) State one factor that contributes to unidirectional conduction of impulses down an axon.

……..[1]

With reference to Fig. 7.1 for all questions following,

(b) explain why there is no action potential generated with a sub-threshold stimulus.

……

……

……..[2]

(c) explain how the time interval between action potentials seen in label **B** is shorter than the time interval between action potentials seen in label **A**.

……

……

……

……..[3]

(d) state the advantages in the ability of neurons to display these characteristics shown in Fig. 7.1.

……

……

……..[2]

(e) explain what would increase the speed of the signal conduction down the neuron.

……

……

……..[2]

[Total: 10]

8 The Grand Canyon National Park is home to two groups of squirrels. The Albert squirrels *Sciurus aberti* live generally on the south rim of the canyon and the Kaibab squirrels *Sciurus kaibabensis* live on the north rim of the canyon (Fig. 8.1 and Fig. 8.2).

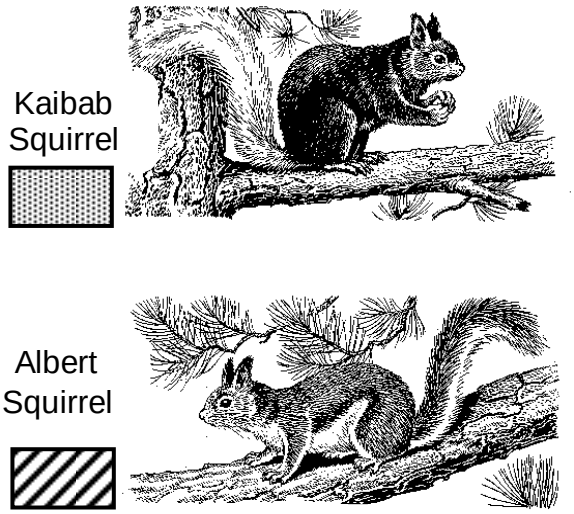


Fig. 8.1

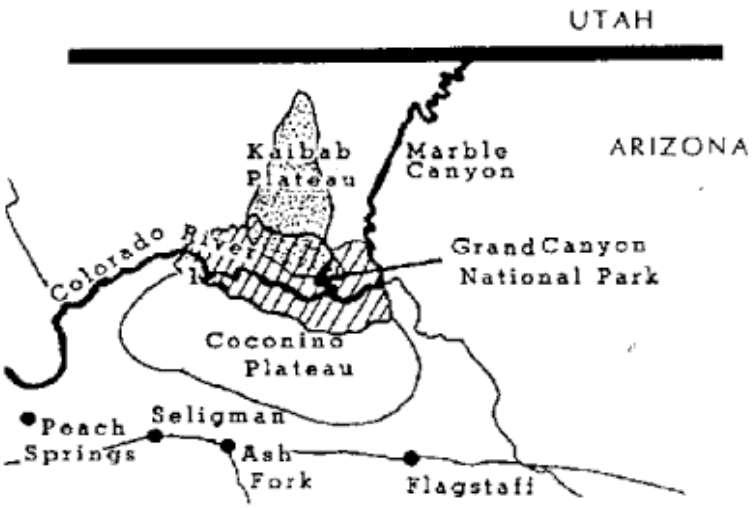


Fig. 8.2

The north rim is about 370 m higher than the south rim. Almost twice as much precipitation falls on the north rim than on the south rim every year. The two groups share many characteristics, but they do not look the same, both groups have tasselled ears, but each group has a unique fur colour pattern.

(a) Explain which Darwinian principles can be applied from the above information on *S. alberti* and *S. kaibabensis*.

……

……

……

……

……[4]

Several studies have been done on the phylogenetic relationship of the squirrels in and around the Grand Canyon region. Fig. 8.3 is one such study based on cytochrome b DNA sequences.

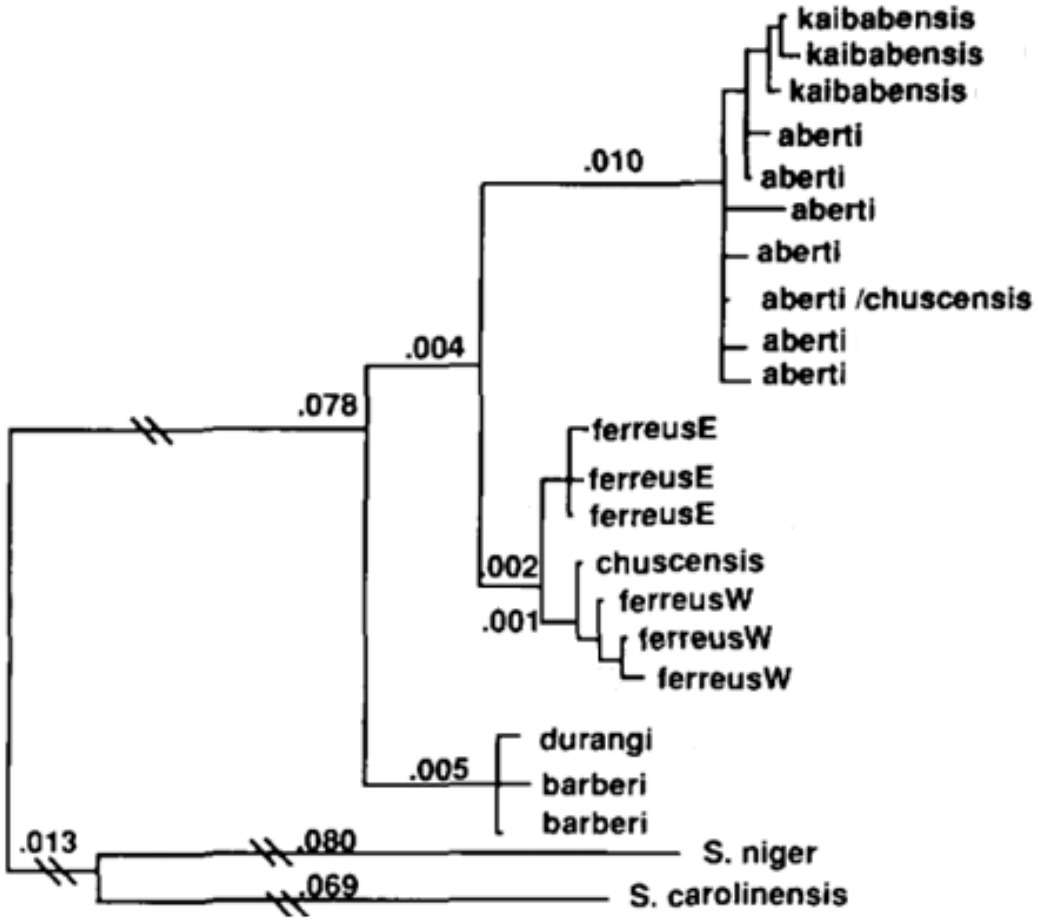


Fig.8.3 Phylogenetic relationship between six *sciurus* subspecies base on cytochrome b sequences constructed by the neighbour-joining method of Saitou and Nei (1987) using the *S. niger* and *S. carolinesis* (Thomas and Martin 1993) sequences as outgroups. Branch lengths and confidence probabilities are noted above and below the branches respectively.

(b) With reference to information already given and also to Fig. 8.3, it is clear that divergent evolution or adaptive radiation is occurring in the evolution of *S. alberti* and *S. kaibabensis*

Explain why it is not convergent evolution.

……

……

……..[2]

(c) (i) With reference to information already given and also to Fig. 8.3, suggest with reasons what kind of speciation *S. Alberti* is undergoing.

……

……

……..[2]

(ii) With a known species concept, explain what would be the determining factor confirming *S. alberti* and *S. kaibabensis* as two separate species.

……

……

……..[2]

[Total: 10]

Section B

Answer **one** question. Answer each part on a **separate** piece of paper.

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

9 **(a)** Describe cell signaling with the G-protein coupled receptor with a named ligand and its corresponding cellular response. [8]

(b) Explain the advantages and disadvantages of a phosphorylation cascade. [6]

(c) Contrast with elaboration, anaerobic respiration with light independent reaction (Calvin cycle). [6]

[Total: 20]

10 **(a)** Contrast binary fission and mitosis. [6]

(b) Describe generalised and specialised transduction. [8]

(c) In an experiment using T4 bacteriophage, different component molecules were labelled.

- T4 bacteriophages with protein coats labelled with radioactive sulfur.
- T4 bacteriophages with DNA labelled with radioactive phosphorus.

The differently-labelled bacteriophages were allowed to infect host bacteria.
The inside and outside of infected bacteria before lysis were tested for radioactive sulfur and radioactive phosphorus.

Describe and explain the expected results of the experiment. [6]

[Total: 20]

END OF PAPER

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JC2 PRELIMINARY EXAMINATIONS
Higher 2

Answers

CANDIDATE NAME					
CLASS	**2T**	**INDEX NUMBER**			

BIOLOGY

9648/02
23rd August 2016
2 hours

Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are two sections in this paper.

Section A]
Answer all questions

Section B]
Answer all questions. Answer each part on a **separate** piece of paper.

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

For Examiner's Use	
Section A	/80
1 [10]	
2 [10]	
3 [10]	
4 [10]	
5 [10]	
6 [10]	
7 [10]	
8 [10]	
Section B	/20
9a/10a	
9b/10b	
9c/10c	
TOTAL	/45

This document consists of **31** printed pages and **0** blank page.

[Turn over

Section A

Answer **all** questions in this section.

1 The figure below shows three structural components of the membrane system in a pancreatic cell.

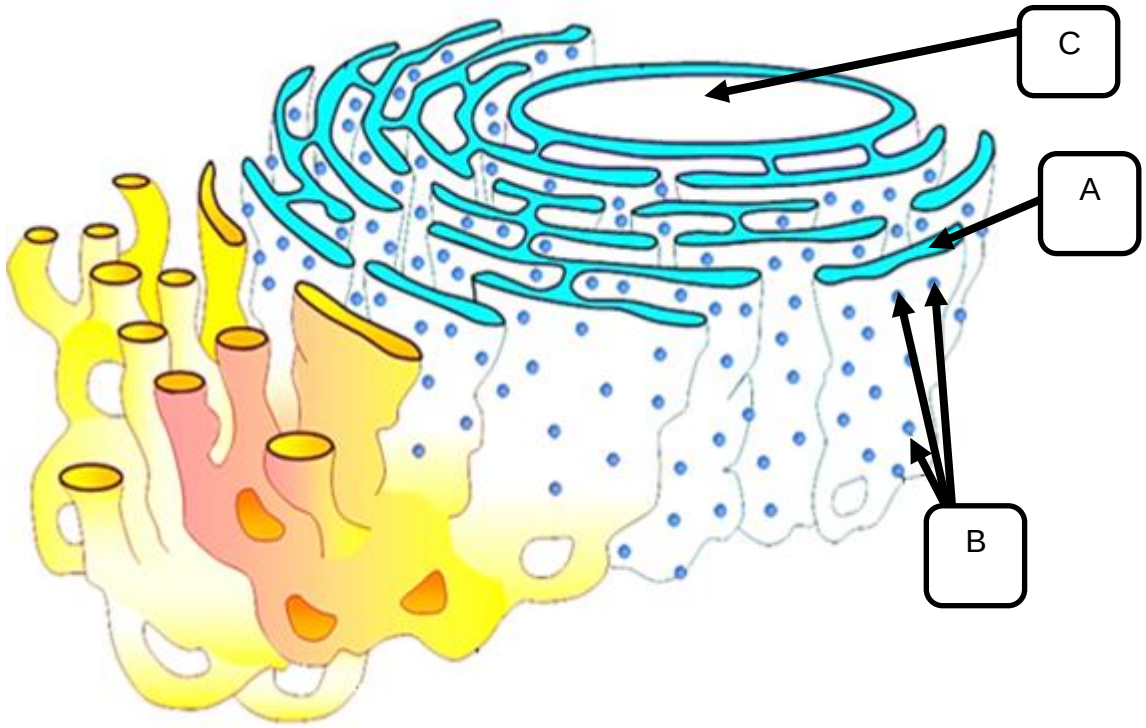


Fig. 1.1

(a) State the name and function of the structures in Fig. 1.1.

Structure A

Name: ……

Function: …… [1]

1. **Cisternae** of rough endoplasmic reticulum / rER, involved in structural **folding** of primary **polypeptide.**

[L1]

Structure B

Name: ……

Function: …… [1]

2. **Bound ribosomes** of rough ER, involved in the **synthesis of polypeptide** chain which enters the rER.

[L1]

(b) State what is **structure C** and explain how **structure A** remains in close proximity to **C.**

……

……[2]

SC: Structure C / How Structure A remains close to structure C
OR: Nucleus / continuous membrane with nucleus

1. **Nucleus,**
2. The **nuclear envelope / membrane** / **double membrane** of the nucleus is **continuous with** the **membrane** system of the **rough ER.**

[L2]

Fig. 1.2 shows a hormone essential for regulation of high blood glucose levels.

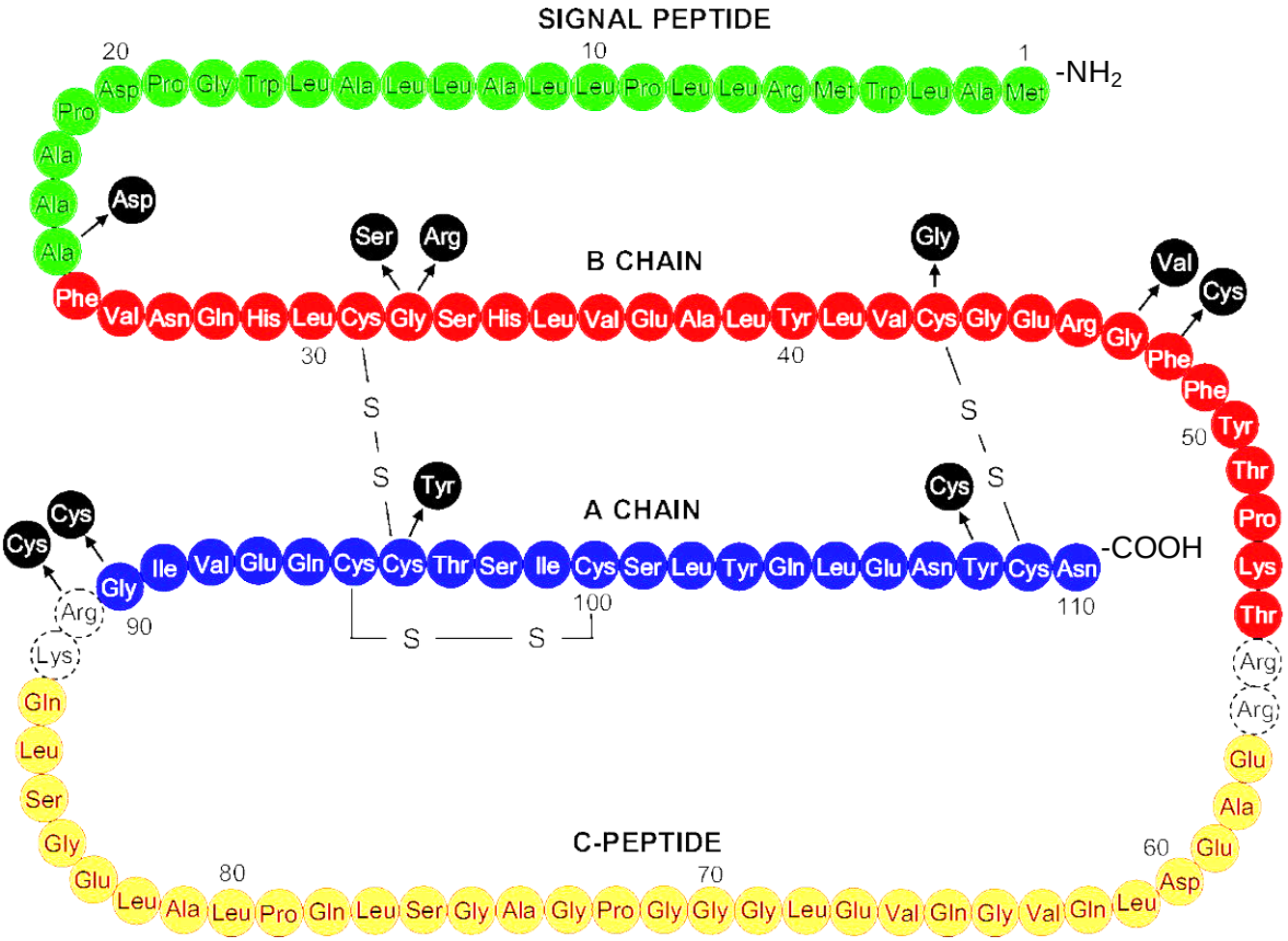


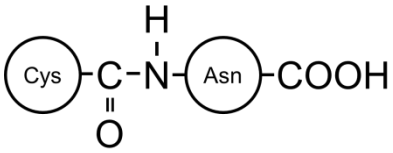
Fig. 1.2 Unit sequences of wild type (WT) and the mutant hormone. The mutations are noted in black circles together with location in the B (25 to 5) or A chain (90-110). The dashed circles indicate the basic residues that are activation cleavage sites.

(c) With reference to Fig. 1.2, draw out the bond (ensure correct orientation) formed between units 109 and 110 of the A-chain.

[2]

SC: Draw / Bond / orientation
OR: Peptide bond / COOH on right same as in aa 110

1. Peptide bond
2. Correct orientation



[L2]

(d) With reference to Fig 1.2, suggest how amino acid substitutions between 90 and 109 could occur and what would be the corresponding effect on the resultant mutant hormone.

……

……

……

……[4]

SC: how aa substitution occur / effect on hormone
OR: base pair substitutions on template strand
– change amino acid Example 96 Cytosine / Cys to Tyrosine / Tys
- Affects the disulphide bond between 31 Cys and 96 Cys
- Changing the quaternary structure [chain A and B >2 molecules]
- Change in overall configuration of hormone

1. **Base pair substitution** on the **non coding strand of DNA**.

Any pair 2 & 3 or 4 & 5
2. results in a change in **codon** for a specific amino acid **96 Cys to Tys**.
3. resulting in **the loss of a disulphide bond** between **96 Cys and 31 Cys**.

Any 1 of the following:
4. results in a change in **codon** for a specific amino acid **108 Tyr to Cys**.
5. resulting in **the gain of a disulphide bond** between **43 Cys and 108 Cys**.

6. **changing** the **quaternary structure** of the hormone and its **overall specific configuration**.

(Max 4)

[L3]

[Total: 10]

2 The figure shows the molecular configuration of chymotrypsin. Chymotrypsin is one of the major proteases in the human digestive tract, in which its role is to hydrolyse large protein molecules into smaller peptides that are then further processed by peptidases. Fig. 2.1a shows a blown up representation of a portion of chymotrypsin shown in Fig. 2.1b.

Fig. 2.1a

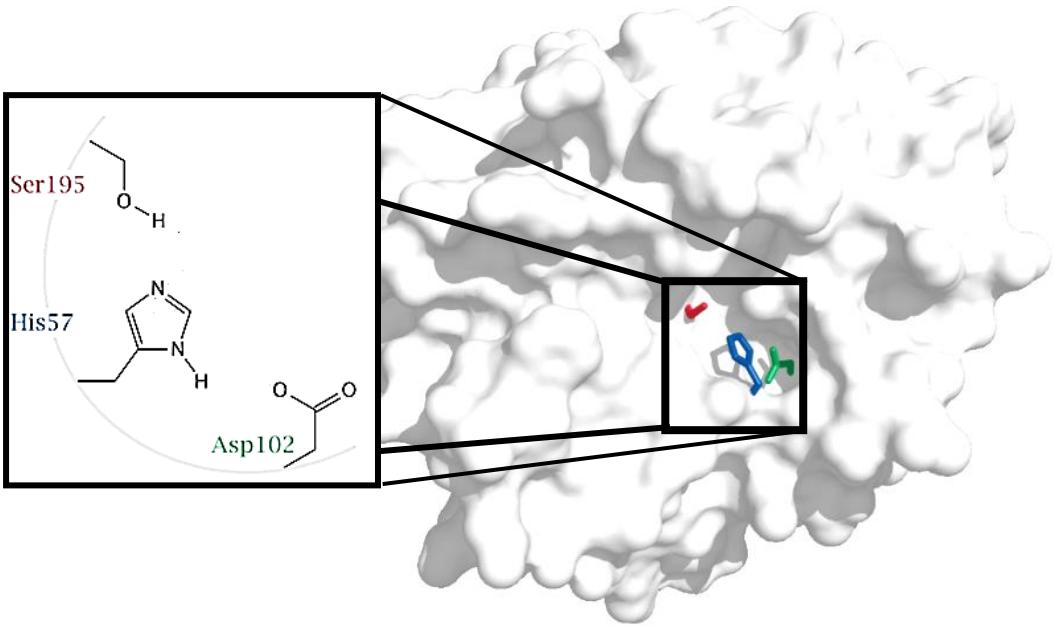


Fig. 2.1b

(a) Using the 'induced-fit hypothesis', explain the mechanism in which chymotrypsin carries out its function.

……..

……

……[2]

SC: Induced fit / mechanism / chymotrypsin / function.
OR: 1. In the induced-fit hypothesis, catalytic R groups of the active site come into correct orientation and bind.
2. The binding causes conformational change that fits the enzyme more closely with the substrate and in so doing a strain on the substrate bond to be broken.

1. In the 'induce fit' hypothesis, **catalytic R groups** of the **active site** come into correct orientation and **bind to the protein**.
2. The bind causes **conformational change** that **fits the enzyme more closely** with the substrate.
3. and in so doing **causes a strain** in the structural bond **lowering the activation energy** of the reaction.

(Max 2)

[L2]

Fig. 2.2 shows the energy exchange in a chemical reaction without the enzyme present.

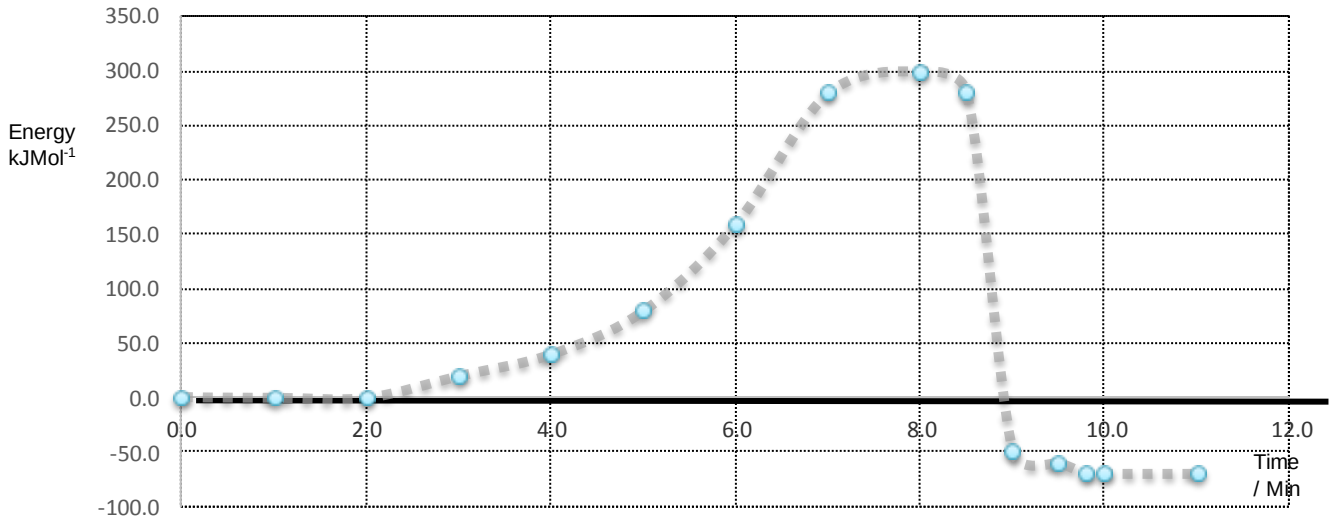
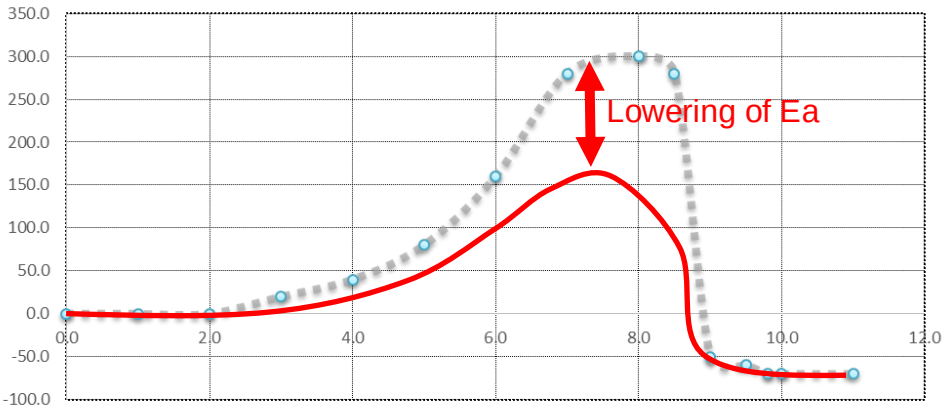


Fig. 2.2

(b) On the graph above draw out the plot tracing the effect of enzyme action and label the effect of enzyme on activation energy. [2]



Correct drawing of the enzyme reaction graph [1 mark]
Lowering of Ea. [1 mark]

[L2]

Fig. 2.3 shows the effects of substrate on enzyme reaction.

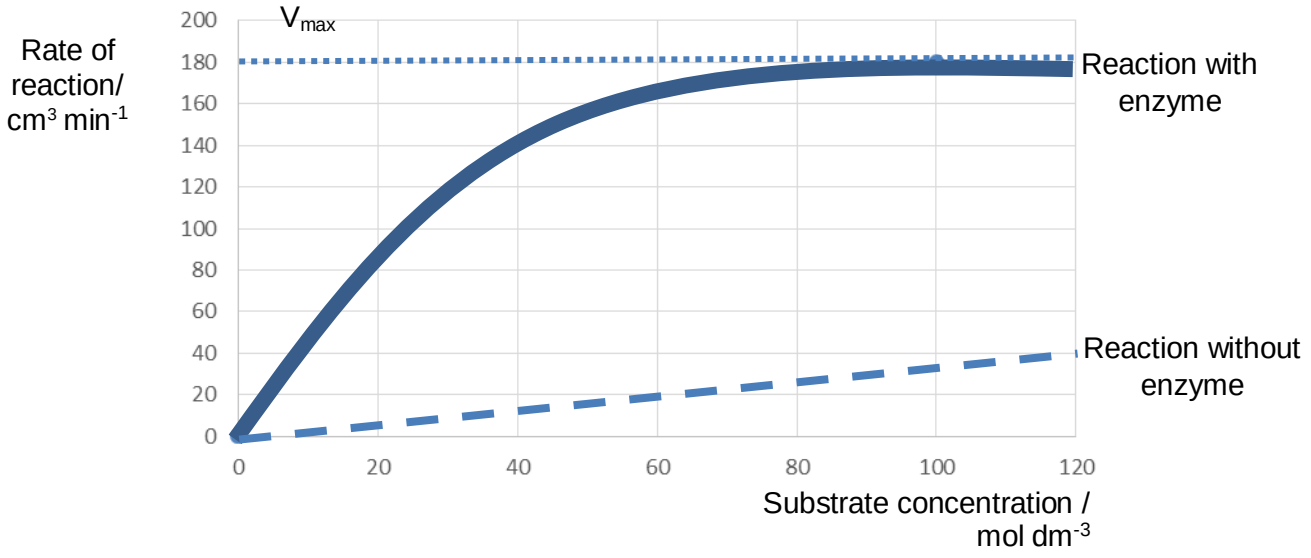


Fig. 2.3

(c) Explain what can be inferred from the graph in Fig. 2.3, with reference to substrate concentration and limiting factors.

……

……[2]

SC: inferred from graph / ref Sub con. & limiting factors..
OR: 1. DRUM substrate con below 80 mol dm^{-3} / limiting factor / adding more rate of reaction increases.
2. From 80 mol dm^{-3} onward, substrate concentration no longer is the limiting factor

.

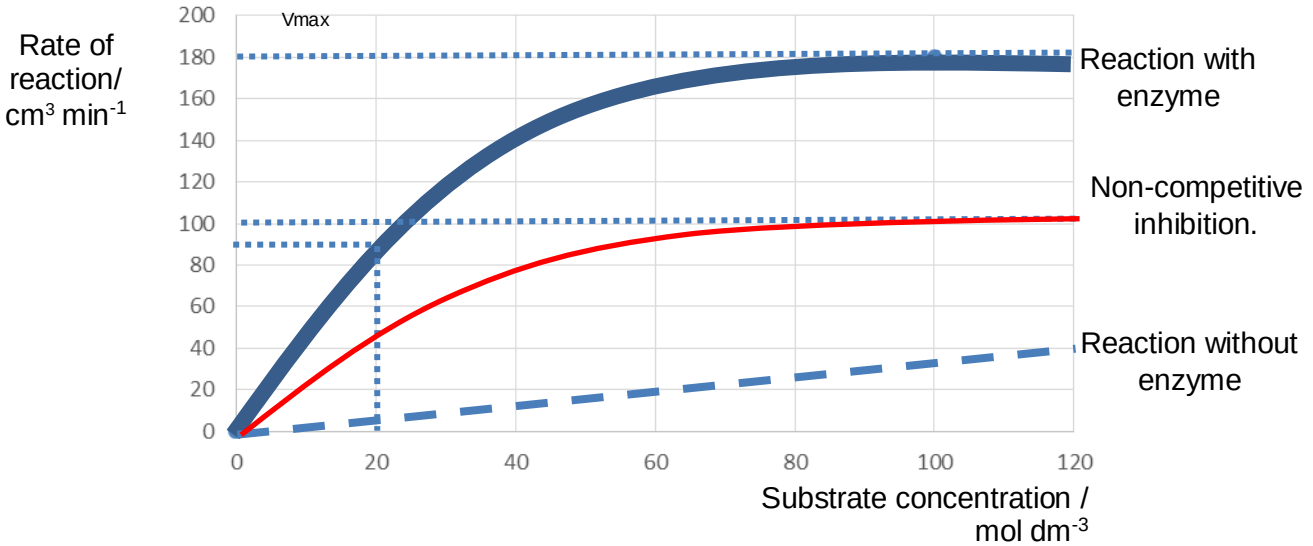
1. From **0 to 80 mol dm^{-3} substrate** is the **limiting factor** since **upon adding more substrate** sees the **rate of reaction increasing**.
2. From **80 mol dm^{-3} onward**, **substrate concentration is no longer the limiting factor.**
3. **Citation of Data**.

(Max 2)

[L2]

(d) On Fig. 2.3 draw a curve representing the effect of a non-competitive inhibitor on rate of reaction with no change in the affinity of the enzyme.

[2]



Non-competitive inhibitor graph plateaus and does not reach V_{max}. [1 mark]
K_m values of Reaction with enzyme and that of the Non-competitive are the same. [1 mark]

[L2]

(e) Account for why the Michaelis constant for both the non-competitive inhibitor and the reaction without inhibitor is the same.

……

……[2]

SC: Michaelis Const / both rxn SAME
OR: 1. **Michaelis constant (Km) / ½ Vmax**

2. Since **binding of the inhibitor** / **a site other than the active site** / **allosteric site** there is **no change in affinity** / **Km** value **remains the same**.

1. **Michaelis constant (K_m)** is derived by **measuring ½ V_{max} of each respective graph..**
2. Since **binding of the inhibitor** is at **a site other than the active site** / allosteric site there is **no change in affinity** of the active site of the enzyme to its substrate and Km value remains the same.
3. The **3D configuration of the active site is changed** with the binding of the inhibitor.

(Max 2)

[L2]

[Total: 10]

3 Cells were transferred and grown in ^{15}N medium for many generations before they were transferred to ^{14}N medium again and allowed to divide.

DNA was extracted periodically from the culture and subjected to density gradient centrifugation using caesium chloride.

Fig. 3.1 shows the density gradient results across three generations.

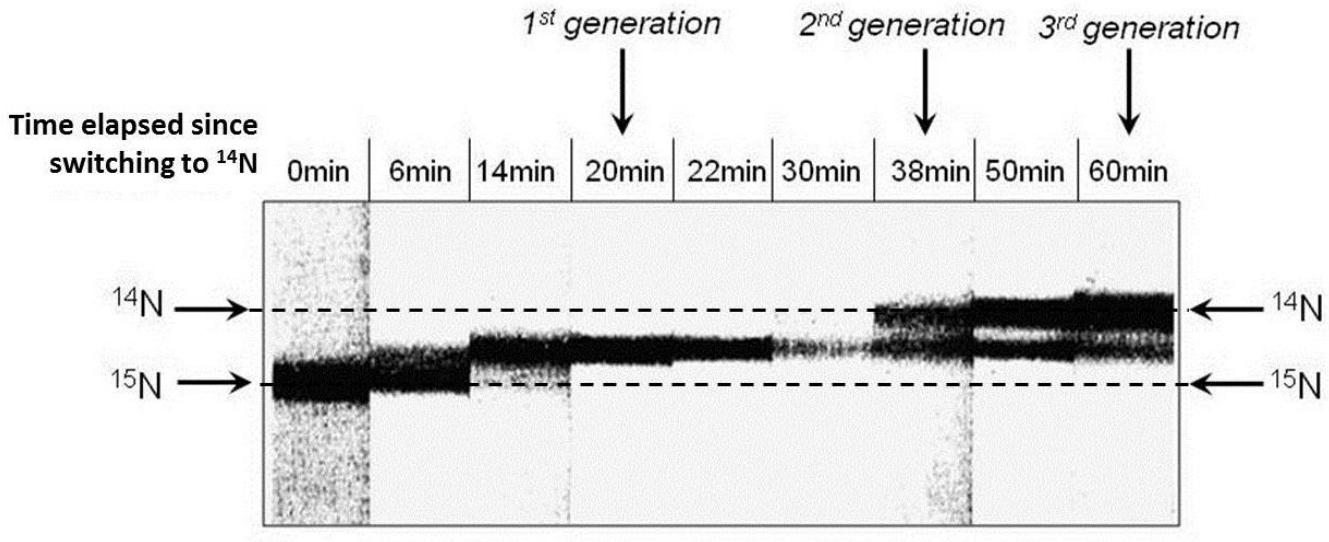


Fig. 3.1

(a) With reference to Fig. 3.1, account for the model of DNA replication which these cells undergo.

……

……

……

……[3]

S: Account (CW), with reference..Fig. 3.1, model..DNA replication, cells…undergo,

C:
- With reference Fig. 3.1 → Must cite information from Fig. 3.1 in answers
- There are 3 models of DNA replication: Semi-conservative, conservative, dispersive
- Model here is semi-conservative
  - 1 intermediate band at 1st generation
  - 2 intermediate band, 2 bands at 2nd generation, 2 bands at 3rd generation with intermediate band becoming thinner and light band becoming thicker.

ORE:

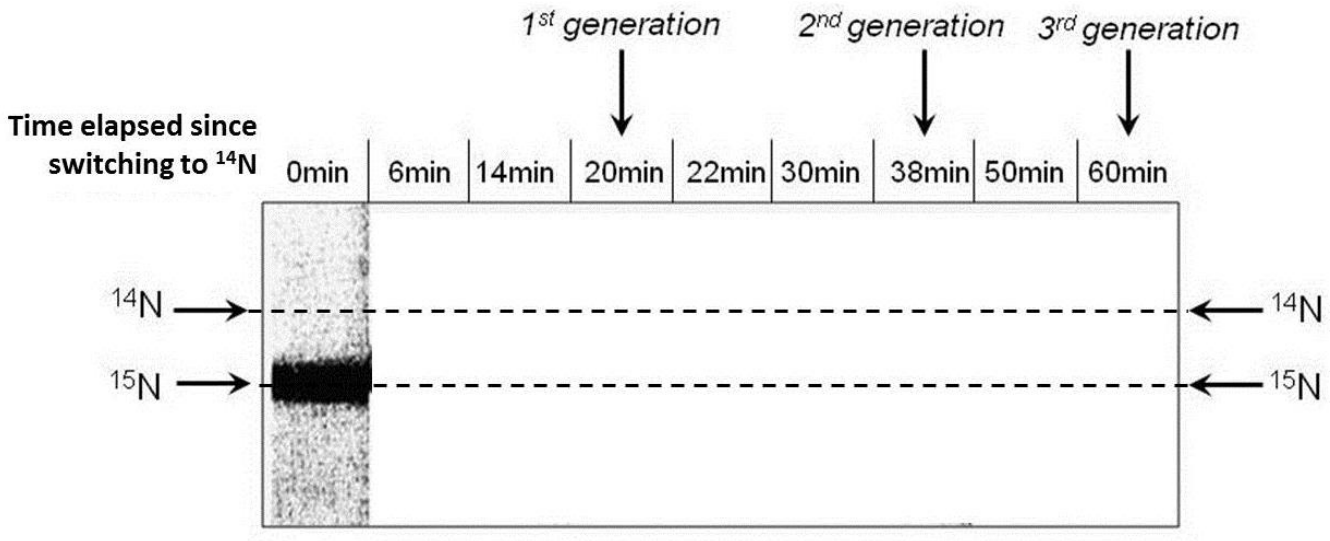
1. The model of DNA replication is **semi-conservative.**
2. At the **first generation**, there is only **one $^{14}N/^{15}N$** / hybrid **band**, which suggests the **parental strands**, that **contain ^{15}N separate** to serve as **template** for the synthesis of the **newly synthesised strand,** which **contains ^{14}N**.
3. At the **second generation**, there is **one $^{14}N/^{15}N$** / hybrid **band** and **1 light band** which align with the semi-conservative model of replication as the former contains DNA with **1 strand containing ^{15}N and another containing ^{14}N**, whereas the latter contains DNA with **both strands containing ^{14}N**.
4. For the **third generation**, there is still **one $^{14}N/^{15}N$** / hybrid **band** and **1 $^{14}N/^{14}N$ band** and the intermediate band becomes thinner whereas the light band becomes thicker due to **more DNA** molecules containing **^{14}N on both strands**.

(Max 3)

[L2]

(b) State another model of DNA replication not shown in Fig. 3.1 draw only its band patterns for the 1st, 2nd and 3rd generations in the Figure below.

Model of DNA replication: ……



[2]

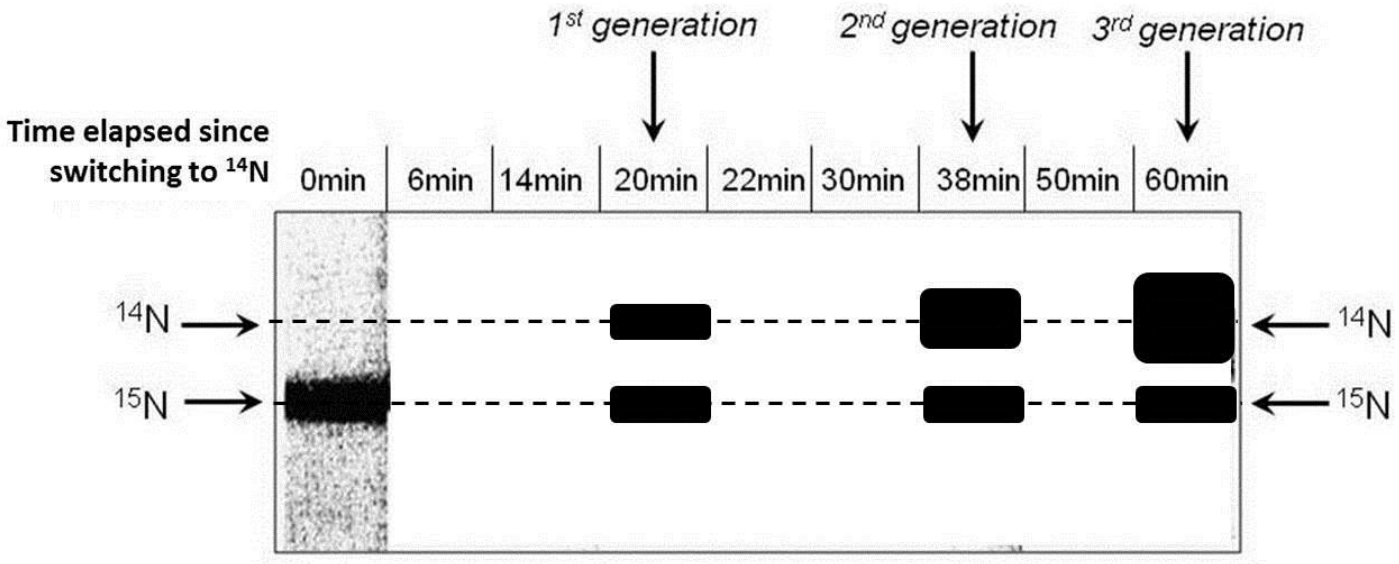
S: State….Draw (CW), model of DNA replication, not shown in Fig. 3.1, draw..band patterns..1st,2nd,3rd,

C:

- Model of DNA replication shown in Fig. 3.1: Semi-conservative
- Other models: Conservative & Dispersive

ORE:

- Model of DNA replication: **Conservative** replication



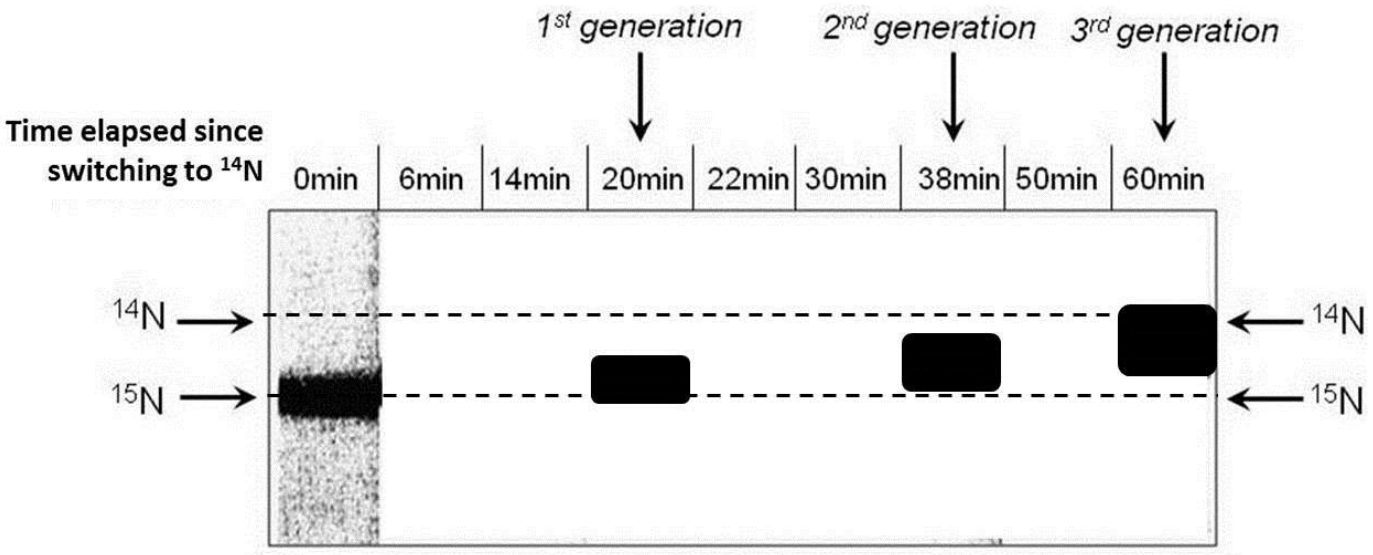
Correct positioning of the bands. [1 mark]

Correct amount of DNA as shown by thickness of band or shade of band. [1 mark]

OR

ORE:

- Model of DNA replication: **Dispersive** replication [1 mark]



Correct positioning of the bands. [1 mark]
Correct amount of DNA as shown by thickness of band or shade of band. [1 mark]

[L2]

Fig. 3.2 shows a simplified representation of DNA replication occurring on a linear chromosome.

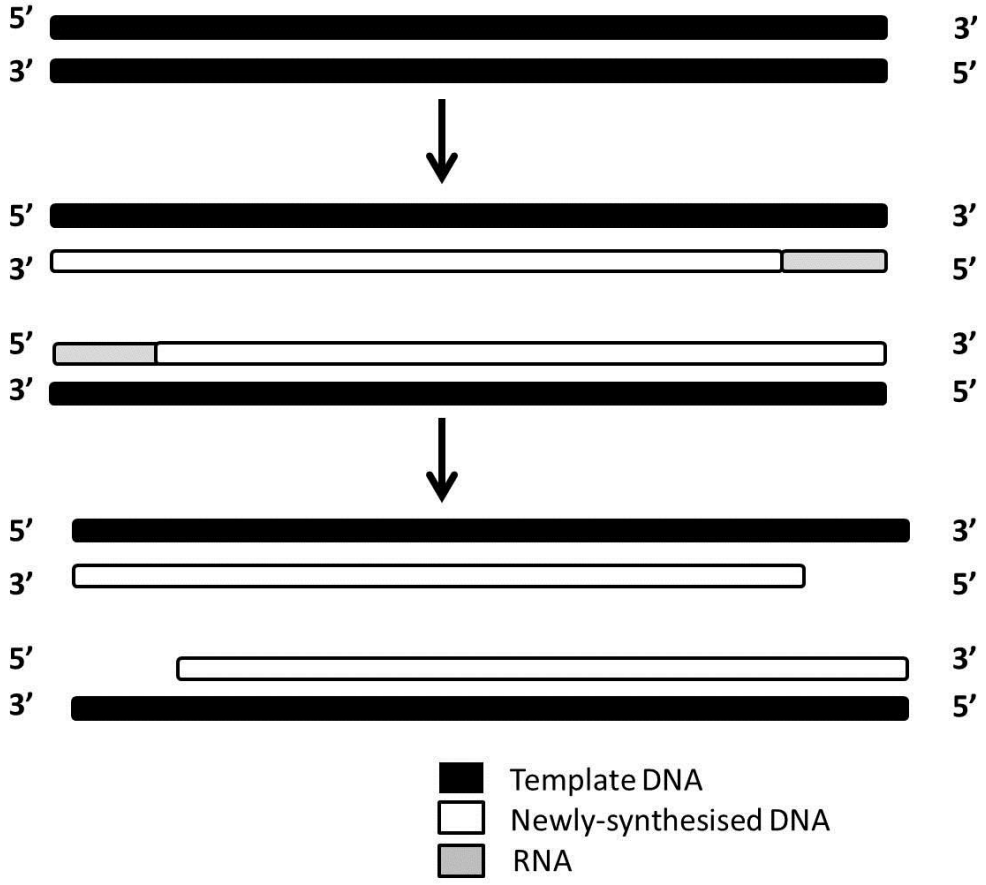


Fig. 3.2

(c) Explain how certain cells address the molecular issue reflected in Fig. 3.2.

……

……

……[2]

S: Explain how (CWs), certain cells, address, molecular issues, reflected..Fig. 3.2

C:

- Molecular issue reflected in Fig. 3.2: End replication problem
- Certain cells: Stem cells and cancer cells
- How:
  - Telomerase lengthen the telomeres
  - They have an RNA template which adds the DNA sequence.

ORE:

1. An enzyme, **telomerase** is an enzyme that **adds telomere** repeat **sequences** to the **3' end** of **DNA** strands to act as a **buffer** for the **end-replication problem**. (Reject: prevent / resolve)
2. Telomerase has a short molecule of **RNA** that serves as a **template** (AAUCCC)
3. which is **complementary** to the **non-coding** **telomere repeat** (TTAGGG).

(Max 2)

[L2]

The cellular process shown in Fig. 3.2 has many similarities with translation even though the products formed are different. Some of the similarities are that they both take place in 3 different stages (initiation, elongation, termination), both require energy, monomers for extension, a template for product synthesis as well as bond formation involving the removal of a water molecule.

(d) State three other similarities between the cellular process shown in Fig. 3.2 and translation.

……

……

……

…… [3]

S: State (CW), cellular process…Fig. 3.2, translation, other similarities

C:

- Cellular process in Fig. 3.2: DNA replication
- Similarities between DNA replication & Translation
- Other similarities: Cannot mention both require energy, monomers for extension, a template for product synthesis as well as bond formation involving the removal of a water molecule

ORE:

1. Both processes require **enzymes** (DNA replication: DNA polymerase &and Translation: Peptidyl transferase).
2. Both processes involve **complementary base pairing**.
3. Both processes are **regulated** by regulatory **factors** (DNA replication: cyclins, CDKs, Helicase & Translation: translational regulatory proteins).
4. Both processes are **compartmentalised** in the **cell** (DNA replication: nucleus, Translation: ribosome).
5. **Errors** can occur for both processes.
6. Both processes **only occur** when **required** by the cell.

[L3]

[Total: 10]

4 Fig. 4.1 shows two different stages, A and B (as shown by arrow) of the HIV reproductive cycle.

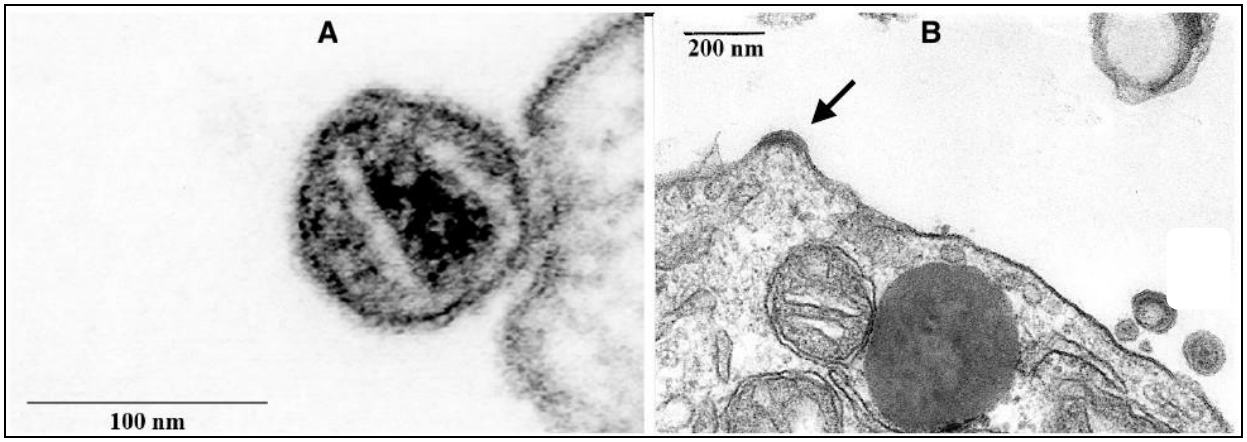


Fig. 4.1

(a) Describe the events occurring in stage A of the HIV reproductive cycle.

……

……

……..[2]

S: Describe (CW), events, occurring, stage A, HIV reproductive cycle

C:
- Stage shown: Adsorption
- GP120 binds CD4 receptor and co-receptor CCR5/CXCR4.

ORE:

1. **GP120** on **viral envelope** binds to **CD4 receptor** on **host cell surface membrane**.
2. **GP120** also **binds** to **co-receptor CCR5/CXCR4** on host cell surface membrane.

Reject: Fusion (as fusion is yet to occur as seen in Fig. 4.1)

[L2]

(b) Compare the stage immediately following stage A with stage B.

……

……

……..[2]

S: Compare(CW), stage immediately following A, with B

C:
- Compare→ Cite one difference and one similarity
- Stage immediately following stage A → Fusion
- Stage B → Budding
- Fusion vs Budding

ORE:

	Basis of comparison	Stage immediately following stage A (Fusion)	Stage B (Budding)
Difference	1. Virus entry/exit	Virus is **entering** the **host cell** during **fusion**.	Virus is **leaving** the **cell** via **budding**.
Difference	2. Membrane interaction	During fusion, **viral envelope fuses** with **cell surface membrane**. (Reject: Endocytosis)	During budding, virus **acquires host cell surface membrane** as **viral envelope**.
Similarity	3. Cytoskeleton involvement	Both processes involve **rearrangement** of the **cytoskeleton** at the cell surface membrane.	
Similarity	4. Location of capsid	For both processes, the viral **capsid** is not totally surrounded by the viral envelope and is partly **in** the host cell **cytoplasm**.	
Similarity	5. Requirement of energy	Both processes **require energy / ATP**.	
Similarity	6. Rearrangement of phospholipid	Both processes involve the **rearrangement of phospholipid**.	

(1 similarity and 1 difference, Max 2)

[L3]

(c) Contrast the final stage of the reproductive cycle of HIV and T4 phage.

……

……....[1]

S: Contrast (CW), stage B, release stage, T4 phage

C:
- Contrast → Only cite difference (reject similarities)
- T4 phage undergoes lytic cycle
- Budding (of HIV) vs. Release via osmotic lysis (of T4 phage)

ORE:

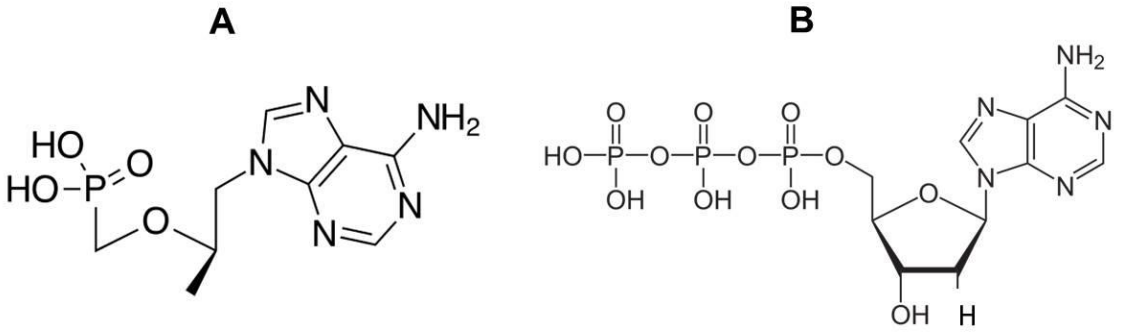
1. Release of **HIV** via **budding** will **not** directly **kill** the **host cell** but release of **T4 phages** via osmotic **lysis** will **kill** the host cell.
2. For the release of T4 phages, a phage-encoded **enzyme, lysozyme** will break down the bacterial peptidoglycan causing osmotic lysis and release of the intact new bacteriophages whereas for the release of HIV **no enzymes** are involved.

(Max 1)

[L3]

For treatment, HIV-infected patients can receive HIV antiviral drugs such as Tenofovir (Fig. 4.2A).

Fig 4.1B shows an adenosine triphosphate (dATP) molecule, which shares similar chemical groups to Tenofovir.



Tenofovir **dATP**

Fig. 4.2

(d) With reference to Fig. 4.2, suggest how Tenofovir acts as a drug that interferes with the HIV reproductive cycle.

……

……

……[2]

S: Suggest how (CW), with reference to Fig. 4.2, Tenofovir, act..drug, interferes HIV cycle

C:
- With reference to Fig. 4.2 → Need to refer to structures of A & B
- A does not have 3' OH but B has.
- Enzyme competing for is reverse transcriptase
- A is competitive inhibitor
- But it causes chain termination → New incoming nucleotides cannot be added.

ORE:

Either 1 or 2

1. Tenofovir is an **analog** of **adenosine triphosphate**. / Tenofovir has a similar shape/conformation to adenosine monophosphate
   OR
2. It is a **competitive inhibitor** for the **reverse transcriptase** enzyme. / It **competes** with **adenosine triphosphate** for the active site of **reverse transcriptase**.

Plus 3 or 4

3. which **lacks** an **3' OH group**,
   - and hence results in **chain termination** (when incorporated into the existing DNA strand.
     OR
4. which **lacks** an **3' OH group**,
   - / and **incoming nucleotide** **cannot form phosphodiester bond** with the DNA molecule.

5. **Reverse transcription** **cannot** be **complete**d (OWTTE) resulting in a **not complete**/ **truncated** **viral DNA** molecule to form.

(Max 2)

[L3]

HIV entry into cells requires involvement of at least one type of co-receptor. CCR5 is required for HIV virus entry. CCR5 Δ32 is a 32-base-pair deletion that introduces a premature stop codon into the CCR5 receptor locus, resulting in a non-functional receptor.

Timothy Ray Brown was an AIDS patient who received a hematopoietic stem cell transplant from a donor with homozygous CCR5 Δ32 on the CCR5 gene. After the transplant, he stopped his antiretroviral treatment. Following that, it was found that Timothy's HIV viral levels steadily decreased and his CD4 T- cell count increased. Eventually, he was found to be cured from HIV.

(e) Suggest why not all HIV-infected patients can be cured with this therapeutic method.

……

……....[1]

S: Suggest why (CWs), not all HIV-infected patients, cured, this therapeutic method
C:
- There are different strains of HIV
- Some strains use a different co-receptor for adsorption and then entry (e.g. CXCR4)

ORE:

1. There are different strains of HIV which use a **different co-receptor**, such as CXCR4 for adsorption and **entry**.

[L2]

(f) Explain how HIV infection may result in the death of infected CD4 cells.

……

……

……....[2]

S: Suggest how (CWs), HIV infection, death, non-infected CD4 cells
C:
- HIV-infected cells release cytokines
- Syncytium form

ORE:

1. HIV-infected cells may undergo **apoptosis.**

2. Multiple bound cells may fuse, forming a giant multinucleated cell or syncytium. The syncytium may rupture / is **destroyed by** the body's **immune system**.

[L2]

[Total: 10]

5 Fig. 5.1 shows the formation of a eukaryotic transcription initiation complex.

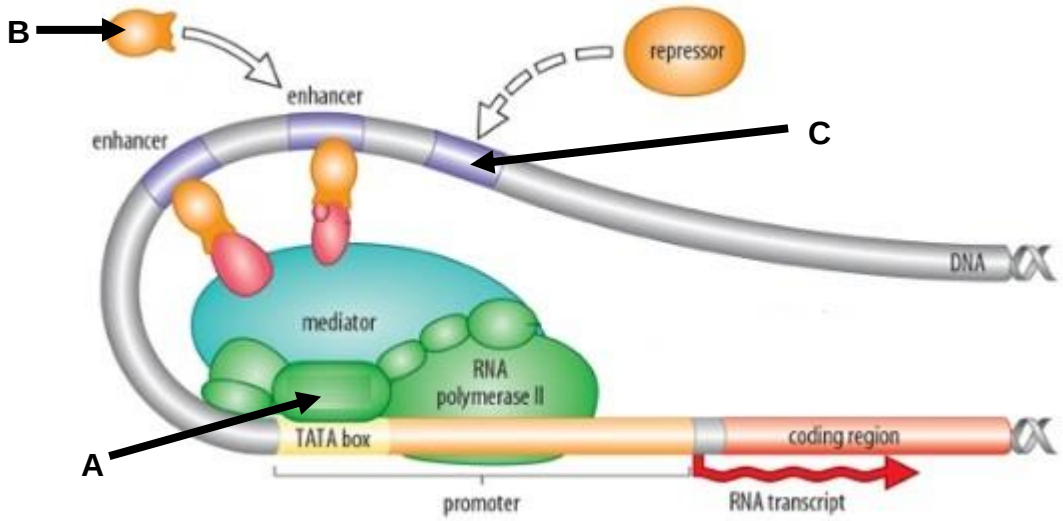


Fig. 5.1

(a) Identify the following proteins.

A: _____ **General transcription factor**

B: _____ Transcriptional **activator** protein

C: _____ **Silencer** sequence

[3]

[L1]

(b) Explain how the eukaryotic transcription initiation complex for high rate of transcription can be formed.

……

……

……

……

……[4]

1. **General transcription factors** must **assemble at the promoter** to **position RNA polymerase** II correctly at the promoter and release it from the promoter into elongation mode for transcription.
2. **Binding to transcriptional activator proteins to enhancer**,
3. resulting in **protein mediated bending of DNA / OWTTE**
4. to **bring bound activators in contact with other proteins of the transcription initiation complex** / Accept **mediator protein action**
5. **Stabilizing RNA polymerase** for **high rate of transcription**.

(Max 4)

[L2]

High rate of transcription caused by mutations in cancer critical genes may result in dysregulation of cell cycle control and subsequently lead to uncontrolled cell division.

c-myc is a regulator gene that codes for a transcription factor. A mutated version of c-myc that is highly expressed is found in many cancers. Fig 5.2 shows the relative level of expression of c-myc in normal and cancer prostate tissue.

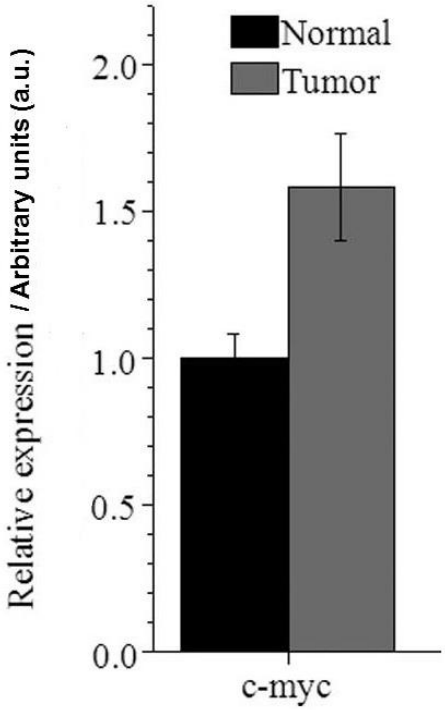


Fig 5.2

(c) With reference to Fig.5.2, explain how mutation in the c-myc gene led to increased expression in cancer prostate tissue.

……

……

……

……[3]

1. c-myc expression in **normal prostate tissue is 1.0 a.u.** as compared to **1.6 a.u in cancer prostate tissue**.
2. c-myc **proto-oncogene** undergoes **gain-of-function mutation** to become **oncogene**.
3. **Translocation beside active promoter / Gene amplification** resulted in increased expression of c-myc.

[L3]

[Total: 10]

6 Fig. 6.1 shows a Calico cat with a mosaic coat with patches of orange and black. It is known that fur coat colour in cats is determined by a single gene. Only female cats can develop calico fur coat. Male cats usually have only orange or black fur coat.

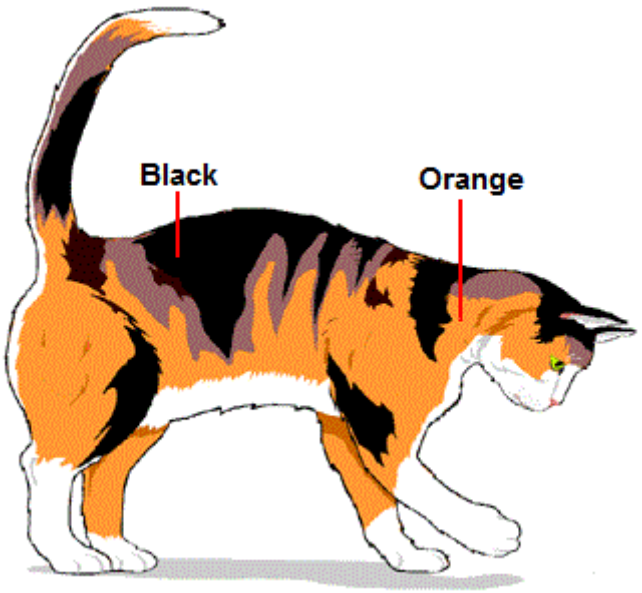


Fig. 6.1

(a) Identify the type(s) of inheritance determining Calico fur coat colour in cats.

……

……[1]

S: State (CWs), type of inheritance, fur coat colour
C:
- Calico (patches of black and orange) → both equally expressed → codominance/epistasis.
- Difference between male and female → possible sex-linked.
- Inheritance determined by single gene → confirm codominance (cannot be epistasis)

ORE:

1. **Co-dominance**
2. **Sex-linked / X-linked**

[L2]

(b) Using B to represent allele for black coat and R to represent allele for orange coat, draw a genetic diagram to show how a cat-breeder can obtain Calico cat from a cross between a pure-breeding black male and an orange female cat.

S: Draw (CWs), genetic diagram, orange female x black male,
C:
- Sex-linked & codominant (X^B & X^R alleles)
- Orange female X^RX^R
- Black male X^BY

ORE:

Let **X^B represent the allele for black coat colour**.
Let **X^R represent the allele for orange coat colour**, where **X^B and X^R** are **codominant**.

Parental phenotypes : Orange Female x Black Male

Parental genotypes (2n): $X^R X^R$ x $X^B Y$ **[1]**

Parental gametes (n): X^R x X^B Y **[1]**

F_1 genotypes and phenotypes (2n):

♀ \ ♂	X^B	Y
X^R	$X^B X^R$ Calico coat	$X^R Y$ Orange coat

[1]

F_1 phenotypic ratio: **1 Calico female: 1 Orange male** **[1]**

[L2]

[4]

Coat colour inheritance in horses is different from cats. Two unlinked genes *E* and *G* control coloured coat in horses. The two genes are thought to be involved in the same metabolic pathway for pigment formation.

- Horses may be bay, black or chestnut in colour.
- Horses may be bay / black when at least one dominant allele *E* is present.
- Chestnut coat colour is always produced in the presence of two copies of the e allele.

Horses coat colour goes through a natural graying process. Horses born with bay, black or chestnut coat colour will steadily turn gray. This process is mediated by a single copy of the dominant allele G regardless of the genotype of the gene E controlling coat colour.

(c) Draw a genetic diagram in the space below to show the result of the cross between two gray horses that were heterozygous at both gene loci G/g and E/e and the resultant phenotypic ratio of the offspring.

S: Draw (CWs), genetic diagram, GgEe (Gray) x GgEe (Gray) Dominant epistasis
C:
- Epistatic gene locus G (result in gray coat regardless of genotype of gene E)
- Hypostatic gene locus E
- Single copy of E allele will result in horses with black/bay coat
- Homozygous recessive (ee) will result in horses with chestnut coat

ORE:

Let G represent the dominant allele for Gray coat colour and g represent the recessive allele for other colour coat.

Let E represent the dominant allele for black/bay coat colour, where e represent the recessive allele for chestnut coat.

Gene locus G is epistatic over Gene locus E **[1]**

P phenotypes : Gray Horse x Gray Horse **[1]**

P genotypes (2n) : GgEe x GgEe

P gametes (n): GE Ge gE ge x GE Ge gE ge **[1]**

Punnett square: **[1]**

♂ gametes / ♀ gametes	*GE*	*Ge*	*gE*	*ge*
GE	*GGEE Gray*	*GGEe Gray*	*GgEE Gray*	*GgEe Gray*
Ge	*GGEe Gray*	*GGee Gray*	*GgEe Gray*	*Ggee Gray*
gE	*GgEE Gray*	*GgEe Gray*	*ggEE Black/Bay*	*ggEe Black/Bay*
ge	*GgEe Gray*	*Ggee Gray*	*ggEe Black/Bay*	*ggee Chestnut*

Offspring phenotypic ratio : **12** Gray: **3** Black/Bay: **1** Chestnut **[1]**

[L3]

[5]

[Total: 10]

7 Fig. 7.1 shows the different modes of signal conduction in a non-myelinated neuron.

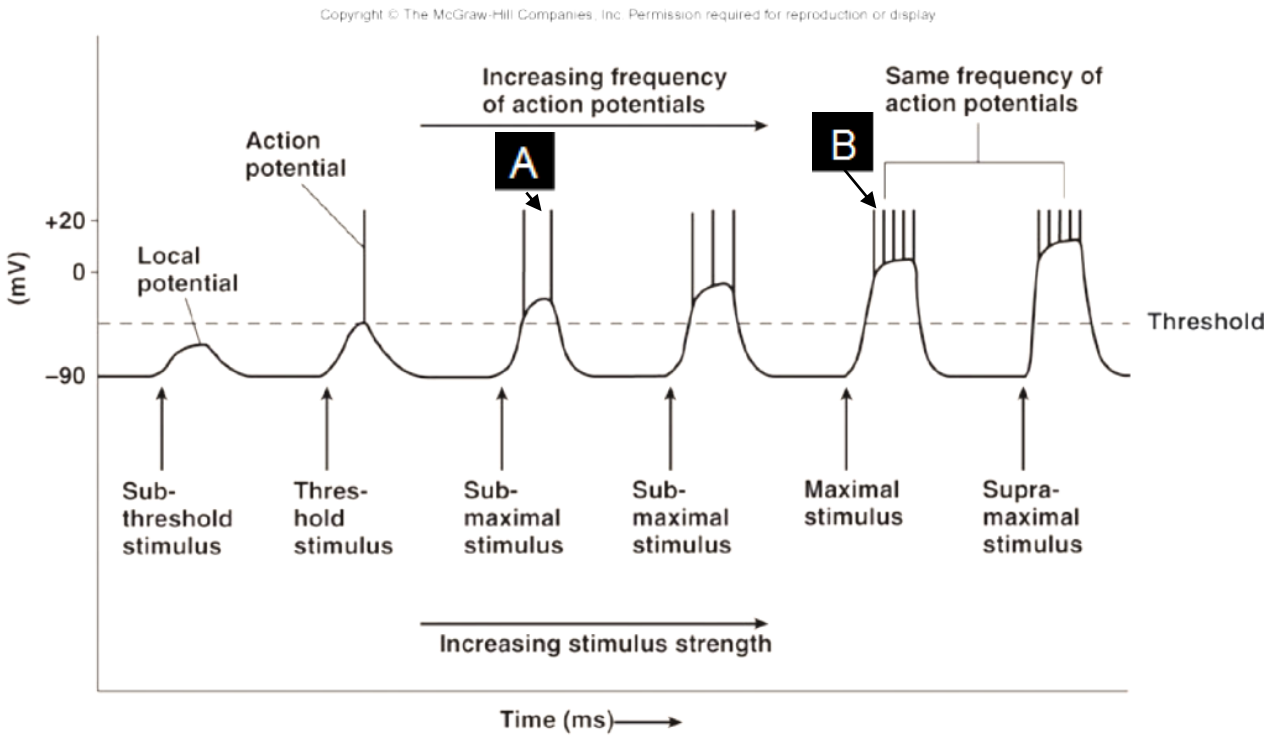


Fig. 7.1

(a) State one factor that contributes to unidirectional conduction of impulses down an axon.

……..[1]

SC: one factor / contributes / unidirectional conduction / neuron.
OR: refractory period

1. **Refractory period** (accept absolute and relative refractory periods)

[L1]

With reference to Fig. 7.1 for all questions following,

(b) explain why there is no action potential generated with a sub-threshold stimulus.

……

……

……..[2]

SC: no AP / sub threshold stimulus.
OR: 1. Sub-threshold stimulus **does not reach threshold**.
2. No opening of VG Na^+ Channels, no influx of Na^+ and subsequently no AP created. .

1. Sub-threshold stimulus **does not reach threshold** therefore **no opening of all voltage-gated Na^+ Channels**,
2. **no influx of Na^+** and subsequently **no AP** created.

[L2]

(c) explain how the time interval between action potentials seen in label **B** is shorter than the time interval between action potentials seen in label **A**.

……

……

……

……..[3]

SC: time interval / B / shorter than / A.
OR: 1. Refractory period
2. dependent on strength of signal
3. B maximal stimulus - A sub maximal stimulus.

1. Time interval between action potentials is **dependent** on the **refractory period**
2. and on the **strength** of the **incoming signal**.
3. **B has maximal stimulus** compared to **A which has sub maximal stimulus**.

[L3]

(d) state the advantages in the ability of neurons to display these characteristics shown in Fig. 7.1.

……

……

……..[2]

SC: advantage / neuron ability / display characteristics .
OR: 1. **Variation** / **differentiation** of **signal frequency**.
3. determines the **sensitivity** of the neuron / OWTTE.

[L2]

(e) explain what would increase the speed of the signal conduction down the neuron.

……

……

……..[2]

SC: increase speed/ down neuron.
OR: 1. Myelin sheath
2. Saltatory conduction

1. With the presence of the **myelin sheath**
2. Signal conductance down the neuron is even **faster** due to **saltatory conduction**.
3. at the **nodes of Ranvier**.

(Max 2)

[L2]

[Total: 10]

10 The Grand Canyon National Park is home to two groups of squirrels. The Albert squirrels *Sciurus aberti* live generally on the south rim of the canyon and the Kaibab squirrels *Sciurus kaibabensis* live on the north rim of the canyon (Fig. 8.1 and Fig. 8.2).

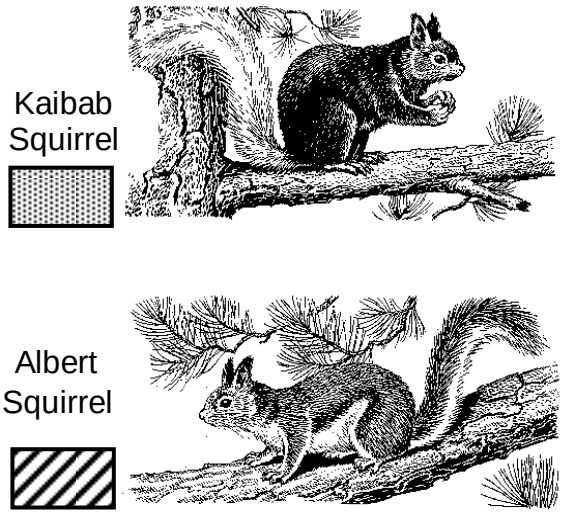


Fig. 8.1

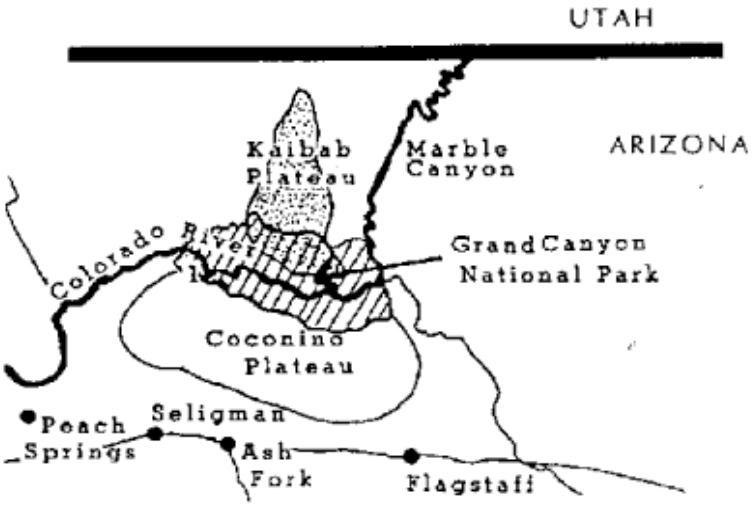


Fig. 8.2

The north rim is about 370 m higher than the south rim. Almost twice as much precipitation falls on the north rim than on the south rim every year. The two groups share many characteristics, but they do not look the same, both groups have tasselled ears, but each group has a unique fur colour pattern.

(a) Explain which Darwinian principles can be applied from the above information on *S. alberti* and *S. kaibabensis*.

……

……

……

……

……[4]

SC: which Darwin Principles / squirrels
OR: 1. High reproductive potential- great range
2. Competition / struggle to survive – no information
3. Constant population- great range seen in both groups.
4. Variation- Seen from the different phenotypic characteristics.
5. Selection pressure – environment on either side of canyon.precipitation
6. Passed down to next generation- phenotypical characteristics.

1. **High reproductive potential** inferred from the wide distribution of both groups in Fig. 8.2
2. **Constant population** inferred from the wide distribution of both groups in Fig. 8.2
3. **Variation** can be inferred from the **different phenotypic characteristics of the squirrels.**
4. **Selection Pressure** inferred from the environmental conditions on either side of the canyon, reference to precipitation being twice greater in the north compared to the south.
5. **Passed down to the next generation**- phenotypical characteristics of each group.

[L2]

Several studies have been done on the phylogenetic relationship of the squirrels in and around the Grand Canyon region. Fig. 8.3 is one such study based on cytochrome b DNA sequences.

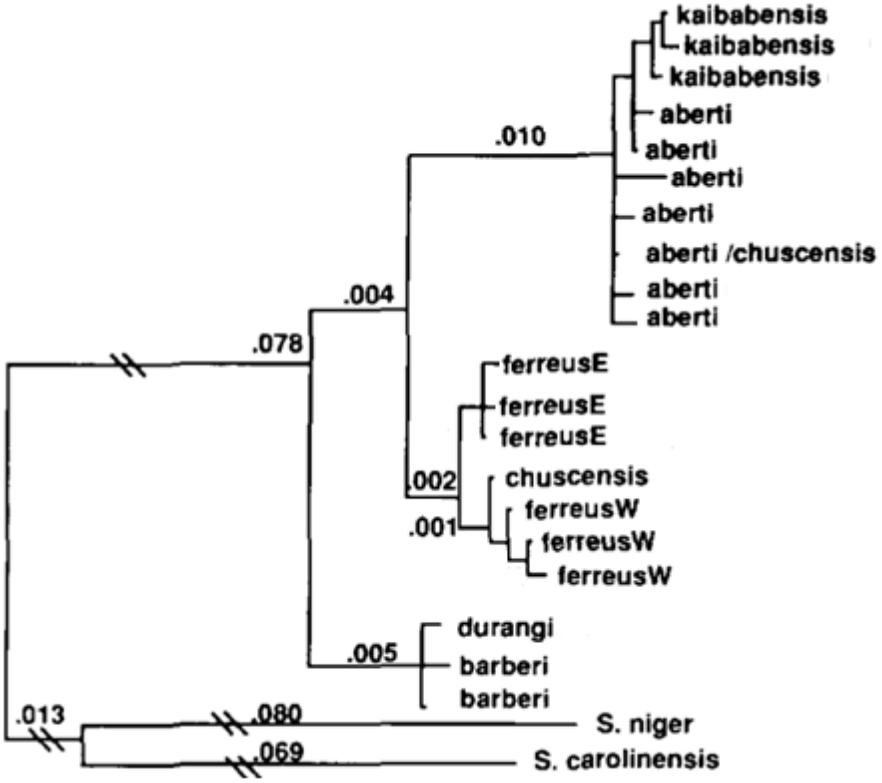


Fig.8.3 Phylogenetic relationship between six *sciurus* subspecies base on cytochrome b sequences constructed by the neighbour-joining method of Saitou and Nei (1987) using the *S. niger* and *S. carolinesis* (Thomas and Martin 1993) sequences as outgroups. Branch lengths and confidence probabilities are noted above and below the branches respectively.

(b) With reference to information already given and also to Fig. 8.3, it is clear that divergent evolution or adaptive radiation is occurring in the evolution of *S. alberti* and *S. kaibabensis*

Explain why it is not convergent evolution.

……

……

……..[2]

SC: kind of evo- not divergent / adaptive rad. / why not convergent evo
OR: 1. common ancestor
2. subspecies
Reject morphological homology

1. share a recent **common ancestor**
2. **convergent evolution** involves **two phylogenetically different groups** with no recent common ancestor.

Or any one of the following-

3. **homology of DNA** sequence for cytochrome b shows **high relation 0.01**
4. **they are subspecies**

(Max 2)

[L2]

(c) (i) With reference to information already given and also to Fig. 8.3, suggest with reasons what kind of speciation *S. Alberti* is undergoing.

……

……

……..[2]

SC: kind of speciation
OR: 1. Probably **allopatric speciation**.

2. Due to the presence of a **physical barrier** (a river).

OR

3. Probably **sympatric speciation**.

4. Due to presence of **overlapping geographical regions**.

(Points 1 and 2 are awarded together, points 3 and 4 are awarded together)

[L2]

(ii) With a known species concept, explain what would be the determining factor confirming *S. alberti* and *S. kaibabensis* as two separate species.

……

……

……..[2]

SC: determining factor / confirming separate species
OR: 1. Random mating between *S. alberti* and *S. kaibabensis* to confirm no fertile offspring
2. Reproductive isolation

1. Probably **no fertile offspring** can be derived between the two species.
2. **Confirming reproductive isolation** as a definitive indication via **biological species concept**.
3. **Phylogenetic - Molecular evidence** (**DNA** + **RNA** or **amino acid** sequence comparison).

Reject: Ecological (insufficient information), Morphological (insufficient information from just comparing phenotype).

[L3]

[Total: 10]

Section B

Answer **one** question. Answer each part on a **separate** piece of paper.

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

9 **(a)** Describe cell signaling with the G-protein coupled receptor with a named ligand and its corresponding cellular response. [8]

1. The **ligand**, **glucagon** **binds** to the **G-protein coupled receptor** (GPCR).This causes a **conformational change** in the GPCR.
2. **G-protein** will be **activated** and undergo a **conformational change** causing **GDP** on G-protein will be **substituted** for **GTP**.
3. **Alpha subunit of the G-protein** will translocated to membrane-bound enzyme, **adenylyl cyclase** and **activate** so that it **catalyse** the conversion of **ATP** to **cAMP**.
4. **cAMP** will act as a **second messenger** and **activate** **protein kinase A**.
5. **Protein kinase A** will **catalyse** the **phosphorylation** of **another protein kinase** resulting in its subsequent activation.
6. A **phosphorylation cascade** will occur.
7. Eventually the a specific **hydrolytic enzyme / glycogen phosphorylase** will be **activated**,
8. which will **hydrolyse glycogen** to **glucose** monomers (glucose-1-phosphate).

[L1]

(b) Explain the advantages and disadvantages of a phosphorylation cascade. [6]

Advantages	Great degree of control – can be stopped at any stage.	1
	Sensitive- can be reset very easily via phosphatases.	2
	Acts as a buffer before the final cellular response.	3
	Is triggered by 2nd messengers which affect more than one metabolic process.	4
	Amplification	5
Disadvantage	Energy consuming ATP needed for each activation of PKA / OWTTE	6
	Will be susceptible to temperature/pH etc.	7
	A mutation that renders a protein kinase non-functional may terminate the cascade.	8
	A mutation that renders a phosphatase non-functional may cause the cascade to continue.	9

[L3]

(c) Contrast with elaboration, anaerobic respiration with light independent reaction (Calvin cycle).[6]

	Anaerobic respiration	Light independent reaction
Reduced co-enzymes	1. Uses **NADH** in the	2. Use of **NADPH** in the conversion
Reduction process	3. **reduction of pyruvate to ethanol.**	4. conversion of **glycerate-3 phosphate** to **glyceraldehyde-3 phosphate**.
ATP	5. **ATP synthesized** via **substrate level phosphorylation**.	6. **ATP used** in the **conversion of glycerate 3 phosphate to glyceraldehyde 3 phosphate**
CO_2	7. **CO_2 produced** in the **conversion of pyruvate to ethanol / lactic**.	8. **CO_2 incorporated** with **RuBP to form citric acid**.

	acid	
Location	9. Occurs in **cytoplasm**.	10. Occurs in the **stroma**.
Molecule regenerated	10. **NAD^+**	11. **RuBP** & **$NADP^+$**

[L3]

[Total: 20]

10 (a) Contrast binary fission and mitosis. [6]

S: Contrast (CW), binary fission, mitosis

C:
- Contrast → Cite differences
- Binary fission vs mitosis (must have clear basis of comparison)
  - Type of cell that process occurs in
  - Location of cell that process occurs in
  - etc……

ORE:

Basis of comparison	**Binary fission**	**Mitosis**
Type of cells that process occurs in	1. Binary fission occurs in **prokaryotes**.	1. Mitosis occurs in **eukaryotes**.
Location of cell that process occurs in	2. Binary fission occurs in the **nucleoid / cytoplasmic** region of prokaryotic cell / OWTTE	2. Mitosis occurs in the **nucleus** of eukaryotic cell./ OWTTE
Type of DNA involved	3. Binary fission occurs on **circular** double-stranded **DNA**.	3. Mitosis occurs on **linear** double stranded **DNA**.
Number of chromosomes involved	4. Only **1 chromosome** is involved in binary fission.	4. **More than 1 chromosome** is involved in mitosis.
Separation of daughter cells	5. There is **division** of **parental cell** to give rise to **2 daughter cells** during binary fission.	5. There is **no division** of **parental cell** to give rise to 2 daughter cells during mitosis. This occurs during cytokinesis.
Type of division	6. Involves **cell division**.	6. Involves **nuclear division**.
Origin of replication	7. DNA replication occurs at **1 point of origin**.	7. DNA occurs at **multiple points** of the genome.
Utilisation of spindle fibres	8. There is **no spindle fibre formation** during binary fission.	8. **Spindle fibre formation** occurs during mitosis.
Presence/absence of end replication problem	9. There is **no End replication problem** during binary fission.	9. **End replication problem occurs** during mitosis.

Reject: Citation of interphase and cytokinesis as these stages occur prior and after mitosis.

[L3]

(b) Describe generalised and specialised transduction. [8]

S: Describe (CW), specialised transduction

C:
- Content knowledge recall

ORE:
Generalised transduction:
1. A **virulent phage** **infects** a **bacteria** cell and **hydrolytic enzymes** **degrade** the host bacteria **chromosome** into **fragments**.
2. A **small fragment** of the **host cell's degraded DNA** is **improperly packaged** within a **capsid**,
3. rather than the phage genome due to an **error** during the viral particle **assembly** process.
4. When this **phage** **attaches**/**infects** to **another bacteria cell**, it will **inject** this foreign **bacterial DNA** into its new host.
5. and may be **integrate**d into new host **bacteria chromsome** under the proper circumstances
6. via **homologous recombination**.
   (Max 4)

Specialised transduction:
7. A **temperate phage** **infects** a **bacteria** cell and has its **viral DNA** genome **integrated** into the bacterial **chromosome**.
8. When the **prophage** viral DNA is **excised** from the **chromosome**,
9. it sometimes takes with it a small region of **adjacent bacterial DNA** due to improper excision.
10. These **bacterial DNA** are **injected**, along with the **phage's genome**, into the **next host bacteria cell** and
11. may be **integrate**d into new host **bacteria chromsome** under the proper circumstances.
12. via **homologous recombination**.
    (Max 4)

(Max 4 marks for generalised, Max 4 marks for specialised)

[L1]

(c) In an experiment using T4 bacteriophage, different component molecules were labelled.

- T4 bacteriophages with protein coats labelled with radioactive sulfur.
- T4 bacteriophages with DNA labelled with radioactive phosphorus.

The differently-labelled bacteriophages were allowed to infect host bacteria.
The inside and outside of infected bacteria before lysis were tested for radioactive sulfur and radioactive phosphorus.

Describe and explain the expected results of the experiment. [6]

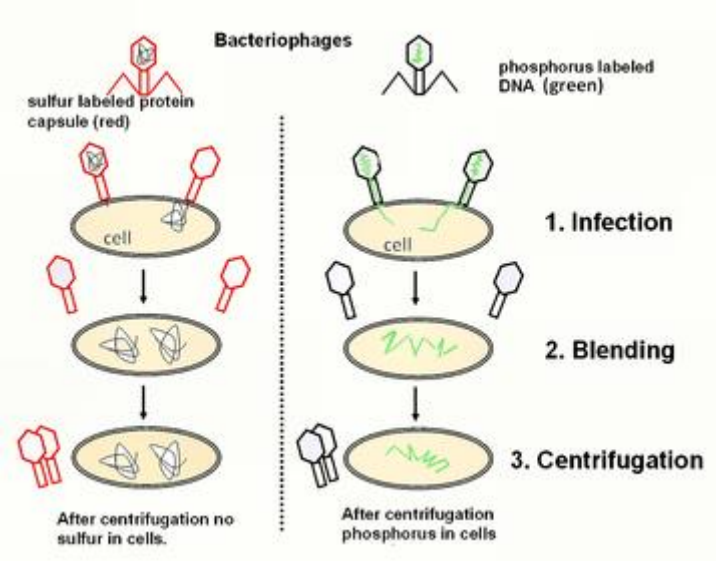
S: Describe..Explain (CWs), expected results, Protein coats…labelled..radioactive sulphur, DNA..labelled..radioactive phosphorus**,** inside…outside..bacteria…before lysis…tested for radioactive

C:
- Description
  - Bacterial cells infected with radioactive sulfur-labelled bacteriophages:
    - Radioactivity will be detected outside

- No radioactivity will be detected inside

- Explanation
  - Protein capsid does not enter the bacteriophage, hence only outside will have radioactivity

- Description
  - Bacterial cells infected with radioactive phosphorus-labelled bacteriophages:
    - No radioactivity will be detected outside
    - Radioactivity will be detected inside
- Explanation
  - DNA will be injected into the bacterial cell during transduction, hence DNA that is radioactive phosphorus-labelled will be detected inside the bacterial cells.



ORE:

Bacteria infected with **radioactive sulfur-labelled bacteriophages:**

Description:
1. There will be **radioactivity detected** **outside** the **bacteria**.
2. There will be no **radioactivity detected inside** the **bacteria**.

Explanation:
3. Protein **capsid**s **do not enter** the **bacteria** cells during **transduction** / but instead **remain** on the **bacteria** cell **surface** membrane after **transduction**.

Bacteria infected with **radioactive phosphorus-labelled bacteriophages:**

Description:
4. There will be **radioactivity detected** **outside** the **bacteria**.
5. There will be no **radioactivity detected inside** the **bacteria**.

Explanation:
6. Bacteriophage DNA **enter /is injected into** the **bacteria** cells during **transduction**.

[Total: 20]

END OF PAPER

JC2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME					
CLASS	**2T**	**INDEX NUMBER**			

BIOLOGY
9648/03

25th August 2016
2 hours

Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are two sections in this paper.

Section A]
Answer all questions

Section B]
Answer all questions. Answer each part on a **separate** piece of paper.

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

For Examiner's Use	
Section A	**52**
1 [13]	
2 [13]	
3 [14]	
4 [12]	
Section B	**20**
5a [6]	
5b [6]	
5c [8]	
TOTAL	**72**

This document consists of **13** printed pages and **1** blank page.

[Turn over

Section A

Answer **all** questions in this section.

1 Human Growth Hormone is important to augment normal growth and development in the treatment of individuals with dwarfism. Fig. 1.1 shows how human growth hormone can be produced via expression of recombinant DNA in *Escherichia coli* host cells.

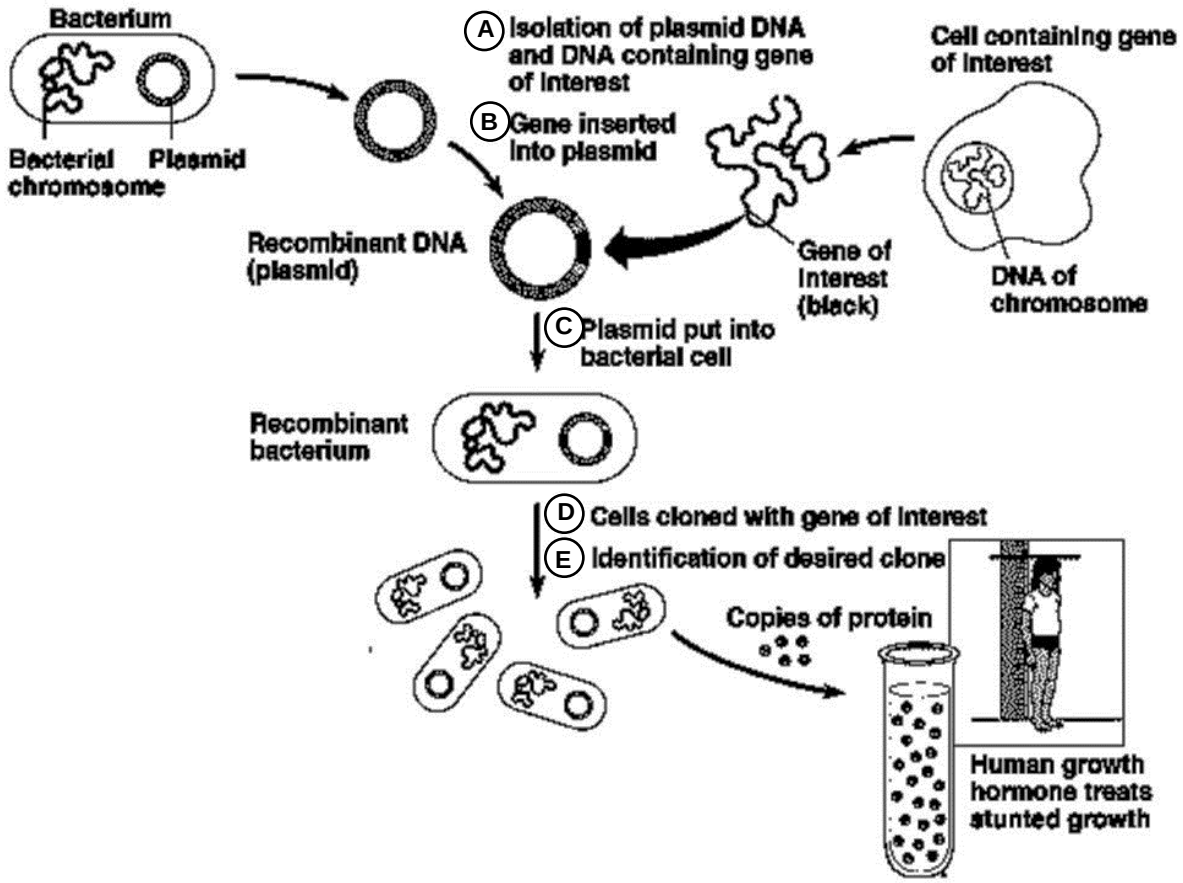


Fig. 1.1

(a) Explain what is meant by recombinant DNA.

……

……[1]

(b) Name the process required in the following procedure in Fig 1.1.

C : ……..

E : ……

[1]

(c) The gene of interest cannot be taken directly from DNA of chromosome but require additional processing in order to produce functional protein.

(i) With reference to Fig. 1.1, explain why the gene of interest cannot be taken directly from chromosomal DNA.

……

……

……[2]

(ii) Outline the additional processing required to yield the gene of interest prior to insertion into the plasmid.

……

……

……

……[3]

(d) State one possible pair of gene markers present on the cloning site of the plasmid for the identification of desired clone in Fig. 1.1.

……

……

……[1]

(e) Outline the process for Stage E in Fig 1.1 using one of the gene markers in (d).

……

……

……

……[3]

Fig 1.2 shows details of how stage A and B are carried out.

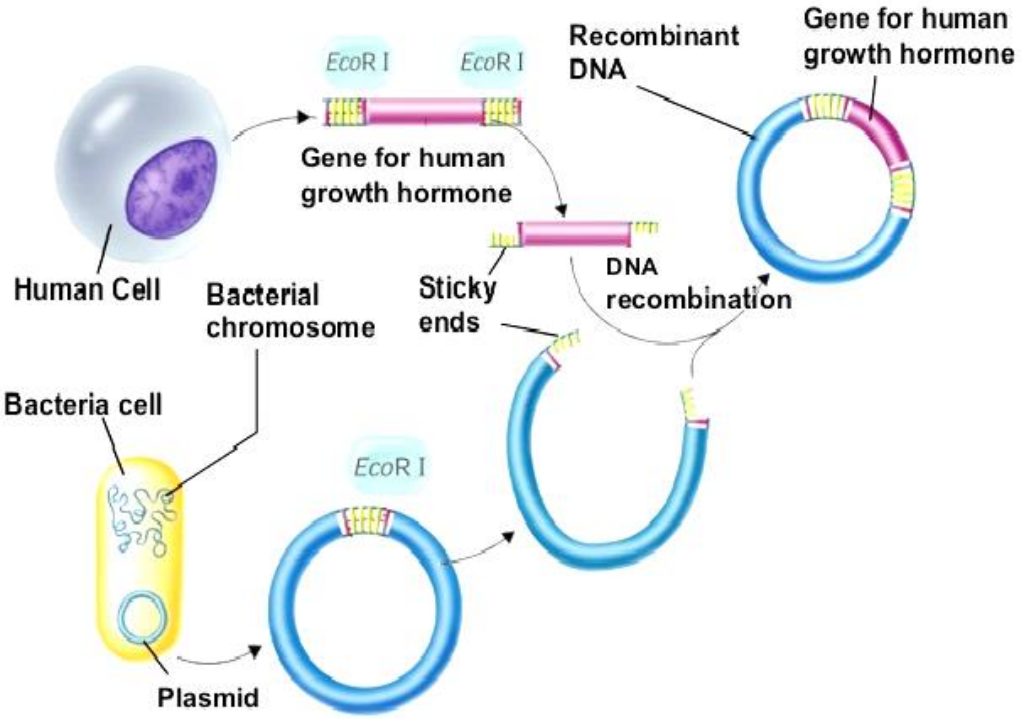


Fig 1.2

(f) A scientist commented that two different restriction enzymes should be used to isolate the gene for human growth hormone instead of using only *EcoRI* restriction enzyme. Explain the rationale behind his comment.

……

……

……[2]

[Total: 13]

2 Restriction Fragment Length Polymorphism (RFLP) is an important application for comparative genetic analysis of normal and diseased individuals.

(a) Outline the key techniques used for RFLP analysis.

……

……

……

……

……[4]

Fig. 2.1 shows the pedigree and southern blots of an RFLP locus that is closely linked with a disease phenotype. Affected individuals are shaded in the pedigree.

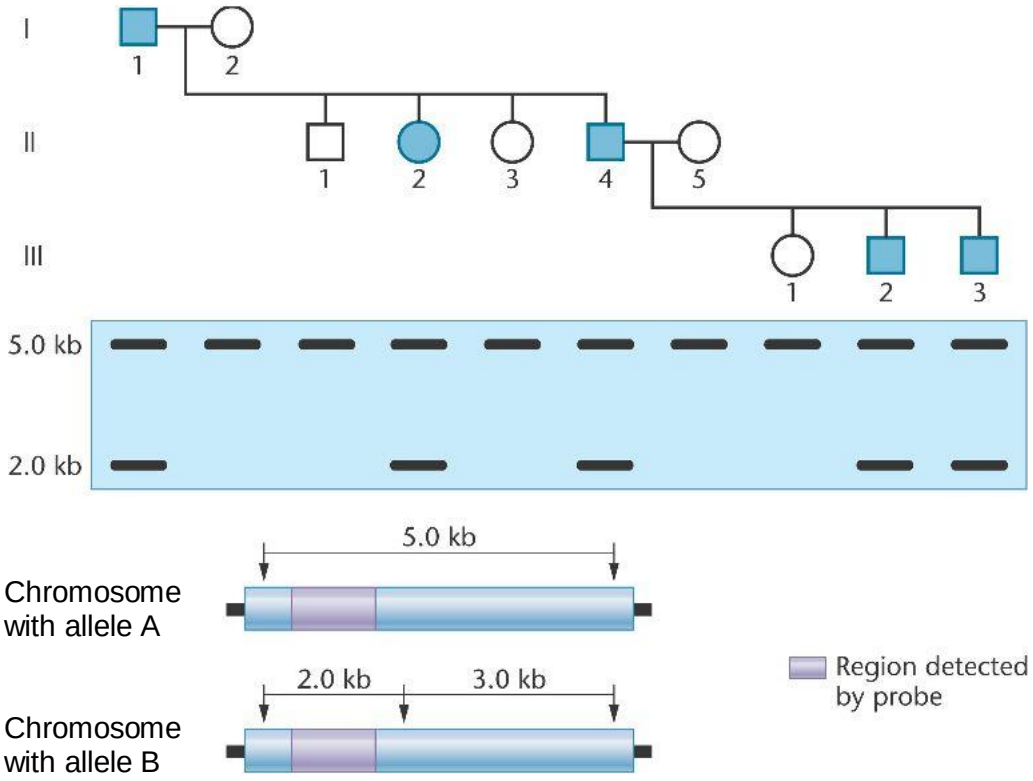


Fig. 2.1

(b) Explain the genetic basis of RFLP in comparative analysis in disease study.

……

……

…… [2]

(c) With reference to Fig. 2.1,

(i) Identify the allele responsible for the disease.

……[1]

(ii) State the considerations for target region of the probe.

……..

……..

……[2]

(iii) Explain if the disease allele is dominant or recessive.

……..

……..

……[2]

(d) Briefly describe two other applications of RFLP.

……..

……..

……[2]

[Total: 13]

3 Fig. 3.1 shows how gene therapy using modified viruses can be carried out.

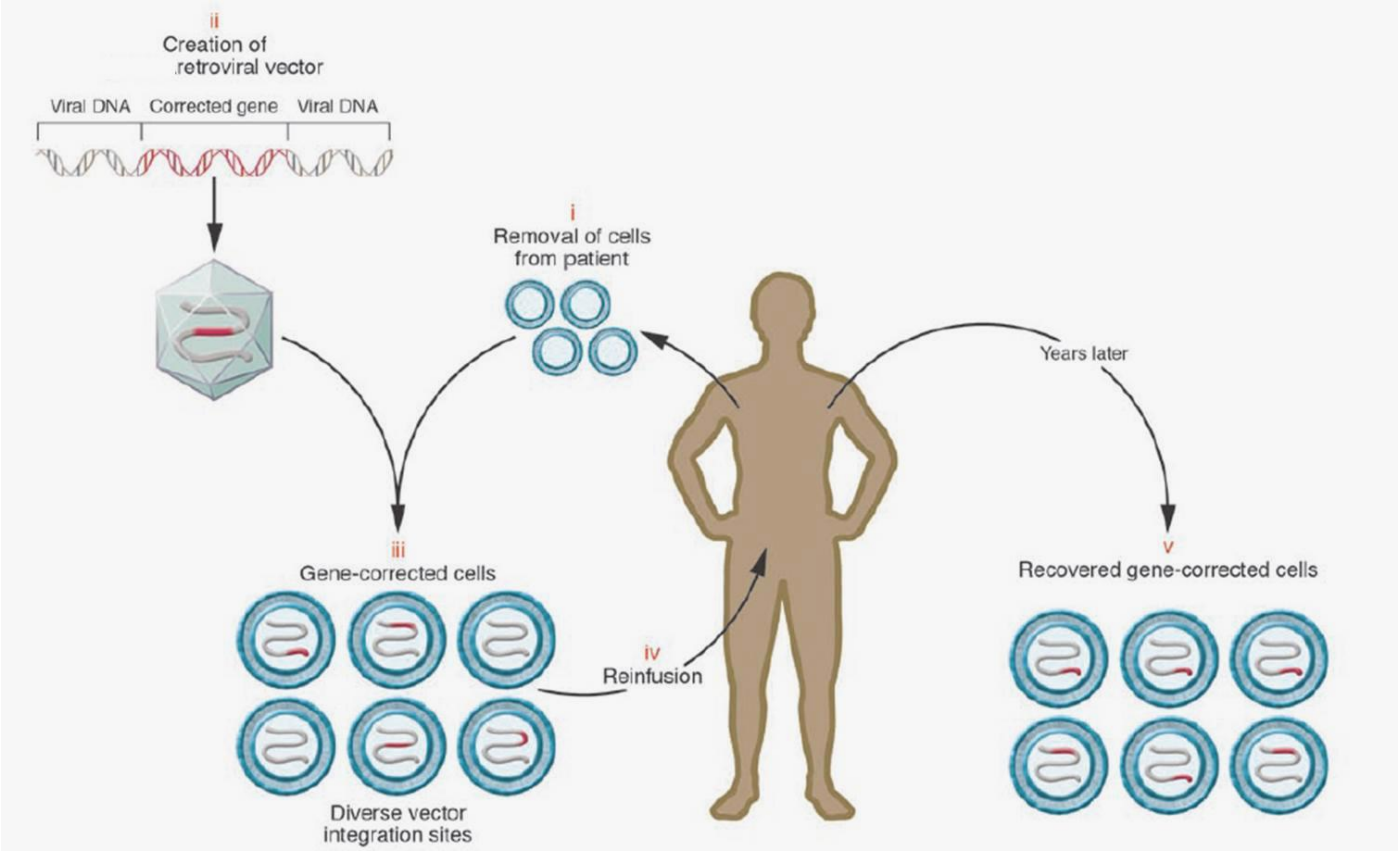


Figure obtained from Retroviral integration and human gene therapy The Journal of Clinical Investigation, Volume 117, Number 8

Fig. 3.1

Severe combined immunodeficiency (SCID) and X-linked SCID are two genetic diseases that can be treated by the gene therapy method shown in Fig. 3.1.

(a) State the genes that can be corrected for SCID and X-linked SCID.

SCID: ……..

X-linked SCID: ……..

[2]

(b) Explain how mutation in one of the genes cited in **(a)** would give rise to immunodeficiency.

……

……

……..[2]

Excerpt from the *The Journal of Clinical Investigation* review titled *Retroviral integration and human gene therapy*:

> "However, with these successes came the first serious adverse events in retrovirus based gene therapy. Three of the SCID-X1 patients treated by the French team developed a leukemia-like lymphoproliferative disease."

(c) Suggest why these patients developed leukemia-like lymphoproliferative diseases.

……

……

……[2]

In 1999, 18-year old Jesse Gelsinger died after suffering from a massive immune response following a clinical trial that administered adenoviral-based gene therapy.

(d) Besides adenovirus' ability to elicit a strong immune response, explain why adenovirus is also not favoured in the treatment of the genetic diseases cited in **(a)**.

……

……

……[2]

(e) Explain why scientists prefer to isolate hematopoietic stem cells rather than T-cells from the patient for the gene therapy treatment shown in Fig. 3.1.

……

……

……

……[3]

Viruses are not the only vectors that are utilised to deliver genes into patients' host cells.

(f) State one other type of vector that is not viral.

……

……[1]

(g) Discuss two ethical implications of gene therapy.

……

……

……

……[2]

[Total: 14]

4 Planning question

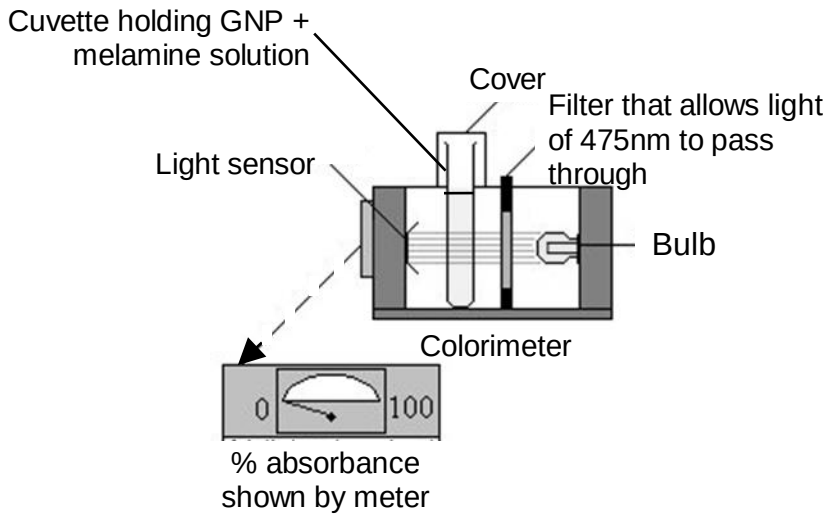
In 2008, contaminated milk and infant formula with melamine in China resulted in over a thousand babies hospitalised and caused several deaths. Melamine with its large number of nitrogen atoms, was unethically added to foods to mimic proteins detected through conventional measurements for nitrogen.

A research group found a way to detect the presence of melamine via a colour indicator. They attached cyanuric acid to gold nanoparticles to produce functionalized gold nanoparticles (GNP) that are red, the cyanuric acid component of GNP detects the melamine through hydrogen-bonding. Upon binding to melamine, the GNP changes from red to blue, giving a clear signal that there is contamination.

GNP (red) + Melamine → GNP-Melamine complex (blue)

The intensity of the blue colour after a set time interval of 5 minutes is a measure of the concentration of the melamine present in a specimen.

The test involves addition of 1 cm^3 of solution (to be tested) to 0.1 cm^3 of GNP in a cuvette (glass container), followed by colourimetric measurement of absorbance (% absorbance) at a specified wavelength. It is known that the blue wavelength is 475 nm.



You are required to plan, but not carry out, an investigation to determine the lowest concentration of melamine detectable by GNP indicator.

Your planning must be based on the assumption that you have been provided with the following equipment and materials which you **must** use:

- 1 % GNP
- Colourimeter
- 6 x Cuvettes (container for colourimeter measurement)
- 6 x Test-tubes
- Test-tube rack
- 2 x 10 cm^3 syringes
- 2 x 1 cm^3 syringes
- Micropipette
- 15 cm^3 of 1% melamine solution labelled M
- 50 cm^3 of buffer solution
- Marker pen
- Stopwatch
- Safety googles

- Disposable gloves

Your plan should have a clear and helpful structure to include:

- an explanation of theory to support your practical procedure
- a description of the method used including the scientific reasoning behind the method
- proposed layout of results tables with clear headings and labels
- the correct use of technical and scientific terms

[Total: 12]

Section B: Free-response question

Answer **all** questions. Answer each part on a **separate** piece of paper.

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

5 **(a)** Compare between Genomic and cDNA libraries used in protein production. [6]

(b) Explain the advantages and limitations of PCR. [6]

(c) Discuss the pros and cons of genetically-modified crop plants. [8]

[Total: 20]

END OF PAPER

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JC2 PRELIMINARY EXAMINATIONS
Higher 2

Answers

CANDIDATE NAME					
CLASS	**2T**	**INDEX NUMBER**			

BIOLOGY

9648/03
25th August 2016
2 hours

Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

Write your index number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper. **[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]**
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are two sections in this paper.

Section A]
Answer all questions

Section B]
Answer all questions. Answer each part on a **separate** piece of paper.

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

For Examiner's Use	
Section A	**/ 52**
1 [13]	
2 [13]	
3 [14]	
4 [12]	
Section B	**/ 20**
5a [6]	
5b [6]	
5c [8]	
TOTAL	**/ 72**

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

[Turn over

Section A

Answer **all** questions in this section.

1 Human Growth Hormone is important to augment normal growth and development in the treatment of individuals with dwarfism. Fig. 1.1 shows how human growth hormone can be produced via expression of recombinant DNA in *Escherichia coli* host cells.

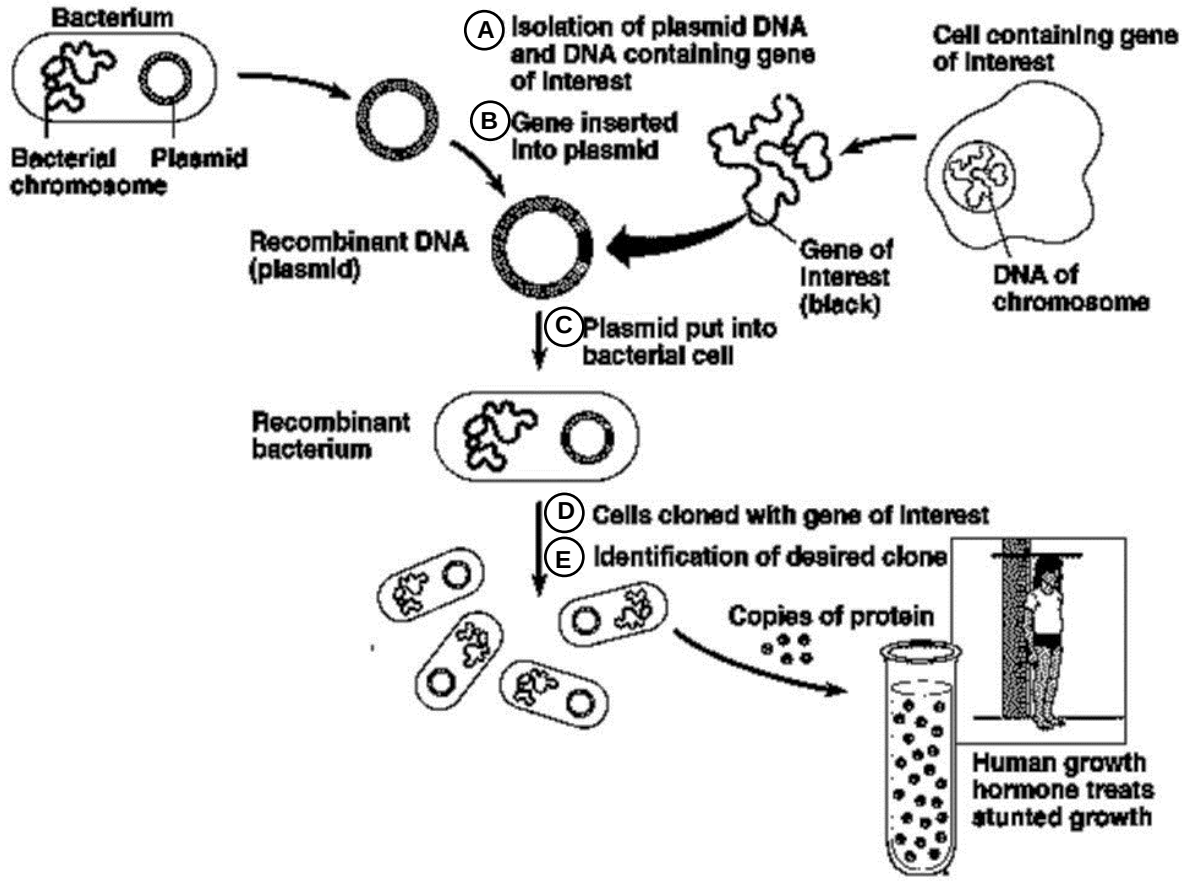


Fig. 1.1

(a) Explain what is meant by recombinant DNA.

……

……[1]

1. **Genes from two different sources / organisms** are **combined** *in vitro* into a single plasmid **/ OWTTE** (accept contextual answers).

[L1]

(b) Name the process required in the following procedure in Fig 1.1.

C : ……**Transformation**

E : ……**Selection / Screening**

[1]

(Both correct – 1 mark)

[L1]

(c) The gene of interest cannot be taken directly from DNA of chromosome but require additional processing in order to produce functional protein.

(i) With reference to Fig. 1.1, explain why the gene of interest cannot be taken directly from chromosomal DNA.

……

……

……[2]

1. **Eukaryotic DNA** contains **introns** and
2. **bacterial** / **prokaryotic** host cells **do not have post-transcriptional modification / splicing to remove introns.**
3. **Non-functional protein may be synthesized** if introns are not removed.

(Max 2)

[L1]

(ii) Outline the additional processing required to yield the gene of interest prior to insertion into the plasmid.

……

……

……

……[3]

1. **Isolate the processed / mature mRNA** coding for human Growth Hormone
2. Use **reverse transcriptase** to **synthesize single-stranded cDNA** using the processed mRNA as template **(Reject: conversion)**
3. Use **DNA polymerase** to replicate the **single-stranded cDNA into double-stranded cDNA**.
4. **Addition of linker DNA** to the **ends** of the double stranded cDNA / Gene of interest.

(Max 3)

[L2]

(d) State one possible pair of gene markers present on the cloning site of the plasmid for the identification of desired clone in Fig. 1.1.

……

……

……[1]

1. **Ampicillin resistance gene** & **Tetracycline resistance gene**

OR

2. **LacZ gene / β-galactosidase gene** & **Ampicillin resistance gene**

(Max 1)

[L2]

(e) Outline the process for Stage E in Fig 1.1 using one of the gene markers in (d).

……

……

……

……[3]

1. **Replica-plate** the **master plate containing the bacterial clones** on two separate **agar plates containing ampicillin and tetracycline**.
2. **Bacterial clones / colonies** that grow on both antibiotic plates are **resistant to both antibiotics are non-recombinant**.
3. **Select for bacterial clones sensitive to the antibiotic of the gene marker in (d)** but **resistant to the other antibiotic** from the **master plate**.
4. Correct reference to **insertional inactivation**.

(Max 3)

OR

1. **Culture the bacterial clones / colonies** on **X-gal** medium with ampicllin.
2. **Bacterial clones / colonies** that appear **blue** are **non-recombinant** as LacZ gene is intact.
3. **Select for white bacterial clones** that are **recombinant**.
4. **LacZ gene is disrupted** due to **insertional inactivation**.

(Max 3)

[L2]

Fig 1.2 shows details of how stage A and B are carried out.

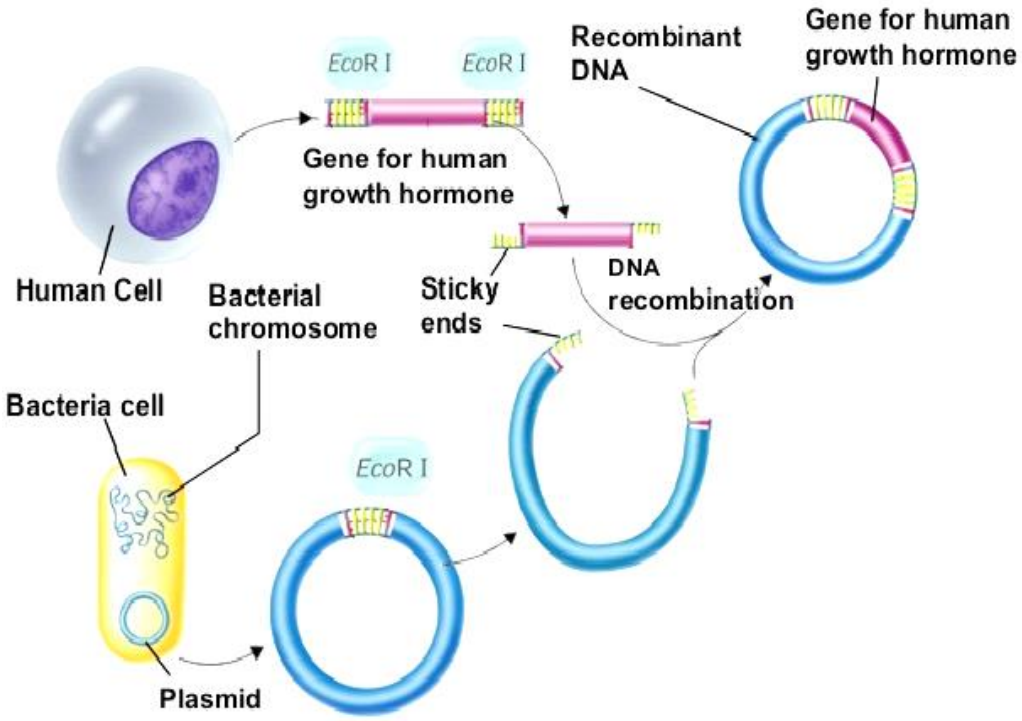


Fig 1.2

(f) A scientist commented that two different restriction enzymes should be used to isolate the gene for human growth hormone instead of using only *EcoRI* restriction enzyme. Explain the rationale behind his comment.

……

……

……[2]

1. The **gene** for human growth hormone **may insert into the plasmid in more than one orientation** / **OWTTE**
2. This may lead to **non-functional protein being synthesized** if the gene is inserted in the wrong orientation
3. Having two different restriction enzymes produces **two different sticky ends** to isolate the gene at the ends will ensure **uni-directional insertion** of the gene into the plasmid.

(Max 2)

[L3]

[Total: 13]

2 Restriction Fragment Length Polymorphism (RFLP) is an important application for comparative genetic analysis of normal and diseased individuals.

(a) Outline the key techniques used for RFLP analysis.

……

……

……

……

……[4]

1. **Same** set of **restriction enzyme(s) to digest DNA** samples.
2. **Gel electrophoresis** to **separate DNA fragments** of different **length**.
3. **Southern Blotting**
4. to **transfer DNA fragments to nitrocellulose membrane**.
5. **Nucleic acid hybridization** with **labelled probes complementary to target sequences**.
6. **UV transillumination / Autoradiography** (relevant to point 4 on type of probes) to **visualized DNA fragment** containing target sequences.

(Max 4)

[L1]

Fig. 2.1 shows the pedigree and southern blots of an RFLP locus that is closely linked with a disease phenotype. Affected individuals are shaded in the pedigree.

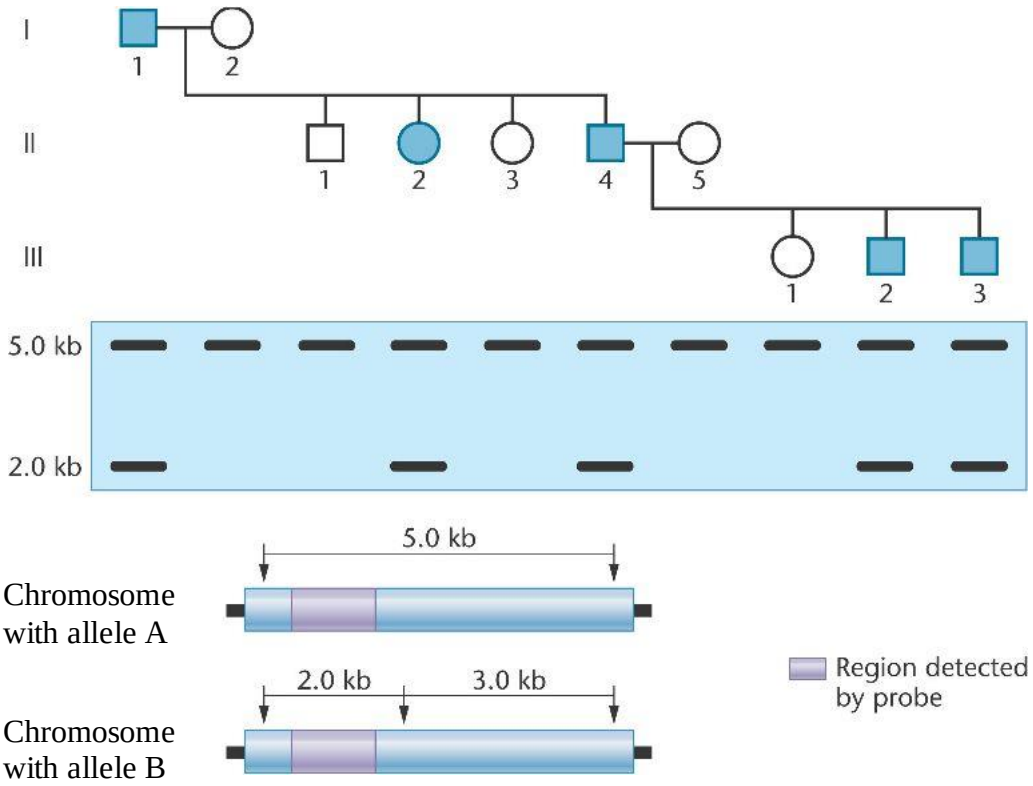


Fig. 2.1

(b) Explain the genetic basis of RFLP in comparative analysis in disease study.

……

……

…… [2]

1. **Normal and disease individual** have **difference(s) in genetic sequence**.
2. Upon **digestion with same set of restriction enzyme(s), different number and length of DNA fragment** will be produced.
3. Gel electrophoresis and nucleic acid hybridization with labelled probes will result in **different RFLP profile / band patterns** for normal and diseased individual.

[L2]

(c) With reference to Fig. 2.1,

(i) Identify the allele responsible for the disease.

……[1]

1. **Allele B**

[L2]

(ii) State the considerations for target region of the probe.

……..

……..

……[2]

1. **Same target sequence for allele A and B**.
2. **Disease allele** is **closely linked/associated** with **polymorphic RFLP locus**.
3. **Probe binds to different fragment lengths** for **normal and disease allele** / **OWTTE**.

[L3]

(iii) Explain if the disease allele is dominant or recessive.

……..

……..

……[2]

1. **Dominant**
2. **2kb fragment** associated with allele B is always present in **affected individuals** (I-1, II-2, II-4, III-2 and III-3).
3. In the **absence of allele B**, **individuals are normal**.

[L2]

(d) Briefly describe two other applications of RFLP.

……..

……..

……[2]

1. RFLP as **genetic markers in genomic/linkage/physical mapping**.
2. **DNA fingerprinting** for **paternity testing / forensic investigation / verification of poaching**.

[L1]

[Total: 13]

3 Fig. 3.1 shows how gene therapy using modified viruses can be carried out.

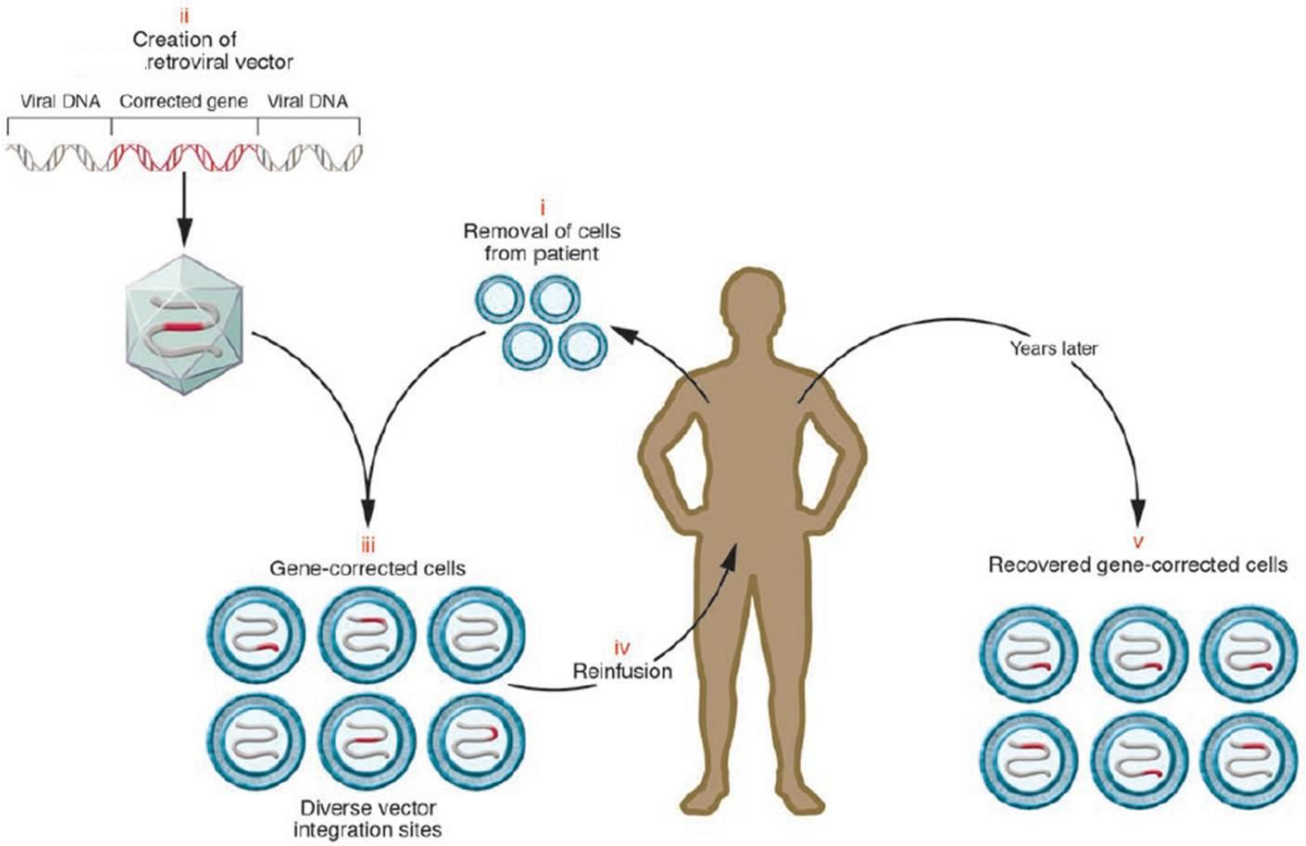


Figure obtained from Retroviral integration and human gene therapy The Journal of Clinical Investigation, Volume 117, Number 8

Fig. 3.1

Severe combined immunodeficiency (SCID) and X-linked SCID are two genetic diseases that can be treated by the gene therapy method shown in Fig. 3.1.

(a) State the genes that can be corrected for SCID and X-linked SCID.

SCID: ……..

X-linked SCID: ……..

[2]

S: State (CW), gene, corrected, X-linked SCID

C: Factual recall

ORE:

1. SCID: **Adenosine deaminase** gene Reject: ADA gene
2. X-linked SCID: Gene coding for a subunit **gamma c** (γc) of an **interleukin receptor**.

[L1]

(b) Explain how mutation in one of the genes cited in **(a)** would give rise to immunodeficiency.

……

……

……..[2]

S: Explain why(CWs), mutations genes, (a), immuodeficiency

C:
- Cause and effect
- Adenosine deaminase gene mutation → Purines cannot be broken down → Toxic to cells
- Mutation in gene coding for a subunit gamma c (γc) of an interleukin receptor → HSC cannot convert to T-cells

ORE:
1. Adenosine deaminase (ADA) **breaks down purine**
2. hence without ADA, purines which **accumulate** is **toxic** to **T** and **B cells**, causing them to **die**.

OR
3. γc subunit of IL receptors is needed to convert **hematopoietic stem cells to progenitors of T cells**,
4. hence without the the progenitors there will be **no derivation / generation** of **T-cells.**

(Points 1 & 2 have to be together & Points 3 & 4 have to be together.)

[L2]

Excerpt from the *The Journal of Clinical Investigation* review titled *Retroviral integration and human gene therapy*:

> "However, with these successes came the first serious adverse events in retrovirus based gene therapy. Three of the SCID-X1 patients treated by the French team developed a leukemia-like lymphoproliferative disease."

(c) Suggest why these patients developed leukemia-like lymphoproliferative diseases.

……

……

……..[2]

S: Suggest why(CWs), patients, developed, leukemia-like lymphoproliferative diseases, retrovirus

C:
- Retroviruses integrate in the genome
- Protooncogene converted to oncogene
- Not tumour suppressor gene as two alleles need to be inactivated.

ORE:

1. **DNA** of modified **retroviruses integrate** into **host** cell **genome** / **insertional mutagenesis**.
2. Integration may cause **gain of function mutation** resulting in **protooncogene** converted to **oncogene**.
3. Integration may cause **loss of function mutation** in **2 alleles** of the **tumour suppressor gene**.

[L3]

In 1999, 18-year old Jesse Gelsinger died after suffering from a massive immune response following a clinical trial that administered adenoviral-based gene therapy.

(d) Besides adenovirus' ability to elicit a strong immune response, explain why adenovirus is also not favoured in the treatment of the genetic diseases cited in **(a)**.

……

……

……..[2]

S: Explain why (CWs), besides, adenovirus, immune response, not favoured, treatment..genetic diseases..(a)

C:
- Cannot mention adenovirus' high immunogenicity
- Adenovirus does not integrate into host genome
- Limited duration of in vivo gene expression

ORE:
1. **Adenovirus does not integrate** into **host** cell **genome** after infection.
2. There is therefore **limited duration** of ***in vivo*** **gene expression / OWTTE**.

[L2]

(e) Explain why scientists prefer to isolate hematopoietic stem cells rather than T-cells from the patient for the gene therapy treatment shown in Fig. 3.1.

……

……

……

……..[3]

S: Explain why (CWs), scientists, prefer, isolate, HSCs vs T-cells, gene therapy, Fig. 3.1

C:
- HSCs

ORE:
1. Gene targeting T-cells does **no**t result in **long-term expression** of the corrected **genes**, since most of these cells **die** rather than self-renew.
2. Gene targeting haematopoietic stem cells result long-term expression of the corrected genes as these cells have the capability to **self-renew**
3. and **differentiate** to give rise to more **T-cells** /
4. and are **multipotent stem cells**.

[L2]

Viruses are not the only vectors that are utilised to deliver genes into patients' host cells.

(f) State one other type of vector that is not viral.

……

……..[1]

S: State (CW), one, other type, vector, not viral

C:
- Factual recall

ORE:

1. **Liposomes**
2. **Gene gun**

(Max 1)

[L1]

(g) Discuss two ethical implications of gene therapy.

……

……

……

……..[2]

S: Discuss (CW), two, ethical implications, gene therapy

C:
- Discursive question

ORE:

1. Philosophical perspective on **morality** of changing genetics / OWTTE.
2. **Germ-line gene therapy** will alter offspring genetics, we may not have the **right to alter** our **children's genes** / OWTTE.
3. Those involved in the research related to **germ-line gene therapy** regularly **create and destroy embryos** as a part of their research. There are objections to killing embryos used for research in gene therapy as **human life** may be considered to have begun at conception.
4. **Genetic determinism / Definition of 'normal' and 'disability'**. The decision of what is normal and what is a disability should not rest on just a small group of individuals or medical professionals. The question of whether disabilities are considered disease and whether these need to be cured or prevented requires thorough consideration.
5. **Patenting** to **develop drug/process at the expense of human life** / OWTTE.
   Reject all social/religious points.
   (Max 2)

[L2]

[Total: 14]

4 Planning question

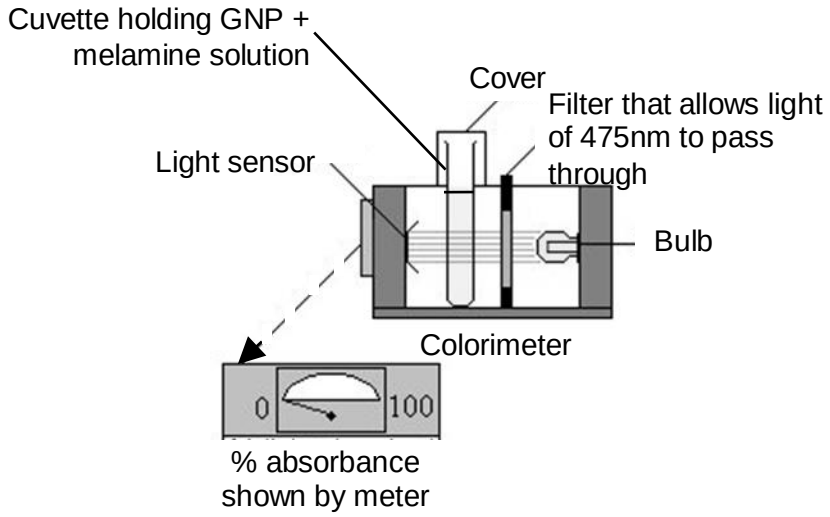
In 2008, contaminated milk and infant formula with melamine in China resulted in over a thousand babies hospitalised and caused several deaths. Melamine with its large number of nitrogen atoms, was unethically added to foods to mimic proteins detected through conventional measurements for nitrogen.

A research group found a way to detect the presence of melamine via a colour indicator. They attached cyanuric acid to gold nanoparticles to produce functionalized gold nanoparticles (GNP) that are red, the cyanuric acid component of GNP detects the melamine through hydrogen-bonding. Upon binding to melamine, the GNP changes from red to blue, giving a clear signal that there is contamination.

GNP (red) + Melamine → GNP-Melamine complex (blue)

The intensity of the blue colour after a set time interval of 5 minutes is a measure of the concentration of the melamine present in a specimen.

The test involves addition of 1 cm^3 of solution (to be tested) to 0.1 cm^3 of GNP in a cuvette (glass container), followed by colourimetric measurement of absorbance (% absorbance) at a specified wavelength. It is known that the blue wavelength is 475 nm.



You are required to plan, but not carry out, an investigation to determine the lowest concentration of melamine detectable by GNP indicator.

Your planning must be based on the assumption that you have been provided with the following equipment and materials which you **must** use:

- 1 % GNP
- Colourimeter
- 6 x Cuvettes (container for colourimeter measurement)
- 6 x Test-tubes
- Test-tube rack
- 2 x 10 cm^3 syringes
- 2 x 1 cm^3 syringes
- Micropipette
- 15 cm^3 of 1% melamine solution labelled M
- 50 cm^3 of buffer solution
- Marker pen
- Stopwatch
- Safety googles
- Disposable gloves

Your plan should have a clear and helpful structure to include:

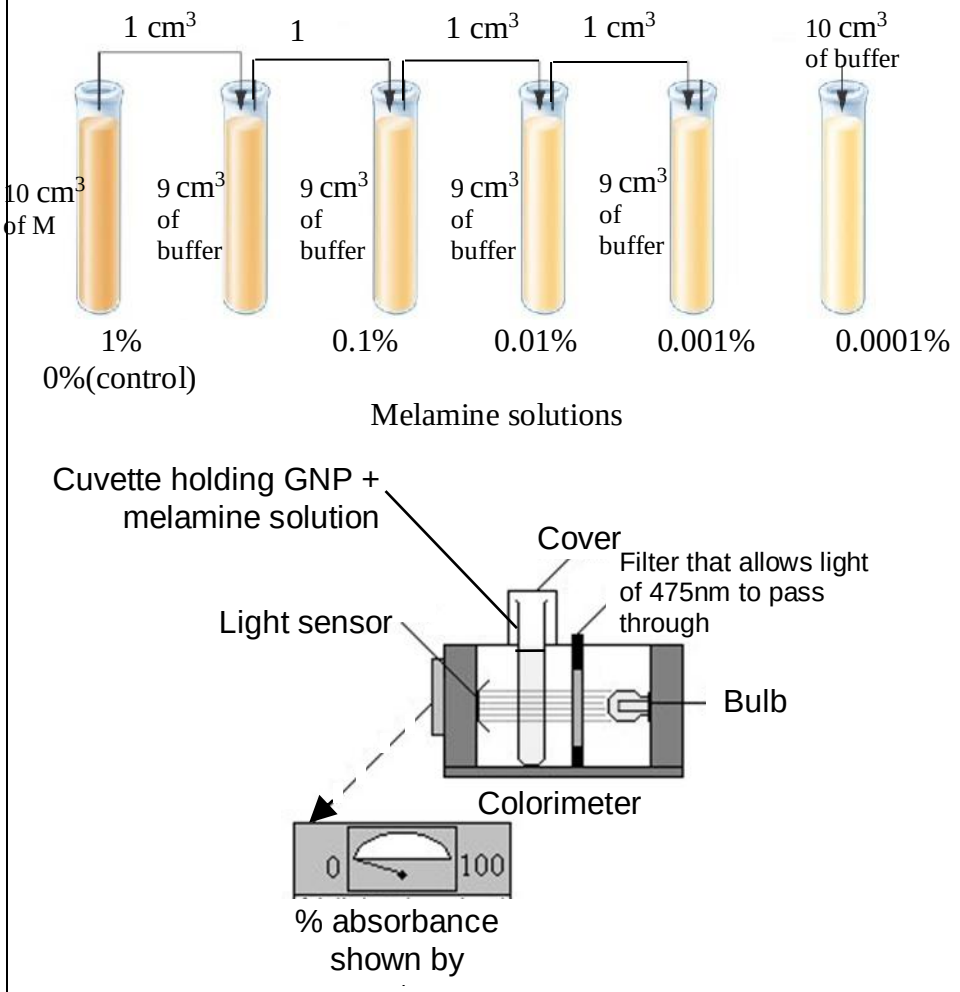
- an explanation of theory to support your practical procedure
- a description of the method used including the scientific reasoning behind the method
- proposed layout of results tables with clear headings and labels
- the correct use of technical and scientific terms

[Total: 12]

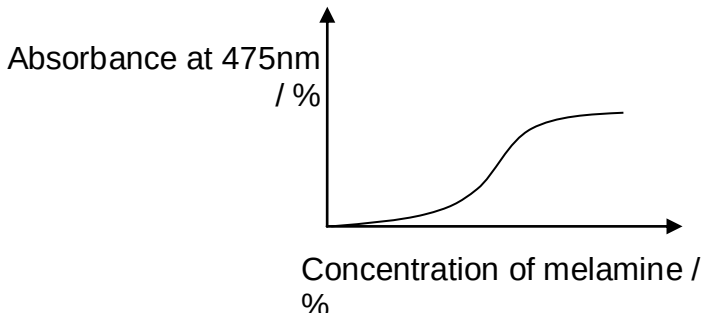
……

……

Section	Marking Points	
Aim, Hypothesis, Introduction [Max 2]	1. **Melamine may mimic protein in infant formula**.	**1**
	2. **Presence of melamine can be detected by a colour change of GNP from red to blue**	**1**
	3. **Melamine binds to cyanuric acid component of GNP through hydrogen-bonding**, is the basis for detection.	**1**
	4. The presence of melamine contaminant could be **measured by a colorimeter** that measure **% absorbance at specifc wavelength**	**1**

	(475nm),	
Variables [1] Both Independent & Dependent variable must be correct.	**5. Independent variable: Concentration of melamine / % (1%, 0.1%, 0.01%, 0.001%, 0.0001%)**	**1**
	6. Dependent variable: % absorbance of solution at specific wavelength (475nm) after **5 mins**	
Apparatus & Procedures [Max 4] **Note: rationale must be included for award of marks.**	**7. Carry out serial dilution of 1% melamine solution using the buffer** to reduce the concentration of melamine solution by a factor of 10 between each of the four successive dilutions, to give **0.1%, 0.01%, 0.001% and 0.0001% (Description / Table of dilution accepted)**	**1**
	8. Clear labelled diagram of experimental setup  	**1**
	9. **Negative Control contains buffer only.** All other conditions remain the same. This shows that colour change of GNP indicator to blue only occurs in the presence of melamine.	**1**
	10. **Data points [Five melamine concentration]: Table of preparation must be shown**	**1**

Concentration of melamine/% (no need to consider s.f.)	**1.0000**	**0.1000**	**0.0100**	**0.0010**	**0.0001**	**0.0000**
Melamine solution to be diluted		**1.0000**	**0.1000**	**0.0100**	**0.0010**	
Volume of melamine solution to be diluted / cm^3	**10.0**	**1.0**	**1.0**	**1.0**	**1.0**	**0.0**
Volume of buffer to be added / cm^3	**0.0**	**9.0**	**9.0**	**9.0**	**9.0**	**10.0**

<table>
<tr><td></td><td>11. Controlled variable: Volume of melamine solution tested kept constant to 1cm^3</td><td>1</td></tr>
<tr><td></td><td>12. Controlled variable: Volume of GNP indicator used kept constant to 0.1 cm^3</td><td>1</td></tr>
<tr><td></td><td>13. Controlled variable: Solution reaction time to GNP indicator kept constant to 5 mins.</td><td>1</td></tr>
<tr><td></td><td>14. After 1 cm^3 of melamine solution is added to 0,1 cm^3 of GNP indicator and stand for 5 mins in the cuvette.</td><td>1</td></tr>
<tr><td></td><td>15. [Colorimeter Calibration] Fill another cuvette with buffer/control to calibrate the colorimeter zero absorbance reading.</td><td>1</td></tr>
<tr><td></td><td>16. Measure the % absorbance of solution using colorimeter.</td><td>1</td></tr>
<tr><td></td><td>17. Repeat Step 11-16 for other concentrations of melamine solutions.</td><td>1</td></tr>
<tr><td></td><td>18. [Data collection]: Record the % absorbance of the solutions in a table.</td><td>1</td></tr>
<tr><td></td><td>19. [Reliability]: Perform 2 repeats to obtain 3 replicates → ensure reliability [See point 23-24]</td><td>1</td></tr>
<tr><td>Safety & Precautions [1]</td><td>20. Specify at least <u>ONE</u> valid risk and corresponding precaution:
• [Risk] Use of glassware during preparation of melamine serial dilution, exercise caution + [Precaution] prevent breakage of glassware to avoid cut injuries.
• [Risk] Wet hands could risk electrocution when switching on colorimeter + [Precaution] Dry hands before switching on colorimeter.
• [Risk] Melamine is poisonous + [Precaution] wear gloves and protective googles to prevent exposure.
• AVP</td><td>1</td></tr>
<tr><td>Results [Max 2]</td><td>19. [Table of results] must include:
• Independent variable with unit
• Dependent variable with unit
• Processed data with unit
• Correct trend (in agreement with hypothesis – lower absorbance at lower concentration of melamine)
[T] <u>Table showing intensity of colour of extract</u>
<table>
<tr><td rowspan="2">Concentration of melamine solution / %</td><td colspan="4">Absorbance at 475nm / %</td></tr>
<tr><td>Replicate 1</td><td>Replicate 2</td><td>Replicate 3</td><td>Average</td></tr>
<tr><td>1.0000</td><td></td><td></td><td></td><td></td></tr>
<tr><td>0.1000</td><td></td><td></td><td></td><td></td></tr>
<tr><td>0.0100</td><td></td><td></td><td></td><td></td></tr>
<tr><td>0.0010</td><td></td><td></td><td></td><td></td></tr>
<tr><td>0.0001</td><td></td><td></td><td></td><td></td></tr>
<tr><td>0.00 (control)</td><td></td><td></td><td></td><td></td></tr>
</table></td><td>1</td></tr>
<tr><td></td><td>20. [Graph] must include:
• Independent variable on x-axis labelled with unit
• Dependent variable on y-axis labelled with unit
• Line graph (Increased % absorbance with increasing melamine concentration)
 
</td><td>1</td></tr>
<tr><td>Interpretation [1]</td><td>21. [Correlate with graph and hypothesis]:
• As shown by the graph, as the concentration of melamine increases, average % absorbance at 475nm increases, given a</td><td>1</td></tr>
</table>

	fixed amount of time of exposure / Vice versa	
	22. **Lowest concentration of melamine that could be detected can be determined based on the graph / comparison against control (same result).**	
	23. Further serial dilutions may be required to determine lowest concentration of melamine that could be detected.	
Correct scientific terms + Reasoning [1]	24. Use **appropriate terms** within answer (e.g. **hydrogen bonding, sensitivity, absorbance** etc.)	**1**

- **Note: Reference to SPA Planning Qn on Membrane structure (SPA Planning Booklet pg)**

Section B: Free-response question

Answer **all** questions. Answer each part on a **separate** piece of paper.

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

5 **(a)** Compare between Genomic and cDNA libraries used in protein production. [6]

Basis of Comparison	Genomic Library	cDNA libraries
Similarities [Max 3]	1. Both store genetic information	
	2. Both requires the use of vectors	
	3. Both require ligation of genetic sequence to vector using DNA ligase	
	4. Both requires storage in host cells.	
Difference [Max 3]		
5. Scope of genetic information	Entire genome inclusive of introns and exons	Expressed part of the genome
6. Starting material for library construction	Genomic DNA	Processed mRNA
7. Cloning Vector	Bacteriophage, Cosmid, BAC, YAC,	Plasmid and λ phage
8. Enzymes involved	Restriction enzymes, DNA ligase, DNA polymerase	Restriction enzymes, DNA ligase, DNA polymerase and reverse transcriptase
9. Ease of library screening	Difficult to locate gene of interest as single gene may be dispersed over several clones.	Easier as gene are isolated whole.
10. Expression of eukaryotic gene in prokaryotic system	Unlikely to produce functional protein due to the presence of introns.	Functional protein can be produced

11. Nature of genetic information stored	Same throughout the life of the cell / regardless on the type of cell	May differ at different time in the life of the cell / dependent on the type of cell
12. Presence of introns	Present	Absent
13. Presence of regulatory sequences	Present	Absent

[L3]

(b) Explain the advantages and limitations of PCR. [6]

Advantages (Max 3]:

1. PCR is **highly specific**, only sequenced flanked by **forward and reverse primers** are replicated.
2. PCR can be performed **in vitro** without the use of cells.
3. PCR is a **cheaper technique as compared to cloning** because no need to culture and maintain large quantities of host cells.
4. PCR is **faster than cloning** in replication of DNA.
5. Only **minute amounts of DNA** is required as **starting material/ for amplification**.

Limitations (Max 3):

6. Process is **not error-free** due to **absence of proofreading activity** in **Taq polymerase**.
7. Possible **contamination from non-template DNA** if primers sequence are not specific.
8. DNA sequences **flanking target sequences** to be amplified **must be known** to enable **synthesis of primers**.
9. **PCR cannot substitute gene cloning** in cells for **longer DNA sequences**.

(c) Discuss the pros and cons of genetically-modified crop plants. [8]

SC	OR	E
CW: Discuss QKW: pros & cons, genetically-modified crop plants PRO	• Crop yield increase	1. Genetic engineering on plants can **enhance crop yields**.
PRO	• May bypass seasonal restrictions	2. Genetic engineering may permit crops to **grow outside** their **usual location** / **season** so that people have **more food**.

PRO	• Enhance nutritional content	3. Genetically modified crop plants can also be **enhanced** with a certain **nutritional content** (e.g. Golden rice) so that people are **better fed/OWTTE**.
PRO	• Pest-resistant crops	4. Genetically modified crop plants can be more **pest-resistant** (e.g BT corn),
PRO	• Lower cost	5. and this will **lower cost** as **pesticide** usage will be **reduced/avoided**.
PRO	• Less pollution	6. As pesticide usage is reduced/avoided, there will be **less damage/pollution** to the **environment**.
PRO	• Drought-resistance	7. Genetically modified crop plants can be more **drought-resistant**, and this will increase crop yield for farmers.
PRO	• Avoid costly irrigation	8. Drought-resistant crops can also help farmers **avoid** installing **costly irrigation** systems to ensure sufficient water is provided.
PRO	• Profits increase → consumer cost drops	9. As farmers' cost is reduced, their **profits increase** / **consumer cost** may also **reduce**.
PRO	• Increased shelf-life	10. **Shelf-life** of **crops** can be **increased** **Flavor Savr PG gene** example must be given
CON	• More invasive plants • Superweeds	11. The introduced gene(s) may be **transferred by pollen** to **wild relatives** whose hybrid offspring will become more **invasive** and hence become **'superweeds'**.
CON	• Cost involved in removing superweeds	12. This may lead to **additional cost for** the **removal** of such **'superweeds'.**
CON	• Plant diversity compromised	13. 'Superweeds' may also **reduce plant biodiversity** by **out-competing** natural plants
CON	• Organic farms may be compromised	14. The introduced gene(s) may be **transferred by pollen** to **unmodified plants** growing on a farm with **'organic'** certification, hence losing organic certification.
CON	• Toxic components	15. The modified plants will be a direct hazard to humans, domestic **animals** or other beneficial animals by being **toxic.** OR For instance, the herbicides that can now be used on the crop will itself **leave toxic residues** in the crop, which will be toxic to humans who consume them.

		OR **Disrupt ecological systems** e.g. Monarch Butterflies affected by BT.
	• Damage environment	16. The toxic residues/ overused pesticide may also affect and cause **unintended damage** to the **environment** by causing pollution to the surroundings.
	• Allergies	17. The modified plants will be a direct hazard to humans, domestic animals or other beneficial animals by being **producing allergies** upon consumption.
	• Farmers pay royalties	18. Farmers may have to **pay royalties** to sow the crops. OR 18. Some companies have extended their **patents on genetically engineered seeds** to prevent farmers from re-sowing the seed from these genetically engineered crops.
	• Higher consumer cost	19. The cost that farmers have to pay for the royalties may be passed on the **consumers** who may have to **pay higher prices** for them.
	• Vulnerability to diseases	20. **Genetically identical** and would be **equally vulnerable to disease.**

(Max 8, Maximum 4 pros and 4 cons)

[L2]

[Total: 20]

END OF PAPER