

**JC 2 PRELIMINARY EXAMINATION**  
in preparation for General Certificate of Education Advanced  
Level  
**Higher 2**

CANDIDATE  
NAME

CLASS

INDEX NUMBER

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**BIOLOGY**

**9648/01**

Paper 1 Multiple Choice

**30 August 2016**

**1 hour 15 minutes**

Additional Materials:          Multiple Choice Answer Sheet

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**READ THESE INSTRUCTIONS FIRST**

Write your name and class on all the work you hand in.  
Write in soft pencil.  
Do not use staples, paper clips, highlighters, glue or correction fluid.

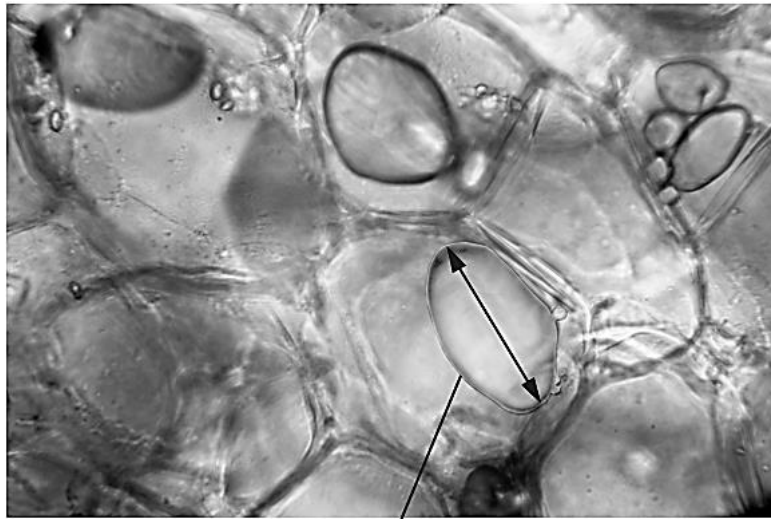
There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.  
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

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

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

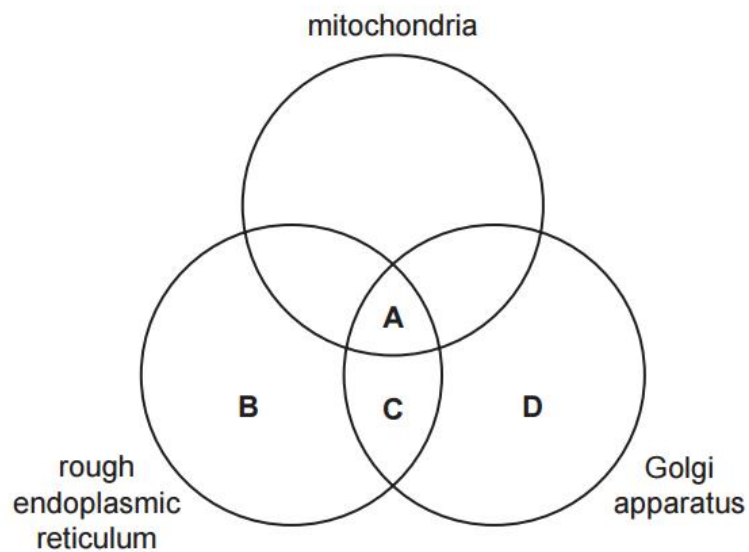
- 1 The picture shows starch grains as seen with an optical microscope. The actual length of the starch grain A is 50  $\mu\text{m}$ .



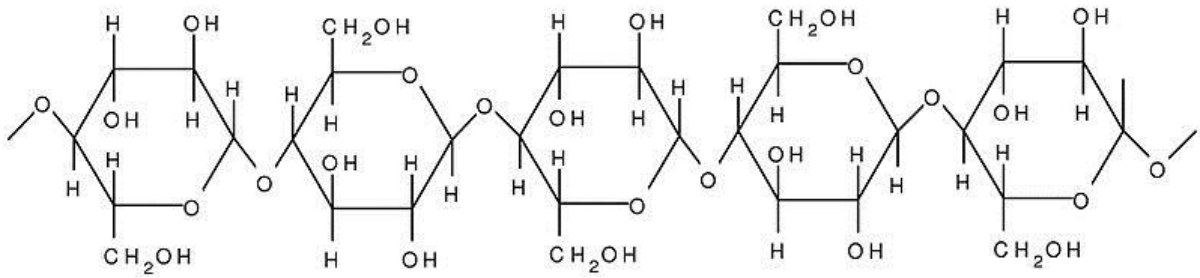
Starch grain A

Calculate the magnification.

- A x 5  
 B x 50  
 C x 500  
 D x 5000
- 2 Which of the following organelle(s) is/are directly required for the formation of the hydrolytic enzymes found in lysosomes?

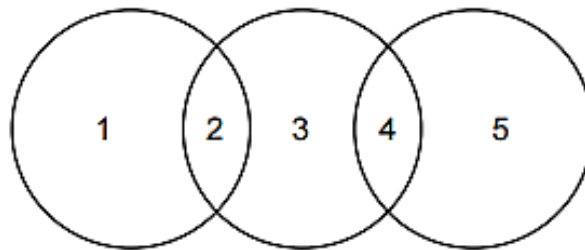


- 3 The figure below shows a portion of a polymer.



Which statement is **true** about the polymer?

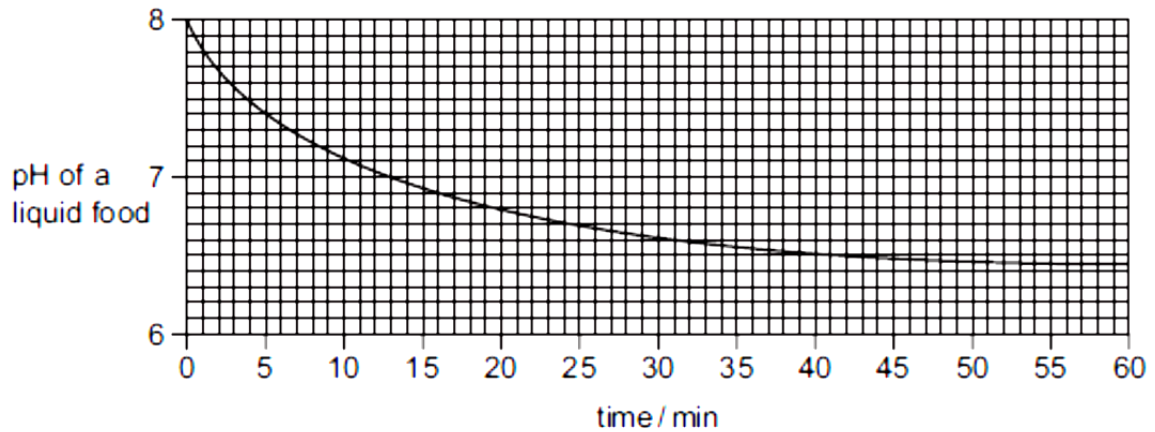
- A The polymer will assume a helical structure.  
 B The polymer can exist in both branched and unbranched forms.  
 C The orientation of the monomer will result in a straight chain polymer.  
 D The monomers are able to form  $\alpha$  (1-6) glycosidic bonds with one another.
- 4 The diagram shows the relationship between the levels of protein structure and bonds.



Which row is **correct**?

	1	2	3	4	5
<b>A</b>	primary	peptide	secondary	ionic	tertiary
<b>B</b>	secondary	hydrogen	tertiary	peptide	primary
<b>C</b>	tertiary	ionic	primary	peptide	quaternary
<b>D</b>	quaternary	ionic	tertiary	ionic	secondary

- 5 Lipase is a digestive enzyme produced by the pancreas that catalyses the hydrolysis of dietary lipids. The table shows how the pH of a liquid food containing a high proportion of lipids decreases over time.



Which of the following statements are possible explanations of the results of the experiment between 50 and 60 minutes?

- 1 Enzyme concentration becomes the limiting factor.
  - 2 Substrate concentration becomes the limiting factor.
  - 3 All the enzyme active sites are saturated.
  - 4 Denaturation of the enzyme by the products.
  - 5 Products are acting as inhibitors.
- A** 1, 2 and 3  
**B** 1, 4 and 5  
**C** 2, 3 and 4  
**D** 2, 4 and 5

**6** Specific enzyme inhibitors inhibit only one enzyme.

The drug disulfiram, which is used as a treatment for alcoholism, is a specific inhibitor of acetaldehyde dehydrogenase. Acetaldehyde dehydrogenase is involved in the detoxification of ethanol. As a result of inhibition by disulfiram, any ethanol that is present in the system can only be partly broken down, resulting in nausea and vomiting.

Why is it important that the enzyme inhibitor disulfiram is specific?

- 1 It cannot disrupt other metabolic pathways.
- 2 It prevents ethanol from binding to the active site.
- 3 It is unlikely to cause unwanted side effects.
- 4 It inhibits aldehyde oxidase.

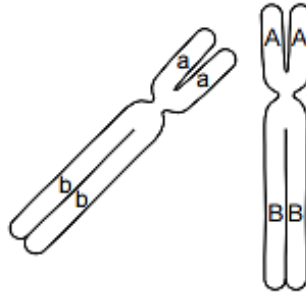
- A** 1, 2, 3 and 4  
**B** 1, 2 and 3 only  
**C** 1 and 3 only  
**D** 2 and 4 only

**7** In a multicellular organism, which of these statements about mitosis can help to explain the control of the mitotic cell cycle?

- 1 In most cells the genes initiating mitosis are not switched on.
- 2 Mitosis produces cells to replace damaged cells that cannot be repaired.
- 3 Mitosis transmits a complete copy of all the alleles in a cell to new cells.
- 4 Daughter cells formed by asexual reproduction develop from unspecialised cells.

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

- 8 The diagram shows two homologous chromosomes in early prophase I of meiosis in an animal cell. Two genes, A/a and B/b, whose loci occur on the homologous chromosomes are also shown.



Which row of diagrams is a possible representation of these chromosomes as they progress from anaphase I to prophase II?

	anaphase I	prophase II
<b>A</b>		
<b>B</b>		
<b>C</b>		
<b>D</b>		

- 9 The nucleic acids present in a cell of the bacterium *Escherichia coli* were analysed. Some of the results are shown in the table.

type of nucleic acid	number of different variants	number of molecules per cell	percentage of dry mass of cell
1	600	2500	2
2	60	160 000	3
3	2	20 000	21

Which row identifies each type of nucleic acid 1, 2 and 3?

	1	2	3
<b>A</b>	DNA	mRNA	tRNA
<b>B</b>	mRNA	tRNA	rRNA
<b>C</b>	rRNA	DNA	mRNA
<b>D</b>	tRNA	rRNA	DNA

- 10 How many of these statements about DNA polymerases are **correct**?

- 1 They transcribe DNA.
- 2 They synthesise DNA in the 3' to 5' direction.
- 3 They require a primer to function.
- 4 They require activated nucleotides.

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

- 11 What is the function of the enzyme RNA polymerase?

- A** to form a polypeptide using mRNA as a template  
**B** to form a strand of DNA using mRNA as a template  
**C** to form a strand of mRNA using DNA as a template  
**D** to form a strand of mRNA using tRNA as a template

- 12 The following sequence of bases shows a short section of linear DNA from which mRNA is transcribed.

TACTCACATTAG...

The table shows a number of mRNA codons and their corresponding amino acids.

codon	AGU	AUC	AUG	CAU	GUA	UAC	UAG	UCA
amino acid	serine	iso-leucine	methionine	histidine	valine	tyrosine	'stop'	serine

Which row shows how this short section of linear DNA would be translated into part of a polypeptide chain?

	tRNA anti-codon order	amino acid sequence
<b>A</b>	AUGAGUGUAAUC	methionine, serine, valine, iso-leucine
<b>B</b>	AUGAGUGUAAUC	tyrosine, serine, histidine, stop
<b>C</b>	UACUCACAUUAG	methionine, serine, valine, iso-leucine
<b>D</b>	UACUCACAUUAG	tyrosine, serine, histidine, stop

- 13 About 20% of all human pregnancies are estimated to be lost by spontaneous abortion (miscarriage). About half of these spontaneous abortions are associated with chromosome aberrations.

The table shows the percentage incidence of each type of chromosome aberration that was detected in spontaneous abortions associated with chromosome aberrations.

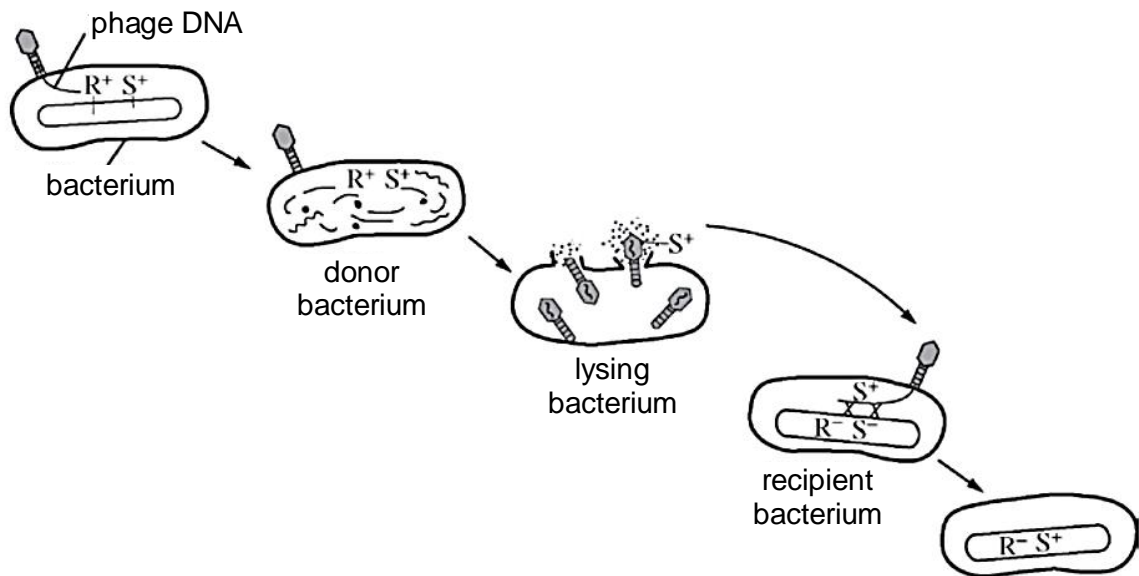
chromosome aberration	percentage incidence
trisomy ( $2n+1$ )	62
monosomy ( $2n-1$ )	18
triploidy ( $3n$ )	17
translocations	3

What may be concluded from these data?

- Numerical aberrations are much more likely to be associated with spontaneous abortions than are structural aberrations.
  - The occurrence of three sets of chromosomes has a similar percentage incidence as monosomy.
  - The presence of an extra chromosome is more likely to be associated with spontaneous abortion than is the lack of one chromosome.
- A** 1, 2 and 3  
**B** 1 and 2 only  
**C** 1 and 3 only  
**D** 2 and 3 only



- 14 The diagram below shows several steps in the gene transfer process between bacteria.



Which of the following statements explains how genetic variation in a population of bacteria may result from this process?

- A** Bacterial proteins are transferred from the donor bacterium to the recipient bacterium and recombine with the chromosome.
- B** The recipient bacterium incorporates the transduced genetic material into its own chromosome and synthesizes the corresponding proteins.
- C** The phage infection of the recipient bacterium and the introduction of the donor's DNA caused random mutations in the recipient's chromosome.
- D** DNA of the recipient's chromosome undergoes recombination with the donor's DNA, leading to a change in its genotype.

- 15 The only cells that an enveloped virus can infect are those whose cell surface membranes have specific receptors complementary to proteins in the virus envelope. The virus enters the cell by a type of endocytosis involving the protein clathrin, which is produced in the host cell.

The following are some of the events that follow attachment of an enveloped virus to a cell surface membrane.

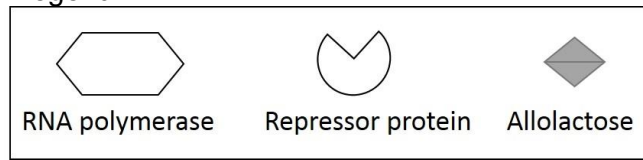
- 1 A vesicle containing a virus fuses with an endosome (cytoplasmic vesicle).
- 2 The virus is surrounded by its envelope, a membrane and a layer of clathrin.
- 3 An acid pH causes the viral envelope to fuse with the membrane of an endosome.
- 4 The protein clathrin produces a depression in a cell surface membrane.
- 5 Clathrin is removed and recycled.

What is the correct sequence of these events in order to leave the virus free of its envelope in the cytoplasm of an infected cell?

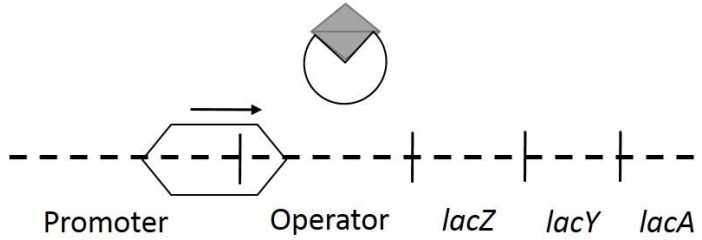
- A** 2 → 3 → 1 → 4 → 5  
**B** 2 → 4 → 5 → 3 → 1  
**C** 4 → 1 → 3 → 2 → 5  
**D** 4 → 2 → 5 → 1 → 3

16 Using the legend provided, which of the following correctly depicts the interactions of the components at the *lac* operon when lactose is absent from the medium?

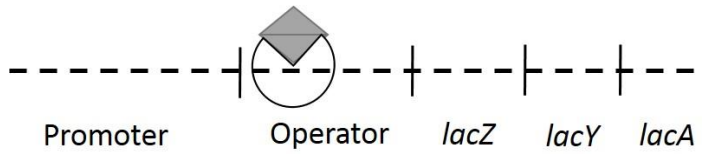
Legend:



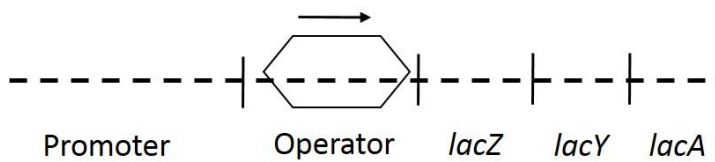
A



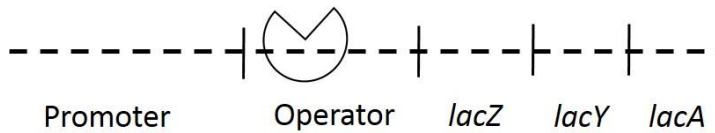
B



C



D



- 17 A type of bacteria caused fatalities in human. These strains of bacteria possess genes for a toxin not found in the other harmless strains.

In an attempt to find out how these genes can be transferred between bacteria, several experimental set-ups were carried out. The results are shown in the table below.

conditions	results
DNA isolated from virulent strain and incubated with harmless strain.	Some virulent strains observed.
Virulent and harmless strains of bacteria incubated in a container with no barrier.	Some virulent strains observed.
Virulent and harmless strains of bacteria incubated in a container but separated by physical membrane barrier.	No virulent strain found in the side with harmless bacteria.

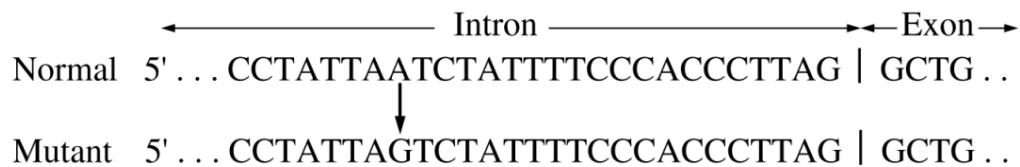
From the information provided only, which of the following gene transfer processes could have taken place?

- 1 transformation
- 2 conjugation
- 3 transduction

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

- 18 Portions of the DNA sequences and mutant  $\beta$ -globin genes are shown below.

The arrow ( $\downarrow$ ) indicates the single base substitution that occurred to result in the disease  $\beta$ -thalassaemia.



The most plausible explanation for the effects of the mutation is that

- A there was a change in the codon that affected the amino acid coded for.  
 B a recognition site for a restriction enzyme was generated, resulting in a DNA break.  
 C a nonsense mutation occurred to result in a truncated polypeptide.  
 D a new splice site was created, such that a portion of the intron was not removed.

- 19 One form of post-translational modification of a protein is the
- A methylation of the CpG islands.
  - B shuffling of exons to produce many types of mRNA from a single gene.
  - C removal of introns from the pre-mRNA.
  - D removal or modification of amino acids in the polypeptide.
- 20 Laboratory mice whose *p53* genes had been switched off developed tumours.

When their *p53* genes were switched on again, the tumour cells stopped dividing and died within a few days. Healthy cells in the mice were unaffected.

What do these observations suggest?

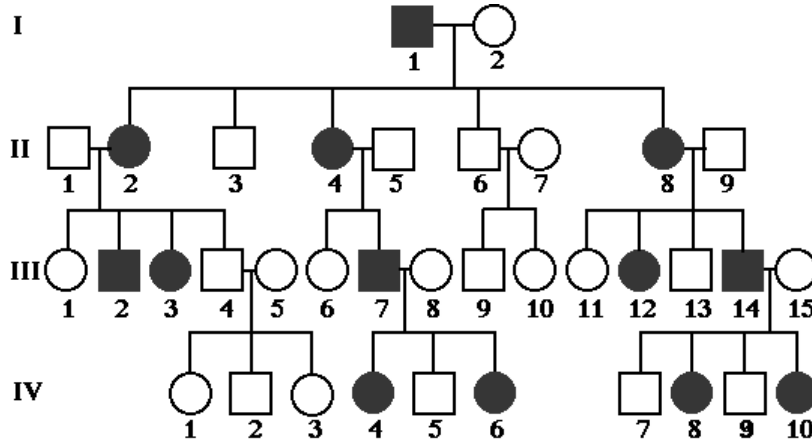
- A *p53* protein speeds up the mitotic cell cycle
  - B *p53* protein causes all cells to die
  - C the *p53* gene acts as a tumour suppressor gene
  - D the *p53* gene encourages the growth of tumours
- 21 In the breeding season, male Anole lizards court females by bobbing their heads up and down while displaying a colourful throat patch. Both characteristics are controlled by genes found on separate chromosomes. Anoles prefer to mate with lizards, which bob their heads fast and have red throat patches. These two alleles are dominant over their counterparts, slow bobbing and yellow throats.

A male lizard heterozygous for head bobbing and homozygous dominant for the red throat patch mates with a female that is also heterozygous for head bobbing but has yellow throat patch.

What percentage of the offspring has fast bobbing and red throat phenotype?

- A 25%
- B 50%
- C 75%
- D 100%

- 22 The inheritance of a genetic disease in a family is presented in a pedigree tree below.



What is the **most likely** type of inheritance shown?

- A autosomal dominant  
 B autosomal recessive  
 C sex-linked dominant  
 D sex-linked recessive
- 23 In a plant, three genes are known to be linked. The table below gives the recombination frequencies obtained from crosses involving pairs of these genes.

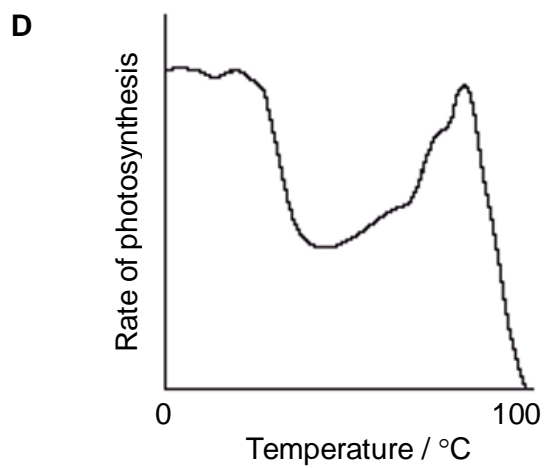
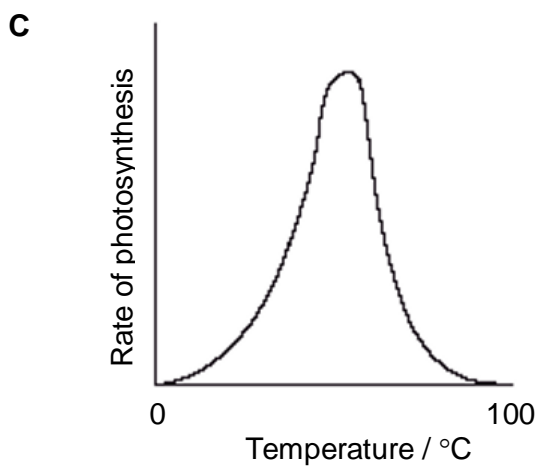
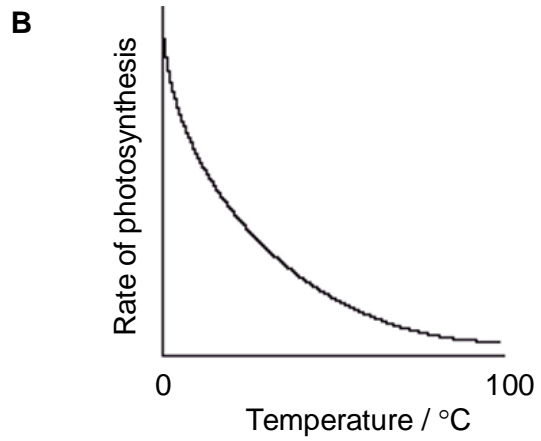
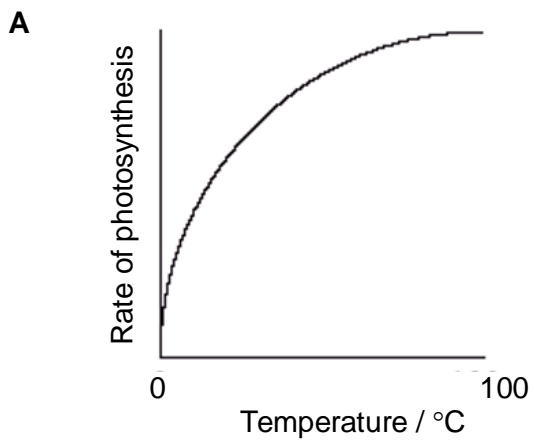
pair of linked genes	recombination frequency
colour of flowers (P) x appearance of fruit (Q)	0.43
appearance of fruit (Q) x presence of prickles (R)	0.17
presence of prickles (R) x colour of flowers (P)	0.26

- The chance of crossing over occurring between genes P and R will be lower than that of Q and R.
- Genes Q and R are 17 map units apart on the same chromosome.
- The order of the genes on the chromosome is P – R – Q.
- The recombination frequencies are obtained based on the proportion of recombinant offspring.

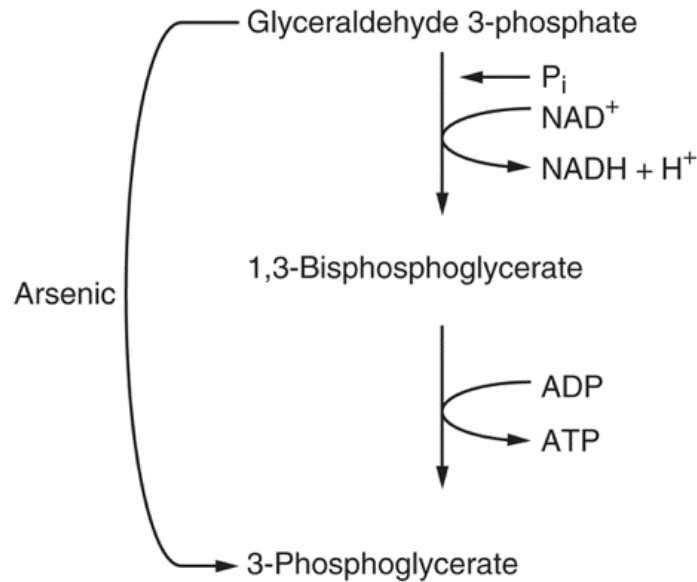
Based on the information, which of the above statement(s) is/are **false**?

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

- 24 Which graph best represents the effect of temperature on the rate of photosynthesis of a plant?



- 25 The diagram shows the effect of arsenic on the metabolism of glyceraldehyde-3-phosphate.

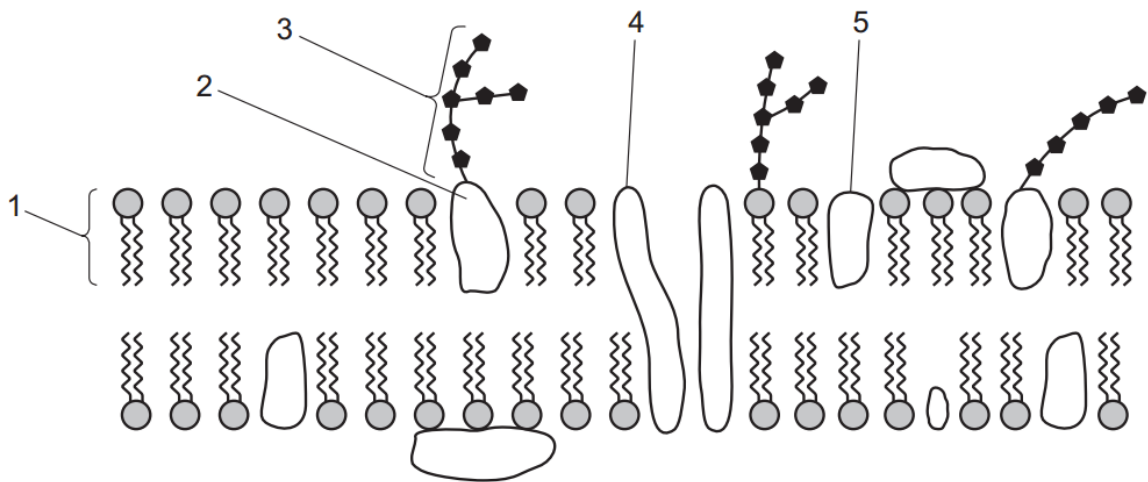


What is the net yield of ATP molecules from the glycolysis process involving 2 molecules of glucose in the presence of arsenic?

- A 0  
 B 1  
 C 2  
 D 4
- 26 For an action potential to occur,
- A  $Na^+$  influx must exceed  $K^+$  efflux.  
 B the membrane must not be in the relative refractory period.  
 C the stimulus must result in the exocytosis of neurotransmitters.  
 D voltage-gated potassium channels must be closed.
- 27 Caffeine is an inhibitor of phosphodiesterase. Therefore, the cells of a person who has recently consumed coffee would have increased levels of
- A ATP  
 B GTP  
 C AMP  
 D cAMP



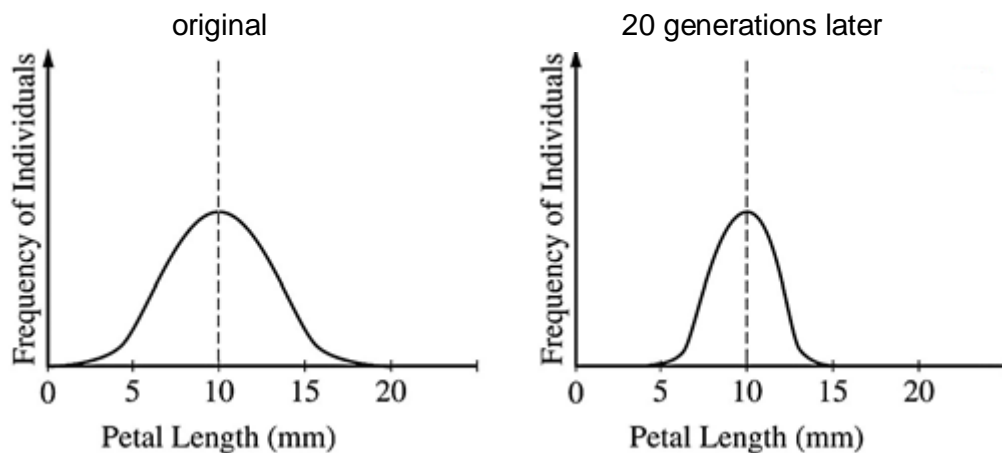
28 The diagram shows part of a cell surface membrane.



Which molecule(s) allow(s) the movement of hydrophilic substances across the membrane?

- A 1 only
  - B 4 only
  - C 2 and 5
  - D 4 and 5
- 29 A plant species arrives at a new island and are exposed to a new set of pollinators.

The diagram below shows the frequency distribution of petal length in the original colonising population and 20 generations later.



Which type of selection is shown in this example?

- A directional selection
- B disruptive selection
- C neutral selection
- D stabilising selection

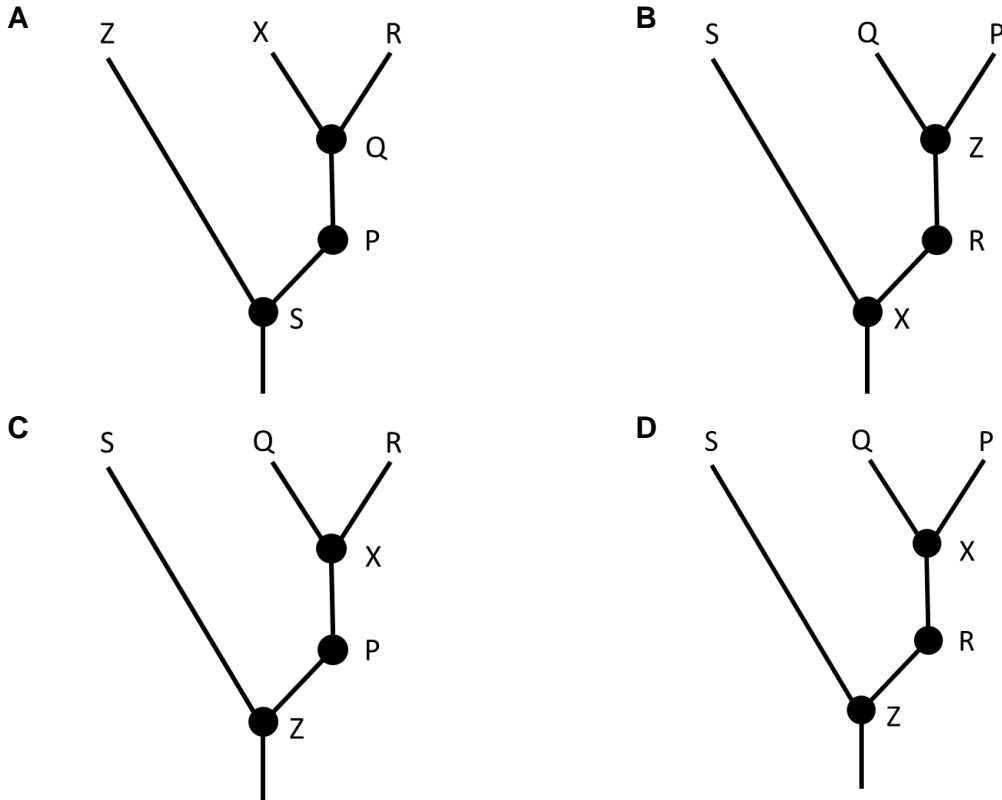
30 Q, P, R and S are related species of organisms.

Species X is an extinct recent common ancestor of species Q and R.

X, Q and R all evolved from species P.

Species S is the least related to the others, with extinct species Z being its most recent phylogenetic link to the other species.

Which of the following phylogenetic trees correctly represents the relationships described above?



31 When considering the neutral theory of molecular evolution, which of the following is a correct assumption of this model?

- A New alleles that confer a higher fitness level tend to increase in frequency over time in the population.
- B New alleles that confer a lower fitness level tend to decrease in frequency over time in the population.
- C New alleles that confer an advantage to the heterozygotes are maintained in the population.
- D New alleles that do not confer any effects on the fitness level tend to fluctuate in the population randomly.

- 32** The human protein hormone somatotrophin can be produced by genetic engineering using plasmid vectors.

Which of the following statements describe the advantages of using such plasmids?

- 1 A gene coding for somatotrophin from a cDNA library can be inserted into the plasmid.
- 2 The plasmid carrying the gene coding for somatotrophin could contain the promoter sequence of DNA that is found in human cells expressing the hormone.
- 3 A synthetic gene produced from knowledge of the amino acid sequence of somatotrophin can be inserted into the plasmid.

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

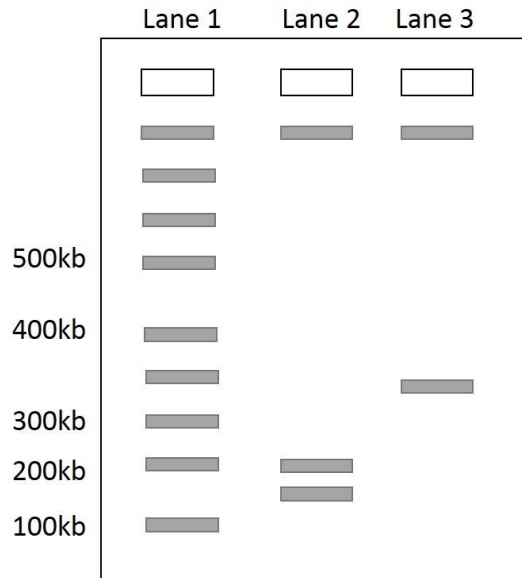
- 33** A polymerase chain reaction (PCR) amplification was performed on human genomic DNA.

Multiple products of varying sizes were obtained, including one of the expected size.

Which of the following modifications to the protocol is the most likely to eliminate the extra PCR products?

- A** increasing length of the primer  
**B** increasing the denaturation temperature from 94°C to 96°C  
**C** decreasing the annealing temperature from 56°C to 52°C  
**D** increasing the elongation temperature from 70°C to 74°C

- 34 The diagram below shows the results from a restriction digestion of a normal *CFTR* allele (lane 2) and a mutant *CFTR* allele (lane 3). Lane 1 contains the DNA ladder.



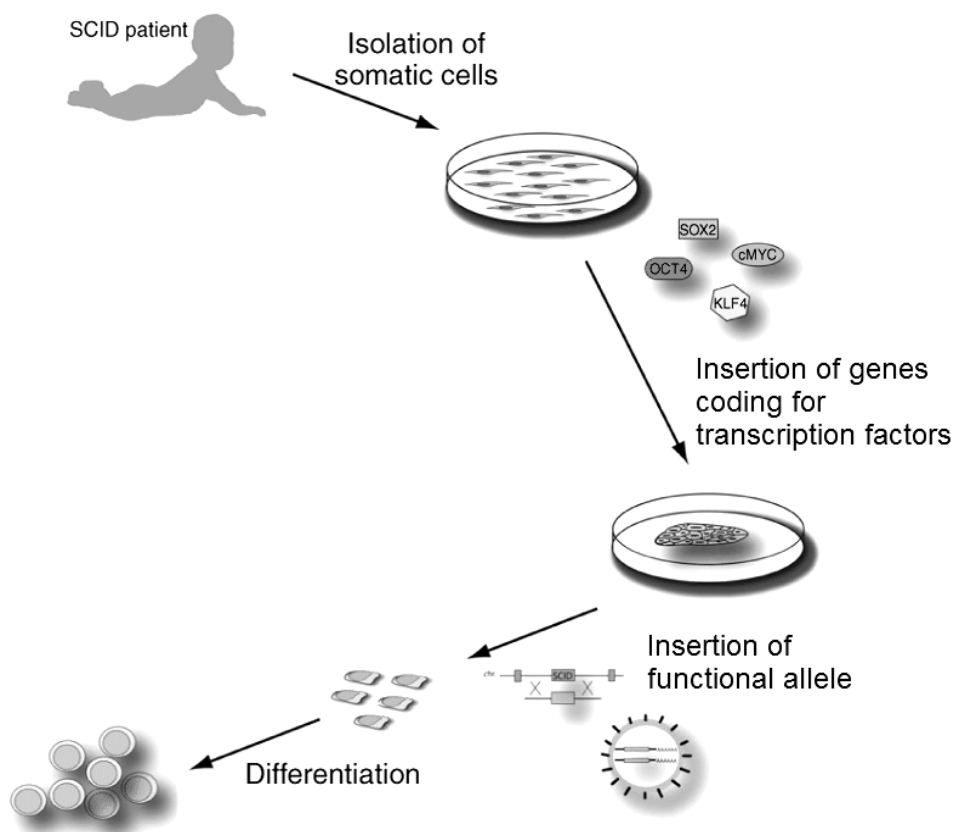
Based on the results shown, which of the following statements best describes the mutation that resulted in the mutant *CFTR* allele?

- A An additional restriction site was generated.  
 B One restriction site was lost.  
 C Two restriction sites were lost.  
 D The number of restriction sites remained unchanged.
- 35 Within its own environment, a particular cell line cannot be induced to produce a cell from a different cell line.

Which statement explains this?

- A Genes not required for a particular cell line are methylated.  
 B Genes not required for a particular cell line are removed by enzymes.  
 C Only pre-mRNA that is required for a particular cell line is processed.  
 D Stem cells have only the genes required for their particular cell line.

- 36 In 2006, scientists have discovered a means to convert somatic cells, such as skin cells, into pluripotent stem cells. By inserting four specific genes which code for transcription factors, somatic cells are able to de-differentiate and achieve pluripotency. Such pluripotent stem cells may one day be used for gene therapy to treat diseases such as severe combined immunodeficiency (SCID), as shown in the following diagram.



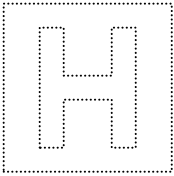
Which statement shows one benefit of using these novel pluripotent stem cells over embryonic stem cells?

- A A functional copy of the allele could be inserted into these novel stem cells using a retroviral vector during gene therapy.
- B These novel stem cells have the potential to differentiate into more types of cells, hence they can be used to treat a greater variety of diseases.
- C These novel stem cells will not be rejected by the host after being transplanted back into the body.
- D These novel stem cells are able to maintain the undifferentiated state for long periods of time due to the insertion of additional genes.

- 37** Research into gene therapy that targets germ cells (sperm and ova) has raised some concerns.
- 1 The inserted gene may interfere with fetal development in unexpected ways.
  - 2 Developing babies cannot choose to have gene therapy.
  - 3 The inserted gene could prevent the inheritance of genetic diseases.

Which concerns are ethical reasons against the use of germ cell gene therapy?

- A 1, 2 and 3
  - B 1 and 2 only
  - C 1 and 3 only
  - D 2 and 3 only
- 38** In a callus culture,
- A a high cytokinin to auxin ratio results in root formation.
  - B a low cytokinin to auxin ratio results in root formation.
  - C only auxin is required to induce shoot and root formation.
  - D only cytokinin is required to induce shoot and root formation.
- 39** Why can improved varieties of plants and animals, used as human food, be developed more quickly by genetic engineering than by traditional selective breeding methods?
- A Genetically engineered organisms mature more quickly and breed sooner.
  - B The existing desirable features of the plants or animals are mostly unchanged.
  - C The introduced genes can improve the quality of the food produced.
  - D The organisms used for genetic engineering are already used for food.
- 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.



INNOVA JUNIOR COLLEGE  
JC2 PRELIMINARY EXAMINATION  
in preparation for General Certificate of Education Advanced Level  
**Higher 2**

CANDIDATE  
NAME

**MARK SCHEME**

CLASS

INDEX NUMBER

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**9648/01**

Paper 1 Multiple Choice

**30 August 2016**

**1 hour 15 minutes**

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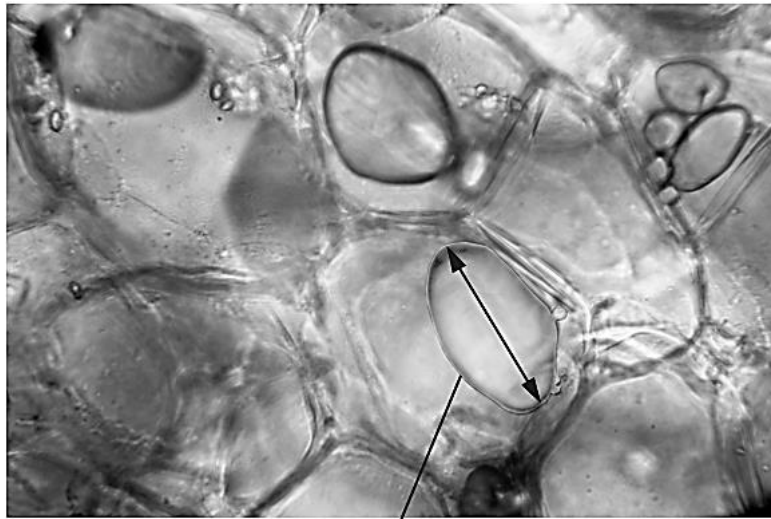
The use of an approved scientific calculator is expected, where appropriate.

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This document consists of **22** printed pages.



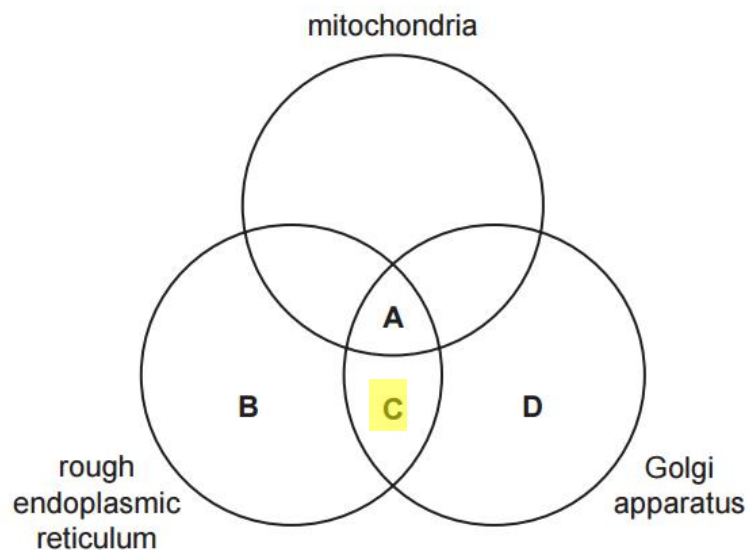
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Starch grain A

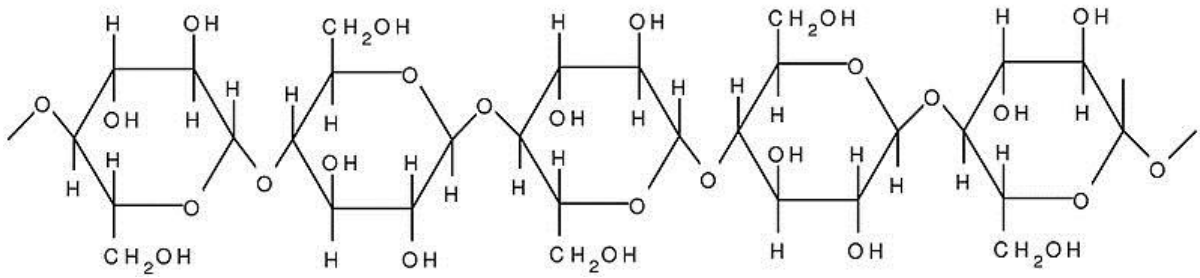
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- 2 Which of the following organelle(s) is/are directly required for the formation of the hydrolytic enzymes found in lysosomes?



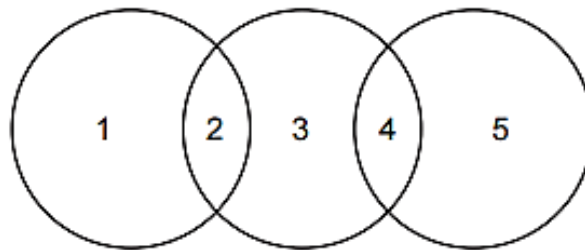


- 3 The figure below shows a portion of a polymer.



Which statement is **true** about the polymer?

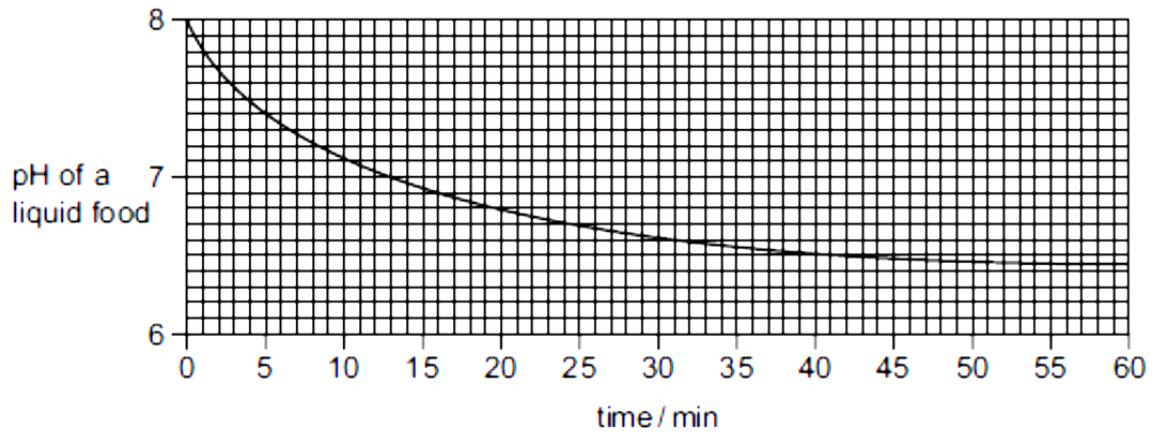
- A** The polymer will assume a helical structure.  
**B** The polymer can exist in both branched and unbranched forms.  
**C** The orientation of the monomer will result in a straight chain polymer.  
**D** The monomers are able to form  $\alpha$  (1-6) glycosidic bonds with one another.
- 4 The diagram shows the relationship between the levels of protein structure and bonds.



Which row is **correct**?

	1	2	3	4	5
<b>A</b>	primary	peptide	secondary	ionic	tertiary
<b>B</b>	secondary	hydrogen	tertiary	peptide	primary
<b>C</b>	tertiary	ionic	primary	peptide	quaternary
<b>D</b>	quaternary	ionic	tertiary	ionic	secondary

- 5 Lipase is a digestive enzyme produced by the pancreas that catalyses the hydrolysis of dietary lipids. The table shows how the pH of a liquid food containing a high proportion of lipids decreases over time.



Which of the following statements are possible explanations of the results of the experiment between 50 and 60 minutes?

- 1 Enzyme concentration becomes the limiting factor.
  - 2 Substrate concentration becomes the limiting factor.
  - 3 All the enzyme active sites are saturated.
  - 4 Denaturation of the enzyme by the products.
  - 5 Products are acting as inhibitors.
- A** 1, 2 and 3  
**B** 1, 4 and 5  
**C** 2, 3 and 4  
**D** 2, 4 and 5

6 Specific enzyme inhibitors inhibit only one enzyme.

The drug disulfiram, which is used as a treatment for alcoholism, is a specific inhibitor of acetaldehyde dehydrogenase. Acetaldehyde dehydrogenase is involved in the detoxification of ethanol. As a result of inhibition by disulfiram, any ethanol that is present in the system can only be partly broken down, resulting in nausea and vomiting.

Why is it important that the enzyme inhibitor disulfiram is specific?

- 1 It cannot disrupt other metabolic pathways.
- 2 It prevents ethanol from binding to the active site.
- 3 It is unlikely to cause unwanted side effects.
- 4 It inhibits aldehyde oxidase.

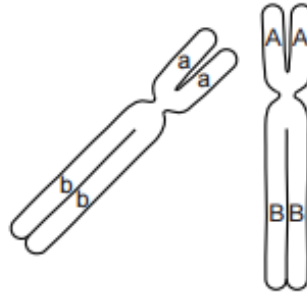
- A** 1, 2, 3 and 4  
**B** 1, 2 and 3 only  
**C** 1 and 3 only  
**D** 2 and 4 only

7 In a multicellular organism, which of these statements about mitosis can help to explain the control of the mitotic cell cycle?

- 1 In most cells the genes initiating mitosis are not switched on.
- 2 Mitosis produces cells to replace damaged cells that cannot be repaired.
- 3 Mitosis transmits a complete copy of all the alleles in a cell to new cells.
- 4 Daughter cells formed by asexual reproduction develop from un specialised cells.

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

- 8 The diagram shows two homologous chromosomes in early prophase I of meiosis in an animal cell. Two genes, A/a and B/b, whose loci occur on the homologous chromosomes are also shown.



Which row of diagrams is a possible representation of these chromosomes as they progress from anaphase I to prophase II?

	anaphase I	prophase II
<b>A</b>		
<b>B</b>		
<b>C</b>		
<b>D</b>		

- 9 The nucleic acids present in a cell of the bacterium *Escherichia coli* were analysed. Some of the results are shown in the table.

type of nucleic acid	number of different variants	number of molecules per cell	percentage of dry mass of cell
1	600	2500	2
2	60	160 000	3
3	2	20 000	21

Which row identifies each type of nucleic acid 1, 2 and 3?

	1	2	3
<b>A</b>	DNA	mRNA	tRNA
<b>B</b>	mRNA	tRNA	rRNA
<b>C</b>	rRNA	DNA	mRNA
<b>D</b>	tRNA	rRNA	DNA

- 10 How many of these statements about DNA polymerases are **correct**?

- 1 They transcribe DNA.
- 2 They synthesise DNA in the 3' to 5' direction.
- 3 They require a primer to function.
- 4 They require activated nucleotides.

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

- 11 What is the function of the enzyme RNA polymerase?

- A** to form a polypeptide using mRNA as a template  
**B** to form a strand of DNA using mRNA as a template  
**C** to form a strand of mRNA using DNA as a template  
**D** to form a strand of mRNA using tRNA as a template

- 12 The following sequence of bases shows a short section of linear DNA from which mRNA is transcribed.

TACTCACATTAG...

The table shows a number of mRNA codons and their corresponding amino acids.

codon	AGU	AUC	AUG	CAU	GUA	UAC	UAG	UCA
amino acid	serine	iso-leucine	methionine	histidine	valine	tyrosine	'stop'	serine

Which row shows how this short section of linear DNA would be translated into part of a polypeptide chain?

	tRNA anti-codon order	amino acid sequence
<b>A</b>	AUGAGUGUAAUC	methionine, serine, valine, iso-leucine
<b>B</b>	AUGAGUGUAAUC	tyrosine, serine, histidine, stop
<b>C</b>	UACUCACAUUAG	methionine, serine, valine, iso-leucine
<b>D</b>	UACUCACAUUAG	tyrosine, serine, histidine, stop

- 13 About 20% of all human pregnancies are estimated to be lost by spontaneous abortion (miscarriage). About half of these spontaneous abortions are associated with chromosome aberrations.

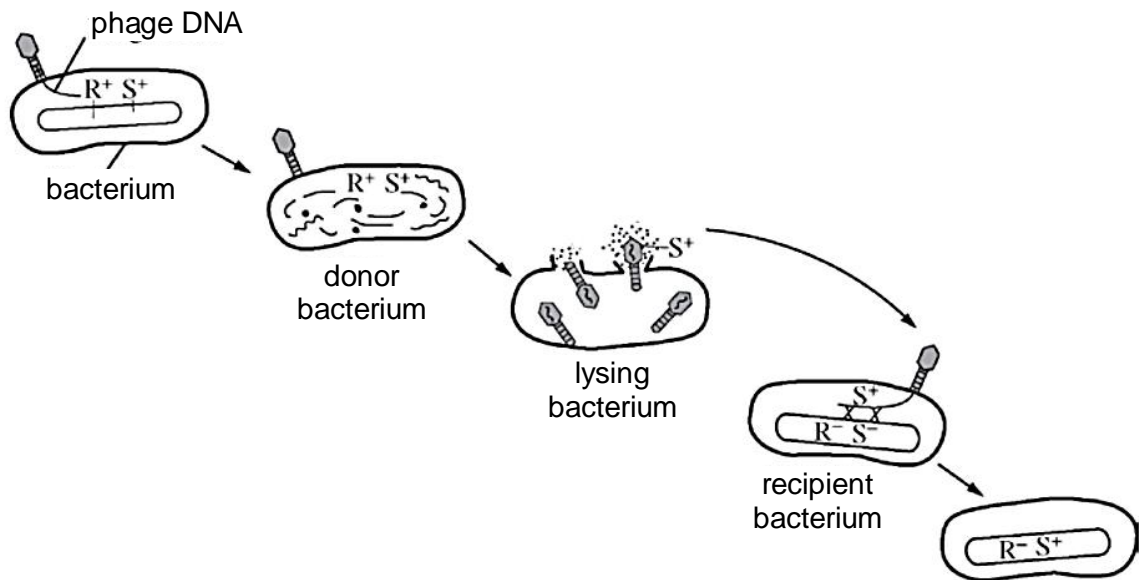
The table shows the percentage incidence of each type of chromosome aberration that was detected in spontaneous abortions associated with chromosome aberrations.

chromosome aberration	percentage incidence
trisomy ( $2n+1$ )	62
monosomy ( $2n-1$ )	18
triploidy ( $3n$ )	17
translocations	3

What may be concluded from these data?

- Numerical aberrations are much more likely to be associated with spontaneous abortions than are structural aberrations.
  - The occurrence of three sets of chromosomes has a similar percentage incidence as monosomy.
  - The presence of an extra chromosome is more likely to be associated with spontaneous abortion than is the lack of one chromosome.
- A** 1, 2 and 3  
**B** 1 and 2 only  
**C** 1 and 3 only  
**D** 2 and 3 only

14 The diagram below shows several steps in the gene transfer process between bacteria.



Which of the following statements explain how genetic variation in a population of bacteria may result from this process?

- A** Bacterial proteins are transferred from the donor bacterium to the recipient bacterium and recombine with the chromosome.
- B** The recipient bacterium incorporates the transduced genetic material into its own chromosome and synthesizes the corresponding proteins.
- C** The phage infection of the recipient bacterium and the introduction of the donor's DNA caused random mutations in the recipient's chromosome.
- D** DNA of the recipient's chromosome undergoes recombination with the donor's DNA, leading to a change in its genotype.

- 15 The only cells that an enveloped virus can infect are those whose cell surface membranes have specific receptors complementary to proteins in the virus envelope. The virus enters the cell by a type of endocytosis involving the protein clathrin, which is produced in the host cell.

The following are some of the events that follow attachment of an enveloped virus to a cell surface membrane.

- 1 A vesicle containing a virus fuses with an endosome (cytoplasmic vesicle).
- 2 The virus is surrounded by its envelope, a membrane and a layer of clathrin.
- 3 An acid pH causes the viral envelope to fuse with the membrane of an endosome.
- 4 The protein clathrin produces a depression in a cell surface membrane.
- 5 Clathrin is removed and recycled.

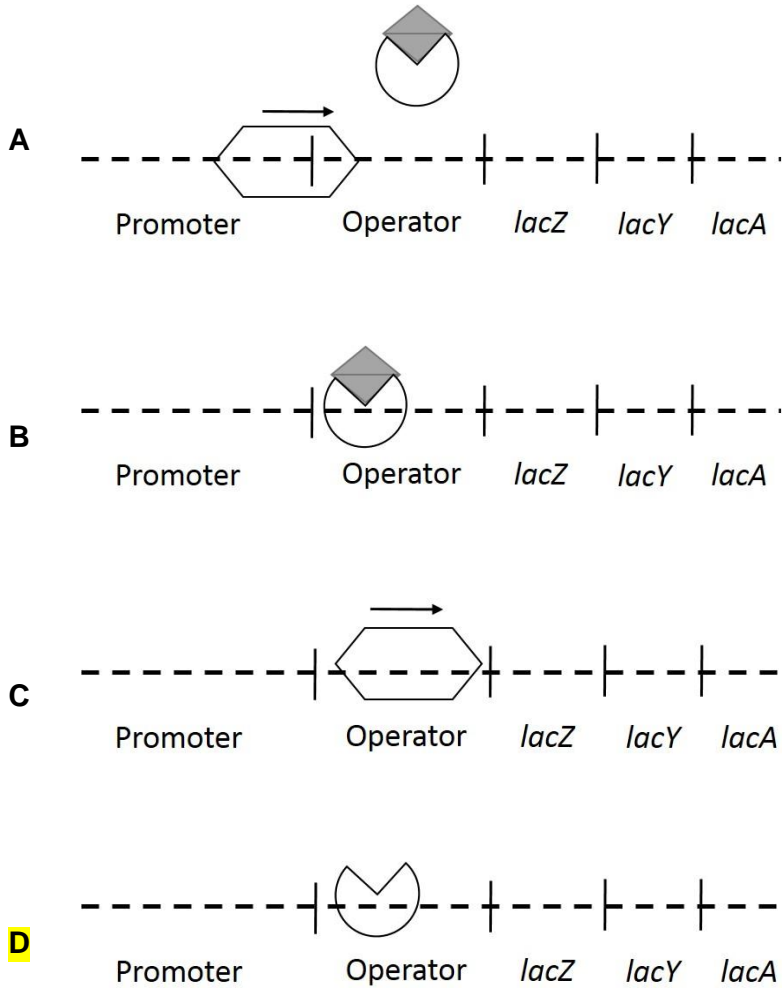
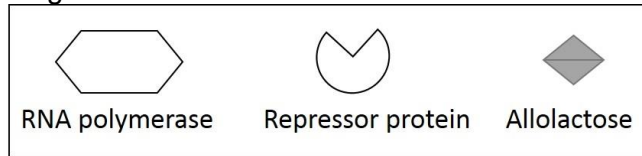
What is the correct sequence of these events in order to leave the virus free of its envelope in the cytoplasm of an infected cell?

- A** 2 → 3 → 1 → 4 → 5  
**B** 2 → 4 → 5 → 3 → 1  
**C** 4 → 1 → 3 → 2 → 5  
**D** 4 → 2 → 5 → 1 → 3



- 16 Using the legend provided, which of the following correctly depicts the interactions of the components at the *lac* operon when lactose is absent from the medium?

Legend:



- 17 A type of bacteria caused fatalities in human. These strains of bacteria possess genes for a toxin not found in the other harmless strains.

In an attempt to find out how these genes can be transferred between bacteria, several experimental set-ups were carried out. The results are shown in the table below.

Conditions	Results
DNA isolated from virulent strain and incubated with harmless strain.	Some virulent strains observed.
Virulent and harmless strains of bacteria incubated in a container with no barrier.	Some virulent strains observed.
Virulent and harmless strains of bacteria incubated in a container but separated by physical membrane barrier.	No virulent strain found in the side with harmless bacteria.

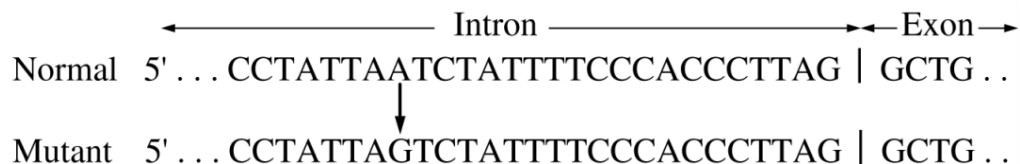
From the information provided only, which of the following gene transfer processes could have taken place?

- 1 transformation
- 2 conjugation
- 3 transduction

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

- 18 Portions of the DNA sequences and mutant  $\beta$ -globin genes are shown below.

The arrow ( $\downarrow$ ) indicates the single base substitution that occurred to result in the disease  $\beta$ -thalassaemia.



The most plausible explanation for the effects of the mutation is that

- A there was a change in the codon that affected the amino acid coded for.  
 B a recognition site for a restriction enzyme was generated, resulting in a DNA break.  
 C a nonsense mutation occurred to result in a truncated polypeptide.  
 D a new splice site was created, such that a portion of the intron was not removed.

- 19 One form of post-translational modification of a protein is the
- A methylation of the CpG islands
  - B shuffling of exons to produce many types of mRNA from a single gene
  - C removal of introns from the pre-mRNA
  - D** removal or modification of amino acids in the polypeptide
- 20 Laboratory mice whose *p53* genes had been switched off developed tumours.

When their *p53* genes were switched on again, the tumour cells stopped dividing and died within a few days. Healthy cells in the mice were unaffected.

What do these observations suggest?

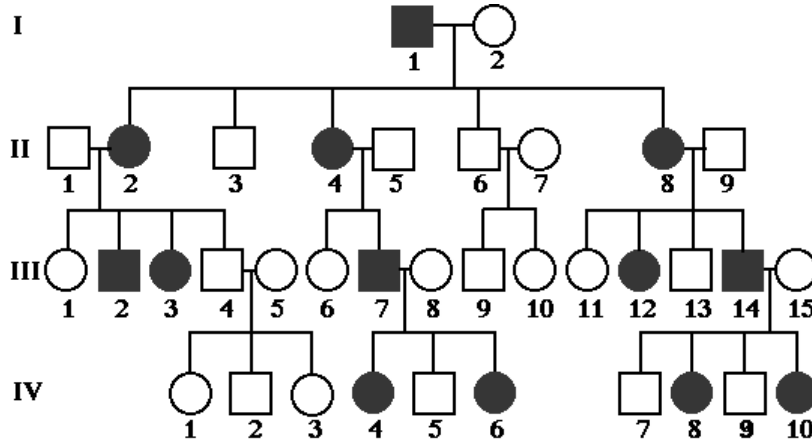
- A *p53* protein speeds up the mitotic cell cycle
  - B *p53* protein causes all cells to die
  - C** the *p53* gene acts as a tumour suppressor gene
  - D the *p53* gene encourages the growth of tumours
- 21 In the breeding season, male Anole lizards court females by bobbing their heads up and down while displaying a colourful throat patch. Both characteristics are controlled by genes found on separate chromosomes. Anoles prefer to mate with lizards, which bob their heads fast and have red throat patches. These two alleles are dominant over their counterparts, slow bobbing and yellow throats.

A male lizard heterozygous for head bobbing and homozygous dominant for the red throat patch mates with a female that is also heterozygous for head bobbing but has yellow throat patch.

What percentage of the offspring has fast bobbing and red throat phenotype?

- A 25%
- B 50%
- C** 75%
- D 100%

- 22 The inheritance of a genetic disease in a family is presented in a pedigree tree below.



What is the **most likely** type of inheritance shown?

- A autosomal dominant
  - B autosomal recessive
  - C** sex-linked dominant
  - D sex-linked recessive
- 23 In a plant, three genes are known to be linked. The table below gives the recombination frequencies obtained from crosses involving pairs of these genes.

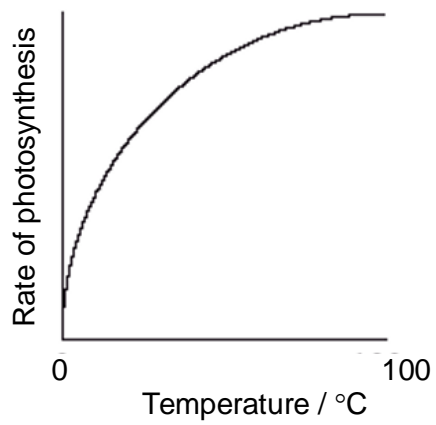
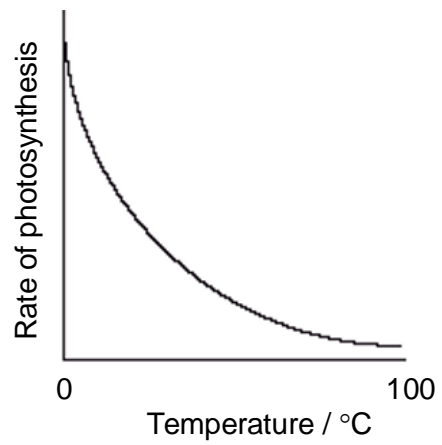
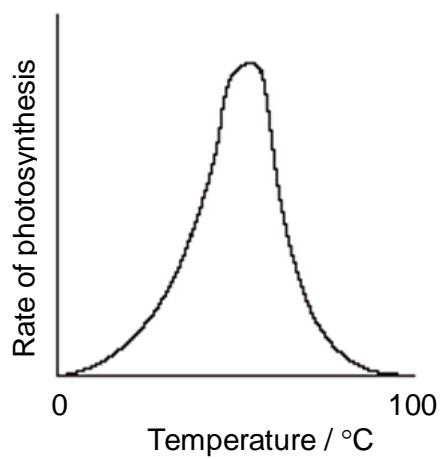
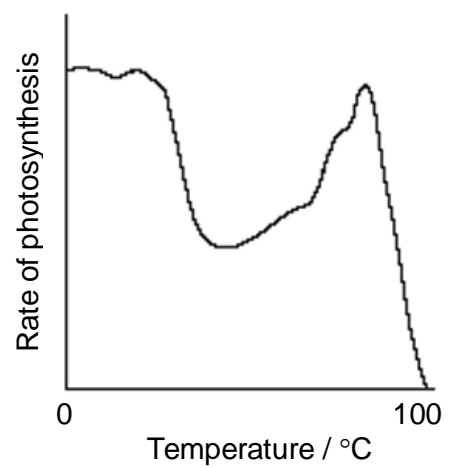
pair of linked genes	recombination frequency
colour of flowers (P) x appearance of fruit (Q)	0.43
appearance of fruit (Q) x presence of prickles (R)	0.17
presence of prickles (R) x colour of flowers (P)	0.26

- 1 The chance of crossing over occurring between genes P and R will be lower than that of Q and R.
- 2 Genes Q and R are 17 map units apart on the same chromosome.
- 3 The order of the genes on the chromosome is P – R – Q.
- 4 The recombination frequencies are obtained based on the proportion of recombinant offspring.

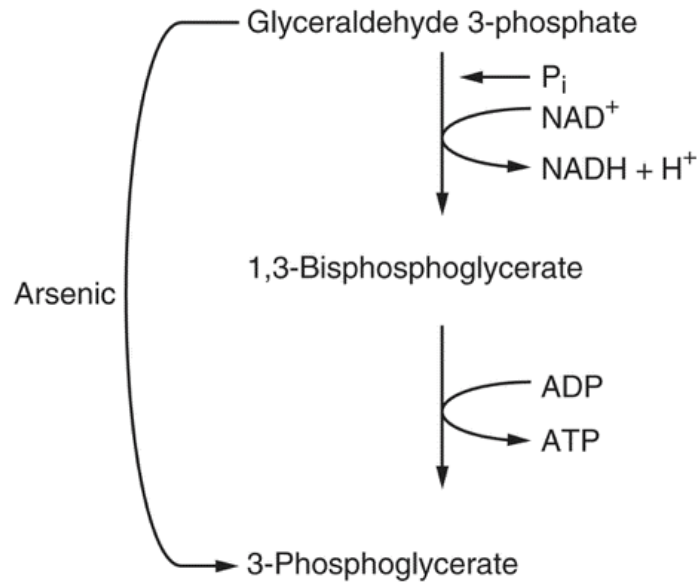
Based on the information, which of the above statement(s) is/are **false**?

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

- 24 Which graph best represents the effect of temperature on the rate of photosynthesis of a plant?

**A****B****C****D**

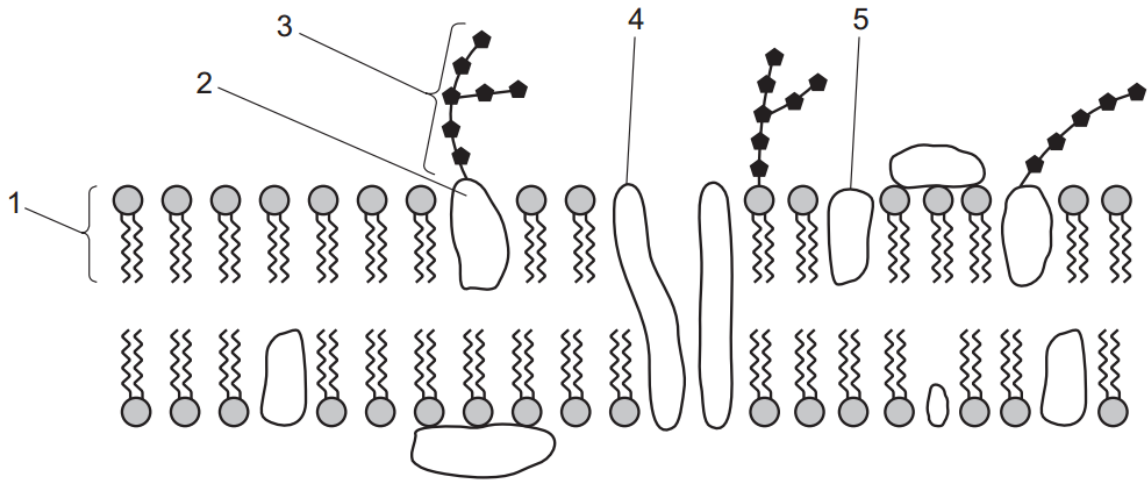
- 25 The diagram shows the effect of arsenic on the metabolism of glyceraldehyde-3-phosphate.



What is the net yield of ATP molecules from the glycolysis process involving 2 molecules of glucose in the presence of arsenic?

- A** 0  
**B** 1  
**C** 2  
**D** 4
- 26 For an action potential to occur,
- A**  $\text{Na}^+$  influx must exceed  $\text{K}^+$  efflux.  
**B** the membrane must not be in the relative refractory period.  
**C** the stimulus must result in the exocytosis of neurotransmitters.  
**D** voltage-gated potassium channels must be closed.
- 27 Caffeine is an inhibitor of phosphodiesterase. Therefore, the cells of a person who has recently consumed coffee would have increased levels of
- A** ATP  
**B** GTP  
**C** AMP  
**D** cAMP

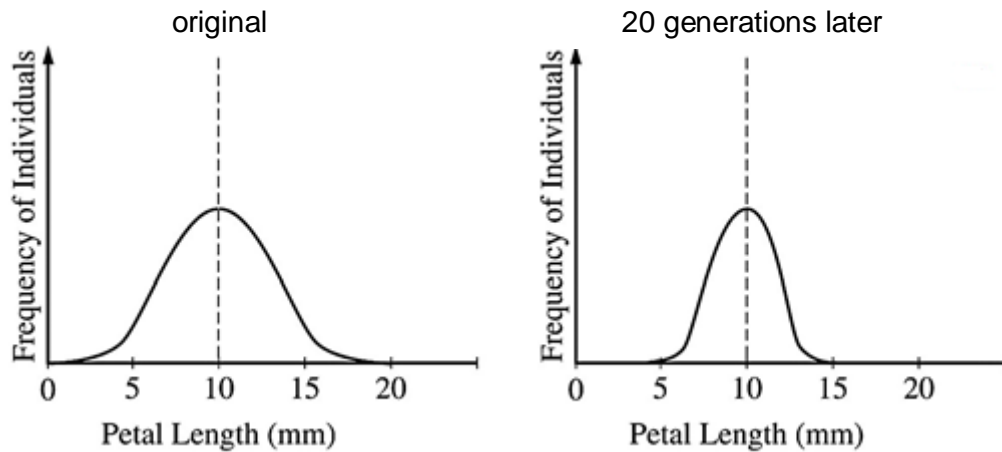
28 The diagram shows part of a cell surface membrane.



Which molecule(s) allow(s) the movement of hydrophilic substances across the membrane?

- A 1 only
  - B 4 only**
  - C 2 and 5
  - D 4 and 5
- 29 A plant species arrives at a new island and are exposed to a new set of pollinators.

The diagram below shows the frequency distribution of petal length in the original colonising population and 20 generations later.



Which type of selection is shown in this example?

- A directional selection
- B disruptive selection
- C neutral selection
- D stabilising selection**

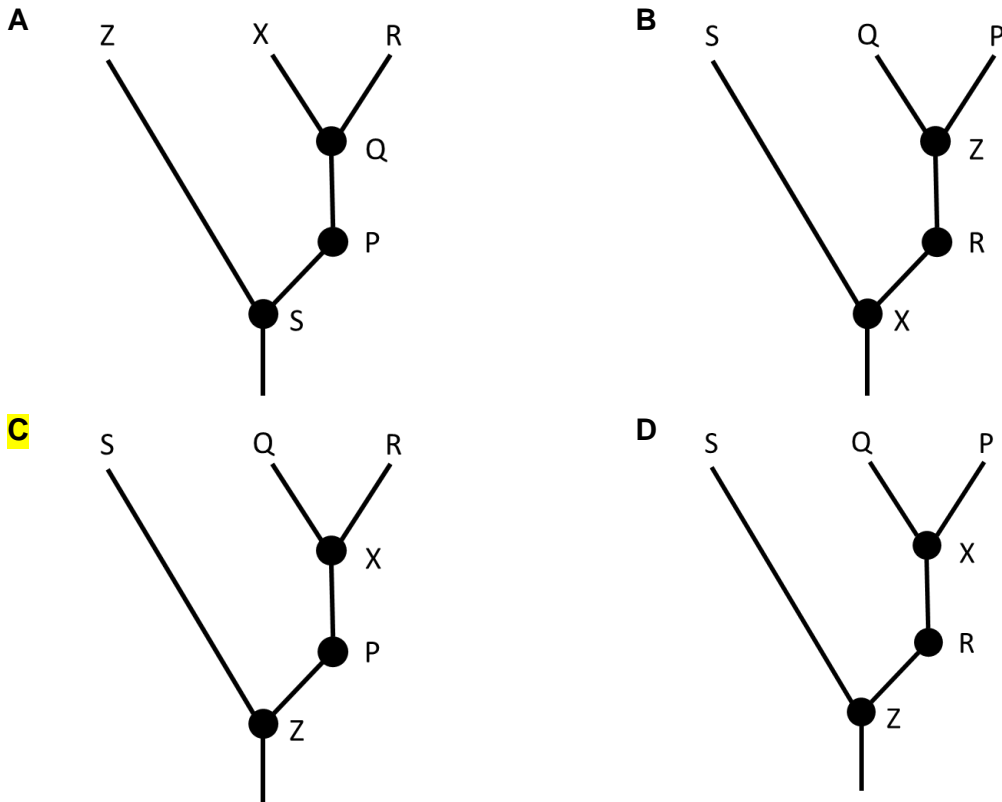
30 Q, P, R and S are related species of organisms.

Species X is an extinct recent common ancestor of species Q and R.

X, Q and R all evolved from species P.

Species S is the least related to the others, with extinct species Z being its most recent phylogenetic link to the other species.

Which of the following phylogenetic trees correctly represents the relationships described above?



31 When considering the neutral theory of molecular evolution, which of the following is a correct assumption of this model?

- A** New alleles that confer a higher fitness level tend to increase in frequency over time in the population.
- B** New alleles that confer a lower fitness level tend to decrease in frequency over time in the population.
- C** New alleles that confer an advantage to the heterozygotes are maintained in the population.
- D** New alleles that do not confer any effects on the fitness level tend to fluctuate in the population randomly.



- 32 The human protein hormone somatotrophin can be produced by genetic engineering using plasmid vectors.

Which statements describe the advantages of using such plasmids?

- 1 A gene coding for somatotrophin from a cDNA library can be inserted into the plasmid.
- 2 The plasmid carrying the gene coding for somatotrophin could contain the promoter sequence of DNA that is found in human cells expressing the hormone.
- 3 A synthetic gene produced from knowledge of the amino acid sequence of somatotrophin can be inserted into the plasmid.

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

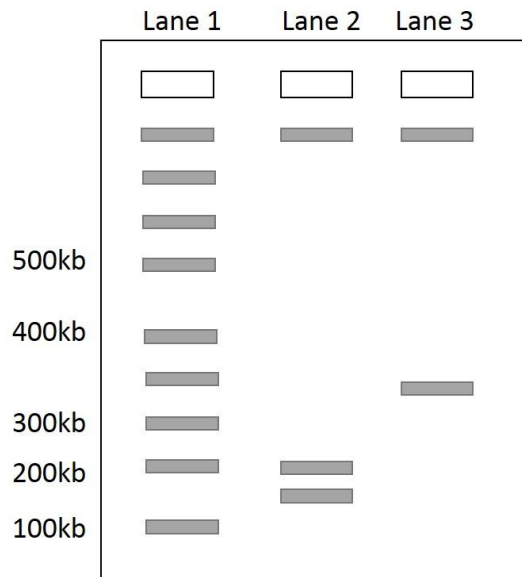
- 33 A polymerase chain reaction (PCR) amplification was performed on human genomic DNA.

Multiple products of varying sizes were obtained, including one of the expected size.

Which of the following modifications to the protocol is the most likely to eliminate the extra PCR products?

- A** increasing length of the primer  
B increasing the denaturation temperature from 94°C to 96°C  
C decreasing the annealing temperature from 56°C to 52°C  
D increasing the elongation temperature from 70°C to 74°C

- 34 The diagram below shows the results from a restriction digestion of a normal CFTR allele (lane 2) and a mutant CFTR allele (lane 3). Lane 1 contains the DNA ladder.



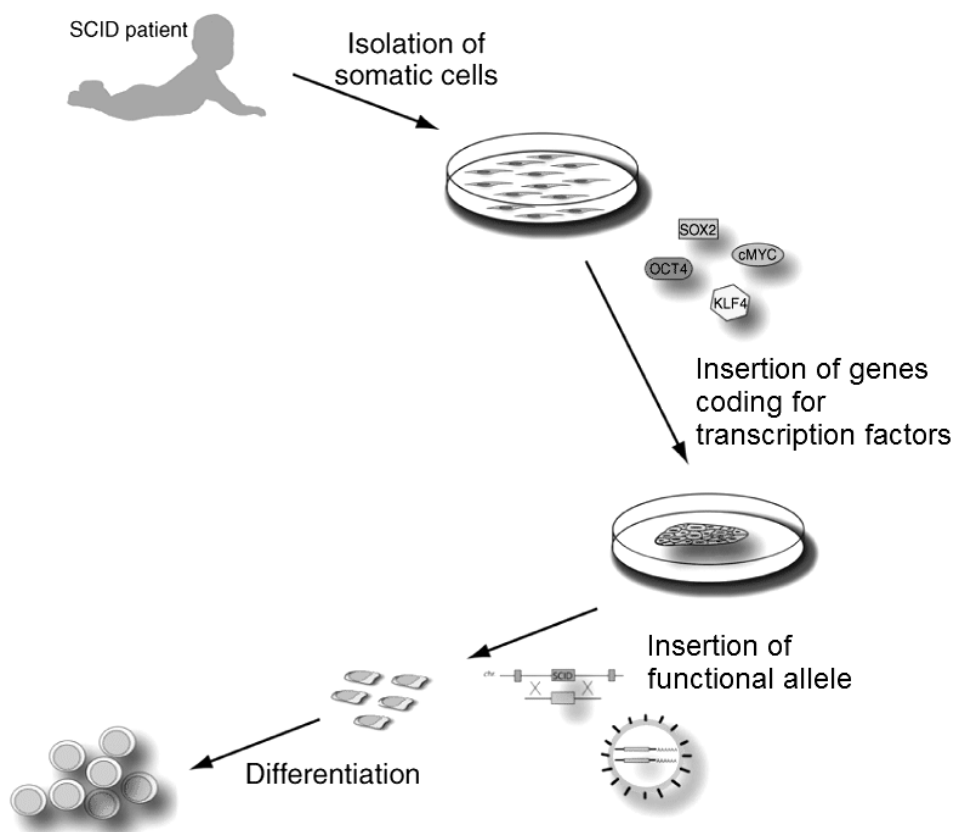
Based on the results shown, which of the following statements best describes the mutation that resulted in the mutant CFTR allele?

- A An additional restriction site was generated.
  - B** One restriction site was lost.
  - C Two restriction sites were lost.
  - D The number of restriction sites remained unchanged.
- 35 Within its own environment, a particular cell line cannot be induced to produce a cell from a different cell line.

Which statement explains this?

- A** Genes not required for a particular cell line are methylated.
- B Genes not required for a particular cell line are removed by enzymes.
- C Only pre-mRNA that is required for a particular cell line is processed.
- D Stem cells have only the genes required for their particular cell line.

- 36** In 2006, scientists have discovered a means to convert somatic cells, such as skin cells, into pluripotent stem cells. By inserting four specific genes which code for transcription factors, somatic cells are able to de-differentiate and achieve pluripotency. Such pluripotent stem cells may one day be used for gene therapy to treat diseases such as severe combined immunodeficiency (SCID), as shown in the following diagram.



Which statement shows one benefit of using these novel pluripotent stem cells over embryonic stem cells?

- A** A functional copy of the allele could be inserted into these novel stem cells using a retroviral vector during gene therapy.
- B** These novel stem cells have the potential to differentiate into more types of cells, hence they can be used to treat a greater variety of diseases.
- C** These novel stem cells will not be rejected by the host after being transplanted back into the body.
- D** These novel stem cells are able to maintain the undifferentiated state for long periods of time due to the insertion of additional genes.

- 37 Research into gene therapy that targets germ cells (sperm and ova) has raised some concerns.
- 1 The inserted gene may interfere with fetal development in unexpected ways.
  - 2 Developing babies cannot choose to have gene therapy.
  - 3 The inserted gene could prevent the inheritance of genetic diseases.

Which concerns are ethical reasons against the use of germ cell gene therapy?

- A 1, 2 and 3  
B 1 and 2 only  
C 1 and 3 only  
D 2 and 3 only
- 38 In a callus culture,
- A a high cytokinin to auxin ratio results in root formation.  
B a low cytokinin to auxin ratio results in root formation.  
C only auxin is required to induce shoot and root formation.  
D only cytokinin is required to induce shoot and root formation.
- 39 Why can improved varieties of plants and animals, used as human food, be developed more quickly by genetic engineering than by traditional selective breeding methods?
- A Genetically engineered organisms mature more quickly and breed sooner.  
B The existing desirable features of the plants or animals are mostly unchanged.  
C The introduced genes can improve the quality of the food produced.  
D The organisms used for genetic engineering are already used for food.
- 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.

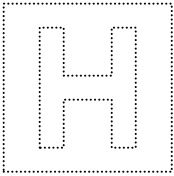
2016 JC2 Prelim  
9648 H2 Biology  
Paper 1  
Suggested Answers

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

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

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

Qn	Ans
31	D
32	C
33	A
34	B
35	A
36	C
37	B
38	B
39	A
40	A



**INNOVA JUNIOR COLLEGE**  
**JC 2 PRELIMINARY EXAMINATION**  
 in preparation for General Certificate of Education Advanced Level  
**Higher 2**

CANDIDATE NAME

CLASS  INDEX NUMBER

**BIOLOGY**

**9648/02**

Paper 2 Core Paper

**19 August 2016**

**2 hours**

Additional Materials: Answer Paper  
 Cover Page

**READ THESE INSTRUCTIONS FIRST**

Write your name and class on all the work you hand in.  
 Write in dark blue or black pen on both sides of the paper.  
 You may use a soft pencil for any diagrams, graphs or rough working.  
 Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A**  
 Answer **all** questions.

**Section B**  
 Answer **one** question.

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
<b>Section A</b>	
<b>1</b>	<b>20</b>
<b>2</b>	<b>11</b>
<b>3</b>	<b>12</b>
<b>4</b>	<b>12</b>
<b>5</b>	<b>13</b>
<b>6</b>	<b>12</b>
<b>Section B</b>	
<b>7 / 8</b>	<b>20</b>
<b>Total</b>	<b>100</b>

This document consists of **18** printed pages.



**Section A**Answer **all** questions.

1 A protease is an enzyme that digests protein.

(a) With the aid of a diagram, describe the reaction catalysed by protease.

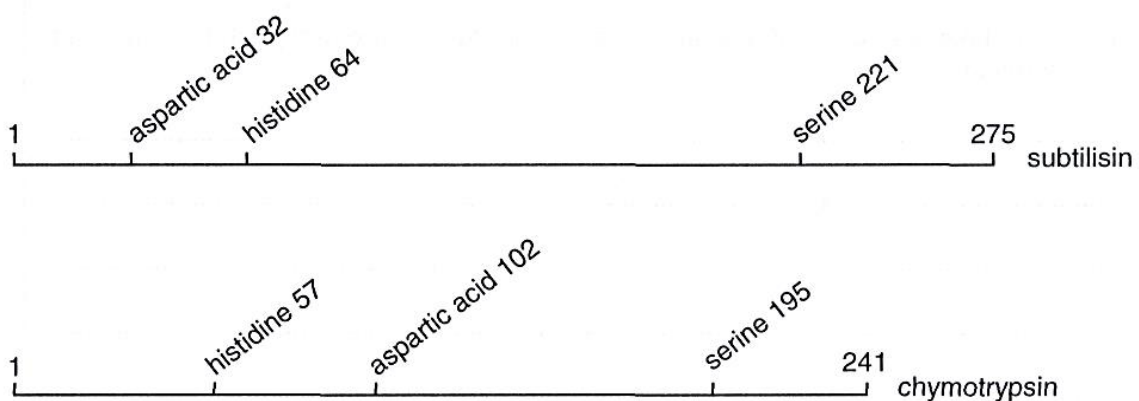
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.....

..... [3]

Subtilisin is a protease synthesised by bacteria and is made up of 275 amino acids. Chymotrypsin is a protease synthesised by bacteria and is made up of 241 amino acids. Both enzymes have the same arrangement of three amino acids, serine, histidine and aspartic acid in their active sites but they are structurally different with the three amino acids being in different positions in the amino acid sequences shown in Fig. 1.1.

**Fig. 1.1**

- (b) With reference to Fig. 1.1 and your knowledge on levels of protein structure, describe how amino acid residues at different positions in the protein may be brought together in the active site.

.....

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.....

..... [2]

The graph in Fig. 1.2 shows how the activity of a protease varies with temperature.

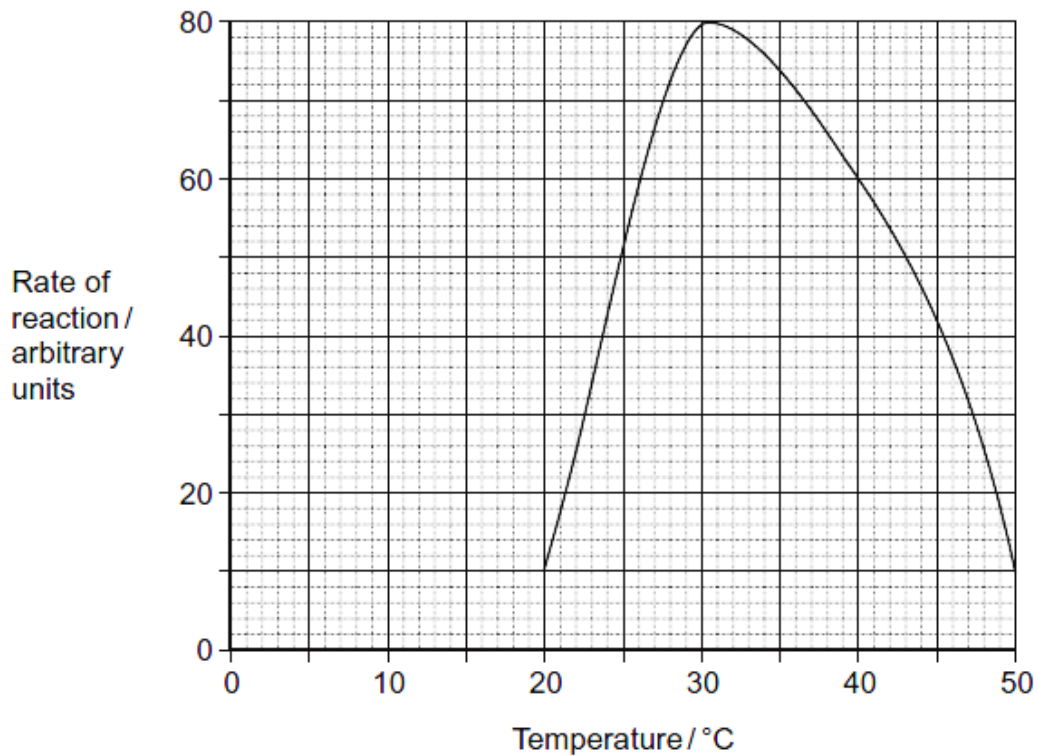


Fig. 1.2

- (c) With reference to Fig. 1.2, explain the shape of the graph between 30°C and 50°C.

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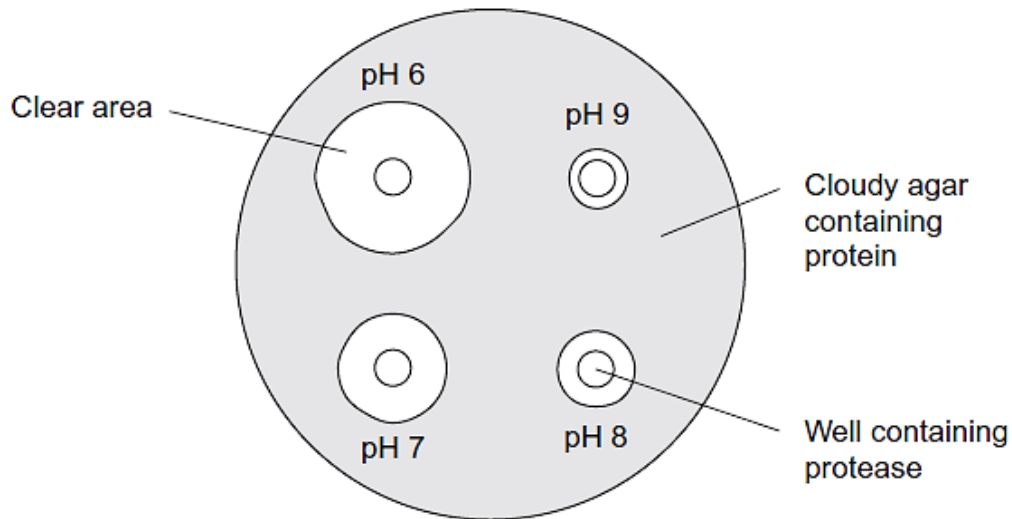
..... [3]



Students investigated the effect of pH on the activity of protease.

- The students used agar plates containing protein. The protein made the agar cloudy.
- They made four wells of equal size in the agar of each plate.
- They added a drop of protease solution to each of the wells. The protease solution in each well was at different pH.
- The students incubated the agar plates for 4 hours at constant temperature.

Fig. 1.3 shows the agar plates after they were incubated and the pH of the protease solution in each well.



**Fig. 1.3**

**(d)** With reference to Fig. 1.3,

- (i)** suggest a suitable temperature for incubating the agar plates and explain your answer.

.....

.....

..... [2]

- (ii)** explain the effect of pH on the activity of this protease.

.....

.....

..... [1]



Aminoacyl tRNA synthetase is an enzyme that catalyses the attachment of amino acids to its corresponding tRNA.

A specific aminoacyl tRNA synthetase allows the amino acid asparagine to bind to its active site. A single base substitution occurred in the gene coding for this enzyme, resulting in the enzyme recognising proline instead of asparagine.

Fig. 1.5 shows the effect of this mutation on the resultant aminoacyl tRNA.

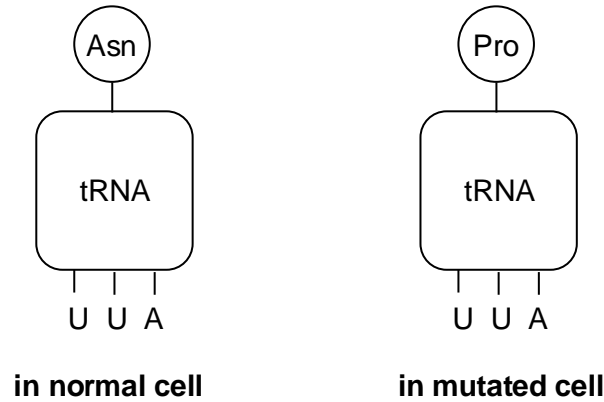


Fig. 1.5

- (f) Explain how the structure of tRNA is adapted to perform its function.

.....

.....

.....

..... [2]

- (g) Suggest why a mutation in this gene would have extremely damaging effects on the organism.

.....

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.....

..... [3]

[Total: 20]

2 Human Immunodeficiency Virus (HIV) is a retrovirus that causes acquired immune deficiency syndrome (AIDS).

(a) Outline the process by which HIV enters the host cell.

.....

.....

.....

..... [2]

Many integrase inhibitors have been discovered in recent years, and some of them are presently in clinical trials. One such inhibitor is Raltegravir.

In a clinical trial, one group of patients was given Raltegravir while the control group was given a placebo (drug-free pills) over 24 weeks. The number of copies of HIV-1 RNA per ml of blood plasma was measured and the results are given in Fig. 2.1.

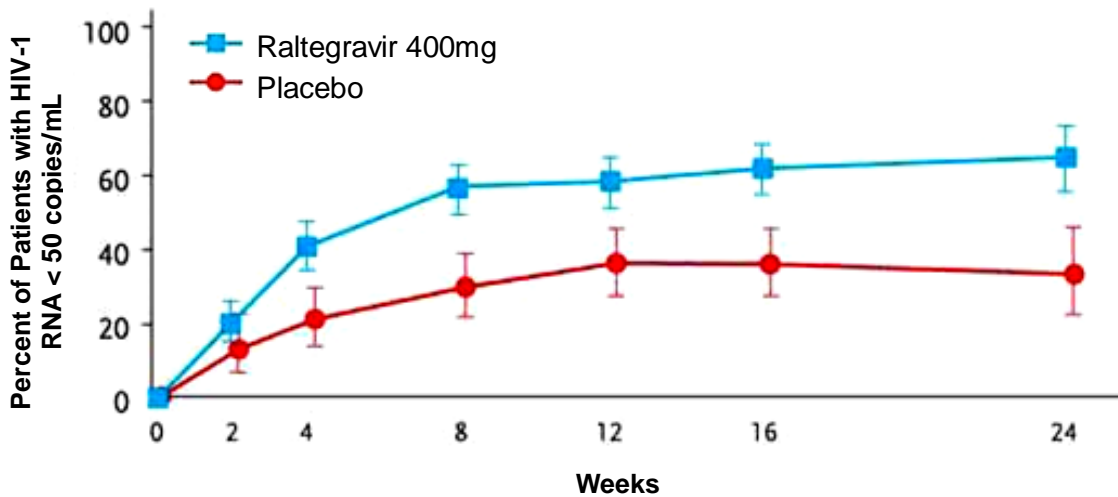


Fig 2.1

(b) With reference to Fig. 2.1, describe the difference in the effect of treating patients with Raltegravir and placebo.

.....

.....

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..... [2]

(c) Suggest how Raltegravir works as an antiretroviral drug.

.....

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.....

.....

..... [2]

(d) The viral genome undergoes frequent mutation.

Suggest why this means that the action of Raltegravir may no longer be effective in future.

.....

.....

.....

..... [2]

Another important process in the reproductive cycle of HIV is the cleaving of polyproteins into functional proteins using protease. Fig. 2.2 shows such a process.

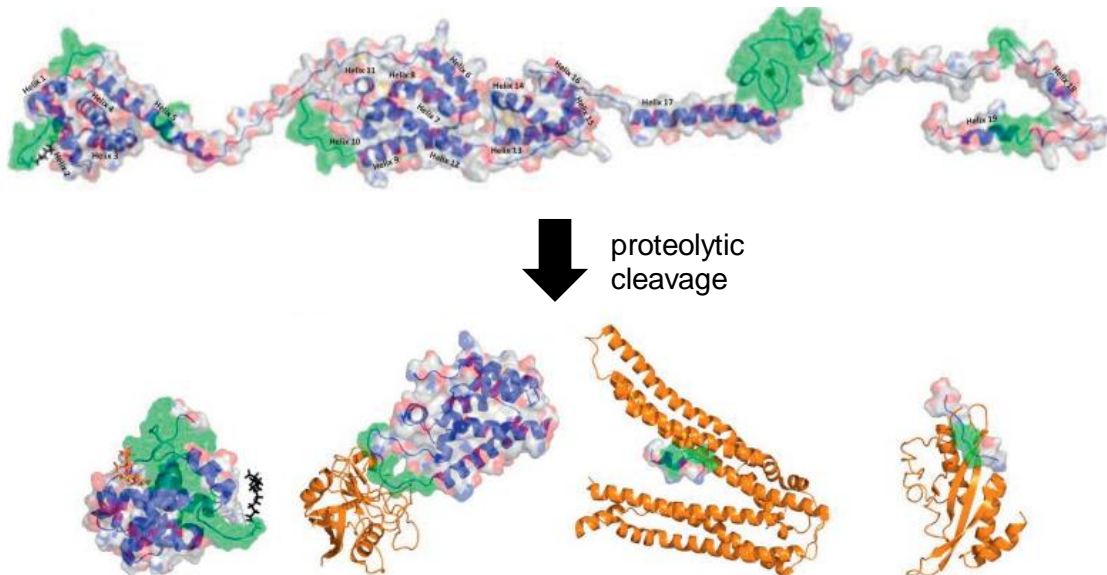


Fig 2.2

(e) Describe the polypeptides and the products formed after proteolytic cleavage.

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.....

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[3]

[Total: 11]

3 Fig. 3.1 shows the structure of a nucleosome.

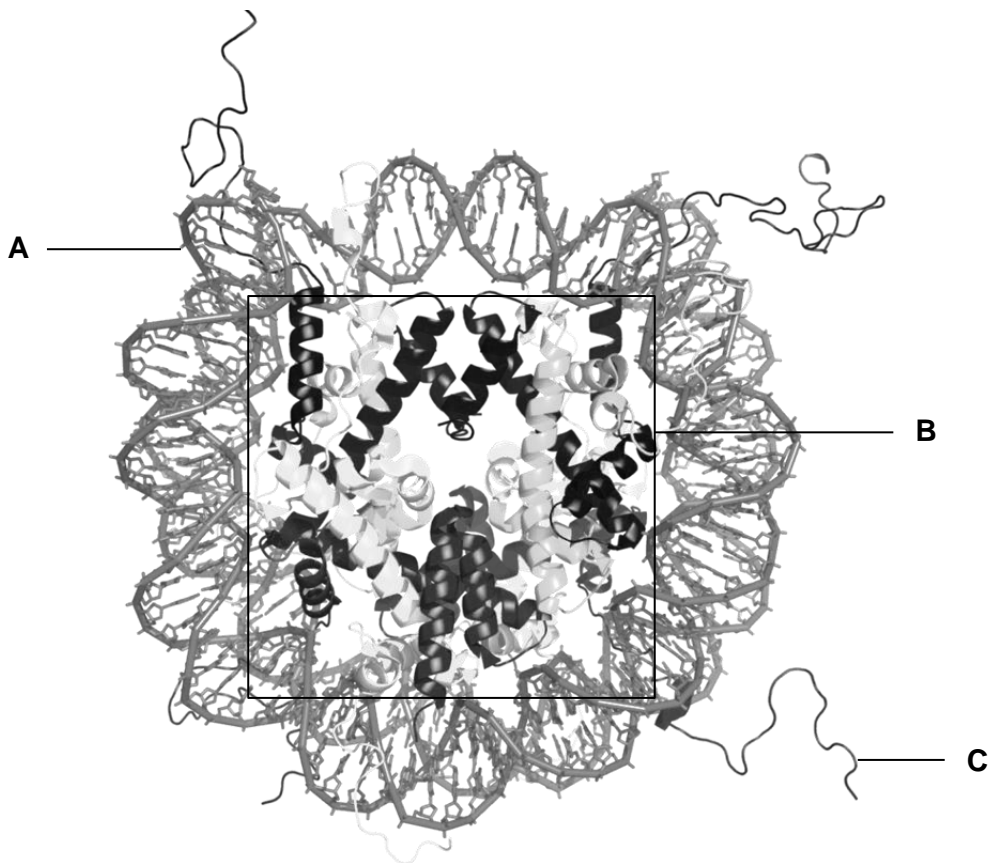


Fig. 3.1

(a) With reference to Fig. 3.1,

(i) label the structures A to C.

A .....

B .....

C .....

[2]

(ii) describe how structure **A** is stabilised.

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

(iii) state the secondary structure observed in structure **B**.

..... [1]

(iv) describe how structure **C** can be modified to influence gene expression.

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

(b) Describe how DNA is packaged in eukaryotes.

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.....  
..... [5]

[Total: 12]

- 4 (a) Explain what is meant by *epistasis*.

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..... [2]

In some species of plants, malvidin is a primary flower pigment that results in the colour wine red. Gene **A/a** codes for an enzyme that synthesises malvidin while gene **H/h** was discovered to inhibit its synthesis resulting in white flowers.

In one experiment, double heterozygote parents were crossed to produce F1 generation progeny comprising of 452 white flowering plants and 114 red wine flowering plants.

- (b) Using the symbols for the alleles stated above, draw a genetic diagram to show the expected phenotypic ratio for the F1 offspring.

[5]



- (c) Determine, using an appropriate statistical test, if the observed results are expected. The critical values for the chi-squared test are provided in Table 4.1.

**Table 4.1**

degree of freedom	Probability, $p$				
	0.1	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

[5]

[Total: 12]

5 (a) A myelinated axon transmits impulses faster than a non-myelinated axon.

Explain this difference.

.....

.....

.....

[2]

Doctors investigated the relationship between myelin in the brain tissue and different types of dementia. All types of dementia involve loss of mental ability.

The doctors measured the mean amount of myelin in samples of brain tissue from:

- a control group of 12 people without dementia
- 20 people with vascular dementia (VaD)
- 19 people with Alzheimer's dementia (AD)
- 31 people with Lewy body dementia (LD).

The doctors' results are shown in Fig. 5.1. The vertical bars show standard errors.

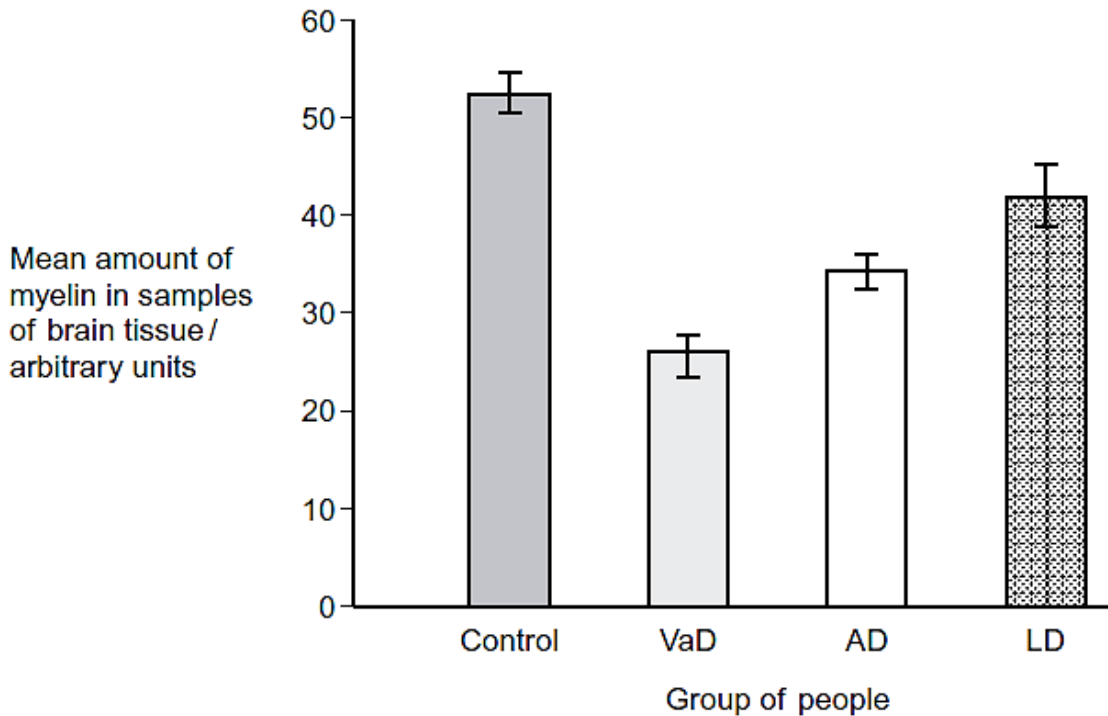


Fig. 5.1

(b) With reference to Fig. 5.1,

(i) explain the significance of the standard error bars.

.....

.....

[1]





6 A region in Southern Australia used to have a huge lake system. About 500 000 years ago, the lakes started to dry up and they now consists of isolated small pools. Ten different species of a particular fish was found living in these pools. However, fossil evidence indicates that over 500 000 years ago there was only one species of the fish living in the lake.

(a) Explain how the ten species of fish evolved.

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[5]

(b) Due to climate change, scientists predict that in 5000 years, water levels will rise and the pools will reform the huge lake system.

Suggest what might happen to the ten species of fish.

.....

.....

.....

[2]

Tree frogs are commonly found in Southern Australia. *Hyla ewingi* and *Hyla verrauxi* are two closely related species of tree frogs. Research from breeding studies and DNA sequence data has shown that they have strong genetic compatibility.

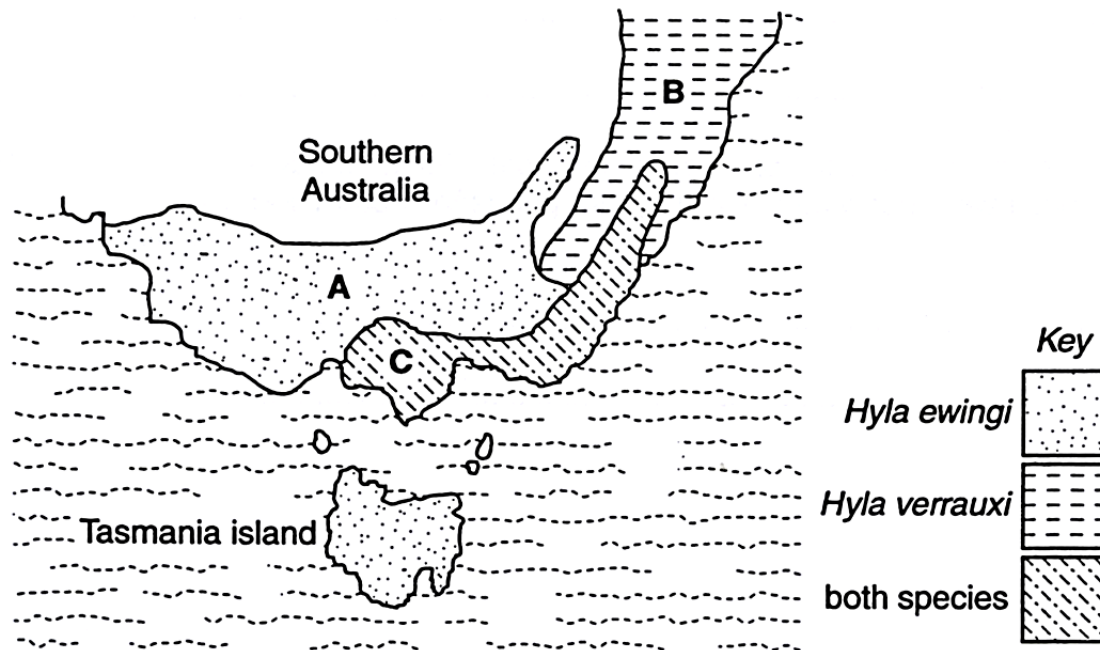


Fig 6.1

(c) (i) State the genus of the tree frog.

[1]

(ii) With reference to Fig. 6.1 and the research studies, explain how the scientists concluded that the two species of tree frogs are closely related.

[4]

[Total: 12]

**Section B**

Answer **one** question.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

- 7 (a) Describe the main stages in Calvin cycle. [8]
- (b) Describe the roles of membranes in photosynthesis and in respiration. [8]
- (c) Explain how membrane fluidity is maintained in a cell when temperature increases. [4]

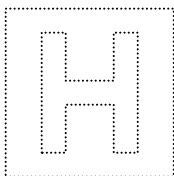
[Total: 20]

- 8 (a) Describe the structural features of collagen and how they contribute to its function. [8]
- (b) Insulin polypeptide synthesised by ribosomes attached to the endoplasmic reticulum will be transported out of the beta cell.

Describe the route taken by insulin out of the beta cell. [8]

- (c) Explain the roles of vesicles that emerge from the Golgi body. [4]

[Total: 20]



JC 2 PRELIMINARY EXAMINATION  
in preparation for General Certificate of Education Advanced  
Level  
**Higher 2**

CANDIDATE  
NAME

**MARK SCHEME**

CLASS

INDEX NUMBER

**BIOLOGY**

**9648/02**

Paper 2 Core Paper

**19 August 2016**

**2 hours**

Additional Materials: Answer Paper  
Cover Page

**READ THESE INSTRUCTIONS FIRST**

Write your name and class on all the work you hand in.  
Write in dark blue or black pen on both sides of the paper.  
You may use a soft pencil for any diagrams, graphs or rough  
working.  
Do not use staples, paper clips, highlighters, glue or correction  
fluid.

**Section A**

Answer **all** questions.

**Section B**

Answer **one** question.

At the end of the examination, fasten all your work securely  
together.

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

For Examiner's Use	
<b>Section A</b>	
<b>1</b>	<b>20</b>
<b>2</b>	<b>11</b>
<b>3</b>	<b>12</b>
<b>4</b>	<b>12</b>
<b>5</b>	<b>13</b>
<b>6</b>	<b>12</b>
<b>Section B</b>	
<b>7 / 8</b>	<b>20</b>
<b>Total</b>	<b>100</b>

This document consists of **18** printed pages.





**Section A**Answer **all** questions.

1 A protease is an enzyme that digests protein.

(a) With the aid of a diagram, describe the reaction catalysed by protease.

**diagram showing substrates – polypeptide / dipeptide and water  
breaking of peptide bond  
products – amino acids  
with appropriate labels;**

**1. hydrolysis reaction**

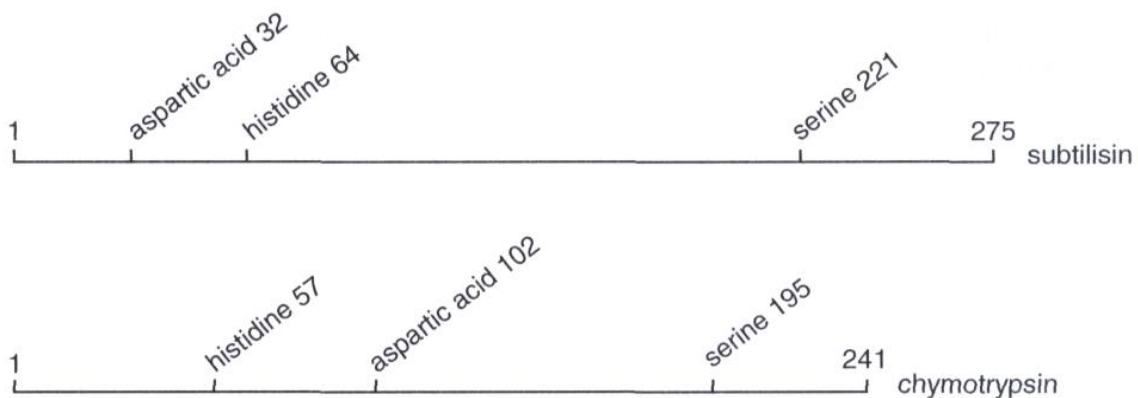
with the addition of a water molecule;

**2. breaking of peptide bond (-CONH)**

btwn amino acids;

[3]

Subtilisin is a protease synthesised by bacteria and is made up of 275 amino acids. Chymotrypsin is a protease synthesised by bacteria and is made up of 241 amino acids. Both enzymes have the same arrangement of three amino acids, serine, histidine and aspartic acid in their active sites but they are structurally different with the three amino acids being in different positions in the amino acid sequences shown in Fig. 1.1.

**Fig. 1.1**

- (b) With reference to Fig. 1.1 and your knowledge on levels of protein structure, describe how amino acid residues at different positions in the protein may be brought together in the active site.

1. **1° str is the unique linear seq of aa**

*e.g. aspartic acid at position 32, histidine at 64 and serine at 221;*

2. **folding of the polypeptide to form 3° str held by R group interactions (e.g. hydrophobic int, H bond, ionic bond, disulfide bridges)**

**to bring together catalytic and contact residues in the active site ➔ specific 3D config;**

[2]

The graph in Fig. 1.2 shows how the activity of a protease varies with temperature.

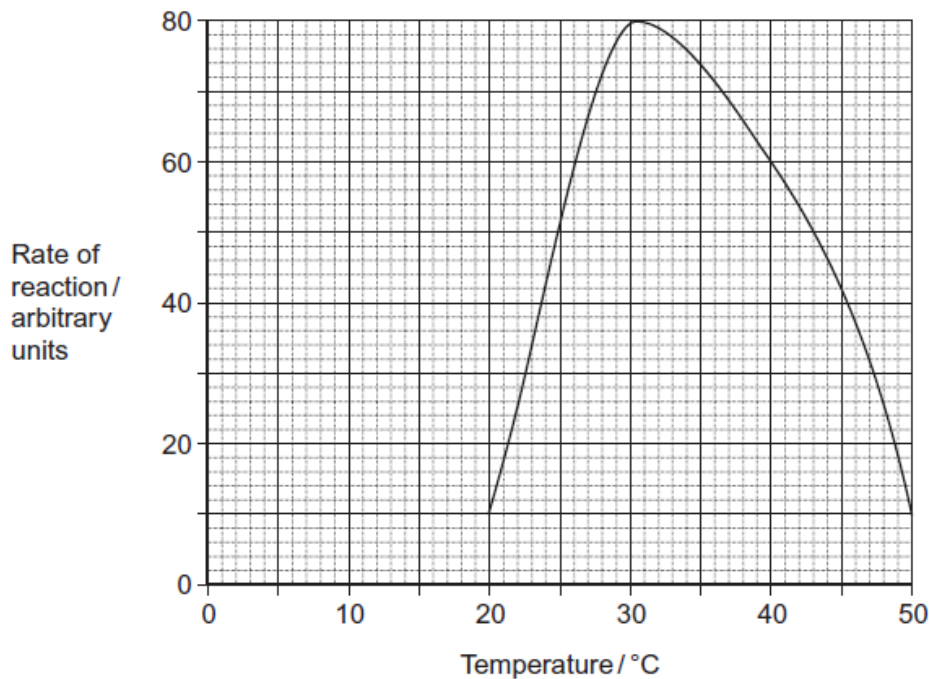


Fig. 1.2

- (c) With reference to Fig. 1.2, explain the shape of the graph between 30°C and 50°C.

1. **sharp ↓ in rate of reaction from 30 to 50°C**

*from 80 to 10 au;*

2. **further ↑ in temp beyond opt temp ➔ ↑ in KE of E**

**violent molecular vibrations ➔ breaking of intramolecular H bonds and hydrophobic interactions;**

3. **denaturation of enz due to unfolding of enz / disrupt 3° str**

**leading loss of specific 3D config of active site ➔ E no longer able to bind to S;**

[3]

Students investigated the effect of pH on the activity of protease.

- The students used agar plates containing protein. The protein made the agar cloudy.
- They made four wells of equal size in the agar of each plate.
- They added a drop of protease solution to each of the wells. The protease solution in each well was at different pH.
- The students incubated the agar plates for 4 hours at constant temperature.

Fig. 1.3 shows the agar plates after they were incubated and the pH of the protease solution in each well.

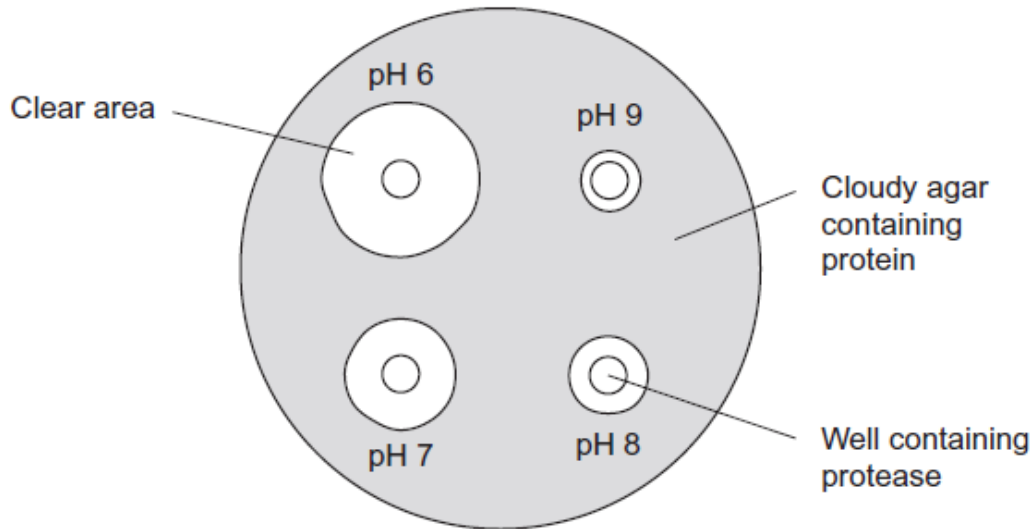


Fig. 1.3

(d) With reference to Fig. 1.3,

- (i) suggest a suitable temperature for incubating the agar plates. Explain your answer.

1. **30°C;**

2. **opt temp of enz**

**highest rate of rxn / temp is not limiting;**

[2]

- (ii) explain the effect of pH on the activity of this protease.

1. **opt pH at pH 6 as seen by the largest clear area → highest rate of digestion of protein in agar plate by protease;**

2. **↑ in pH → ↓ in enz activity as seen by ↓ in size of clear area;**

[1]

The gene encoding for protease is transcribed to give rise to mRNA. The mRNA transcribed leaves the nucleus and is translated by ribosomes in the cytosol. Fig. 1.4 shows the process of translation.

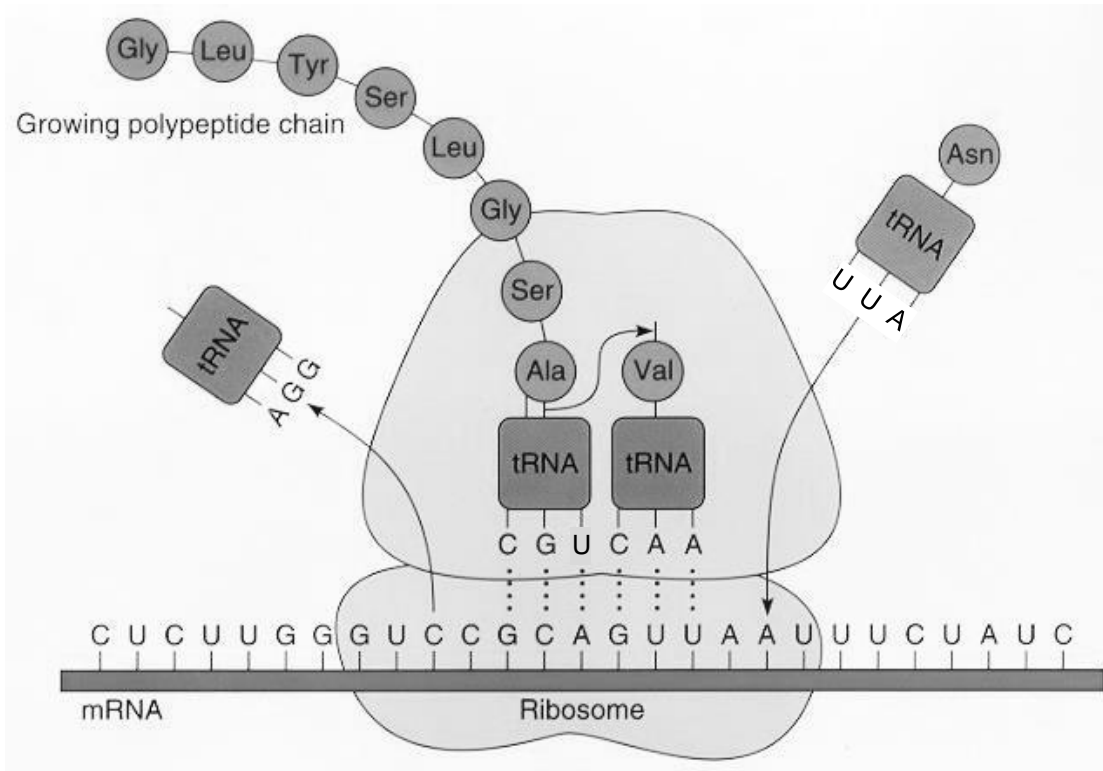


Fig. 1.4

(e) With reference to Fig. 1.4, describe how the amino acid asparagine (Asn) is incorporated into the growing polypeptide chain.

1. *tRNA with anticodon UUA carrying the aa asn*

*binds to mRNA codon AAU via formation of H bonds btwn comp bp at A site of large ribosomal subunit;*

2. *formation of peptide bond between asn and val*

*catalysed by peptidyl transferase;*

3. *ribosome translocates in 5' to 3' direction*

*tRNA with (asn and) growing polypeptide chain is now at P site;*

4. *tRNA carrying val / with anticodon CAA is now at the E site*

*and is released;*

[4]

Aminoacyl tRNA synthetase is an enzyme that catalyses the attachment of amino acids to its corresponding tRNA.

(f) Explain how the structure of tRNA is adapted to perform its function.

1. **contains amino acid attachment arm**

*for attachment of specific amino acid (via ester bond);*

2. **contains anticodon**

*that binds to mRNA codon via H bonds btwn comp bp;*

3. **clover-leaf shape**

*contributes to specific 3D config → allows binding to ribosome aminoacyl tRNA synthetase;* [2]

*(max 2m)*

(g) A specific aminoacyl tRNA synthetase allows the amino acid asparagine to bind to its active site. A single base substitution occurred in the gene coding for this enzyme, resulting in the enzyme recognising proline instead of asparagine.

Fig. 1.5 shows the effect of this mutation on the resultant aminoacyl tRNA.

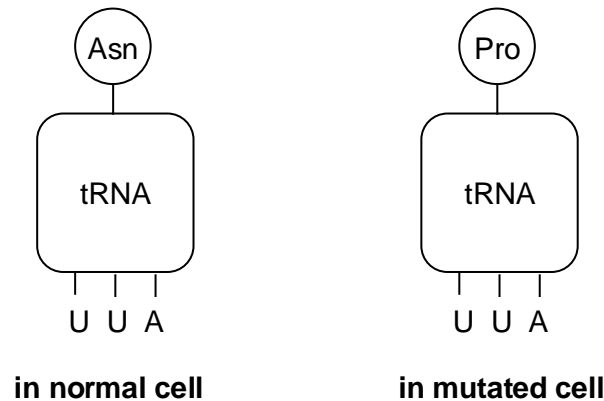


Fig. 1.5

Suggest why a mutation in this gene would have extremely damaging effects on the organism.

1. **enz would attach pro instead of asn**

*to the tRNA with anticodon for asn / UUA;*

2. **during translation, mRNA codon AAU will code for pro instead of asn**

*all resultant polypeptides will have asn replaced by pro;*

3. **Δ in R group of all resultant polypeptides → Δ in R group interactions**

*Δ in specific 3D config of all resultant prot → affect cellular f(x);* [3]

[Total: 20]

2 HIV is a retrovirus that causes acquired immune deficiency syndrome (AIDS).

(a) Outline the process by which HIV enters the host cell.

1. ***gp 120 (and gp 41) on HIV envelope***

*recog and binds to CD4 cell surface receptors on T cells;*

2. ***viral env fuses with CSM of host cell***

*releases viral nucleocapsid into host cell cytoplasm;*

[2]

Many integrase inhibitors have been discovered in recent years, and some of them are presently in clinical trials. One such inhibitor is Raltegravir.

In a clinical trial, one group of patients was given Raltegravir while the control group was given a placebo (drug-free pills) over 24 weeks. The number of copies of HIV-1 RNA per ml of blood plasma was measured and the results are given in Fig. 2.1.

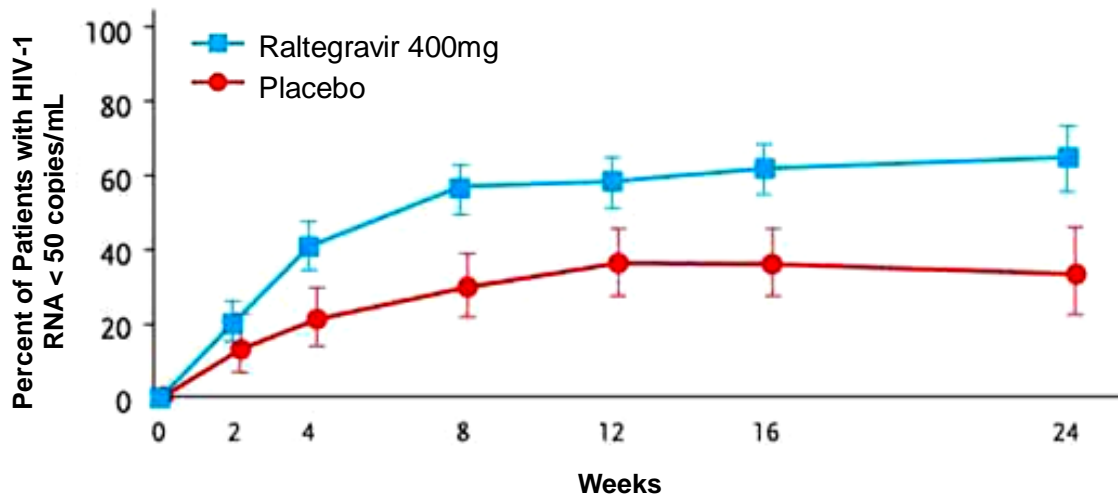


Fig 2.1

(b) With reference to Fig. 2.1, describe the difference in the effect of treating patients with Raltegravir and placebo.

1. ***higher percentage of patients with HIV-1 RNA < 50 copies per ml in grp treated with Raltegravir vs placebo throughout 24 week treatment;***

2. ***[QV] for Raltegravir grp: ↑ to 60% patients with HIV-1 RNA < 50 copies at week 8***

***for placebo grp: ↑ to 30% patients with HIV-1 RNA < 50 copies at week 8;***

[2]

(c) Suggest how Raltegravir works as an antiretroviral drug.

1. *(inhibits integrase) → inhibits integration of HIV DNA into human chr*

*preventing formation of provirus;*

2. *resulting in HIV unable to undergo replication / viral protein synthesis*

*preventing formation of new virions;*

[2]

(d) The viral genome undergoes frequent mutation.

Suggest why this means that the action of Raltegravir may no longer be effective in future.

1. *mutations in viral genome alter gene seq coding for integrase*

*results in change in 3D conformation of enzyme;*

2. *inability of Raltegravir to bind / inhibit integrase*

*due to non-complementary to binding site / active site;*

[2]

Another important process in the reproductive cycle of HIV is the cleaving of polyproteins into functional proteins using protease. Fig. 2.2 shows such a process.

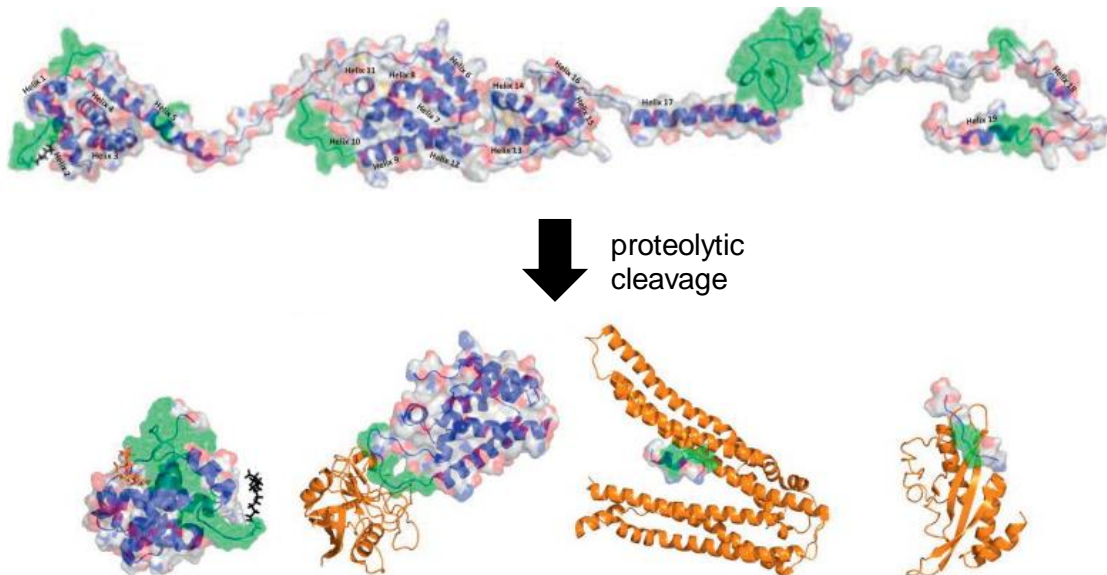


Fig 2.2

(e) Describe the polyproteins and the products formed after proteolytic cleavage.

1. *Pol polyprotein cleaved by viral protease*

*produces enzymes such as RT / IN / HIV protease;*

2. *Gag polyprotein cleaved by viral protease*

*produces structural proteins such as capsid proteins;*

3. *Env polyprotein cleaved by cellular protease*

*produces glycoproteins gp120 and gp41;*

[3]

[Total: 11]

3 Fig. 3.1 shows the structure of a nucleosome.

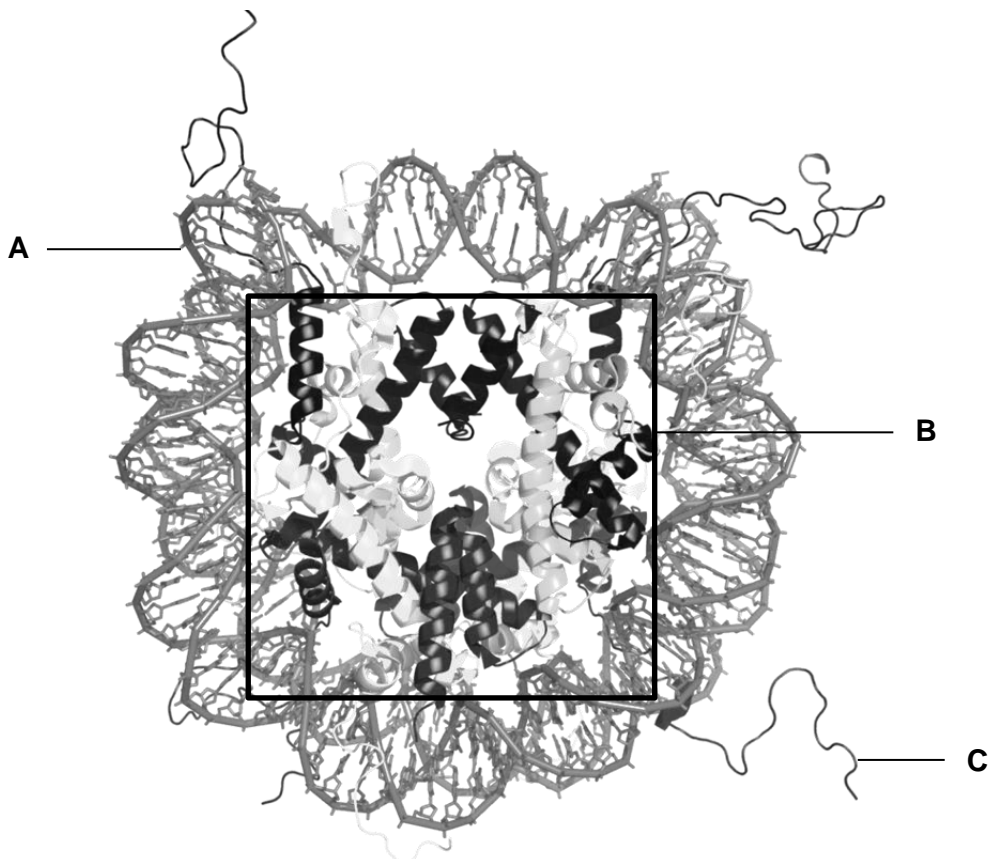


Fig. 3.1

(a) With reference to Fig. 3.1,

(i) label the structures A to C.

A *deoxyribonucleic acid*

B *histone protein / octamer*

C *histone tail;;*

[2]

*(2m for all correct ans, -1m for any wrong ans)*



(ii) describe how structure **A** is stabilised.

1. *hydrogen bonds btwn comp bp*

*where A = T, C ≡ G;*

2. *hydrophobic interactions*

*btwn stacked bases;*

[2]

(iii) state the secondary structure observed in structure **B**.

*α-helix;*

[1]

(iv) describe how structure **C** can be modified to influence gene expression.

1. *acetylation of (lys residues on) histone tails by histone acetyltransferase*

*↓ +ve charge of histones ⇒ ↓ histone's affinity for -ve charged DNA;*

2. *chromatin in more relaxed conformation*

*allow access of TFs and RNA pol to promoter ⇒ ↑ transcription;*

[2]

*(accept rev argument, i.e. deacetylation)*

(b) Describe how DNA is packaged in eukaryotes.

1. *DNA molecule wrapped 1¾ times (146bp) around histone octamer, forming a nucleosome core;*

2. *nucleosome core assoc with H1 prot forming the complete nucleosome;*

3. *linked by spacer DNA forming 10nm 'beads on a string' structure;*

4. *further coiled into solenoid with 6 nucleosomes per turn, forming 30nm fibre;*

5. *30 nm fibre assoc with scaffold prot ⇒ 300 nm fiber;*

6. *further coiling to form 700 nm chromatid;*

[5]

*(max 5m)*

[Total: 12]

4 (a) Explain what is meant by *epistasis*.

1. *interaction between two genes*

*coding for gene pdts controlling the same characteristic / in same metabolic pathway;*

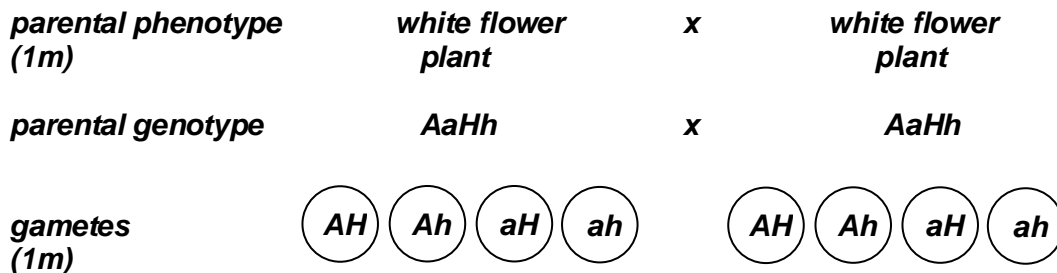
2. *epistatic gene overrides expression of hypostatic gene*

*to express its own phenotype;* [2]

In some species of plants, malvidin is a primary flower pigment that results in the colour wine red. Gene **A/a** codes for an enzyme that synthesises malvidin while gene **H/h** was discovered to inhibit its synthesis resulting in white flowers.

In one experiment, double heterozygote parents were crossed to produce F1 generation progeny comprising of 452 white flowering plants and 114 red wine flowering plants.

(b) Using the symbols for the alleles stated above, draw a genetic diagram to show the expected phenotypic ratio for the F1 offspring.



punnett square (1m)

Gametes	(AH)	(Ah)	(aH)	(ah)
(AH)	AAHH	AAHh	AaHH	AaHh
(Ah)	AAHh	AAhh	AaHh	Aahh
(aH)	AaHH	AaHh	aaHH	aaHh
(ah)	AaHh	Aahh	aaHh	aahh

offspring genotype (1m)                      9 A\_H\_ : 3 aaH\_ : 1 aahh : 3 A\_hh

offspring phenotypic ratio (1m) (genotype must correlate with phenotype)                      13 white : 3 wine red

[5]

- (c) Determine, using an appropriate statistical test, if the observed results are expected. The critical values for the chi-squared test are provided in Table 4.1.

Table 4.1

degree of freedom	Probability, $p$				
	0.1	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

Let  $H_0$  be the inheritance of plant colour that follows the ratio of 13:3

Phenotype	Expected ratio	Observed (O)	Expected (E)	$\frac{(O - E)^2}{E}$
white	13	452	460	0.1349
red	3	114	106	0.5844
<b>df = 2 - 1</b>	<b>Total =</b>	<b>566</b>		

Hence,  $\chi^2$  (calculated) = 0.719 (3s.f.)

1. correct working;
2. correct answer;
3. at  $p = 0.05$ ,  $df = 1$ , critical  $\chi^2 = 3.84$   
calculated  $\chi^2 < \text{critical } \chi^2$ ;
4. deviation btw observed and expected ratios is not statistically significant and the difference is due to chance alone;
5. hence,  $H_0$  is not rejected, inheritance of plant colour follows the expected ratio of 13:3;

**ECF for 12:4 and 9:7 in (b)**

**For 12:4**

**(E) 424.5, 142.5**

**$\chi^2 = 71.2$ , reject  $H_0$**

**For 9:7**

**(E) 318, 248**

**$\chi^2 = 128.9$ , reject  $H_0$**

[5]

[Total: 12]

- 5 (a) A myelinated axon transmits impulses faster than a non-myelinated axon.

Explain this difference.

1. *in myelinated neurone, myelin (is lipid-rich thus) act as electrical insulator*

*preventing movement of ions across axolemma;*

2. *cause AP to be generated only at nodes of Ranvier / nerve impulse 'jumps' from node to node*

*via saltatory conduction;*

3. *in non-myelinated axon, AP is generated along whole length of axon*

*via continuous conduction;*

[2]

Doctors investigated the relationship between myelin in the brain tissue and different types of dementia. All types of dementia involve loss of mental ability.

The doctors measured the mean amount of myelin in samples of brain tissue from:

- a control group of 12 people without dementia
- 20 people with vascular dementia (VaD)
- 19 people with Alzheimer's dementia (AD)
- 31 people with Lewy body dementia (LD).

The doctors' results are shown in Fig. 3.1. The vertical bars show standard errors.

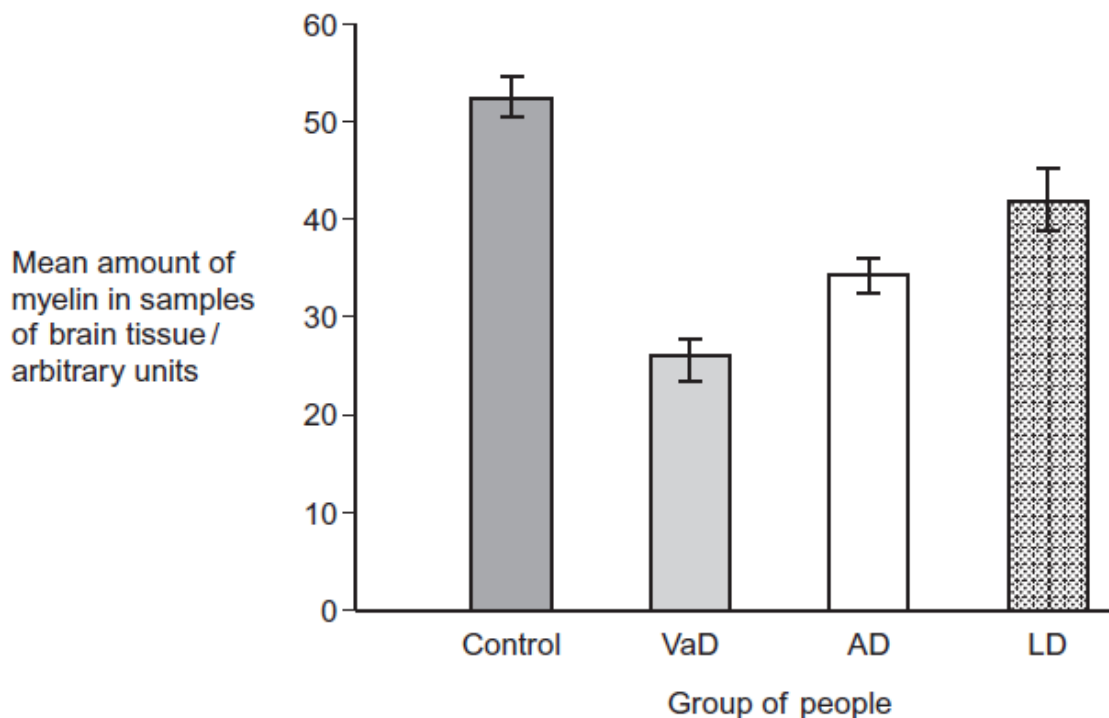


Fig. 5.1

(b) With reference to Fig. 5.1,

(i) explain the significance of the standard error bars.

1. **to indicate the range of amount of myelin in samples of brain tissue**

**to allow for statistical comparison;**

[1]

(ii) discuss whether the data supports the conclusion that there is a relationship between incidence of dementia and the amount of myelin in a person's brain.

1. **mean amt of myelin lower in all dementia groups cf control**

**[QV] control: 52 au, VaD: 25 au, AD: 33 au, LD: 41 au;**

2. **[support] error bars do not overlap**

**diff btw mean amt of myelin are (possibly) significant / statistically significant / not due to chance;**

3. **[support] diff mean % related to diff types of dementia;**

4. **[do not support] dementia may be due to other factors / not only due to lack of myelin (e.g. genetic)**

**as there are significant differences in myelin in different types of dementia;**

5. **[do not support] small sample sizes**

**of  $n < 25$  for some grps  $\rightarrow$  large error;**

[3]

**® do not support due to diff sample sizes**

Cocaine is a drug that interferes with synaptic transfer. It affects neurones that release dopamine, an excitatory neurotransmitter associated with feelings of pleasure.

Fig. 5.2 shows the mechanism of action of cocaine.

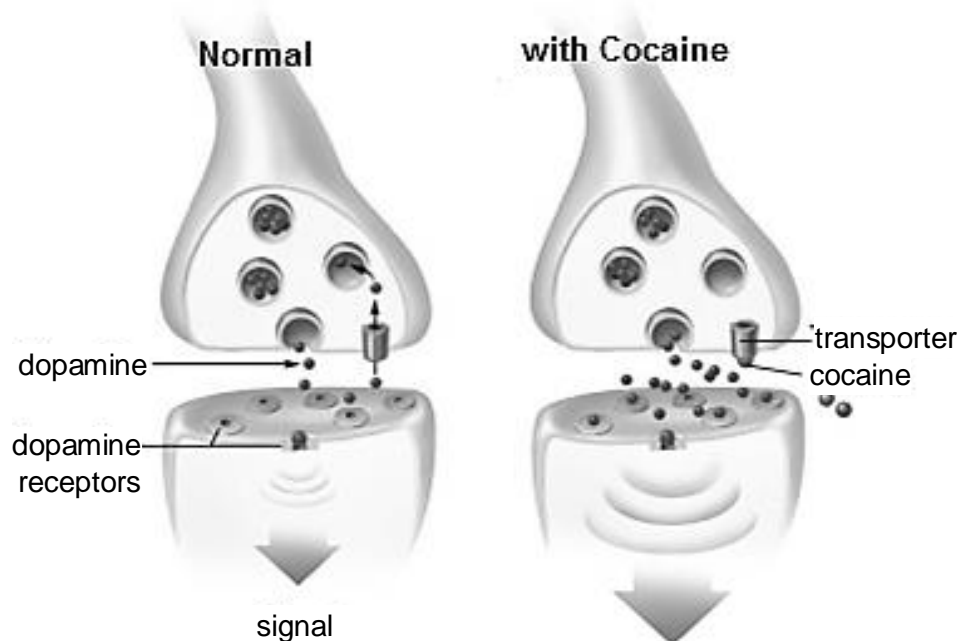


Fig. 5.2

- (c) (i) Describe the process of synaptic transfer in normal individuals.
1. **arrival of stimulus at synaptic knob  $\Rightarrow$  opening of voltage-gated  $\text{Ca}^{2+}$  channel**  
-----  
 **$\text{Ca}^{2+}$  influx;**  
-----
  2. **translocation of synaptic vesicles containing dopamine to pre-synaptic mem (with aid of cytoskeleton)**  
-----  
**fuse pre-synaptic mem to release contents via exocytosis;**  
-----
  3. **dopamine diffuses across synaptic cleft**  
-----  
**binds to ligand-gated  $\text{Na}^+$  channels  $\Rightarrow$  opening of ligand-gated  $\text{Na}^+$  channel;**  
-----
  4.  **$\text{Na}^+$  influx  $\Rightarrow$  depolarisation  $\geq$  threshold pot of  $-50 \text{ mV}$**   
-----  
**generate action potential in post-synaptic neurone;**  
----- [4]
- (ii) With reference to Fig. 5.2, explain the effects of cocaine.
1. **cocaine blocks dopamine transporters  $\Rightarrow$   $\otimes$  uptake of dopamine**  
-----  
**dopamine accumulates in the synaptic cleft;**  
-----
  2. **con't binding of dopamine to dopamine receptor  $\Rightarrow$  temporal summation (of graded potential)**  
-----  
**resulting in  $\uparrow$  depol / opening of  $\text{Na}^+$  gates thus continued feelings of pleasure;**  
----- [2]
- (iii) Long-term cocaine use results in a decrease in the number of dopamine receptors in the post-synaptic membrane.
- Suggest why cocaine abusers are no longer able to feel pleasure naturally.
- $\downarrow$  no. of receptors  $\Rightarrow$   $<$  dopamine can bind dopamine receptors**  
-----  
 **$\Rightarrow$  insufficient  $\text{Na}^+$  influx to reach threshold pot thus fewer AP generated;**  
----- [1]

[Total: 13]

6 A region in Southern Australia used to have a huge lake system. About 500 000 years ago, the lakes started to dry up and they now consists of isolated small pools. Ten different species of a particular fish was found living in these pools. However, fossil evidence indicates that over 500 000 years ago there was only one species of the fish living in the lake.

(a) Explain how the ten species of fish evolved.

1. **variation present**

*in ancestral pop of fish (due to spontaneous mutation);*

2. **drying up of land  $\Rightarrow$  diff env condition in each pool  $\Rightarrow$  diff selection pressures**

*indiv with favourable phenotype / adaptations selected for / have selective adv;*

3.  **$\uparrow$  survival rate & repro success**

*advantageous / favourable alleles passed down to offspring  $\Rightarrow$   $\Delta$  in allelic freq in gene pools;*

4. **geographical isolation / geographical barrier of dry land**

*fish pop isolated i.e. prevent interbreeding / gene flow btw pops;*

5. **mutations arise independently in each pop**

*not shared btw gene pools;*

6.  **$\uparrow$  genetic variation between pop  $\Rightarrow$  repro isolation / inability to interbreed**

*resulting in allopatric speciation / adaptive radiation;*

[5]

(b) Due to climate change, scientists predict that in 5000 years, water levels will rise and the pools will reform the huge lake system.

Suggest what might happen to the ten species of fish.

1. **nos of each spp  $\uparrow$  initially due to  $\uparrow$  space / food;**

2.  **$\uparrow$  competition btw spp  $\Rightarrow$  reduction in nos for some / all spp some spp outcompeted for food / habitat and therefore unable to survive / extinct;**

3. **spp may be able to interbreed due to lack of repro barriers as they only diverged fr common ancestor recently (500 000 yrs ago);**

4. **interbreeding btw spp  $\Rightarrow$  hybrids that  $\otimes$  interbreed with parents  $\Rightarrow$  new spp;**

5. **diff spp occupies diff habitats / ecological niches;**

6. **remain as diff spp /  $\otimes$  interbreed due to presence of repro barriers e.g. pre/post zygotic as gene pool has become too diversified;**

[2]

Tree frogs are commonly found in Southern Australia. *Hyla ewingi* and *Hyla verrauxi* are two closely related species of tree frogs. Research from breeding studies and DNA sequence data has shown that they have strong genetic compatibility.

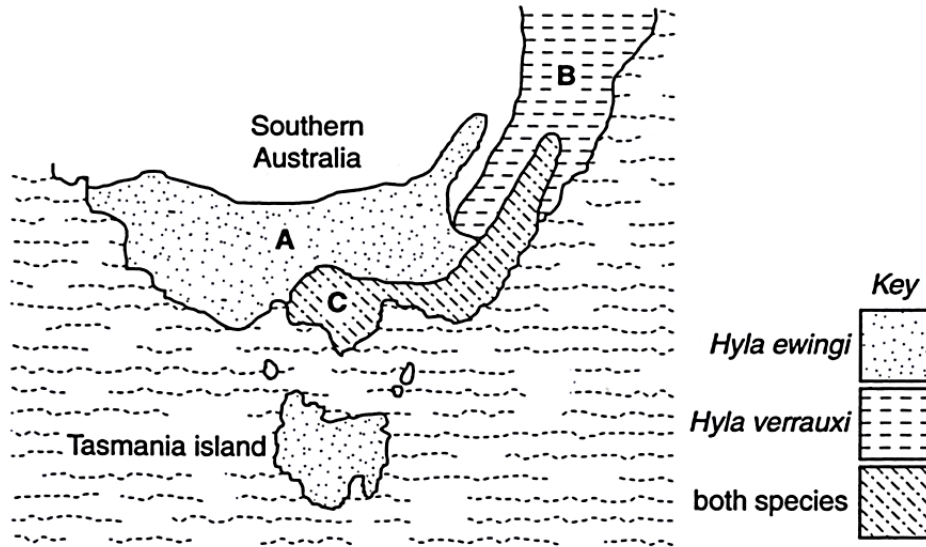


Fig 6.1

- (c) (i) State the genus of the tree frog.

*Hyla*;

[1]

- (ii) With reference to Fig. 6.1 and the research studies, explain how the scientists concluded that the two species of tree frogs are closely related.

1. **from breeding studies** ⇒ **both spp able to interbreed**

**to give viable fertile offspring;**

2. **absence of genetic isolation / repro barrier**

**gene flow btw spp still able to occur;**

3. **strong genetic compatibility** ⇒ **few diff btw DNA seq**

**short time frame for accumulations of mutations / indicates recent divergence from common ancestor;**

4. **present in same geographical region (of Southern Australia) overlapping habitat in C**

**indicates close relatedness according to ESC / biogeographical evidence (as descendants from common ancestor tend to be located in the same region);**

[4]

[Total: 12]



**Section B**

Answer **one** question.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

7 **(a)** Describe the main stages in Calvin cycle. [8]

1. *occurs in stroma of chloroplast;*
2. *first stage: carbon fixation, where CO<sub>2</sub> combines with ribulose biphosphate;*
3. *catalysed by RuBP carboxylase / Rubisco;*
4. *forms unstable 6C intermediate, which breaks down to form 2 molecules of 3C glycerate-3-phosphate / PGA;*
5. *second stage: carbon reduction, where PGA phosphorylated → forms 1,3-bisphosphoglycerate using ATP;*
6. *then reduced to form 3C glyceraldehyde-3-phosphate / TP using reduced NADP;*
7. *1 out of 6 G3P exits cycle to be converted to glucose / carbo / lipids;*
8. *remaining 5 mol of G3P remains in cycle to regenerate (3 mols of) RuBP utilising ATP;*

**(b)** Describe the roles of membranes in photosynthesis and in respiration. [8]

1. *contains electron carriers of the ETC;*
2. *during e<sup>-</sup> transfer, energy is released to pump H<sup>+</sup> from mitochondrial matrix and stroma into mitochondrial intermembrane space and thylakoid space;*
3. *impermeability of membrane to ions;*
4. *allows formation of proton gradient across inner mito memb and thylakoid memb;*
5. *contains ATP synthase to harness proton motive force / which allows H<sup>+</sup> to diffuse through;*
6. *to phosphorylate ADP to form ATP;*
7. *thylakoid membrane contains photosynthetic pigments that absorb light energy during photosynthesis;*
8. *membranes of mitochondrion contains transport proteins to allow transport of metabolites e.g. glucose / triose phosphate / pyruvate;*
9. *the envelopes of mito and chloroplast allows for compartmentalisation of the cell as mito. and chloroplast enz require different / specific conditions from the rest of the cell to function;*

- (c) Explain how membrane fluidity is maintained in a cell when temperature increases. [4]
1. **increase temp** ➔ **increased KE** ➔ **phospholipids move further apart** ➔ **increased fluidity**;
  2. **↑ cholesterol composition** ➔ **binds to FA tails of phospholipids to restrict movement** ➔ **↓ memb fluidity**;
  3. **↑ carbon chain length of FA tails** ➔ **↑ SA for hydrophobic int** ➔ **↓ memb fluidity**;
  4. **↓ degree of saturation of FA tails** ➔ **straight chains** ➔ **more closely packed** ➔ **more hydrophobic int** ➔ **↓ memb fluidity**;
- 8 (a) Describe the structural features of collagen and how they contribute to its function. [8]
1. **fibrous protein made up of amino acids linked by peptide bonds**;
- [Struct to Fn] allows tight twisting to increase tensile strength*
2. **tropocollagen, 3 polypeptides twisted into triple helix**;
  3. **each polypeptide has gly-X-Y motif where X is usually proline (pro) and Y is usually proline or hydroxyproline (hyp)**;
  4. **3.3 a.a. per turn with gly in centre of helix, as it is the smallest amino acid** ➔ **allow tight twisting to ↑ tensile strength**;
- [Struct to Fn] bonds / cross-linkages increase tensile strength*
5. **presence of hydrogen bonds and covalent cross-links (at N-terminals) within the tropocollagen** ➔ **↑ tensile strength**;
  6. **covalent cross links form between N terminal and C terminal of tropocollagens involving Lys and Hyl** ➔ **↑ tensile strength**;
- [Struct to Fn] allows deposition of minerals to increase mechanical strength*
7. **staggered arrangement / array of tropocollagen create hole region / 40nm gaps** ➔ **allow deposition of minerals** ➔ **↑ mechanical strength**;
- [Struct to Fn] bundling increases tensile strength*
8. **collagen fibrils are further strengthened and stabilized by the formation of covalent cross-links involving Lys and Hyl between tropocollagen molecules in the fibril** ➔ **↑ tensile strength**;
  9. **bundling of collagen fibrils to form collagen fibres** ➔ **↑ tensile strength**;
  10. **Insolubility due to position of non-polar amino acids in exterior and interior of tropocollagen/ collagen fibres, do not allow interaction with water** ➔ **structural support**;

- (b) Insulin polypeptide synthesised by ribosomes attached to the endoplasmic reticulum will be transported out of the beta cell.

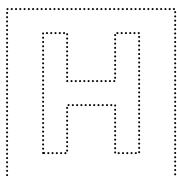
Describe the route taken by insulin out of the beta cell. [8]

1. *insulin polypeptide / preproinsulin enters cisternal space of rER;*
2. *cleaving of signal peptide of preproinsulin → formation of 3 disulfide bridges → folding to form proinsulin;*
3. *further cleavage of C-peptide to form insulin protein, where chain A and B linked by 2 disulfide bridges;*
4. *transport vesicle containing insulin protein pinches off from rER and is transported to and fuses with membrane of cis face of GA;*
5. *protein is packaged, sorted, tagged in cisternae of GA;*
6. *addition, substitution and deletion of sugar monomers on oligosaccharide chain and phosphorylation to form molecular identification tag;*
7. *protein moves from cis face to trans face;*
8. *packaged into secretory vesicle & bud off from trans face of GA → vesicle is transported to CSM via microtubules;*
9. *membrane of secretory vesicle fuses with CSM → release of insulin out of beta cell via exocytosis;*

- (c) Explain the roles of vesicles that emerge from the Golgi body. [4]

1. *secretory vesicles carrying proteins to be released out of the cell via exocytosis;*
2. *secretory vesicles containing memb components → insert membrane components such as phospholipids / proteins into CSM;*
3. *lysosomes containing hydrolytic enz;*
4. *carry out phagocytosis of pathogens / food particles;*
5. *digestion of worn-out organelles / autophagy;*
6. *lysosomal pathway of apoptosis*
7. *AVP;*

[Total: 20]



**INNOVA JUNIOR COLLEGE**  
**JC 2 PRELIMINARY EXAMINATION**  
in preparation for General Certificate of Education Advanced Level  
**Higher 2**

CANDIDATE NAME

CLASS  INDEX NUMBER

**BIOLOGY**

**9648/03**

Paper 3 Applications Paper

**25 August 2016**

**2 hours**

Additional Materials: Answer Paper  
Cover Page

**READ THESE INSTRUCTIONS FIRST**

Write your name and class on all the work you hand in.  
Write in dark blue or black pen on both sides of the paper.  
You may use a soft pencil for any diagrams, graphs or rough working.  
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

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

For Examiner's Use	
1	16
2	13
3	11
4	12
5	20
<b>Total</b>	<b>72</b>

This document consists of **16** printed pages.



**Section A**Answer **all** questions.

- 1 Diabetes mellitus is a disease that results in the inability to regulate one's blood glucose levels, either due to lack of insulin or insensitivity to insulin.

Injection of insulin before meals helps patients to keep blood glucose within set point. Insulin used to be purified from animal sources but genetic engineering has now provided an alternative source.

- (a) State **two** advantages of genetically engineered insulin compared to those obtained from animal sources.

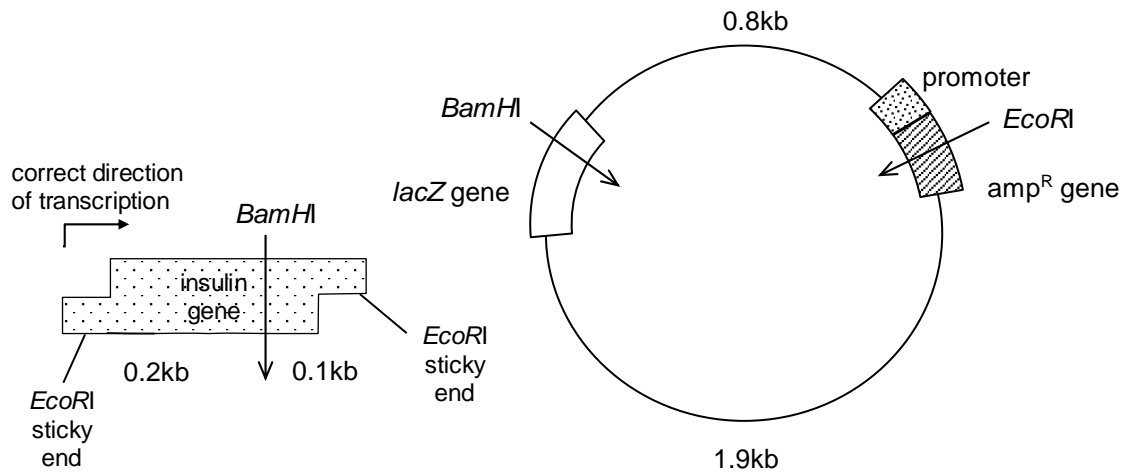
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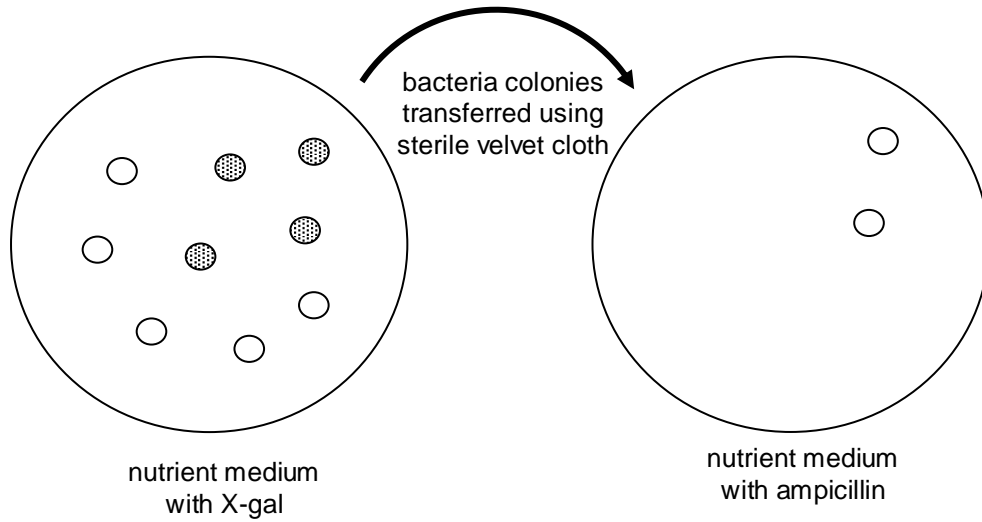
..... [2]

Human insulin is isolated using *EcoRI* from the cDNA library and ligated into plasmid shown in Fig. 1.1. The number of base pairs between the restriction recognition sites is shown.



**Fig. 1.1**

Plasmids were introduced into bacteria host cells and grown on nutrient medium containing X-gal. A replica plate was made by transferring bacteria colonies from the first plate to nutrient medium containing ampicillin. Colonies growing in the two plates are shown in Fig. 1.2.



**Fig. 1.2**

Legend

- blue colony
- white colony

**(b) (i)** State **one** possible bacteria host cell.

..... [1]

**(ii)** Explain how plasmids were introduced into host cells.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

- (c) (i) On Fig. 1.2, label the recombinant colony/colonies with an 'X'. [1]
- (ii) Explain how you arrive at your answer in (c)(i).

.....

.....

.....

..... [2]

The insulin gene was found to be inserted into plasmids in two possible orientations. To determine if the insulin gene was inserted correctly, recombinant plasmids were isolated, digested with *Bam*HI and separated by gel electrophoresis.

Fig. 1.3 shows the outline of the electrophoresed gel.

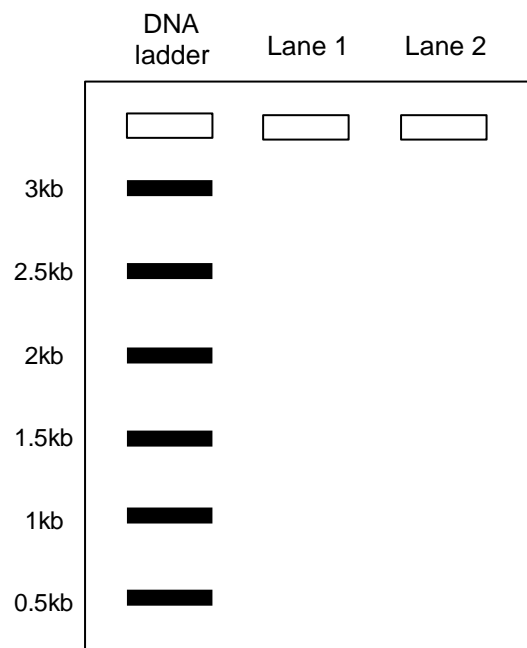


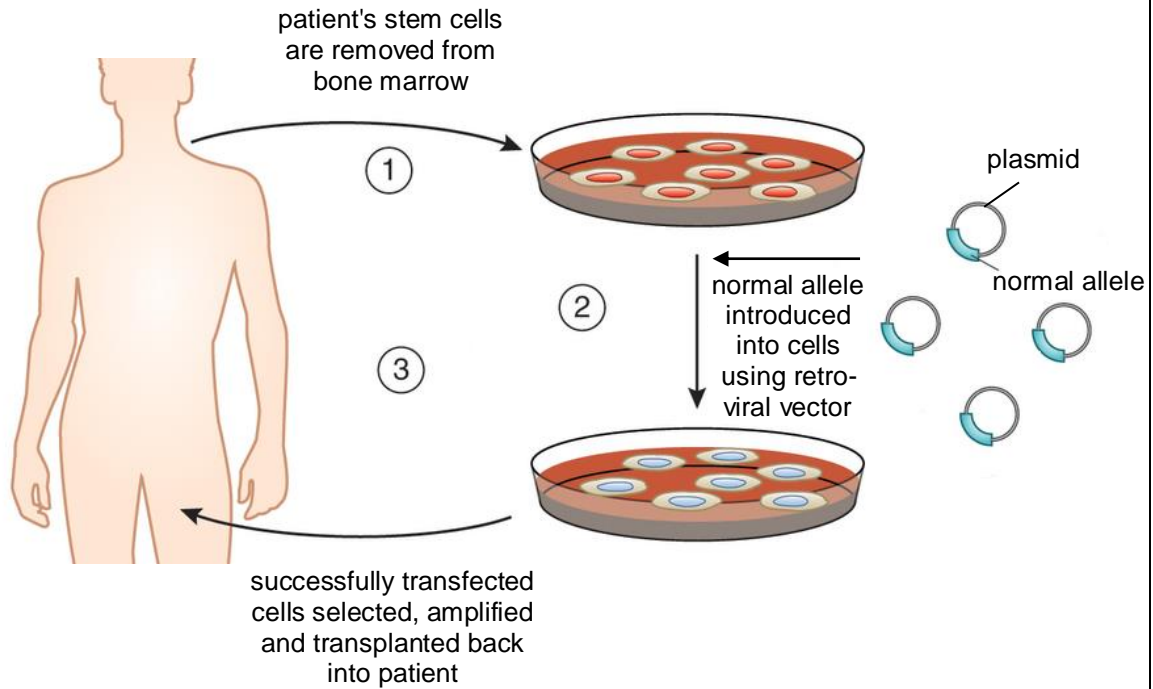
Fig. 1.3

- (d) On Fig. 1.3, illustrate the bands found if plasmids with insulin gene inserted
- (i) correctly was loaded in lane 1; [1]
- (ii) wrongly was loaded in lane 2. [1]





X-SCID can be treated by *ex vivo* gene therapy shown in Fig. 2.1.



**Fig. 2.1**

- (b) (i) State **two** reasons why the *ex vivo* approach was used instead of *in vivo*.

.....

.....

.....

.....

[2]

- (ii) Suggest why the normal allele was ligated into a plasmid before introduction into cells.

.....

.....

[1]

- (iii) Suggest how successfully transfected cells were selected.

.....

.....

.....

.....

[2]

Normal lymphocytes were detected in some patients' blood for several months following gene therapy. Some of the patients who underwent this treatment were subsequently diagnosed to suffer from leukaemia (cancer of blood cells).

- (c) (i) Explain why normal lymphocytes were detected in patients' blood for several months following gene therapy.

.....

.....

.....

..... [2]

- (ii) Explain how gene therapy could have led to the development of leukaemia in other patients.

.....

.....

.....

..... [2]

[Total: 13]

- 3 The carp, shown in Fig. 3.1, is a large freshwater fish native to central Asia. It was introduced to Australia by humans in the mid-1800s, where it subsequently became an aquatic pest.

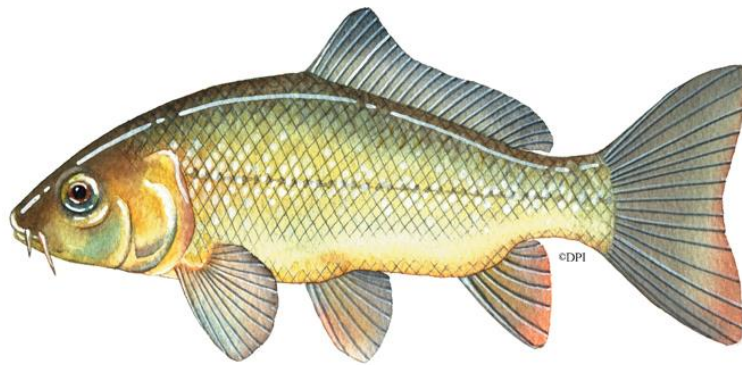


Fig. 3.1

- (a) Suggest why the carp became a pest when it was introduced into Australia.

[1]

Scientists tried to control the carp by using gene technology. They inserted a gene into carp embryos that prevents the production of an enzyme, aromatase. Aromatase catalyses the conversion of testosterone into oestrogen. The inserted gene causes female embryos to develop as males.

The inserted gene produces mRNA with a base sequence that is complementary to the base sequence of the mRNA produced by the aromatase gene. Table 3 shows part of the base sequence of the aromatase gene. It also shows part of the base sequence of the mRNA produced by the inserted gene.

Table 3

	base sequence					
template strand of aromatase gene	T	G			A	
mRNA transcribed from aromatase gene						
template strand of inserted gene						
mRNA transcribed from inserted gene			G	C		U

- (b) Complete Table 3 to show the base sequences in the mRNAs transcribed and the inserted gene. [3]

(c) Describe how the inserted gene was introduced into the carp embryos.

.....

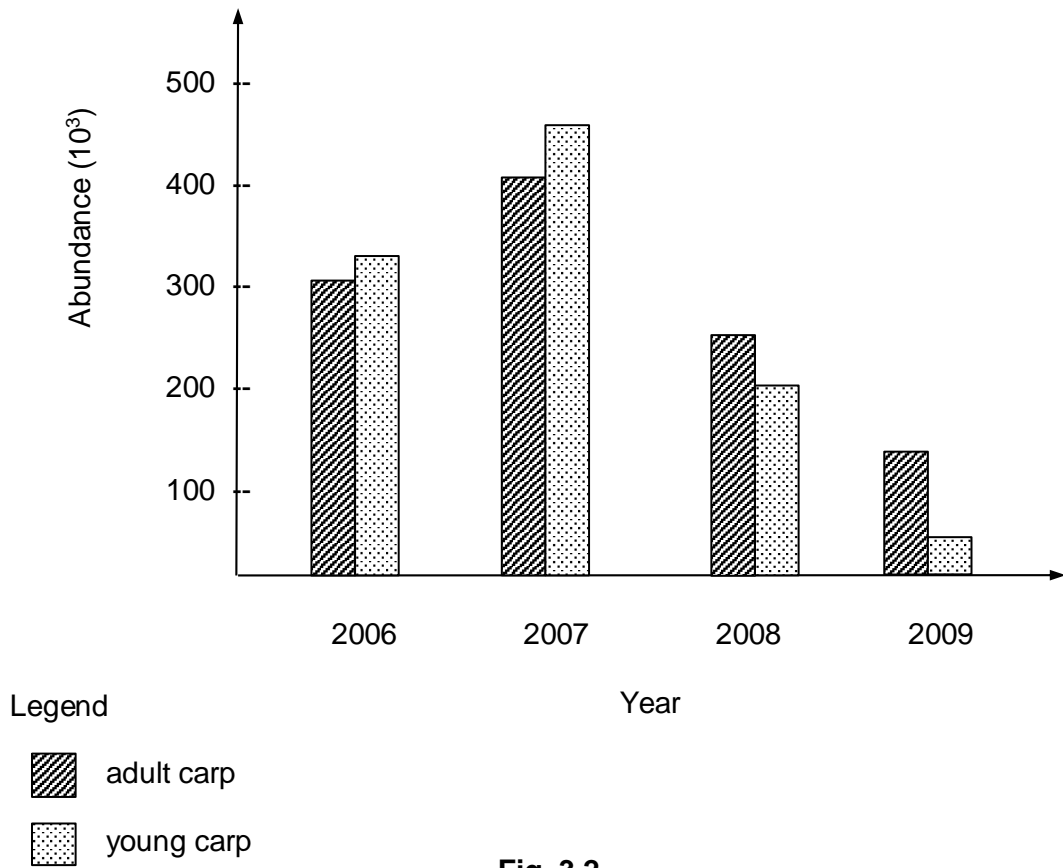
.....

.....

.....

[2]

The genetically modified (GM) carp were released into the environment in 2006. Fig. 3.2 shows the effect on wild carp populations for the subsequent years.

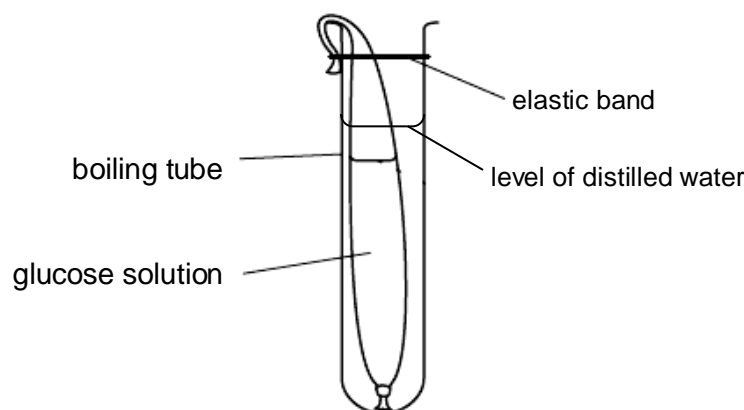


**Fig. 3.2**



#### 4 Planning question

Visking tubing is a selectively permeable membrane that allows small molecules like glucose to pass through. Fig. 4.1 shows how a Visking tubing can be set up to investigate diffusion rates.



**Fig. 4.1**

Using this information and your own knowledge, design an experiment to investigate the effect of concentration on rate of glucose diffusion.

You must use:

- 10% glucose solution,
- distilled water,
- Benedict's solution,
- Visking tubing,
- boiling tube,
- elastic band.

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

- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,
- syringes,
- Bunsen burner, tripod stand.

Your plan should:

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

[Total: 12]











## 5 Free-response question

Write your answers to this question on the separate answer paper provided.

Your answers:

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

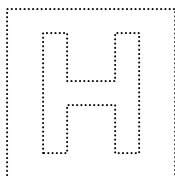
- (a)** The patient's own stem cells are frequently modified for use in treating genetic diseases via gene therapy.

Explain why these stem cells are suited for this purpose. [6]

- (b)** The therapeutic gene used for gene therapy can be amplified using polymerase chain reaction (PCR). Describe the process of PCR. [8]

- (c)** The therapeutic gene can be delivered using viral or non-viral vectors. Compare the use of these two modes of gene delivery. [6]

[Total: 20]



JC2 PRELIMINARY EXAMINATION  
in preparation for General Certificate of Education Advanced  
Level  
**Higher 2**

CANDIDATE  
NAME

**MARK SCHEME**

CLASS

INDEX NUMBER

**BIOLOGY**

**9648/03**

Paper 3 Applications Paper

**25 August 2016**

**2 hours**

Additional Materials: Answer Paper  
Cover Page

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Innova Junior College

**[Turn over**

**Section A**Answer **all** questions.

- 1 Diabetes mellitus is a disease that results in the inability to regulate one's blood glucose levels, either due to lack of insulin or insensitivity to insulin.

Injection of insulin before meals helps patients to keep blood glucose within set point. Insulin used to be purified from animal sources but genetic engineering has now provided an alternative source.

- (a) State **two** advantages of genetically engineered insulin compared to those obtained from animal sources.

**1. religious considerations**

*insulin may be purified from animals that violate religious practices e.g. Muslims cannot use porcine insulin;*

**2. insulin from animal sources may cause allergy rxn in patients**

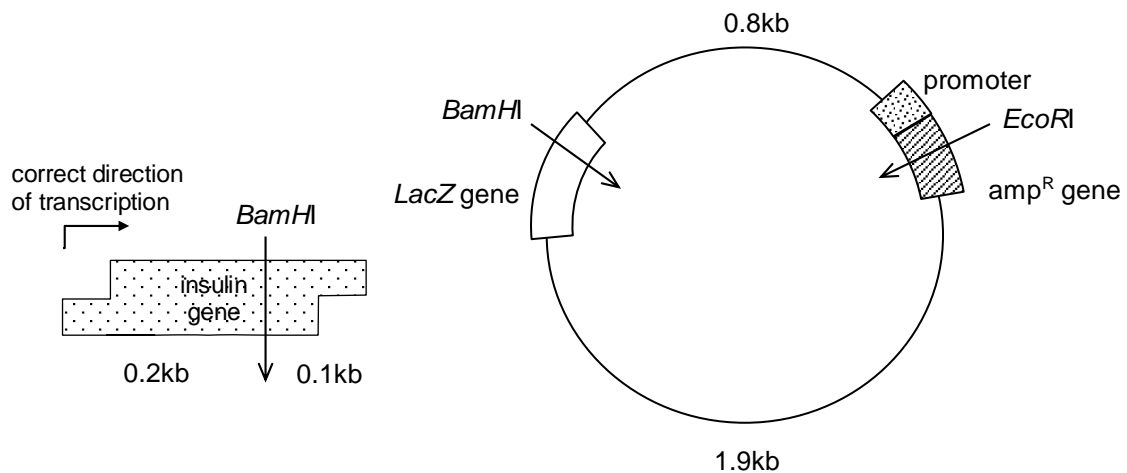
*GE source is identical to human insulin as it is transcribed & translated from human insulin gene;*

**3. can be produced in larger quantities**

*to meet high demands; (ANY 2)*

[2]

Human insulin is isolated using *EcoRI* from the cDNA library and ligated into plasmid shown in Fig. 1.1. The number of base pairs between the restriction recognition sites is shown.



**Fig. 1.1**

Plasmids were introduced into bacteria host cells and grown on nutrient medium containing X-gal. A replica plate was made by transferring bacteria colonies from the first plate to nutrient medium containing ampicillin. Colonies growing in the two plates are shown in Fig. 1.2.

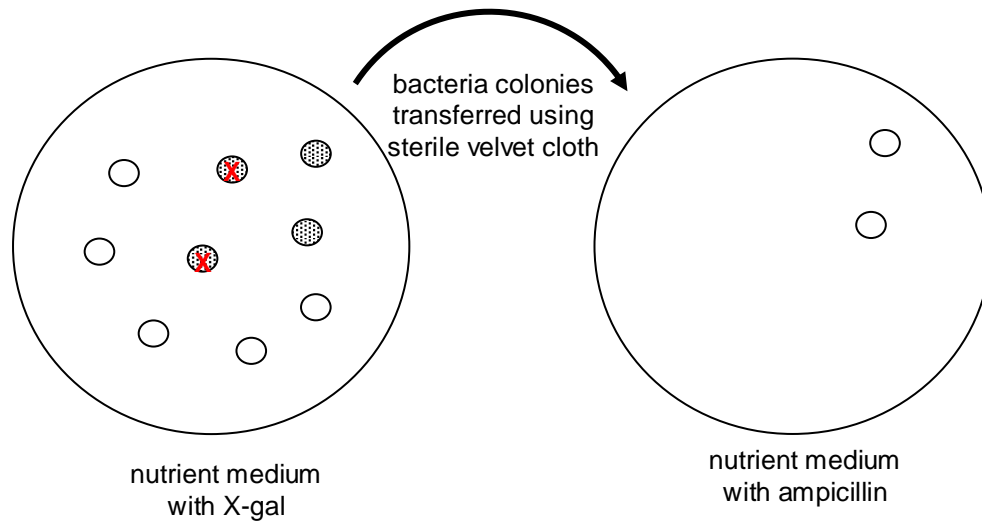


Fig. 1.2

Legend

- blue colony
- white colony

(b) (i) State **one** possible bacteria host cell.

*Escherichia coli*;

[1]

(ii) Explain how plasmids were introduced into host cells.

1. **(artificial) transformation**

**via heat shock;**

2. **in cold  $\text{CaCl}_2$**

**to induce competence / reduce repulsion btw mem & DNA;**

3. **in  $42^\circ\text{C}$  for 1 – 2 min**

**to cause temporary poration in mem;**

4. **back into  $0^\circ\text{C}$**

**to close pores to prevent plasmid from escaping;**

[4]

(c) (i) On Fig. 1.2, label the recombinant colony/colonies with an 'X'. [1]

(ii) Explain how you arrive at your answer in (c)(i).

**1. successfully transformed bact has plasmid intact lacZ gene**

**coding for  $\beta$ -galactosidase which converts X-gal  $\rightarrow$  blue cpd thus are blue;**

**2. transformed bact with recombinant plasmid will have disrupted amp<sup>R</sup> gene / have undergone insertional inactivation**

**thus recombinant bact are blue colonies in the 1<sup>st</sup> plate that does not grow in replica plate;** [2]

The insulin gene was found to be inserted into plasmids in two possible orientations. To determine if the insulin gene was inserted correctly, recombinant plasmids were isolated, digested with *Bam*HI and separated by gel electrophoresis.

Fig. 1.3 shows the outline of the electrophoresed gel.

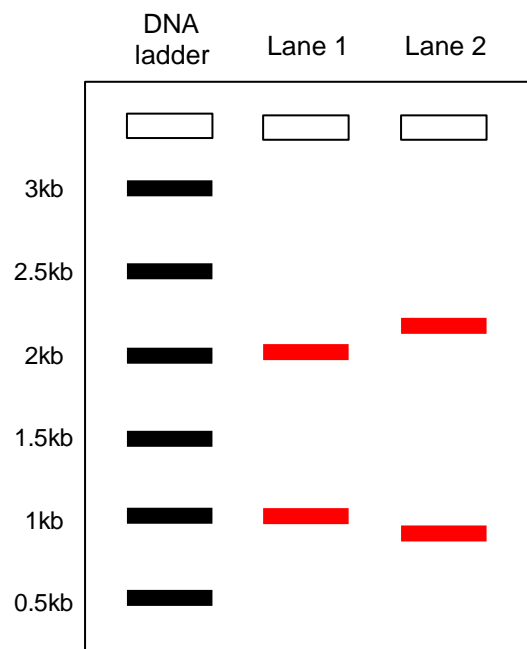


Fig. 1.3

(d) On Fig. 1.3, illustrate the bands found if plasmids with insulin gene inserted

(i) correctly was loaded in lane 1, [1]

(ii) wrongly was loaded in lane 2. [1]

(e) Describe how gel electrophoresis is used to separate the restriction fragments.

**1. restriction fragments are loaded in wells of agarose gel near cathode**  
 .....  
**gel submerged in buffer with ions to maintain pH & conduct electricity;**  
 .....

**2. DC / voltage applied aX gel**  
 .....

**–vely charged DNA migrates towards anode;**  
 .....

**3. with gel acting as molecular sieve that impedes movement of DNA**  
 .....  
**at speeds inversely proportional to fragment length;**  
 .....

**4. fragments of the same length would be found at the same region**  
 .....  
**forming a band;**  
 .....

[4]

[Total: 16]

2 X-linked Severe Combined Immunodeficiency (X-SCID) is a recessive genetic disorder. Diseased individuals suffer from compromised immune system due to malfunctioning lymphocytes.

(a) (i) Describe the cause and explain the symptoms of X-SCID.

**1. mutation in gene on X chromosome**  
 .....

**coding for  $\gamma_c$  chain in IL2;**  
 .....

**2. unable to bind cytokines / interleukins**  
 .....

**due to  $\Delta$  in 3D config;**  
 .....

**3. unable to  $\oplus$  cell division & proliferation of B & T lymphocytes**  
 .....

**lack of / malfunctioning WBC  $\Rightarrow$  immune sys is compromised;**  
 ..... [3]

(ii) Explain why males are more likely to suffer from the disease compared to females.

**males only have 1 copy of X chromosome  $\Rightarrow$  inheritance of a single copy of the recessive allele results in the disease;**  
 .....

**Accept alternative argument of females having 2 X chromosome**  
 .....

[1]



X-SCID can be treated by *ex vivo* gene therapy shown in Fig. 2.1.

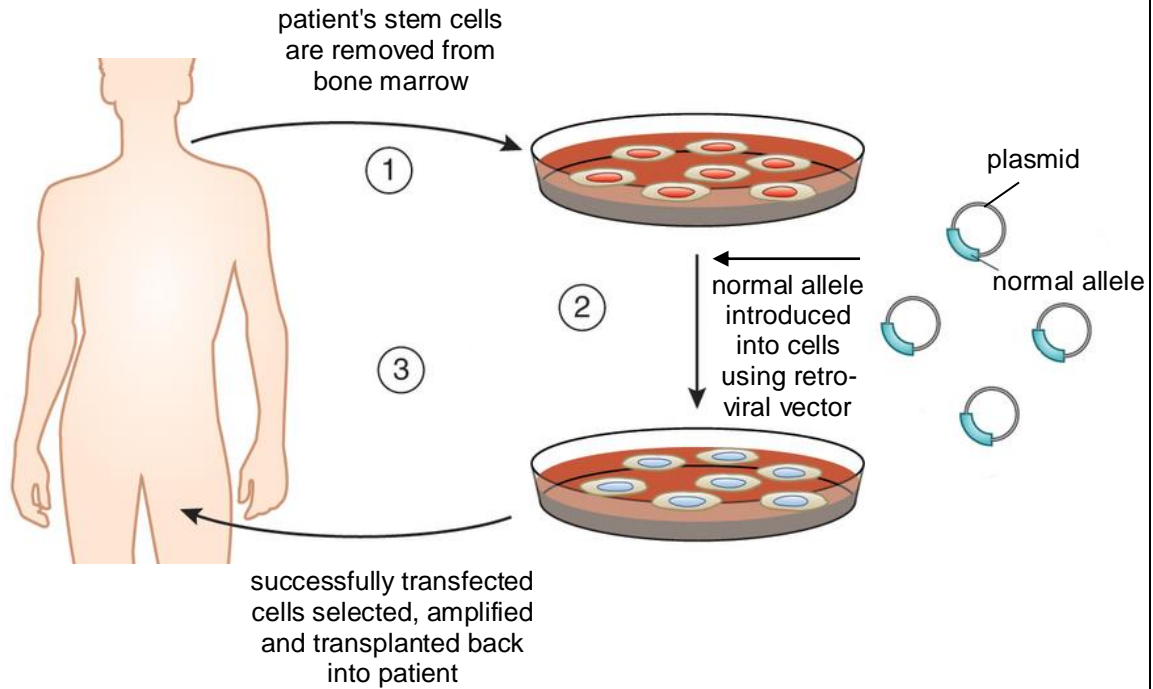


Fig. 2.1

- (b) (i) State **two** reasons why the *ex vivo* approach was used instead of *in vivo*.
- 1. allows selection of successfully transfected cells;**
  - 2. allows cells to be amplified in culture to ↑ nos. before transplanting**  
↑ chance of SC successfully residing in bone marrow;
  - 3. allows cells to be screened for insertional mutagenesis;** [2]
- (ii) Suggest why the normal allele was ligated into a plasmid before introduction into cells.
- 1. linear fragments of DNA are easily digested by cellular enz**  
after intro into cells; [1]
- (iii) Suggest how successfully transfected cells were selected.
- 1. DNA from some cells of the colony isolated**  
subj to restriction digestion;
  - 2. restriction fragments separated by gel electrophoresis**  
to check for presence of transgene; [2]

Normal lymphocytes were detected in some patients' blood for several months following gene therapy. Some of the patients who underwent this treatment were subsequently diagnosed to suffer from leukaemia (cancer of blood cells).

- (c) (i) Explain why normal lymphocytes were detected in patients' blood for several months following gene therapy.

**1. normal allele is integrated into SC genome**

*stably propagated to daughter cells when SC divides;*

**2. transgene is present and expressed in new lymphocytes**

*allow maturation and proliferation of normal lymphocytes;* [2]

- (ii) Explain how gene therapy could have led to the development of leukemia in other patients.

**1. due to insertional mutagenesis**

*where transgene is inserted in e.g. TSG;*

**2. leading to LOF mutation**

*causing SC to undergo uncontrolled proliferation to give too many WBCs;* [2]

[Total: 13]

- 3 The carp, shown in Fig. 3.1, is a large freshwater fish native to central Asia. It was introduced to Australia by humans in the mid-1800s, where it subsequently became an aquatic pest.

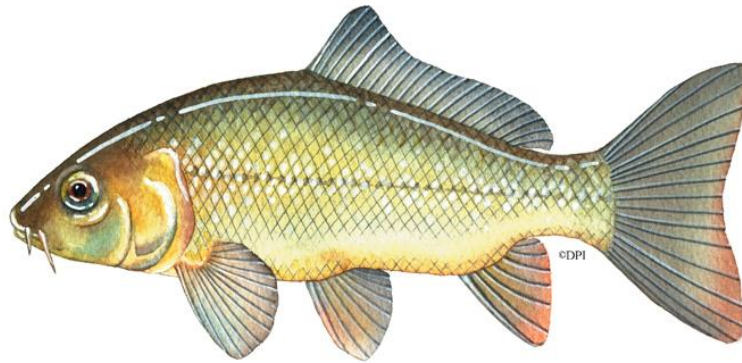


Fig. 3.1

- (a) Suggest why the carp became a pest when it was introduced into Australia.

1. *no natural predators*

*thus reproduce at rapid rate; OR*

2. *is a large fish*

*able to outcompete local spp for resources / food;*

[1]

Scientists tried to control the carp by using gene technology. They inserted a gene into carp embryos that prevents the production of an enzyme, aromatase. Aromatase catalyses the conversion of testosterone into oestrogen. The inserted gene causes female embryos to develop as males.

The inserted gene produces mRNA with a base sequence that is complementary to the base sequence of the mRNA produced by the aromatase gene. Table 3 shows part of the base sequence of the aromatase gene. It also shows part of the base sequence of the mRNA produced by the inserted gene.

Table 3

	Base sequence					
Template strand of aromatase gene	T	G	<b>G</b>	<b>C</b>	A	<b>T</b>
mRNA transcribed from aromatase gene	<b>A</b>	<b>C</b>	<b>C</b>	<b>G</b>	<b>U</b>	<b>A</b>
Template strand of inserted gene	<b>A</b>	<b>C</b>	<b>C</b>	<b>G</b>	<b>T</b>	<b>A</b>
mRNA transcribed from inserted gene	<b>U</b>	<b>G</b>	G	C	<b>A</b>	U

(b) Complete Table 3 to show the base sequences in the mRNAs transcribed and the inserted gene. [3]

(c) Describe how the inserted gene was introduced into the carp embryos.

1. *by particle bombardment;*

2. *gene to be inserted is ligated into plasmids & coated on tungsten beads;*

*and shot at high speed into embryo cells;*

[2]

The genetically modified (GM) carp were released into the environment in 2006. Fig. 3.2 shows the effect on wild carp populations for the subsequent years.

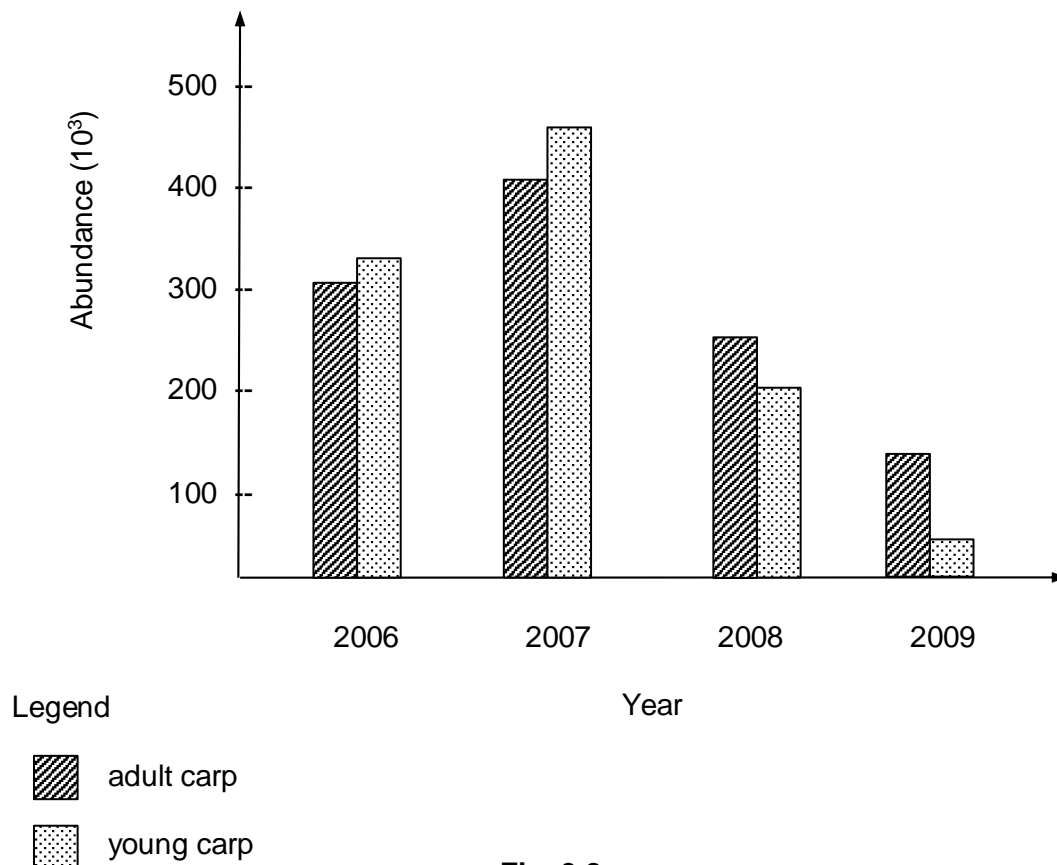


Fig. 3.2

(d) With reference to Fig. 3.2 and information on the inserted gene, explain the effect of releasing GM carp on carp populations.

1. *initial ↑ in 2007 due to more carp available for repro*

*both adult & young carp ↑ from 300,000 to 400,000 & 330,000 to 450,000 respectively;*

2. *popn of both adult & young carp ↓ from 2008 – 2009*

*to 150,000 for adult & 50,000 for young carp;*

3. *as GM carp mating with carp in wild & pass down inserted gene to offspring*

*inserted gene is transcribed into anti-sense mRNA;*

4. *that compl bp with aromatase mRNA (forming a duplex)*

*that ⊗ (ribosome binding thus) translation into aromatase;*

5. *testosterone is ⊗ converted into oestrogen ➔ all offspring develop into males*

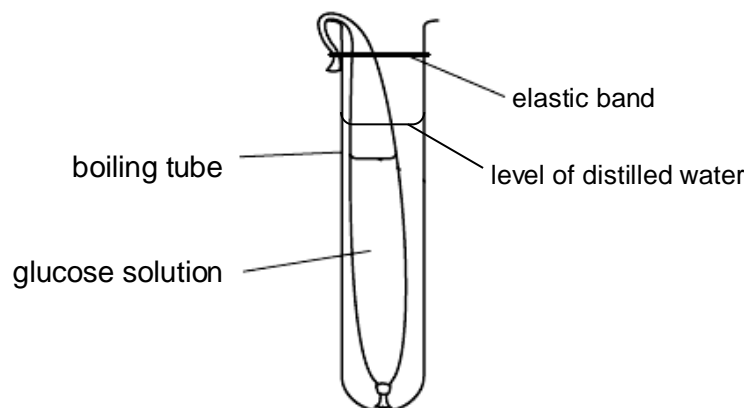
*➔ ↓ of no. of females in the popn thus ↓ repro rate;*

[5]

[Total: 11]

#### 4 Planning question

Visking tubing is a selectively permeable membrane that allows small molecules like glucose to pass through. Fig. 4.1 shows how a Visking tubing can be set up to investigate diffusion rates.



**Fig. 4.1**

Using this information and your own knowledge, design an experiment to investigate the effect of concentration on rate of glucose diffusion.

You must use:

- 10% glucose solution,
- distilled water,
- Benedict's solution,
- Visking tubing,
- boiling tube,
- elastic band.

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

- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,
- syringes,
- Bunsen burner, tripod stand.

Your plan should:

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

[Total: 12]

**Theoretical background [2m]**

1. **define diffusion ref to movement from region of higher to lower conc., conc. gradient, passive process**
2. **state hypothesis ref to faster rate when [glc] is higher in Visking tubing, steeper conc. gradient, until equilibrium with no net movement**

**ER: Some candidates think glucose diffusion is dependent on water potential rather than solute conc.**

**Independent variable [1m]**

3. **conc. of glucose, at least 5 conc. of regular interval & wide range, vol of 10% glucose & distilled water used for dilution shown in dilution table (either simple or serial)**

**ER: Some attempted to describe vol used in prose resulting in confusing phrasing. Others excluded final glucose conc., an important info, in the table.**

**Dependent variable [1m]**

4. **amount of glucose diffused into distilled water measured by amount & colour of ppt in Benedict's test / time of 1<sup>st</sup> ppt appearance**

**Benedict's procedure must be feasible to score this mark**

*ER: Majority of the candidates are not able to describe Benedict's test correctly either adding too little Benedict's soln e.g. 2 – 3 drops or not placing samples in boiling water bath.*

*Many candidates stated colour of ppt as data to record, failing to understand that amount of ppt also indicates glucose conc.*

*Candidates also did not think through their answers coherently and examiners wonder how one can calculate an average of colours in the results table.*

**Controlled variable (any 2) [2m] rationale must be stated**

5. temperature, use of water bath at specified temp ® **direct heating with Bunsen flame**

6. time allowed for diffusion

7. vol of glucose in Visking tubing

**Procedure [2m]**

8. coherent sequence of steps e.g. sequence of adding solns (® set up according to Fig. 1), starting stopwatch

9. rinsing Visking tubing, vol distilled water > glucose, removing sample for Benedict's test, time 1 tube at a time etc.

*ER: Majority of the candidates did not understand the basic principle of conducting expt. Many candidates heated the solutions while diffusion is occurring, being totally oblivious to the obvious fact that diffusion rates would be affected by this setup.*

*Some candidates listed temperature as a controlled variable and yet still heated the Visking tubing, showing a lack of understanding of what they are writing.*

*Others decided to record the time taken for brick red ppt to appear even for control setups.*

**Reliability [1m]**

10. replicates & repeats (**only if procedure is largely feasible**)

**Results [1m]**

11. table of results

*describe means of deciphering conc. of glucose in distilled water*

**® colour of ppt as results as average of replicates cannot be calculated nor plotted in graph**

**Graph [1m]**

12. plots theoretical graph of initial glucose conc. vs conc. of glucose diffused into distilled water / time / amt of ppt



**Safety [1m] (any 1)**

**13. states hazard, risk, precaution**

**e.g. hot water from boiling waterbath may cause scalding, handle waterbath with cotton gloves**

**e.g. Benedict's solution may cause skin & eye irritation, wear gloves & goggles when handling**

**® Benedict's soln is corrosive**

**® glucose is skin irritant**

**® Bunsen flame may cause burns thus handle with gloves. Flames should not be handled.**

**® hazard not stated in procedure**



### Free-response question

Write your answers to this question on the separate answer paper provided.

Your answer:

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

- 5 (a)** Patient's own stem cells are frequently modified for use in treating genetic diseases via gene therapy.

Explain why these stem cells are suited for this purpose. [6]

- 1. patient's own cells are used to prevent immune rejection**  
*as WBCs would not recognise these cells as foreign due to absence of Ag on cell surface;*
- 2. patient will not need to take immunosuppressant & immune sys ⊗ be compromised**  
*patient less susceptible to opportunistic infections;*
- 3. undifferentiated / unspecialised**  
*i.e. they ⊗ possess any specific cellular features;*
- 4. and are multipotent**  
*able to differentiate to give rise to limited cell types;*
- 5. able to undergo asymmetrical division to provide a supply of ASC**  
*and progenitor cells to differentiate into a related grp of cells to replace diseased cells;*
- 6. unlimited self-renewal capacity**  
*due to ✓ active telomerase that prevents telomere shortening with every cell division;*
- 7. preventing the cell from undergoing apoptosis due to replicative senescence;**
- 8. provides a supply of normal cells throughout lifetime of patient**  
*eliminating the need for repeated treatment;*

- (b)** The therapeutic gene used for gene therapy can be amplified using polymerase chain reaction (PCR). Describe the process of PCR. [8]

- 1. target DNA added to reaction tube with dNTPs, excess fwd & rev primers, Taq DNA pol in buffer**  
*in thermal cycler;*
- 2. denaturation**  
*heated to 95°C;*
- 3. ↑ KE to break H bonds btw compl bp**  
*to separate ds DNA → 2 ssDNA;*

**4. annealing**

*lower temp to 55°C;*

**5. to allow forward & reverse primers to bind**

*to seq flanking the target seq to provide free 3'OH end for Taq pol;*

**6. primers added in excess to ↑ chance of primer binding cf to DNA renaturing;**

**7. elongation**

*heating to 72°C;*

**8. Taq pol binds to 3' end of primer to add DNA nucleotides w bases compl to target DNA / using target DNA as template;**

**9. syn new DNA strand in 5' → 3' direction;**

**10. cycle is repeated 25 – 30 times**

*to produce 2n copies of target DNA where n = no. of cycles;*

(c) The therapeutic gene can be delivered using viral or non-viral vectors. Compare the use of these 2 modes of gene delivery. [6]

**1. cf gene size;**

**2. cf tissue specificity;**

**3. cf ability to integrate thus stability of gene propagation;**

**4. cf possibility of insertional mutagenesis;**

**5. cf probability of triggering immune response;**

**6. cf ease of preparation;**

**Any elaboration on the answers to this?**

[Total: 20]

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